Linear deformation of PP-R pipes under heat influence

Thermoplastic plastics PP-R pipes are exposed to thermal expansion. The linear extension of such pipes is higher than with steel pipes. This fact must be all means be taken into consideration in the laying process. Already in the pipe arrangement planning stage each possibility should therefore be utilized fully to compensate all extension processes within a pipe section.

The linear thermal expansion coefficient for PP-R and PP-R CT pipes is:

$$\varepsilon t = 1.5 \cdot 10^{-4} \quad (K^{-1})$$

Polypropylene pipes mechanically stabilized by an aluminium coating on the pipe periphery (Stabi-Rohr/Stabi-Pipe) have a reduced thermal expansion coefficient. The aluminium coating prevents linear extension at about4/5.

The linear thermal expansion coefficient for PP-R Stabi-Pipes can by approximation assumed as:

$$\varepsilon t = 0.3 \cdot 10^{-4} \quad (K^{-1})$$

The linear thermal expansion coefficient for PP-R Fibre-Pipes is:

$$\varepsilon t = 0.35 \cdot 10^{-4} \quad (K^{-1})$$

The linear deformation of a pipe is thus calculated according to the following formula:

$$\Delta l = \varepsilon t \cdot L \cdot \Delta t \quad (mm)$$

Δl = Linear extension in (mm)

εt = Thermal expansion coefficient in $\left(\frac{mm}{m\ °C}\right)$

L = Pipe length (m)

Δt = Temperature difference (°K)

The calculation of the linear deformation is based on the laying temperature. The following example gives you an idea of how to calculate.

Example for a pipe length of 8m:

1. Lowest pipe wall temperature		+ 9° C	(cold-water pipe)
	Difference	7° K ↕	
2. Laying temperature		+ 16° C	
	Difference	54° K ↕	
3. Highest pipe wall temperature		+ 70° C	(hot-water pipe)

To 1. Shortening of the pipe: 8 m • 7° • 0,03 = 1,68 mm

To 3. Extension of the pipe: 8 m • 54° • 0,03 = 12,96 mm

Linear Expansion Chart
P-R and PP-RCT Solid Wall Pipes

dynatherm® PP-R PIPE SYSTEMS

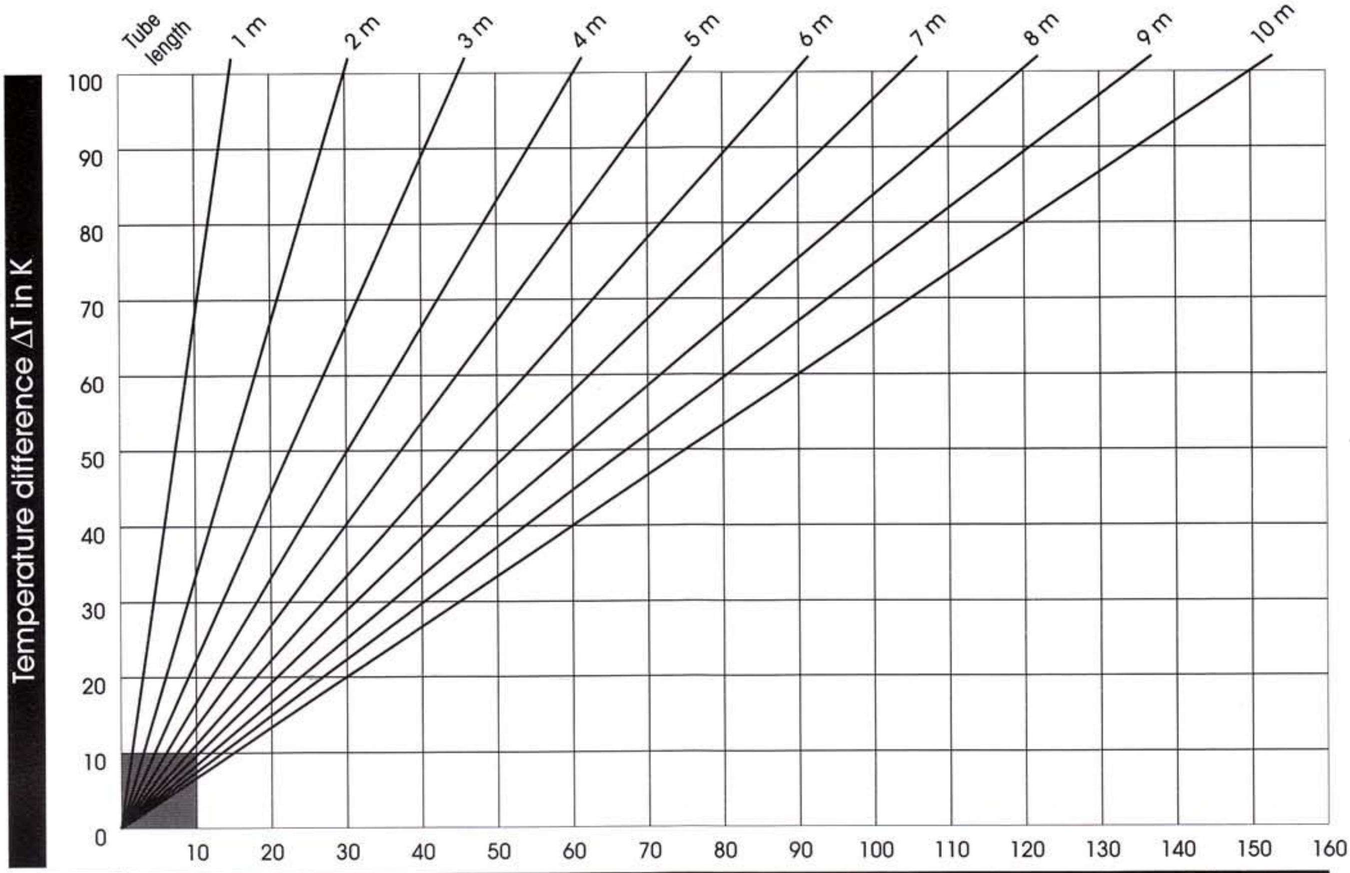


Fig. 4 Linear expansion ΔL in mm

Tube length	Temperature difference ΔT in K									
	10	20	30	40	50	60	70	80	90	100
0,1 m	0,15	0,30	0,45	0,60	0,75	0,90	1,05	1,20	1,35	1,50
0,2 m	0,30	0,60	0,90	1,20	1,50	1,80	2,10	2,40	2,70	3,00
0,3 m	0,45	0,90	1,35	1,80	2,25	2,70	3,15	3,60	4,05	4,50
0,4 m	0,60	1,20	1,80	2,40	3,00	3,60	4,20	4,80	5,40	6,00
0,5 m	0,75	1,50	2,25	3,00	3,75	4,50	5,25	6,00	6,75	7,50
0,6 m	0,90	1,80	2,70	3,60	4,50	5,40	6,30	7,20	8,10	9,00
0,7 m	1,05	2,10	3,15	4,20	5,25	6,30	7,35	8,40	9,45	10,50
0,8 m	1,20	2,40	3,60	4,80	6,00	7,20	8,40	9,60	10,80	12,00
0,9 m	1,35	2,70	4,05	5,40	6,75	8,10	9,45	10,80	12,15	13,50
1,0 m	1,50	3,00	4,50	6,00	7,50	9,00	10,50	12,00	13,50	15,00
2,0 m	3,00	6,00	9,00	12,00	15,00	18,00	21,00	24,00	27,00	30,00
3,0 m	4,50	9,00	13,50	18,00	22,50	27,00	31,50	36,00	40,50	45,00
4,0 m	6,00	12,00	18,00	24,00	30,00	36,00	42,00	48,00	54,00	60,00
5,0 m	7,50	15,00	22,50	30,00	37,50	45,00	52,50	60,00	67,50	75,00
6,0 m	9,00	18,00	27,00	36,00	45,00	54,00	63,00	72,00	81,00	90,00
7,0 m	10,50	21,00	31,50	42,00	52,50	63,00	73,50	84,00	94,50	105,00
8,0 m	12,00	24,00	36,00	48,00	60,00	72,00	84,00	96,00	108,00	120,00
9,0 m	13,50	27,00	40,50	54,00	67,50	81,00	94,50	108,00	121,50	135,00
10,0 m	15,00	30,00	45,00	60,00	75,00	90,00	105,00	120,00	135,00	150,00

Fig. 4a Linear expansion ΔL in mm

Linear Expansion Chart
'Stabi' Pipe (aluminum-coated PP-R)

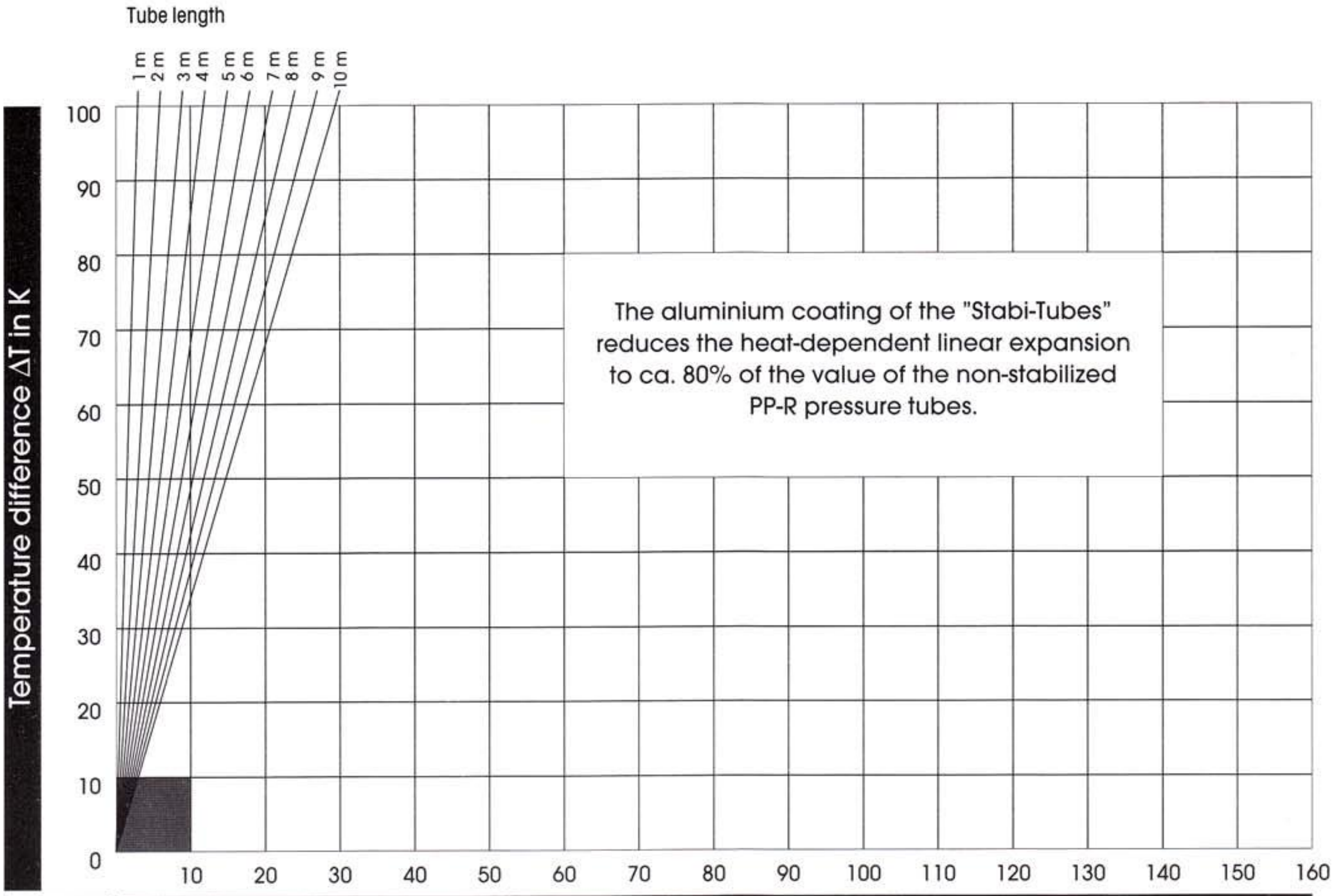


Fig. 5 Linear expansion ΔL in mm

Tube length	Temperature difference ΔT in K: 10	20	30	40	50	60	70	80	90	100
0,1 m	0,03	0,06	0,09	0,12	0,15	0,18	0,21	0,24	0,27	0,30
0,2 m	0,06	0,12	0,18	0,24	0,30	0,36	0,42	0,48	0,54	0,60
0,3 m	0,09	0,18	0,27	0,36	0,45	0,54	0,63	0,72	0,81	0,90
0,4 m	0,12	0,24	0,36	0,48	0,60	0,72	0,84	0,96	1,08	1,20
0,5 m	0,15	0,30	0,45	0,60	0,75	0,90	1,05	1,20	1,35	1,50
0,6 m	0,18	0,36	0,54	0,72	0,90	1,08	1,28	1,44	1,62	1,80
0,7 m	0,21	0,42	0,63	0,84	1,05	1,26	1,47	1,68	1,89	2,10
0,8 m	0,24	0,48	0,72	0,96	1,20	1,44	1,68	1,92	2,16	2,40
0,9 m	0,27	0,54	0,81	1,08	1,35	1,62	1,89	2,16	2,43	2,70
1,0 m	0,30	0,60	0,90	1,20	1,50	1,80	2,10	2,40	2,70	3,00
2,0 m	0,60	1,20	1,80	2,40	3,00	3,60	4,20	4,80	5,40	6,00
3,0 m	0,90	1,80	2,70	3,60	4,50	5,40	6,30	7,20	8,10	9,00
4,0 m	1,20	2,40	3,60	4,80	6,00	7,20	8,40	9,60	10,80	12,00
5,0 m	1,50	3,00	4,50	6,00	7,50	9,00	10,50	12,00	13,50	15,00
6,0 m	1,80	3,60	5,40	7,20	9,00	10,80	12,80	14,40	16,20	18,00
7,0 m	2,10	4,20	6,43	8,40	10,50	12,60	14,70	16,80	18,90	21,00
8,0 m	2,40	4,80	7,20	9,60	12,00	14,40	16,80	19,20	21,60	24,00
9,0 m	2,70	5,40	8,10	10,80	13,50	16,20	18,90	21,60	24,30	27,00
10,0 m	3,00	6,00	9,00	12,00	15,00	18,00	21,00	24,00	27,00	30,00

Fig. 5a Linear expansion ΔL in mm

Linear Expansion Chart - 'Faser' Pipe (PP-RCT with fibre glass layer))

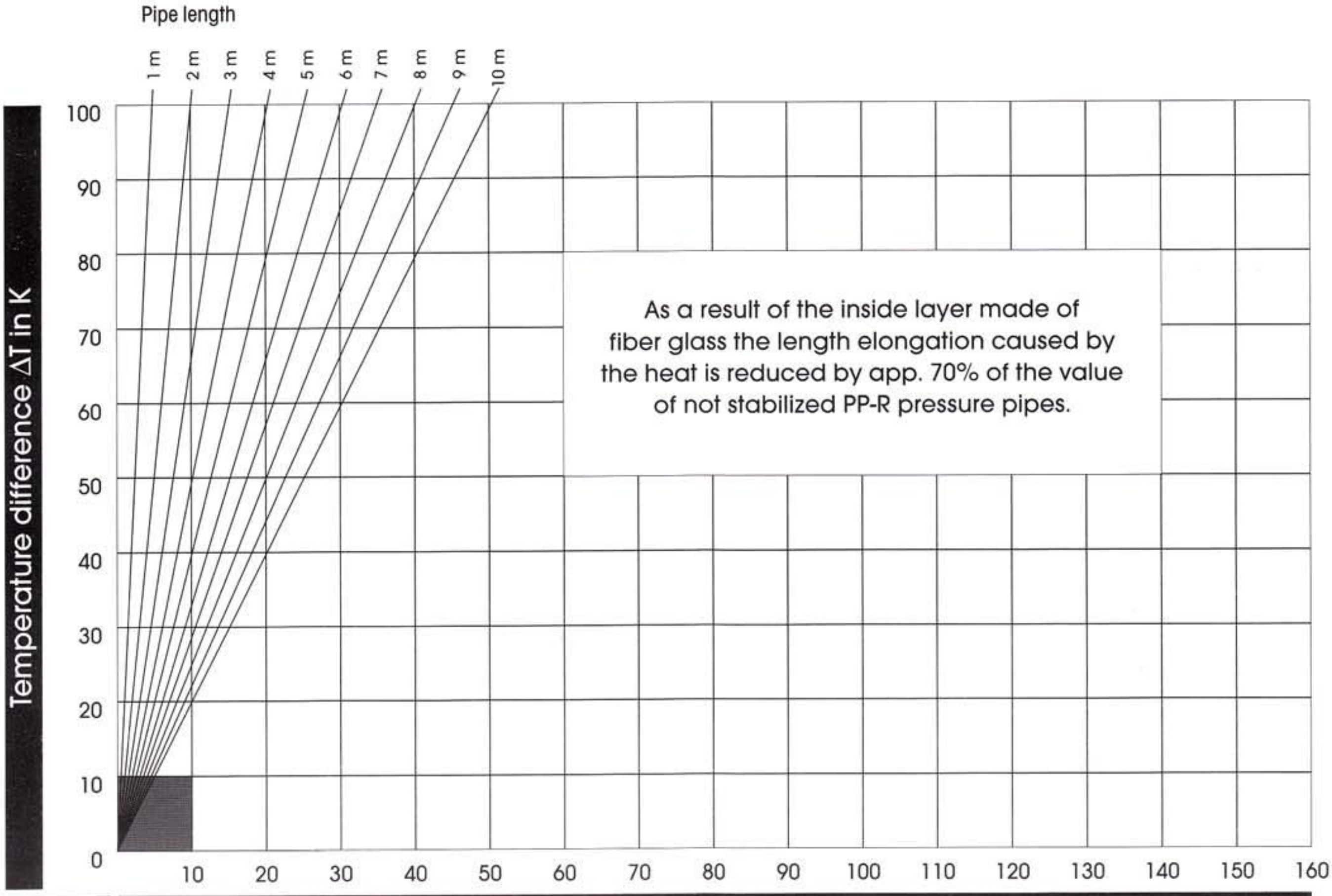


Fig. 5b Linear expansion ΔL in mm

	Temperature difference ΔT in K									
Tub length	10	20	30	40	50	60	70	80	90	100
0,1 m	0,05	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50
0,2 m	0,10	0,20	0,30	0,40	0,50	0,60	0,70	0,80	0,90	1,00
0,3 m	0,15	0,30	0,45	0,60	0,75	0,90	1,05	1,20	1,35	1,50
0,4 m	0,20	0,40	0,60	0,80	1,00	1,20	1,40	1,60	1,80	2,00
0,5 m	0,25	0,50	0,75	1,00	1,25	1,50	1,75	2,00	2,25	2,50
0,6 m	0,30	0,60	0,90	1,20	1,50	1,80	2,10	2,40	2,70	3,00
0,7 m	0,35	0,70	1,05	1,40	1,75	2,10	2,45	2,80	3,15	3,50
0,8 m	0,40	0,80	1,20	1,60	2,00	2,40	2,80	3,20	3,60	4,00
0,9 m	0,45	0,90	1,35	1,80	2,25	2,70	3,15	3,60	4,05	4,50
1,0 m	0,50	1,00	1,50	2,00	2,50	3,00	3,50	4,00	4,50	5,00
2,0 m	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00
3,0 m	1,50	3,00	4,50	6,00	7,50	9,00	10,50	12,00	13,50	15,00
4,0 m	2,00	4,00	6,00	8,00	10,00	12,00	14,00	16,00	18,00	20,00
5,0 m	2,50	5,00	7,50	10,00	12,50	15,00	17,50	20,00	22,50	25,00
6,0 m	3,00	6,00	9,00	12,00	15,00	18,00	21,00	24,00	27,00	30,00
7,0 m	3,50	7,00	10,50	14,00	17,50	21,00	24,50	28,00	31,50	35,00
8,0 m	4,00	8,00	12,00	16,00	20,00	24,00	28,00	32,00	36,00	40,00
9,0 m	4,50	9,00	13,50	18,00	22,50	27,00	31,50	36,00	40,50	45,00
10,0 m	5,00	10,00	15,00	20,00	25,00	30,00	35,00	40,00	45,00	50,00

Fig. 5c Linear expansion ΔL in mm

The linear extension of a PP-R pipe can in most of the cases be compensated by a change in direction.With this, see to free mobility of the piping in axial direction. Should linear extension compensation by directional change not be possible, the fitting in of an expansion bend is required. Axial bellow expansion joints are mostly unfit and uneconomical. For optimum resiliency of the pipe the size of the bending limb is important. It is calculated by the opposite formula.

The figures 6. and 7. show the effects of the linear deformation and its compensation. With regard to the required bending limbs L_s make sure to chose the correct locating points.

$$L_s = C \cdot \sqrt{d \cdot \Delta L} \quad (mm)$$

L_S = Length of bending limb (mm)

d = Outside pipe diameter (mm)

DL = Linear deformation (mm)

C = Material-depending constant for PP-R = 20

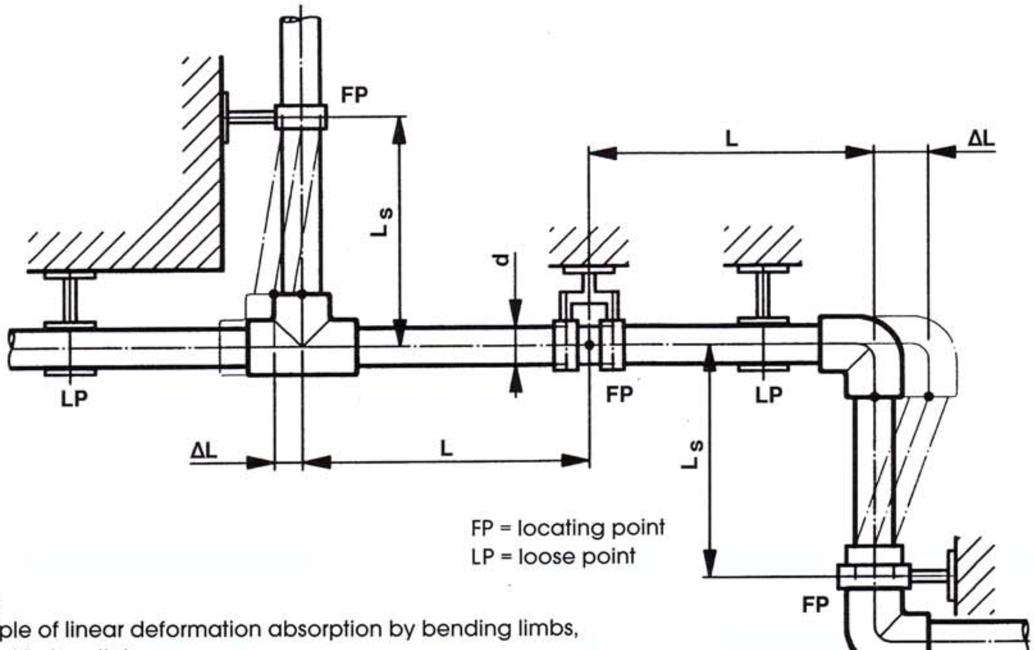


Fig. 6:
Principle of linear deformation absorption by bending limbs, related to length L

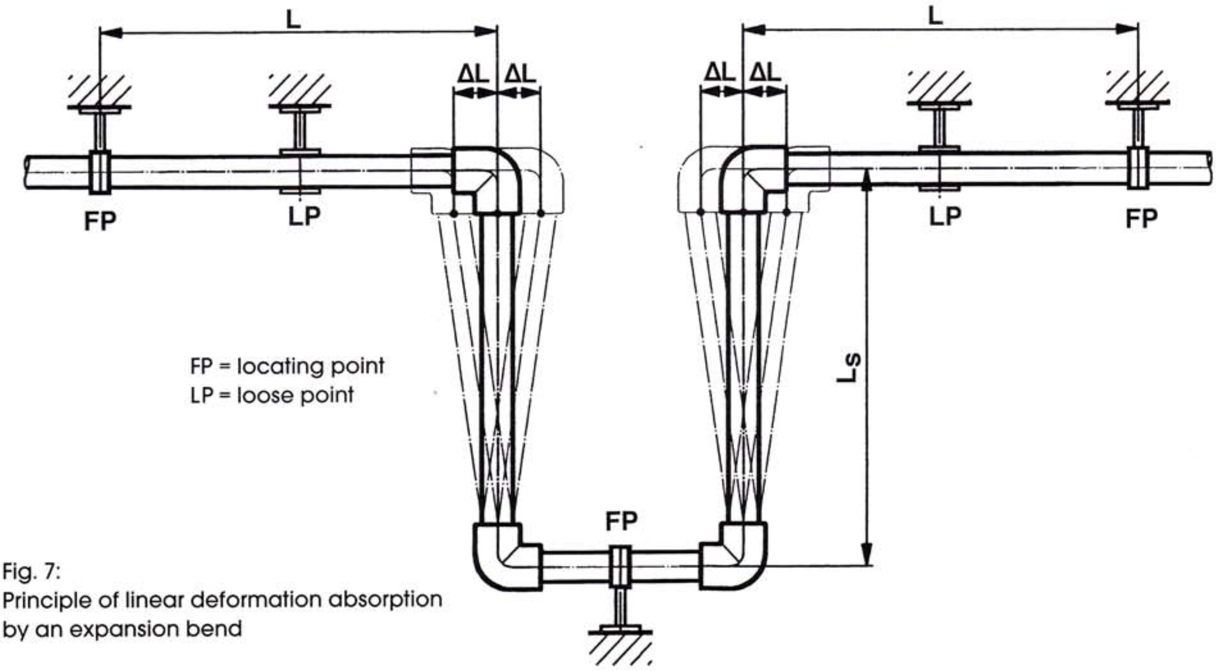


Fig. 7:
Principle of linear deformation absorption by an expansion bend

Expansion bends can easily be made right at the site.
Beside the required pipe length 4 elbows (8090) or 4 pipe bends (8002a) are needed.
To construct an expansion bend, the bending limb L_s is calculated in dependence on the linear deformation ΔL. As standard value, the L_s value given in the Fig. 8 diagram can be used.
Spacing B should be at least 10 • d.

Fig. 7:
Expansion bend, made of PP-R pipe and 90° elbow

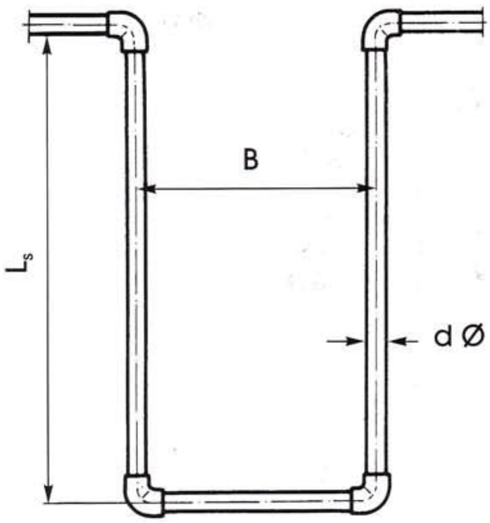
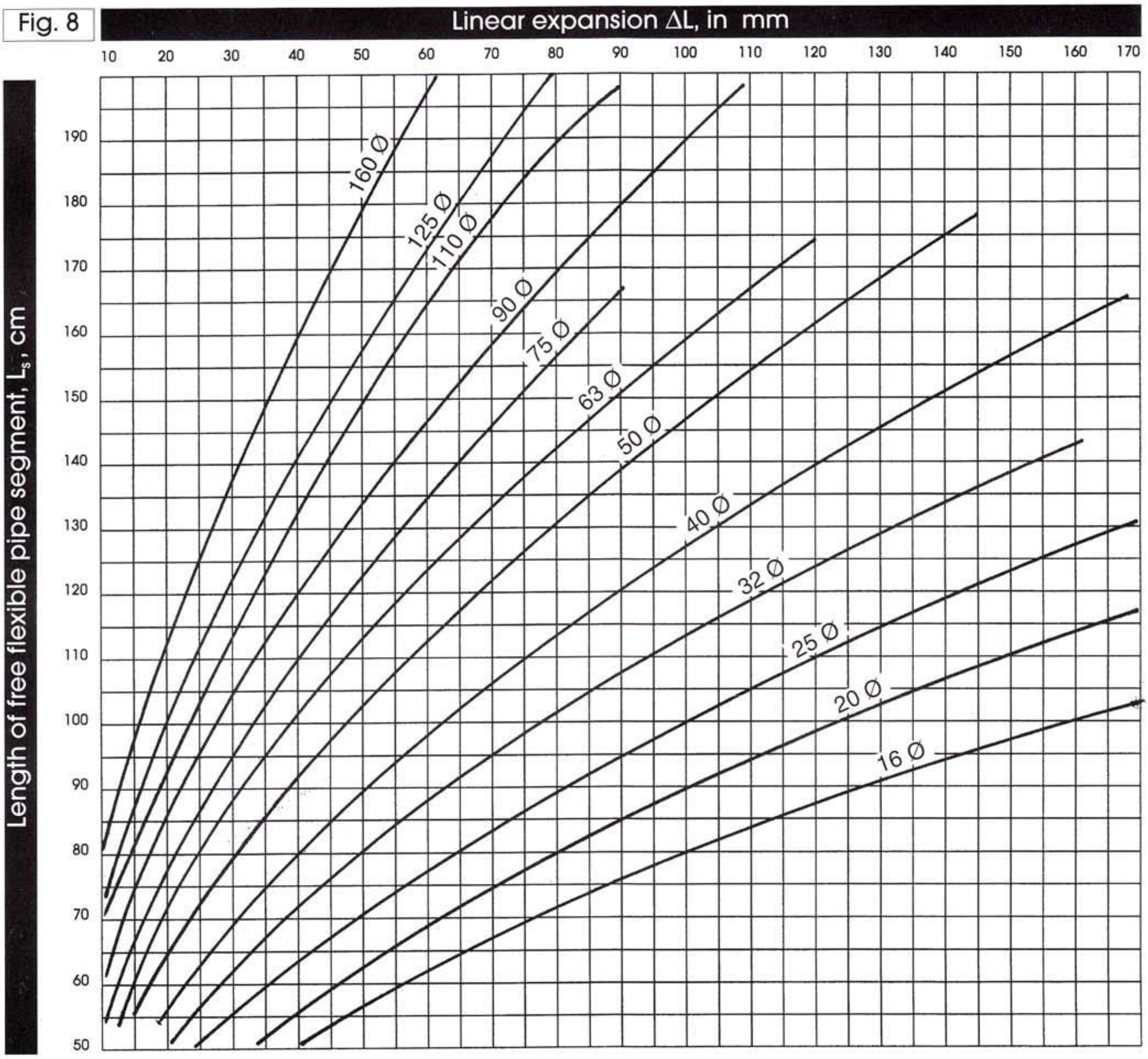


Fig. 8



Example for concealed piping

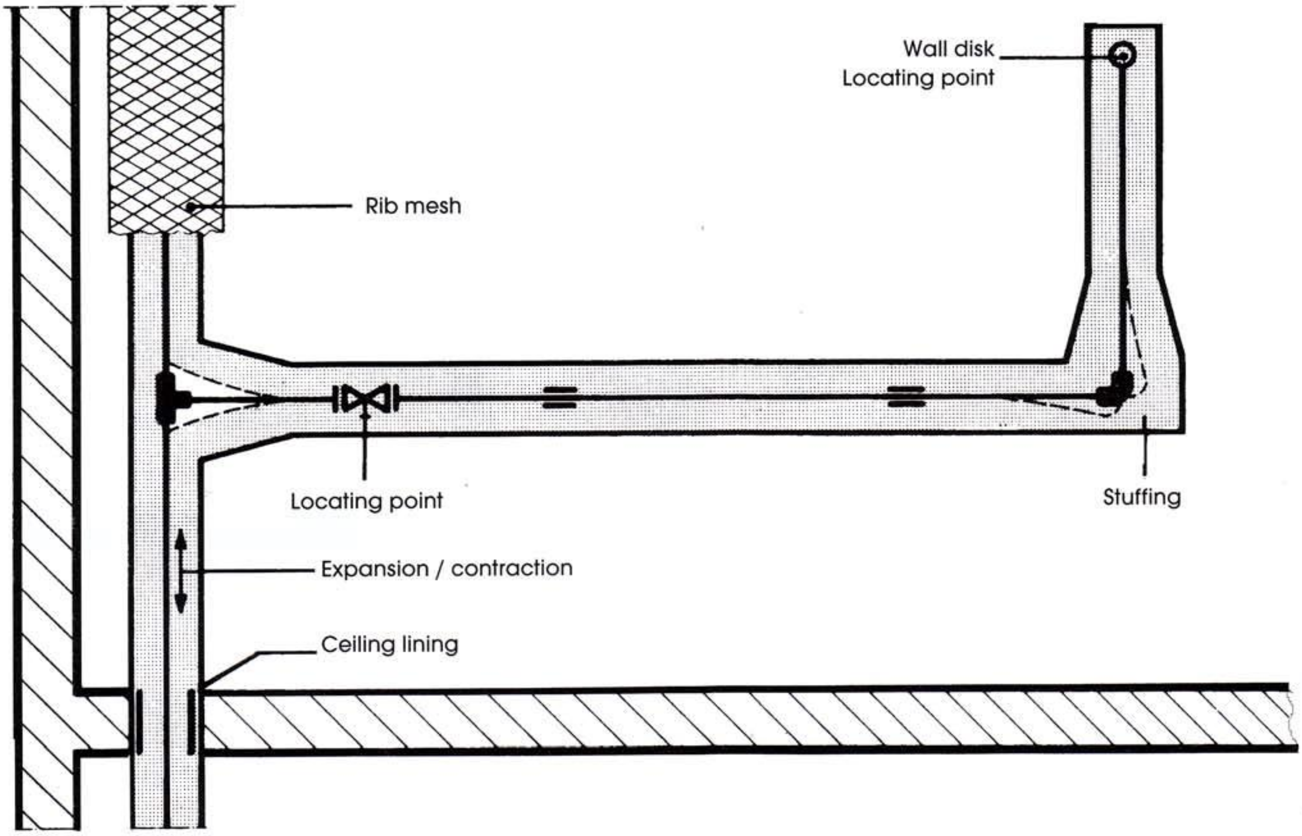


Fig. 9

Applications in Sanitary Installation Shaft:

When making the apartment pipe connections from main pipe, the following alternative techniques can be applied in order to compensate for the pipe thermal expansions:

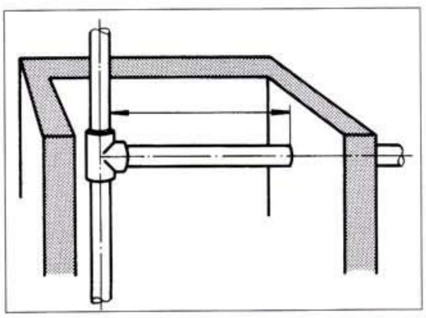


Fig. 1
Pipe connection can be made at some distance "a" away from the wall.

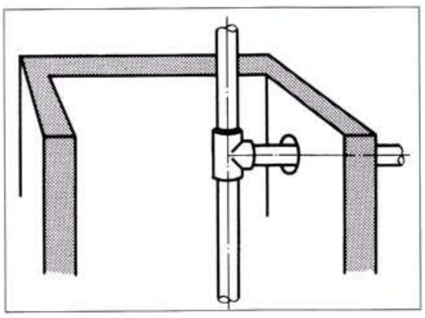


Fig. 2
The connecting pipe can be passed through a hole much larger than the pipe diameter.

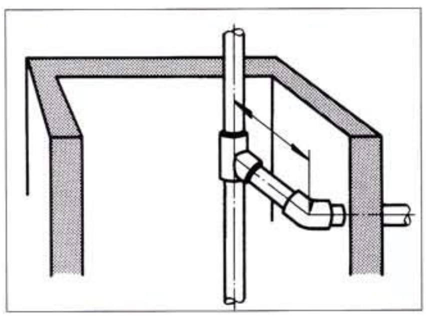


Fig. 3
The appartment connection can be made through a branch pipe to provide flexibility