TERRAIN

Controlling Expansion in Pressure Systems

Technical Bulletin

Bulletin 2 | 2017 | P1

Effast from Polypipe is a well-established brand name that is recognised for its range of thermoplastic pipework suitable for use within industrial, food & beverage processing and building services.

PVCu

ABS

Polypropylene

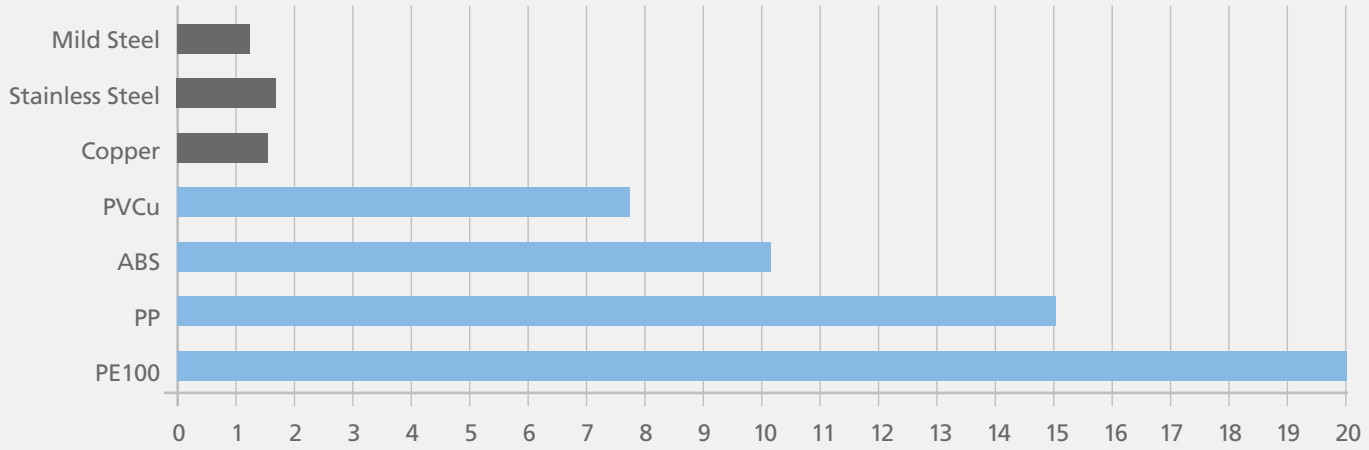
PE100

The Effast range consists of 4 different systems

- PVCu
- ABS
- Polypropylene
- PE100

Thermoplastics expand and contract to a greater extent than metals and this movement needs to be calculated and controlled.

The chart below shows the comparison between the thermal expansion of plastics and metals.



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There are two factors to consider when calculating expansion or contraction in pipes:

- Environmental temperature (external temperature) at which the pipe will stabilise prior to installation
- Fluid temperature (internal temperature) which is the operational temperature of the pipeline system

Where:

ΔT = Difference in temperature between the installation and the operating temperatures in °C **ΔT** = (**T** operate - **T** install)

L = Length of pipe when installed

δ = Coefficient of expansion

The change in length due to thermal expansion or contraction in a pipeline system is determined by the following formula:-

$$\Delta L = \Delta T \times L \times \delta$$

COEFFICIENT OF LINEAR EXPANSION FOR THERMOPLASTICS (δ)

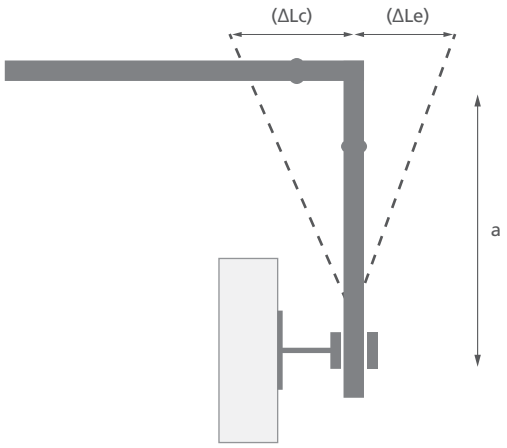
Thermoplastic material	Coefficient δ (10-5m/m°C)	Length/temperature equivalent (mm/m°C)
PVCu	7.8	0.078
ABS	10.1	0.101
PP	15.0	0.150
PE100	20.0	0.200

Flexible arms in pipeline installations

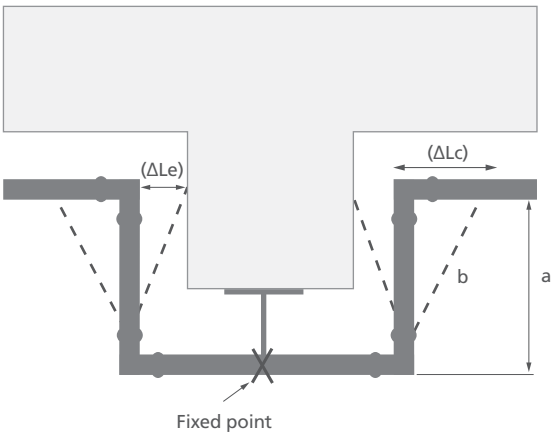
Flexible arms or expansion bellows are used in order to avoid the associated stresses generated from a pipe's change in length due to expansion or contraction. Expansion bellows are not a prime concern of this document and the installer is advised to seek specialist guidance from the manufacturers of such products.

The flexibility of plastics permits expansion or contraction to be compensated for by means of either directional change within a pipe system (single flexible arm) or by the installation of expansion loops consisting of two flexible arms (double flexible arm), as shown in the following illustrations: -

Single arm



Double arm (expansion loop)



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How to find the flexible arm (a) length

To calculate the length of a flexible arm (a) the following formulae can be used:-

Single arm: $a = (\sqrt{D \times \Delta L}) \times Cm$

Double arm: $a = (\sqrt{D \times \frac{\Delta L}{2}}) \times Cm$

Where:

a = Flexible arm length (mm)

D = Pipe outside diameter (mm)

ΔL = Expansion or Contraction (mm) for single arm, for double arm use ΔL/2

Cm = Constant for material, see table below

THERMOPLASTIC MATERIAL CONSTANT (Cm)

Thermoplastic material	Constant
PVCu	33.5
ABS	32.7
PP	30.0
PE100	26.0

Worked Example

Find the expansion length and leg size on a 20mm diameter PVCu pipe system installed at 10°C, where the maximum and minimum operating temperatures are 30°C and 8°C respectively and the overall length of the installation is 30m.

SOLUTION

	Step	Operating temperature (°C)	
		30	8
1	Calculate temperature difference ΔT =(T operate–T install)	= 30–10 = +20°C	= 30–10 = -2°C
2	Calculate change in length due to expansion and contraction ΔL = ΔT x L x δ (δ = 0.078 for PVCu)	= 20 x 30 x 0.078 = 46.8mm	= -2 x 30 x 0.078 = -4.68mm*
3	Select length of flexible arm or compensator	Take the greater value (change in length) regardless of whether it is due to expansion or contraction that can accommodate the maximum movement. In this case ΔL = 46.8mm	

*Please note a (-) minus value represents the difference in temperature (it is not a subzero) and hence it causes a contraction of the length of the pipe.

The next step is to take this ΔL and work out the size of the expansion leg.

SOLUTION

Single arm	Double arm (expansion loop)
$a = (\sqrt{D \times \Delta L}) \times Cm$	$a = (\sqrt{D \times \frac{\Delta L}{2}}) \times Cm$
$a = (\sqrt{20 \times 46.8}) \times 33.5$	$a = (\sqrt{20 \times \frac{46.8}{2}}) \times 33.5$
a = 1024.9mm	a = 724.7mm

Pre-stressing flexible arms

Sometimes changes of length (ΔL) can only be channelled in one direction, possibly due to a flexible section having to operate in a confined space. When this occurs the flexible arm can be prestressed achieving the following:

- The flexible arm can be reduced in length
- The flexible arm will straighten under working conditions thus relieving a large amount of stress
- The installation will look better when in service

TECHNICAL WORKSHOP

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Next month's bulletin will be on Bracketry

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