Pipeconnect

Exhaust gas expansion joint

Technical information

Introduction

The use of expansion joints, in a piping system, is not a substitute to the design stress analysis of the system. Expansion joints shall be treated as elements of the piping system and the designer shall consider all the loadings that may arise during the design as well as when exceptional conditions occur, and ensure that the piping system behaves in an acceptable, predictable and controlled manner at all times.

The piping designer shall consider the use of expansion joints to provide a practical and economical means of achieving the compliance with the requirements of the applicable code, where the calculated displacements and forces at some points in the system cannot be readily accommodated by the natural flexibility of the piping alone, or where loads created by the free expansion of the piping brings unacceptable loads on connecting equipment.

In general, expansion joints shall be located where the pipe movements are simple, and preferably axial, to minimize complexity and cost. The system should be divided into sections, those requiring expansion joints and those where natural pipe work or system flexibility is adequate.

The system designer shall locate the expansion joints in order to avoid or minimize torsion in the bellows. Internally pressurized bellows tend to become unstable under excessive internal pressure, but also, this tendency is accelerated when the bellows is subject to torsional loadings around its axis.

The type of expansion joints used will depend on the size, the direction of the pipe run in the system, the movement to be accommodated and the working conditions. The amount of pressure thrust limits the use of axial expansion joints although this type is preferred.

Expansion joints are generally located to encourage free axial movements of long pipe runs, with the movements of shorter connecting offsets and branches being controlled by natural flexibility of the pipe or by expansion joints selected according to the principal of imposed movement.

The flexibility in steel expansion joints is given by the corrugated part, called the bellows.
The bellows are made from one or more thin plies of stainless steel plate. Each ply is rolled into a shell and welded longitudinally. The shells are pushed into each other and the corrugations are made.

The number and thickness of plies and the number of corrugations are depending on the pressure and temperature of the actual application and the movement to be obtained.
Special expansion joints can be designed for nearly any special customer requirements and applications.

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Expansion joint standard programme

The steel expansion joint standard programme from PipeCon consists mainly of two different types:

- Single bellow design
- Double bellow design

Both types can be delivered with either welding ends or loose (turnable) flanges.

Both types are unrestricted, which means that the pressure thrust generated by the bellows must be obtained by fix points and guides in the system. See also section for mounting and installation. The single bellow types are generally used to obtain the axial movements in the piping system.
The double bellow types are used to obtain both axial and lateral movements in the piping system.

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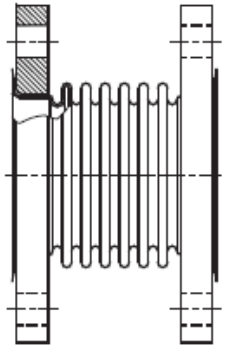
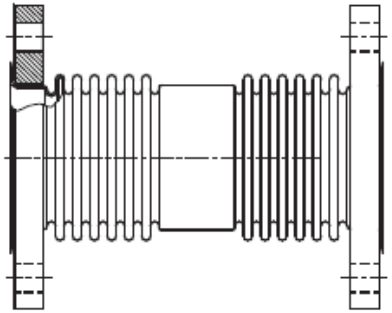
Single bellow design



Double bellov design



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The following variations of the two types are available as standard:

Type	Description	Design temp. [°C]	Design pressure [bar]	Minimum cycles by 100% utilization of	Application
01000	Expansion joint with multi-ply single or double bellow design with loose (turnable) flanges.	550	2,5	1.000	Exhaust system and other low pressure systems.
01100	Expansion joint with one ply single or double bellow design with welding ends.	450	0,5	1.000	Exhaust system and other low pressure systems.
01200	Expansion joint with one ply single or double bellow design with loose (turnable) flanges.	450	0,5	1.000	Exhaust system and other low pressure systems.
01300	Expansion joint with multi-ply double bellow design with loose (turnable) flanges.	550	1,5	10.000	Turbo charger outlet. High flexible bellows.

All standard bellows are made of stainless steel, grade 1.4541.
Welding ends and flanges are made of carbon steel, grade S235JRG2 or equal.

The type 01300 is a highly flexible expansion joint, especially designed for the turbo charger outlet side. This type is designed for a cycle life of minimum 10.000 cycles and with a very low spring rate which protects the turbo charger from over loading.

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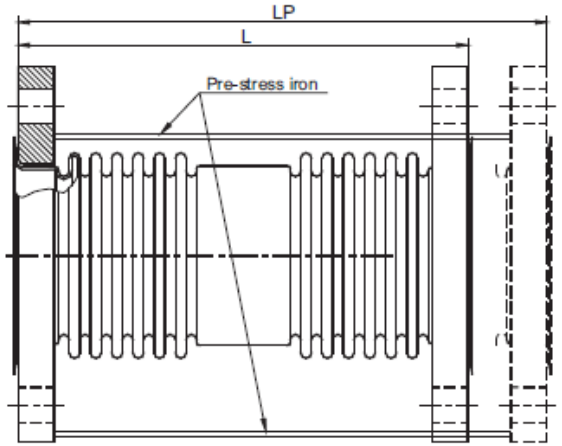
Pre-stressed bellows

In order to achieve optimal cycle life and function of the expansion joint the bellows are delivered pre-stressed. The pre-stressed length depends on the actual movement which the bellows must obtain.

Example:
Expansion joint neutral length L=230 mm. It is calculated that the expansion joint must obtain ±10 mm.
The expansion joint will then be pre-stressed 10 mm and will be delivered at pre-stressed length LP=240 mm.



Pre-stress irons and bellow protection must not be removed before installation. See also section about mounting and installation.
Pre-stress irons and bellow protection must be removed before the system is insulated and before the system is started.

Of course our supply of expansion joints includes expansion joints according to customer's special requirements and applications.

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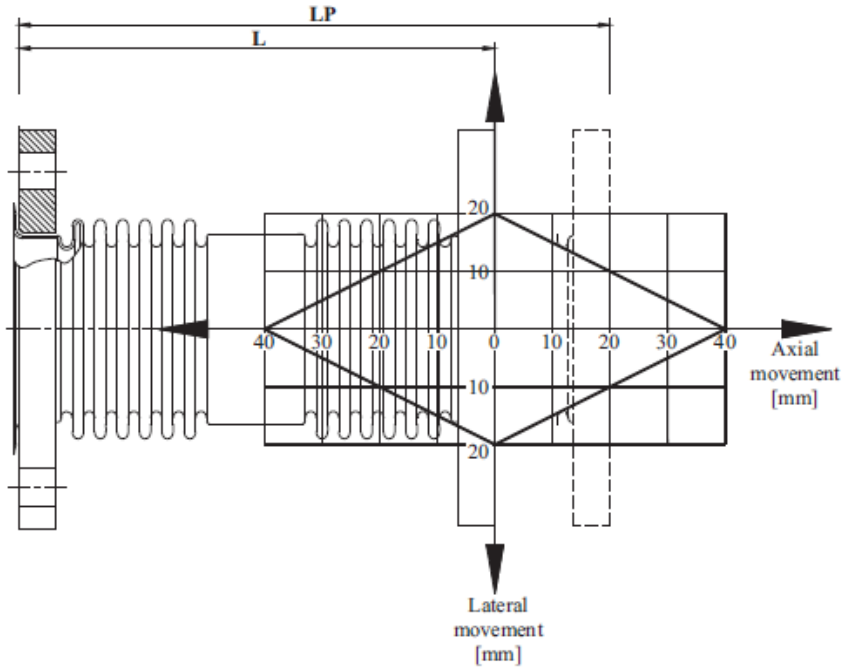
Allowable movements:

The movements given in the data tables are the maximum movement which can be obtained by the expansion joint in **either** axial **or** lateral direction.
If an expansion joint is subject to more movement than specified the cycle life time will be reduced drastically.
Allowable combinations of axial and lateral movement can be found by plotting the movement into an x-y diagram as shown on the sketch.
Allowable axial movement taken from the data tables for the specific expansion joint is drawn on the x-axis in plus- and minus direction. Allowable lateral movement taken for the same expansion joint is drawn on the y-axis in plus- and minus direction.

Four lines are now drawn between the points. The four lines will now indicate a rhomb area.
Now the movement combination in question can be plotted into the diagram with axial movement as x-coordinate and lateral movement as y-coordinate.
The point, which is given by these coordinates, must be within the area limited by the four lines.



By plotting the movements into an x-y diagram the combination possibilities can be read.

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Use of the different types of expansion joints

Specific symbols and definitions used in this section

	FP	Fixed point or main anchor		***Sp***	Spring support
	IA	Intermediate anchor		***Gn***	Axial pipe guide
	Ps	Rigid weight support		***Pg***	Planar guide

Use of axial expansion joints

Ordinary types of expansion joints do not restrain the pressure thrust, which then has to be restrained by means of external devices such as fix points and guides.

For axial expansion joints not restraining the pressure thrust, the fix points have to be designed to carry the whole pressure thrust and any loads due to movements and spring rate.

Straight pipe runs when compensated by unrestrained axial expansion joints tend to buckle under the influence of both the internal pressure, acting on the bellows, the flexibility of the bellows itself and also the influence of the pressure thrust developed by the bellows which loads axially the pipe and causes it to act like a straight beam subject to compressing axial forces.

Besides a proper supporting of the pipeline for weight and external forces, it is of vital importance that correct alignment of the pipe is maintained to ensure proper function of the expansion joint.

Pipe fix points and other restraining devices shall be designed for the full pressure thrust acting on the effective area of the bellows, plus the bellows spring reaction load. Also the loads generated by the friction within the guides or at partial anchors shall be considered.

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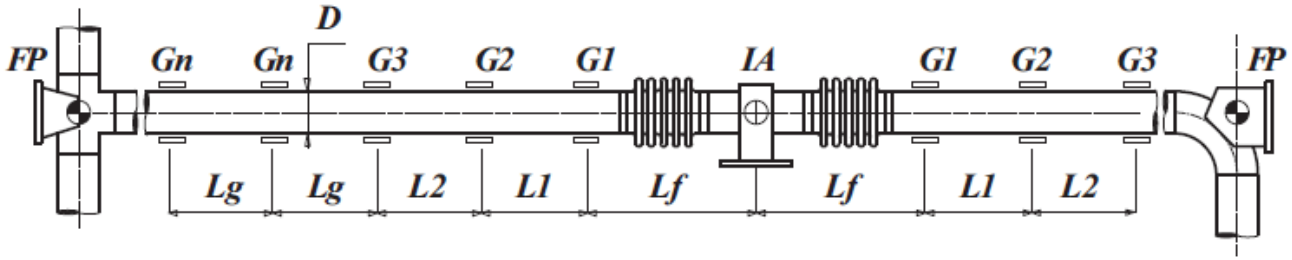

The figure shows an axial expansion joint not restraining the pressure thrust

L1 < 4D
L2 < 14D
Lf must be as small as possible
Lg to be calculated as below:

Lg is the maximum distance between two guides at any conditions shall be limited to:

$$Lg = \frac{\pi}{\beta} \cdot \sqrt{\frac{E \cdot J}{F_i \cdot S}}$$

Where:

- β is the guiding factor for relevant pipe portion, i.e:
  - β =1 if both sides of the expansion joints are simple supported,
  - β=0,7 if one side is simple supported and the other side is axially guided.
  - β=0,5 if both sides of the expansion joint are axially guided.

- E is the modulus of elasticity of the pipe material
- J is the moment of inertia of the pipe cross section:

$J = \frac{\pi}{8} \cdot e \cdot D_{mp}^3$, with D_{mp}^3 as mean pipe diameter and e as its wall thickness.

- S is the safety factor (recommended S=3)

- F_i is the buckling force consistence of the following components, which may act on the pipe simultaneously.
$F_i = F_P + F_B + F_F$.

Where:

- $F_P = p \cdot a$ is the pressure thrust.
The bellows effective area "a" is taken from the membrane calculation.

- $F_B = \pm x \cdot K_B$ is the axial displacement force generated by the bellows.
The axial displacement "x" of the expansion joint is starting from the neutral position.
It is plus for compression and minus for extension. K_B is the bellows spring rate.

- $F_F = \pm \sum \mu \cdot F_N$ are the friction forces in the pipe guides.

All the singular forces brought by every guide on the section of straight run have to be taken in consideration to calculate the friction axial force. These friction forces will occur when the system is moving, mainly when the temperature changes or for any other matter. The value of μ is the friction coefficient in the guides.

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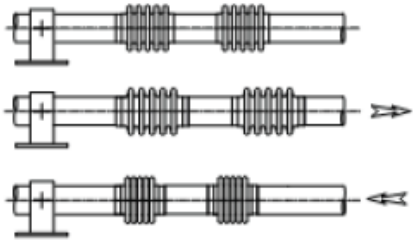
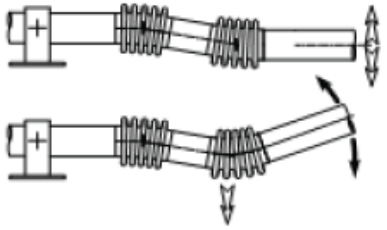
Use of lateral expansion joints

Most lateral expansion joints are similar to the axial expansion joint, which means they are unrestrained, but subject to lateral movement.
The use of unrestrained expansion joints is strictly restricted to piping system without or with extremely low pressure.



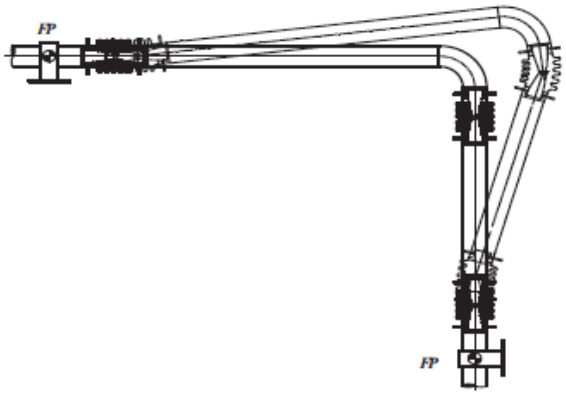


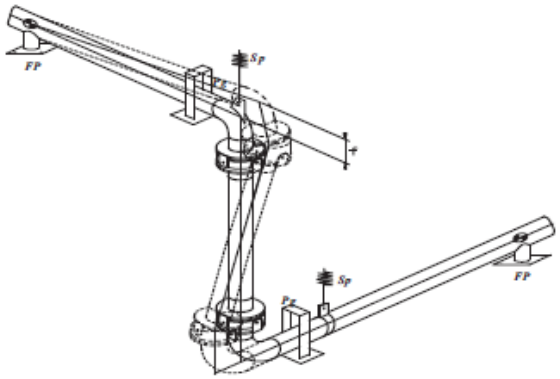
Use of angular expansion joints

Angular expansion joints are designed to absorb angular movements. When they are fitted with hinges, they allow the movements in a single plane. When they are fitted with gimbal rings, they allow movement in any plane.

The angular expansion joints are usually working in a set of two or three between two anchors.

The hinges, gimbal rings and hardware attachments on the pipe, shall be designed to restrain the full pressure thrust and external loadings.
The design of the piping system anchors and supporting system shall incorporate the angular stiffness of the bellows and the friction moment in the bearings of the expansion joints.





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