BOA Group

Your Flexible Solutions Partner

Lateral Expansion Joints

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General information

Lateral expansion joints

A lateral expansion joint works in the same way a hinged expansion joint does. It utilizes the ability of a bellows to rotate in angular direction. The lateral movement capability is the result of the angular rotation of the bellows and their center to center distance. The longer the distance between the bellows, the larger is the movement capacity (Fig. 1).

A longer center to center distance also results in lower displacement forces of the expansion joint.

Lateral expansion joints are independent expansion systems in contrast to single hinged expansion joints. They are practically a two pin system. Lateral expansion joints are usually installed with a 50% pre-stressing. This is accomplished by pre-stressing the entire pipe system after the expansion joint is installed. The pre-stressing amount can be determined from the pre-stressing diagram in the section "assembly instructions" taking into account the installation temperature.

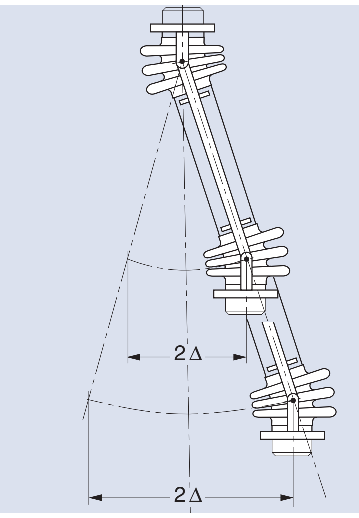


Fig. 1

Features

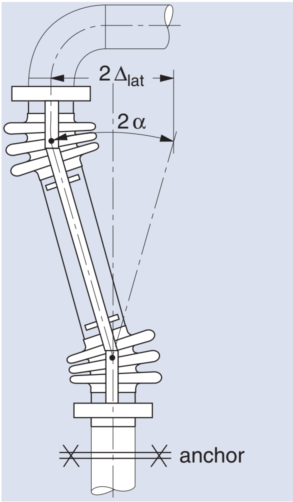
The special features of lateral expansion joints are:

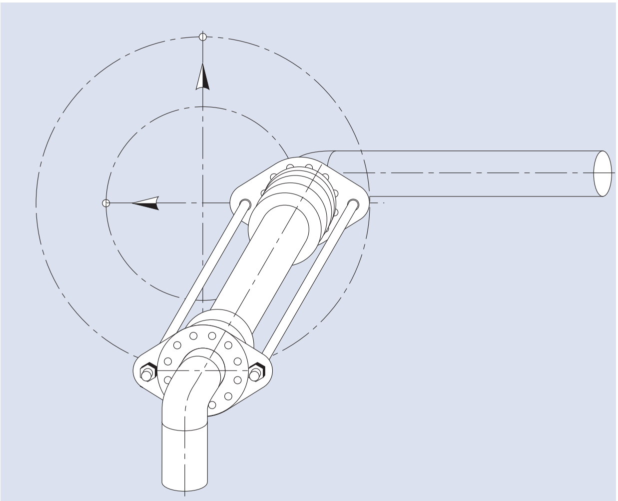
1.) Very low anchor loads as the tie bars / rods restrain the pressure thrust resulting from the internal pressure.
2.) Large movement capacities.
3.) Less demanding with regard to pipe supports / guides.

Even pipe hangers might be acceptable.

Dependent on their ability to compensate different movements, one differentiates between two basic types of lateral expansion joints:

Fig. 2





Lateral expansion joints that are suited to compensate for lateral movements on one plane (Fig. 2)

and lateral expansion joints that are suited to compensate for lateral movements in any direction perpendicular to the expansion joint axis (Fig. 3).

Types

Tied universal expansion joints that use tie rods and washer nuts to restrain the pressure thrust forces represent the simplest design of lateral expansion joints. They are suited to compensate for movements in any direction perpendicular to their axis.
For higher pressure conditions, the use of a cardanic universal expansion joint is recommended. This type of expansion joint uses tie bars with cardanic hinges to restrain the pressure thrust. They too are suited to compensate for movements in any direction perpendicular to the expansion joint axis. Another alternative is the installation of double gimbal expansion joints or two gimbal joints in a two pin gimbal system if the compensation of movements in various perpendicular directions is required. Expansion joints that are suited to compensate for lateral movements are also used to decouple pipe systems from the vibration that is generated by pumps, compressors or other engines (Fig. 4).

If the unit is firmly mounted to its foundation, the installation of one lateral expansion joint in both the suction and discharge pipe is sufficient (Fig. 4). If tied universal expansion joints are used, the installation of additional lock washers should be considered in anticipation of compression forces caused by vacuum that might occur in the suction pipe.
If the unit, however, is mounted on flexible supports such as spring or rubber mountings, then the vibrations occur in all directions. In this case, an additional angular or lateral expansion joint must be installed (Fig. 5).
One possibility is the installation of a three pin W-system comprising one lateral and one single hinged expansion joint.
To allow the elbow between the expansion joints to rotate without forcing the tie rods to release from their tied position one must assure that the positioning of the tie rods of the lateral expansion joint corresponds to the positioning of the pins of the single hinged unit (Fig. 6).

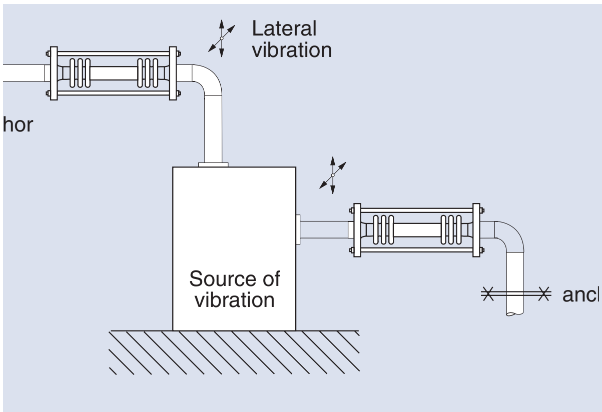


Fig. 4

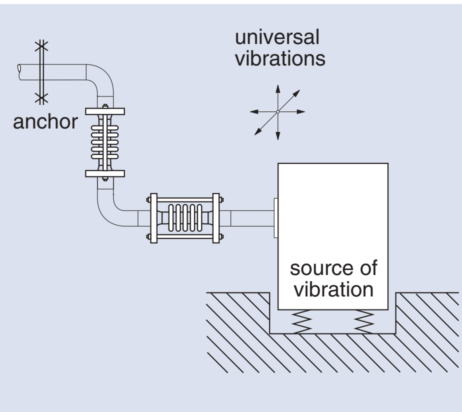


Fig. 5

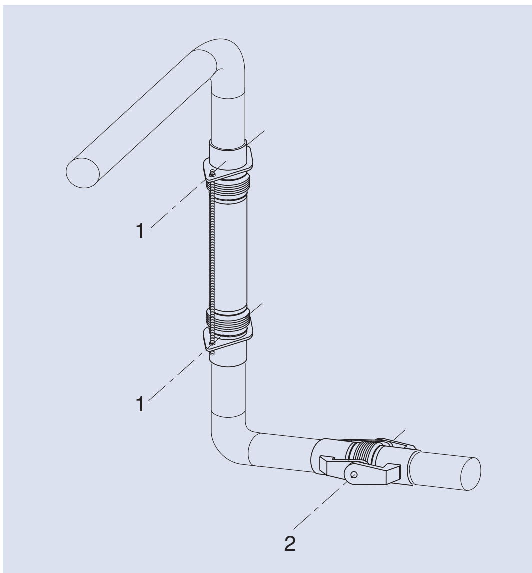


Fig. 6

High energy and high frequency vibrations of the pipeline that are caused by turbulent flow after safety blow-down valves, shut-down valves or pressure reducers or vibrations (pulsation) in the gas or liquid column itself cannot be compensated for.

Pipe supports / guides, anchors

To ensure that the lateral expansion joint compensates for the thermal expansion correctly, pipe anchors and pipe supports / guides must be installed to define the amount and direction of the thermal expansion. According to the peripheral conditions of the installation, this can be achieved by placing two pipe guides adjacent to the elbows on each side of the expansion joint with anchors further away from the location of the expansion joint or by the installation of one anchor and one pipe guide in the afore mentioned positions (Fig. 8).

The pipe supprts / guides must comply with the following requirements:

1. Support the weight of the pipeline and the weight of the expansion joints including the weight of the flow, insulation etc.
2. Guide the pipeline in its axis.
3. Provide sufficient clearance [s] to allow free pipe movement from the uncompensated thermal expansion ΔL of the pipe section L and from the arc height h (Fig. 7) without causing the guide to jam.

$$s \geqq h + \Delta L$$

Short pipe routings that are typical for power station piping do not normally require pipe guides. The dead weight of the pipeline should be supported by suitable spring or constant pipe supports / hangers in a way that they do not interfere with the movement of the expansion joint.

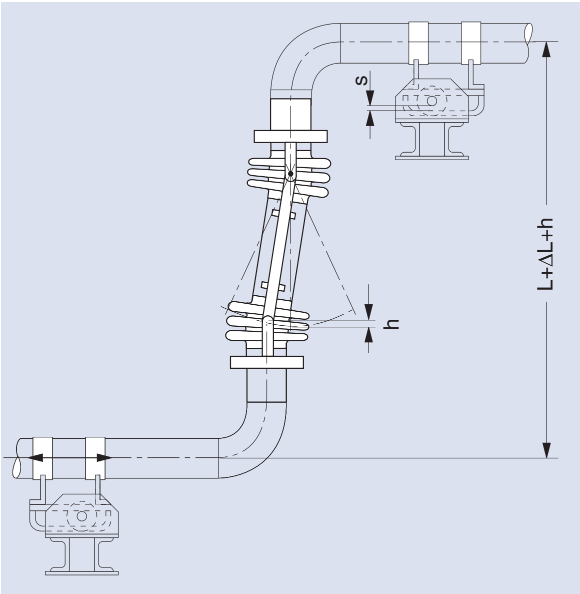


Fig. 7

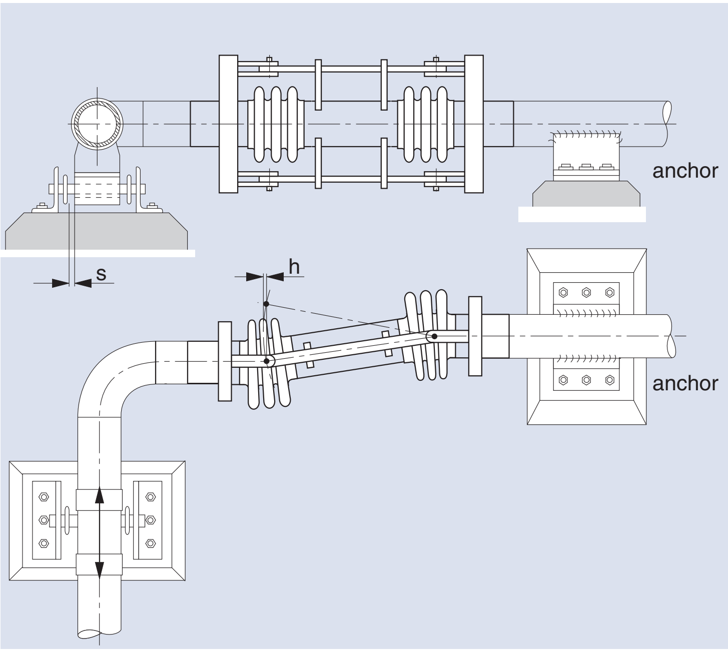


Fig. 8

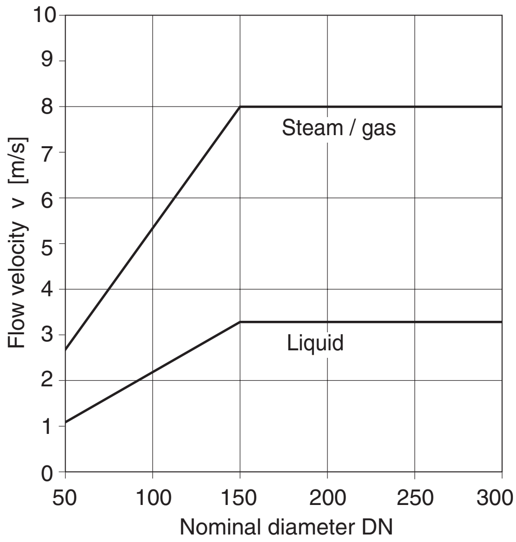
Calculations

Sleeves

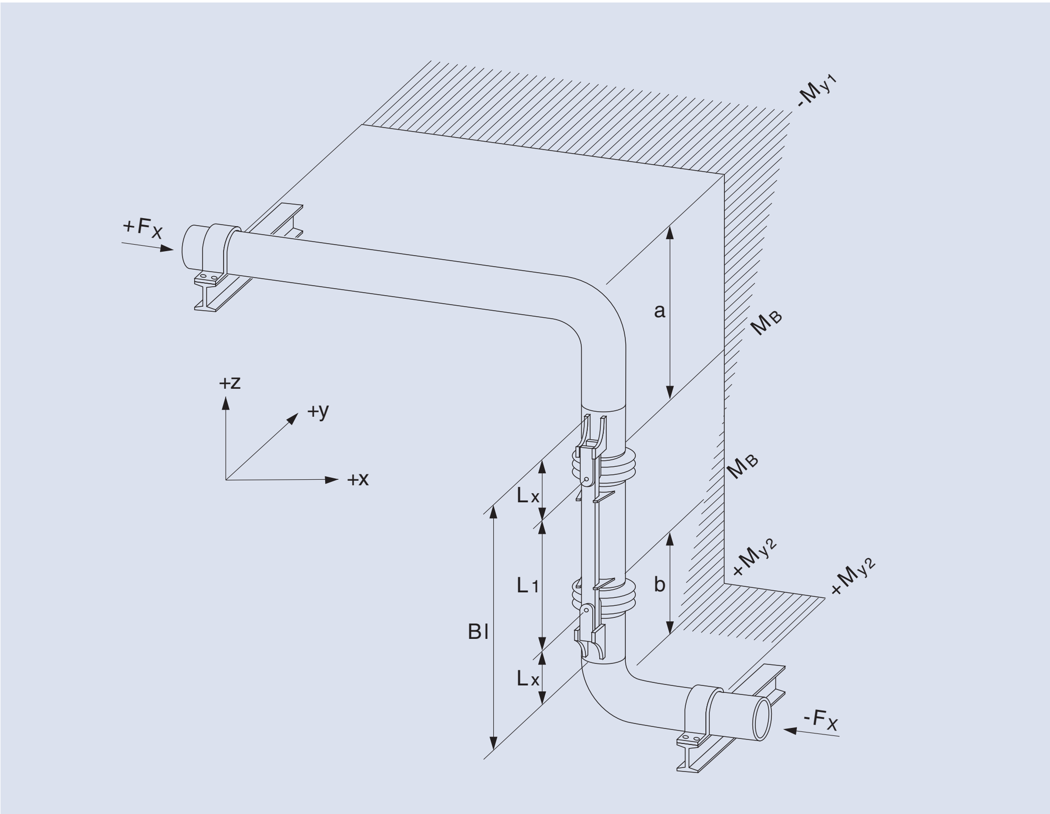
We recommend the installation of expansion joints with sleeves if high-frequency oscillations or turbulences are to be expected in the medium, or if the medium has a high flow velocity.

The diagram “Guidelines for use of sleeves” shows the limit curves for steam, gas and liquids, above which the use of sleeves is absolutely recommended.

The sleeves serve to protect the bellows and reduce its tendency towards oscillation induced by the flow, and to also reduce deposits and wear.



The lateral expansion joints as a two pin system



System calculation

Lateral expansion joint for movement compensation on one plane.

Please note:

As a result of the deflection of a lateral expansion joint, a bending moment and a force occur and load the anchors.

The moment and force are caused by the bellows spring rate and by the friction in the hinges.

The pressure thrust from the internal pressure and the effective cross section of the bellows are restrained by the hinged hardware.

All formulae refer to a 50% pre-stressing of the pipe movement Δ, that must be compensated for, which means that the lateral expansion joint will be deflected by the amount of $\pm\Delta/2$.

In case of a 100% or 0% pre-stressing, the amount of 2 times Δ should be used in the equation.

Permissible movement capacity

Following the recommendations explained in section “basic principals / nominal design conditions”, the permissible lateral movement capacity $\pm\Delta_{zul}$ is determined taking into account the nominal lateral movement capacity $\pm\Delta_{lat}$ as follows:

$$\pm \Delta_{zul} = \pm \Delta_{lat} \cdot K_{\Delta} (t_B) \cdot K_L \text{ [mm]}$$

The effective pipe movement $\pm\Delta/2$ must be equal to or less than the permissible lateral movement capacity $\pm\Delta_{zul}$:

$$\pm \Delta/2 \leq \pm \Delta_{zul}$$

Resulting arc height

At the maximum lateral deflection ($\Delta/2$) to one side, the vertical distance between the bellows L_1 is shortened by the amount of the arc height [h] that is determined as follows:

$$h = L_1 - \sqrt{(L_1^2 - 0.25 \cdot \Delta^2)} \text{ [mm]}$$

The arc height [h] and the uncompensated thermal expansion of the pipe section in which the expansion joint is installed must be taken into account when the clearance in the pipe guide is determined or a sufficient distance to the guide must be provided to allow the pipe to compensate for this movement by means of natural compensation.

Anchor/connection point forces

Forces at the connection points

$$F_x = c_r \cdot p + c_{lat} \cdot \frac{\Delta}{2} + c_z \cdot p \cdot \frac{\Delta}{2} \text{ [N]}$$

When the system is 50% pre-stressed, then the force and the moments occur with different signs in the pre-stressed and operating position.

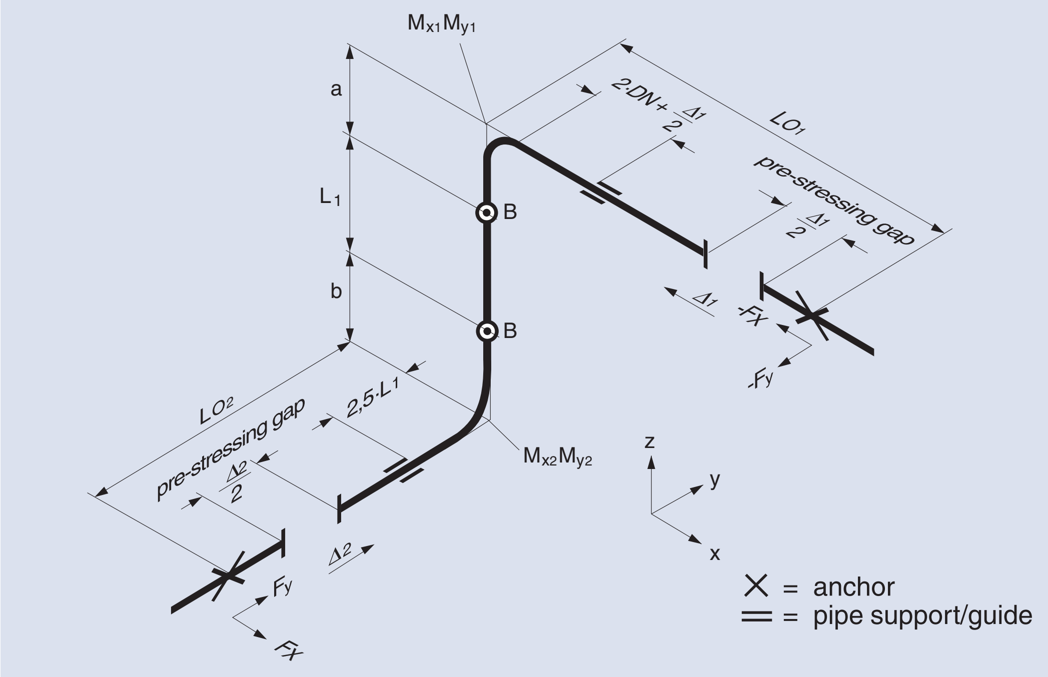
Bending moments at the connection points

$$M_{y1} = F_x \cdot \frac{0.5 \cdot L_1 + a}{1000} \text{ [Nm]}$$

$$M_{y2} = F_x \cdot \frac{0.5 \cdot L_1 + b}{1000} \text{ [Nm]}$$

Calculations

The lateral expansion joints as a two pin system



System calculation

Lateral expansion joint for movement compensation in any direction perpendicular to its axis.

All formulae refer to 50% pre-stressing of the pipe movement Δ_1 and Δ_2, that must be compensated for, which means that the lateral expansion joint will be deflected in both, the pre-stressed and operating position by the amount of $\pm\Delta/2$.

Resulting movement

$$\Delta = \sqrt{(\Delta_1^2 + \Delta_2^2)}\ [\mathrm{mm}]$$

Permissible movement capacity

Following the recommendations explained in section “basic principals / nominal design conditions”, the permissible lateral movement capacity $\pm\Delta_{zul}$ zul is determined taking into account the nominal lateral movement capacity $\pm\Delta_{lat}$ as follows:

$$\pm\Delta_{zul} = \pm\Delta_{lat} \cdot K_\Delta(t_B) \cdot K_L\ [\mathrm{mm}]$$

The resulting effective pipe movement $\pm\Delta/2$ must be equal to or less than the permissible lateral movement capacity $\pm\Delta_{zul}$:

$$\pm\Delta/2 \leq \pm\Delta_{zul}$$

If the system is pre-stressed by 100 % or 0 %, then the resulting effective pipe movement Δ must be equal to or less than Δ_{zul}:

$$\Delta \leq \Delta_{zul}$$

Resulting arc height

At the maximum lateral deflection ($\Delta/2$) to one side, the vertical distance between the bellows (L_1) is shortened by the amount of the arc height [h] that is determined as follows:

$$h = L_1 - \sqrt{(L_1^2 - 0.25 \cdot \Delta^2)}\ [\mathrm{mm}]$$

In case of a 100% or 0% pre-stressing, the amount of 2 times Δ should be used in this formula.

The arc height [h] and the uncompensated thermal expansion of the pipe section in which the expansion joint is installed must be taken into account when the clearance in the pipe guide is determined or a sufficient distance to the guide must be provided to allow the pipe to compensate for this movement by means of natural compensation.

Anchor/connection point forces

Forces at the connection points

$$F_x = c_r \cdot p + c_{lat} \cdot \frac{\Delta_1}{2} + c_z \cdot p \cdot \frac{\Delta_1}{2} \text{ [N]}$$

$$F_y = c_r \cdot p + c_{lat} \cdot \frac{\Delta_2}{2} + c_z \cdot p \cdot \frac{\Delta_2}{2} \text{ [N]}$$

When the expansion joint types 7810, 7820 and 7850 (tied universal expansion joints with tie rods and washers) are used, the force $c_z \cdot p \cdot \Delta / 2$ does not occur.

When the system is 50% pre-stressed, then the forces and the moments occur with different signs in the pre-stressed and operating position.

Bending moments at the connection points

$$M_{y1} = F_x \cdot \frac{0.5 \cdot L_1 + a}{1000} \text{ [Nm]}$$

$$M_{y2} = F_x \cdot \frac{0.5 \cdot L_1 + b}{1000} \text{ [Nm]}$$

$$M_{x1} = F_y \cdot \frac{0.5 \cdot L_1 + a}{1000} \text{ [Nm]}$$

$$M_{x2} = F_y \cdot \frac{0.5 \cdot L_1 + b}{1000} \text{ [Nm]}$$

Nomenclature

a, b	Center to center distance between bellows and connection point [mm]
h	Arc height [mm]
L_1	Center to center distance between bellows [mm]
c_{lat}	Lateral spring rate [N/mm]
c_r	Hinge friction [N/bar]
c_z	Additional force from pressure and rotation [N/bar · mm]
K_L	Fatigue factor [–]
K_Δ	Movement adjustment factor [–]
$F_{x,y}$	Displacement force in x and y-direction [N]
$M_{y\,1,2}$	Bending moment at the connection point [Nm]
$M_{x\,1,2}$	Bending moment at the connection point [Nm]
$\pm\Delta_{zul}$	Permissible lateral movement of the expansion joint [mm]
Δ	Resulting movement of the pipeline [mm]
$\Delta_{1,2}$	Movement of the pipeline sections 1 and 2 [mm]
p	Operating pressure [bar]

Calculations

Lateral expansion joints in three pin systems

General

The chapter “angular expansion joints” describes different three-pin expansion systems that comprise three angular expansion joints.
If the center to center distance between the joints is short, it is often more economical to use one lateral expansion joint instead of the two angular units that are installed in tandem.
The lateral expansion joints type 7710 and 7720, that are suited for movement compensation on one plane are suitable for the 3W, 3L and 3Z expansion systems.
In 3 pin gimbal systems, the two gimbal joint can be replaced by one lateral expansion joint with movement compensation capabilities in any direction perpendicular to the expansion joint axis. The double gimbal joints type 7410 and 7420 are kinematically absolutely identical with two individual gimbal joints. If tied universal expansion joints with tie rods or cardanic hinges are used (types 78..), then these joints must be installed with the correct positioning of the restraining hardware to allow the joints to rotate in an angular direction around the same axis as the single hinged expansion joint in the system. (Fig. 9 shows an example using one single hinged and one tied universal expansion joint with tie rods. The line between the tie rods [1] must be parallel to the line [2] between the hinges).

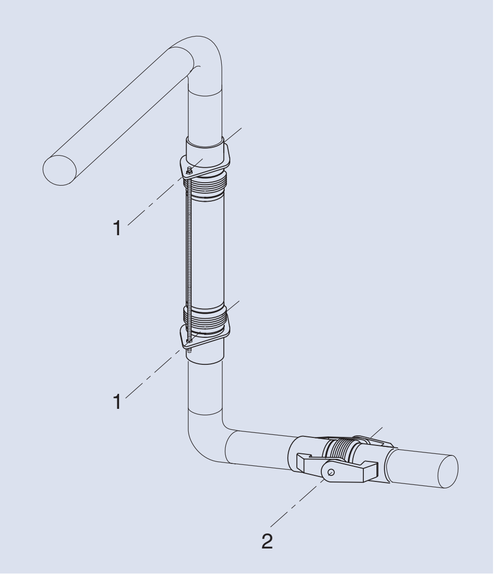


Fig. 9

Note: Lateral expansion joints that are used in three pin systems are not allowed to have more than two tie rods or bars. Three or more tie rods / bars will not allow an angular rotation of the individual bellows of a lateral joint.

In order to apply the design calculations of three pin expansion systems to systems that comprise a lateral expansion joint, the spring rates and displacement force of the lateral expansion joint must be converted into an equivalent bending spring rate and bending moment of two “substitute” angular joints.

These two “substitute” angular expansion joints represent the lateral expansion joint in the design calculation of the expansion system.

The following conversion applies for tied universal expansion joints with tie rods only as an approximate since the distance between the spherical washers is not the same as the center to center distance between the bellows. Please contact us if an exact calculation is required.

The bending spring rate c_α of the “substitute” angular expansion joint is determined from the lateral spring rate c_{lat} of the lateral expansion joints as follows:

$$c_\alpha = c_{lat} \cdot L_1^2 \cdot \frac{\pi}{360} \cdot 10^{-3} \left[\frac{\text{Nm}}{1^\circ}\right]$$

The angular hinge friction c_r of the “substitute” angular expansion joints is determined from the lateral friction $c_{r\,(lat)}$ of the lateral expansion joint as follows:

$$c_r = c_{r\,(lat)} \cdot \frac{L_1}{2000} \left[\frac{\text{Nm}}{\text{bar}}\right]$$

The additional angular moment c_z of the “substitute” angular expansion joint is determined from the additional lateral force $c_{z(lat)}$ of the lateral expansion joint as follows:

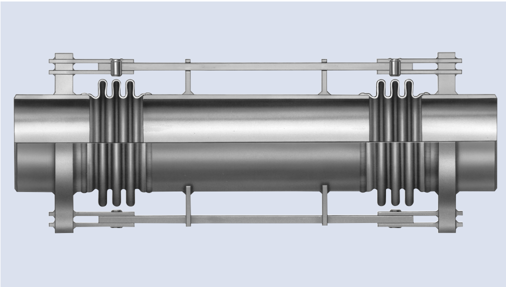
$$c_z = c_{z\,(lat)} \cdot L_1^2 \cdot \frac{\pi}{360} \cdot 10^{-3} \left[\frac{\text{Nm}}{\text{bar} \cdot 1^\circ}\right]$$

The permissible angular rotation $\pm\alpha_{zul}$ of the “substitute” angular expansion joint is determined from the permissible lateral movement capacity $\pm\Delta_{zul}$ as follows:

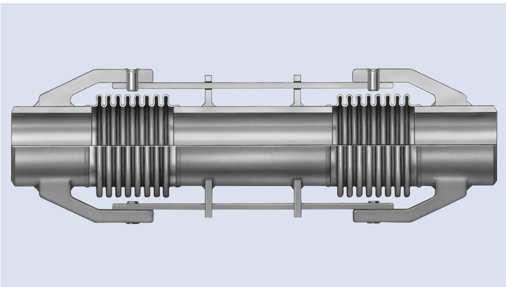
$$\pm\,\alpha_{zul} = \pm \arcsin\left(\frac{\Delta_{zul}}{L_1}\right) \text{[degr.]}$$

c_{lat}	Lateral spring rate [N/mm]
$c_{r(lat)}$	Hinge/washer friction [N/bar]
$c_{z(lat)}$	Additional force from internal pressure and rotation [N/bar · mm]
L_1	Center to center distance between bellows [mm]

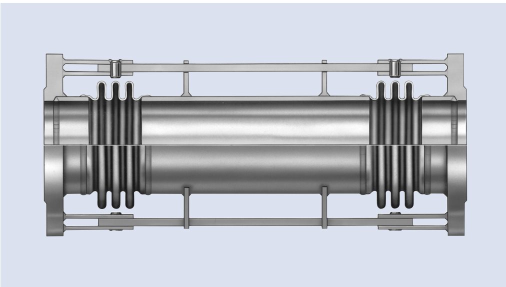
Lateral expansion joints for lateral movements on one plane



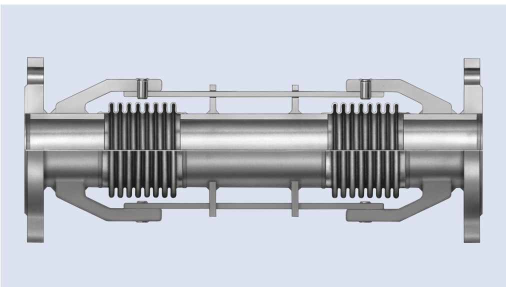
Lateral expansion joint (double hinged)
Bellows made of stainless steel 1.4571 (up to and including DN 50), or 1.4541 from DN 65 and larger. Both sides with weld ends made of carbon steel, external restraints in carbon steel. Suited for lateral movement compensation on one plane.
Type BKT-7710 (previous: 307/270 and 272)
DN ..... / PN ... / Δ $_{lat}$ ..... / BI .....



Hardware design according to the manufacturing program.



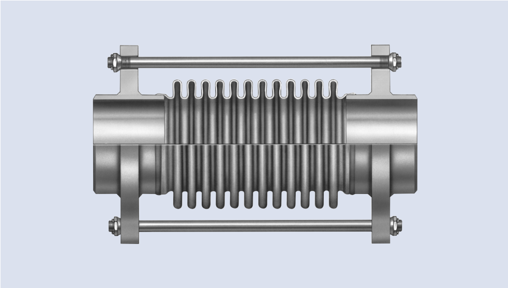
Lateral expansion joint (double hinged)
Bellows made of stainless steel 1.4571 (up to and including DN 50), or 1.4541 from DN 65 and larger. Both sides with flanges made of carbon steel, external restraints in carbon steel. Suited for lateral movement compensation on one plane.
Type BKT-7720 (previous: 307/271 and 273)
DN ..... / PN ... / Δ $_{lat}$ ..... / BI .....



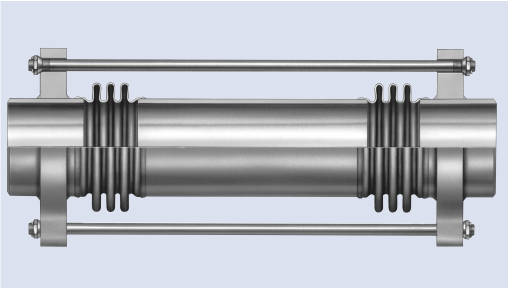
Hardware design according to the manufacturing program.

Program

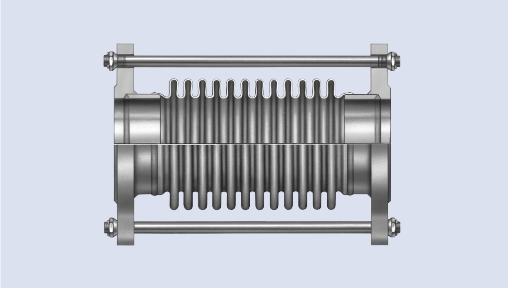
Lateral expansion joints for lateral movements on any plane



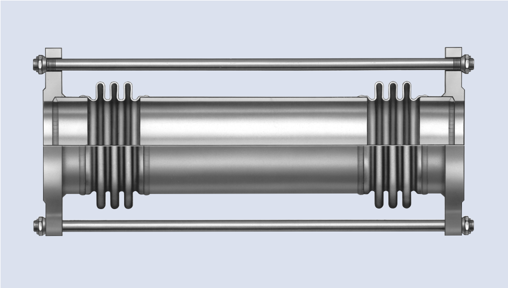
Lateral expansion joint (tied universal)
Bellows made of stainless steel 1.4571 (up to and including DN 50), or 1.4541 from DN 65 and larger. Both sides with weld ends made of carbon steel, external restraints in carbon steel. Suited for lateral movement compensation on any plane.
Type BKT-7810 (previous: 307/280 and 282)
DN ..... / PN ... / Δ lat ..... / Bl .....



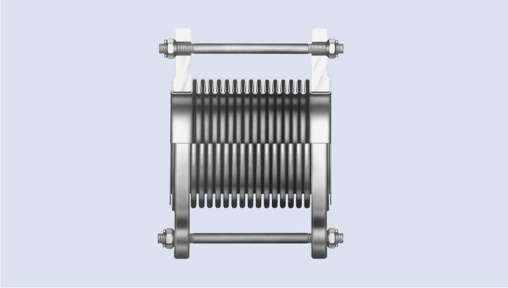
Hardware design according to the manufacturing program.



Lateral expansion joint (tied universal)
Bellows made of stainless steel 1.4571 (up to and including DN 50), or 1.4541 from DN 65 and larger. Both sides with flanges made of carbon steel, external restraints in carbon steel. Suited for lateral movement compensation on any plane.
Type BKT-7820 (previous: 307/281 and 283)
DN ..... / PN ... / Δ lat ..... / Bl .....



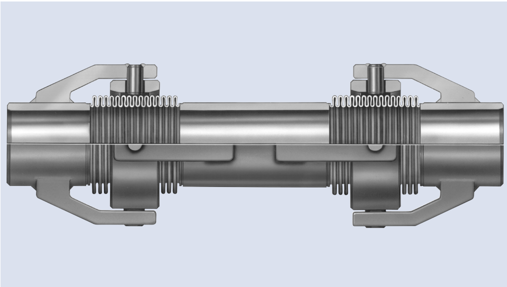
Hardware design according to the manufacturing program.



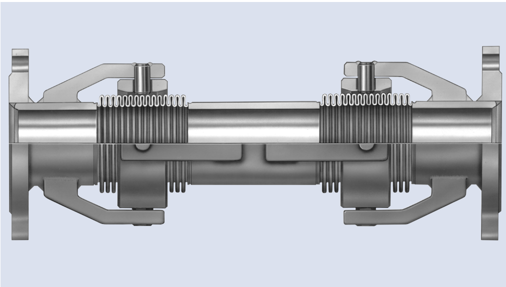
Lateral expansion joint (tied universal)
Bellows and van-stone ends made of stainless steel 1.4571 (up to and including DN 50), or 1.4541 from DN 65 and larger. Both sides with van-stone flanges made of carbon steel, external restraints in carbon steel. Suited for lateral movement compensation on any plane.
Type BKT-7850 (previous: 307/285 and 287)
DN ..... / PN ... / Δ lat ..... / Bl .....

Program

Lateral expansion joints for lateral movements on any plane

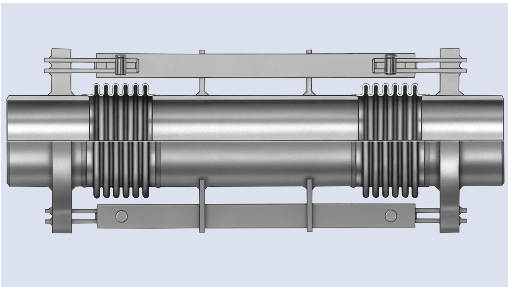


Double gimbal expansion joint
Bellows made of stainless steel 1.4571 (up to and including DN 50), or 1.4541 from DN 65 and larger. Both sides with weld ends made of carbon steel, external gimbal restraints in carbon steel. Suited for lateral movement compensation on any plane.
Type BKT-7410 (previous: 307/290)
DN ..... / PN ... / Δ_{lat} ..... / Bl .....



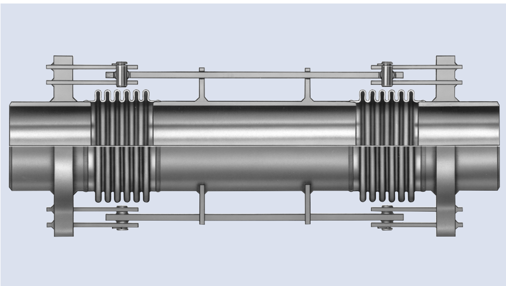
Double gimbal expansion joint
Bellows made of stainless steel 1.4571 (up to and including DN 50), or 1.4541 from DN 65 and larger. Both sides with flanges made of carbon steel, external gimbal restraints in carbon steel. Suited for lateral movement compensation on any plane.
Type BKT-7420 (previous: 307/291)
DN ..... / PN ... / Δ_{lat} ..... / Bl .....

Special designs



Lateral expansion joint with cardanic hinges
Bellows made of stainless steel 1.4541. Both sides with weld ends made of carbon steel, external anchor plate restraints in carbon steel. Suited for lateral movement compensation on any plane.
Type BKT-7810 BDO (previous: 307/286)
DN ..... / PN ... / Δ_{lat} ..... / Bl .....

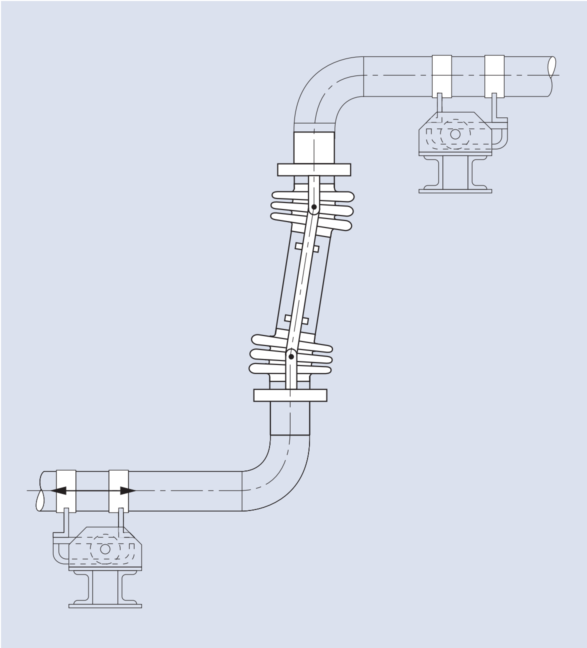
With flanges: Type BKT-7820 BDO



Lateral expansion joint with ball joint hinges
Bellows made of stainless steel 1.4541. Both sides with weld ends made of carbon steel, external anchor plate restraints in carbon steel. Suited for lateral movement compensation on any plane.
Type BKT-7810 BEO (previous: 307/288)
DN ..... / PN ... / Δ_{lat} ..... / Bl .....

With flanges: Type BKT-7820 BEO

Lateral expansion joints that allows a lateral movement on one plane only must be installed with a correct positioning of the tie bars with respect to the direction of the pipe expansion that is to be compensated for. The pipe movement must always be perpendicular to the axis of the pins.



Pipe guides / supports

In contrast to axial expansion joints, lateral expansion joints are less demanding with regards to pipe supports and guides. They have to support the weight of the pipeline including the insulation, flow, wind and other external loads in such a way that relieve the expansion joints from those loads without hindering their movement.

In short pipe routings such as in compact power house pipe systems, pipe supports and guides may not be necessary at all.
In long pipelines, a pipe guide should be installed on each side of the lateral expansion joint.

Anchors

Only one lateral expansion joint should be installed between two anchors. These anchors must withstand the displacement force of the lateral expansion joint that results from the bending spring rate of each bellows, the friction of the pins in the hinges as well as the friction forces in the pipe supports and guides.

Pipe guides with excess friction as a result of overloading, deposits of dirt or rust may gall and cause excessive strain in the pipe, its anchors and connections.

Start-up of plant

Pipe anchors, supports and guides must be firmly installed prior to filling the system or commencing the pressure test. The permissible pressure test must not be exceeded. The bellows must be protected against weld, mortel or plaster splatter, dirt or any form of mechanical damage during installation.
Steam pipe systems must be installed on an incline and must further be heated at a slow rate to assure that condensate, that might cause steam hammers, is drained in time. Sufficient insulation and the avoidance of water pockets are recommended. Steam cleaning should be avoided due to the risk of water hammers and unwanted vibrations of the bellows.
Expansion joints with inner sleeves must be installed taking into account the flow direction with the fixed end of the sleeves facing up-stream. Otherwise, common principles of failure prevention such as proper water treatment, electrical bridges in copper and galvanized pipes etc. for the avoidance of corrosion defects, must be followed.

Vibration compensation

Lateral expansion joints with tie rods (tied universal expansion joints) are suited to compensate for mechanical vibrations in one plane, for example in discharge pipes of pumps, compressors and other rotating machinery (Fig. 1).
If the machinery is mounted rigidly to its foundation, the installation of one tied universal expansion joint is usually sufficient. If the machinery however is mounted on flexible supports, then the installation of two tied universal expansion joints is necessary to compensate for the movements that occur in all directions (Fig. 2). A pipe anchor is required immediately after the expansion joint and must be separated from the vibrating foundation.

The installation occurs without pre-stressing!

Vibrations with high frequencies as a result of a turbulent flow as apparent for example after safety and relief valves or emergency shut-down valves or vibrations that are generated by the gaseous or liquid flow itself cannot be compensated for.

The expansion joint should always be installed as close as possible to the source of the vibration.

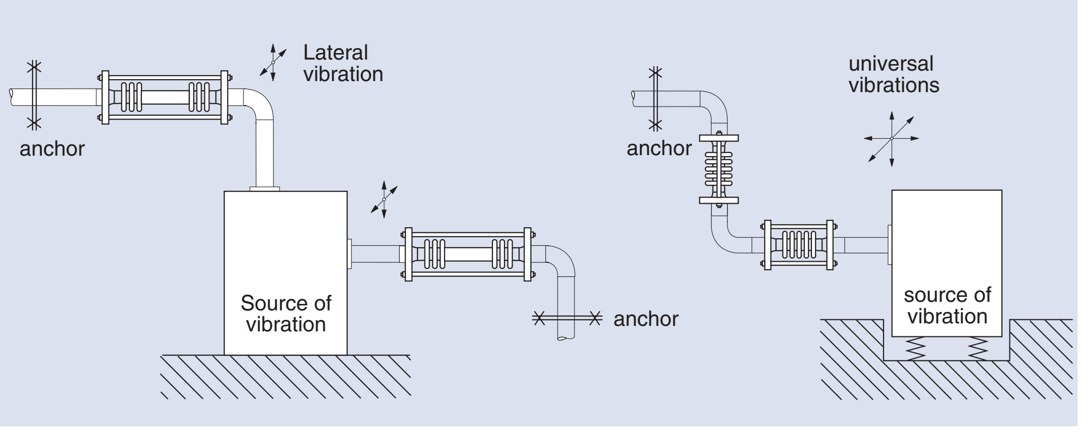


Fig. 1 Fig. 2

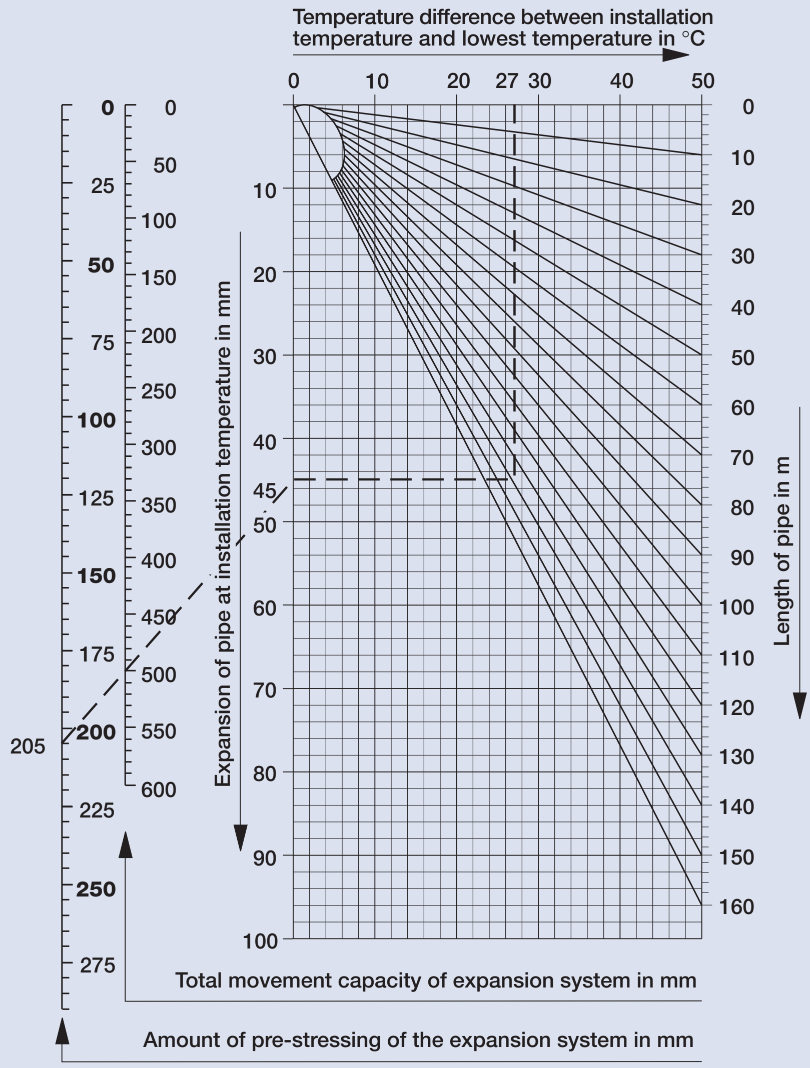
Operating pressure

The permissible operating pressure results from the nominal pressure, taking into account the reduction factors according to the technical data sheets.

Pre-stressing

Lateral expansion joints are commonly installed at 50% pre-stressing of their anticipated movement. The actual temperature of the pipeline at the time of installation must be taken into acount when pre-stressing is applied. This is particulary important for long distance pipelines.
If the temperature of the pipeline at the time of installation deviates form the lowest possible temperature, then the amount of pre-stressing must be determined according to the following pre-stressing diagram.

Pre-stressing diagram



only applicalbe for pipes of St 35 material

Example

Given:

– Lateral expansion joint for a 140 m long pipeline
– Lowest possible temperature: –7 °C
– Maximum temperature: +293 °C
– Maximum thermal expansion according to Δt 300 °C = 500 mm

Determine the correct amount of pre-stressing if the expansion system is to be pre-stressed at 50% of the total movement (= 250 mm) and when the actual temperature at the time of installation is +20 °C.
Answer: The thermal expansion of the pipeline between –7 °C and +20 °C (Δt = 27 °C) is 45 mm. To determine the correct amount of pre-stressing, this amount must be deducted from the total amount of pre-stressing i.e. 250 – 45 = 205 mm.
The diagram provides a quick resolution without the need of a mathematical calculation:

1. Temperature difference between installation temperature (+20 °C) and lowest temperature (–7 °C) = 27 °C.
2. Total length of pipeline = 140 m
3. Draw a vertical line from point “27 °C” at the top of the diagram downwards to the line that connects the point “0” and the point “140” at the right side of the diagram.
4. From this intersection, draw a horizontal line to the left side of the diagram. The number 45 [mm] indicates the thermal expansion of the pipe at installation temperature.
5. Draw a line from point “45” to the point “500” in the next diagram to the left and extend this line to the far left diagram.

The number 205 [mm] indicates the amount of pre-stressing by which the expansion joint must be pre-stressed into the opposite direction of the expected thermal growth of the pipeline.

Recommendations

Avoid the installation of standard expansion joints in the immediate proximity of pressure reducers, superheated steam condensers and quick activated shut-off valves as high frequency vibrations might be generated by this equipment. Provide heavy wall sleeves for the expansion joints, perforated flow visors in the pipeline or equalizing sections to protect the bellows against failures.

If high frequency vibrations, turbulence or high flow velocities are anticipated, we recommend the installation of expansion joints with inner sleeves (liners).

For pipeline diameters equal to or larger than 150 mm, we recommend internal sleeves if the flow velocity exceeds 8 m/s for a gaseous flow and 3 m/s for liquids.

Expansion joint data sheet

BOA Group

Type of expansion joint: ____________________

Nominal diameter DN: ____________________

Design conditions

Design pressure ________ bar
Design temperature ________ °C
Movements
– axial compress. +/– ________ mm
– axial extension +/– ________ mm
– lateral +/– ________ mm
– angular +/– ________ degr.
Vibrations frequency ________ Hz
amplitude ________ mm
Type of vibration ________

Number of cycles ________
Flow medium ________
Flow velocity ________

Limitations mechanical properties:

axial spring rate ________ N/mm
lateral spring rate ________ N/mm
angular spring rate ________ Nm/degr.
axial force ________ N
lateral force ________ N
angular moment ________ Nm
pressure thrust ________ N

Quality tests:

Hydraulic press. test ◯ yes ◯ no
Leak test
with air ◯ yes ◯ no
with helium ◯ yes ◯ no
permissible leak rate ________ mbar l/s

Auxiliary items:

Inner sleeve ◯ yes ◯ no
External shroud ◯ yes ◯ no
Other items (specify) ________
____
____
____
____

End fittings: **Size/ material:**

◯ Weld ends
◯ Fixed flange
◯ Loose flange
◯ Other (specify)

Space:

maximum length: ________ mm
maximum diameter: ________ mm

Additional NDE		BL	RL	BRR	RR	other items
X-ray examination	%					
dye penetrant examination	%					
ultrasonic examination	%					
magnetic particle examination	%					

BL = bellows longitudinal weld seam
BRR = bellows to pipe circumferential weld seam
RL = pipe longitudinal weld seam
RR = pipe circumferential weld seam

QA/QC requirements

Design code ____________________
Special specifications ____________________
Certification ____________________
Authorized inspection party ____________________

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