Bellows Factory ĐURO ĐAKOVIĆ, Kompenzatori d.o.o. is the factory in the structure of company ĐURO ĐAKOVIĆ Holding d.d. industry of rolling stock, industrial and power plants and steel structures, and is a result of the Joint Venture between company Đuro Đaković - Slavonski Brod, Croatia and bellows manufacturer firm "Teddington Bellows Ltd." - Pontardulais, Swansea, Great Britain.

Teddington Bellows Ltd. is the largest manufacturer of bellows in Great Britain and one of the greatest in the world. It has its subsidiary companies in Sweden, France and West Germany. It employs scientists, engineers and technicians, and several hundred workers have been specially trained for manufacturing on thin walled bellows. This production has been developed from production of bellows for aircraft's control instruments, which is and today a part of Teddington's production programme.

With the joint efforts of experts from both firms, this long time experience in manufacturing of bellows has been conveyed to the new production programme in firm Đuro Đaković - Slavonski Brod, whose long-term tradition and experience in production industry and power equipment are guarantee that the quality of bellows manufactured at the ĐURO ĐAKOVIĆ - Kompenzatori d.o.o., Slavonski Brod - Croatia, is the same as in Great Britain.

Thin-wall bellows is adopted all over the world as the principal method of compensation for pipework expansion caused through variations of temperature, pressure and external physical movement, in petrochemical plant, in heating and ventilating systems, on exhaust manifolds, in factories, power generation stations, laundries, dairies, district heating installations... wherever pipes are subjected to movement through the effects of temperature, pressure or physical force, you will find in use bellows.

In theory bellows are one of the most vulnerable parts of a pipework installation in which thin-gauge metal, a fraction of the thickness of the pipework into which it is fitted, has to withstand the same extremes of temperature and pressure. Yet, today the modern bellows expansion joint is considered as a permanent part of a pipework installation.

In this publication - which is part text book, part catalogue - you are introduced to a range of bellows developed, manufactured and tested by the world's foremost specialist in bellows technology. These are standard bellows, in popular pipe sizes, often available of-the-shell to save your time and money. Custom-built bellows to meet special applications are also available. In that case our engineers will be pleased to advise you the application and installation of bellows and expansion joints to meet your particular requirements.

When you choose bellows, choose OUR bellows, because it is a guarantee for good quality.

INTRODUCTION

Expansion compensation of pipes subject to movement due to the effects of temperature, pressure, and external sources has for many years been carried out in various ways. Primarily the most effective method is to use the inherent natural flexibility of the pipework system utilising bends etc. to form natural loops. When stress levels either within the pipes or at vessel connections become too great other means of compensation are employed, namely the made up loop and the sliding joint. Examples of which are illustrated in Fig. 1.

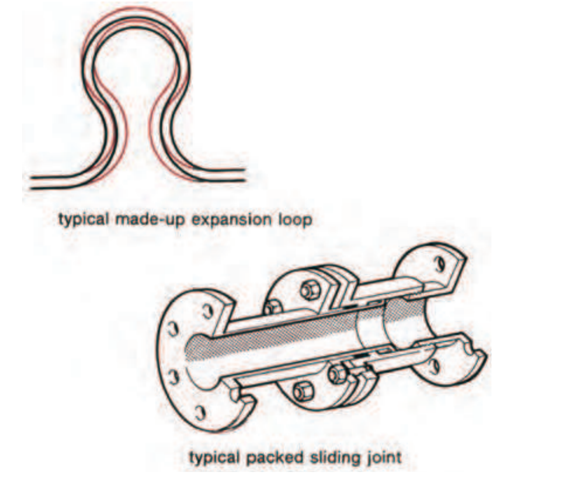


Fig. 1. Typical made - up expansion loop

Expansion loops apart from being expensive in material and wasteful of space, are restricted by the stress limits of pipe under bending. Packed sliding joints, which operate on the principle of the simple telescope are vulnerable to scaling problems and require constant maintenance. The limitations of these two system led to the development of fabricated bellows. These were essentially thick wall bellows, in effect dished plates welded together circumferentially to form a series of convolutions. Heavy gauge metal is used (hence the Thick Wall description) and considerable force is required to induce movement.

To overcome this problem it was discovered that by careful cold-rolling of a thin gauge tube a bellows could be formed and could be compressed or extended without exerting undue strain on the material or creating unacceptable counter forces acting against the pipe anchors.

Thus thin wall bellows were evolved to meet the requirements of piping system and subsequent development has led to the universal acceptance of these bellows as a permanent component part of a complete piping system.

This section of the publication deals with the manufacture performance and selection of the appropriate bellows expansion joint to suit particular applications.

VARIABLES TO BE CONSIDERED

When selecting a bellows expansion joint the following variables must be considered.

1. Pressure-working, design and test.
2. Temperature-working and design.
3. Media flowing through the pipe.
4. Pipework system
5. Movements to be applied to the bellows.
6. Type of bellows expansion joint.

PRESSURE

The design of a bellows element being partly dependent on the pressure applied to the pipeline, either negative or positive. It is important to know the design, working and test pressures to which the bellows will be subjected. Normally the element is designed for operation at the higher of either the design or operating pressure except where a test condition is required which exceeds 1.5 times these conditions. In this situation a bellows having a higher pressure rating must be used. Fig. 2. shows the effect of pressure acting upon the bellows convolutions trying to open the bellows both longitudinally and circumferentially.

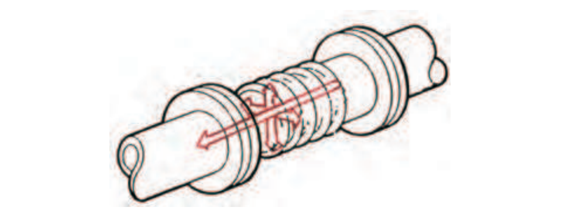


Fig. 2. Effect of internal pressure on a bellows unit

TEMPERATURE

Table 1.
Temperature factor

OPERATING TEMP.,°C	TEMP FAKTOR, t_k	MATERIALS CONVOLUTION	PIPE END	FLANGES
20 100 200 300	1	1.4541	St 37.0	RSt 37-2
400	0,92		15Mo3 (H II)	15Mo3 (H II)
500	0,80		15Mo3	15Mo3
550	0,60		1.4541	1.4541
600	0,83	Incoloy 800H	Incoloy 800H	Incoloy 800H
700	0,55			
800	0,32			
NOTE: Standard bellows are designed to work up to 300°C at specific nominal pressure. For higher temperatures we have to choose bellows for higher nominal pressure at the base of t_k.				

This factor generally is responsible for the pipeline movement and again both working and design conditions must be considered. It is also important to assess the effects of installation conditions in some circumstances, in particular in sub zero climates for cryogenic applications and the use of cold-pull up should be employed. (See for method of calculation.)

MEDIA

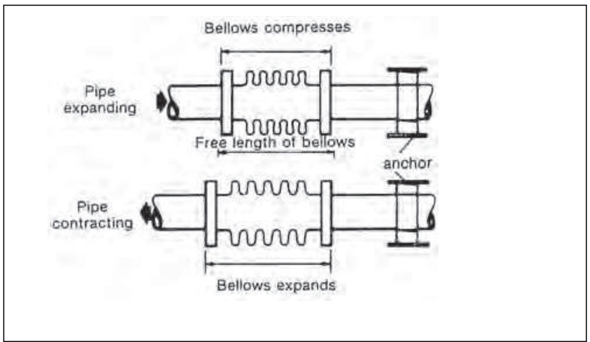
Standard range of bellows are manufactured in 18/8 stainless steel which is suitable for a large number of conditions but it should be borne in mind that for applications where a corrosive media is present bellows are available in other materials.

PIPEWORK SYSTEM

The pipeline layout and the positions of major items of equipment will already be established and from this point it is possible to establish anchor positions and hence the expansions of the various sections of pipework.

MOVEMENT

It is always important to remember that a bellows is a living device and changes shape in sympathy with the forces applied to it. Bellows movement can always be expressed quantitatively, axially, laterally or angularity and from known factors of temperature and thermal coefficients of expansion of pipe material it is a straight-forward exercise to calculate the movements to be absorbed by the bellows. Fig. 3. shows how a simple axial bellows moves in and out as the anchored pipeline expands and contracts with temperature changes, while Fig. 4. shows how an articulated bellows joint allows the expanding pipework to move out of line without straining pipework supports and hems of equipment.



Movement caused by external physical force must also be considered as in some instances this can be the primary source of movement. e. g. long lengths of pipework installed along the deck of a ship is subject to the hogging and sagging of the deck. Bellows are installed to take up this movement in addition to the thermal expansion of the pipeline.

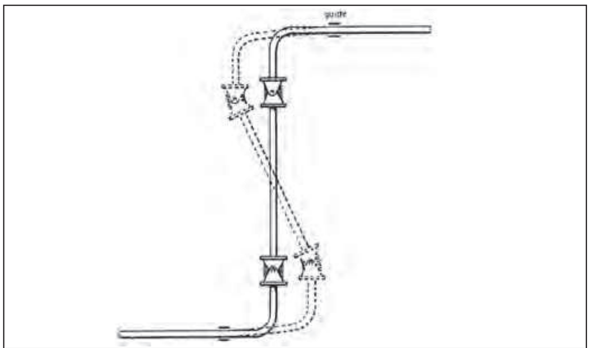


Fig. 4. The operation of hing units

Vibration in pipework caused by compressors, pumps, or other in-line equipment can be counteracted and in some instances bellows are used where both vibration and thermal movements are present as in the case of movements at the nozzle of a turbine caused by machine vibrations and the thermal expansion of the hot turbine casing.

For applications where vibration is present it is important to consult Đuro Đaković - Kompenzatori to ensure that the correct bellows is specified. The following information is required to be given:

a. Frequency of vibration movement
b. Amplitude
c. Natural frequency of system (if known)

PRODUCT IDENTIFICATION CODE

Having calculated bellows movement and selected the bellows type most suited to your installation you will be ready to make an actual bellows selection from the data sheets provide at the rear of this publication, and describe your requirement in terms of the following:

a) bellows type
b) pressure
c) pipe diameter
d) movement
e) end fitting

Every bellows manufactured by Đuro Đaković - Kompenzatori d.o.o. can be expressed in an a), b), c), d), e) sequence of these factors, and in Section 2 we explain how to use the data sheets, isolate the bellows you require, and finally describe your requirement in a manner which enables us to supply standard bellows, off-the-shelf, or manufacture custom built units to your specific requirements.

GLOSSARY OF TERMS

MAIN ANCHOR

A main anchor is one installed at any of the following locations in a pipe system containing one or more bellows:

1. At a change in direction of flow
2. Between two bellows units of different size installed in the same straight run.
3. At the entrance of a side branch into the main line if this branch contains a bellows.
4. Where a shut-off or pressure-reducing valve is installed in a pipe run between two bellows units.
5. At a blind end of pipe.

A main anchor must be designed to withstand the forces and moments imposed upon it by each of the pipe sections to which it is attached. In the case of a pipe section containing an unrestrained bellows these will consist of the thrust due to pressure, the force required to deflect the bellows unit and the frictional force due to the pipe moving over its guides. Where a main anchor is installed at a change of direction of flow, the effect at the bend of the centrifugal thrust due to flow must be considered.

INTERMEDIATE ANCHOR

An intermediate anchor is one which divides a pipeline into individual expanding pipe sections. Such an anchor must be designed to withstand the forces and moments imposed upon it by each of the pipe sections to which it is attached. In the case of a pipe section containing a bellows these will consist of the forces and/or moments required to deflect the bellows unit plus the friction forces due to the pipe moving over its guides. The pressure thrust is absorbed by the main anchors or devices on the bellows unit such as limit rods, tie rods, hinge restraints, gimbal restraints etc.

DIRECTIONAL ANCHOR

A directional anchor, or sliding anchor is one which is designed to absorb loading in one direction while permitting motion in another. It may be either a main or intermediate anchor, depending upon the application considered. When designed for the purpose, a directional anchor may also function as a pipe guide. When designing a directional anchor, an effort should be made to minimise the friction between its moving or sliding parts, since this will reduce the loading on the pipe and equipment and ensure correct functioning of the anchor.

PIPE ALIGNMENT GUIDE

A pipe alignment guide is a form of sleeve or framework attached to some rigid part of the installation which permits the pipeline to move freely in only one direction, i. e. along the axis of the pipe. Pipes alignment guides are designed primarily for use in applications involving axial movement only.

DIRECTIONAL PIPE GUIDE

A directional pipe guide is a pipe alignment guide designed to permit the pipeline to move freely in one plane with a limited movement, movement in another plane. This type of guide is used in applications involving movements in more than one plane as in a 3 pin piping configuration.

BELLOWS EXPANSION JOINT

A device containing one or more bellows elements used to absorb movements such as those caused by thermal expansion or contraction of a pipe line duct, or vessel.

BELLOWS ELEMENT

The flexible membrane of a bellows unit, consisting of one or more convolutions.

CONVOLUTION

The smallest flexible unit of a bellows. The total movement of a bellows being proportional to the number of convolutions.

RESTRAINING RING

A device which fits closely into the crest or root of a convolution to reinforce the bellows against the effects of either internal or external pressure. Restraining rings are manufactured from solid round bar or heavy gauge tube in stainless steel or other suitable alloys.

EXTERNAL SHROUD

A device used to protect the external surface of the bellows from damage by foreign objects or mechanical damage.

INTERNAL SLEEVE

A device which minimises the detrimental effect of media flow through the bellows expansion joint.

LIMIT STOPS OR RODS

Devices used to restrict the range of movement of a bellows unit or its component parts. Various designs such as rods, bars or sliding stops may be used. It should be noted that to function properly as limit stops these devices must be designed for full pressure loading, unless the load is absorbed by other structural devices.

THE RODS

Rods or bars for the purpose of restraining the bellows unit from the pressure thrust due to internal pressure and other internal applied forces. Tie rods may also act as limit stops when provided with the necessary stops.

WELD ENDS

The ends of a bellows unit equipped with pipe suitably bevelled for welding to adjacent piping or equipment.

FLANGED ENDS

The ends of a bellows unit equipped with flanges for the purpose of booting the unit to the mating flanges of adjacent piping or equipment.

CENTRE PIPE OR TUBE

A length of pipe connecting the bellows elements to form a double bellows unit, the length of which is critical to the stability of the assembly.

MOVEMENT

Axial Compression. The dimensional shortening of a bellows unit parallel to its longitudinal axis.

Axial Extension. The dimensional lengthening of a bellows unit parallel to its longitudinal axis.

Lateral Deflection. The relative displacement of the two ends of a bellows unit perpendicular to its longitudinal axis. This is sometimes referred to as lateral off-set, lateral movements, parallel misalignment, direct shear, etc.

Angular Rotation. The Angular displacement of one bellows connecting face relative to the other from its straight line position. This is, not to be confused with torsional rotation about the longitudinal axis which must be avoided. Sometimes known as rotational or radial movement.

BELLOWS CUFF

Plain cylindrical end of bellows extending beyond convolutions.

HINGE RESTRAINTS

Fabricated assembly on single and double hinged or gimbal bellows unit which allows the bellows to angulate and containing the effect of pressure within the unit.

BACKING RING

Cylinder attached to cuff to provide reinforcement.

COLD PULL-UP OR COLD DRAW

Extension of bellows from free length so that maximum movement of bellows can be utilised.

PRESSURE THRUST OR END LOAD

The force due to internal or external pressure acting on the bellows trying to extend or compress the bellows (see for method of calculation).

FREE LENGTH

The natural length of the assembly without cold pull or lateral offset.

LATERAL OFFSET

Is the lateral, or shear, pre-setting of one connection to the other to enable the maximum movement to be obtained from the bellows unit.

STABILITY

The ability of a bellows to withstand internal pressure without distortion of the convolutions. This is sometimes known as squirm and can be compared with strut instability of long thin columns.

SPRING RATE

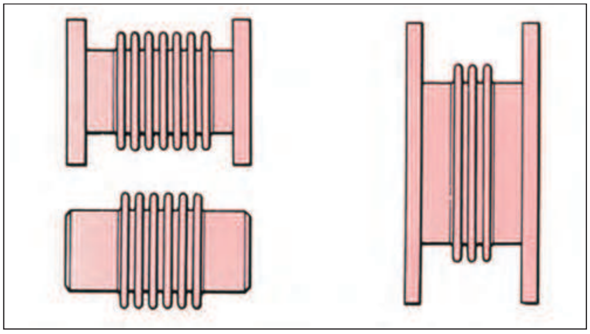
The force required to extend or compress the bellows unit length.

MULTI PLY

A bellows constructed from a multiple of tubes fitting closely inside each other.

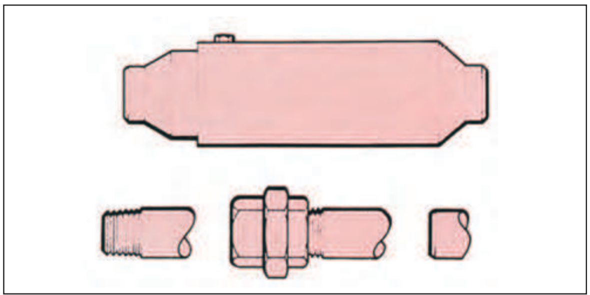
BELLOWS TYPES

AXIAL BELLOWS
Code: **AR**



Axial bellows expansion joints are designed to accommodate compressive or extension movements along the bellows longitudinal axis. Movements available are usually specified as ± amounts from free length. The free length is the theoretical length before movement. From this free length the unit will provide an equal amount of movement in either extension or compression. Therefore, to utilise all the movement available from the unit when it is known that the movement will be in one direction only, it is recommended that the units are installed with either pre-extension or pre-compression, dependent upon the pipe movements.
Care is required during installation to ensure that the unit is installed at its correct length so that it will only work within its specified limit. Any deviation would have a detrimental effect upon the bellows life. It should also be ensured that axial units are adequately anchored and guided.
Axial bellows are supplied flanged or with pipe ends suitable for welding into pipelines, or as a combination of both.

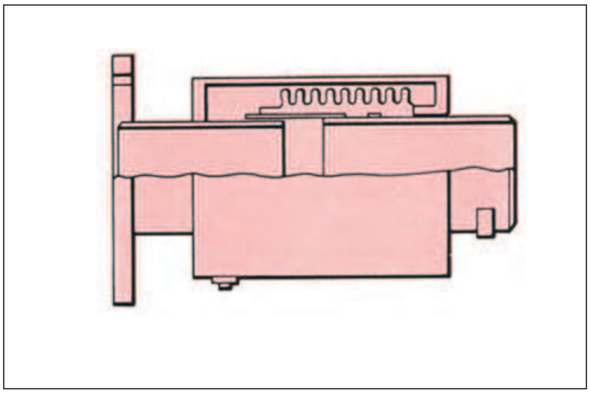
SELF GUIDED AXIAL BELLOWS
Code: **AS**



Experience has shown that there is a need for a special type of unit for use by the heating and ventilating trade.

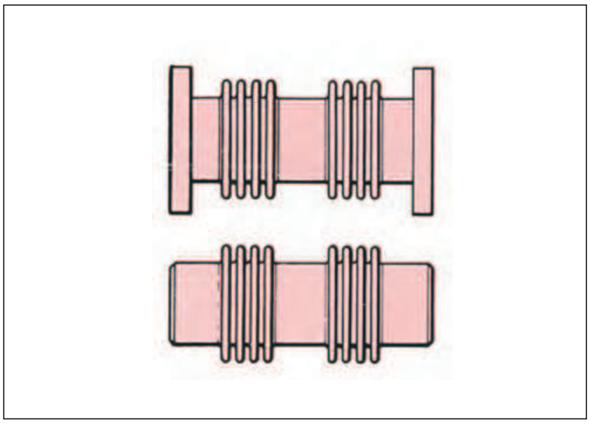
As can be seen from the above diagram these units have an internal sleeve and an external shroud which makes it impossible to install them into pipework which is initially misaligned. In addition to being practical the shroud also gives the Self Guided Axial a pleasing streamlined appearance. The units are supplied at their extended length and held at this length by a small set screw. This ensures that they are at all times installed at their correct length which in turn ensures a life-time of trouble free operation. The internal sleeve gives a smooth flow of the water through the unit and the direction of flow is clearly indicated on the outer shroud. They can be supplied with end prepared for welding into pipework. Having installed the unit into the pipeline it only remains for the set screw to be removed.

EXTERNALLY PRESSURISED AXIAL BELLOWS
Code: **AE**



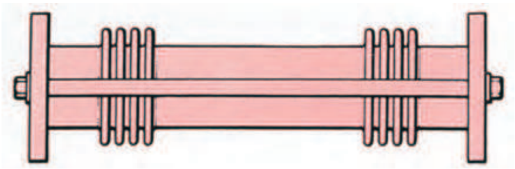
Applications where a combination of high pressure and long axial movements exist have resulted in the development the externally pressurised unit.
It can be seen that the working pressure is transferred to the outside of the bellows via a gap between the "rolled and welded" section and the pipe. The unit is completed by a purpose-made outer casing which contains the working pressure.

UNTIED DOUBLE BELLOWS
Code: **UD**



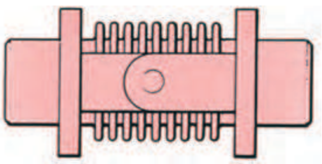
A double bellows assembly is formed by connecting two bellows with a length of centre pipe. This type of unit will cater for both axial and lateral movements.
Although a conventional axial bellows will offer a limited amount of lateral movement it is usually advisable for a double unit to be used if the amount of lateral movement required is significant or there is a limitation to the amount of lateral forces which can be applied to the connecting pipework. This type of unit is ideal for some exhaust applications or where there are combination movements in low pressure applications.

TIED DOUBLE BELLOWS
Code: **TD** (two bar), **TM** (multi bar)



For higher pressure applications where there is a limitation to the forces that connecting pipework can accommodate, double units are restrained against the opening-out effect due to pressure and load by the use of tie bars. These are designed to contain the pressure end load within the unit length and do not transmit this load to the adjacent pipework.
The tie bars are connected to the restraining flanges through spherical washers which allow for movement between the tie bars and the flanges during operation. This type of unit can accommodate large movements in the lateral plane and can operate in any direction. Provided there are no more than two tie bars, they can also accommodate angulation movements of the flanges. The amount of lateral movement is dependent upon the unit's length.

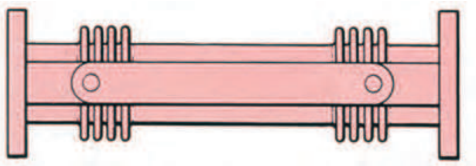
SINGLE HINGED BELLOWS
Code: **HS**



Hinged units offer movements in one plane only and operate by angulating the bellows. The pressure end load is contained by the hinged parts and therefore this type of assembly is ideal where is not practical to install robust guiding or strong anchors.

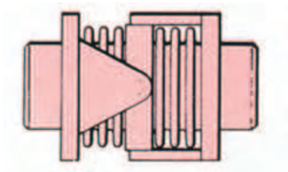
Single Hinged Bellows are usually used in pairs to give lateral movement in any plane.

DOUBLE HINGED BELLOWS
Code: **HD**



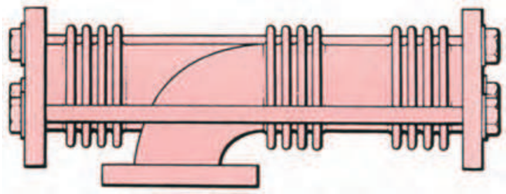
Double Hinged Bellows are basically two Single Hinged Bellows combined into one unit with a common tie bar joining the two extremities. Therefore, any expansion of the centre pipe within the limits of the tie bar will simply compress the bellows, and will not exert movements on the adjoining pipework. This type of unit allows for lateral movement in one plane only.

GIMBAL BELLOWS
Code: **GS**



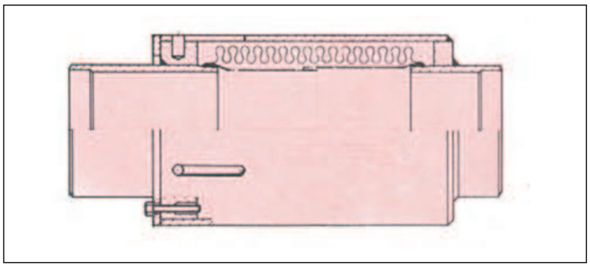
Gimbal Bellows are designed to allow angular rotation in any plane using two pairs of hinges fixed to a common floating gimbal ring. The gimbal ring and hinged parts are designed to restrain the end thrust of the expansion joint due to internal pressure and any external forces which are imposed on the joint. As in the case of Single Hinged Bellows, Gimbal Bellows are usually used in pairs to give lateral movements in any plane.

PRESSURE BALANCED BELLOWS
Code: **PB**



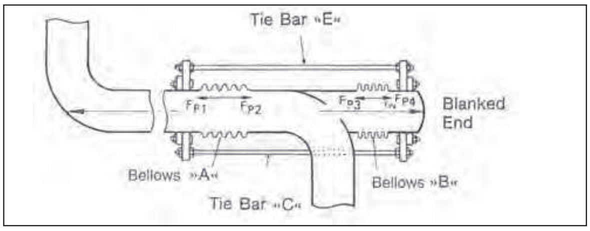
One of the major problems to overcome when using expansion bellows with a combination of large diameters and high pressure is that these units must be adequately guided and anchored. There are, however, certain conditions where it is not practical to install anchors; e. g. on a plant where space is at a premium, and also where equipment such as pumps, turbines or valve connections has a limitation to the forces which may be exerted on flanges (which are very often integral castings of the plant casting). Also, when movements of the pipework and plant are in more than one plane, this can prove to be a major problem.

This problem of pressure and loads can be overcome by the use of pressure balanced bellows units. There are a variety of arrangements but in every case the object is to eliminate the effect of pressure and loads by arranging bellows so that two pressure end loads-which are equal but act in opposite directions-cancel each other out, which results in the plant only having to accommodate the values of spring rates. Theses are relatively small when compared with pressure end loads and are usually within loading limitations.



MAX-COMP BELLOWS

Code: **MC**



One of the most commonly used pressure balance bellows is shown in the diagram.
In this case the effects of line pressure is balanced by allowing the pressure to pass, via a hole in the back of the bend, into a sealed outboard section of the same effective area as the line. By tying the unit over the extremities of the bellows, balance is obtained. When one bellows is compressed due to axial movement of the pipework, so the other is extended by the same amount due to the pressure end load acting on the blank end plate. The tie bar is always in contact with the support flanges, and therefore at all time the pressure and load is contained within the unit itself.
In addition it is possible to have pressure balanced units suitable for axial movement only. Also, where it is not convenient to have a bend or elbow in the pipeline, special units can be designed which are not part of our standard range.

"Max Comp" bellows are designed particularly for use in polyurethane pre-insulated main pipeworks. The unit is a fully enclosed and protected expansion device which can be easily installed into pipework, without the usual need to cold-pull or extend the bellows

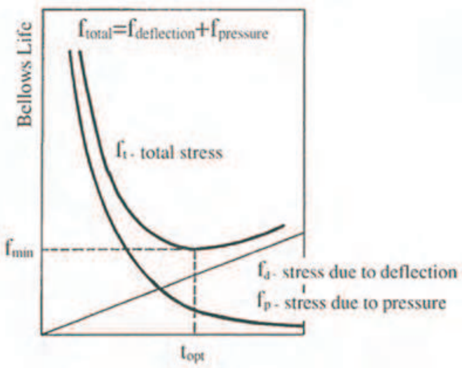


Fig. A Bellows Material Thicknes Per Ply

CYCLIC LIFE

Cyclic life, which is the anticipated number of complete expansions and contractions that a given bellows can accommodate in its working life, is a most important consideration in bellows design. It is associated with obtaining the correct balance between the pressure containing characteristics and the movement. Fig. A shows how these two features are optimised.
The optimum design finds expression in the thickness of the bellows element, the number of plies and the shape of the convolution, together with their number.
Certain known constraints are also made in respect of temperature.
As a result of extensive tests it has built up a series of life curves which relate the above features. An example of these is shown in Fig. B and from this bellows performance under different conditions can be predicted.
As can be seen from the relationship between stress and cycle life, we obtain a graph (Fig. B) showing an increase in cycle life due to reduced movement and also a reduced movement due to increase in temperature.

Fig. B Cyc ... ature

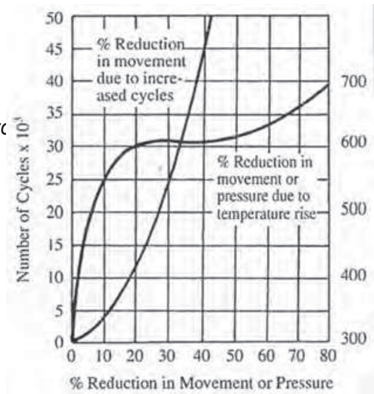
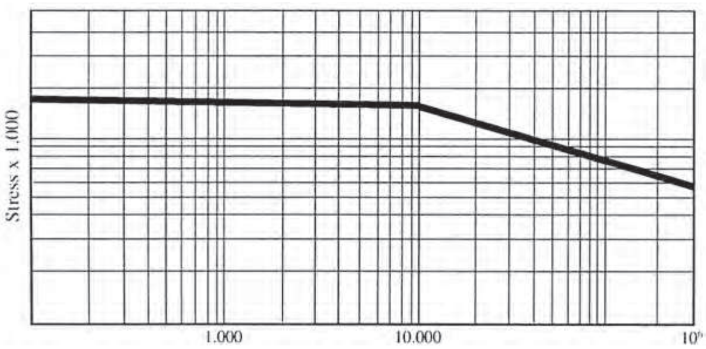


Fig. B Cycle life related to movement and temperature



No. of Cycles

Fig. C Relationship between stress and material thickness

Aplication of mount-demount expansion joints are joining of phase and valve elements in pipe-lines. If necessery, a simple demounting and lateral mounting is easily done.
In our standard manufactures program we have diameters from NB 150 up to NB 1000, for pressures 10, 16, 25 and 40 bar. On special request other diameters from NB 15 up to NB 5000 can be done.

Working media: Crude, drinking, sea and waste water, oil and oil derivates.

Materials:
- Convolution:
  DIN 17441 W. Nr. 1.4541 (EN-Norm 10088)
- "Insert" (Type B):
  DIN 17441 W. Nr. 1.4541 (EN-Norm 10088)
- Flange
  DIN 17155 W. Nr. 1.0038 (EN-Norm 10088)

Anticorosive protection:
- Screws and nuts galvanized by zink,

TYPE A:
- For drinking water colour with certificate for drinking water,
- For other media primary colour or as a customer request,

TYPE B:
- Flanges colored by primary colour or as a customer request.

Ordering data:
- Nominal pressure (NP)
- Nominal diameter (NO)
- Type A or. B.

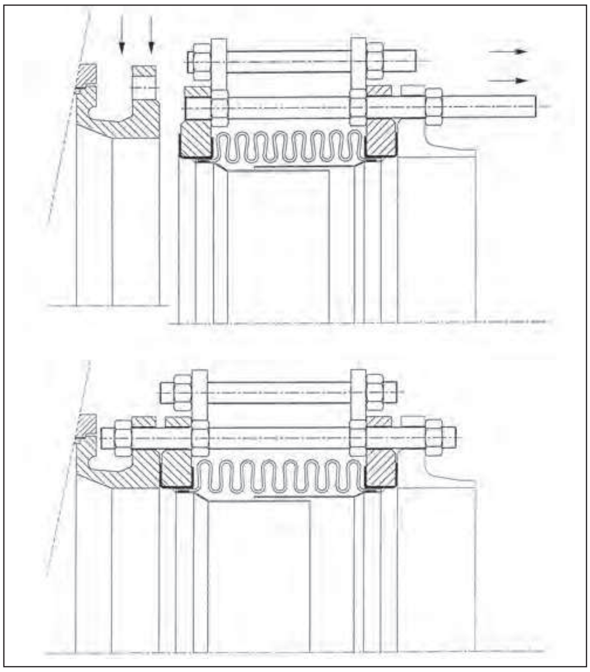


Fig. 6. Aplication of mount-demount expansion joints

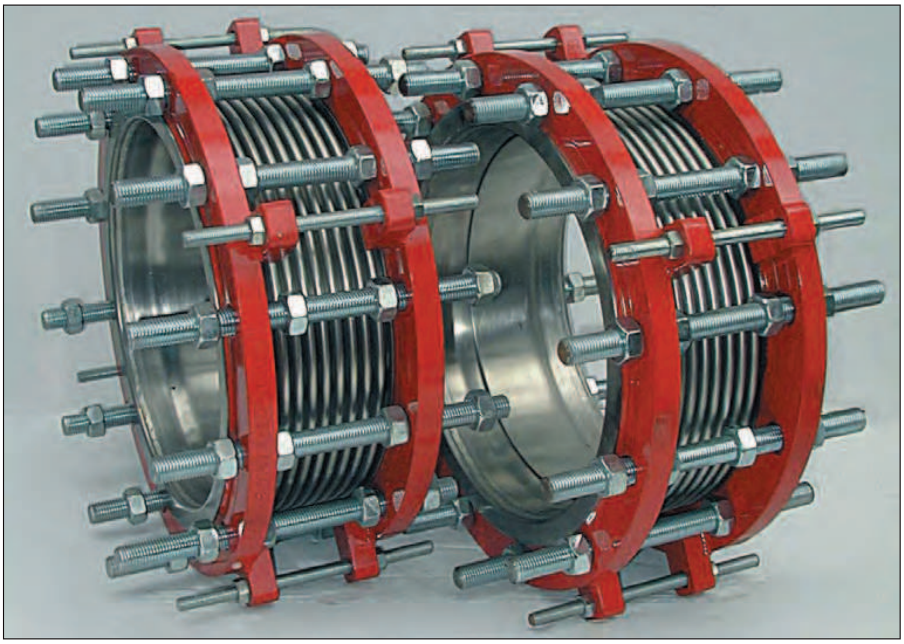


Fig.5. Mount-demount expansion joints, Type B

BELLOWS MANUFACTURE

The basic method of bellows manufacture is not complicated, and every bellows manufacturer forms his bellows convolutions in one of two ways: either by mechanical forming, or by hydraulic forming. The principle is the same for both. First of all a sheet of suitable material (usually stainless steel) is selected to withstand the pressures and temperatures specified and which will resist the known corrosive influences. This sheet is then cut, rolled to pipe size and welded longitudinally.

The quality of the butt weld stock sheet into cylinders prior to convolution forming is of paramount importance to bellows life. Recognising this, we have developed our own automatic welding machines which are an engineering achievement in our own right.

These machines produce a weld which is as strong as the parent metal, but does not thicken the material. Absence of either factor could seriously affect bellows life.

The next stage is to form convolutions. This can be done either by roll-forming the convolutions between external and internal wheels, or by forcing the tube radially under hydraulic pressure into required convolution profile.

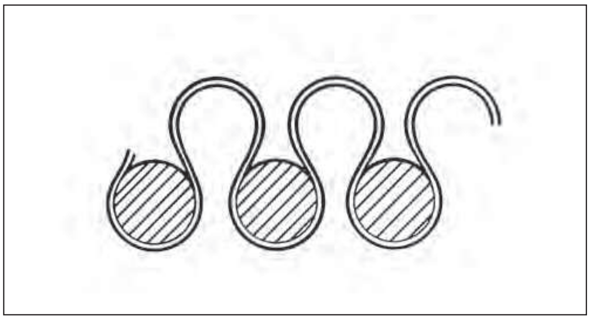


Fig. 7. Bellows convolutions with reinforcing rings

These can have reinforcing rings fitted into the convolution roots depending on pressure resistance and movement requirements. An example is show in Fig. 7.

An important development in the design of bellows was the introduction of more than one ply of metal in each construction. It was discovered that by making bellows plies of thin-gauge metal rather than from one sheet of thicker gauge stock, flexibility and stress loading through movement could be extended further up the pressure range. Multi-ply bellows are a standard feature of our designs. Fig.8.

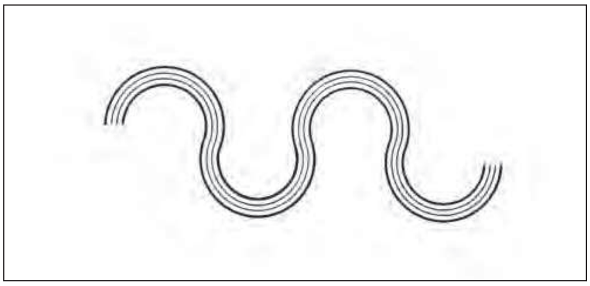
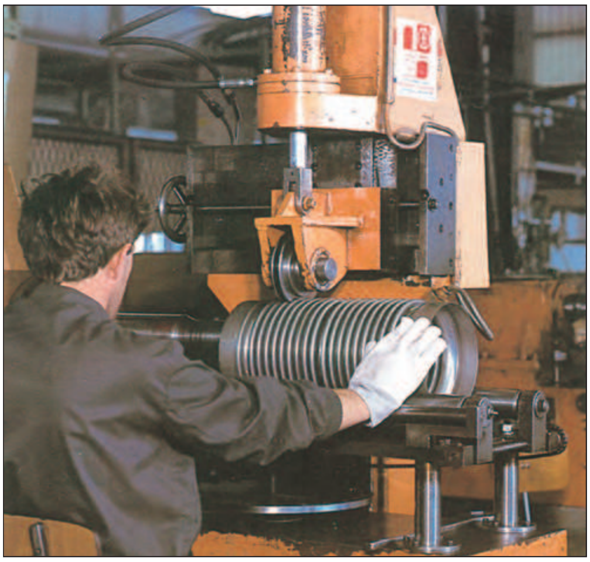


Fig. 8. Multy-ply bellows



QUALITY ASSURANCE

Quality Assurance is very important point in expansion joint production and is achived throught total project, technology manufacture and test procedure.
Maintenance and quality assurance system is realised in according with factory's quality assurance programme based at ISO 9001: 94.

Fig. 7. Lloyd Register Inspection

1994 LRQA London approved Programe and application of Quality Assurance programe and issued ISO 9001 certificate.
For system continuing the following activities are performed:
- Internal audits (internal auditors have LR's certificates),
- Review of the system is done every 6 months by LRQA (London, Köln).

Fig. 8. Fatigue test of expansion joint

Fig. 9. Microstructure of material examination

DESTRUCTIVE TESTING

Equipment for destructive testing in our lab includes the following:

a) Fatigue test
b) Burnst test
c) Examination of mechanical properties of material and welds (tensile strenght, elongation, impact, yield point)
d) Examination of chemical composition – spectrofotometer
e) Metalographic microscope with equipment for photography (x 800)
f) Lab examination of base materials, welds
g) Examination of spring rate

Fig. 10. Radiographic weld control

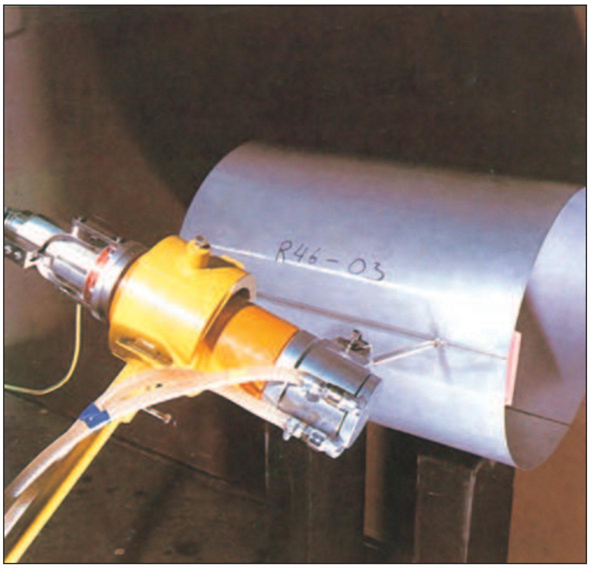


Fig. 11 Radiographic thin-wall pipe control

Fig. 12. Examination of chemical structure of material

Fig. 13. Examination of mechanical properties

NDT – NON DESTRUCTIVE TESTING

Equipment for NDT includes the following:

a) Radiography
b) Penetrants examination
c) Ultrasonic examination
d) Magnetic particle testing
e) Hydraulic and pneumatic pressure testi

Fig. 14. Hydraulic testing

TYPE APPROVALS

Every 4th year type approvals in presence of classification societies representatives is carried out:

- Lloyd's Register of Shipping – London, Zagreb Office
- Bureau Veritas – Paris, Rijeka Office
- Det Norske Veritas – Pula Office
- Croatian Register of Shipping – Split
- RWTÜV
- ABS

According to those examination we realise type approvals with which we prove constant level of quality.
Besides type approvals our customers can ask for inspection or classification society for each special order.

Fig. 15. Type Approval Certificates

SPECIAL APPLICATIONS

HEAT EXCHANGERS AND CONDENSERS

Axial bellows are used to cater for the differential expansion between tubes and shell in fixed head and floating head heat exchangers. In the case of the fixed head type, the bellows are designed for shell side conditions. With floating head heat exchangers the bellows are designed for shell and tube side conditions independently.

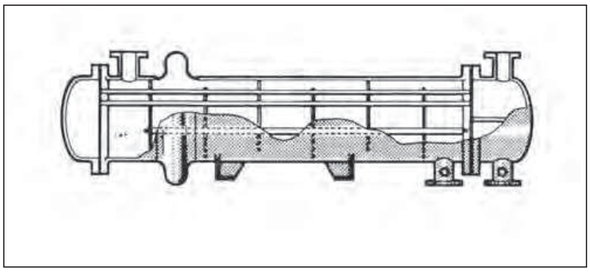


Fig. 18. Fixed head heat exchanger

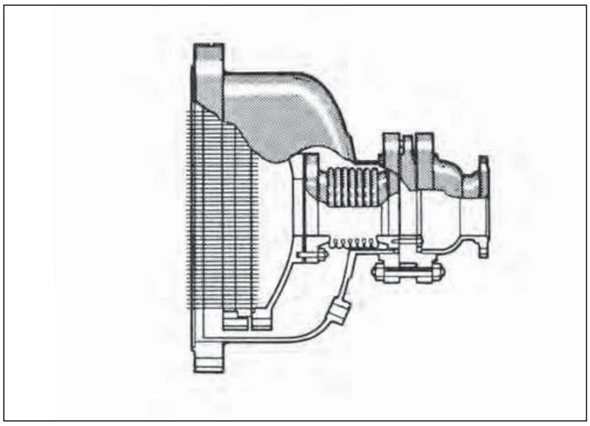


Fig. 19. Floating head heat exchanger

SHIP DECK SERVICES AND PRODUCT LINES

For this application, in the majority of cases axial bellows are used to provide expansion compensation for pipelines providing the following services on tankers and bulkcarriers: steam, condensate, deck wash, fire fighting foam, hot and cold tank washing, compressed air, and on liquefied natural gas (LNG) tankers, product suction and discharge. In this application the bellows have not only to be designed to cater for thermal expansion of the pipe runs but also for any additional movement due to hagging and sagging of ship generally specified in terms of extension and compression for an infinite cycle life under varying service conditions. Also in this application, because of the effects of corrosion precipitated by salt water spraying onto the outer surface of the bellows, care should be taken in the selection of bellows material.

BELLOWS - VALVE'S SEALS

In this application, a bellows seal is used in place of conventional packing where the seal must be absolutely leak-proof; for example, in nuclear installations. The necessary movement is taken up in the convolutions of the bellows.

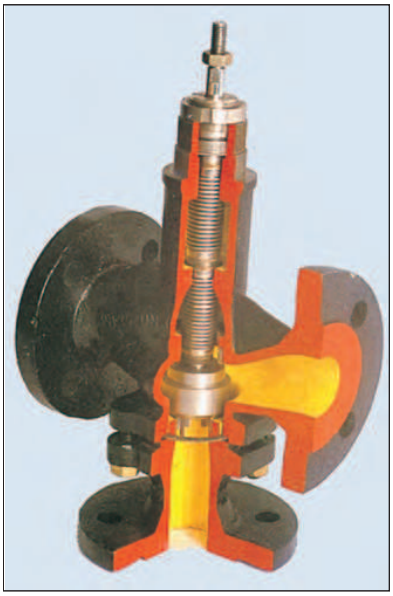


Fig. 20. Bellows - valves seal

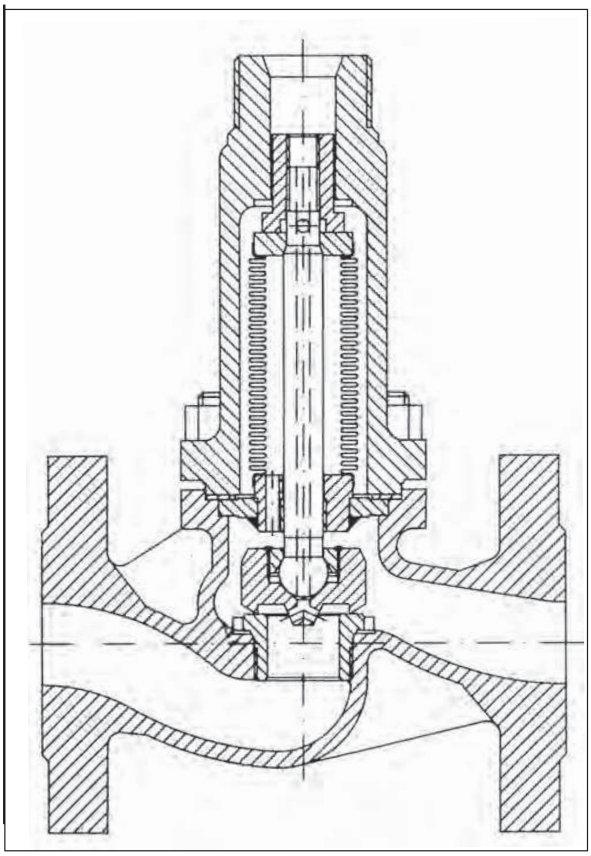


Fig. 21. Bellows - valves seal

RECTANGULAR BELLOWS (PK)

Rectangular bellows (PK) are not standardised in our data sheet and therefore they are manufactured according to a special enquire.

The biggest dimensions are limited only by transport possibilities, however this problem can be solved making the rectangular bellows at the site.

Rectangular bellows are made of convolutions which height is 70 mm and thickness approximately 1 mm.

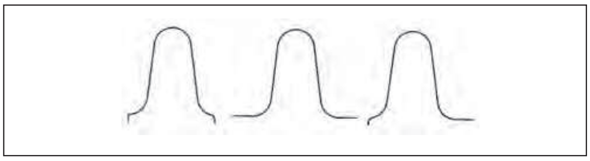


Fig. 22. Possible forms of convolution

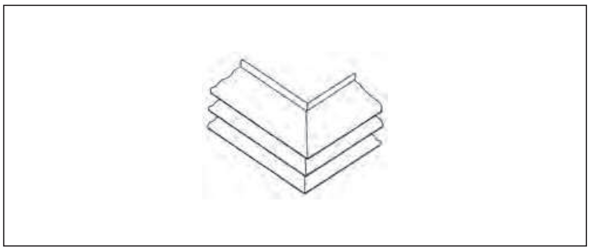


Fig. 23. Single miter corner

One convolution can absorb total axial movement of 15 mm with 1000 cycles guarantee.

The bellows have a single corner which is the most common in practice.

Rectangular bellows are available in systems where working pressure is not high for absorbing thermal expansion and vibration of pipe.

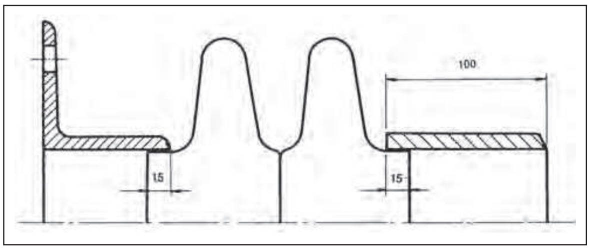


Fig. 24. Longitudinal cross-section of rectangular bellows

Fig. 25. Mounting of rectangular expansion joint

Fig. 26. Visual inspection of rectangular bellows

How to make code formes

PK L_L/L_S/b_V/P/x

L_L	- mean length of long side (inside length) (mm)	
Ls	- mean length of short side (inside length) (mm)	
b_V	- number of convolutions	
p	- connection:	LP - L - profile
		CN - pipe ends
x	- accessories:	0 - no accessories required
		1 - accessories required

Example 12:

L_L = 3000 mm
L_S = 2000 mm
b_V = 2
p = L profile
x = no accessories required

PK 3000/2000/2/LP/0

VOLUMETRIC DISPLACEMENT

When fluid is contained within a sealed chamber, expansion must be allowed for. One of the simplest yet most satisfactory methods is to incorporate a bellows in the structure of the container to take up changes in volume by expansion and contraction. A typical application is oil-filled electrical equipment.

BULKHEAD SEALS

A typical example of this application is that of a rotating shaft passing through a wall; each side of which must be totally sealed from the other. This bellows application is similar to that of the rotary shaft seal. Also, as is shown below, bellows can be used where pipes pass through walls or bulkheads; e.g. between compartments on a ship. Fig. 27.

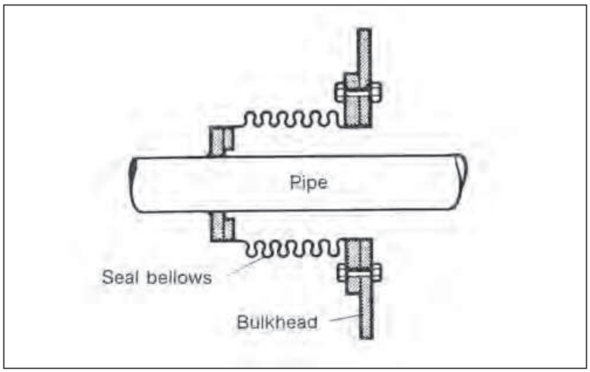


Fig. 27. Bulkhead seals

Fig. 28. Bellows for exhaust gay system of airplane engine

MATERIAL SELECTIONS

For the large majority of applications involving thin wall bellows, the question: Which type of material shall I select? Is readily answered. The 18/9 titanium stabilised (BS 1449: Part 2:83 321931) type of stainless steel is perfectly adequate for almost every expansion situation, and it is only in exceptional circumstances that an alternative need be considered.

However, where exceptions do occur they must never be overlooked, as the effects of both media and external environmental conditions can cause a bellows unit to fail in operation if the material is not sufficiently resistant.

The following notes refer to the most common service conditions where care in the selection of bellows material must be exercised.

STEAM

For the majority of steam applications the use of 18/8 stainless steel gives satisfactory service life. In some applications Chlorides may be present in such quantity that there is risk of failure of stainless steel bellows due to stress corrosion. Similarly, in some high temperature steam services, where conditions are highly alkaline, there may be risk of failure due to Caustic stress corrosion. In these cases the use of Incoloy 825 or other high Nickel alloy may be necessary.

MARINE SERVICES

The 17/11/2,25 Mo (Bs.1449.316S31) stainless steel has been shown to give satisfactory service in general marine use, including pipelines carrying sea water (for example tankwashing aboard oil tankers), where pipework is exposed to sea water spray, and in general where temperatures do not exceed 80 ºC. However, under ambient conditions, where for example crude oil or sea water remains static in the convolutions for prolonged periods. Type 316 material may sometimes fail. Also, where the pipe-work operates at temperatures in excess of 80 ºC - for example steam services - and where there is prolonged contact with sea water either inside or outside the bellows, there could be used Incoloy 825 material.

CRUDE OIL LINES

For pipelines carrying crude oil-for example, discharge and suction lines to crude oil storage tanks - consideration must be given to the Sulphur or seawater content in the oil. In many cases, where the oil is reasonably pure, Type 316 stainless steel will give satisfactory service, but if the above impurities are present, Incoloy 825 provides better resistance towards pitting corrosion and is to be preferred.

FLUE GASES

Where flue gases contain such constituents as Sulphur Dioxide-for example, from boilers burning oil containing Sulphur - problems can arise if the temperature falls bellow the Sulphuric Acid dew point, and lagging should be used to prevent this where possible. If there is any uncertainty on this point it is preferable to use Incoloy 825.

DIESEL ENGINE EXHAUST MANIFOLDS

Generally 18/9 Ti stainless steel is perfectly satisfactory, but where oils have a high Sulphur content or where very high temperatures are present, alternative materials should be considered.

HYDROCARBON LINES

Stainless steel is satisfactory for many Hydrocarbon lines, for some of the more arduous applications it is sometimes necessary to use an appropriate high Nickel alloy such as Incoloy 825.

OTHER APPLICATIONS

There are very few companies in the world which can rival Đuro Đaković Kompenzatori d.o.o. experience of different bellows materials used for different applications, and advice on new or problematical applications is freely available from Đuro Đaković Kompenzatori metallurgical staff.

END FITTINGS

It is often the case that bellows manufactured from one material need to be welded to end fittings of another material. Đuro Đaković Kompenzatori d.o.o. have evolved techniques for producing welds of the necessary high quality, and many years of service experience have proved that these welds are fully reliable.

Table 2
Comparative material table

DIN			USA	
HRN	W. Nr.	Short mark	ASTM	AISI
Č 0361	1.0038	RSt. 37-2	A570 Gr.36	
Č 1202	1.0345	H I	A515 Gr.65,55 A516 Gr. 65,55 A414 Gr.C	
Č 1204	1.0425	H II	A 515 Gr.60	
Č 1214	1.0305	St. 35-8		
Č 1330		C 22		
Č 7100	1.5415	15 Mo3	A 204 Gr.A	
Č 4580	1.4301	x5CrNi1810		304 L
Č 4571	1.4306	x2CrNi1911		304 L
Č 4572	1.4541	x6CrNiTi18.10		321
Č 4573	1.4401	x5CrNiMo17.12.2		316
Č 4573	1.4404	x2CrNiMo18143		316 L
Č 4574	1.4571	x6CrNiMoTi17.12.2		316 Ti
	2.4360	NiCu30Fe MONEL 400	B 127 B164-165	
	2.4816	NiCr15Fe INCONEL 600	B 163 B 166-168	
	2.4856	NiCr22Mo9Nb INCONEL 625	B 443,B 44 B 446	
	1.4876	x10NiCrAlTi3220 INCOLOY 800 INCOLOY 800H	B 163 B 407-409 B 514, 515 B 564	
	2.4858	NiCr21Mo INCOLOY 825	B 163 B 423-425	

A Guide To Bellows Material Selection

AMERICAN STD:	GERMAN STD./B.S.	HRN	Manufacturing feasibility and availability
1. ASTM A 240 Gr. 321	W. Nr. 1.4541/321 S31	Č.4572	Standard material for convolution and manufacture; adequate corrosion and mechanical properties at ambient and elevated temperatures for over 90% of all bellows applications. Standard units held in stock have convolutions in this grade of material.
2. ASTM A 240 Gr. 316Ti	W. Nr. 1.4571/320S31	Č.4574	Improved corrosion resistance as compared to 321S31, especially with regard to pitting corrosion. Specified where 321S31 is inadequate but where conditions are not sufficiently severe to require the use of more expensive materials, such as high Nickel alloys. Typical uses include high Sulphur crude oils, brackish waters, flue gases, good processing and numerous applications in chemical and petrochemical processing.
3. ASTM A 240 Gr. 304	W. N r. 14301/304S 1 1	Č.4580	Bellows can be supplied in this unstabilised grade where specially required but it is our normal practice to offer 321S31 as a superior alternative material where this grade is requested.
4. ASTM A 240 G r. 31 0			This grade is sometimes requested for special Purposed. Because of difficulty in obtaining material suitable for bellows manufacture it is our practice to offer lncoloy 800 as a superior alternative material where necessary.
5. ASTM B 424 INCOLOY 825	W. Nr. 24858		A very useful high Nickel alloy having good corrosion resistance towards a variety of media, and excellent resistance to Chloride and Caustic stress corrosion. Applications include steam service when the highest degree of reliability is required, and cases where Type 316S11 stainless steel may be inadequate, for example dewpoint conditions in flue gas service, static or contaminated sea water, and sulphuric and phosphoric acids. Đuro Đaković Kompenzatori maintain a substantial stock of this alloy for bellows manufacture.
6. ASTK4 B 409 INCOLOY 800	W. Nr. 1.4876		Bellows can be supplied in this material when its good corrosion resistance and high temperature properties are required to meet service conditions. The similar alloy 'Incoloy 800 can also be supplied for special service conditions at high temperatures 'Incoloy 800 is preferred to Type 310 Stainless Steel for bellows manufacture.
7. ASTM B 168 INCONEL 600	W. Nr. 2.4816		Bellow can be manufactured from this material when required. The alloy combines good general corrosion resistance with virtual immunity to Chloride stress corrosion and also has good high temperature strength and oxidation resistance. For high temperature service where corrosion resistance is not a requirement. Nimonic 75 is often preferable because of its superior mechanical properties.
8. ASTM B 127 MONEL 400	W. Nr. 2.4360		This Nickel-Copper alloy finds limited use for bellows manufacture in some specialised applications; for example, Chlorine service, and bellows can be supplied when required. However, the manufacture of small diameter bellows would be uneconomic, and we advise that an alternative material should be used where the service conditions permit.
9. HASTELOY B2	W. Nr. 2.4617		This Nickel-Molybdenum alloy possesses outstanding resistance to Hydrochloric Acid, and is also resistant to Hydrogen Chloride gas and Sulphuric Acetic and Phosphoric acids. Bellows can be supplied when required, subject to the availability of sheet material.
10. ASTM B 443 INCONEL 625	W. Nr. 2.4856		One of the more recent Nickel-Chrome Molybdenum alloys combining good high variety of corrosive environments.

INSTRUCTION FOR THE INSTALLATION AND INSPECTION OF BELLOWS EXPANSION JOINTS

INSTALLATION

The necessary steps for the installation of all expansion joints should be pre-planned. The installers shall be made aware of these steps. It is important that the joints are installed at the correct lengths and should not be extended or compressed to make-up deficiencies in pipe length, or offset to accommodate piping which has not been properly aligned. Any precompression or pre-extension of the joint should not be neglected if this has been specified.

The most critical phases of the installation are as follows:

a) Carried should be taken to prevent damage to the thin wall bellows section, such as dents, scores, arc strikes and weld spatter.
b) No movement of the joint due to pipe misalignment, for example, shall be imposed which has not been anticipated. If such movements are imposed, this can result in damage to the bellows or other components. Specifically the fatigue life can be substantially reduced, forces imposed on adjacent equipment may exceed their design limits, internal sleeve clearance may be adversely affected, and the pressure capacity and stability of the bellows may be reduced.
c) Anchors, guide and pipe supports shall be installed in strict accordance with the piping system drawings. Any field variations may affect proper functioning of the joint and must be brought to the attention of a competent design authority.
d) The joint, if provided with internal sleeves, shall be installed with the proper orientation with respect to flow direction.
e) Once the anchors or other fixed points are installed and the piping is properly supported and guided, shipping devices should normally be removed in order to allow the joint to compensate for changes in ambient temperature during the remainder of the construction phase.

POST INSTALLATION INSPECTION PRIOR TO SYSTEM PRESSURE TEST

Careful inspection of the entire system shall be made with particular emphasis on the following:

a) Are the anchors, guides and supports installed in accordance with the system drawing?
b) Is the proper joint installed in the proper location?
c) Are the joints flow direction and pre-positioning correct?
d) Have all shipping devices been removed?
e) If the system has been designed for gas, and it is to be tested with water, has provision been made for the support of the additional dead weight load? Some of the water may remain after test. If this is detrimental to the joint or the system, this should be removed before commissioning.
f) Are all guides and supports free to permit pipe movement?
g) Has any joint been damaged during handling or installation?
h) Is any joint misaligned?
i) Is the bellows and other moveable parts of the joint, free from foreign material?

INSPECTION DURING AND IMMEDIATELY AFTER SYSTEM PRESSURE TESTS.

WARNING: Extreme care must be taken while inspecting any pressurised system or components. A visual inspection of the system shall include checking the following:

a) Evidence of leakage or loss of pressure.
b) Distortion or yielding of anchors, joint hardware, bellows element and other piping components.
c) Any unanticipated movement of the system due to pressure.
d) Any evidence of instability (squirm) in the bellows.
e) The guides, joints and other moveable parts shall be inspected for binding.
f) Any evidence of abnormality or damage shall be reviewed and evaluated by a competent design authority.

PERIODIC SERVICE INSPECTIONS

a) Immediately after placing the system in operation, a visual inspection shall be carried out to ensure that the thermal expansion is being absorbed by the joints in the manner for which they were designed.

b) The bellows shall be inspected for evidence of unanticipated vibration.

c) A programme of periodic inspection shall be planned and conducted throughout the operating life of the system. These inspections shall include examination for evidence of external corrosion, loosening of threaded fastenings and deterioration of anchor guides and supports.

This inspection programme, without other information, cannot give evidence of fatigue, stress corrosion or general internal corrosion.

SYSTEMS OPERATION

A record should be maintained of change of system operating conditions (such as pressure, temperature, cycling, etc.) and piping modifications. Any such change shall be reviewed by a competent design authority to determine its effect on the performance of the joint, anchors, guides and pipework supports.

Table 3
Thermal expansion of pipe

TEMPERATURE		Cr-Mo (up to 3% Cr)mm/m	Cr-Mo (5-9%) mm/m	STAINLESS STEEL 18/8 mm/m	COPPER mm/m
°C	°F				
-100	-148	-1,04	-0,96	-1,60	-1,57
-90	-130	-0,93	-0,87	-1,43	-1,42
-80	-112	-0,83	-0,78	-1,27	-1,27
-70	-94	-0,72	-0,69	-1,10	-1,12
-60	-76	-0,61	-0,59	-0,93	-0,96
-50	-58	-0,51	-0,50	-0,76	-0,81
-40	-40	-0,41	-0,41	-0,61	-0,65
-30	-22	-0,30	-0,30	-0,45	-0,49
-20	-4	-0,20	-0,20	-0,30	-0,32
-10	14	-0,10	-0,10	-0,15	-0,16
0	32	0	0	0	0
10	50	0,10	0,10	0,15	0,16
20	68	0,20	0,20	0,30	0,33
30	86	0,32	0,31	0,47	0,50
40	104	0,43	0,41	0,65	0,67
50	122	0,55	0,51	0,82	0,84
60	140	0,66	0,61	0,99	1,01
70	158	0,78	0,72	1,16	1,19
80	176	0,89	0,82	1,33	1,36
90	194	1,01	0,92	1,50	1,53
100	212	1,13	1,04	1,67	1,70
110	230	1,24	1,16	1,83	1,86
120	248	1,36	1,28	2,00	2,02
130	266	1,48	1,40	2,16	2,19
140	284	1,60	1,52	2,33	2,35
150	302	1,72	1,64	2,49	2,52
160	320	1,86	1,76	2,67	2,70
170	338	1,99	1,88	2,85	2,88
180	356	2,13	2,00	3,04	3,06
190	374	2,27	2,12	3,22	3,25
200	392	2,41	2,24	3,40	3,43
210	410	2,54	2,36	3,58	
220	428	2,67	2,49	3,76	
230	446	2,81	2,62	3,94	
240	464	2,94	2,75	4,12	
250	482	3,07	2,87	4,29	
260	500	3,20	3,00	4,47	

TEMPERATURE		Cr-Mo (up to 3% Cr)mm/m	Cr-Mo (5-9%) mm/m	STAINLESS STEEL 18/8 mm/m	COPPER mm/m
°C	°F				
270	518	3,35	3,14	4,65	
280	536	3,50	3,28	4,83	
290	554	3,65	3,42	5,01	
300	572	3,80	3,56	5,19	
310	590	3,94	3,70	5,37	
320	608	4,09	3,83	5,56	
330	626	4,25	3,95	5,76	
340	644	4,40	4,08	5,95	
350	662	4,55	4,20	6,14	
360	680	4,71	4,32	6,34	
370	698	4,86	4,44	,53	
380	716	5,02	4,59	6,73	
390	734	5,18	4,73	6,93	
400	752	5,34	4,88	7,12	
410	770	5,51	5,03	7,32	
420	788	5,67	5,18	7,52	
430	806	5,83	5,33	7,72	
440	824	6,00	5,48	7,92	
450	842	6,17	5,63	8,13	
460	860	6,34	5,79	8,34	
470	878	6,50	5,94	8,55	
480	896	6,67	6,09	8,76	
490	914	6,84	6,23	8,96	
500	932	7,00	6,36	9,16	
510	950	7,17	6,49	9,35	
520	968	7,33	6,63	9,55	
530	986	7,50	6,76	9,75	
540	1004	7,67	6,89	9,95	
550	1022	7,83	7,05	10,16	
560	1040	8,00	7,20	10,38	
570	1058	8,17	7,35	10,60	
580	1076	8,34	7,50	10,82	
590	1094	8,50	7,66	11,04	
600	1112	8,67	7,81	11,23	
610	1130	8,83	7,96	11,41	
620	1148	8,99	8,11	11,59	
630	1166	9,15	8,26	11,76	

BELLOWS SELECTION

UNTIED BELLOWS

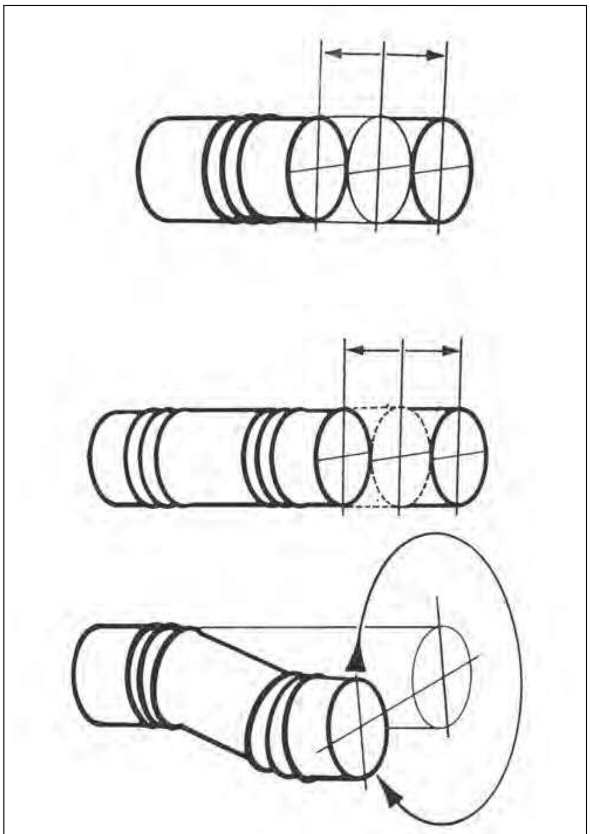


Fig. 29. Possible movements of *untied bellows*

AXIAL BELLOWS

The first alternative for compensation of movement is with axial bellows. Axial bellows have low cost per unit, but strong anchor points and pipe guides are essential.
Therefore it is necessary following the instructions, to calculate the anchor loads and consider if there were any limits (technical or economical) to make so strong anchor points. If there are, it is necessary to apply compensation with tied bellows for lateral or angular movement (See page 24.).
The most influential force which loads an anchor point is pressure thrust (working pressure x effective bellows cross-section), which means that axial bellows can be applied usually for relatively small diameters and low pressures.
Axial bellows can also be installed in front of sensitive equipment (pumps, engines, compressors) to absorb all movements, vibrations or failures during montage.

Advantages:
- easily understood solution of the compensation problem
- no change in the direction of flow
- small lateral or angular movements are possible
- useful element for stress-free connections in front of sensitive equipment, if the operating pressures are low
- minimum installation space low cost per unit

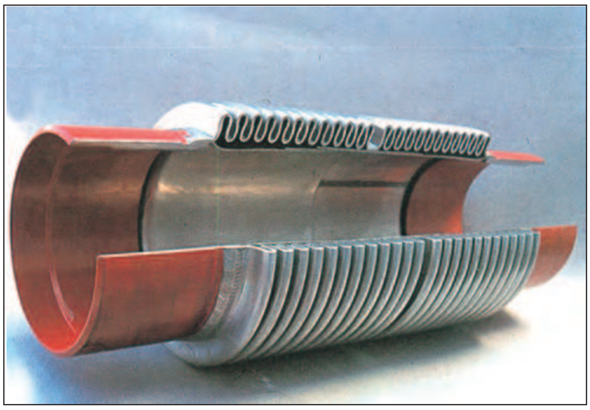


Fig. 30. Axial expansion joint

Disadvantages:
- strong anchor points, which may be technical or economical problem
- in long straight sections and for large movements it is necessary to have more than one axial bellows
- short sections which contain more elbows require a large number of anchors and each subsection has to be individually compensated

- stress-free connections in front of sensitive equipment is not guaranteed in the case of relatively higher pressures or larger diameters.

SYSTEM DESIGN PROCEDURE

When designing your axial bellows system a useful discipline is to observe the following procedure:
1. Establish the nominal pressure
2. Calculate thermal dilatation
3. Divide the pipeline installation into sub-sections and establish position of bellows
4. Establish position of anchor points and quides
5. Calculate "cold-pull" dimensions
6. Calculate forces acting on anchors

Once these six tasks have been completed you will have all the information you require to complete your design of an axial bellows system, and by referring to data sheets on axial bellows section you can select specific bellows to your requirements or can define your requirements in terms related to standard units.
1. ESTABLISH THE NOMINAL PRESSURE

For most applications, the pressure rating must be established as specified in DIN 2401.
In the table 1 on the page 2 you can find the data about temperature coefficient (t_k) for materials we commonly use.

Example 1:

Hot water, NO 150, p = 11 bar, t = 130°C

$$NP = \frac{P}{t_k}$$

P - working pressure
t_k -temperature coefficient

$$NP = \frac{11}{1} = 11$$ (round up to full nom. pressure)

NP = 16 bar

2. CALCULATE THERMAL DILATATION

The calculation of thermal dilatation (dilatation) is according to the following equation:

$\Delta_{total} = \alpha_t \cdot \Delta t \cdot L$

Δ_{total} - total thermal expansion of the pipe (mm)
Δ_t - difference between max. and min. temperature
α_t - coefficient of thermal expansion
L - length between anchors (m)

Example 2:

$t_{max} = 130$ °C, $t_{min} = -20$ °C, L = 35 m
$\Delta_t = 130 - (-20) = 150$ °C
$\Delta = 1{,}72$ mm/m
$\Delta_{total} = \Delta \cdot L = 1{,}72 \cdot 35 = 60{,}2$ mm

In the table 3 on page you can find already calculated thermal expansion of pipe for temperatures and materials we commonly use.

3. DIVIDE THE PIPELINE INSTALLATION INTO SUB SECTIONS AND ESTABLISH POSITION OF BELLOWS

Dividing the pipe work installation into sub-sections is only necessary when a single axial bellows is not enough to absorb the axial movement or if the pipework insulation has one or more elbows. A sub-section length is determined by permissible axial movement which an axial bellows can absorb.

Referring to data sheets on axial bellows section for each nominal diameter (ND) and nominal pressure (NP) you can select several movements.

In theory bellows can be positioned anywhere between two anchors, but in practice only two positions are used:

1. Near one anchor
2. At the centre between two anchors

In the first case, illustrated in Fig. 31 the axial bellows unit is positioned near an anchor point. In practice it is normally installed within roughly two pipe diameters (2 · D) of the anchor point and the quide, or max. four pipe diameters (max. 4 · D).

In the second case, illustrated in Fig. 32 the axial bellows unit is positioned at the centre of the pipe between two anchors. Therefore quides have to be positioned on both sides of the bellows unit (2 · D, or max. 4 · D) to prevent bowing. Usually we use this position of the axial bellows unit when we have a main pipework and several branch pipeworks. In this case bowing of branch pipeworks is reduced to a minimum.

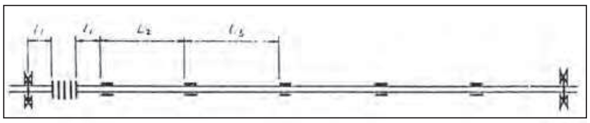


Fig. 31. Bellows positioned near an anchor

NOTE:
It is allowed to install only one axial bellows unit between two anchors points

In the case when we have several parallel pipeworks which are installed near each other, we have to know that the diameter of the bellows is larger than the diameter of the pipework. Therefore is not necessary to increase the pipeworks distance, but to move one bellows further, (Fig. 33).

If pipeworks have not the same diameter, and we desire to have common anchors and guides, the length between the axial bellows and the anchor is determined regarding to the smallest diameter, (Fig. 34).

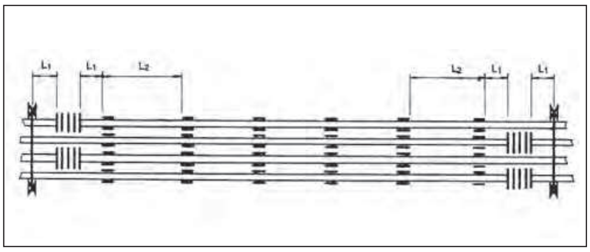


Fig. 33. Bellows positioned in case of small distance between pipelines

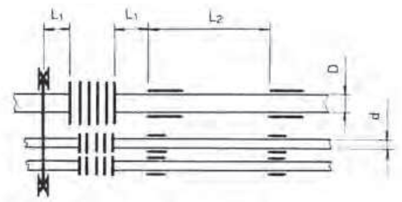


Fig. 34. Anchors and guides positioned in case of different pipe diameters

4. ESTABLISH POSITION OF ANCHOR POINTS AND GUIDES

Actually the position of the anchor points is established at the moment we have divided the pipework installation into subsections, which means that the sub-sections are separated by the anchor point.

Anchor points:
- Terminal anchor
- Deflection anchor
- Intermediate anchor
- Sliding anchor

The guiding of a pipe is most important if axial bellows units installed are to function correctly. Guides are necessary to ensure proper application of movement to the bellows and to prevent bowing or buckling of the pipework, Fig. 36. A good general rule regarding the location of guides related to expansion joints is that the first guide should be positioned within a distance of four pipe diameters (4 · D) from the expansion joint.
Our recommendation is that this distance has to be roughly two pipe diameters (2 · D). The distance between the first and the second guide must not be more than fourteen pipe diameters (max. 14 · D).The distance among the rest of the guides has to be determined by the application engineer, because there are several ways how to calculate it, (Fig. 35).

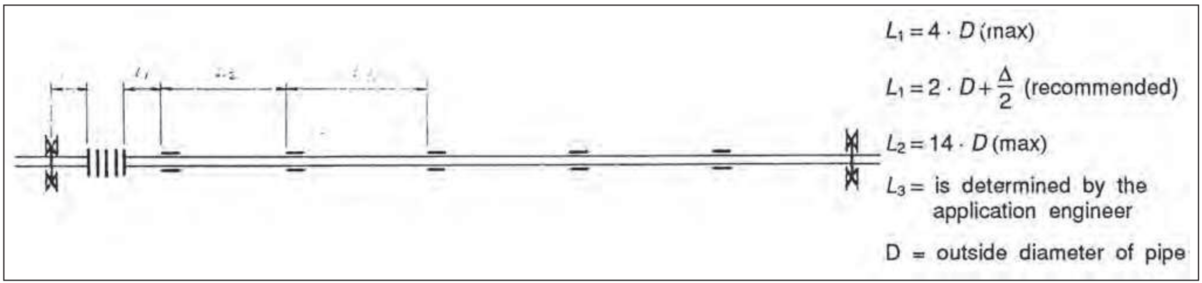


Fig. 35. Correct guides scheme at compensation with axial expansion joints

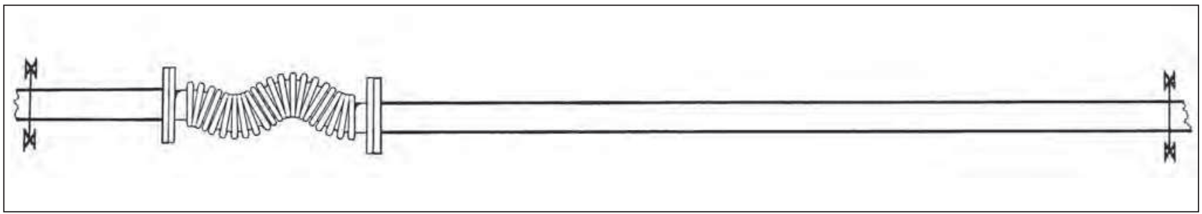


Fig. 36. Outlook of expansion joint in the case of irregular guide installation or designing of anchor points.

Example 3:

Hot water:
NO 150, p = 11 bar
t_{max} = 130 °C, t_{min} = -20 °C, L = 35 m
$L_{1max} = 4 \cdot NO = 4 \cdot 150 = 600\ mm$

$$L_{1recomm.} = 2 \cdot NO + \frac{\Delta\, total}{2} = 2 \cdot 150 + \frac{60{,}2}{2} = 330{,}1 \approx 330\ mm$$

$L_{2max} = 14 \cdot NO = 14 \cdot 150 = 2100$ mm

L_3 - is determined by the application engineer

5. CALCULATE "COLD-PULL" DIMENSIONS

Bellows movement is usually expressed as a ± figure based on a free length (Lb). This represents the equal movement in expansion and compression of which a bellows is capable. However, because it is more usual to find pipes carrying hot media than cold media (except of course in cryogenic applications), in practice bellows are usually selected for their capacity to compensate for pipe expansion. In order to make maximum use of the total movement available in any one bellows it is therefore necessary to do perform "cold-pull" (See Fig. 37).

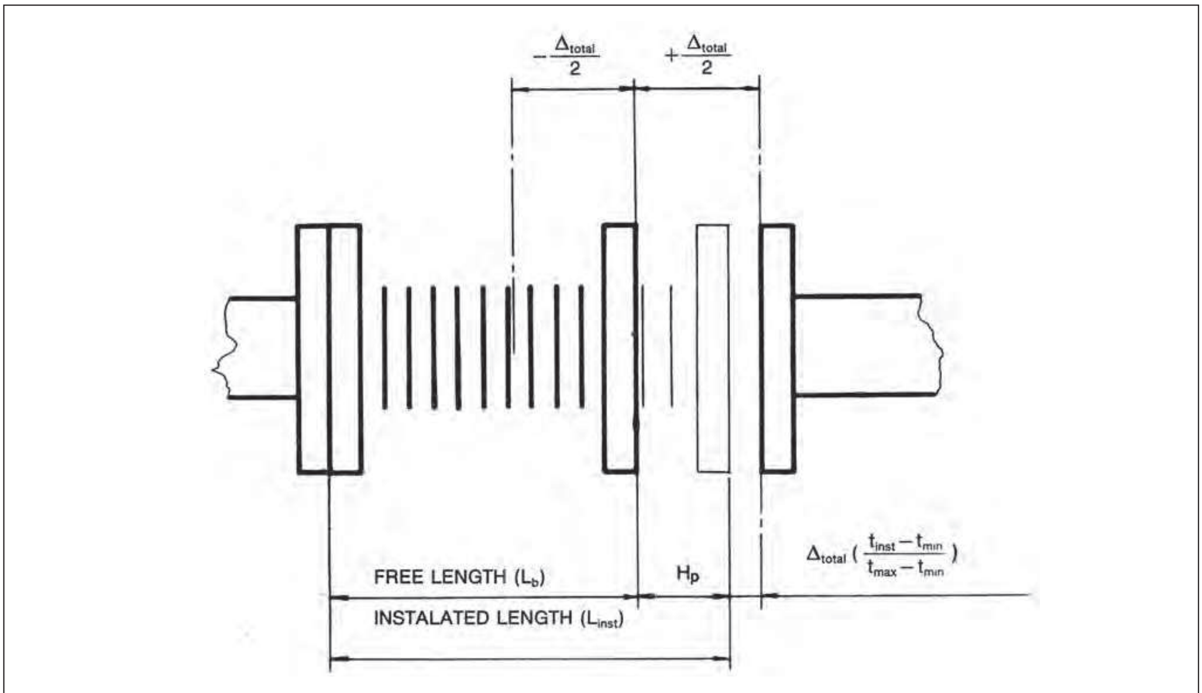


Fig. 37. Cold-pull dimension

During the installation of axial bellows it is necessary to leave a proper free space in pipework, and than axial bellows must be extended and change its free length (L_b) into installation length (L_{inst}).
The following formula is for calculation of "cold-pull":

$$H_p = \frac{\Delta_{total}}{2} - \left(\frac{t_{inst} - t_{min}}{t_{max} - t_{min}}\right) \cdot \Delta_{total} \quad \text{(mm)}$$

$L_{inst} = L_b + H_p$ (mm) - only for axial expansion joints

It is not possible to change installation length of the tied bellows. It is the most important to ensure that an axial bellows is never over-compressed at maximum operating temperature, or over-extended at minimum operating temperature.

EXTENSION:

$t_{inst} > t_{min}$ $\quad H_p = \Delta_{total} \cdot \left(0{,}5 - \frac{t_{inst} - t_{min}}{t_{max} - t_{min}}\right)$

$t_{inst} = t_{min}$ $\quad H_p = \Delta_{total} \cdot 0{,}5$

$t_{inst} < t_{min}$ $\quad H_p = \Delta_{total} \cdot \left(0{,}5 - \frac{t_{min} - t_{inst}}{t_{max} - t_{min}}\right)$

COMPRESSION:

$$H_p = \Delta_{total} \cdot \left(\frac{t_{max} - t_{inst}}{t_{max} - t_{min}} - 0{,}5\right)$$

Δ_{total} - total thermal expansion of pipe, (mm)
H_p - cold pull, (mm)
t_{max} - maximum temperature, (°C)
t_{min} - minimum temperature, (°C)
t_{inst} - installation temperature, (°C)
L_{inst} - installation length, (mm)
L_b - free length of bellows, (mm)

NOTE: A total thermal expansion of pipe must be less or equal to a total axial movement of an axial bellows unit.

$\Delta_{total} \leq (\pm)\ \Delta_b$

Example 4:

Pipeline, NO 300 mm, p = 14 bar
t_{max} = 60 °C, t_{min} = -20 °C, t_{inst} = 10 °C, L = 72 mm
$\Delta_{total} = \Delta \cdot L = 0{,}89 \cdot 72 = 64{,}08 \approx 64$ *mm*
Select the axial bellows: Data sheet, page 45

AR 16/300/70/N/1

L_b = 335 mm

$$H_p = \Delta_{total} \cdot \left(0{,}5 - \frac{t_{inst} - t_{min}}{t_{max} - t_{min}}\right)$$

$$k = 0{,}5 - \frac{10 - (-20)}{60 - (-20)} = 0{,}5 - \frac{30}{80} = 0{,}5 - 0{,}375 = 0{,}125$$

This coefficient you can use only for temperatures in this example. If these temperatures (t_{max}, t_{min}, t_{inst}) are constant simply multiply total thermal expansion (Δtotal) of each sub-sections with this coefficient (k). If the installation temperature (t_{inst}) is changeable it is necessary to calculate coefficient "k" again.

$H_p = \Delta_{total} \cdot k = 64 \cdot 0{,}125 = 8$ *mm*
$L_{inst} = L_b + H_p = 335 + 8 = 343$ *mm*

6. CALCULATE FORCES ACTING ON ANCHORS

To calculate the sum total of forces acting on any anchor in a pipe system incorporating axial bellows you must calculate the following:

1. Pressure thrust (Fp)
2. Deflection load (Fb)
3. Pipe friction (Ff)
4. Centrifugal force (Fc)

PRESSURE THRUST

Pressure thrust is the force due to internal pressure trying to extend the bellows into the pipe (See Fig. 38). This force is calculated using the following formula:

$F_p = p \cdot A \cdot 10^2$ [N]

p - operating pressure (MPa)
A - effective bellows cross section (cm^2)

$$A = \frac{d_s^2 \cdot \pi}{4}$$

d_s - mean bellows diameter

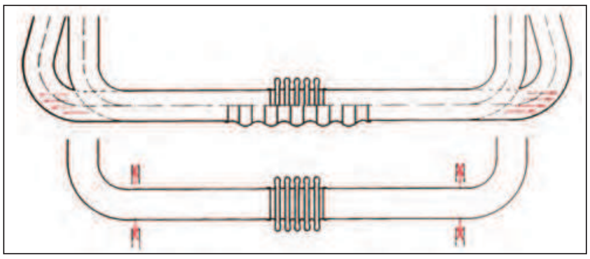


Fig. 38. Acting of pressure thrust

As is shown in Fig. 39 the effective cross section of a bellows is the mean diameter of the bellows taking the tip and the root of the convolutions as the extremes. Values for effective area are given for each unit in the data sheets.

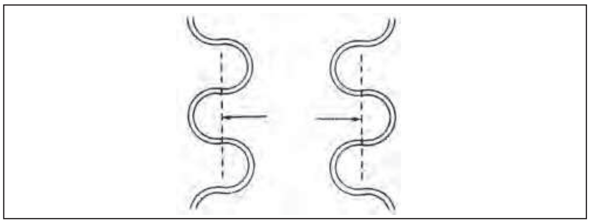


Fig. 39. Effective bellows cross section

DEFLECTION LOAD

Deflection load is due to the spring rate of the axial bellows. Values for spring rates are given for each unit in the data sheets. If you require a bellows which is not in the data sheets, all data you can find in our drawings.

This force is calculated using the following formula.

$F_k = OD \cdot \Delta_k$ [N]

OD - spring rate (N/mm)

A_k - movement (mm)

Movement is considered to be the maximum movement of which the bellows unit is capable within the design parameters of the installation, but it should be remembered that a stretched bellows (with a cold-pull allowance) is trying to pull anchors together.

PIPE FRICTION

The frictional resistance of a pipe moving over its guides can be calculated using the following formula:

$$F_t = \mu \cdot m \cdot L \cdot g \quad , \; [N]$$

- μ - coefficient of friction (in the event of this not being available the value 0.3 can be taken for the majority of installations)
- m - total mass of pipe (is the sum of pipe mass, media mass, insulation mass, and attached equipment mass) (kg/m)
- L - distance between anchor and expansion joint (m)
- g - gravity (9,81 m/s^2)

CENTRIFUGAL FORCE

In the case of anchors situated at a pipe elbow the effect of centrifugal force due to flow of media within the pipe must be considered.

This force is calculated using the following formula:

$$F_c = 2 \cdot A \cdot p \cdot v^2 \cdot \sin\frac{\alpha}{2} \cdot 10^{-4} \qquad [N]$$

A - effective bellows cross section (cm^2)

p - density of media (kg/m^3)

v - velocity of flow (m/s)

α - angle of pipe elbow

Each of these forces must be calculated for it self before summarising of the total force which act on anchor. Before you do that it is necessary to consider as follow

a) In the case of anchor situated at a pipe elbow (See Fig. 40) the total force is calculated using the following formula:

If $\alpha = 90°$

$$R = \sqrt{F_1^2 + F_2^2}$$

If $\alpha \neq 90°$

$$R = \sqrt{F_1^2 + F_2^2 + 2 \cdot F_1 \cdot F_2 \cdot \cos\alpha}$$

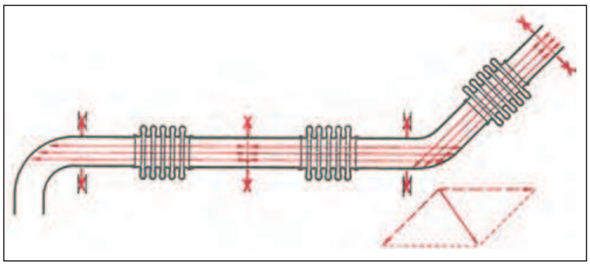


Fig. 40. Resultant force when direction of pipeline changes

b) If a long straight pipe changes its diameter the intermediate anchor situated between the axial bellows with different diameters is loaded with two different forces.

c) In the case of valve situated at a pipe one bellows under a pressure, and the other is not. Therefore the anchor between a valve and a bellows is the terminal anchor.

FORCE ON INTERMEDIATE ANCHORS

There is a limit to the amount of movement you can get out of a single axial bellows. When you are faced with an expansion problem in a straight run of a pipe which requires more movement then you can get out of one bellows, you must install additional bellows and with them additional intermediate anchor. If the pipe is the same diameter throughout its length the thrusts on intermediate anchors are balanced by the bellows on either side and in theory there is no force on the anchor once the full expansion has been taken up. It is recommended, however, that do not have the strength, rigidity and resistance to wear necessary for long term operation and therefore the force acting on intermediate anchor is a sum of deflection load and pipe friction.

SPECIAL DESIGN CONDITIONS

Except the forces acting on anchors at high above ground pipelines very important is a moment of force (See Fig 41).

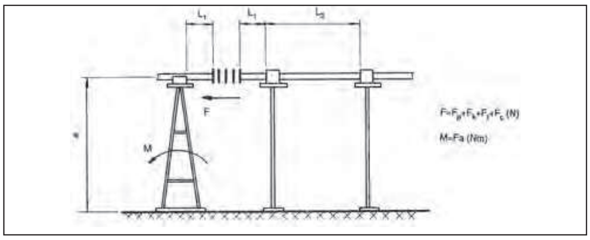


Fig. 41. Designing of anchors at high above ground pipelines

One of the ways how to decrease load an anchors is to eliminate the pressure thrust. For this reason we have made a construction of "PB" expansion joint (pressure balanced). See Fig. 42. This expansion joint is not in our standard data sheet but is always designed in accordance with special requirements.

Fig. 42. Pressure balanced expansion joint

Example 5
Pipeline
NO = 400 mm - nominal diameter
p = 1,3 MPa -working pressure
t_{max} = 165 °C - maximum temperature
t_{min} = -20 °C - minimum temperature
t_{inst} = 20 °C - installation temperature
v = 10 m/s - velocity of flow
Calculations
1. ESTABLISH THE NOMINAL PRESSURE

$$N_p = \frac{p}{t_k}$$

p = 1,3 MPa, t_k = 1

$$N_p = \frac{1{,}3}{1} = 1{,}3 \qquad N_p = 16 \ bar$$

2. CALCULATE THERMAL DILATATION
See Table 3, thermal expansion for difference between temperatures
$(t_{max} - t_{min})$ = 165 - (-20) = 185 °C   Δ = 2,20 mm/m

A) $\Delta_1 = 90 \cdot 2{,}20 =$ *198 mm*
   $\Delta_2 = 30 \cdot 2{,}20 =$ *66 mm*

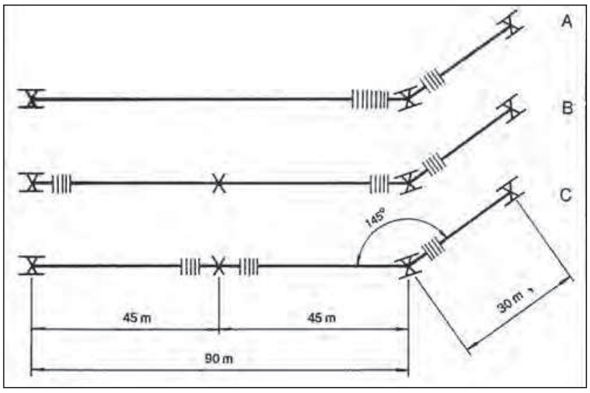
B,C) $\Delta_1 = 45 \cdot 2{,}20 =$ *99 mm (2x)*
   $\Delta_2 = 30 \cdot 2{,}20 =$ *66 mm*

3. DIVIDE THE PIPELINE INSTALLATION INTO SUB-SECTIONS AND ESTABLISH POSITION OF BELLOWS

Most of pipeline installations is possible to divide into sub-sections in several ways. An application engineer can choose a way which is the most convenient (technical and economical). In our example we offer you two solutions (1.A., 2.B.C.) The difference between solutions B and C is in different place of bellows. For required and calculated parameters it is possible to use three different movements of bellows (± 35, ± 62,5, ± 125) see page 45. The bellows are made with pipe ends:

AR 16/400170/U/1	a=1520 cm^2,	OD=607 N/mm
AR 16/400/125/U/1	a=1520 cm^2,	OD=495 N/mm
AR 1614001250/U/1	a=1520 cm^2,	OD=248 N/mm

A)
Δ_1 = *198 mm, choose movement (*± 125) = *250 mm*
Δ_2 = *66 mm, choose movement (*± 35) = *70 mm*



B,C)
Δ_1 = *99 mm, choose movement* (±62,5) = *125 mm*
Δ_2 = *66 mm, choose movement* (±35) = 70 mm

In case you want to have all the bellows the same, you must choose the bellows which is suitable for maximum expansion of pipe. In this case it is the unit type AR 16/400/250/U/1, and of course this is not optimum solution. As we have divided our pipeline installation into the sub-sections, it is possible to situate the bellows in several ways. In our example we offer three solutions (A, B, C).

4. ESTABLISH POSITION OF ANCHORS POINTS AND GUIDES SEE FIG. 28. AND THE EXPLANATION ON PAGE 18

5. CALCULATE COLD-PULL DIMENSIONS
$t_{inst} > t_{min}$

$$H_p = \Delta_{total} \cdot \left(0{,}5 - \frac{t_{inst} - t_{\min}}{t_{\max} - t_{\min}}\right)$$

$$k = \left(0{,}5 - \frac{20 - (-20)}{165 - (-20)}\right) = (0{,}5 - 0{,}216) = 0{,}284$$

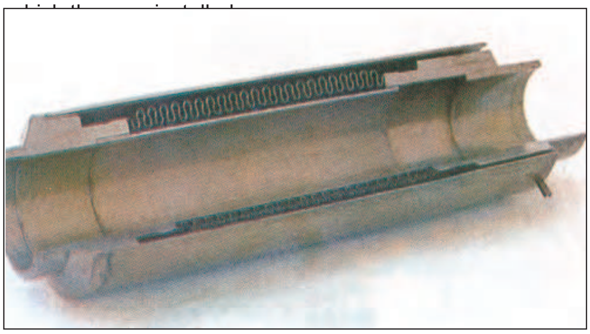
A)
$H_{p1} = \Delta_1 \cdot 0{,}284 = 198 \cdot 0{,}284 = 56{,}2 \approx 56$ mm
$H_{p2} = \Delta_2 \cdot 0{,}284 = 66 \cdot 0{,}284 = 18{,}7 \approx$ *19* mm
B,C)
$H_{p1} = \Delta_1 \cdot 0{,}284 = 99 \cdot 0{,}284 = 28{,}1 \approx 28$ mm
$H_{p2} = \Delta_2 \cdot 0{,}284 = 66 \cdot 0{,}284 = 18{,}7 \approx$ *19 mm*

6. CALCULATE FORCES ACTING ON ANCHORS

SOLUTION / ANCHOR / FORCE	A			B				C			
Pressure thrust (F_p) $F_p = p \cdot A \cdot 100$ p = 1.3 MPa, A = 1520 cm^2,	197600	118839	197600	197600	-	118839	197600	197600	-	118839	197600
Deflection load (F_b): $F_b = \frac{\Delta}{2} \cdot OD$ A) Δ_1 = 198 mm OD = 247,5 N/mm Δ_2 = 66 mm OD = 607 N/mm B,C) Δ_1 = 99 mm OD = 495 N/mm Δ_2 = 66 mm OD = 607 N/mm	24503	14023	20031	24503	24503	14023	20031	24503	24503	14023	20031
Pipe friction $F_t = \mu \cdot m \cdot L \cdot 9{,}81$ μ = 0,3 m = 98 kg/m A) L_1 = 87 mm B,C) L_1 = 42,5 mm L_2 = 28 mm L_2 = 28 m	25092	-	8076	-	12258	-	8076	12258	-	12258	8076
Centrifugal thrust (F_c) $F_c = 2 \cdot A \cdot \rho \cdot v^2 \cdot \sin\frac{\alpha}{2} \cdot 10^{-4}$ A= 1520 cm^2 ρ = 1000 kg/m^3 v = 10 m/s α = 35°	-	9141	-	-	-	9141	-	-	-	9141	-
RESULTANT FORCES (kN)	247,2	142	225,7	222,1	36,8	142	225,7	234,4	25,4	154,3	225,7

COMPENSATORS FOR CENTRAL HEATING

ĐURO ĐAKOVIĆ - Kompenzatori d.o.o. Compensators represent a new stage in the development of bellows devices to absorb expansion in steam and hot water piping. They offer to a very high degree a combination of economy, simple installation and reliable service. By the use of high performance materials and exclusive manufacturing techniques, Đuro Đaković - Kompenzatori d.o.o. have produced a range of compensators which are maintenance free and virtually as permanent as the piping system in



A number of features contribute to the reliability of these compensators. One is the uniformity of the stainless steel bellows, made under strict quality control supervision. Another is the full length inner sleeve which directs pipe movement squarely into the bellows, preventing offset movement being applied to the bellows, thus avoiding undue stresses. This inner sleeve also provides for a smooth flow and reduces pressure drop to a minimum. A third is the robust external casing which protects the bellows and ensures that pipe movement is applied axially, this method of construction allowing them to be completely lagged without interfering with the bellows action. Đuro Đaković - Kompenzatori d.o.o. bellows expansion compensators are available with a choice of end fittings either pipe ends, flanges or threaded unions. Each individual compensator is hydraulically tested to one-and-a-half times its rated working pressure before despatch. For the actual installation it is simply necessary to fit the compensator into the pipeline and then remove an installation pin. This installation on pin holds the compensator at its optimum length for installation and also protect the bellows from torsional damage installation.

SPECIFICATION

Bellows: Made from type ASME SA 240 type 321 (DIN 17441 W. Nr. 1.4541 x 10 CrNiTi 18 9, HRN Č.4572) stainless steel. Conservatively rated for a working pressure of 1 MPa (10 bar) at 300 °C, and hydraulicaly tested to 1.5 MPa (15 bar).

Casing and other components of mild steel.

Inner sleeve: Attached at one end and quided at the other, thus preventing off-set movement being transmitted to the bellows full length sleeve for minimum internal friction. Installation pin: Holds bellows at correct length for installation. Removed after fitting, and after quides and anchors have been installed.

End fittings: Welding ends, flanges or threaded unions. Movement: Bellows expansion compensators allow axial movement of 30 mm.

INSTALLATION OF COMPENSATORS FOR CENTRAL HEATING

Anchors: The pressure thrust acting on the bellows must be absorbed by rigid anchors.

Note: Anchors must be designed to withstand test pressure being applied to the system. Main anchors should be located at branches and locations at which either the size or direction of the line changes. In addition, intermediate anchors should be used to break up straight runs to limit expansion in each section to 30 *mm.*

Guides: The compensator and attached piping must be guided axially to limit any lateral movement which would reduce the life of the bellows. Guides should be at least as long as two pipe diameters with the clearance between pipe and guide not more than 1,5 mm.

In locating guides it is recommended that the expansion compensator be located close to an anchor and that the first pipe guide be located within a distance of four pipe diameters from the compensator.

The distance between the first pipe guide and the second must be no more than fourteen pipe diameters. Spacing of subsequent guides may be determined from Fig. 44.

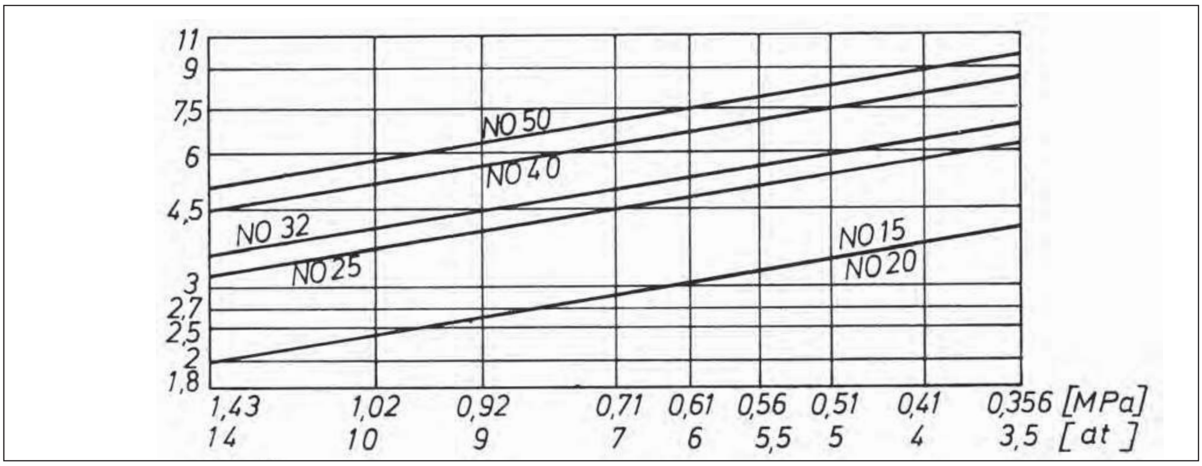


Fig. 44. Recommended distances between guides for standard steel pipelines

MAX-COMP EXPANSION JOINTS

Fig. 45. Max-comp expansion joint

RECOMMENDED PIPE ALIGNMENT GUIDE SPACING FOR STANDARD STEEL PIPES

USER ADVANTAGES

1 . The unit is supplied with pipe ends prepared for welding.
2. A robust outer cover ensures that the convolutions ar fully protected against damage in transit or on site.
3. The outer cover also acts as a guide tube in which guide ring welded to one pipe end is free to slide. This in built guide assembly prevents any lateral forces bein imposed on the convolutions.
4. Guide pins are incorporated in the guide ring which mov in linear slots machined in the outer guide cover. Thes pins act as stops and limit the travel of the expansio joint both in compression and extension. Thus is th impossible to disengage the telescopic sleeves due t over extension of the unit during installation.

5. Two Max-Comp expansion joints may be installed in straight length of pipe between two anchors without a intermediate anchor between the units. The movemer stops ensure even allocation of total pipe movemer between the Max-Comp units.

6. The guide pins also prevent torsion being applied to th convolutions during installation on site.

7. The guide pins are designed to retain the pressure en load. In the event of an anchor failure the expansion joir will simply extend to its maximum permitted movemer within the limit of the guide pin slots.

INSTALLATION

The unit is cold pulled to maximum length prior to dispatch by means of the pre-tensioning bolts. When the unit is installed by preinsulated pipe manufactures these pre-tensioned bolt may be left in position and they are designed to break off when the pipe line is heated to operating temperature. There is no longer to personnel as the broken bolts are contained within the insulation.
The Bolt breaking load, must be considered in the anchor design when the pretensioning bolts are left in position. Full recommendations for anchor designs are given in our "Designers Guide". Where the pipe line is open and the pre-tensioning bolts are not adequately covered, it is advisable to remove them prior to commissioning of the pipe line and after the anchors and guides have been installed.

If the installation temperature is higher then the minimum anticipated line temperature it will be necessary to adjust the installation length by means of the pre-tensioning bolts.

GUIDING

All axial compensators should be adequately guided in accordance with recommendations prior to pressure testing the pipe line. On each side of the Max-Comp the pipe should be provided with a guide at a max. distance from the Max-Comp equal to 18 times the pipe diameter. Where Max-Comp units are installed in pre-insulated pipe lines guides, other than those incorporated in the pipe system are not necessary. However it is essential to back-fill the pipe trench prior to pressure testing the pipe line.

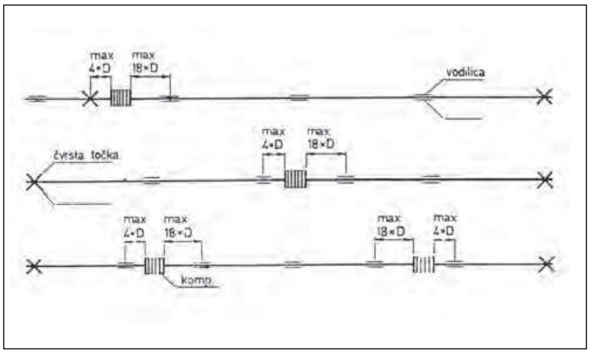


Fig. 46. Correct guides scheme

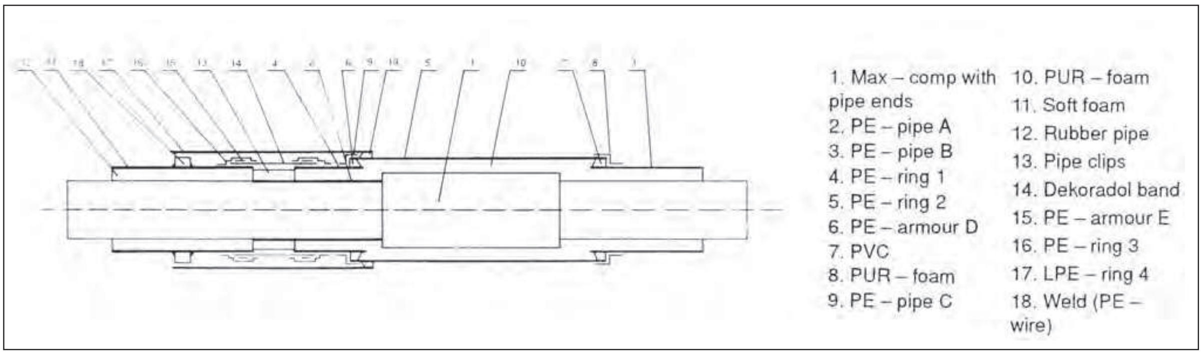


Fig. 47. Pre-insulated expansion joint

TIED BELLOWS

There are two groups of tied bellows:
- Bellows for lateral movement (TD, TM, HD, GD)
- Bellows for angular movement (HS, GS)

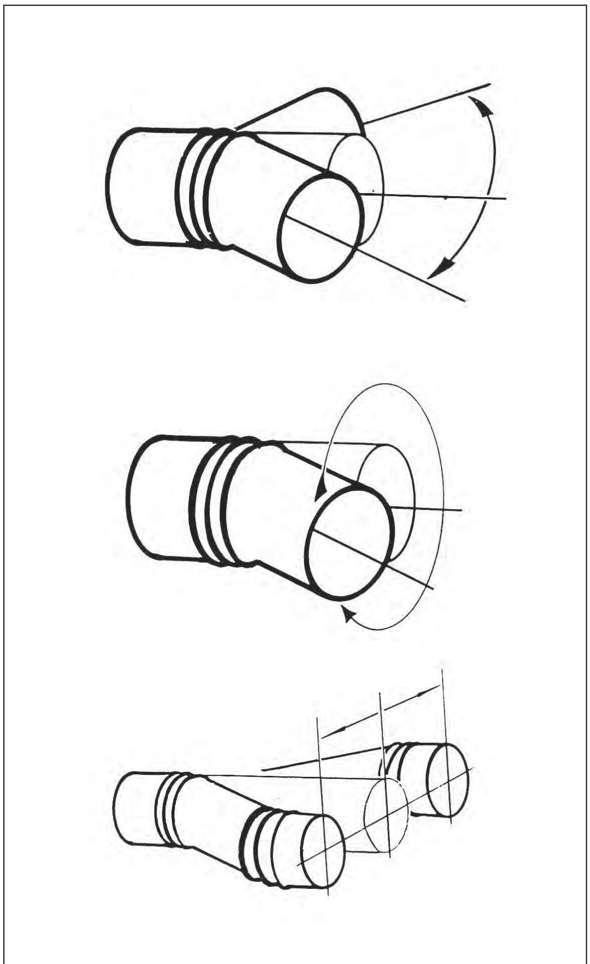


Fig. 48. Possible movements of tied bellows

It means that the tied bellows are not allowed to be installed like axial bellows for absorbing of axial movement. In that case, it is necessary to have changes in direction of flow (deflections) which allow converting of axial expansion into the lateral or angular movement of expansion joint. The tied bellows are named after tie elements (rods, bars) which take the pressure thrust ($F_p = p \cdot A$). As we know that the pressure thrust is the most influential force which loads anchors, therefore the main advantage of tied expansion joints, in contrast to the axial expansion joints, is that only very light anchors are necessary.
The areas between lateral and angular expansion joints are not rigidly defined, and a definite decision can only be made when the actual application is known. As a rule, three individual angular bellows are needed to absorb the movement properly. As long as the first guide support has been installed at a sufficiently long distance or that the required lateral deflections is limited so that as a result the circular are is minimal there will be no difficulties.

Advantages:

- anchor points question is of a secondary importance
- absorption of movements or expansions of any length is possible
- less intermediate anchors and pipe quides in comparation with absorption of movement with axial bellows
- absorption of movement in all three planes
- stress-free connection to sensitive pieces of equipment (pumps, engines, compressors) is guaranteed.

Disadvantages:

- deflection in the pipeline is necessary
- requires more installation space than an axial bellows

SYSTEM DESIGN PROCEDURE

When designing your tied bellows system a useful discipline is to observe the following procedure:

1. Establish the nominal pressure
2. Calculate thermal dilatation
3. Divide the pipeline installation into sub-sections and establish position of bellows
4. Establish position of anchor points and quides
5. Calculate "cold-pull" dimensions
6. Calculate forces acting on anchors

1. ESTABLISH THE NOMINAL PRESSURE

For establishing the nominal pressure the same formula as for the axial bellows is available, page 16

2. CALCULATE THERMAL DILATATION

See page 17

3. DIVIDE THE PIPELINE INSTALLATION INTO SUB-SECTIONS AND ESTABLISH POSITION OF BELLOWS

The tied bellows are installed in pipeline at the deflection place in contrast to the axial bellows. The most often applications:

- Z compensation
- L compensation
- compensation with a pipe loop

It is necessary to divide the pipeline installation into subsections:

- when the pipeline installation has many elbows and when movements occur in more than two planes.
- when an individual straight section is very long and the large movement occurring are therefore no longer absorbed by a single expansion joint
- when the anchor points of the piping is only possible at certain points.

The tied bellows are mostly situated near pipe elbows. However it is necessary to establish the distance between convolutions. In several practical examples is showed the way how to determinate the correct lateral bellows (TD, TM, HD, GD), angular bellows (HS, GS) and distance between convolutions.

4. ESTABLISH POSITION OF ANCHORS POINTS AND GUIDES

Anchor points and guides do not have the same meaning in comparation with axial bellows. The total force which loads anchor points is less for the pressure thrust and guides are necessary because of regular pipe extension. Ex. in the case of a long straight section to prevent any radial pipe movement. The distance between bellows and guides is determined for each compensation type itself but it is allowed max. four pipe diameters (max. 4 . D) for calculation. The additional necessary movement over coming of the lateral expansion joints (See Fig. 49) which the guides next to the bellows must absorb.

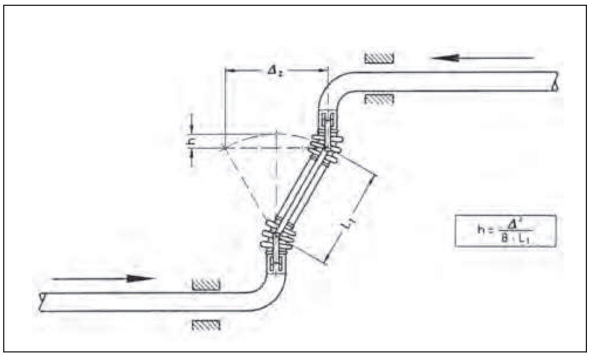


Fig. 49. Additional movement of bellows for lateral movement

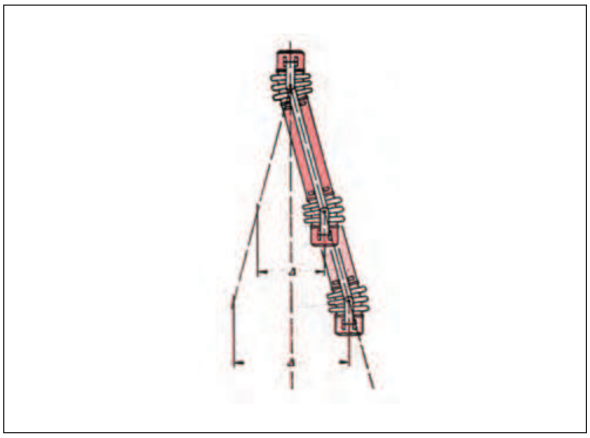


Fig. 50. Possibility of increasing lateral movement

5. CALCULATE COLD - PULL DIMENSIONS

See page 18

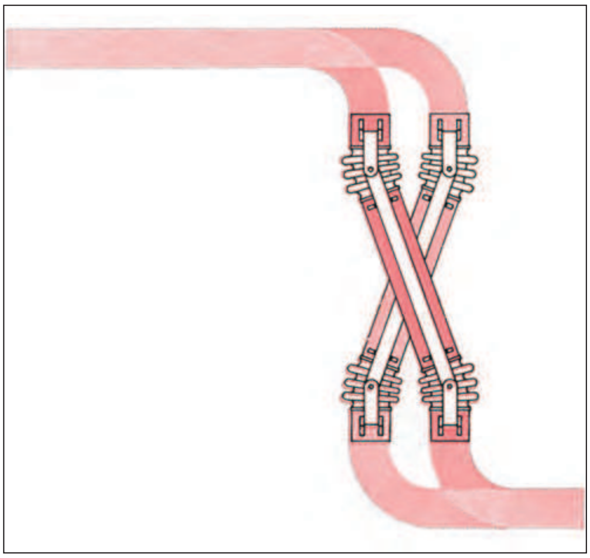


Fig. 51. Lateral movement

6. CALCULATE FORCES ACTING ON ANCHORS

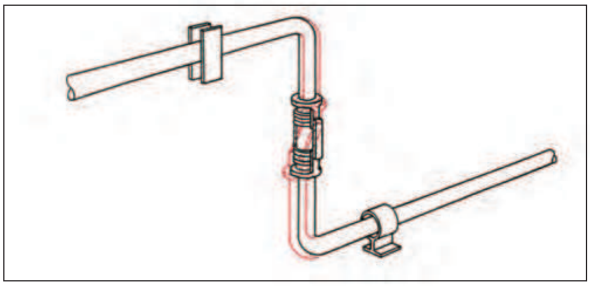
For the calculation of forces acting on anchors in pipeline installation with tied bellows it is necessary to know as follow:
- force or moment of bellows, which depends of bellows type (lateral or angular)
- pipe friction (See page 20)

The force of a lateral bellows consists of:
- spring rate (N/mm)
- force of friction in hinges (N/bar)

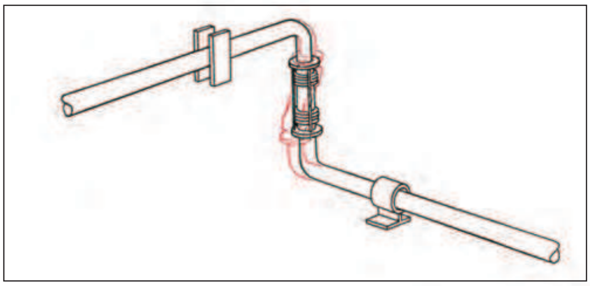
The moment of an angular bellows consist of:
- moment rate (Nm/°)
- moment of friction in hinges (N/bar)

Each of the forces and moments data of tied bellows you can find in data sheet section. If you require a tied bellows which is not in our data sheet, all data you can find in our drawings.

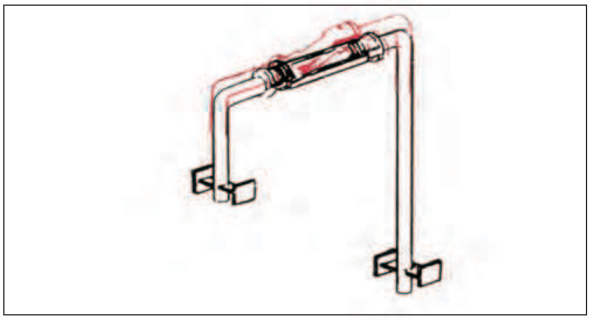
Fig. 52. Typical systems



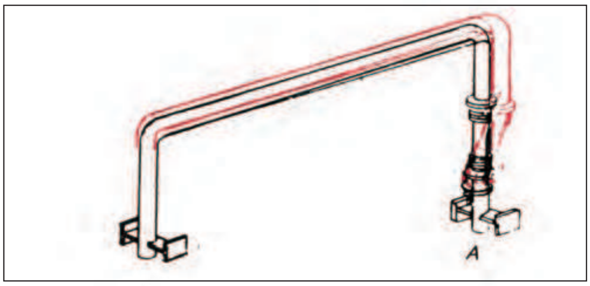
2-Pin *Where there is available offset in long straight pipe run, use Double Hinged Bellows (HD).*



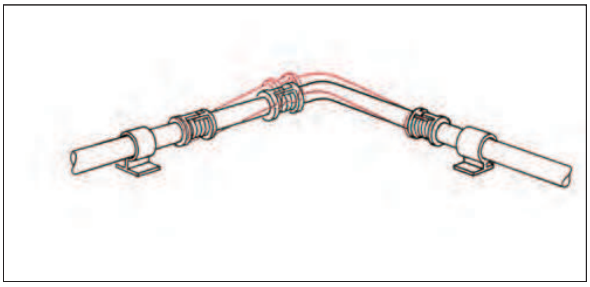
2-Pin System *Where there is available offset with expansion in two planes, use Multi Bar Tied Double Bellows (TM) or two Gimbal Bellows (GS)*



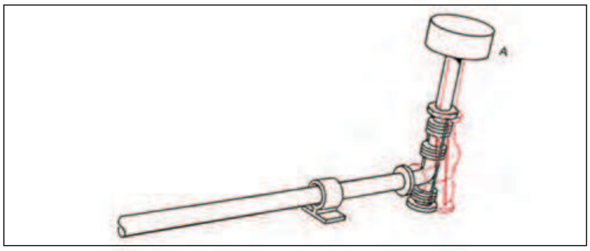
2-Pin "U" System *For pipe up the side of a vessel, a cross-over between two vessels, or other machinery, use either Double Hinged Bellows (HD) or 2-bar Tied Double Bellows (TD) where vertical pipes are very short tying over the centre line elbows.*



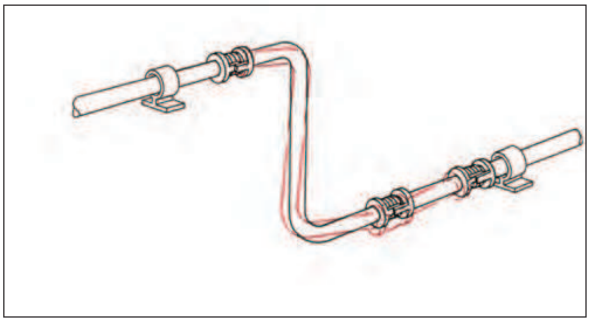
2-Pin "U" *System For pipe between two vessels or other machinery where legs are unequal, the differential vertical expansion being compensated for by making the bellows unit length equal to the difference in the vertical leg lengths. Use Double Hinged Bellows (HD) or 2-bar Tied Double Bellows (TD) where there is movement in a second plane at point "A".*



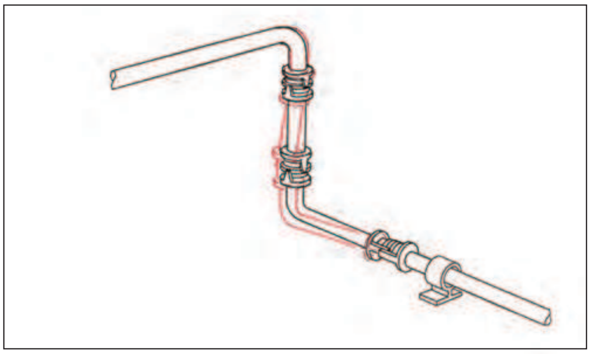
3-Pin System 90° *For taking expansion in two directions from two long pipe runs at 90°, use three Single Hinged Bellows (HS).*



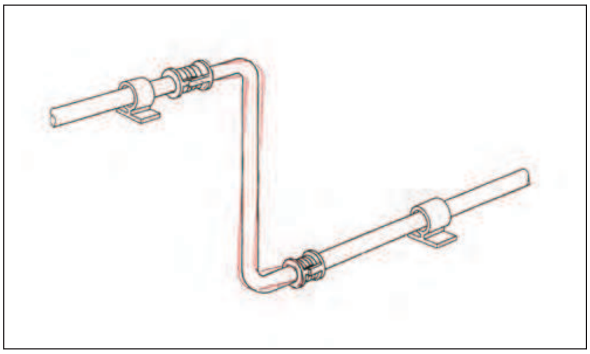
Pressure Balance System *To absorb expansion and reduce stresses on turbines, compressors, etc. Used where space is restricted and movements are small, suitable for three-plane movement due to pipe expansion, and machine nozzle movement at "A".*



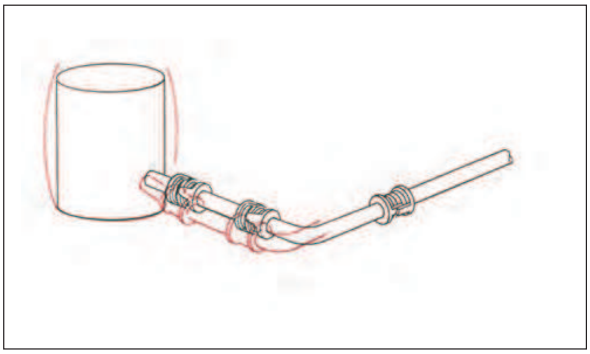
3-Pin System *For straight pipe runs using maximum centre-to-centre distance between pipes. A third unit caters for expansion of offset and maintains the two parallel runs in alignment. Use three Single Hinged Bellows (HS).*



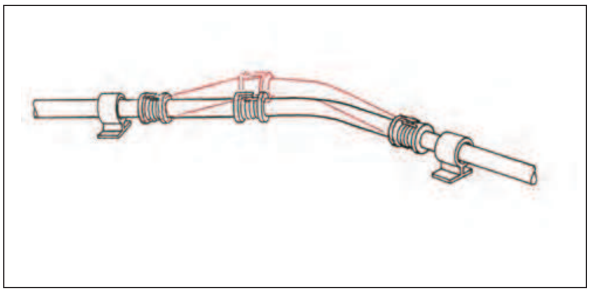
3-Pin *For two pipe runs at right angles with offset between them, use 2-bar Tied Double Bellows (TD) or two Gimbal Bellows (GS) in offset with Single Hinge Bellows (HS) to cater for expansion offset.*



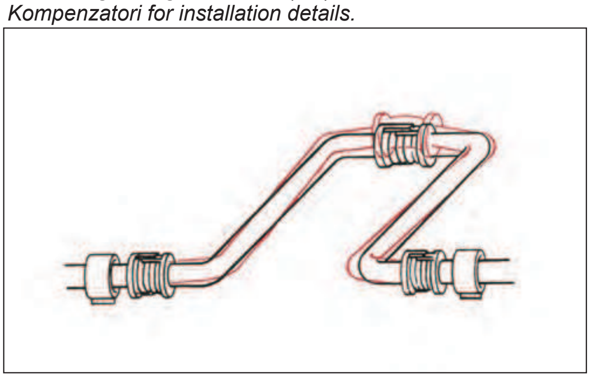
2-Pin System *For straight runs, using maximum centre-to-centre distance between pipe centres, use two Single Hinge Bellows (HS)*



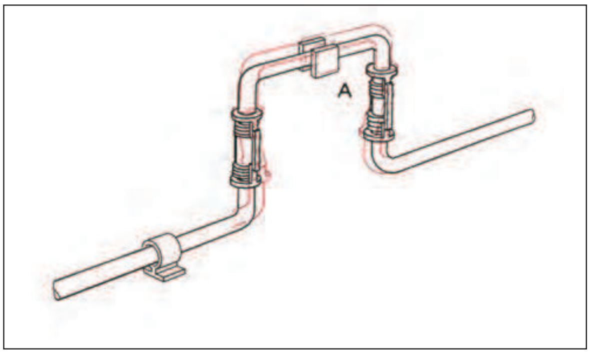
Storage Tank Settlement *As for previous system but also catering for movement in line with centre line of tank where adjacent pipe is not self flexing. Use two Gimbal Bellows (GS) and a single Hinge Bellows (HS).*



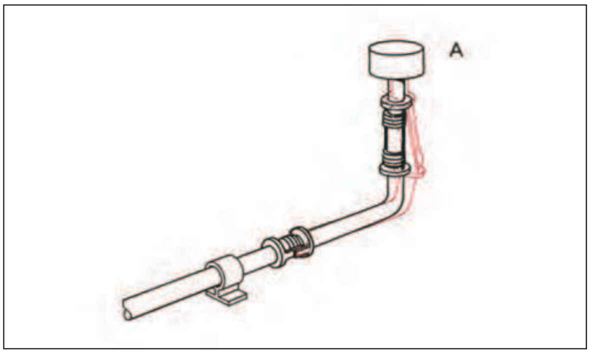
3-Pin System greater than 90° *For taking expansion in two directions from two pipes at an angle greater than 90°, use 3 Single Hinged Bellows (HS). Consult Đuro Đaković Kompenzatori for installation details.*



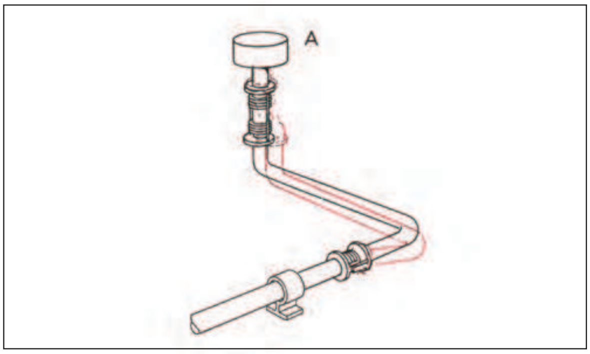
3-Pin "U" System *For taking up expansion in very long straight pipe runs. Use tree Single Hinged Bellows (HS)*



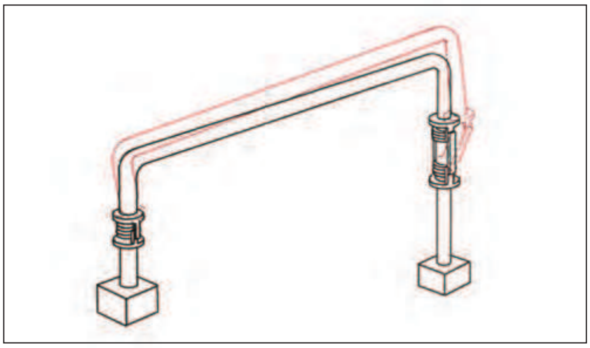
2-Pin "U" System *For taking up expansion in long straight pipe runs. Use two Double Hinged Bellows (HD) with directional anchor at "A".*



3-Pin System *To absorb expansion and reduce stresses on turbines, compresors, etc., use two Gimbal Bellows (GS) or a 2-bar Tied Double Bellows (TD) with a Single Hinged Bellows (HS), which will absorb movement in tree planes including pipe expansion and machine nozzle movement at "A".*



3-Pin System *Similar to previous system but with pipe run in tree planes.*



3-Pin "U" System *For pipe between two vessels or other machinery use Double Hinged Bellows (HD) and Single Hinge Bellows(HS).*

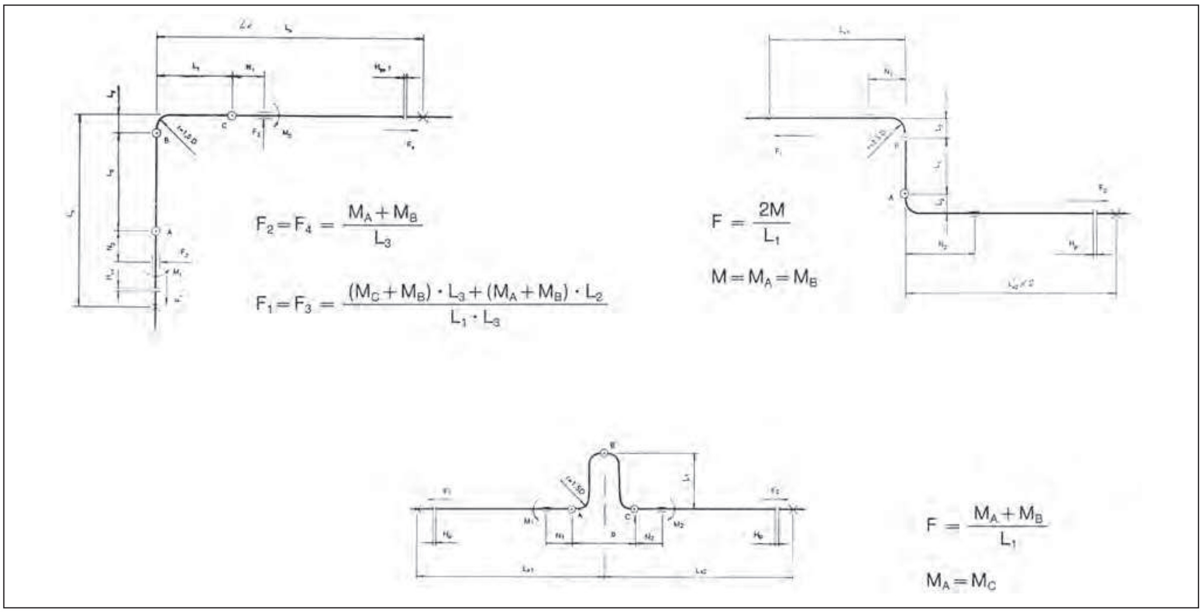


Fig. 53. Simplified calculation of load on anchors due to the bellows acting

TD - EXPANSION JOINTS

TD- Expansion joints (two bars double tied) is used for absorbing lateral and angular movements. In our data sheets (page 54-56) bellows designed movements are ± 25 mm. For bigger movements it is necessary to increase distance between bellows. (Fig. 50). In case high pressure and bigger movements are required it is possible that TD-expansions joint become insatiable. In that case consult our engineers.

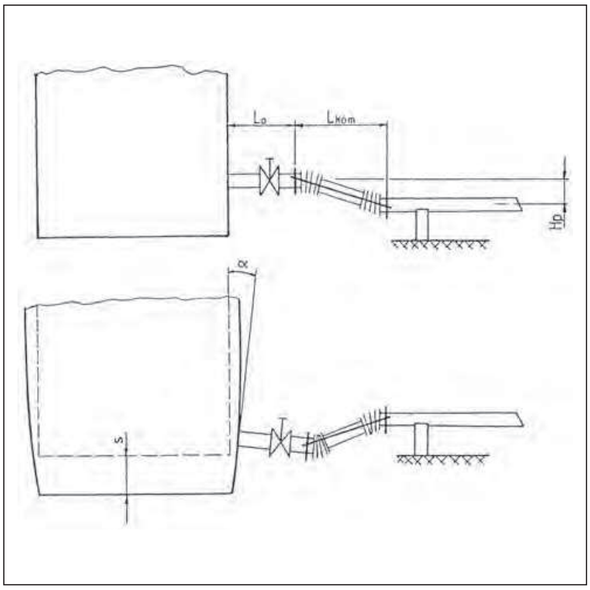


Fig. 54. Installation of TD expansion joint

Example 7:

When pipework is connected to an oil storage tank, provision has to be made so that the movements due to settlement and bulging of the tank are not transmitted on to that piping. The most common method of overcoming this problem is to install a two bar double tied bellows close to the tank inlet as shown in Fig. 54. This will also absorb thermal expansion in the "X" direction. (Any in-line movement i.e. in the "y" direction is absorbed by natural flexibility of the pipework at 90° to the bellows unit). Consider a 500 mm ND standard pipe carrying oil at 10 bar maximum pressure and ambient temperature connected to a storage tank as shown. It is known that the tank will settle by 200 mm and the tank wall will angulate 3/4° local to the nozzle due to bulging.

1. ESTABLISHING THE NOMINAL PRESSURE

$$NP = \frac{p}{t_k}$$

p = 10 bar, t_k = 1

$$NP = \frac{10}{1} = 10\ bar$$

2. CALCULATING THERMAL DILATATION

-Dilatation in direction "X" is 10 mm.
-Dilatation in direction "Y" is calculated by standard procedure, but in this case we shall not calculate it because it is compensated by natural pipe line flexibility and it doesn't affect on determination of movement.
- Dilatation in direction "Z" doesn't exist, but there is settlement of tank (200 mm) which is most important component for designing of expansion joint in our case.

$$\Delta_{total} = \sqrt{\Delta x^2 + \Delta z^2}$$

Δ_x = 10 mm
Δ_z = s + b

s = settlement of tank (s = *200 mm)*

b = bulging (b = sin$\alpha \cdot L_1$)

Δ_z = 200 + sin 0,75° · 1225 = 200 + 16 = *216 mm*

TD 10/500/50/M/1

$$L_2 = L_0 + \frac{(L_{kom} - z)}{2}$$
$$= 1000 + \frac{(685 - 240)}{2} = 1222{,}5 \approx 1225 \quad mm$$

$$\Delta_{total} = \sqrt{10^2 + 216^2} = 216{,}23 \approx 217 \quad mm$$

Required centre distance:

$$L_1 = \frac{\Delta_{total} \cdot z}{50}$$
$$L_1 = \frac{216{,}23 \cdot 240}{50} = 1041{,}60 \quad mm \approx 1050 \quad mm$$

(it is usual to measure this figure to the nearest multiple of 10)

New length of expansion joint:
$L_k = L_1 + L_b - z$ = 1050 + 685 - 240
L_k = *1495 mm*

3. DIVISION OF PIPELINE INTO SECTIONS AND DETERMINATION OF EXPANSION JOINT'S POSITIONS

Division of pipeline is solved within example 50 we don't need to make further divisions. Expansion joint has to be placed 1 m from tank wall and bolt between tank and expansion joint.

4. ESTABLISHING POSITION OF ANCHOR POINTS AND GUIDES

One anchor point is tank itself and the other is somewhere on the axis "X". If distance between expansion joint and an elbow is not over 4 · D, we have to place guide in direction "X" and if that distance is over 4 · D place it in direction "Y".

5. CALCULATING COLD-PULL DIMENSION

In cases where temperature changes and dilatations do not affect on movement we take 50% cold-pull:

$$H_p = \frac{\Delta_z}{2} = 108 \quad mm$$

6. CALCULATING FORCES AND MOMENTS ON ANCHOR POINTS

Force (F_2) and moment(M_x) act on place of the connection due to bulging

$$F_z = F_{OD(new)} \cdot \frac{\Delta_z}{2} + F_{t(new)} \cdot p$$

F_{OD} = 975 N/ mm (data sheet, page 55)
F_t = 453 N/bar (data sheet, page 55)

$$F_{OD\ (new)} = \frac{F_{OD(datasheet)}}{n_1^2}; \quad n_1 = \frac{L_1}{z}$$
$$F_{OD\ (new)} = \frac{975}{4{,}375^2} = 50{,}94 \quad (N/mm); \quad n_1 = \frac{1050}{240} = 4{,}375$$
$$F_{OD\ (new)} \approx 51 (N/mm)$$
$$F_{t\ (new)} = \frac{F_{t(datasheet)}}{n_2^2}; \quad n_2 = \frac{L_k}{L_b}$$
$$F_{t\ (new)} = \frac{453}{2{,}182} = 207{,}61 (N/bar); \quad n_2 = \frac{1495}{685} = 2{,}182$$
$$F_{t\ (new)} \approx 208 \quad (N/bar)$$
$$F_z = 51 \cdot 108 + 208 \cdot 10 = 5508 + 2080 = 7588 \quad (N)$$
$$M_x = F_z\left(L_2 + \frac{L_1}{2}\right)$$
$$M_x = 7588\left(1{,}225 + \frac{1{,}050}{2}\right) = 7588 \cdot 1{,}75 = 13279 \quad (Nm)$$

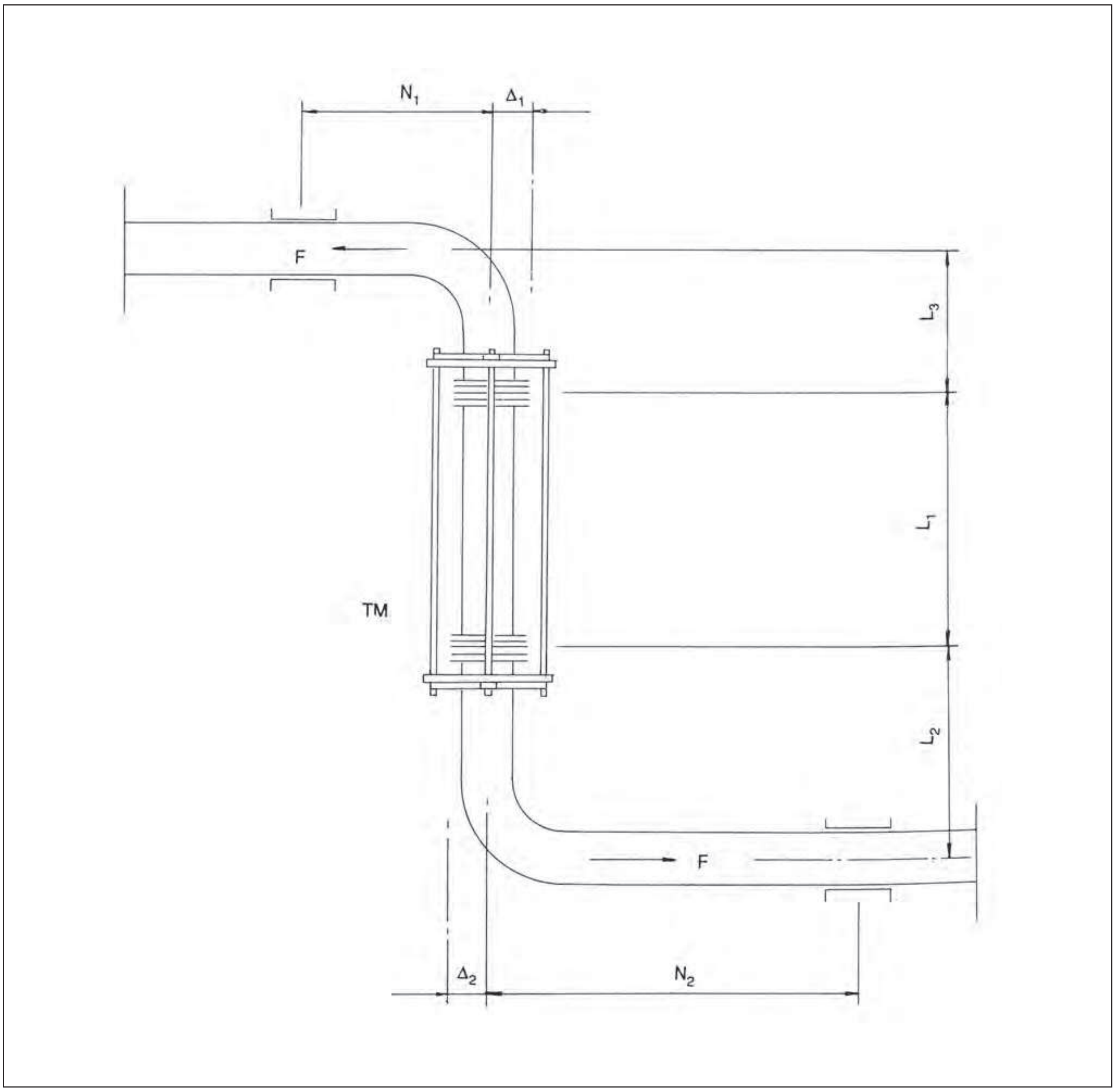
Force(F_x) and moment(M_z) act on the place of the connection due to bulging

$$F_x = F_{OD(new)} \cdot \Delta_x + F_{t(new)} \cdot p$$
$$F_x = 51 \cdot 10 + 208 \cdot 10 = 510 + 2080 = 2590 \quad (N)$$
$$M_z = F_x\left(L_2 + \frac{L_1}{2}\right)$$
$$M_z = 2590\left(1{,}225 + \frac{1{,}050}{2}\right) = 2590 \cdot 1{,}75 = 4532{,}5 \quad (Nm)$$

NOTE:

At TD expansion joint it is necessary to determine exact distance L_1. If that distance is greater than needed one it means longer cyclic life of expansion joint and force of expansion joint reduces. To determine total force on anchor points we have to add frictional resistance to force of expansion joint.

TM – EXPANSION JOINT

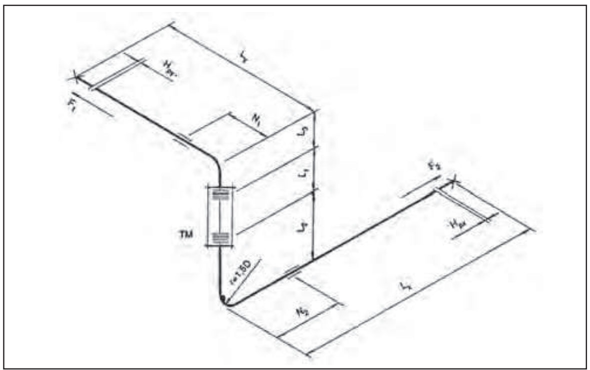


$F_k = F_o + F_t$

F_k - force of expansion joint (N)
F_o - spring rate (N)
F_t - frictional force (N)
F_{lat} - lateral force (N/mm) (see data sheet)
Δ_k - movement of expansion joint (mm)
F_{tr} - frictional force in hinges (N/bar) (see data sheet)
p - working pressure (bar)

Example 8:

Steam
NO = 350 mm
t_{max} = 210 °C
t_{min} = -8 °C
t_{inst} = 5 °C
p = 9,2 bar



PROCEDURE:
1.

$$NP = \frac{p}{t_k} = \frac{9{,}2}{1} = 9{,}2 \qquad NP = 10$$

2.

Δ_t = 210 + 8 = 218 °C

Δ = *2,64 mm/m*

$\Delta_x = \Delta \cdot L_x$ = 2,64 · 90 = 237,6 ≈ *238 mm*

$\Delta_y = \Delta \cdot L_y$= 2,64 · 60 = 158,4 ≈ *158 mm*

3. The pipeline is already defined, so only question is which type of expansion joint to choose and where to place it. Problem could be solved by several ways: TD, TM, 2xGS, GD, 2xGS+lxHS. We choose TM expansion joint TM 10/350 with weld end

$$\Delta_{total} = \sqrt{\Delta x^2 + \Delta y^2}$$
$$\Delta_{total} = \sqrt{238^2 + 158^2} = 258{,}67 \approx 286\ mm$$

Δ_{total} - resultant total movement

$$L_1 = \frac{\Delta_{total} \cdot z}{50}$$
$$L_1 = \frac{286 \cdot 240}{50} = 1372 \approx 1380 \quad mm$$

$L_k = L_1 + L_b - z$
= 1380 + 810 - 240
L_k = *1950 mm*

On the base of acceptable distance "L" we accept solution with TM expansion joint and we refuse variant 2xGS or GD because it is more expensive.

Variant 2xGS +1xHS is not necessary because the dilatation in direction "Z" is not big and it is solved by self compensation.

4. Anchor points are defined within example. Guides have to be placed on following way:

$N_1 = 4 \cdot D$ (max)

$N_2 = L_1 + 2 \cdot L_2$ (max), because of self compensation (natural flexibility)

5.

$t_{inst} > t_{min}$

$$H_{px} = \Delta x\left(0{,}5 - \frac{t_{inst} - t_{min}}{t_{max} - t_{min}}\right) = 238\left(0{,}5 - \frac{5-(-8)}{210-(-8)}\right) =$$
$$H_{px} = 238 \cdot 0{,}44 = 104{,}72 \approx 105 \quad mm$$
$$H_{py} = \Delta y \cdot 0{,}44 = 158 \cdot 0{,}44 = 69{,}52 \approx 70 \quad mm$$

6.

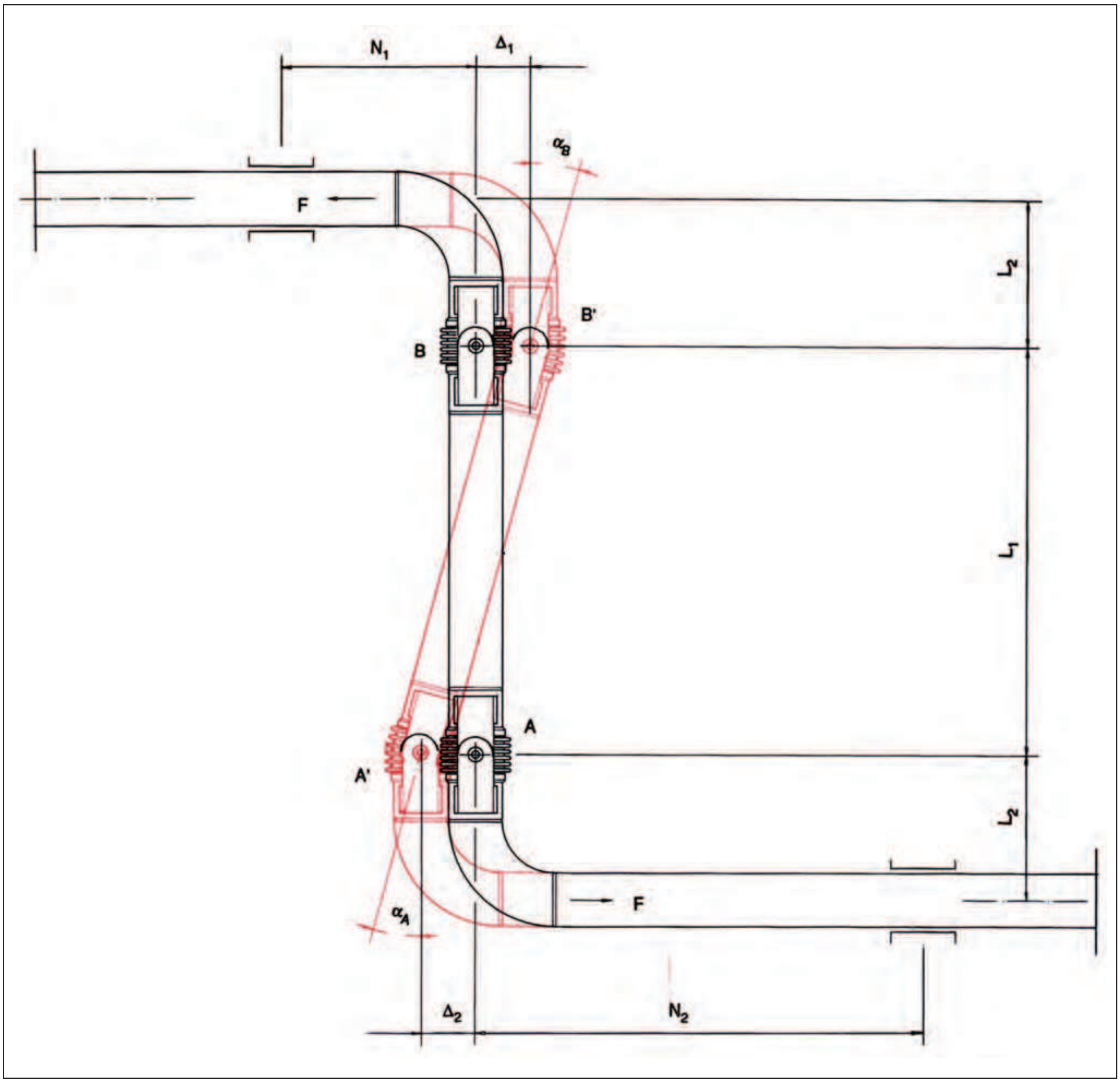
$$F_x = F_{OD\,(new)} \cdot \frac{\Delta x}{2} + F_{tr\,(new)} \cdot p$$

F_{OD} = *240 N/mm (data sheet, page* 58)
F_{tr} = *133 N/bar (data sheet, page* 58)

$$F_{OD\ (new)} = \frac{F_{OD(datasheet)}}{n_1^2}; \quad n_1 = \frac{L_1}{z}$$
$$F_{OD\ (new)} = \frac{240}{5{,}75^2} = 7{,}25 \quad (N/mm); \quad n_1 = \frac{1380}{240} = 5{,}75$$
$$F_{OD\ (new)} \approx 7 \quad (N/mm)$$
$$F_{t\ (new)} = \frac{F_{t(datasheet)}}{n_2^2}; \quad n_2 = \frac{L_k}{L_b}$$
$$F_{t\ (new)} = \frac{133}{2{,}41} = 55{,}18\ (N/bar); \quad n_2 = \frac{1950}{810} = 2{,}41$$
$$F_{t\ (new)} \approx 55 \quad (N/bar)$$
$$F_x = 7 \cdot \frac{238}{2} + 55 \cdot 9{,}2 = 833 + 506 = 1339 \quad (N)$$
$$F_x = 1339 \quad (N)$$
$$F_y = F_{OD\,(new)} \cdot \frac{\Delta y}{2} + F_{tr\,(new)} \cdot p$$
$$F_y = 7 \cdot \frac{158}{2} + 55 \cdot 9{,}2 = 553 + 506 = 1059 \quad (N)$$
$$F_y = 1059 \quad (N)$$

HINGE EXPANSION JOINT

"L" or "Z" - compensation



$$L_1 = \frac{\Delta_1 + \Delta_2}{\sin\alpha}$$

$M = M_A = M_B$

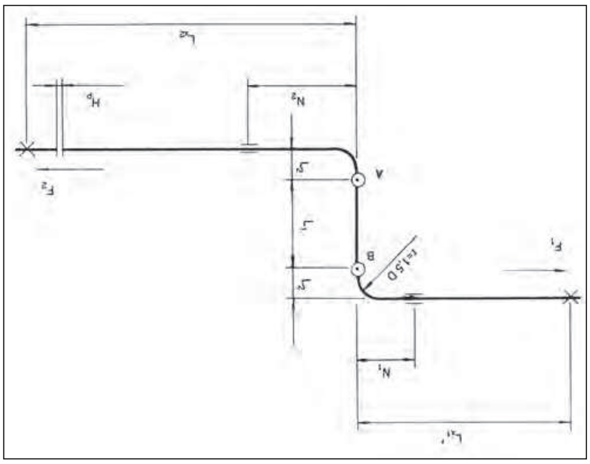
$M = M_O + M_t$

$$F = \frac{2 \cdot M}{L_1}$$

M_O, M_t – see data sheet

Example 9:

Drawing shows pipeline ND 300, medium is steam p = 16 bar and t = 450 °C.
Distance between anchor points is 70 m (L_{x1} = 25 m, L_{x2} = 45 m) t_{min} = -10 °C, t_{inst} = 50 °C



PROCEDURE:

1.

$$NP = \frac{p}{t_k} = \frac{16}{0{,}92} = 17{,}39 \qquad NP = 25$$

2.

$\Delta_{total} = \Delta \cdot (L_{x1} + L_{x2})$

Δ_t = 450 + 10 = 460 °C

Δ = 6,34 *mm/m*

Δ_{total} = 6,34 (35 + 45) 443,8 ≈ 444 *mm*

3. The pipeline is already defined, so only question is which type of expansion joint to choose and where to place it. Problem could be solved by several ways: TM, HD, 2xHS, 3xHS. We shall choose 2 x HS.

$$\frac{\Delta}{2} = 222 \quad mm, \quad tg5° = \frac{222}{L_1}$$

$$L_1 = \frac{222}{0{,}087} = 2551{,}7 \approx 2560 \quad mm$$

(it is usual to measure this figure to the nearest multiple of 10)

On the base of distance L1 we refuse variant TM and HD (Expansion joint would be to long). Variant with 3 x HS is not necessary because dilatation in direction "y" is not big and it is solved by self compensation.

We choose HS 25/300/10/V/1 with L_b = 785 mm, page 65

4. Anchor points are already defined within example. Guides have to be placed on following way.

$N_1 = 4 \cdot$ D (max)

$N_2 = L_1 + 2 \cdot L_2$ (max), because of self compensation (natural flexibility)

5.

$t_{inst} > t_{min}$

$$H_p = \Delta_{total}\left(0{,}5 - \frac{t_{inst} - t_{min}}{t_{max} - t_{min}}\right) = 444\left(0{,}5 - \frac{5-(-10)}{450-(-10)}\right) =$$

$$H_p = 444 \cdot 0{,}467 = 207{,}35 \approx 207 \quad mm$$

6.

$$F = \frac{2M}{L_1}$$

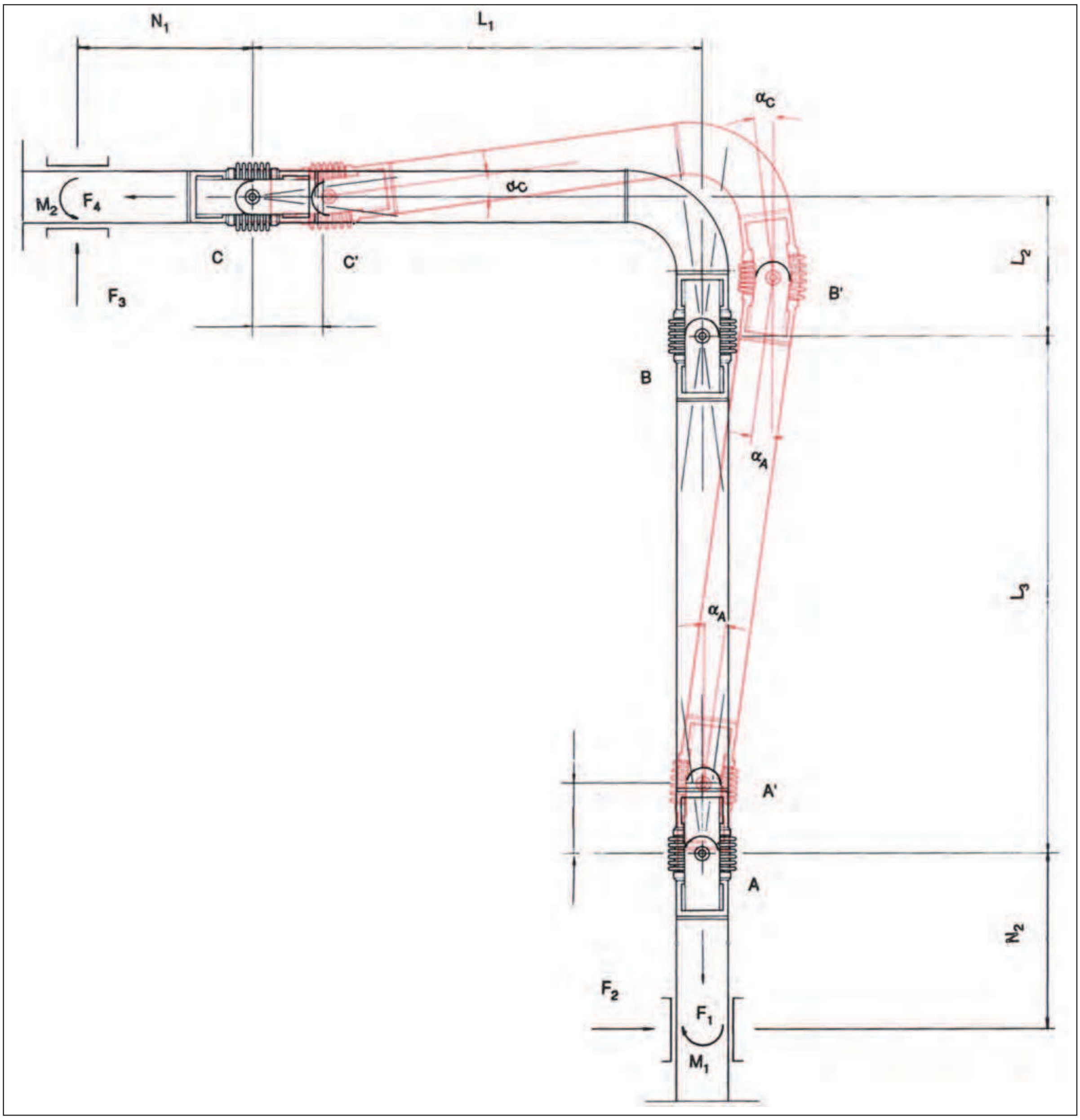
M_0 = 335 Nm/°
M_t = 25 Nm/°
Data sheet, page 65.

$M = M_o \cdot \alpha + M_t \cdot \rho$
M = 335 · 5 + 25 ·16 = 1675 + 400 = 2075 *Nm*

$$F = \frac{2 \cdot 2075}{2{,}560} = 1621{,}09 \approx 1621 \quad N$$

NOTE:
Pipeline length in direction "y" has to be minimum $L_1 + 2L_2$ (we weld expansion joints directly to elbow). In case that this length is greater, distance L_1 can remain the same or we can increase it and with this we shall have longer cycle life and decreased force on anchor point. To determine total force on anchor points we have to add frictional force and centrifugal force to the force of expansion joint.

3 PIN-ARCH SYSTEM



$\Delta_x \geq \Delta_y$

$$\sin\alpha_C = \frac{\Delta_y}{L_1}$$

$$\sin\alpha_A = \frac{\Delta_x + \dfrac{\Delta_y + L_2}{L_1}}{L_3}$$

$$\alpha_B = \alpha_A + \alpha_C$$

$$F_2 = F_4 = \frac{M_A + M_B}{L_3}$$

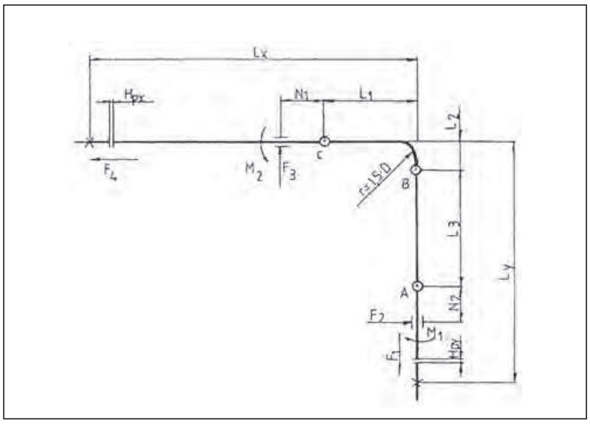
$$F_1 = F_3 = \frac{(M_C + M_B)\cdot L_3 + (M_A + M_B)\cdot L_2}{L_1 \cdot L_3}$$

$M_1 = F_4 \cdot N_2 + M_A$
$M_2 = F_1 \cdot N_1 + M_C$
$M_A = M_O \cdot \alpha_A + M_t \cdot p$
$M_B = M_O \cdot \alpha_B + M_t \cdot p$
$M_C = M_O \cdot \alpha_C + M_t \cdot p$

M_O, M_t - see data sheet

Example 10:

Pipeline for hot water
NO = 400 mm
t_{max} = 165 °C
t_{min} = -20 °C
t_{inst} = 20 °C
p = 3,5 bar



PROCEDURE:

1.

$$NP = \frac{p}{t_k} = \frac{3,5}{1} = 3,5 \qquad NP = 3,5$$

2.

Δ_t = 165 + 20 = 185 °C

Δ = *2,20 mm/m*

$\Delta_x = \Delta \cdot L_x$ = 2,20 · 152 = 334,4 ≈ 334 *mm*

$\Delta_y = \Delta \cdot L_y$= 2,20 · 34,5 = 75,9 ≈ 76 *mm*

3. Pipeline is already defined, so we have only to determine distance between expansion joints. We choose HS 3,5/400/16/T/1 (page 63)

L_b= 610 *mm*
$\alpha_B = \alpha_A + \alpha_c$
α_B = 16°
α_A = 10°
α_c = 6°

Because of designing reasons we accept $L_1 = 1,5D + 0,5L_b$

L_1 = 1,5 · 406,4 + 0,5 · 610= 609,6 + 305 = 914,6 ≈ 915 mm

L_2 = we accept as small as it can be considering design (L_2 = 915 mm)

$$L_3 = \frac{\Delta_x + \dfrac{\Delta_y \cdot L_2}{L_1}}{\sin\alpha_A} = \frac{334 + \dfrac{76 \cdot 915}{915}}{0,174} = 2356,3$$

L_3 = *2360 mm* (it is usual to measure this figure to the nearest multiple of 10)

4. Anchor points are already defined within example. Guides have to be placed on distance maximum 4xD. We recommend to place them on distance:

$$N = 2 \cdot D + \frac{\Delta_x}{2} (N_1 = N_2 = 2 \cdot 406,4 + \frac{334}{2} = 979,8 \approx 980 \quad m$$

5.

$t_{inst} > t_{min}$

$$H_{px} = \Delta x \left(0,5 - \frac{t_{inst} - t_{\min}}{t_{\max} - t_{\min}} \right) = 334 \left(0,5 - \frac{20 - (-20)}{165 - (-20)} \right) =$$
$$H_{px} = 334 \cdot 0,284 = 94,85 \approx 95 \quad mm$$
$$H_{py} = \Delta y \left(0,5 - \frac{t_{inst} - t_{\min}}{t_{\max} - t_{\min}} \right) = 76 \cdot 0,284 = 21,58 \approx 70 \quad mm$$

6.

$$\sin\alpha_A = \frac{\Delta_x + \dfrac{\Delta_y \cdot L_2}{L_1}}{L_3} = \frac{334 + \dfrac{76 \cdot 915}{915}}{2360} = 0,173 \rightarrow \alpha_A = 10°$$

$$\sin\alpha_C = \frac{\Delta_y}{L_1} = \frac{76}{915} = 0,083 \rightarrow \alpha_C = 4,75°$$

$\alpha_B = \alpha_A + \alpha_C$ = 10° + 4,76° = 14,76°
M_o = 66 Nm/°
M_t = 19 Nm/bar
Data sheet, page 63.

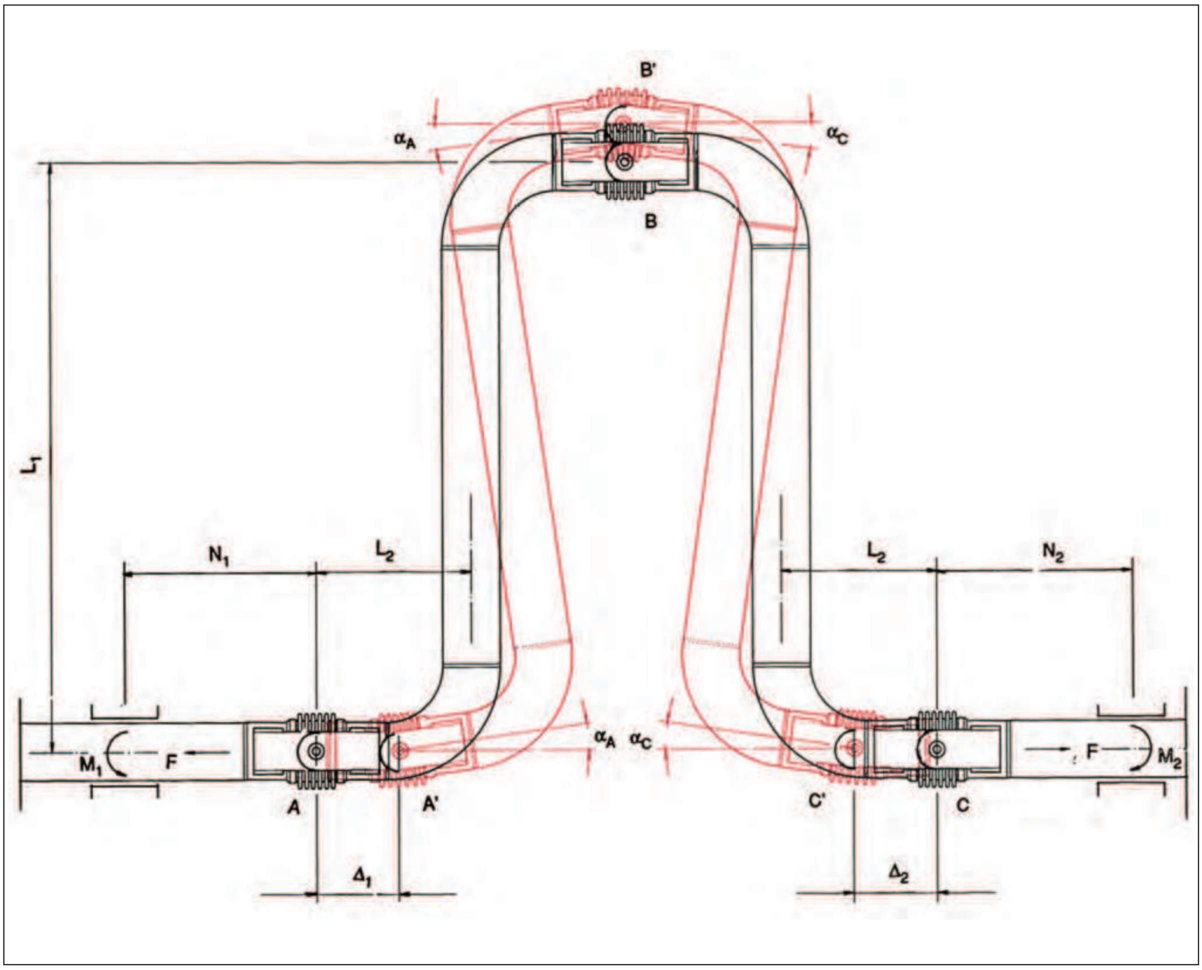
M_A = 66 · 10 + 19 · 3,5 = 660 + 66,5 = 726,5 *(Nm)*
M_B = 66 · 14,76 + 19 · 3,5 = 974,16 + 66,5 = *1040,66 (Nm)*
M_C = 66 · 4,76 + 19 · 3,5 = 314,16 + 66,5 = 380,66 *(Nm)*

$$F_2 = F_4 = \frac{M_A + M_B}{L_3} = \frac{726,5 + 1040,66}{2,360} = 748,79 \approx 749 \quad N$$
$$F_1 = F_3 = \frac{(M_C + M_B) \cdot L_3 + (M_A + M_B) \cdot L_2}{L_1 \cdot L_3} =$$
$$\frac{(380,66 + 1040,66) \cdot 2,36 + (726,5 + 1040,66) \cdot 0,915}{0,915 \cdot 2,360} =$$
$$2302,15 \approx 2302 \quad (N) \rightarrow M_1 = F_4 \cdot N_2 + M_A =$$
$$749 \cdot 0,980 + 726,5 = 1460,52 \quad (Nm)$$
$$M_2 = F_1 \cdot N_1 + M_C = 2302 \cdot 0,980 + 380,66 = 2636,62 \quad (Nm)$$

NOTE:

For this type of compensation it is necessary to determine exact distance L_1, L_2 and L_3. Length L_2 in any case, has to be minimum value, that is we weld expansion joint directly to the elbow. If we increase lengths L_1 and L_3 we shell have longer cycle life and decreased forces and moments on anchor points. If those lengths are to great, we have to additionally lean on pipeline at elbow, length L_1 or Length L_3. To determine total force on anchor points we have to add frictional force and centrifugal force to force of expansion joint. When we have elbow at an angle greater than 90° it is possible to make compensation with 3 PIN-ARCH system. Determination distances (L_1, L_2, L_3) and forces is different so please contact manufacturer ĐURO ĐAKOVIĆ - Kompenzatori d.o.o.

PIPE LOOP WITH EXPANSION JOINT



$$L_1 = \frac{\Delta_1 + \Delta_2}{\sin\alpha_B} \; i \quad \sin\alpha_B = \frac{\Delta_1 + \Delta_2}{L_1}$$

$$\alpha_B = \alpha_A + \alpha_C (\alpha_A = \alpha_C = \alpha_{B/2})$$

$$M_A = M_C$$

$$F = \frac{M_A + M_B}{L_1}$$

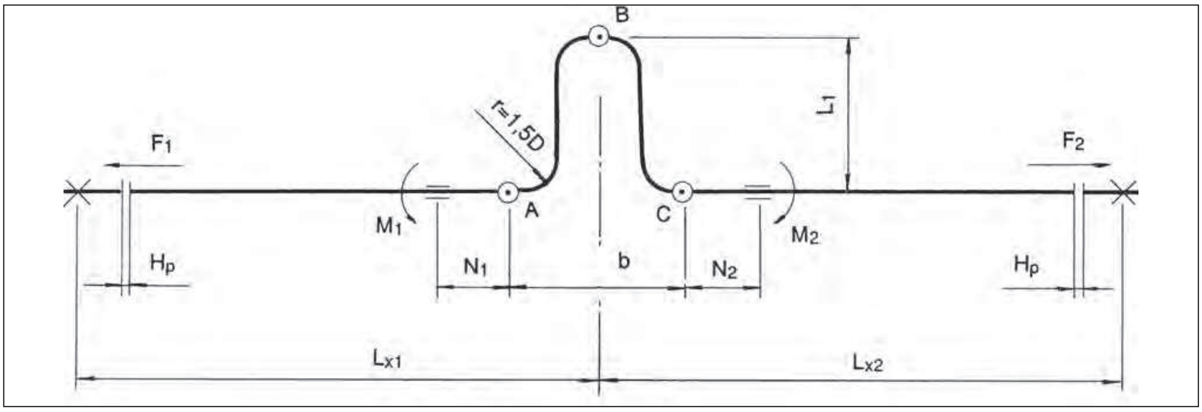
$$M_A = M_O \cdot \alpha_A + M_t \cdot p$$

$$M_B = M_O \cdot \alpha_B + M_t \cdot p$$

$M_O = M_t$ - see data sheet

Example 11:

STEAM PIPELINE
NO = 250 mm
t_{max} = 250 °C
t_{min} = 0 °C
t_{inst} = 40 °C
p = 18 bar



PROCEDURE:

1.

$$NP = \frac{p}{t_k} = \frac{18}{1} = 18 \qquad NP = 18$$

2.

Δ_t = 250 + 0 = 250 °C

Δ = 3,07 *mm/m*

$\Delta_{total} = \Delta \cdot (L_{1x} + L_{x2})$ = 3,07(115+115)= 706,1 *mm* ≈ 706 *mm*

3. Pipeline is already defined so we have to determine only position of expansion joint and height of the pipe loop (L_1). We choose HS 25/250/12/V/1 (page 65).

L_b= 660 *mm*

$$L_1 = \frac{\Delta_{total}}{\sin \alpha_B} (\min)$$

$$L_1 = \frac{706}{0{,}208} = 3394{,}23 \quad mm \approx 3400 \quad mm$$

(it is usual to measure this figure to the nearest multiple of 10.)

4. Anchor points are defined within example. Guides have to be placed on distance maximum 4 · D. We recommend to place them on distance:

$$N_1 = N_2 = 2 \cdot D + \frac{\Delta_{total}}{4} = 2 \cdot 273 + \frac{706}{4} = 722{,}5 \approx 730 \quad mm$$

If height of the pipe loop is greater we have to install additional supports on length L_1.

5.

$t_{inst} > t_{min}$

$$H_p = \frac{\Delta_{total}}{2}\left(0{,}5 - \frac{t_{inst} - t_{\min}}{t_{\max} - t_{\min}}\right) = \frac{706}{2}\left(0{,}5 - \frac{40-0}{250-0}\right) =$$

$$H_p = 353 \cdot 0{,}34 = 120{,}02 \approx 120 \quad mm$$

6.

$$\sin \alpha_B = \frac{\Delta_{total}}{L_1} = \frac{706}{3400} = 0{,}207$$

$$\alpha_B = 11{,}95°$$

$$\alpha_A = \alpha_C = \frac{\alpha_B}{2} = 5{,}975°$$

$$M_O = 161 \quad Nm/°$$

$$M_t = 16 \quad Nm/bar$$

Data sheet, page 65.

$M_A = M_C$ = 161 · 5,975 + 16 · 18 =

961,975 + 288 = 1249,975 = 1250 *(Nm)*

M_B = 161 · 11,95 + 16 · 18 =
1923,95 + 288 = 2211,95 = 2212 *(Nm)*

$$F = \frac{M_A + M_B}{L_1} = \frac{1250 + 2212}{3400} = 1018{,}23 \quad N$$

F = 1018,23 (*N*)

NOTE:
We recommend installation of pipe loop in the central part of pipeline. If it is not possible than we can install it anywhere between two anchor points. Height of the pipe loop (L_1) is important dimension which has to be determined and if it is longer we shall have longer cycle life. Finally we have to add frictional force and centrifugal force to the force on the anchors.

HOW TO ORDER BELLOW

Any bellows in the Đuro Đaković Kompenzatori d.o.o. range can be specified by quoting the following information in its coded form.

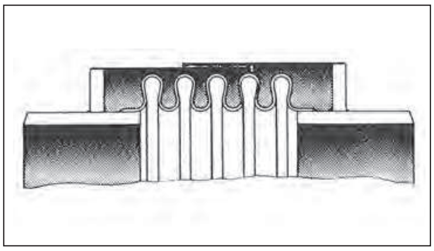
BELLOWS TYPE	NOMINAL BORE	TOTAL MOVEMENT	END FITTINGS	ACCESSORIES
The types of bellows available are described in the first section of this Catalogue. For example, if an axial bellows is suitable and the working pressure is 6 bar, then the bellows type is expressed as	The nominal bores available are given in the first column of each data sheet. Assuming, for example, that you are working in 300 mm pipe, the second part of the identification code would read	Knowing the operating temperature and the pipe material, the thermal expansion can be calculated using the coefficients given in the table on page 15. Assuming, for example, that the total movement is less than 70 mm, the third part of the code would read	The standard end fittings available are shown in the table bellow. If, for example, you require end fittings to DIN 2631 then the fourth part of the code would read	Finally, the codes for shrouds and sleeves are as follows 0 - no accessories required 1 - sleeves required 2 - shrouds required 3 - sleeves and shrouds required If, for example, no accessories are required the final part of the code would read
AR6	**300**	**70**	**L**	**1**

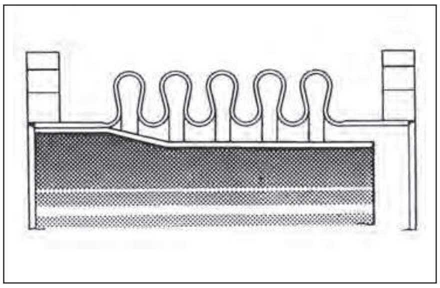
The complete code would now be written as: **AR6/300/70/L/1**

Following the same procedure, a Double Hinge Unit for a design pressure of 10 bars nominal diameter 800 mm for 100 mm (± 50 mm) total movement with ISO. weld ends and with internal sleeves would be expressed thus:
HD 10 800 100 T 1 written as:

HD10/800/100/T/1

TYPE	DESCRIPTION	ĐĐ -" Code"
Flange	ASA 150	H
Flange	ASA 300	I
Flange	ASA 400	J
Flange	DIN 2631	L
Flange	DIN 2632	M
Flange	DIN 2633	N
Flange	DIN 2634	0
Flange	DIN 2635	P
Pipe ends	ISO 6 and 10 bar	T
Pipe ends	ISO 16 bar	U
Pipe ends	ISO 25 bar	V

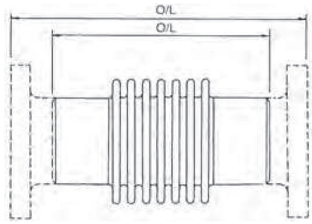




AR	1

AXIAL BELLOWS

Design pressure	1 bar
Design temperature	300 °C
Test pressure	1.5 bar

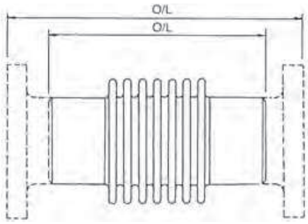


NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		PIPE O/D mm	BELLOWS O/D mm	EFFECTIVE AREA cm^2	SPRING RATE N/mm	MASS kg
	± mm	total mm	flange mm	weld end mm					
300	25 50	50 100	185 230	280 355	323,9	377	967	85 37	10 11
350	25 50	50 100	190 235	285 360	355,8	418	1171	93 47	11 12
400	25 50	50 100	190 235	285 360	406,5	469	1498	106 53	12 14
450	30 60	60 120	230 285	300 395	455	533	1919	140 70	17 20
500	30 60	60 120	230 285	300 395	510	583	2332	155 78	19 22
550	30 60	60 120	230 285	300 395	560	637	2814	171 86	21 25
600	30 60	60 120	230 285	300 395	610	685	3281	185 93	23 27
650	30 60	60 120	230 285	300 395	660	714	3580	194 97	25 30
700	35 70	70 140	230 285	300 395	710	812	4551	258 129	30 35
750	35 70	70 140	230 285	300 395	760	863	5177	276 138	30 35
800	35 70	70 140	230 285	300 395	815	914	5844	294 147	35 40
850	35 70	70 140	230 285	300 395	865	962	6514	310 155	35 40
900	35 70	70 140	230 285	300 395	915	1015	7297	332 165	35 45
950	35 70	70 140	230 285	300 395	965	1069	8131	344 172	40 45
1000	35 70	70 140	230 285	300 395	1015	1116	8909	374 187	40 50
1050	35 70	70 140	230 285	300 395	1065	1167	9780	390 195	40 50
1100	35 70	70 140	230 285	300 395	1120	1218	10692	406 203	45 55
1150	35 70	70 140	230 285	300 395	1170	1249	11261	410 205	45 55
1200	35 70	70 140	230 285	300 395	1220	1320	12637	437 219	50 60

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

AXIAL BELLOWS

Design pressure 3.5 bar
Design temperature 300 °C
Test pressure 5.25 bar



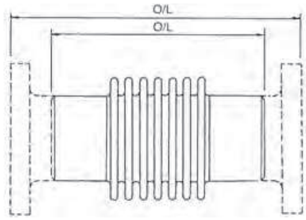
AR 3.5

NOMINAL DIAMETER mm	MOVEMENT ± mm	MOVEMENT total mm	FREE LENGHT O/L flange mm	FREE LENGHT O/L weld end mm	PIPE O/D mm	BELLOWS O/D mm	EFFECTIVE AREA cm^2	SPRING RATE N/mm	MASS kg
300	25 50	50 100	190 250	286 362	323,9	377	967	148 74	18 21
350	25 50	50 100	222 318	305 400	355,6	418	1171	167 84	23 27
400	25 50	50 100	230 330	305 400	406,4	469	1498	190 95	30 32
450	25 50	50 100	230 330	305 400	457.2	533	1919	323 162	34 39
500	25 50	50 100	230 330	350 445	508	584	2332	358 179	39 43
600	25 50	50 100	240 336	350 445	609,2	685	3281	428 214	50 57
700	25 50	50 100	250 344	350 445	711,2	813	4552	675 214	59 68
750	25 50	50 100	260 355	350 445	762	864	5178	722 361	64 77
800	25 50	50 100	260 355	350 445	812,8	915	5845	769 385	71 82
900	25 50	50 100	285 380	350 445	914,4	1016	7300	863 432	80 93
1000	30 60	60 120	285 380	360 470	1016	1118	8921	740 410	91 105
1050	30 60	60 120	300 394	360 470	1065	1169	9787	785 435	96 109
1100	30 60	60 120	300 394	360 470	1120	1220	10697	823 456	100 116
1200	30 60	60 120	310 406	360 470	1220	1321	12637	910 497	112 130

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

AXIAL BELLOWS

Design pressure 6 bar
Design temperature 300 °C
Test pressure 9 bar



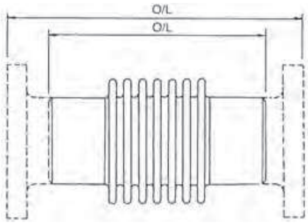
AR	6

NOMINAL DIAMETER mm	MOVEMENT ± mm	MOVEMENT total mm	FREE LENGHT O/L flange mm	FREE LENGHT O/L weld end mm	PIPE O/D mm	BELLOWS O/D mm	EFFECTIVE AREA cm^2	SPRING RATE N/mm	MASS kg
40	19 30	38 60	145 210	200 265	48,3	59	22	80 46	1 1
50	20 30	40 60	170 225	235 290	60,3	80	38	49 33	1 2
65	22,5 35	45 70	180 225	240 290	76,1	95	57	58 42	2 3
80	15 30 55	30 60 110	180 200 300	245 265 370	88,9	115	78	123 57 31	3 3 4
100	17,5 30 55	35 60 110	185 205 305	245 265 370	114,3	140	127	161 70 38	4 4 5
125	20 30 55	40 60 110	200 225 340	270 295 410	139,7	170	190	239 109 57	5 6 7
150	20 30 55	40 60 110	200 225 340	270 295 410	168,3	200	264	289 130 71	7 8 9
175	20 30 55 110	40 60 110 220	220 235 335 1020	295 305 410 915	193,7	235	356	448 186 103 52	9 10 13 35
200	20 30 60 120	40 60 120 240	225 240 365 1110	295 305 435 915	219,1	260	446	507 209 105 53	12 13 16 46
225	20 30 60 120	40 60 120 240		295 305 435 975	244,5	285	547	567 233 117 59	14 15 18 52
250	20 30 60 120	40 60 120 240	235 250 390 1145	295 305 445 1020	273	315	675	635 260 124 62	16 17 22 61
300	35 62,5 125	70 125 250	265 385 1180	345 465 1055	323,9	380	967	336 180 90	24 29 89
350	35 62,5 125	70 125 250	250 355 1130	330 435 1005	355,6	420	1175	261 142 71	25 32 93
400	35 62,5 125	70 125 250	255 360 1135	330 435 1005	406,4	475	1503	296 162 81	27 35 105
450	35 75 150	70 150 300		380 535 1185	457,2	535	1927	478 217 109	41 47 145
500	35 75 150	70 150 300	265 420 1325	380 535 1190	508	585	2341	529 241 121	45 59 160
600	35 75 150	70 150 300	265 420 1355	380 535 1190	609,6	690	3291	631 287 144	55 75 195
700	35 75	70 150	265 420	380 535	711,2	790	4404	733 333	82 91
750	35 75	70 150		380 535	762	840	5020	784 357	86 108
800	35 75	70 150	265 420	380 535	812,8	890	5678	835 380	90 115
900	35 75	70 150	265 420	380 535	914,4	995	7114	937 426	105 130
1000	35 75	70 150	265 420	380 535	1016	1095	8713	1039 473	115 145
1050	35 75	70 150		380 535	1065	1145	9573	1091 496	120 150
1100	35 75	70 150		380 535	1120	1195	10474	1142 520	125 160
1200	35 75	70 150	310 460	380 535	1220	1300	12397	1244 560	135 170

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

AXIAL BELLOWS

Design pressure 10 bar
Design temperature 300 °C
Test pressure 16 bar



AR | **10**

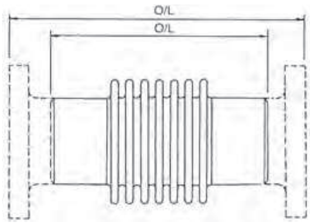
NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		PIPE O/D mm	BELLOWS O/D mm	EFFECTIVE AREA cm^2	SPRING RATE N/mm	MASS kg
	± mm	total mm	flange mm	weld end mm					
40	19 30	38 60	150 215	200 265	48,3	59	22	80 46	1 1
50	20 30	40 60	185 250	240 300	60,3	80	39	68 43	2 2
65	22,5 35	45 70	190 250	245 300	76,1	95	58	79 54	2 3
80	12,5 25 55	25 50 110	195 215 335	245 265 385	88,9	115	79	123 83 42	3 3 4
100	15 30 55	30 60 110	200 235 335	245 265 385	114,3	140	127	161 92 54	4 5 6
125	15 30 55	30 60 110	215 240 375	270 295 430	139,7	175	192	239 161 82	6 7 10
150	15 30 55	30 60 110	215 240 375	270 295 430	168,3	205	266	289 193 97	8 9 11
175	15 30 55 110	30 60 110 220	235 260 345 1025	295 320 400 900	193,7	235	358	448 260 163 82	12 12 15 41
200	15 30 55 110	30 60 120 220	240 265 360 1045	295 320 415 920	219,1	260	447	507 293 172 86	14 14 18 50
225	15 30 60 120	30 60 120 240		295 320 440 1015	244,5	285	549	567 326 172 86	16 17 22 60
250	15 30 60 120	30 60 120 240	250 275 415 1180	295 320 455 1040	273	315	677	635 363 182 91	18 19 26 68
300	35 62,5 125	70 125 250	285 400 1200	350 465 1060	323,9	385	967	461 263 132	27 34 100
350	35 62,5 125	70 125 250	270 385 1145	340 450 1005	355,6	425	1181	362 198 99	29 39 105
400	35 62,5 125	70 125 250	280 390 1150	340 450 1005	406,4	475	1510	412 225 113	33 45 120
450	35 75 150	70 150 300		390 555 1225	457,2	540	1934	670 305 153	47 65 180
500	35 75 150	70 150 300	290 450 1380	390 555 1220	508	595	2349	741 337 169	52 75 195
600	35 75 150	70 150 300	300 465 1380	390 555 1220	609,6	695	3301	881 401 202	80 90 240
700	35 75	70 150	300 465	390 555	711,2	795	4415	1022 465	93 120
750	35 75	70 150		390 555	762	850	5032	1092 497	95 125
800	35 75	70 150	315 485	390 555	812,8	900	5690	1163 529	100 135
900	35 75	70 150	325 490	390 555	914,4	1000	7128	1304 593	115 150
1000	35 75	70 150	325 490	390 555	1016	1100	8728	1445 657	125 170
1050	35 75	70 150		390 555	1065	1150	9589	1515 689	130 180
1100	35 75	70 150		390 555	1120	1205	10491	1586 721	140 190
1200	35 75	70 150		390 555	1220	1305	12415	1728 786	155 205

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

AR 16

AXIAL BELLOWS

Design pressure 16 bar
Design temperature 300 °C
Test pressure 25 bar



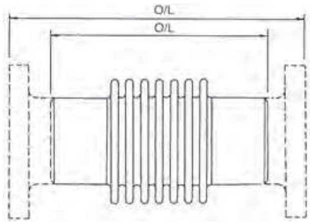
NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		PIPE O/D mm	BELLOWS O/D mm	EFFECTIVE AREA cm^2	SPRING RATE N/mm	MASS kg
	± mm	total mm	flange mm	weld end mm					
40	19 30	38 60	160 230	210 280	48,3	60	23	109 64	1 2
50	20 30	40 60	180 250	230 300	60,3	85	39	79 48	2 3
65	22,5 30	45 60	190 265	240 315	76,1	100	57	132 78	3 4
80	15 25 50	30 50 100	195 220 350	245 275 405	88,9	115	79	123 140 70	4 5 6
100	15 30 55	30 60 110	200 225 355	245 275 405	114,3	145	129	161 213 107	5 6 8
125	15 30 55	30 60 110	215 260 395	270 315 450	139,7	180	193	239 185 101	7 10 13
150	15 30 55	30 60 110	215 260 395	270 315 450	168,3	205	268	289 219 120	10 13 17
175	15 30 55	30 60 110	235 270 400	295 330 460	193,7	240	360	448 320 178	14 18 24
200	15 30 55	30 60 110	240 275 405	295 330 460	219,1	265	450	507 358 199	16 21 26
225	15 30 55	30 60 110		295 330 460	244,5	290	552	563 398 221	18 23 30
250	15 30 55	30 60 110	255 290 420	295 330 460	273	315	680	635 443 246	20 25 33
300	35 62,5 125	70 125 250	335 475 1340	385 525 1180	323,9	385	980	506 426 213	39 48 130
350	35 62,5 125	70 125 250	350 465 1310	390 505 1145	355,6	430	1191	535 438 219	48 50 140
400	35 62,5 125	70 125 250	355 475 1315	390 505 1145	406,4	480	1520	607 495 248	55 57 160
450	35 62,5 125	70 125 250		430 545 1130	457,2	545	1943	695 417 209	66 84 200
500	35 62,5 125	70 125 250	355 475 1315	430 545 1130	508	595	2358	766 460 230	73 93 225
600	35 62,5 125	70 125 250	365 480 1325	430 545 1130	609,6	700	3312	909 545 273	89 114 270
700	35 70	70 140	375 520	430 575	711,2	800	4427	1052 574	104 139
750	35 70	70 140		430 575	762	850	5045	1124 613	111 148
800	35 70	70 140	385 535	430 575	812,8	900	5704	1195 652	118 159
900	35 70	70 140	395 545	430 575	914,4	1005	7144	1339 730	134 177
1000	35 70	70 140	415 560	430 575	1016	1105	8745	1482 805	147 198
1050	35 70	70 140		430 575	1065	1155	9607	1554 848	156 207
1100	35 70	70 140		430 575	1120	1205	10509	1626 887	164 218
1200	35 70	70 140	435 580	430 575	1220	1310	12435	1770 966	177 239

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

AR 25

AXIAL BELLOWS

Design pressure 25 bar
Design temperature 300 °C
Test pressure 37,5 bar



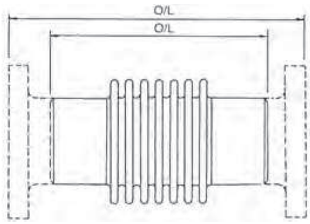
NOMINAL DIAMETER mm	MOVEMENT ± mm	MOVEMENT total mm	FREE LENGHT O/L flange mm	FREE LENGHT O/L weld end mm	PIPE O/D mm	BELLOWS O/D mm	EFFECTIVE AREA cm^2	SPRING RATE N/mm	MASS kg
40	10 20	20 40	150 215	190 255	48,3	60	23	135 68	1 2
50	12,5 24	25 48	175 255	220 300	60,3	80	38	137 69	2 3
65	12,5 24	25 48	190 265	225 300	76,1	95	58	158 86	3 4
80	15 30	30 60	220 330	255 370	88,9	115	80	187 94	4 5
100	15 30	30 60	235 345	255 370	114,3	140	128	236 118	6 7
125	22,5 45	45 90	280 430	310 460	139,7	175	192	254 127	9 13
150	22,5 45	45 90	290 440	310 460	168,3	205	267	305 153	13 17
175	22,5 45	45 90	290 445	320 470	193,7	240	360	484 242	19 25
200	22,5 45	45 90	300 455	320 470	219,1	265	450	545 273	21 27
225	22,5 45	45 90		320 470	244,5	290	552	603 302	23 31
250	22,5 45	45 90	320 470	320 470	273	315	680	673 337	25 34
300	30 40 80	60 80 160	370 425 1115	390 445 925	323,9	385	979	724 557 279	28 48 120
350	30 45 90	60 90 180	375 450 1175	380 455 970	355,6	430	1191	750 525 263	54 60 145
400	30 45 90	60 90 180	395 475 1195	380 455 970	406,4	480	1521	850 595 298	53 70 170
450	30 45 90	60 90 180		430 505 985	457,2	535	1891	950 665 333	65 78 205
500	30 45 90	60 90 180	500 1265	430 505 985	508	585	2302	1050 735 368	73 85 235
600	30 45 90	60 90 180	425 500 1265	430 505 985	609,6	685	3245	1250 875 438	90 105 315
700	30 45	60 90	445 535	450 535	711,2	800	4427	1618 1123	100 130
750	30 45	60 90		450 535	762	850	5045	1731 1212	120 140
800	30 45	60 90	465 550	450 535	812,8	900	5704	1844 1291	125 150

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

AR 40

AXIAL BELLOWS

Design pressure 40 bar
Design temperature 300 °C
Test pressure 60 bar

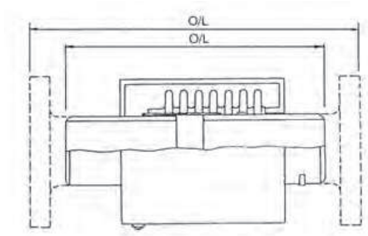


NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		PIPE O/D mm	BELLOWS O/D mm	EFFECTIVE AREA cm^2	SPRING RATE N/mm	MASS kg
	± mm	total mm	flange mm	weld end mm					
50	6,25 12,5	12,5 25	155 475	180 375	60,3	75	36	240 120	2 5
65	6,25 12,5	12,5 25	165 490	180 380	76,1	90	55	280 140	3 7
80	10 20	20 40	195 590	230 470	88,9	110	72	317 159	4 11
100	10 20	20 40	210 615	230 485	114,3	135	121	421 211	5 14
125	15 30	30 60	250 745	285 605	139,7	170	184	450 225	9 24
150	15 30	30 60	265 765	285 610	168,3	195	257	543 272	12 31
175	20 40	40 80	320 930	335 760	193,7	230	349	594 297	19 52
200	20 40	40 80	335 970	335 785	219,1	255	437	670 335	21 60
225	20 40	40 80		335 805	244,5	280	539	742 371	23 64
250	20 40	40 80	370 1040	335 825	273	310	665	829 415	26 73
300	22,5 45	45 90	405 1175	380 940	323,9	375	943	1282 641	40 115
350	25 50	50 100	460 1310	415 1055	355,6	415	1140	1093 545	48 145
400	25 50	50 100	480 1355	415 1085	406,4	465	1464	1249 625	60 175
450	30 60	60 120		495 1220	457,2	535	1891	1193 597	100 270
500	30 60	60 120	520 1560	495 1225	508	585	2302	1323 662	115 320
600	30 60	60 120		495 1250	609,6	685	3245	1582 791	155 425

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

EXTERNALY PRESSURIED
AXIAL BELLOWS

Design pressure 10 bar
Design temperature 300 °C
Test pressure 16 bar



AE 10

NOMINAL DIAMETER mm	MOVEMENT ± mm	MOVEMENT total mm	FREE LENGHT O/L flange mm	FREE LENGHT O/L weld end mm	PIPE O/D mm	BELLOWS O/D mm	EFFECTIVE AREA cm^2	SPRING RATE N/mm	MASS kg
80	100 150	200 300	1075 1470	975 1370	88,9	170	128	27 18	32 48
100	100 150	200 300	1075 1470	975 1370	114,3	220	192	45 30	39 55
125	100 150	200 300	1090 1485	975 1370	139,7	245	266	53 36	41 57
150	100 150	200 300	1115 1515	1000 1405	168,3	275	357	72 48	48 68
175	100 150	200 300	1120 1525	1000 1405	193,7	305	446	85 57	56 80
200	100 150	200 300	1130 1535	1000 1405	219,1	330	546	95 63	70 100
225	100 150	200 300		1015 1430	244,5	350	674	104 69	95 135
250	100 150	200 300	1155 1570	1015 1430	273	405	976	154 103	115 160
300	100 150	200 300	1155 1570	1015 1430	323,9	510	1181	121 81	175 245
350	100 150	200 300	1155 1570	1015 1430	355,6	560	1509	136 91	215 300
400	100 150	200 300	1160 1508	1015 1430	406,4	610	1934	209 140	260 355
450	100 150	200 300		1015 1430	457,2	660	2349	231 154	325 455
500	100 150	200 300	1165 1585	1015 1430	508	760	3301	275 184	395 560
600	100 150	200 300	1180 1590	1015 1430	609,6	890	4414	319 213	585 820

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

EXTERNALY PRESSURIED
AXIAL BELLOWS

Design pressure 16 bar
Design temperature 300 °C
Test pressure 25 bar

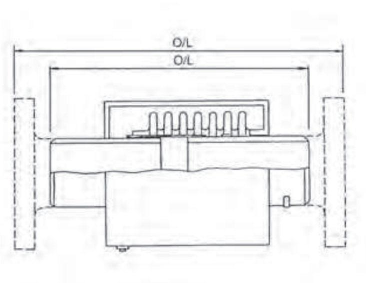
AE 16

NOMINAL DIAMETER mm	MOVEMENT ± mm	MOVEMENT total mm	FREE LENGHT O/L flange mm	FREE LENGHT O/L weld end mm	PIPE O/D mm	BELLOWS O/D mm	EFFECTIVE AREA cm^2	SPRING RATE N/mm	MASS kg
80	100 150	200 300	1115 1520	1015 1420	88,9	170	126	53 36	32 45
100	100 150	200 300	1140 1560	1040 1460	114,3	220	190	53 35	43 60
125	100 150	200 300	1115 1570	1040 1460	139,7	245	246	65 44	45 61
150	100 150	200 300	1155 1570	1040 1460	168,3	275	354	88 59	50 70
175	100 150	200 300	1160 1580	1040 1460	193,7	305	443	98 66	60 85
200	100 150	200 300	1165 1600	1040 1470	219,1	330	543	109 73	80 110
225	100 150	200 300		1040 1470	244,5	350	669	121 81	98 140
250	100 150	200 300	1180 1635	1090 1545	273	405	966	162 108	120 170
300	100 150	200 300	1250 1730	1140 1625	323,9	510	1194	214 143	200 280
350	100 150	200 300	1305 1790	1140 1625	355,6	560	1513	238 159	245 345
400	100 150	200 300	1310 1795	1140 1625	406,4	610	1943	231 154	295 420
450	100 150	200 300		1140 1625	457,2	660	2358	255 170	370 520
500	100 150	200 300	1320 1850	1140 1625	508	760	3311	303 202	455 645
600	100 150	200 300	1330 1865	1140 1625	609,6	890	4427	350 234	665 940

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

EXTERNALY PRESSURIED
AXIAL BELLOWS

Design pressure	25 bar
Design temperature	300 °C
Test pressure	37,5 bar



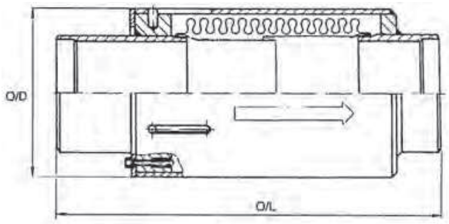
AE 25

NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		PIPE O/D mm	BELLOWS O/D mm	EFFECTIVE AREA cm^2	SPRING RATE N/mm	MASS kg
	± mm	total mm	flange mm	weld end mm					
80	100 150	200 300	1130 1790	1015 1675	88,9	170	127	81 54	35 55
100	100 150	200 300	1260 1805	1130 1675	114,3	220	191	89 60	45 68
125	100 150	200 300	1270 1815	1130 1675	139,7	245	265	106 71	50 72
150	100 150	200 300	1330 1825	1180 1675	168,3	275	355	158 106	55 80
175	100 150	200 300	1330 1825	1180 1675	193,7	305	444	178 119	70 98
200	100 150	200 300	1340 1830	1180 1675	219,1	330	544	198 132	90 125
225	100 150	200 300		1180 1675	244,5	350	670	221 147	114 159
250	100 150	200 300	1365 1860	1190 1685	273	405	965	257 171	135 190
300	100 150	200 300	1375 1870	1190 1685	323,9	510	1191	202 135	210 295
350	100 150	200 300	1410 1930	1205 1725	355,6	560	1521	229 153	260 370
400	100 150	200 300	1440 1960	1215 1735	406,4	610	1891	256 171	315 450
450	100 150	200 300		1215 1735	457,2	660	2302	283 189	395 565
500	100 150	200 300	1495 2005	1245 1750	508	760	3245	337 225	495 695
600	100 150	200 300	1495 2005	1245 1750	609,6	890	4426	628 419	730 1020

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

MAX - COMP

Design pressure 10 bar
Design temperature 300 °C
Test pressure 16 bar

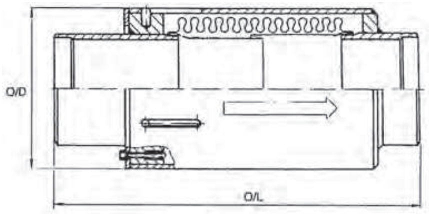


MC	10

NOMINAL DIAMETER mm	TOTALL MOVEMENT COMPRESSION mm	INSTALLED LENGHT O/L mm	PIPE O/D mm	BELLOWS O/D mm	EFFECTIVE AREA cm^2	SPRING RATE N/mm	MASS kg
40	38 60	267 364	48,3	76,1	21	77 45	5 6
50	40 60	300 391	60,3	101,6	37	51 36	6 6
65	45 70	321 415	76,1	114,3	56	57 38	7 8
80	50 100	337 531	88,9	139,7	76	64 32	10 14
100	60 110	376 552	114,3	159	126	66 36	13 18
125	60 110	381 593	139,7	193,7	182	80 43	22 32
150	60 110	381 593	168,3	219,1	255	95 51	25 36
175	60 110	406 564	193,7	273	358	187 163	35 43
200	60 110	406 578	219,1	298,5	447	211 172	49 62
250	60 120	406 634	273	355,6	677	259 182	55 79
300	70 125	488 683	323,9	419	971	299 180	99 118
350	70 125	475 671	355,6	457,2	1134	326 196	120 147
400	70 125	480 676	406,4	508	1457	372 223	146 181
450	70 150	523 803	457,2	609,6	1820	417 209	227 294
500	70 150	523 808	508	660,4	2224	463 231	281 368
600	70 150	531 816	609,6	762	3154	554 277	344 445

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

MAX - COMP
Design pressure 16 bar
Design temperature 300 °C
Test pressure 25 bar



MC 16

NOMINAL DIAMETER mm	TOTALL MOVEMENT COMPRESSION mm	INSTALLED LENGHT O/L mm	PIPE O/D mm	BELLOWS O/D mm	EFFECTIVE AREA cm^2	SPRING RATE N/mm	MASS kg
40	38 60	275 379	48,3	76,1	21	105 61	5 7
50	40 60	293 394	60,3	101,6	37	77 52	6 7
65	45 70	315 428	76,1	114,3	57	83 53	7 10
80	50 100	346 551	88,9	139,7	77	134 67	13 16
100	60 110	367 572	114,3	159	129	134 72	15 20
125	60 110	404 613	139,7	193,7	192	163 82	25 35
150	60 110	404 613	168,3	219,1	266	195 98	27 38
175	60 110	417 621	193,7	273	347	213 107	39 52
200	60 110	417 621	219,1	298,5	436	238 119	53 70
250	60 110	417 631	273	355,6	663	293 147	60 84
300	70 125	520 742	323,9	419	976	451 246	108 129
350	70 125	527 725	355,6	457,2	1140	499 266	137 175
400	70 125	532 730	406,4	508	1453	568 303	164 208
450	70 125	562 762	457,2	609,6	1827	636 340	251 308
500	70 125	572 771	508	660,4	2232	705 376	312 387
600	70 125	580 779	609,6	762	3162	842 449	383 472

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

MAX - COMP
Design pressure 25 bar
Design temperature 300 °C
Test pressure 37,5 bar

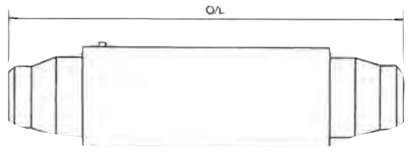
MC 25

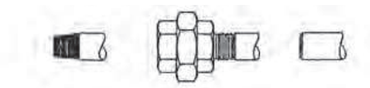
NOMINAL DIAMETER mm	TOTALL MOVEMENT COMPRESSION mm	INSTALLED LENGHT O/L mm	PIPE O/D mm	BELLOWS O/D mm	EFFECTIVE AREA cm^2	SPRING RATE N/mm	MASS kg
40	38 60	295 380	48,3	76,1	22	96 60	5 7
50	40 60	330 422	60,3	101,6	38	101 69	6 7
65	45 70	335 428	76,1	114,3	56	126 86	7 10
80	50 100	355 551	88,9	139,7	80	174 87	12 16
100	60 110	418 573	114,3	159	128	181 64	17 22
125	60 110	425 635	139,7	193,7	175	221 110	22 30
150	60 110	436 635	168,3	219,1	241	241 120	30 41
200	60 110	440 640	219,1	298,5	450	472 236	54 71
250	60 110	440 650	273	355,6	680	583 292	66 90
300	70 125	565 760	323,9	419	965	804 459	115 150
350	70 125	580 780	355,6	457,2	1141	1057 662	140 175
400	70 125	585 780	406,4	508	1467	951 535	162 210
450	70 125	595 810	457,2	609,6	1829	1344 878	250 325
500	70 125	595 810	508	660,4	2234	1490 972	315 350
600	70 125	595 810	609,6	762	4169	1278 1052	320 415

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

AXIAL BELLOWS
FOR CENTRAL HEATING

Design pressure 10 bar
Design temperature 300 °C
Test pressure 16 bar





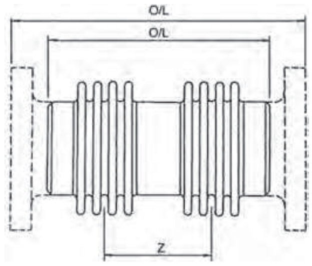
AS 10

NOMINAL DIAMETER mm	TOTALL MOVEMENT COMPRESSION mm	INSTALLED LENGHT O/L mm	PIPE O/D mm	BELLOWS O/D mm	COMPRESSION FORCE N	MASS kg
15	30	209	21,3x2,65	36	257	0,5
20	30	206	26,9x2,65	42	260	0,7
25	30	215	33,7x3,25	53	319	0,9
32	30	233	42,2x3,25	60	380	1,3
40	30	241	48,3x3,25	70	452	2,2
50	30	241	60,3x3,65	75	512	3,6

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

UNRESTRAINED DOUBLE BELLOWS

Design pressure 2 bar
Design temperature 300 °C
Test pressure 3 bar



UD 2

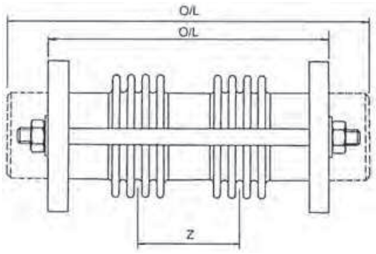
NOMINAL DIAMETER mm	MOVEMENT				FREE LENGHT O/L mm	BELLOWS CENTRE DISTANCE "Z" mm	EFFECTIVE AREA cm^2	SPRING RATE	
	axial mm	lateral mm	COMBINATION					axial N/mm	lateral N/mm
			axial mm	lateral mm					
50	18	65	10	30	479	330	37	32	1
65	18	65	10	30	489	330	55	41	2
80	24	65	12	30	501	330	75	32	2
100	24	65	12	30	501	332	126	42	3
125	45	65	18	30	476	254	189	45	9
150	45	65	18	30	476	254	263	53	14
175	58	65	22	30	489	254	354	64	23
200	58	65	22	30	514	305	443	72	22
225	58	65	22	30	570	330	545	82	26
250	58	65	22	30	609	356	672	90	31
300	60	65	22	30	672	406	967	110	42
350	65	65	25	40	733	457	1171	84	30
400	65	65	25	40	733	457	1498	95	44
450	78	65	25	45	781	457	1919	129	76
500	78	65	25	45	860	533	2332	143	75
600	78	65	25	45	901	584	3281	171	105
700	78	65	25	45	1009	660	4391	199	128
750	78	65	25	45	1022	698	5007	213	140
800	78	65	25	45	1089	737	5664	227	151
900	78	65	25	45	1124	762	7099	256	199
1000	100	65	35	50	1200	813	8918	288	248
1050	100	65	35	50	1251	864	9787	302	252
1100	100	65	35	50	1276	890	10697	316	272
1200	100	65	35	50	1378	991	12639	344	283

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

TD	3,5

TWO TIE BAR
DOUBLE TIED BELLOWS

Design pressure	3,5 bar
Design temperature	300 °C
Test pressure	5,25 bar
Basic lateral movement	±25 mm



NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
350	610	760	635	635	240	90	45	96
400	610	760	735	685	240	131	66	148
450	665	840	785	760	255	203	115	214
500	660	840	865	840	255	273	155	262
600	685	865	1015	940	255	459	260	422
700	710	890	1145	1065	270	638	404	631
750	735	915	1220	1115	290	675	494	695
800	760	965	1320	1170	330	751	711	860
900	785	990	1420	1245	360	854	962	1049

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

TD	6

TWO TIE BAR
DOUBLE TIED BELLOWS

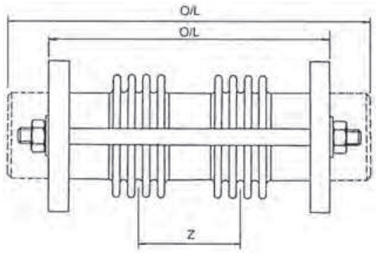
Design pressure	6 bar
Design temperature	300 °C
Test pressure	10 bar
Basic lateral movement	±25 mm

NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
80	570	550	255	205	150	14	3	3
100	605	585	305	255	150	29	7	5
125	615	595	355	280	150	65	13	7
150	680	660	380	330	150	109	22	16
175	700	680	455	355	150	227	45	26
200	715	700	485	405	150	321	63	38
225	730	710	535	430	200	249	87	45
250	740	725	560	480	200	343	120	55
300	775	755	660	560	240	243	122	93
350	610	785	710	660	240	171	86	143
400	610	810	790	711	240	248	124	217
450	635	840	865	787	240	513	257	267
500	635	865	965	865	240	690	346	376
600	660	890	1115	940	240	1155	579	579
700	710	940	1220	1065	265	1472	899	819
750	735	990	1320	1145	290	1499	1096	1011
800	785	1040	1370	1195	330	1394	1320	1071
900	840	1145	1549	1320	365	1602	1856	1342

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

TWO TIE BAR
DOUBLE TIED BELLOWS

Design pressure	10 bar
Design temperature	300 °C
Test pressure	16 bar
Basic lateral movement	±25 mm



TD 10

NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
80	570	550	280	230	150	14	3	3
100	605	585	305	255	150	29	7	5
125	615	595	355	280	150	65	13	13
150	680	660	380	330	150	109	22	20
175	700	680	455	380	150	227	45	31
200	715	700	480	405	215	181	63	38
225	730	710	560	430	200	249	87	46
250	740	725	585	480	215	297	120	68
300	775	755	660	560	240	337	169	94
350	660	840	785	660	240	240	120	158
400	685	865	865	735	240	348	175	225
450	685	915	965	815	240	728	365	328
500	685	915	1065	865	240	975	489	453
600	710	965	1220	990	240	1628	815	688
700	785	1020	1370	1115	265	2068	1263	934
750	815	1095	1475	1195	290	2103	1538	1112
800	865	1090	1550	1270	330	1954	1850	1185
900	1575	1345	1700	1395	365	2241	2597	906

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

TWO TIE BAR
DOUBLE TIED BELLOWS

Design pressure	16 bar
Design temperature	300 °C
Test pressure	25 bar
Basic lateral movement	±25 mm

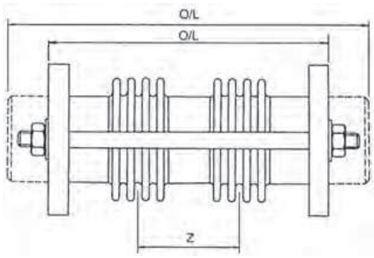
TD 16

NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
80	570	550	330	230	150	14	3	6
100	605	585	380	280	150	29	7	11
125	615	595	430	330	150	65	13	19
150	680	660	480	355	205	58	22	24
175	700	680	480	380	205	122	45	31
200	715	700	560	430	215	157	63	46
225	755	735	585	455	240	172	87	54
250	770	750	685	510	240	238	120	77
300	940	915	710	858	240	422	212	141
350	810	1015	845	685	305	222	179	170
400	810	1040	940	735	305	321	260	247
450	810	1090	1015	835	305	472	382	355
500	810	1145	1120	910	305	631	511	484
600	810	1145	1295	1040	305	1049	848	736
700	1420	1145	1475	1195	305	1619	1310	624
750	1420	1270	1320	1320	325	1735	1593	789
800	1525	1320	1370	1370	330	2022	1915	831
900	1625	1420	1525	1525	365	2315	2682	1098

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

TWO TIE BAR
DOUBLE TIED BELLOWS

Design pressure	25 bar
Design temperature	300 °C
Test pressure	37,5 bar
Basic lateral movement	±25 mm



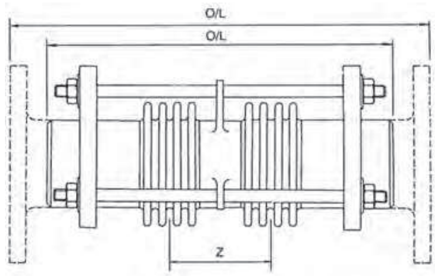
TD **25**

NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		**ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT** ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
80	570	550	330	255	150	24	5	7
100	615	595	405	305	150	49	10	13
125	655	635	430	330	150	95	10	18
150	680	660	480	380	175	116	31	29
175	770	750	535	405	175	231	62	41
200	820	800	635	455	215	215	87	49
225	895	875	635	510	215	291	117	63
250	920	900	685	535	240	320	161	76
300	735	1065	710	610	290	458	335	155
350	735	1015	890	735	265	486	297	240
400	760	1069	990	810	265	702	429	332
450	760	1090	1090	865	265	973	595	448
500	760	1090	1165	965	265	1307	798	545
600	1320	1090	1115	1115	290	1827	1336	546
700	1500	1220	1295	1295	365	2029	2350	697
750	1575	1270	1370	1370	415	1912	2863	756
800	1625	1295	1500	1500	415	2301	3446	969

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

MULTI TIE BAR
DOUBLE TIED BELLOWS

Design pressure 3,5 bar
Design temperature 300 °C
Test pressure 5,25 bar
Basic lateral movement ±25 mm



TM 3,5

NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
350	610	735	660	635	240	90	45	96
400	610	735	735	685	240	131	66	148
450	660	760	785	760	255	203	115	175
500	660	810	840	815	255	273	155	212
600	660	810	990	940	255	459	260	368
700	685	810	1115	1040	270	638	404	564
750	710	840	1195	1090	290	675	494	621
800	760	890	1245	1145	330	751	711	652
900	810	990	1400	1245	360	854	962	894

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

TM 6

MULTI TIE BAR
DOUBLE TIED BELLOWS

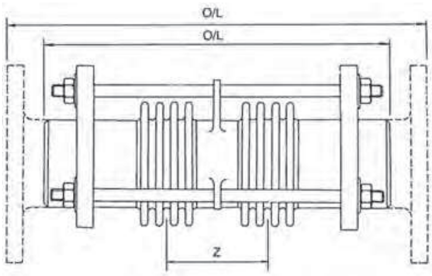
Design pressure 6 bar
Design temperature 300 °C
Test pressure 10 bar
Basic lateral movement ±25 mm

NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
80	570	550	255	205	150	14	3	3
100	605	585	305	255	150	29	7	5
125	615	595	355	280	150	65	13	7
150	680	660	380	330	150	109	22	8
175	700	680	455	355	150	227	45	21
200	715	700	480	405	150	321	63	25
225	730	710	535	430	200	249	87	38
250	740	725	560	480	200	343	120	46
300	775	775	660	560	240	243	122	76
350	595	760	685	635	240	171	86	119
400	595	785	785	710	240	248	124	187
450	635	810	840	785	240	513	257	225
500	635	840	940	840	240	690	346	325
600	635	865	1065	965	240	1155	579	529
700	685	915	1195	1065	265	1472	899	746
750	710	915	1270	1195	290	1499	1096	821
800	760	990	1320	1170	330	1394	1320	867
900	810	990	1475	1270	365	1602	1856	1160

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

MULTI TIE BAR
DOUBLE TIED BELLOWS

Design pressure	10 bar
Design temperature	300 °C
Test pressure	16 bar
Basic lateral movement	±25 mm



TM 10

NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
80	570	550	280	230	150	14	3	3
100	605	585	305	255	150	29	7	5
125	615	595	355	285	150	65	13	7
150	680	660	380	330	150	109	22	16
175	700	680	455	380	150	227	45	26
200	715	700	480	405	200	181	63	38
225	730	710	560	430	200	249	87	45
250	740	725	585	480	215	297	120	55
300	775	755	660	560	240	337	169	94
350	660	810	760	660	240	240	120	133
400	660	810	840	710	240	348	175	202
450	685	840	915	785	240	728	365	249
500	685	890	990	865	240	975	489	350
600	710	890	1170	940	240	1628	815	540
700	760	915	1295	1040	265	2068	1263	767
750	785	965	1370	1115	290	2103	1538	847
800	865	1015	1420	1170	330	1954	1850	869
900	890	1090	1575	1295	365	2241	2597	1186

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

MULTI TIE BAR
DOUBLE TIED BELLOWS

Design pressure	16 bar
Design temperature	300 °C
Test pressure	25 bar
Basic lateral movement	±25 mm

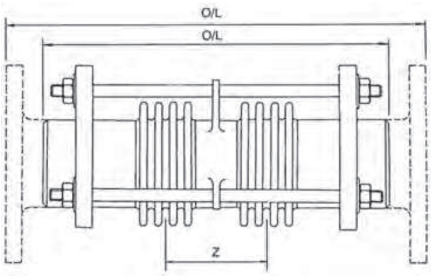
TM 16

NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
80	570	550	330	230	150	14	3	3
100	605	585	380	280	150	29	7	9
125	615	595	430	330	150	65	13	13
150	680	660	480	355	200	58	22	20
175	700	680	480	380	200	122	45	31
200	715	700	560	430	215	157	63	38
225	755	735	585	455	240	172	87	54
250	770	750	685	510	240	238	120	77
300	940	915	710	585	240	422	212	92
350	785	965	785	660	305	222	179	133
400	785	1015	865	710	305	321	260	197
450	785	1015	965	785	305	472	382	287
500	785	1040	1040	840	305	631	511	349
600	810	1040	1195	965	305	1049	848	540
700	840	1065	1345	1090	305	1619	1310	780
750	890	1120	1445	1165	325	1735	1593	941
800	890	1170	1525	1245	330	2022	1915	1154
900	940	1245	1675	1370	365	2315	2682	1368

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

MULTI TIE BAR
DOUBLE TIED BELLOWS

Design pressure	25 bar
Design temperature	300 °C
Test pressure	37,5 bar
Basic lateral movement	±25 mm

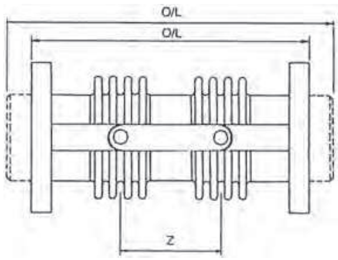


TM 25

NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
80	570	550	330	255	150	24	5	6
100	615	595	405	305	150	49	10	11
125	655	635	430	330	150	95	19	18
150	680	660	480	380	175	116	31	24
175	770	750	535	405	175	231	62	35
200	820	800	635	455	215	215	87	41
225	895	875	635	510	215	291	117	55
250	920	900	685	535	240	320	161	65
300	735	1065	710	610	290	458	335	136
350	710	940	840	685	265	486	297	195
400	710	940	915	735	265	702	429	249
450	710	940	990	810	265	973	595	352
500	735	965	1090	890	265	1307	798	464
600	760	1040	1270	1015	290	1827	1336	709
700	865	1170	1420	1170	365	2029	2350	921
750	940	1270	1400	1220	415	1912	2863	966
800	940	1320	1575	1295	415	2301	3446	1214

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

DOUBLE HINGE BELLOWS
Design pressure 3,5 bar
Design temperature 300 °C
Test pressure 5,25 bar
Basic lateral movement ±25 mm



HD 3,5

NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
350	610	840	610	585	240	90	45	122
400	610	865	685	635	240	131	66	156
450	660	890	710	685	255	203	115	226
500	660	890	785	735	255	273	155	275
600	685	965	890	840	255	459	260	515
700	710	1015	1015	965	270	638	404	732
750	735	1015	1090	1015	290	675	494	777
800	760	1065	1170	1065	330	751	711	853
900	785	1065	1270	1170	360	854	962	1184

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

DOUBLE HINGE BELLOWS
Design pressure 6 bar
Design temperature 300 °C
Test pressure 10 bar
Basic lateral movement ±25 mm

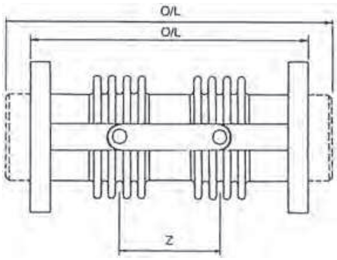
HD 6

NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
80	570	550	205	205	150	14	3	12
100	605	585	230	230	150	29	7	19
125	615	595	255	255	150	65	13	32
150	680	660	280	280	150	109	22	44
175	700	680	330	330	150	227	45	71
200	715	700	355	355	150	321	63	89
225	730	710	380	380	200	249	87	96
250	740	725	405	405	200	343	120	118
300	775	755	480	480	240	243	122	142
350	610	840	610	585	240	171	86	147
400	610	865	685	635	240	248	124	251
450	635	915	710	685	240	513	257	361
500	660	915	785	735	240	690	346	439
600	685	965	915	865	240	1155	579	689
700	711	1015	1040	990	265	1472	899	1080
750	760	1090	1115	1065	290	1499	1096	1126
800	810	1170	1195	1115	330	1394	1320	1205
900	890	1015	1320	1245	365	1602	1856	1462

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

DOUBLE HINGE BELLOWS

Design pressure 10 bar
Design temperature 300 °C
Test pressure 16 bar
Basic lateral movement ±25 mm



HD 10

NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
80	570	550	205	205	150	14	3	12
100	605	585	255	230	150	29	7	19
125	615	595	280	255	150	65	13	32
150	680	660	330	280	150	109	22	44
175	700	680	330	330	150	227	45	71
200	715	700	380	355	200	181	63	67
225	730	710	405	380	200	249	87	96
250	740	725	455	405	215	297	120	110
300	775	755	535	480	240	337	169	143
350	635	915	660	585	240	240	120	197
400	660	965	735	635	240	348	175	283
450	685	965	810	710	240	728	365	403
500	685	1015	890	760	240	975	489	588
600	710	1040	1040	890	240	1628	815	894
700	710	915	1170	1015	265	2068	1263	1250
750	785	965	1245	1090	290	2103	1538	1302
800	840	1040	1295	1145	330	1954	1850	1465
900	1370	1145	1445	1295	365	2241	2597	1856

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

DOUBLE HING BELLOWS

Design pressure 16 bar
Design temperature 300 °C
Test pressure 25 bar
Basic lateral movement ±25 mm

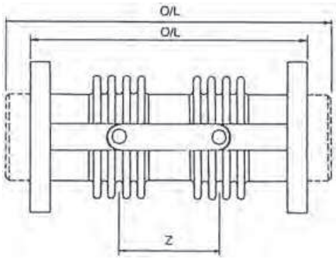
HD 16

NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
80	560	550	205	205	150	14	3	12
100	605	585	255	230	150	29	7	19
125	615	595	280	255	150	65	13	32
150	680	660	330	280	205	58	22	39
175	700	680	330	330	205	122	45	52
200	715	700	380	355	215	157	63	62
225	755	735	405	380	240	172	87	80
250	770	750	455	455	240	238	120	99
300	940	915	535	535	240	422	212	184
350	810	1090	685	585	305	222	179	195
400	810	1145	760	635	305	321	260	298
450	810	1145	840	735	305	472	382	414
500	810	1170	915	810	305	631	511	542
600	865	1170	1065	965	305	1049	848	869
700	915	1145	1220	1090	305	1619	1310	1379
750	1345	1170	1295	1145	325	1735	1593	1553
800	1575	1370	1345	1220	330	2022	1915	1902
900	1625	1420	1500	1345	365	2315	2682	2349

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

DOUBLE HINGE BELLOWS

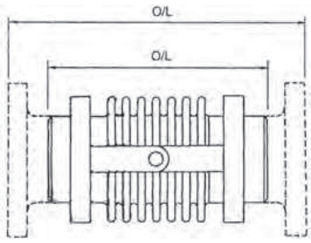
Design pressure	25 bar
Design temperature	300 °C
Test pressure	37,5 bar
Basic lateral movement	±25 mm



HD 25

NOMINAL DIAMETER mm	FREE LENGHT O/L		MAXIMUM O/D		**ADDITIONAL MEASURE "Z" TO GIVE ADDITIONAL MOVEMENT** ±25 mm	SPRING RATE N/mm		FRICTION FORCE N/bar
	flange mm	weld end mm	flange mm	weld end mm		lateral N/mm	angular Nm/°	
80	570	550	205	205	150	24	5	12
100	615	595	255	230	150	49	10	19
125	655	635	280	255	150	95	19	32
150	680	660	330	330	175	116	31	46
175	770	750	355	355	175	231	62	62
200	820	800	405	405	215	215	87	74
225	895	875	455	455	215	291	117	116
250	920	900	480	480	240	320	161	128
300	735	1065	635	585	290	458	335	169
350	735	1090	735	660	265	486	297	293
400	760	1145	810	710	265	702	429	402
450	760	890	890	810	265	973	595	607
500	760	890	965	1170	265	1307	798	782
600	760	1040	1145	1065	290	1827	1336	1119
700	865	1220	1320	1245	365	2029	2350	1456
750	940	1295	1370	1295	415	1912	2863	1581
800	945	1320	1445	1370	415	2301	3446	1924

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!



HS 3,5

SINGLE HINGE BELLOWS

Design pressure	3,5 bar
Design temperature	300 °C
Test pressure	5,25 bar

NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		MAXIMUM O/D		ANGULAR SPRING RATE Nm/°	FRICTION MOMENT Nm/bar
	±°	total °	flange mm	weld end mm	flange mm	weld end mm		
350	8	16	380	610	610	585	45	15
400	8	16	380	610	685	635	66	19
450	8	16	405	635	710	685	115	29
500	7	14	405	635	785	735	155	35
600	7	14	430	760	890	840	260	66
700	5,5	11	430	760	1015	965	404	99
750	5	11	455	760	1090	1015	494	113
800	4,5	9	455	760	1170	1065	711	141
900	4	8	480	785	1270	1170	962	213

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

HS 6

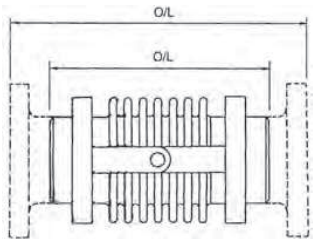
SINGLE HINGE BELLOWS

Design pressure	6 bar
Design temperature	300 °C
Test pressure	10 bar

NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		MAXIMUM O/D		ANGULAR SPRING RATE Nm/°	FRICTION MOMENT Nm/bar
	±°	total °	flange mm	weld end mm	flange mm	weld end mm		
80	10	20	380	360	205	205	3	1
100	10	20	400	380	230	230	7	2
125	10	20	405	385	255	255	13	3
150	10	20	470	450	280	280	22	4
175	10	20	480	465	330	330	45	6
200	10	20	500	480	355	355	63	7
225	8	16	515	495	380	380	87	10
250	8	16	525	510	405	405	120	12
300	8	16	535	515	480	480	122	17
350	8	16	380	585	610	585	86	18
400	8	16	380	610	685	635	124	30
450	8	16	405	660	710	685	257	44
500	7	14	430	685	785	735	346	53
600	6	12	455	760	915	865	579	83
700	5,5	11	455	785	1040	990	899	144
750	5	10	480	810	1115	1065	1096	164
800	4,5	9	510	840	1195	1115	1320	199
900	4	8	535	685	1320	1245	1856	267

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

SINGLE HINGE BELLOWS
Design pressure 10 bar
Design temperature 300 °C
Test pressure 16 bar



HS 10

NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		MAXIMUM O/D		ANGULAR SPRING RATE Nm/°	FRICTION MOMENT Nm/bar
	±°	total °	flange mm	weld end mm	flange mm	weld end mm		
80	10	20	380	360	205	205	3	1
100	10	20	400	380	255	230	7	2
125	10	20	405	385	280	255	13	3
150	10	20	470	450	330	280	22	4
175	10	20	480	465	330	330	45	6
200	8	16	500	480	380	355	63	7
225	8	16	515	495	405	380	87	10
250	7	14	525	510	455	405	120	12
300	8	16	535	515	535	480	169	17
350	8	16	405	660	660	585	120	24
400	8	16	430	710	735	635	175	34
450	8	16	430	735	810	710	365	49
500	7	14	455	785	890	760	489	71
600	6	12	480	785	1040	890	815	108
700	5,5	11	535	660	1170	1015	1263	166
750	5	10	560	680	1245	1090	1538	189
800	4	8	610	735	1295	1145	1850	242
900	4	8	1016	785	1445	1295	2597	339

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

SINGLE HINGE BELLOWS
Design pressure 16 bar
Design temperature 300 °C
Test pressure 25 bar

HS 16

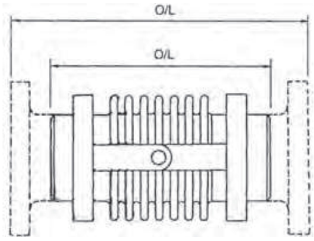
NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		MAXIMUM O/D		ANGULAR SPRING RATE Nm/°	FRICTION MOMENT Nm/bar
	±°	total °	flange mm	weld end mm	flange mm	weld end mm		
80	10	20	380	360	205	205	3	1
100	10	20	400	380	255	230	7	2
125	10	20	405	385	280	255	13	3
150	8	16	470	450	330	280	22	4
175	8	16	480	465	330	330	45	6
200	7	14	500	480	380	355	63	7
225	6	12	515	495	405	380	87	10
250	6	12	525	510	455	455	120	12
300	8	16	685	660	535	535	212	22
350	8	16	480	785	685	585	179	30
400	8	16	480	810	760	635	260	46
450	8	16	510	840	840	735	383	64
500	7	14	510	865	915	810	511	83
600	6	12	560	915	1065	965	848	133
700	5,5	11	610	940	1220	1090	1310	211
750	5	10	1015	940	1295	1145	1593	253
800	4,5	9	1245	1040	1345	1220	1915	314
900	4	8	1270	1065	1500	1345	2682	429

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer

HS 25

SINGLE HINGE BELLOWS

Design pressure 25 bar
Design temperature 300 °C
Test pressure 32,5 bar



NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		MAXIMUM O/D		ANGULAR SPRING RATE Nm/°	FRICTION MOMENT Nm/bar
	±°	total °	flange mm	weld end mm	flange mm	weld end mm		
80	10	20	380	360	205	205	5	1
100	10	20	400	380	255	230	10	2
125	10	20	445	425	280	255	19	3
150	9	18	470	450	330	330	31	4
175	9	18	535	535	355	355	62	6
200	7	14	585	585	405	405	87	8
225	7	14	660	660	455	455	117	13
250	6	12	660	660	480	480	161	16
300	5	10	455	785	635	585	335	25
350	7	14	455	810	735	660	297	39
400	6,5	13	510	865	810	710	429	54
450	6	12	560	685	890	810	595	81
500	5,5	11	585	710	965	1170	798	104
600	5	10	365	890	1145	1065	1336	163
700	4	8	1270	1090	1320	1245	2350	266
750	3,5	7	1370	1195	1370	1295	2863	328
800	3,5	7	1525	1320	1445	1370	3445	400

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

HS 40

SINGLE HINGE BELLOWS

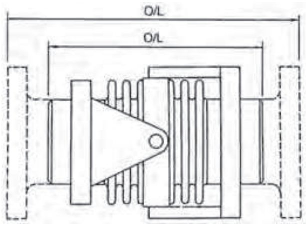
Design pressure 40 bar
Design temperature 300 °C
Test pressure 60 bar

NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		MAXIMUM O/D		ANGULAR SPRING RATE Nm/°	FRICTION MOMENT Nm/bar
	±°	total °	flange mm	weld end mm	flange mm	weld end mm		
80	4	8	456	430	230	230	12	1
100	3,5	7	480	455	255	255	27	2
125	3,5	7	510	480	305	305	48	3
150	3	6	535	510	355	355	80	5
175	3	6	560	535	380	380	129	7
200	3	6	635	610	455	455	181	10
225	2,5	5	660	635	480	480	247	14
250	2,5	5	685	660	535	535	339	19
300	2,5	5	685	660	610	610	688	31
350	2,5	5	700	685	660	660	705	43
400	2,5	5	965	840	710	710	1031	66
450	2,5	5	1065	940	810	810	1066	90
500	2,5	5	1115	965	890	890	1436	127
600	2,5	5	1270	1115	1040	1040	2415	203

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

GS	3,5

SINGLE GIMBAL BELLOWS
Design pressure 3,5 bar
Design temperature 300 °C
Test pressure 5,25 bar



NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		MAXIMUM O/D		ANGULAR SPRING RATE Nm/°	FRICTION MOMENT Nm/bar
	±°	total °	flange mm	weld end mm	flange mm	weld end mm		
350	8	16	380	610	660	610	45	15
400	8	16	380	610	735	685	66	19
450	8	16	405	635	785	760	115	29
500	7	14	405	635	865	810	155	35
600	7	14	430	760	990	965	260	66
700	5,5	11	430	760	1115	1095	404	99
750	5	11	480	760	1220	1170	494	113
800	4,5	9	510	760	1295	1245	711	141
900	4	8	610	785	1445	1370	962	213

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

GS	6

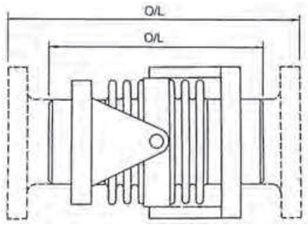
SINGLE GIMBAL BELLOWS
Design pressure 6 bar
Design temperature 300 °C
Test pressure 10 bar

NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		MAXIMUM O/D		ANGULAR SPRING RATE Nm/°	FRICTION MOMENT Nm/bar
	±°	total °	flange mm	weld end mm	flange mm	weld end mm		
80	10	20	380	360	190	140	3	1
100	10	20	400	380	230	150	7	2
125	10	20	405	385	255	175	13	3
150	10	20	470	450	280	205	22	4
175	10	20	480	465	35	240	45	6
200	10	20	500	480	340	265	63	7
225	8	16	515	495	380	330	87	10
250	8	16	525	510	405	380	120	12
300	8	16	535	515	510	510	122	17
350	8	16	380	585	660	610	86	18
400	8	16	380	610	735	685	124	30
450	8	16	405	660	785	760	257	44
500	7	14	405	685	865	810	346	53
600	6	12	495	760	990	965	579	83
700	5,5	11	570	785	1115	1090	899	144
750	5	10	635	710	1220	1170	1096	164
800	4,5	9	840	685	1300	1245	1320	199
900	4	8	925	685	1445	1370	1856	267

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

SINGLE GIMBAL BELLOWS

Design pressure 10 bar
Design temperature 300 °C
Test pressure 16 bar



GS 10

NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		MAXIMUM O/D		ANGULAR SPRING RATE Nm/°	FRICTION MOMENT Nm/bar
	±°	total °	flange mm	weld end mm	flange mm	weld end mm		
80	10	20	380	360	215	190	3	1
100	10	20	400	380	255	215	7	2
125	10	20	405	385	280	240	13	3
150	10	20	470	450	315	290	22	4
175	10	20	480	465	330	330	45	6
200	8	16	500	480	380	365	63	7
225	8	16	515	495	405	405	87	10
250	7	14	525	510	445	445	120	12
300	8	16	535	515	530	530	169	17
350	8	16	405	660	660	610	120	24
400	8	16	430	710	735	685	175	34
450	8	16	430	735	810	760	365	49
500	7	14	480	785	875	840	489	71
600	6	12	560	785	1040	990	815	108
700	5,5	11	805	660	1170	1090	1263	166
750	5	10	840	685	1245	1195	1538	189
800	4,5	9	900	735	1295	1220	1850	242
900	4	8	1015	785	1445	1345	2597	339

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

SINGLE GIMBAL BELLOWS

Design pressure 16 bar
Design temperature 300 °C
Test pressure 25 bar

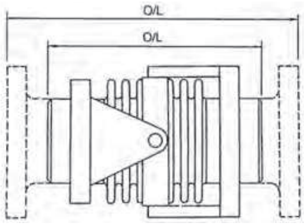
GS 16

NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		MAXIMUM O/D		ANGULAR SPRING RATE Nm/°	FRICTION MOMENT Nm/bar
	±°	total °	flange mm	weld end mm	flange mm	weld end mm		
80	10	20	380	360	215	190	3	1
100	10	20	400	380	255	215	7	2
125	10	20	405	385	280	240	13	3
150	8	16	470	450	315	290	22	4
175	8	16	480	465	330	330	45	6
200	7	14	500	480	380	370	63	7
225	6	12	515	495	405	405	87	10
250	6	12	525	510	445	445	120	12
300	8	16	685	660	535	535	212	22
350	8	16	480	785	660	610	179	30
400	8	16	510	810	735	685	260	46
450	8	16	560	840	810	760	383	64
500	7	14	620	865	890	840	511	83
600	6	12	1085	915	1040	990	848	133
700	5,5	11	1115	840	11245	1090	1310	211
750	5	10	1145	940	1320	1190	1593	253
800	4,5	9	1245	1040	1395	1244	1915	314
900	4	8	1270	1065	1550	1346	2682	429

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer

SINGLE GIMBAL BELLOWS

Design pressure 25 bar
Design temperature 300 °C
Test pressure 32,5 bar



GS 25

NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		MAXIMUM O/D		ANGULAR SPRING RATE Nm/°	FRICTION MOMENT Nm/bar
	±°	total °	flange mm	weld end mm	flange mm	weld end mm		
80	10	20	380	360	215	205	5	1
100	10	20	400	380	255	230	10	2
125	10	20	445	425	280	255	19	3
150	9	18	470	450	315	305	31	4
175	9	18	535	535	340	340	62	6
200	7	14	585	585	380	380	87	8
225	7	14	660	660	420	420	117	13
250	6	12	660	660	455	455	161	16
300	5	10	635	535	545	545	335	25
350	7	14	950	810	660	635	297	39
400	6,5	13	1015	865	785	760	429	54
450	6	12	850	685	865	810	595	81
500	5,5	11	890	710	940	890	798	104
600	5	10	1065	890	1065	990	1336	163
700	4	8	1280	1090	1270	1145	2350	266
750	3,5	7	1395	1195	1345	1220	2863	328
800	3,5	7	1525	1320	1445	1295	3445	400

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

GS 40

SINGLE GIMBAL BELLOWS

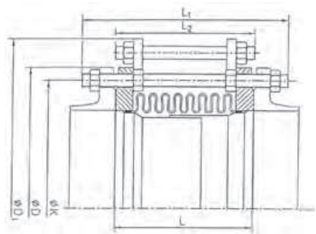
Design pressure 40 bar
Design temperature 300 °C
Test pressure 60 bar

NOMINAL DIAMETER mm	MOVEMENT		FREE LENGHT O/L		MAXIMUM O/D		ANGULAR SPRING RATE Nm/°	FRICTION MOMENT Nm/bar
	±°	total °	flange mm	weld end mm	flange mm	weld end mm		
80	4	8	455	430	240	240	12	1
100	3,5	7	480	455	280	280	27	2
125	3,5	7	510	480	340	340	48	3
150	3	6	535	510	405	405	80	5
175	3	6	560	535	430	430	129	7
200	3	6	635	610	510	510	181	10
225	2,5	5	660	635	535	535	247	14
250	2,5	5	685	660	595	595	339	19
300	2,5	5	685	660	695	695	688	31
350	2,5	5	785	685	735	735	705	43
400	2,5	5	965	840	810	810	1031	66
450	2,5	5	1065	940	940	940	1066	90
500	2,5	5	1115	965	1015	1015	1436	127
600	2,5	5	1320	1115	1195	1195	2415	203

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

MOUNT-DEMOUNT EXPANSION JOINTS

Design pressure	10 bar
Design temperature	100 °C
Test pressure	15 bar
Total axial movement	± 25 mm



DK 10

NOMINAL DIAMETER mm	D mm	k mm	D_1 mm	L mm	L_1 mm	L_2 mm	n	M	Mass kg
150	285	240	335	150	265	200	8	M20	21
175	315	270	365	150	270	200	8	M20	25
200	340	295	395	150	270	210	8	M20	27
250	395	350	450	155	280	215	12	M20	37
300	445	400	500	165	290	225	12	M20	43
350	505	460	560	165	295	225	16	M20	58
400	565	515	625	165	300	230	16	M24	72
450	615	565	675	170	305	235	20	M24	85
500	670	620	735	170	310	235	20	M24	93
600	780	725	860	195	340	265	20	M27	127
700	895	840	975	200	350	270	24	M27	160
800	1015	950	1095	200	360	270	24	M30	210
900	1115	1050	1200	220	385	295	28	M30	255
1000	1230	1160	1320	220	390	295	28	M33	305

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!

MOUNT-DEMOUNT EXPANSION JOINTS

Design pressure	16 bar
Design temperature	100 °C
Test pressure	24 bar
Total axial movement	± 25 mm

DK 16

NOMINAL DIAMETER mm	D mm	k mm	D_1 mm	L mm	L_1 mm	L_2 mm	n	M	Mass kg
150	285	240	340	150	265	205	8	M20	22
175	315	270	370	150	270	205	8	M20	27
200	340	295	395	150	270	205	12	M20	32
250	405	355	460	155	285	210	12	M24	47
300	460	410	520	165	300	230	12	M24	55
350	520	470	580	170	310	235	16	M24	77
400	580	525	660	175	325	245	16	M27	100
450	640	585	720	175	330	245	20	M27	120
500	715	650	795	180	340	250	20	M30	160
600	840	770	920	200	370	270	20	M33	220
700	910	840	1000	200	370	275	24	M33	240
800	1025	950	1120	210	390	285	24	M36	295
900	1125	1050	1255	235	420	330	28	M36	350
1000	1255	1170	1385	240	435	330	28	M39	450

Note: For unit sizes or operating conditions outside of the range specified above, please refer to manufacturer!