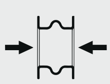
Pipeline planning > Rubber expansion joint variants

A rubber expansion joint is a flexible connector fabricated of synthetic elastomers and fabrics to provide stress relief in piping systems due to vibration and/or movements. They effectively dampen and insulate against the transmission of noise and vibration generated by mechanical equipment. ditec's rubber expansion joints have a cycle life in the tens of millions. The highly compliant and resilient characteristics make them ideally suited for earthquake, as well as pressure-surge and water hammer dampening. Given the inherent characteristics of synthetic elastomers, they are not subject to fatigue breakdown or embrittlement. A wide variety of synthetic elastomers and fabrics are available to the industries. Materials are treated and combined to meet a wide range of practical pressure/temperature operating conditions, corrosive attack, abrasion and erosion. ditec offers a variety of elastomers and construction materials chosen specifically to meet the needs of even the most demanding applications. Minimal face-to-face dimensions in rubber expansion joints offer advantages, compared with costly expansion bends, loops or metal expansion joints. It is common in both new construction and replacement applications to encounter pipe misalignment. Minor misalignment can be taken up with standard rubber expansion joints, and custom units can be fabricated with large permanent offsets.

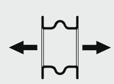
Find out more on our website at
www.ditec-adam.de/qr/movements

Movements

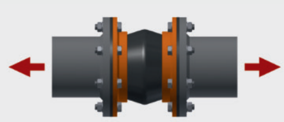
Rubber expansion joints take over

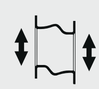


axial compression

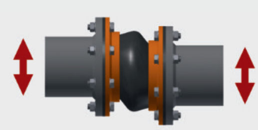


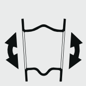
axial extension



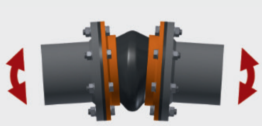


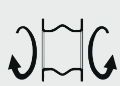
lateral displacement



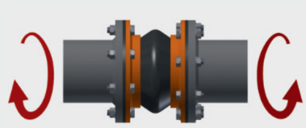


angular

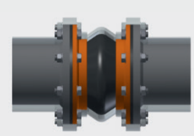




torsional



vibrating



movements as a result of thermal changes in pipeline length, prevent the transfer of mechanical vibrations from machines, apparatus or pumps on the connected pipeline and compensate for tensions or assembly imprecision.

Combined movement calculation

The potential axial, lateral and angular movements are specified for the respective expansion joint systems. In the event of combined axial extension and lateral displacement, the values drop as follows:

Permitted lateral displacement for a given axial extension

$$l_{per} = l_{max} * \left(1 - \frac{ae_{eff}}{ae_{max}}\right)$$

Permitted lateral displacement for a given axial compression

$$l_{per} = \frac{l_{max}}{2} * \left(2 - \frac{A}{ac_{max} * 0{,}75}\right)$$

with $A = ae_{eff} - ac_{max} * 0{,}25$ in case of $A < 0 \rightarrow$ insert 0

Permitted axial extension for a given lateral displacement

$$ae_{per} = ae_{max} * \left(1 - \frac{l_{eff}}{l_{max}}\right)$$

Permitted axial compression for a given lateral displacement

$$ac_{per} = \frac{ac_{max}}{4} * \left(4 - \frac{3 * B}{l_{max} * 0{,}5}\right)$$

with $B = l_{eff} - l_{max} * 0{,}5$ in case of $B < 0 \rightarrow$ insert 0

ac_{eff}	[mm]	given axial compression
ae_{eff}	[mm]	given axial extension
l_{eff}	[mm]	given lateral displacement
ac_{max}	[mm]	maximum axial compression
ae_{max}	[mm]	maximum axial extension
l_{max}	[mm]	maximum lateral displacement
ac_{per}	[mm]	permitted axial compression
ae_{per}	[mm]	permitted axial extension
l_{per}	[mm]	permitted lateral displacement

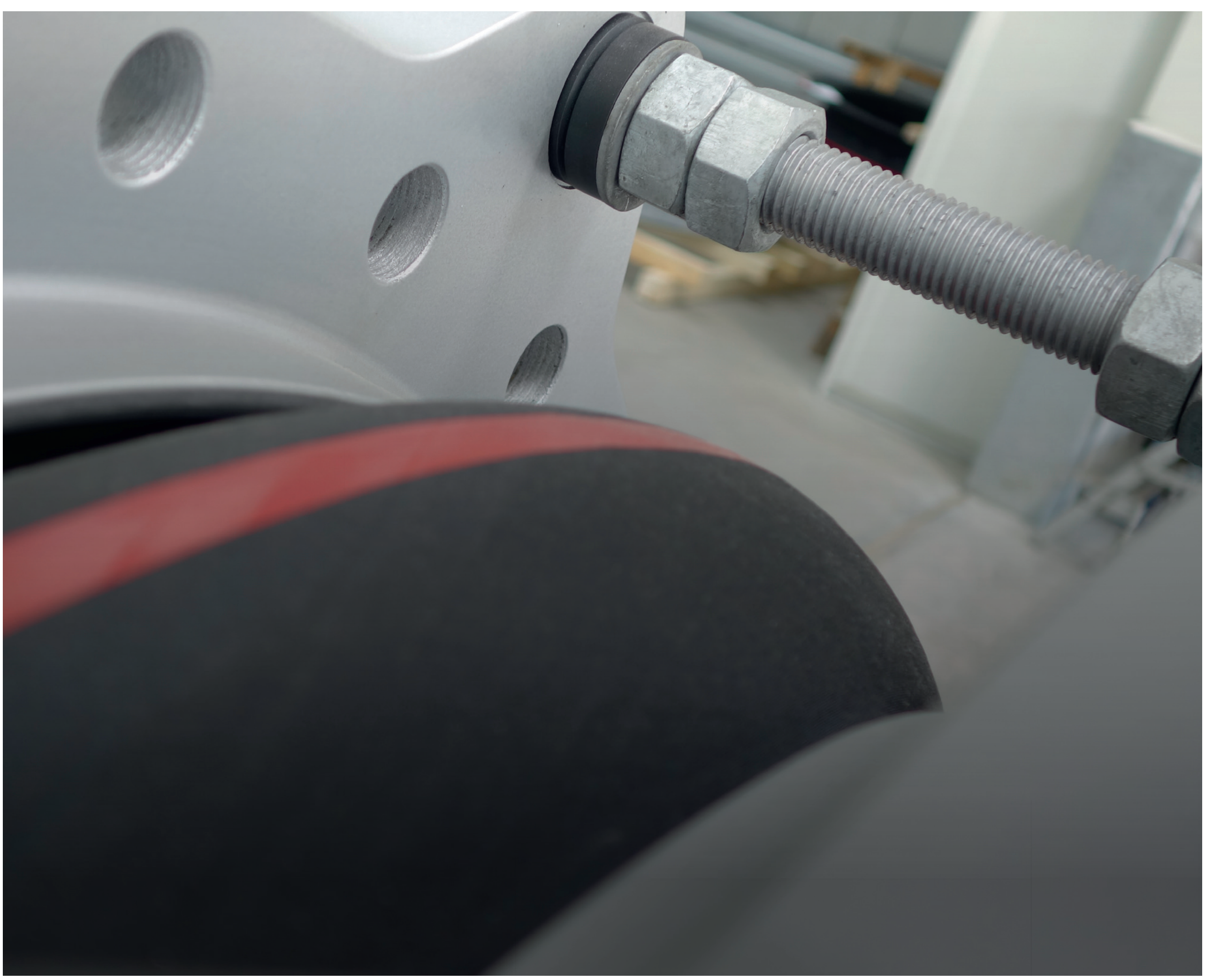
Example

For an expansion joint with a given axial compression of ac_{eff} = 25 mm, the permitted lateral displacement l_{per} is searched. The maximum values for the movements of the expansion joint are:

ac_{max}	[mm]	40
ae_{max}	[mm]	15
l_{max}	[mm]	30

$$A = ae_{eff} - ac_{max} * 0{,}25 \quad = \quad 25\,\text{mm} - 40\,\text{mm} * 0{,}25 = 15\,\text{mm}$$

$$l_{per} = \frac{l_{max}}{2} * \left(2 - \frac{A}{ac_{max} * 0{,}75}\right) \quad = \quad \frac{30\,\text{mm}}{2} * \left(2 - \frac{15\,\text{mm}}{40\,\text{mm} * 0{,}75}\right) = 22{,}5\,\text{mm}$$



Expansion joint thrust calculation

Thermal movements along with other external forces and displacements, including ground settlement can quickly exceed allowable pipe and anchor stresses. Rubber expansion joints absorb these stresses and replace them with their own low stiffness (spring rate). The inherent flexibility of rubber expansion joints permits almost unlimited flexing to recover from imposed movements, requiring relatively less force to move, thus preventing damage to motion equipment.

When expansion joints are installed in the pipeline, the static portion of the thrust is calculated as a product of the area of the inner diameter of the arch of the expansion joint times the maximum pressure that will occur with the line. The result is a force expressed in Newton which causes stress on the adjacent pipeline anchors. In order to reduce the forces, a lower arch can be used in case of small movements.

$$T = \frac{\pi * D^2}{4} * P$$

T	[N]	thrust
D	[mm]	inner diameter of the arch
P	[MPa]	pressure

Expansion joint spring rates

The force to deflect an expansion joint is defined as, the total load required to deflect the expansion joint a distance equal to the maximum rated movement of the product. This force figure is expressed in Newton for compression, elongation and lateral movements. The force is expressed in Newtonmeter for angular deflection.

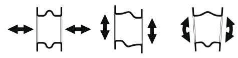
The spring rate is defined as the force in Newton required to deflect an expansion joint one millimeter in compression and elongation or in lateral direction. For angular movement the spring rate is the force needed in Nm to deflect the expansion joint one degree. These forces should be considered only as approximates which may vary with the elastomers and fabrics used in fabrication and depend from the specific construction type.

The spring rate for a filled arch type expansion joint is approximately 4 times that of a standard single arch type. This rate is dependent upon the material used in the filled arch section of the expansion joint.

The spring rate of a multi-arch type expansion joint is equal to the spring rate for a single arch type divided by the number of arches.

Spring rates can be found in the technical appendix (> page 296).

Universal expansion joint

Movement: 

Universal expansion joints are installed in piping systems that are anchored on both sides of the joint. No tie rods are necessary. If tie rods are installed as a safety measure, the locking nuts must be backed off with a clearance equal to the specified axial movement. This construction, as a standalone expansion joint, represents the most cost-effective arrangement when used in rigid piping systems with main anchors and numerous guides at specific spacing.

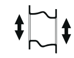
Bellows: Expansion joint with one or more moulded arches.

Tie rod: None

Pressure: The expansion joint will exert a thrust force on the anchors. The pressure from the active bellows cross-section causes stress on the adjacent pipeline anchors. In order to reduce the forces, a lower arch can be used for small movements.

Stiffness rate: Movements give rise to forces that rise under pressure and need to be taken into account in dimensioning the pipeline. Axial and lateral stiffness rates to move the expansion joint under pressure can be found in the appendix. (> page 296)

Lateral expansion joint

Movement: 

Lateral expansion joints are installed in unanchored piping or connected to isolated equipment. Tie rods are necessary. Once tie rods are installed the joint will no longer act as an expansion joint, since the pressure will extend the joint to the nuts of the tie rods. The joint will no longer take up axial movement. It will make up for misalignment, lateral and possibly angular movement. The nuts of the tie rods should be threaded against tie rod bearings, thereby preventing joint from extending.

Bellows: Expansion joint with one or more moulded arches.

Tie rod: Several threaded rods mounted around the circumference receive pressure from the active bellows cross-section.

Pressure: The tie rods assimilate the axial stresses of the expansion joint.

Stiffness rate: Movements give rise to forces that rise under pressure and which need to be taken into account in dimensioning the pipeline. Lateral stiffness rates to move the expansion joint under pressure can be found in the technical appendix. (> page 296)

Friction: Frictional forces arise in the tie rod bearings and must be overcome in addition to the stiffness rates.

Angular expansion joint

Movement:

An angular rubber expansion joint is designed to facilitate and isolate angular rotation in one plane. The arrangement consists of a pair of hinge plates connected with pins and attached to the internal hardware of the expansion joint. The hinge assembly must be designed for the internal pressure thrust forces of the system. They can be used in sets of two to absorb large lateral movements in a single plane. This optimally designed arrangement is an effective solution for absorbing large axial thermal movements from an adjacent pipe run. They are commonly used when the support structure or adjacent equipment have load limitations.

Bellows: Expansion joint with one moulded arch.

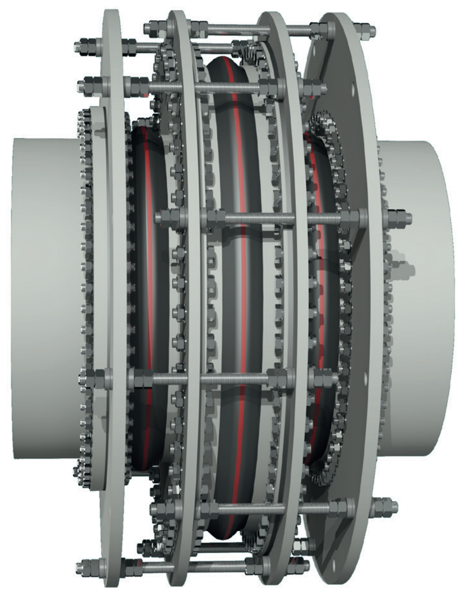
Joint: The angular joints bear the pressure forces from the active bellows cross-section. Angular joints for movement on one plane. Cardan joints for movement on two planes.

Pressure: The joints bear the axial reaction forces of the expansion joint.

Friction: Frictional forces arise in the joint bearings and must be overcome in addition to the stiffness rates.

In-line pressure balanced expansion joint

Movement:



In-line pressure balanced rubber expansion joints are the only effective solution for directly absorbing large axial movements while continuously self-restraining the pressure thrust forces.

They are designed to absorb all-directional movement, compensate for misalignments and relieve pipe and anchor stresses.

Bellows: The two outer main rubber expansion joints need to have the same effective area as the center balancing rubber expansion joint.

Tie rod/ Pressure: This arrangement consists of tie rods inter-connecting its balancing joint to its opposing two main joints and is commonly used when the support structure or adjacent equipment have load limitations.

Friction: Frictional forces arise in the tie rod bearings and must be overcome in addition to the stiffness rates.

Pipeline planning > Installation of expansion joints, sliding points and fixed points

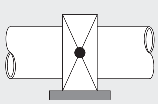
The selection and application of expansion joints plays a significant role in system performance, quality and reliability. Leveraging our extensive industry experience since 1973, ditec uses a systematic approach to finding the optimal solutions for any piping system. We apply the most sophisticated analysis and calculation software tools such as Finite Element Analysis (FEA), 3D Modelling and CAD to select the most appropriate expansion joint to fit into the corresponding pipeline system.

The pressure in the line gives rise to forces that may lead to line instability if no sliding points and fixed points are provided. If movements occur in different directions inside a pipeline, these need to be divided by planning anchors at suitable intervals. If stable anchors are not possible, the expansion joints need to be mounted such that the axial movement is diverted and can be received by tied lateral expansion joints. The correct mounting of universal, lateral and angular expansion joints is crucial to the functionality of the entire pipeline system.

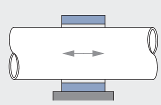
Pipeline systems should be fitted with ventilation equipment at high points and draining equipment at low points in order to avoid uncontrolled water ingress or vacuum.

Pressure and vacuum safety mechanisms in the lines prevent the expansion joints from being overloaded. Likewise, the medium temperature should be monitored using appropriate means. Information about the maximum operating temperatures and pressures is specified based on the respective expansion joint types.

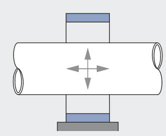
Fixed point



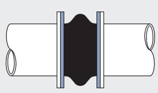
Sliding point



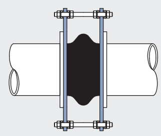
Guidance



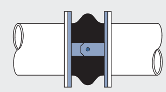
Universal expansion joint



Lateral expansion joint

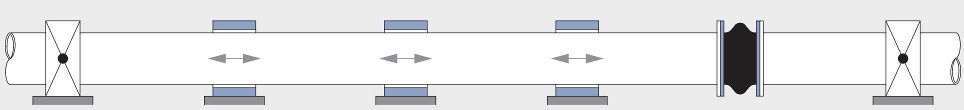


Angular expansion joint



Universal expansion joints for axial, lateral and angular movement

Expansion joint to receive axial movements along the pipeline axis. The fixed points receive the stresses from the active bellows cross-section of the expansion joint in the event of pressure or vacuum. In the event of large axial movements, the pipeline should be subdivided into several sections using sliding and fixed points.



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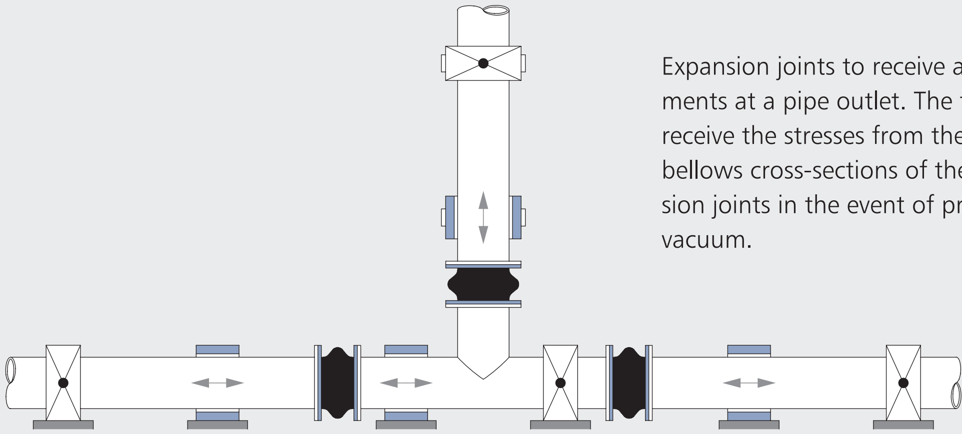
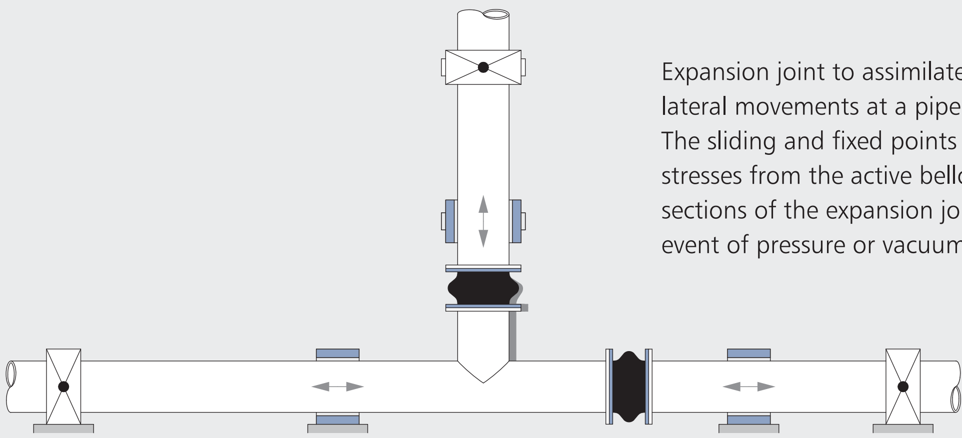
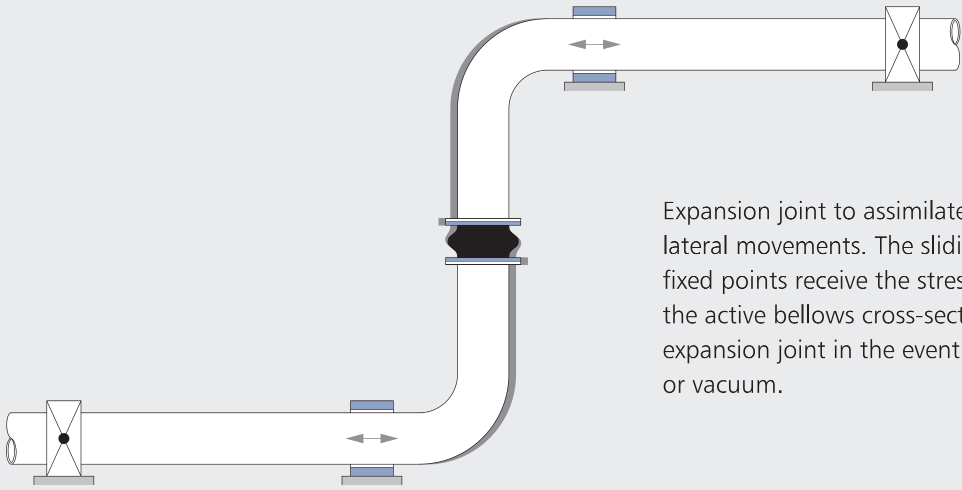


Expansion joints to receive axial movements at a pipe outlet. The fixed points receive the stresses from the active bellows cross-sections of the expansion joints in the event of pressure or vacuum.



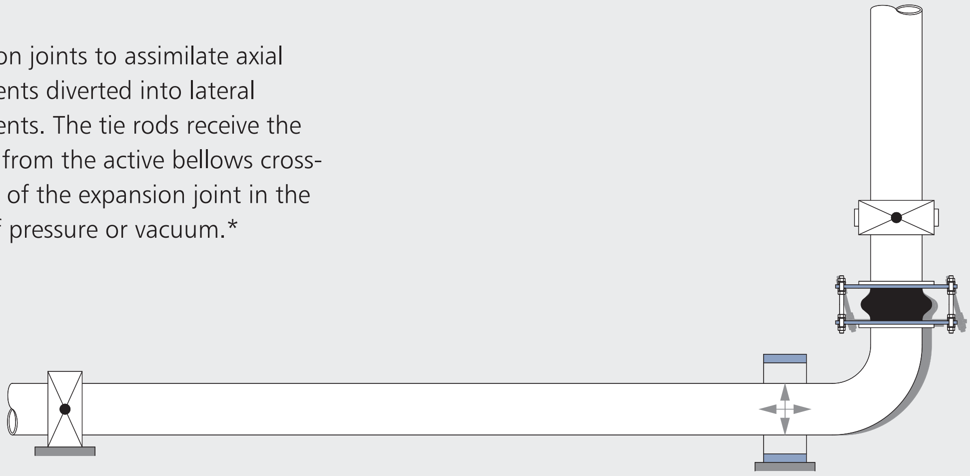
Expansion joint to assimilate axial and lateral movements at a pipe outlet. The sliding and fixed points receive the stresses from the active bellows cross-sections of the expansion joints in the event of pressure or vacuum.



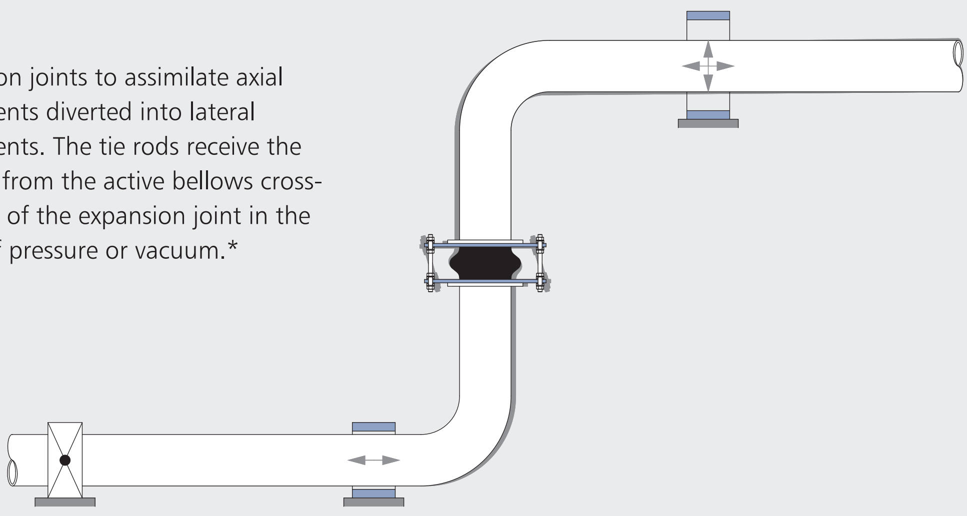
Expansion joint to assimilate axial and lateral movements. The sliding and fixed points receive the stresses from the active bellows cross-section of the expansion joint in the event of pressure or vacuum.

Lateral expansion joints for lateral movement

Expansion joints to assimilate axial movements diverted into lateral movements. The tie rods receive the stresses from the active bellows cross-sections of the expansion joint in the event of pressure or vacuum.*



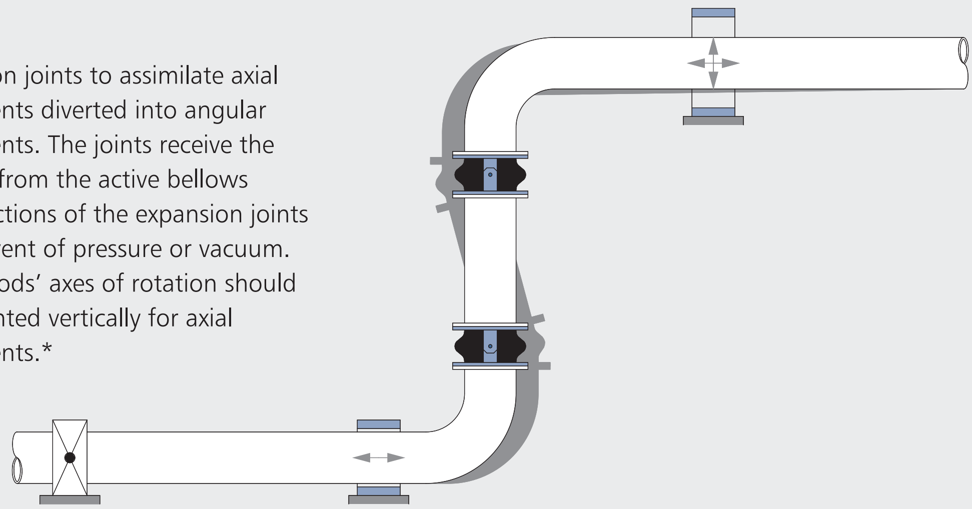
Expansion joints to assimilate axial movements diverted into lateral movements. The tie rods receive the stresses from the active bellows cross-sections of the expansion joint in the event of pressure or vacuum.*

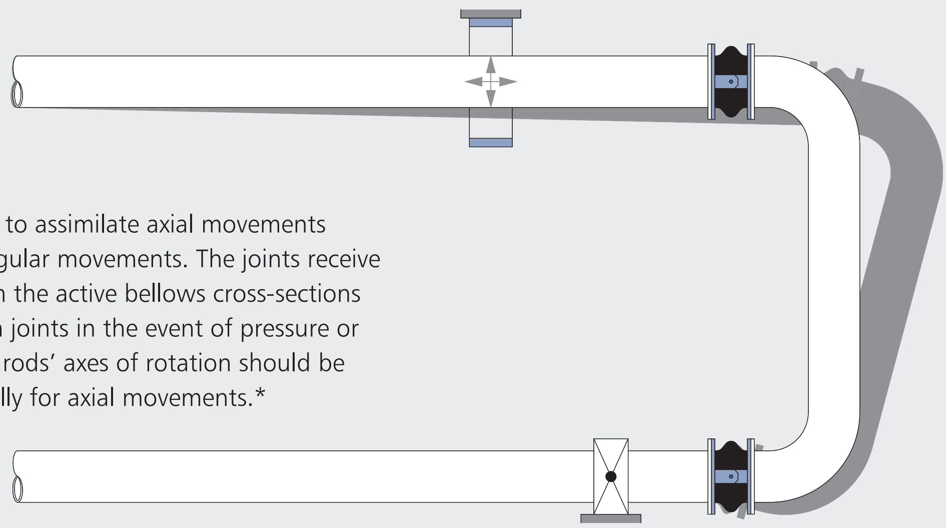


*Tie rods and hinges are designed to absorb the reaction forces of the expansion joint under pressure. Additional forces (e.g. weight forces) to be transmitted by the expansion joints must be specified.

Angular expansion joints for angular movement

Expansion joints to assimilate axial movements diverted into angular movements. The joints receive the stresses from the active bellows cross-sections of the expansion joints in the event of pressure or vacuum. The tie rods' axes of rotation should be mounted vertically for axial movements.*

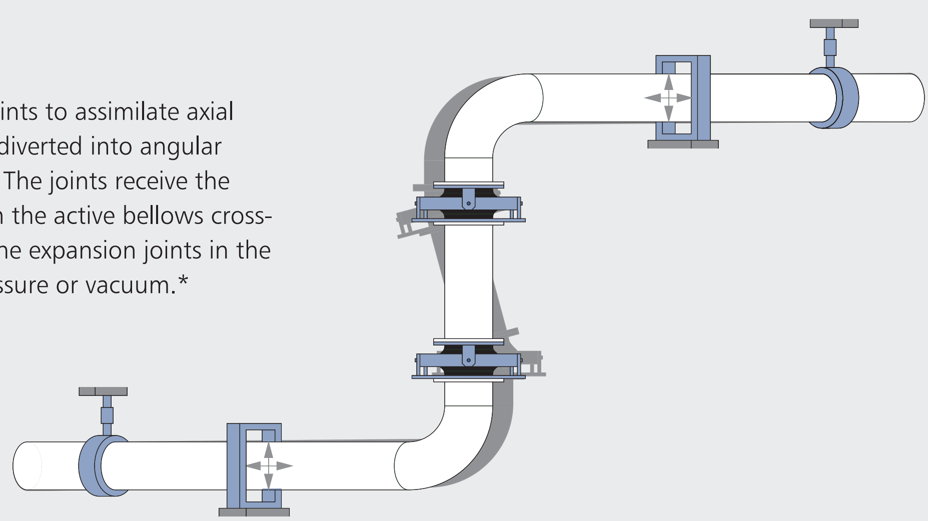




Expansion joints to assimilate axial movements diverted into angular movements. The joints receive the stresses from the active bellows cross-sections of the expansion joints in the event of pressure or vacuum. The tie rods' axes of rotation should be mounted vertically for axial movements.*

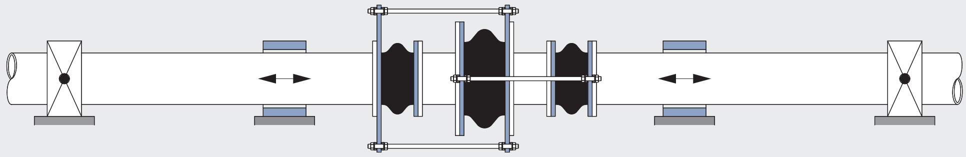
Cardan joint expansion joints

Expansion joints to assimilate axial movements diverted into angular movements. The joints receive the stresses from the active bellows cross-sections of the expansion joints in the event of pressure or vacuum.*



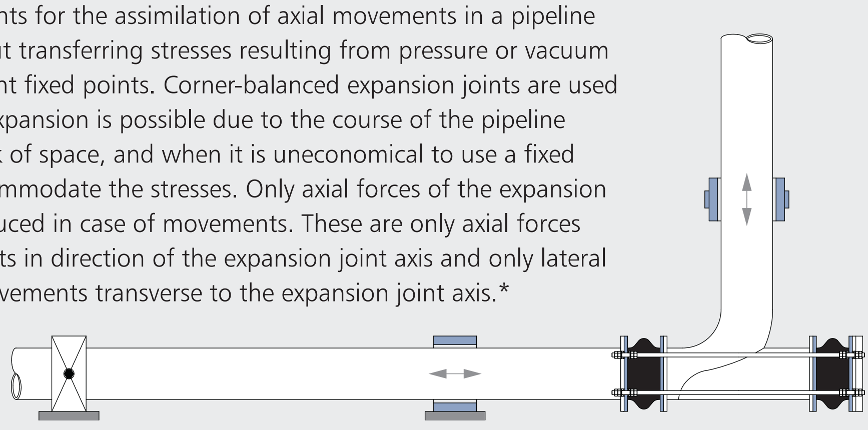
* Tie rods and hinges are designed to absorb the reaction forces of the expansion joint under pressure. Additional forces (e.g. weight forces) to be transmitted by the expansion joints must be specified.

Pressure balanced expansion joints

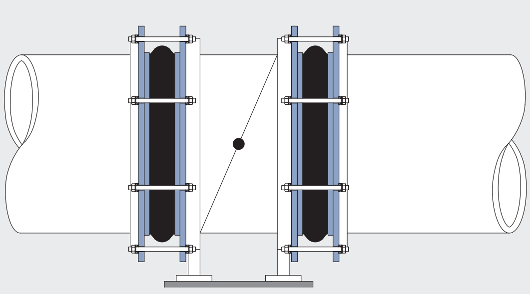


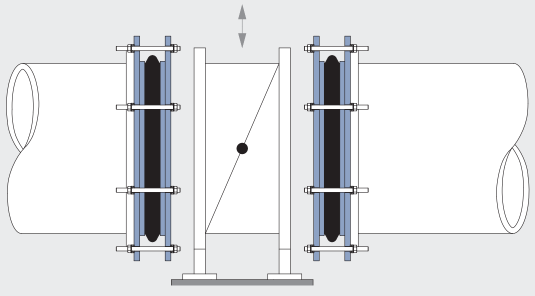
Expansion joints for the assimilation of axial movements without transferring stresses resulting from pressure or vacuum to the adjacent fixed points, apparatus or machines. The difference between the active bellows cross-sections of a large and small expansion joint corresponds to the active bellows cross-section surface area of a small expansion joint. If the tie rods are installed so that they intersect, the stresses will cancel each other out. Only axial forces of the expansion joints are induced in case of movements.*

Expansion joints for the assimilation of axial movements in a pipeline elbow without transferring stresses resulting from pressure or vacuum to the adjacent fixed points. Corner-balanced expansion joints are used if only axial expansion is possible due to the course of the pipeline or due to lack of space, and when it is uneconomical to use a fixed point to accommodate the stresses. Only axial forces of the expansion joints are induced in case of movements. These are only axial forces for movements in direction of the expansion joint axis and only lateral forces for movements transverse to the expansion joint axis.*



Dismantling joints



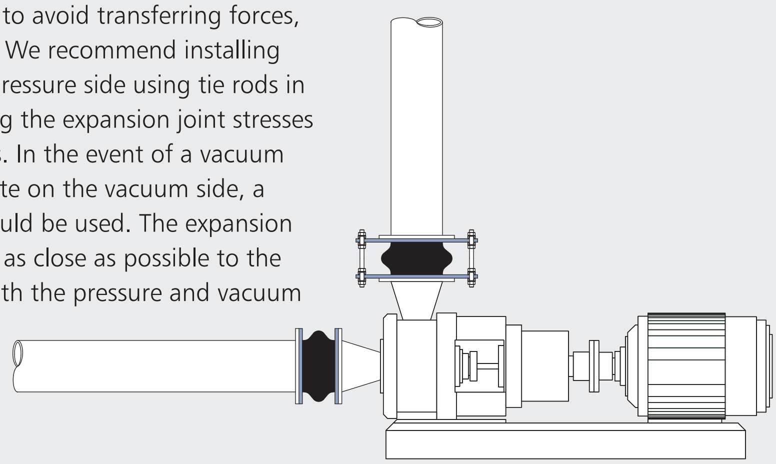


In order to compensate for installation imprecision or to simplify connection and disconnection, tied expansion joints can be used. On the one hand, the tie rods prevent the transfer of stresses to the connected armature. On the other hand, after the flange connection is loosened using the tie rod flange, the rubber bellows can be compressed by its maximum potential axial movement capability in order to create clearance for dismantling of the armature.*

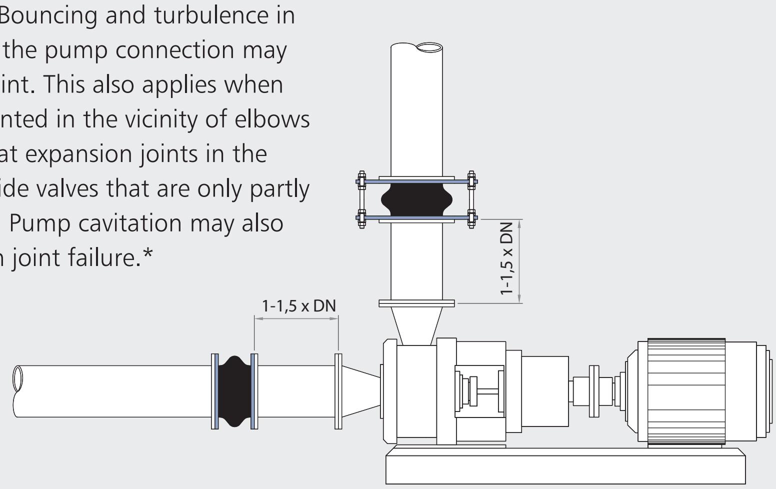
*Tie rods and hinges are designed to absorb the reaction forces of the expansion joint under pressure. Additional forces (e.g. weight forces) to be transmitted by the expansion joints must be specified.

Pump connection

Expansion joints are used to disconnect pumps from pipeline systems in order to avoid transferring forces, tensions and oscillations. We recommend installing expansion joints on the pressure side using tie rods in order to avoid transferring the expansion joint stresses to the pump connections. In the event of a vacuum exceeding 0.8 bar absolute on the vacuum side, a vacuum support ring should be used. The expansion joints should be installed as close as possible to the pump connections on both the pressure and vacuum sides.



For the transport of abrasive media (liquids containing solids), a distance of 1 to 1.5 x the pipeline diameter should be maintained between the pump connections and the expansion joint. Bouncing and turbulence in the immediate vicinity of the pump connection may damage the expansion joint. This also applies when expansion joints are mounted in the vicinity of elbows and outlets. Also note that expansion joints in the vicinity of flap gates or slide valves that are only partly closed may be destroyed. Pump cavitation may also lead to sudden expansion joint failure.*

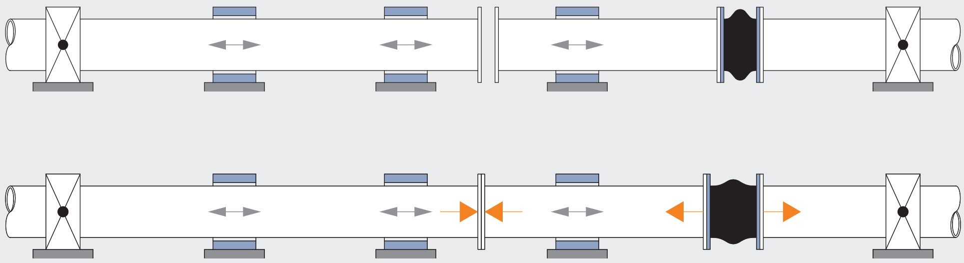


*Tie rods and hinges are designed to absorb the reaction forces of the expansion joint under pressure. Additional forces (e.g. weight forces) to be transmitted by the expansion joints must be specified.

Expansion joint preload

Large axial and lateral movements can be reduced by presetting the line against the direction of movement.

In order to increase axial movement, the expansion joint can be pre-loaded to its maximum extension during installation. There is a risk, however, that for expansion joints with swivel flanges, the sealing bead will spring free of the groove of the backing flange and that for expansion joints with full-faced rubber flanges, the latter cannot be positioned so as to be congruent with the pipe flange. If pre-loads of more than 10 mm are needed, a flange connection will need to be disconnected at another location. Now the expansion joint can be installed free of tension and the flange disconnection sites that were opened before can be closed again.



In order to increase lateral movement, the expansion joint can be pre-loaded to its maximum lateral displacement against the direction of flow during installation. During operation, it will move back to the opposite side through the zero point. In this way, the lateral movement can be increased by up to 100%. There is a risk, however, that for expansion joints with swivel flanges, the sealing bead will spring free of the groove of the backing flange and that for expansion joints with full-faced rubber flanges, the latter cannot be positioned so as to be congruent with the pipe flange. If pre-loads of more than 5 mm are needed, a flange connection will need to be disconnected at another location. Now the expansion joint can be installed free of tension and the flange disconnection sites that were opened before can be closed again.