



INTRODUCTION

Since 2002 our manufacture has built a strong reputation for quality, consistency, and reliability in the manufacture of various metal expansion bellows.

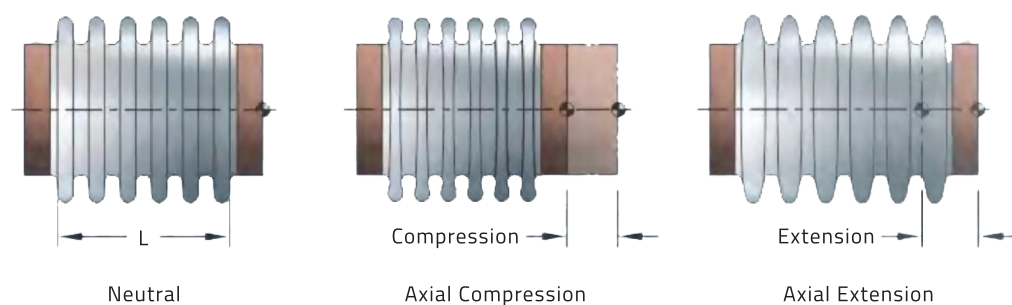
Our manufacture is an Australian joint venture company specializing in the design and manufacture of METAL EXPANSION BELLOWS. This high quality and superior performance products meet the various needs of power Plants (Gas, Steam, Coal, Solar, and Geothermal), Refineries, Styrene, LNG, Desalination, Polypropylene, PTA, Mining Plants, Cement Plant, Steel Plants Including Tuyere Bellows & Stave Seals for Blast Furnaces, Food & Beverage industry, and more.

Hidroflex is approved by the majority of Oil & Gas (SHELL, CALTEX, Singapore Refinery, PETRONAS, PERTAMINA, THAI OIL, IRPC-Thailand, Kuwait Oil Company, Qatar Petroleum, TAKREER, ESSAR OIL, Chevron) EPC's & Engineering Houses (Toyo Engineering, Siemens, Saipem, Technip), and more.

HOW AN EXPANSION BELLOWS WORKS

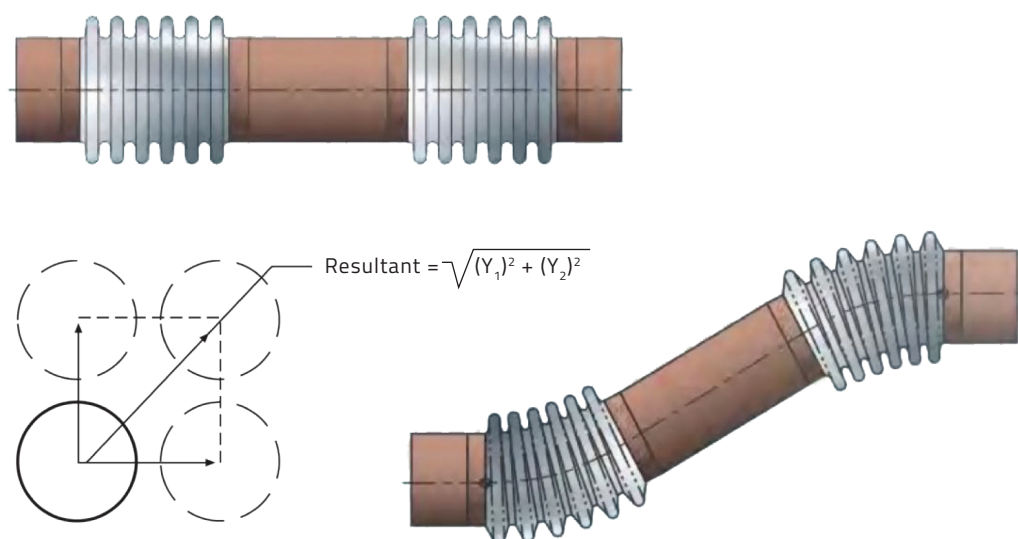
Axial Movement

This is the most common type of bellows deflection and is simply the dimensional change of the bellows along its longitudinal axis. This axial movement is typically a shortening of the bellows or COMPRESSION. This compression of the bellows would occur as the piping heats up and expands. Another type of axial movement in a bellows is the elongation of the bellows EXTENSION.



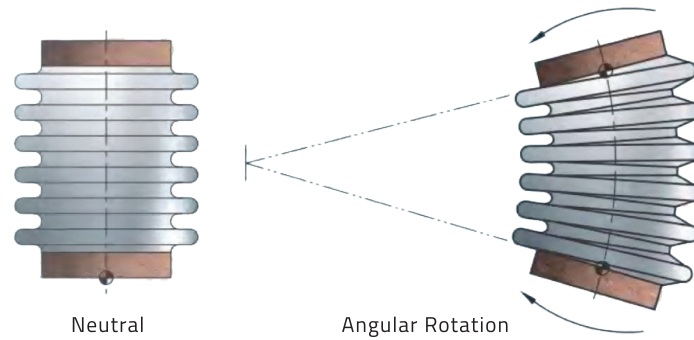
Lateral Movement

This type of bellows deflection is the relative displacement of the bellows ends perpendicular to its longitudinal axis. This type of displacement occurs with the bellows ends remaining parallel to each other and can occur in more than one plane. If lateral deflection does occur in more than one plane, a resultant is calculated and used in the bellows evaluation. This movement in multiple planes should be evaluated concerning the life cycle and hardware orientation.



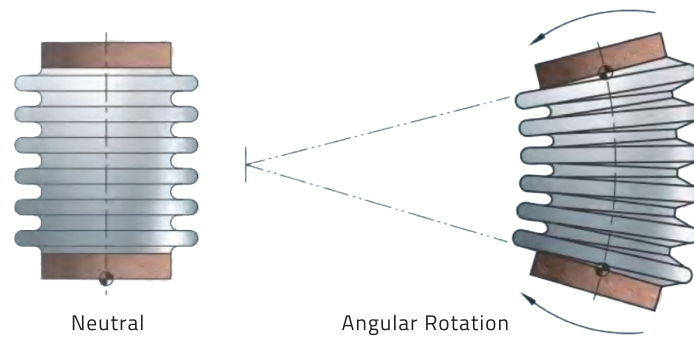
Angular Movement

This type of bellows deflection is the displacement of the longitudinal axis of the bellows into a circular arc about its center and its midpoint. This deflection may also occur in numbers of planes and should be properly evaluated concerning the life cycle and hardware orientation. ROTATIONAL MOVEMENT is another term for angular deflection or rotation. This is not to be confused with torsional rotation.



Torsional Movement

Torsion or twisting is rotation around the longitudinal centreline of the bellows and is sometimes confused with angular motion. A bellows does not absorb torsional displacement, and although a bellows can react to torsional movement, it should be avoided at all times.

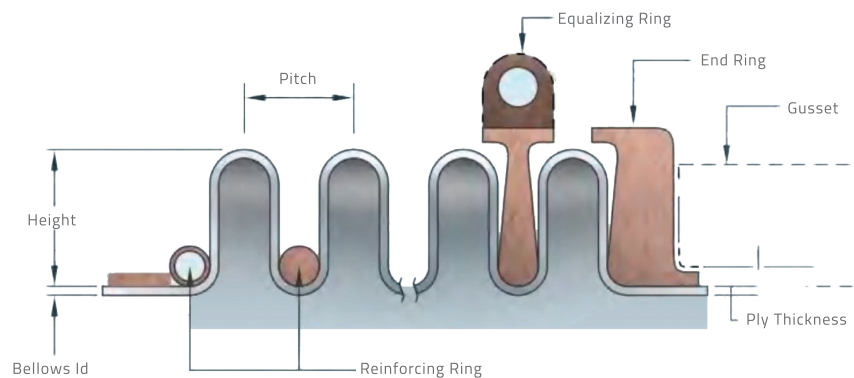


CONVOLUTIONS OR CORRUGATION

The bellows convolution is the element of bellows that makes it flexible. Each convolution is like a pair of thin washers, which can deflect easily by bending parallel to bellows centerline. The amount of flexibility of each of this convolution is a direct function of the height of the convolution. The height is limited by pressure and the ability to form convolution.

Single Convolution

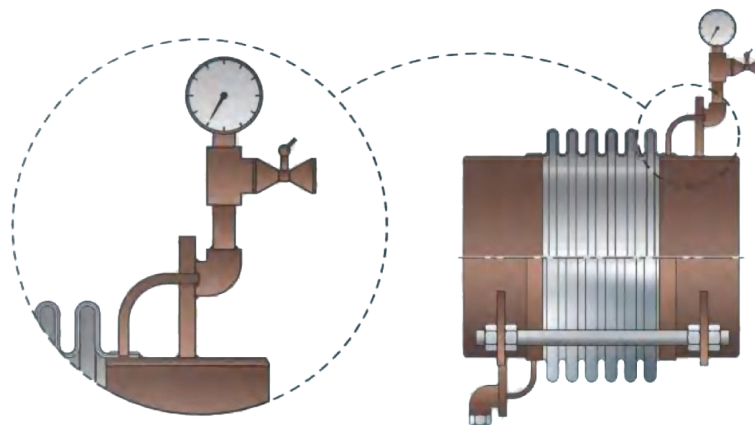
A single convolution can only deflect in an axial direction. A single convolution is incapable of accepting lateral deflection and providing the amount of movement. Therefore, the bellows element will usually have several convolutions.



The expansion bellows carries several different characteristics. One of the differentiating characteristics is whether or not it is a single-layer or a multilayer. The basic principle is simple; a single-ply has one shell and a multilayer has two or more shells telescoped together prior to forming.

Multilayer Expansion Bellows

A multilayer bellows can be used in many applications. It is important to understand the functional characteristics of each type of construction. Corrosion considerations may indicate the desirability of different materials for the inner and outer bellows layers to suit the internal/external environment. In this manner, the primary layer specified to resist corrosion can be supplemented by less costly additional layers.



BASIC DESIGN TYPES

Redundant two-layer bellows are used when it is desired to continue normal system operation if one ply fails, until such time as a suitable replacement can be made. The pressure capacity of each bellows layer (ply) is the same as an equivalent single layer (ply) design since the redundant layer (plies) has been designed to withstand the system pressure independently.

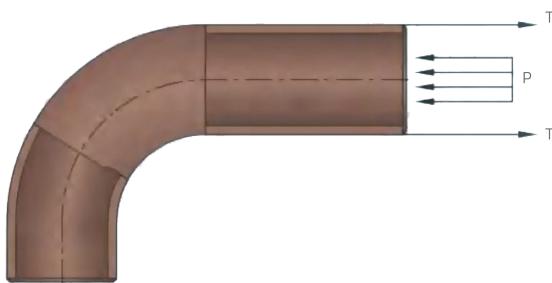
The annular space between layers can be monitored for leakage to detect a ply failure. This will serve as a warning of an impending problem, reducing the chances of a costly unscheduled shutdown.

The main advantages of multiplayer (ply) Bellows can be seen below:

- Resistance to high and very high pressures
- Large movement absorption
- Small dimensions
- Small spring force
- Optimal compensation in a very small space
- Early leak indication (in case of damage) via standard leak detection device
- Complete burst resistance
- Possibility of permanent leak monitoring, leak detection device in critical media
- Economical use of high quality, corrosion-resistant: material such as Inconel, Incoloy, Hastelloy, SAF & Titanium

WHAT IS A PRESSURE THRUST?

Normally, pressure in a pipeline is absorbed by tension in the pipe walls:



Example

Standard pipe outside diameter : 323.8 mm
 Pipe thickness : 10.31 mm (SCH40)
 Design pressure : 1.5 N/mm²

$$\begin{aligned}\text{Axial Tension} &= \text{Area} \times \text{Pressure} \\ &= \pi_{i_4} \times D_i^2 \times 1.5 \\ &= 108275 \text{ Newton}\end{aligned}$$

Calculate Unbalance Pressure Force or Axial Force Caused by The Internal Pressure

$$FS = P \times \pi/4 \times Dm^2$$

Dm : Effective / mean diameter of expansion bellows, mm

$$Db + w + nt$$

Db : inside diameter of cylindrical tangent and bellows convolution, mm

Di : inside diameter of pipe, mm

w : convolution height, mm

n : number of bellows material plies

t : bellows nominal material thickness of one ply or layer, mm

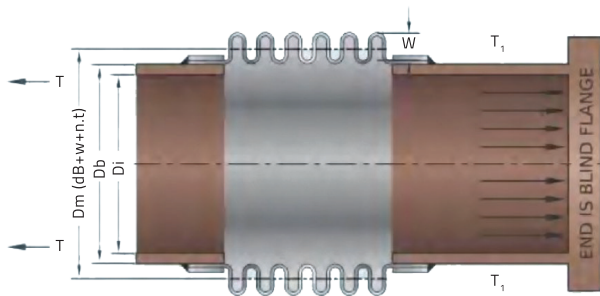
P : design pressure, N/mm²

Fs : axial force caused by internal pressure, Newton

The pressure thrust is actually developed at point where the pressure encounters first metal area perpendicular to the axis of expansion bellows.

Example: A capped ends or a change in direction. The distribution of pressure thrust load in various configuration as follow figure 2 to 6

Pressure Thrust Force in Untied, Unanchored Expansion Bellows



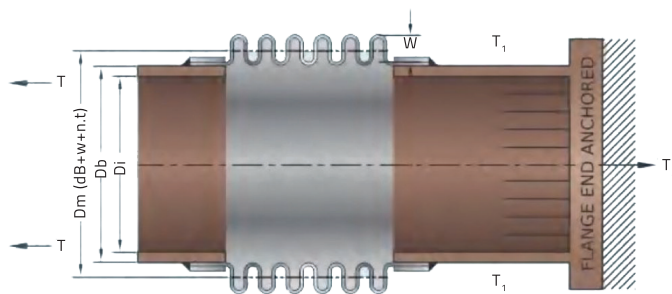
T = tension in bellows walls (tending to blow the bellows apart), Newton

$$= P \times \pi^4 \times Dm^2$$

T_1 = tension in pipe wall, Newton

$$= P \times \pi^4 \times Di^2$$

Pressure Thrust Force in Anchored Expansion Bellows Installation

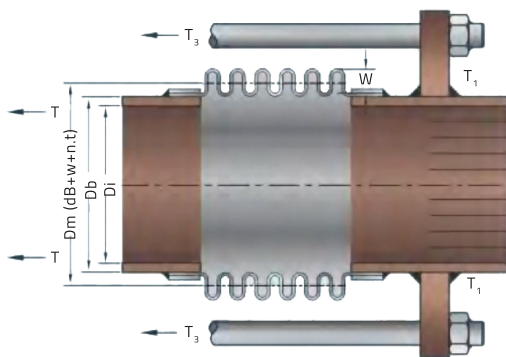


T = tension in bellows walls, Newton
= N/A

T_1 = compression in pipe wall, Newton
 $= P \times \pi/4 \times (Dm^2 - Di^2)$

T_2 = total load on anchor, Newton
 $= P \times \pi/4 \times Dm^2$

Pressure Thrust in Tied Expansion Bellows

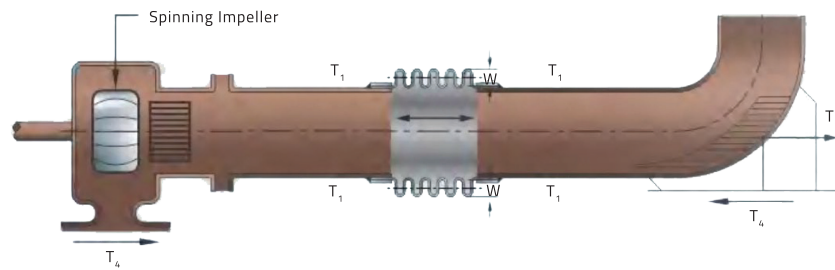


T = tension in bellows walls, Newton
= N/A

T_1 = compression in pipe wall, Newton
 $= P \times \pi/4 \times (Dm^2 - Di^2)$

T_2 = total load on anchor, Newton
 $= P \times \pi/4 \times Dm^2$

Pressure Thrust in Force in Rotating Equipment without Tie Rods (Ends are Anchored)



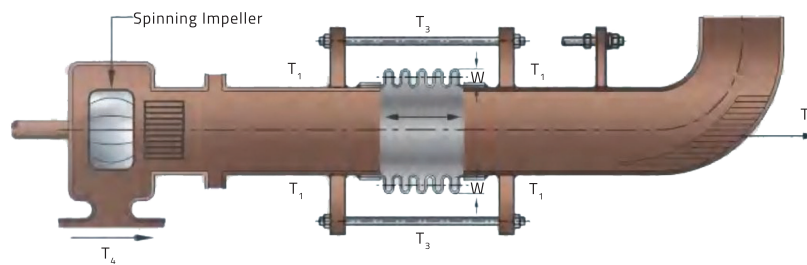
T = tension in bellows walls, Newton
= N/A

T_1 = compression in pipe on either side of expansion bellows, Newton
= $P \times \pi/4 \times (Dm^2 - Di^2)$

T_2 = total load on impeller and on inside of elbow, Newton
= $P \times \pi/4 \times Di^2$

T_4 = total load on anchor, Newton
= $P \times \pi/4 \times Dm^2$

Pressure Thrust Force On Rotating Equipment with Tie Rods



T = tension in bellows walls, Newton
= N/A

T_1 = tension in pipe on either side of expansion bellows, Newton
= $P \times \pi/4 \times Di^2$

T_2 = pressure load on impeller and on inside of elbow, Newton
= $P \times \pi/4 \times Di^2$

T_3 = load on tie rods, Newton
= $P \times \pi/4 \times Dm^2$

T_4 = there is no reaction load (T) on pump base and anchor, since tie rods are used

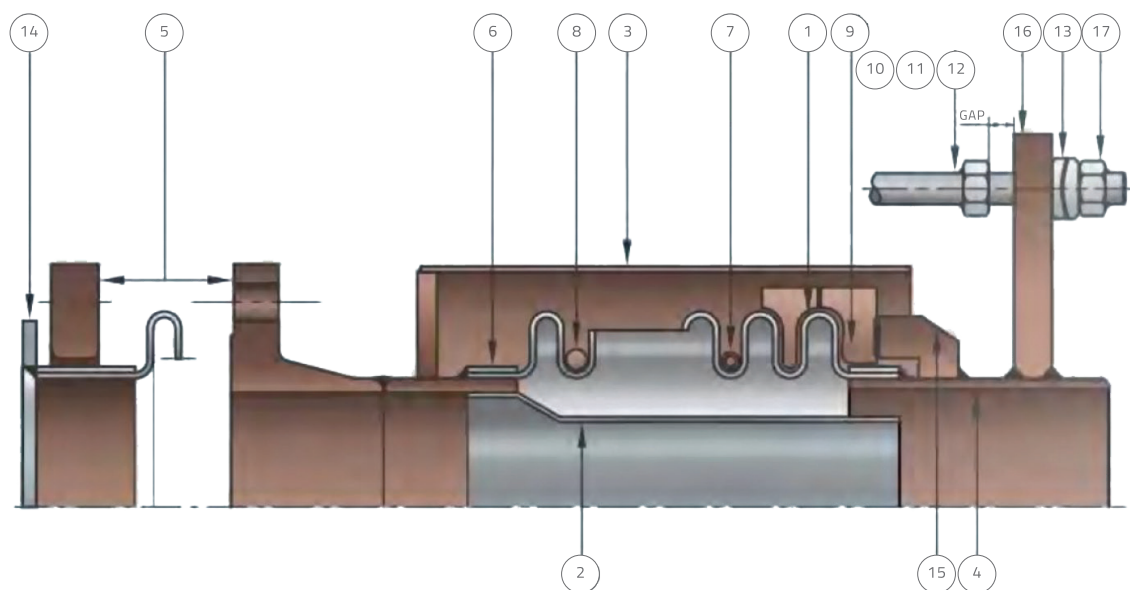
Most pipe stress programs such as CAESAR II automatically calculate the unbalanced pressure thrust load and simplify the model by applying the entire magnitude at either end of the bellows. In most cases, this is an adequate approximation of the actual situation. Greater modelling accuracy can be achieved by disabling the application of pressure load at the bellows (by defining and effective diameter as 0.0), and calculating and applying the thrust load manually to the model.

EFFECT OF ALLOYING ELEMENTS IN HEAT RESISTANT ALLOYS

Chromium (Cr)	The basis for oxidation resistance is from the protective chromium oxide scale formed at high temperature, Cr adds strength carburization resistance, and promotes sigma.
Nickel (Ni)	From 8 to 80% Ni is all austenitic heat resistant alloys. Ni improves the adherence of the Cr2O3 scale, hence oxidation resistance, and reduces carburization. Ni reduces sigma formation. High Ni alloys may be susceptible to sulfidation.
Iron (Fe)	Present from 0 to 75% in heat resistant alloys. A ferritizing element.
Silicon (Si)	Improves oxidation and carburization resistance. Si is a ferritizer, promotes sigma.
Carbon (C)	A strengthening element used 0.04% in 0.4% in wrought and to 0.75% in cast alloys. C is an austenitizing element, retards sigma formation.
Nitrogen (N)	Strengthening element used up to about 0.25 more commonly around 0.15%. N is an austenitizing element, retards sigma formation.
Baron (B)	Strengthening element from 0.0005 to 0.005% improves hot workability, decreases weldability.
Titanium (Ti)	Strengthening element as a carbide former, in higher amounts, it forms gamma prime ferritizer and promotes sigma.
Alumunium (Al)	Strength in small amounts of oxidation in the range 1-5% ferritizer, promotes sigma.
Cerium (Ce)	Improving oxidation resistance, as do the other rare earth La. Y.
Cobalt (Co)	Solid solution strengthener and austenitizing.
Tungsten (W)	Solid solution strengthener.
Molybdenum (Mo)	Solid solution strengthener. A high level can lead to catastrophic oxidation promotes intermetallic phase formation.

EXPANSION JOINT ACCESSORIES

The basic unit of every expansion joint is the bellows. By adding additional components, expansion joint of increasing complexity and capability are created which are suitable for a wide range of applications. Please refer to below figure and the following list for a description of the basic expansion joint accessories.



1. Bellows

The flexible of an expansion joint, consisting of one or more convolutions, formed from the material.

2. Liner

A device that minimizes the effect on the inner surface of the bellows by the fluid flowing through it. Liners are primarily used in high-velocity applications to prevent erosion of the inner surface of the bellows and to minimize the probability of flow-induced vibration. Liners come in single, tapered, or telescoping configurations according to the requirements of the application. An expansion joint, if provided with liners, must be installed in the proper orientation concerning to flow direction. Liners are sometimes referred to as internal sleeves.

3. Cover

A device used to provide external protection to the bellows from foreign objects, mechanical damage, and/or external flow. The use of cover is strongly recommended for all applications. A cover is sometimes referred to as a shroud.

4. Weld End

The ends of expansion joint equipped with pipe for weld attachment to adjacent equipment or piping. Weld ends are commonly supplied beveled for butt welding.

5. Flange End

The ends of the expansion joint equipped with flanges to bolt the expansion joint to the mating flanges or adjacent equipment or piping.

6. Collar

A ring of suitable thickness which is used to reinforce the bellows tangent, or cuff, from bulging due to pressure.

7. Hollow Reinforcing Rings

Devices used on some expansion joints, fitting snugly in the roots of the convolutions. The primary purpose of these devices is to reinforce the bellows against internal pressure. Hollow rings are formed from a suitable pipe or tubing section.

8. Solid Root Rings

Identical in function to hollow root rings, but formed from solid bar stock for greater strength.

9. Equalizing Rings

"T" Shaped in cross-section, these rings are made of cast iron, steel, stainless steel, or other suitable alloys in the amount of compression movement per convolution.

10. Control Rods

Devices, usually in the form of rods or bars, attached to the expansion joint assembly whose primary function is to distribute the applied movement between the two bellows of a universal expansion joint. Control rods are NOT designed to restrain bellows pressure thrust.

11. Limit Rods

Devices, usually in the form of rods or bars, attached to the expansion joint assembly whose primary function is to restrict the bellows movement range (axial, lateral, and angular) during normal operation. In the event of main anchor failure, limit rods are designed to prevent bellows over-extension or over-compression while restraining the full pressure loading and dynamic forces generated by the anchor failure.

12. Tie Rods

Devices usually in the form of rods or bars, attached to the expansion joint assembly whose primary function is to continuously restrain the full bellows pressure thrust during normal operation while permitting only lateral deflection. Angular rotation can be accommodated only if two tie rods are used and located 90° from the direction of rotation.

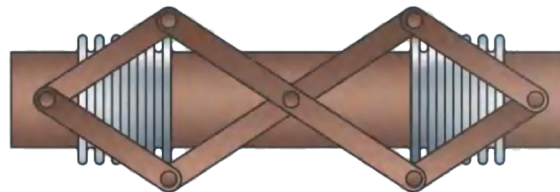
13. Spherical Washer

Two-piece washer that compensates whenever a stud and clamping surface is not perpendicular. The top washer has a convex spherical radius, while the bottom washer has a matching concave spherical radius.

14. Van Stone

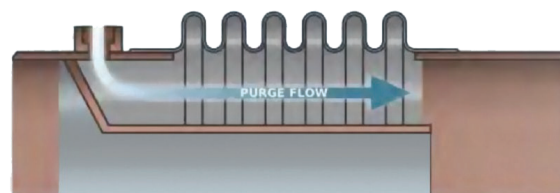
A van stone flange is fabricated by lapping the cuff (tangent) of a bellows over the flange face, it allows the flange to rotate before tightening the bolting. A benefit with van-stone design is the flowing media does not contact the flange, even bellows entire internal surface is wet. An application that requires all stainless steel parts, due to corrosive media, can use economical carbon steel flanges with a stainless steel van-stone.

15. Gusset, 16. Lungs, 17. Nuts



18. Pantographic Linkages

A scissor-like device. A special form of control rod attached to the expansion joint assembly whose primary function is to assuredly distribute the movement equally between the two bellows of the universal joint throughout its full range of movement. Pantographic linkages, like control rods, are NOT designed to restrain pressure thrust.



19. Purge Ports

Purge ports are sometimes called aeration connections. They are usually installed at the closed end of each internal sleeve to inject a liquid or gas between the bellows and the internal sleeve to keep the area clear from erosive and corrosive media and/or solids that could pack the convolutions.

20. Slotted Hinges

Slotted hinges are devices permitting axial and one plane angular movement. Slotted hinges do not restrain pressure thrust. They can be used to transmit extraneous loads and forces, such as system dead weight, wind, and seismic loads transverse to the expansion joint axis, rather than across the flexible bellows element.

EXPANSION BELLOWS TYPE

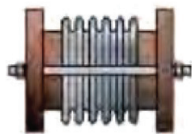


U E B

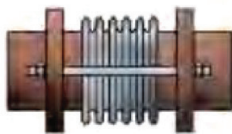


Universal Expansion Bellows

Universal Expansion Bellows have one bellows. Axial compression and extension, lateral and angular movement can be accommodated. These expansion bellows cannot restrain the internal pressure thrust. The piping designer must provide the system with separate anchoring to resist the pressure thrust.

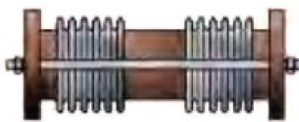


T E B

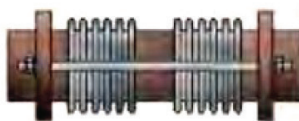


Tied Expansion Bellows

Tied Expansion Bellows also have one bellows, except that their length is restrained by tie rods, which can accept the pressure generated thrust. When under pressure, they are usually not designed to accept any axial movements but can accept lateral movement. The two tie rod designs can accept angular deflections in a single plane.

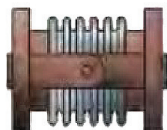


T U E B

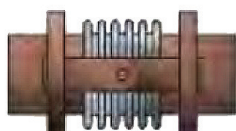


Tied Universal Expansion Bellows

Tied Universal Expansion Bellows contains two bellows separated by a pipe spool to accept large amounts of lateral movements. Because tie rods are provided to resist thrust, these bellows cannot accept axial movements. Also, if more than two tie rods are used, angular movements are not accepted. The tie rods are usually at or near ambient temperatures and therefore do not expand and contract as a function of the temperature of the media within the pipe. As a result, the thermal expansion of the length between the tie rods occurs within expansion bellows and is not applied to the rest of the piping system. The bellows design must accommodate this axial thermal expansion as well as the lateral movement for which the Expansion Bellows is needed.



H E B



Hinge Expansion Bellows

Hinge Expansion Bellows has a single bellows and have their length restrained by the addition of a hinge mechanism which is strong enough to accept the pressure generated thrust but will allow angular movement in a single plane.



H U E B



Hinge Universal Expansion Bellows

Hinge Universal Expansion Bellows has two bellows separated by pipe spool to accept large lateral movements. The ability to resist pressure thrust is provided by a hinge assembly at each bellows, which also permits angular movement in a single plane. Unlike the tied universal, the thermal expansion of the entire expansion bellows is applied to the piping as if the bellows were another length of pipe.



S H E B



Slotted Hinge Expansion Bellows

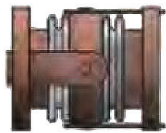
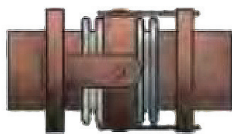
These are a variant of the above "hinged" type, in that while providing for angular movements, some axial movement can be accepted because the hinge pin passes through slots in the hinge plates. When the axial movement is occurring, the expansion bellows is incapable of accepting the pressure thrust. Therefore, adequate anchors must be provided. The hinge structure can be designed to accept the full pressure thrust when the pin is at the limit of its travel within the slot.

**M E E B**

Multiply Exhaust Expansion Bellows

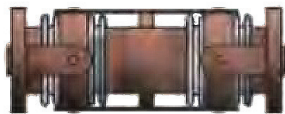
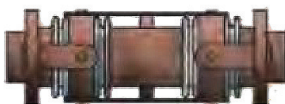
Multiply Exhaust Expansion Bellows and vibration eliminators are specifically designed to relieve stresses from the turbocharger and isolate exhaust during form damaging vibration on stationary or mobile diesel engines/gas engines or turbines.

A special multiply construction ensures maximum flexibility and vibration damping effect at elevated temperatures all standard expansion bellows are fitted with special internal flow liner (internal sleeve) to protect the bellows element from a high velocity, high-temperature exhaust, gases. Lightweight attachment flanges or weld ends are also fitted as standard.

**G E B**

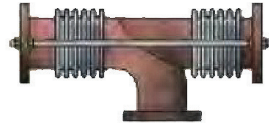
Gimbal Expansion Bellows

Gimbal Expansion Bellows have single bellows and a unique pressure thrust resisting structure which permits angular movements in any plane. The structure contains two hinge mechanisms, which allow simultaneous rotation about two perpendicular axes which intersect at the centerline of the bellows. This mechanism functions the same way that an automobile drive shaft universal joint operates.

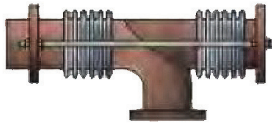
**G U E B**

Gimbaled Universal Expansion Bellows

These are similar to the hinged universals above except that the two bellows are gimbals type. The advantage of this arrangement is the ability of the expansion bellows to accept large lateral movements in any plane at each end. Because the gimbals are attached to each end of the bellows, the thermal expansion of the center spool will not be accepted by the universal but must be accepted by adjacent piping.

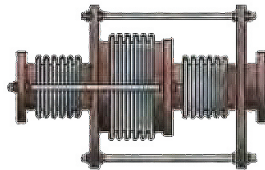


P B E B

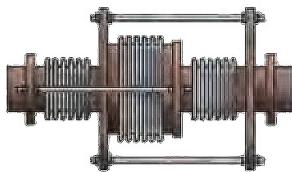


Pressure Balanced Expansion Bellows

Pressure Balanced Expansion Bellows is designed to absorb axial movement and for lateral deflection, while restraining the bellows pressure thrust force by means of the tie rods interconnecting the line bellows to balancing bellows. This bellow is installed where a change of direction occurs in a run of pipe. The purpose is to retain and balance the pressure thrust so that the main anchoring of the pipe of adjacent equipment is not required, and forces and movements on attachment flanges of delicate equipment, are kept acceptably low level.



I P B E B



In-Line Pressure Balanced Expansion Bellows

In-Line Pressure Balanced Expansion Bellows consist of single or double (universal) bellows to accept the piping induced axial compression, extensions, lateral and angular movements. The larger bellows create an angular pressure chamber that produces thrust forces, which by trying to each end of the bellows, balance the pressure thrust. They are typically used in straight pipe runs between intermediate anchors (non-pressure thrust resistant) or adjacent to equipment, such as turbines, which cannot operate with heavy externally applied loads.



S X B



D X B



Externally Pressurized Expansion Bellows

While the pipeline or duct is internally pressurized, the bellows are externally pressurized. Externally pressurized expansion bellows are capable of absorbing large axial movements because it can be designed with many convolutions. Externally pressurized bellows do not have column squirm limitation, since the external pressure stabilizes the bellows. The bellows element of externally pressurized expansion bellows is protected from external damage also minimizes the effect of environmental factors. It is good engineering practice to provide drain coupling at the lowest point of the expansion joint to flush out the material or dust particles trapped inside expansion bellows. If very large axial movements are needed to be absorbed, universal externally pressurized bellows can be used. These are simply two bellows attached to the common center spool and pressurized expansion bellows are not designed to absorb lateral or angular movements.