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## LAYMAN'S GUIDE TO BELLOWS & EXPANSION JOINTS

### Why use them?

Bellows and expansion joints are used in a wide variety of applications to absorb vibration and thermal movement in pipework, pumps, turbines, tanks and other equipment.

Their application has become widespread in engine exhaust systems, propulsion systems, flow-lines, process lines, valve systems and all types of pipework for all types of media.

Expansion joints are also used to accommodate line misalignment. They accommodate the movement of pressurized piping systems caused by thermal growth, vibration, subsidence and seismic disturbance. With modern methods of design and development, today's bellows have become accepted as a permanent part of piping installation systems.

### What are they?

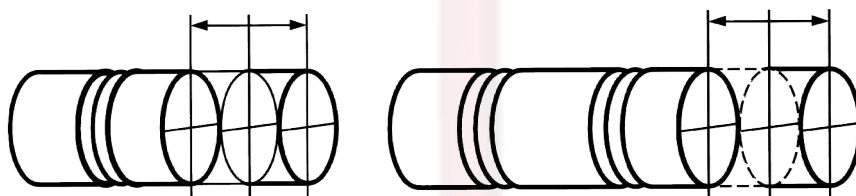
Essentially, a bellows or expansion joint is a length of pipe with a series of convolutions that allow the pipe to move along one, two or all three planes of movement. The convolutions give the expansion joint flexibility, but they also need structural strength. This is why the design and manufacture of expansion joints is a specialised area and requires significant engineering.

The simplest way to visualise expansion joints is to imagine one of those plastic straws used in fast-food restaurants with the rippled section that lets you bend the straw over. Those ripples mimic the bellows part of an expansion joint, or the convolutions. They let you expand or compress the straw along its axial plane (e.g. pull it apart so that the ripples straighten out, or squash them together), bend it to the side, offset the two straight sections by creating an S-bend in the convolutions or move one straight section in circular motions while the other straight section remains stationary.

### How do they work?

The most obvious form of movement accommodated by bellows is axial movement. This is defined as the dimensional shortening or lengthening of an expansion joint along its longitudinal axis (compression or extension). In lay-man's terms, this is where a bellows mimics an accordion effect, in other words it expands or contracts along its length.

This is critical in most piping systems, for example when pipework is subjected to variations in temperature, the piping will naturally expand and contract as it heats and cools down respectively. As pipework is fixed at various points (for example, at either end), this can put a load on these anchor points and result in pipe bursts. Through the application of a bellows at key points along the line, they themselves will absorb this axial movement leaving all anchor points intact.



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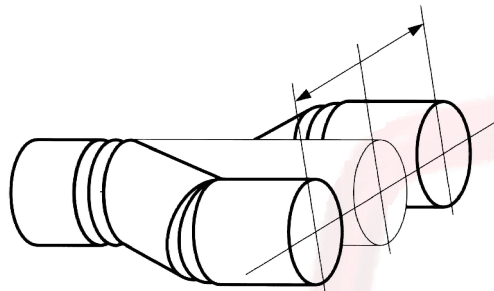
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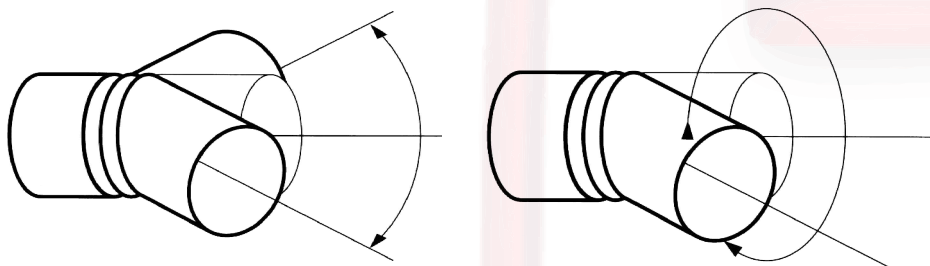
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A second type of movement is lateral deflection, defined as the relative displacement of the two ends of an expansion joint perpendicular to its longitudinal axis. Simply put, imagine two pipes connected together. At their "free" ends they are connected to a fixed point. If one of those fixed points moved (e.g. an oil tank will sink several inches into the ground as it is filled with fluid due to the sheer weight of the oil), the connection between the pipes would be broken. By fitting an expansion joint, the pipes are free to move but remain connected as the bellows unit essentially S-bends to accommodate the movement.



The final type of movement is angular rotation, defined as the relative angular displacement of the two ends of the expansion joint so as to displace the longitudinal axis of the expansion joint from its initial straight line position into a circular arc. Again, imagine the above example of an oil tank, the tank will also bulge when it is filled with oil. Without an expansion joint, this would alter the angle at which the pipe is connected to the tank and cause breakage. With an expansion joint built in, it will basically bend to allow the pipe to maintain the same angle at which it is connected to the tank.

In the last example, the bellows also has to accommodate lateral movement of course.



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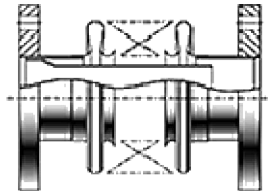




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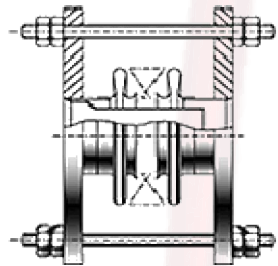
What types are there?

Depending on the combination of movements that a piping system may have to undertake, there are numerous designs of expansion joints. The most simple is the axial bellows:



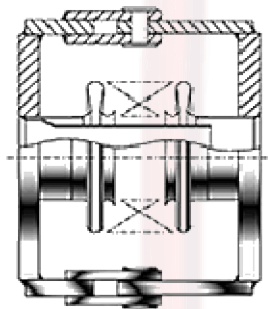
#### **Single Bellows Units**

The most commonly used expansion joints, they essentially constitute a pipe with convolutions along their length and are mainly used for axial movement applications, although small amounts of lateral movement may also be accommodated.



#### **Single Tied Units**

End thrust as a result of the internal pressure is contained by means of tie rods (the number of which depends on the size of the unit and the pressure contained). These units are suitable for small lateral movement applications.



#### **Single Hinged Units**

These units are designed to perform angular movement in one plane only and when installed in combinations of two or more, are able to accommodate very large movements. End thrust in this case is contained by the hinge pin.



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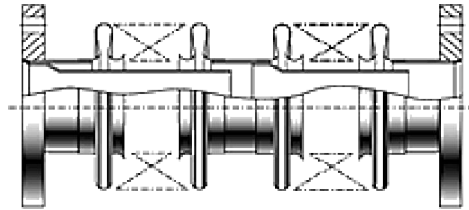


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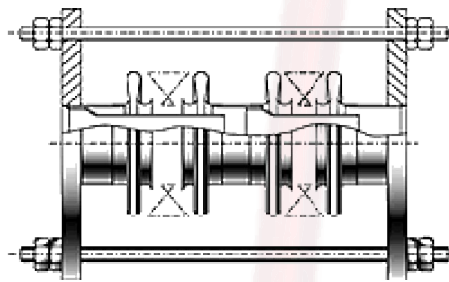


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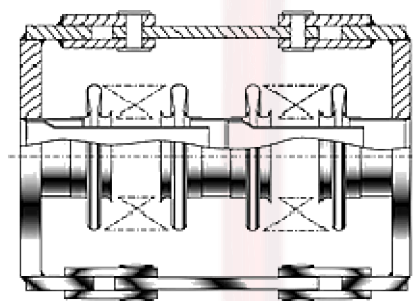
#### **Untied Double Bellows Unit**

Capable of absorbing combinations of axial, lateral and angular movement type of expansion joint is sometimes referred to as a Universal Expansion Joint. It consists of two bellows separated by a short connecting tube used to accommodate larger movements than possible with a single bellows. These units are suitable for both axial and lateral movement. Working pressure is sometimes limited due to the instability of the centre tube under certain conditions.



#### **Double Tied Unit**

Sometimes referred to as an Articulated Expansion Joint, the pressure thrust is carried by external or internal tie rods across the bellows. These ties may be in the form of hinged or spherical ended bars attached to opposite ends of the unit or in the form of individual hinges or gimbal rings spanning each bellows. Because of these ties, the units are capable of absorbing lateral and/or angular movements. Two ties bars are designed to allow limited angular rotation in one plane, whilst three or more tie bars prevent this rotation altogether. Pressure containment is by the same means as the single tied units, but these units are suitable for larger lateral movement applications.



#### **Double Hinged Units**

These units are designed to perform large lateral movement in one plane only. Additionally the hinge to pipe connection gives greater stability under pressure.



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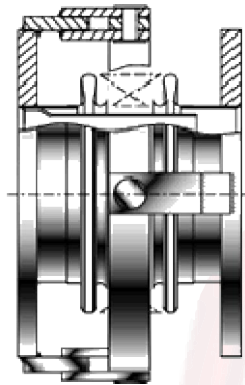


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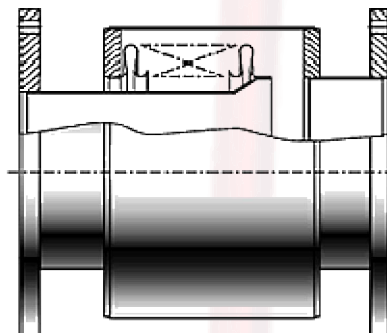


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#### **Gimbal Units**

Containing one bellows unit, this joint is designed to permit angular rotation in any plane by the use of two pairs of hinges affixed to a common floating gimbal ring. The gimbal rings hinges and pins are designed to restrain the thrust of the expansion joint due to internal pressure and extraneous forces. These units are able to allow angular movement in any plane. When these units are installed in conjunction with other gimbal or hinged units, very large and complex movements can be achieved, even when high internal pressures are present.



#### **External Pressure Units**

These units are used in applications where the internal pressure would render conventional units unstable. Pressure is directed to the exterior of the convolutions making them inherently more stable, allowing greater axial movement.



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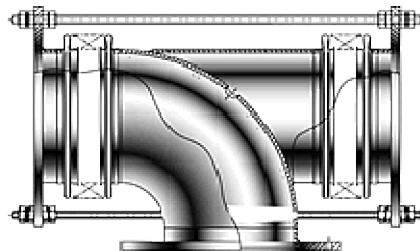
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### Pressure Balanced Units

In some cases, it is essential that the loads in the anchor points are kept very low, as in turbine castings. This can be achieved by installing a pressure balanced unit. The design principle employed is that a pressure bellows outside the system counteracts the pressure of the bellows inside the system. These joints are designed to absorb axial movement and/or lateral deflection while restraining the pressure thrust by means of tie rods interconnecting the flow bellows with an opposed bellows, whilst also subjected to line pressure. Hence, the pressure on these two bellows work against each other and essentially balance or cancel each other out, thereby “removing” the pressure on the pipework itself. A second bellows in the flow section is sometimes included to permit greater lateral movement. The drawing illustrates a unit outside the 90° bend, but the design can be modified to suit most pipe configurations.

### Who manufactures them?

Teddington Engineered Solutions, based in the UK, is one of the world's leading bellows manufacturers and a recognised authority in thin wall bellows technology. The company is renowned for the contribution it has made to the international acceptance of thin wall bellows as the principal, modern method of movement compensation in pipework.

Wherever pipes are subjected to movement through the effects of temperature, pressure or physical force, our range of bellows can be found, including Alpha, Brockington, Vokes GenFlex, MaxComp and Teddington. They have become an accepted part of equipment in industrial markets worldwide, including Defence, Aerospace, Marine, Shipbuilding and Repair, Steel, Power Generation, Power Distribution, Oil & Gas, Petrochemical & Chemical, Processing Industries, District Heating, Automotive and Rail.

Nominal bore sizes range from 10mm to 5000mm, with design pressures ranging from full vacuum to 200 bar pressure. Our bellows can accommodate temperatures ranging from -190°C to +1200°C and expansion joints are made in a variety of materials including various grades of stainless steel, Incoloy, Inconel, Monel, Nimonic, Hastelloy, Titanium, Aluminium and other exotic alloy materials.

Teddington is accredited to ISO 9001: 2008. We are also one of the first of a small number of bellows manufacturers to have gained accreditation to the European Pressure Equipment Directive (PED 97/23/EC to module) to CE marking module H.

Teddington has been designing and manufacturing bellows since 1927, lodging a patent for one of the original bellows designs in 1928.

Teddington is considered as a world leader in this field which is recognised by us being an Expansion Joint Manufacturers Association (EJMA) committee member. This code is followed by all expansion joint manufacturers and it is our role to help develop all future revisions to the code.



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Teddington is also one of very few expansion joint manufacturers to hold the ASME U-Stamp. Teddington is the only UK manufacturer of bellows expansion joints to hold the ASME U-Stamp.

We also supply rectangular bellows, instrument bellows, edge-welded bellows and valve bellows.

As well as metallic bellows and expansion joints, we supply flexible hose, valves, actuators, gaskets, hangers, piping supports, assemblies and accessories, as well as fabric and rubber bellows.

We are located:

**Teddington Engineered Solutions Ltd.**

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Llanelli,

Carmarthenshire,

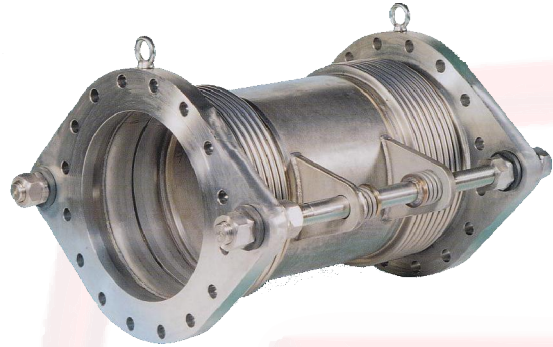
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