Metal Bellows Expansion Joints

Application Guide for Piping Systems

AN INDUSTRY LEADER 55 FOR FIFTY-FIVE YEARS

FLEX-HOSE CO. INC.

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Contents

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Basic Principles: Thermal Expansion

THERMAL EXPANSION is a major problem confronting engineers designing, installing and maintaining piping systems.

To help you save time and money we have developed this metal expansion joint application guide to assist you in applying metal expansion joint technology to your piping system.

We also invite you to call us toll free for technical support at **1.877.Metal EJ.**

Anything Worth Doing is Worth Doing Right.

It's not very hard to understand that people are influenced by innovation, long-term reliability, ease of installation, and extreme cost savings. It's a no-brainer. This essence is built into the very fabric of our business and products since 1968.

Flex-Hose Co. expansion joints are engineered and manufactured for a broad range of requirements. They have been used in some of the most demanding applications worldwide. They are capable of isolating critical mechanical equipment from a piping or duct work system, thermal growth, dampen vibration, and reduce noise. Our renowned products are backed by the best warranties in the business that other manufacturers find easier to talk about than to duplicate.

Our expansion joint products have also been inspected and tested by the Technical Standards & Safety Authority of Canada, and hold a CSA Standard B51 Certificate to meet the high quality standards of the Canadian market.

So enjoy years of service with our flexible piping connections. Flex-Hose Co. products give you that choice. Don't compromise.

Phil Argersinger, *President/Owner*

As Temperature Increases, Pipe Grows in Length

APPLICATION	TEMPERATURE RANGE	Thermal Expansion
Chilled Water	40°F → 100°F	**.453** inches per 100 ft
Condensor Water	40°F → 100°F	**.453** inches per 100 ft
Domestic Hot Water*	40°F → 140°F	**1.139** inches per 100 ft
Hot Water	40°F → 200°F	**1.220** inches per 100 ft
Steam 100 psig	40°F → 338°F	**2.400** inches per 100 ft

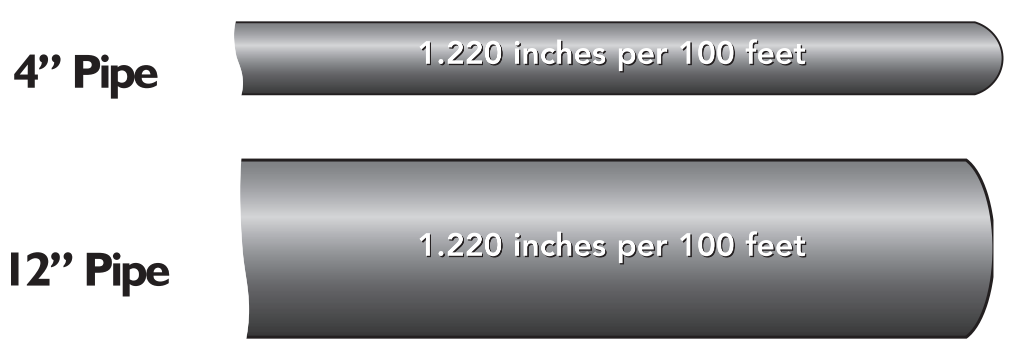
* Copper Pipe

Thermal Expansion for carbon steel pipe is the same for all pipe sizes.

Example: Hot Water

40°F → 200°F

Pipe Growth



Note: Anchor Thrust loads will vary

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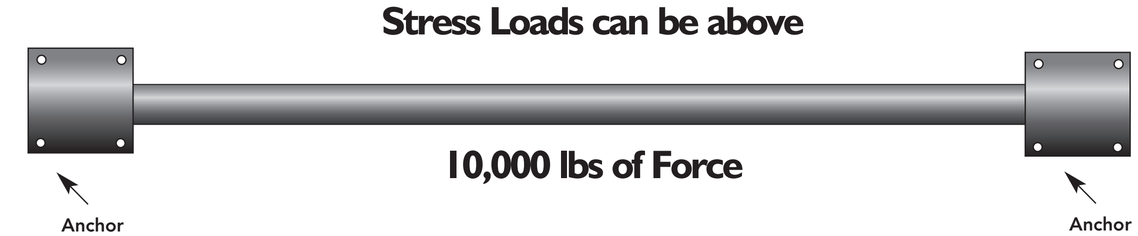
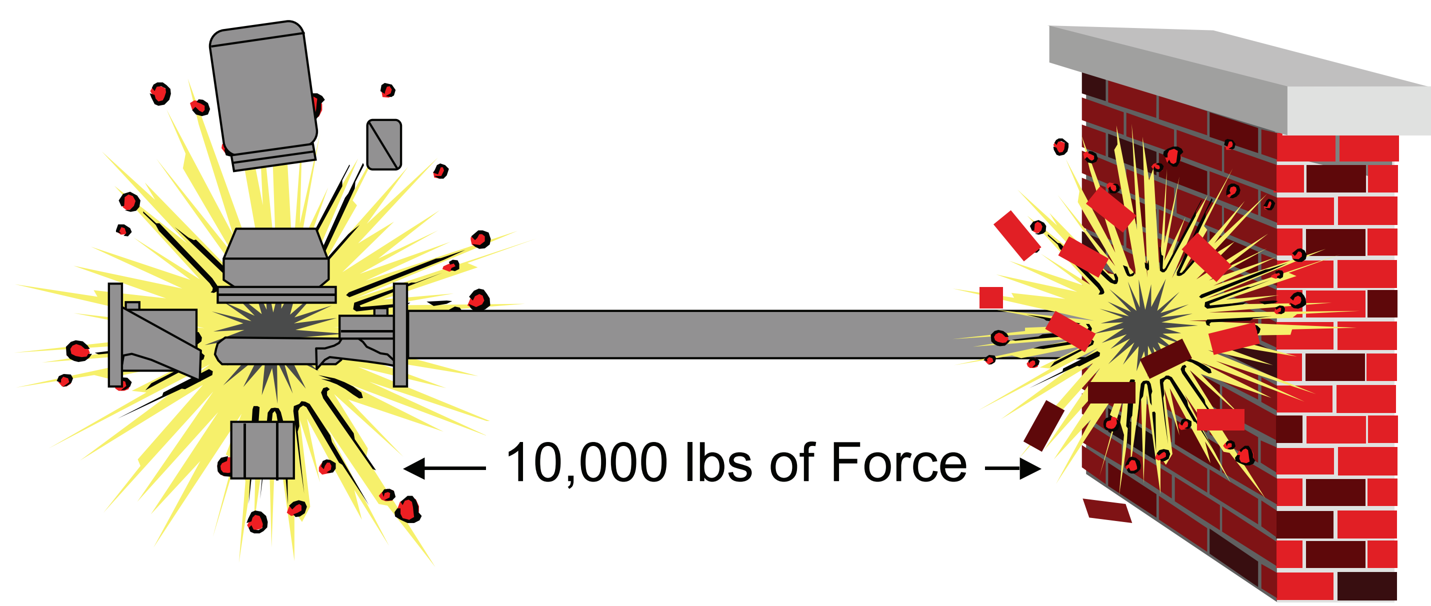
The Consequence of Thermal Expansion: Serious Problem



Unless compensation is provided for these dimensional changes, high stress loads will be transmitted throughout the system to pumps, chillers, anchors and the connected equipment. The above illustration does not incorporate any expansion devices to compensate for thermal movement in the straight of pipe which would result in failure of the piping system.

Uncontrolled Thermal Expansion



Thermal Expansion of Metal Pipe

Linear Thermal Expansion, in/100 ft.

Saturated Steam Pressure, psig	Temperature °F	Carbon Steel	Copper	Type 304 Stainless Steel
	-30	-0.19	-0.32	-0.30
	-20	-0.12	-0.21	-0.20
	-10	-0.06	-0.11	-0.10
	0	0	0	0
	10	0.08	0.12	0.11
	20	0.15	0.24	0.22
-14.6	32	0.24	0.37	0.36
-14.6	40	0.30	0.45	0.45
-14.5	50	0.38	0.57	0.56
-14.4	60	0.46	0.68	0.67
-14.3	70	0.53	0.79	0.78
-14.2	80	0.61	0.90	0.90
-14.0	90	0.68	1.02	1.01
-13.7	100	0.76	1.13	1.12
-13.0	120	0.91	1.37	1.35
-11.8	140	1.06	1.59	1.57
-10.0	160	1.22	1.80	1.79
-7.2	180	1.37	2.05	2.02
-3.2	200	1.52	2.30	2.24
0	212	1.62	2.38	2.43
2.5	220	1.69	2.52	2.48
10.3	240	1.85	2.76	2.71
20.7	260	2.02	2.99	2.94
34.6	280	2.18	3.22	3.17
52.3	300	2.35	3.46	3.40
75.0	320	2.53	3.70	3.64
103.3	340	2.70	3.94	3.88
138.3	360	2.88	4.18	4.11
181.1	380	3.05	4.42	4.35
232.6	400	3.23	4.87	4.59
666.1	500	4.15	5.91	5.80
1528	600	5.13	7.18	7.03
3079	700	6.16	8.47	8.29
	800	7.23	9.79	9.59
	900	8.34	11.16	10.91
	1000	9.42	12.54	12.27

Vacuum (-14.6 to -3.2 psig)

Calculating Pipe Growth

Application:
Heating Hot Water

Example:
A 2" copper pipe line is 134 feet long. Maximum temperature the line will encounter is 200°F. Lowest temperature is 40°F.

Calculation:
From chart – the expansion of copper pipe at:

200°F 2.30"per 100 ft. pipe
40°F .45" per 100 ft. pipe
Difference 1.85"per 100 ft. pipe

134/100 x 1.85 = 2.48" total length change

Application:
110# Steam

Example:
A 6" steel pipe line is 152 feet long. Maximum temperature the line will encounter is 340°F.
Lowest ambient temperature is -20°F.

Calculation:
From chart – the expansion of steel pipe at:

340°F 2.70"per 100 ft. pipe
-20°F .12" per 100 ft. pipe
Total 2.82"per 100 ft. pipe

152/100 x 2.82 = 4.29" total length change

Thermal Expansion and Contraction

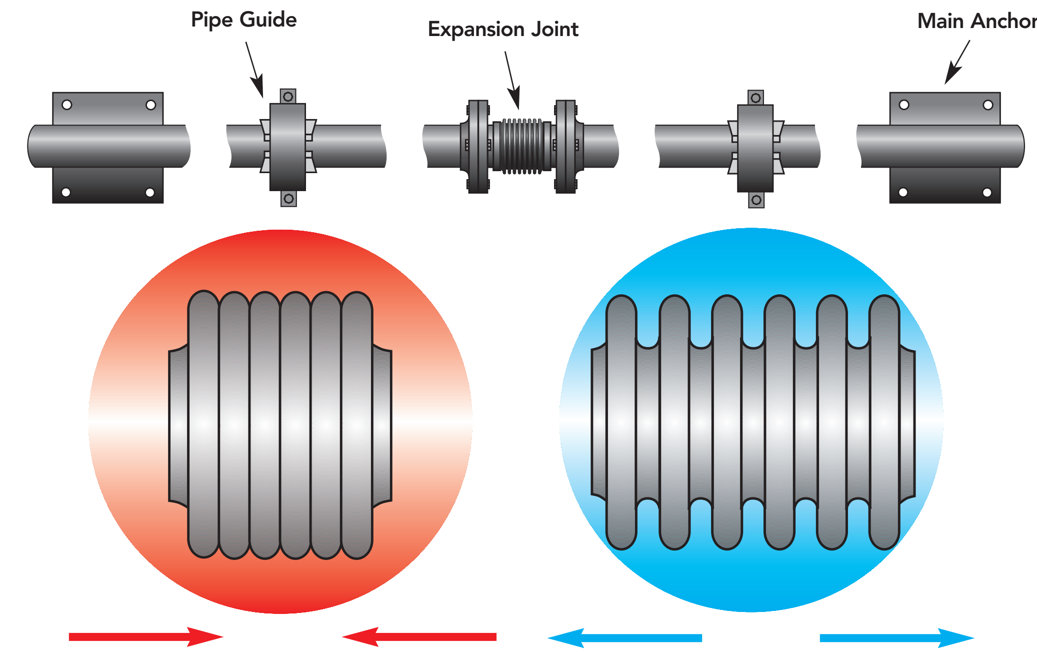
Application	Temperature Range (°F)	Thermal Expansion (per 100 ft.)
Chilled Water	40° - 100°	.46"
Condenser Water	40° - 100°	.46"
Domestic Hot Water *(Copper Pipe)*	40° - 140°	1.14"
Hot Water	40° - 200°	1.22"
Steam 100 psig	40° - 338°	2.40"

Thermal Movement

All materials **expand** and **contract** due to temperature changes. In a piping or ducting system, these thermal changes can produce stress on the system at fixed points such as vessels and rotating equipment as well as the piping or duct work system itself.

Thermal changes are produced by the following:

- The temperature of the system when installed is different from operating temperature.
  For example: chilled water, 100°F when installed, operates at 40°F
- The temperature cycle during operation
- The system is exposed to ambient temperature changes



Axial compression: *Heat in a piping system causes the expansion joint to compress axially when piping system is properly anchored.*

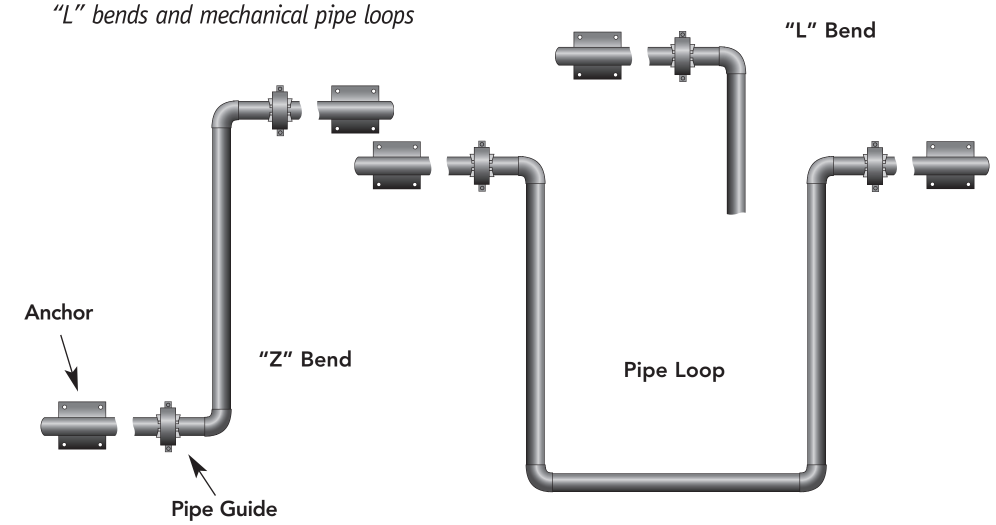
Axial extension: *Cold in a piping system causes the expansion joint to extend axially when piping system is properly anchored.*

Note: 80/20 Rule: 80% motion compression/20% extension.
Example: Expansion joints rated for 3" total axial travel = 2.40 axial compression/.60 axial extension

Compensating for Thermal Movement

The basic methods of compensating for thermal movement in a piping system are:

- Design a flexible piping system which utilizes changes of direction to absorb movement *For example: "Z" bends, "L" bends and mechanical pipe loops*
- Design expansion devices, expansion joints or flexible loop technology



Why Expansion Joints?

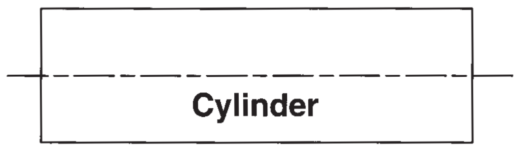
- Flex-Hose can assist with product selection, layout & design
- Inline, compact design saves valuable space reducing welding & other labor costs
- Ability to handle large amounts of axial expansion with one device vs. multiple devices

Pipe bends and loops:

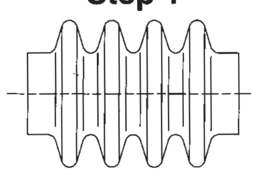
- Proper design requires accurate calculations for contraction, expansion & anchor loads
- Requires minimum lengths of offsets
- Pipe guides are essential
- May require more piping & labor costs
- May add to heat/friction lost & operating cost
- Require large space to install & may need multiple locations.

Basic Principles: Bellows Anatomy

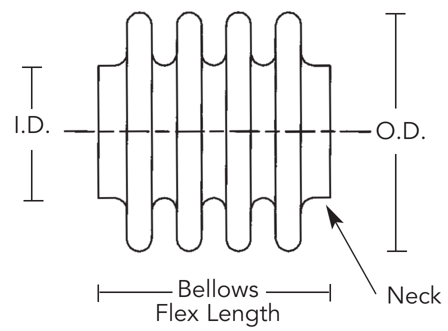
- Bellows formed from a metal cylinder in two steps
- Bellows length approximately one-third the length of original cylinder

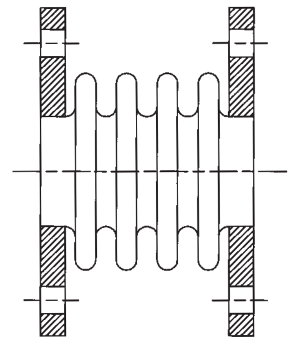


Step 1



Step 2

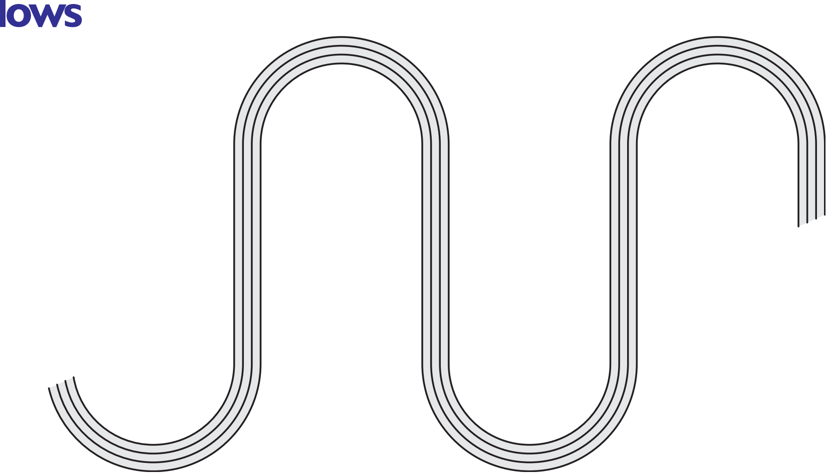




- Adding flanges completes assembly of the single bellows expansion joint

Single Ply vs. Laminated Bellows

Single Ply		
Pipe Size	=	6.0″
Corrugation Depth	=	0.6″
Corrugation Pitch	=	0.63″
Material Thickness	=	.036″
Laminated		
Pipe Size	=	6.0″
Corrugation Depth	=	0.6″
Corrugation Pitch	=	0.63″
Material Thickness is 3 plys of .11″	=	.036″



Laminated of multi-ply bellows for maximum flexibility and endurance

The reduced thickness of the laminations results in lower bending stresses due to axial motion increasing the life of the bellows

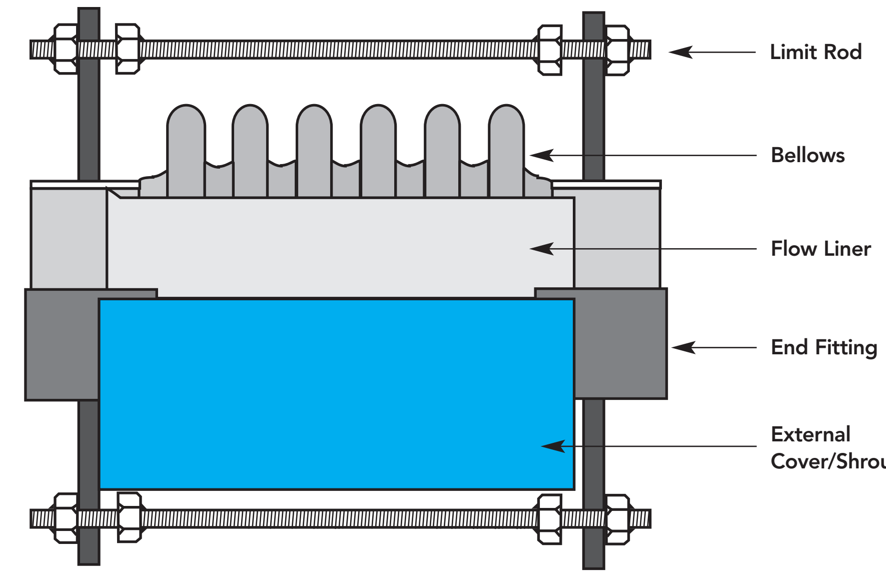
Bellows Design Basics

Flex-Hose Co. metal expansion joints are designed for a wide range of service conditions. They consist of a flexible bellows element, appropriate end fittings to match adjoining pipe fittings and schedule. The bellows is a flexible seal design to contain the media, absorb thermal movement, and pressures of the system.

The bellows are manufactured from thin-walled tubing to form a corrugated cylinder. The corrugations are commonly referred to as convolutions and add the structure necessary for the bellow material to contain system pressure.

The bellows design incorporates the thickness and convolution geometry that meets the capacity of the adjoining pipe to contain system pressure at the specified design temperature.

Flexibility of the bellows is acheived through the convolution profile and pitch as multiple convolutions are required to provide the expected expansion and contraction of the piping system.



Accessories

Covers

Expansion joints require careful handling and must be protected from any impact, weld spatter, etc. Before insulating an expansion joint, care must be taken that foreign material is not trapped in the corrugations impeding its movements. It is suitable to install a metal cover over the flanges and then wrap the insulation around it.

Flow Liners

Flow liners are installed in the inlet bore of the expansion joint to protect the bellows from erosion damage due to abrasive media or resonant vibration caused by turbulent flow or excessive velocities.

Tie Rods

Tie Rods are devices with the primary function to restrain the bellows pressure thrust. It should be pointed out that when tie rods are furnished on expansion joints subject to external axial movement, they will only restrain the pressure thrust in the event of an anchor failure. During normal operation the anchor or adjacent equipment will be subjected to the pressure thrust forces.

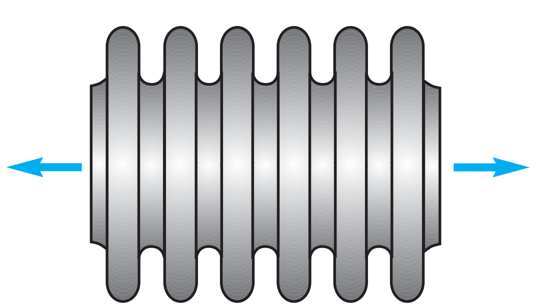
Limit Rods

Limit Rods are devices with the primary function of restricting the bellows movement range. The limit rods are designed to prevent bellows over-extension or over-compression while restraining the full pressure thrust in the event of a main anchor failure.

Control Rods

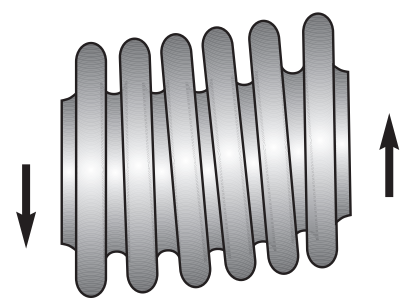
Control Rods are devices attached to the expansion joint with the primary function of distributing movement between the two bellows of a universal joint. Control rods are not designed to restrain bellows pressure thrust.

Expansion Joint Movement Capabilities



Axial Extension

Extension of the bellows length due to pipe contraction when piping system is anchored properly.

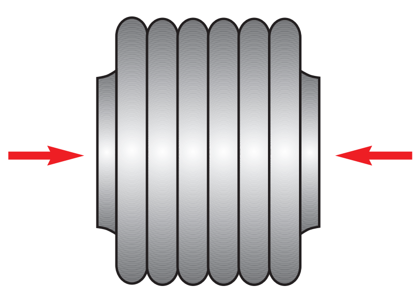


Lateral Offset

Motion which is perpendicular to the plane of the pipe with the expansion joint fittings remaining parallel.

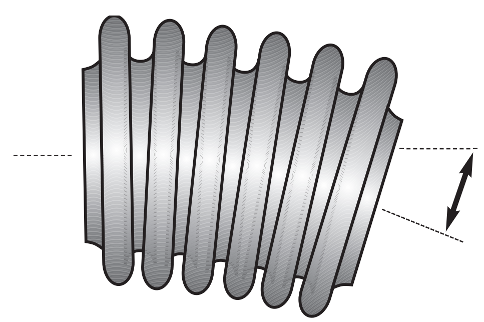
Installation Misalignment

Misalignment of the expansion joint on installation reduces the total movement capacity of an expansion joint. Misalignment of the piping system should be corrected prior to installation of the expansion joint. If the misalignment can not be corrected, please contact Flex-Hose Co. for technical support.



Axial Compression

Compression of the bellows length due to pipe expansion when piping system is anchored properly.



Angular Rotation

Bending about the longitudinal centerline of the expansion joint.

Concurrent Movements

Expansion joint movement capacity published in the catalog is maximum capacity for non-current movement. Axial, lateral, and angular movements can occur simultaneously, i.e. on reactor vessels or piping systems utilizing expansion joints at building/seismic interfaces. If your application involves concurrent motions it is essential that the movement capacity of the expansion joint be determined. The sum of these values may not exceed 100%.

For example:

Expansion Joint design parameters

Non-concurrent

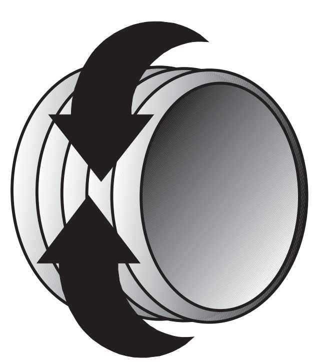
Axial	1.5″
Lateral	.50″
Angular	10°

Concurrent

Axial	**.75″**	**=**	**50%**
Lateral	**.125″**	**=**	**25%**
Angular	**2.5°**	**=**	**25%**
	TOTAL	**=**	**100%**

WARNING

TORSION: Twisting about the longitudinal axis of a metal expansion joint will reduce bellows life or cause expansion joint failure and should be avoided. Expansion joints should not be located at any point in a piping system that would impose torque to the expansion joint device.



TORSION

Bending about the longitudinal centerline of the expansion joint

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Expansion Joint Design Considerations

We have noted how placing a flexible metal bellows at selected locations in a piping system can accommodate its thermal growth. There are some side effects which occur when a pipe is cut in two and a bellows is inserted to take up the movement of the pipe. The side effects are pressure thrust or spring rate. It is essential for proper anchor designs to determine which one will impact your design.

Spring Rate

In very low pressure application the more significant force may be the spring rate (force to compress the bellows) which is expressed in pounds per inch of motion. Thus, as the pipe grows due to increasing temperature, the bellows will resist compression by the force noted in the spring rate (Figure A).

A comparison of pressure and force data to spring rate will show that it does not require very much line pressure for pressure thrust to be the dominant factor of the two in expansion joint applications.

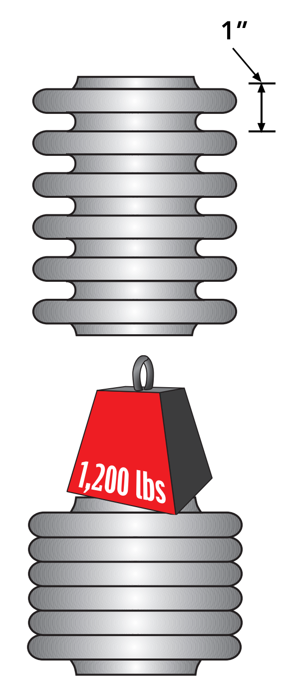


Figure A.

Pressure Thrust

The bellow's very nature of being flexible (to absorb movement) will extend (straighten out) due to the line pressure (Figure B). This pressure thrust must then be absorbed by some means or the line pressure will cause the bellows to over extend and tear itself apart. This force may be accommodated by anchoring the pipe or by using an expanion joint which incorporates tie rods or limit rods.

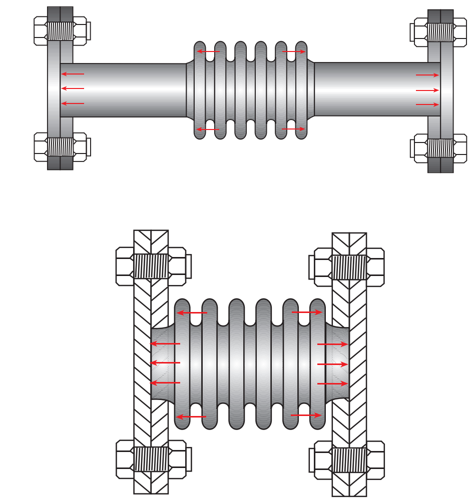


Figure B. Pressure Thrust
For example, see page 8.

Squirm

Convolutions can be added to increase movement without sacrificing cycle life, but there is a limit to this process which is reached when the bellows, under internal pressure, exhibits a condition known as squirm (bellows instability). (Figure C).

Externally pressurized bellows are not subject to this condition, as they become more stable under pressure. A bellows is a a flexible seal. This convoluted part of the expansion joint is designed to flex when thermal movement in the piping system occurs. Therefore, by determining the thermal movements that will occur in the piping system, expansion joints may be specified, manufactured, and installed in the system to accommodate these movements.

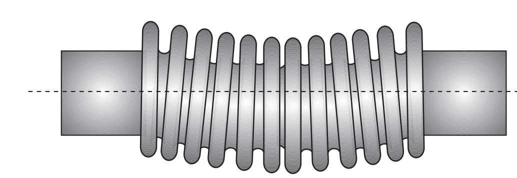
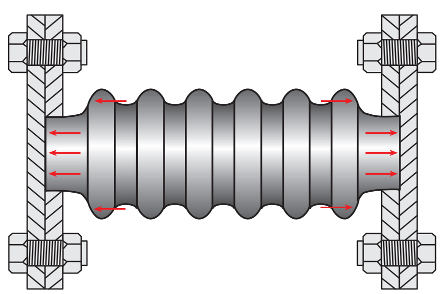


Figure C. Squirm/Bellows Instability

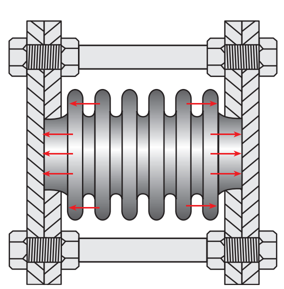
Pressure Thrust

PRESSURE THRUST

By its very nature of being flexible (to absorb movement) a bellows will extend (straighten out) due to the line pressure. This pressure thrust must then be absorbed by some means or the line will tear itself apart. This force may be accommodated by anchoring the pipe or by using an expansion joint which incorporates tie rods, hinges, gimbals or pressure balancing bellows.

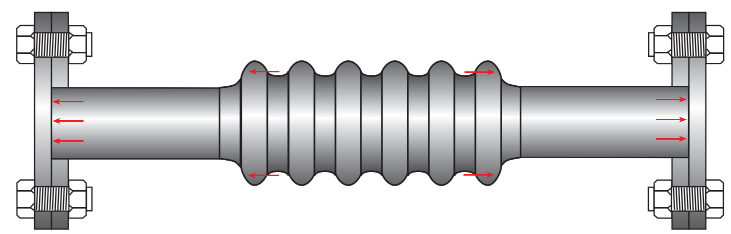


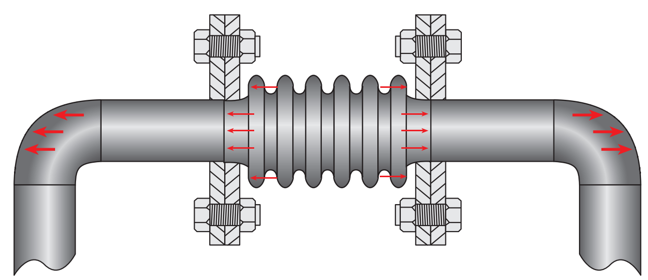
Unless restrained, the pressure thrust force will stretch the bellows of the expansion joint back into a cylinder



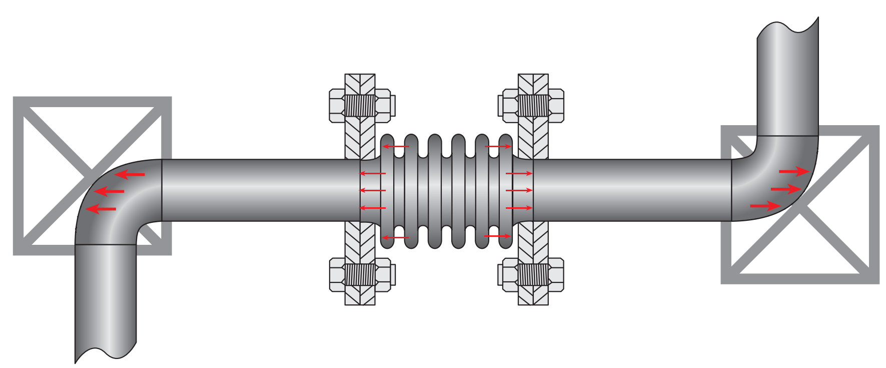
Rods are installed temporarily to restrain the expansion joint during the hydostatic test

Pressure thrust pushes the bellows apart at the end convolutions and pulls the bellows apart by pushing on the blind flanges





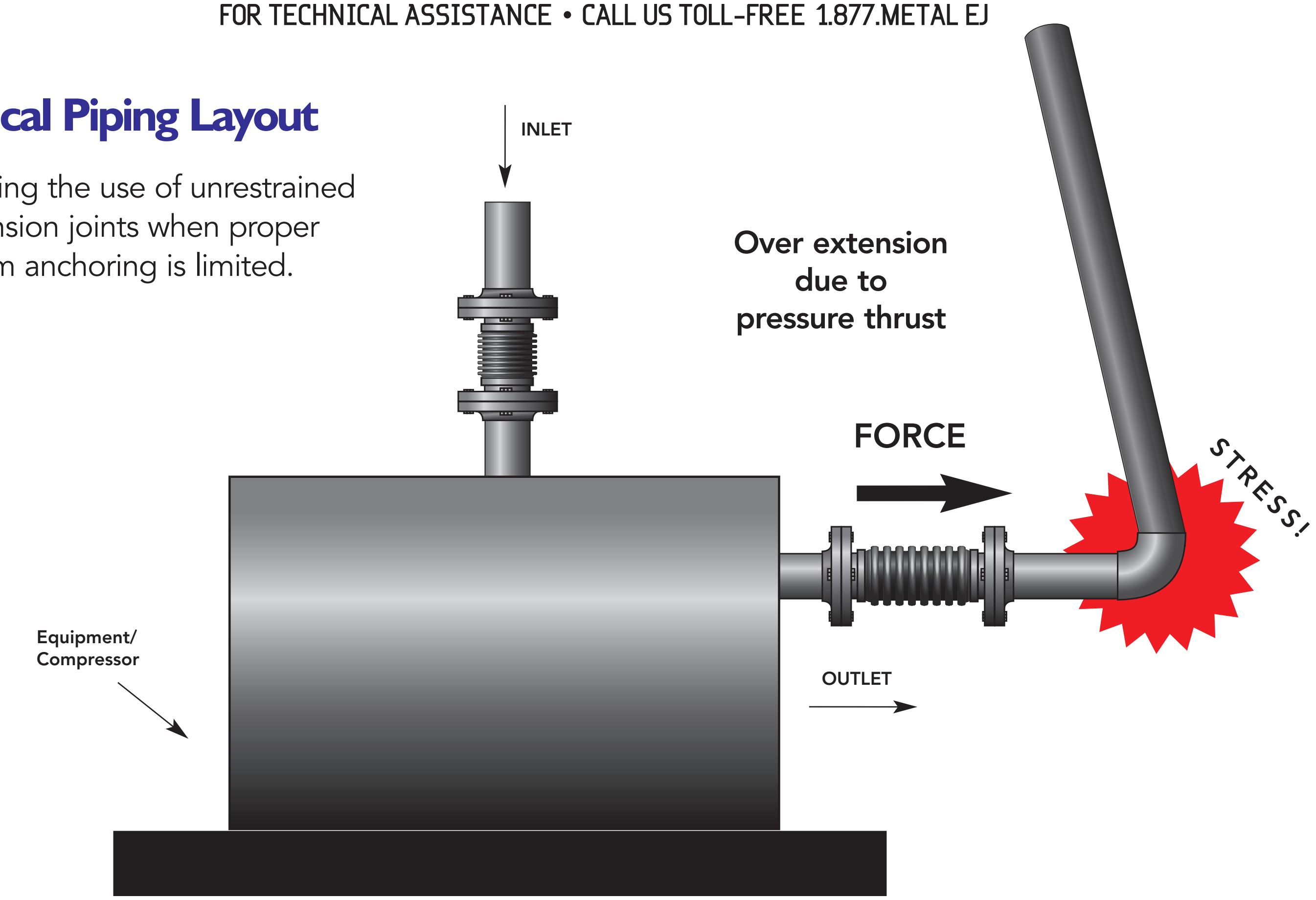
Unless restrained, the pressure thrust force will stretch the bellows of the expansion joint back into a cylinder



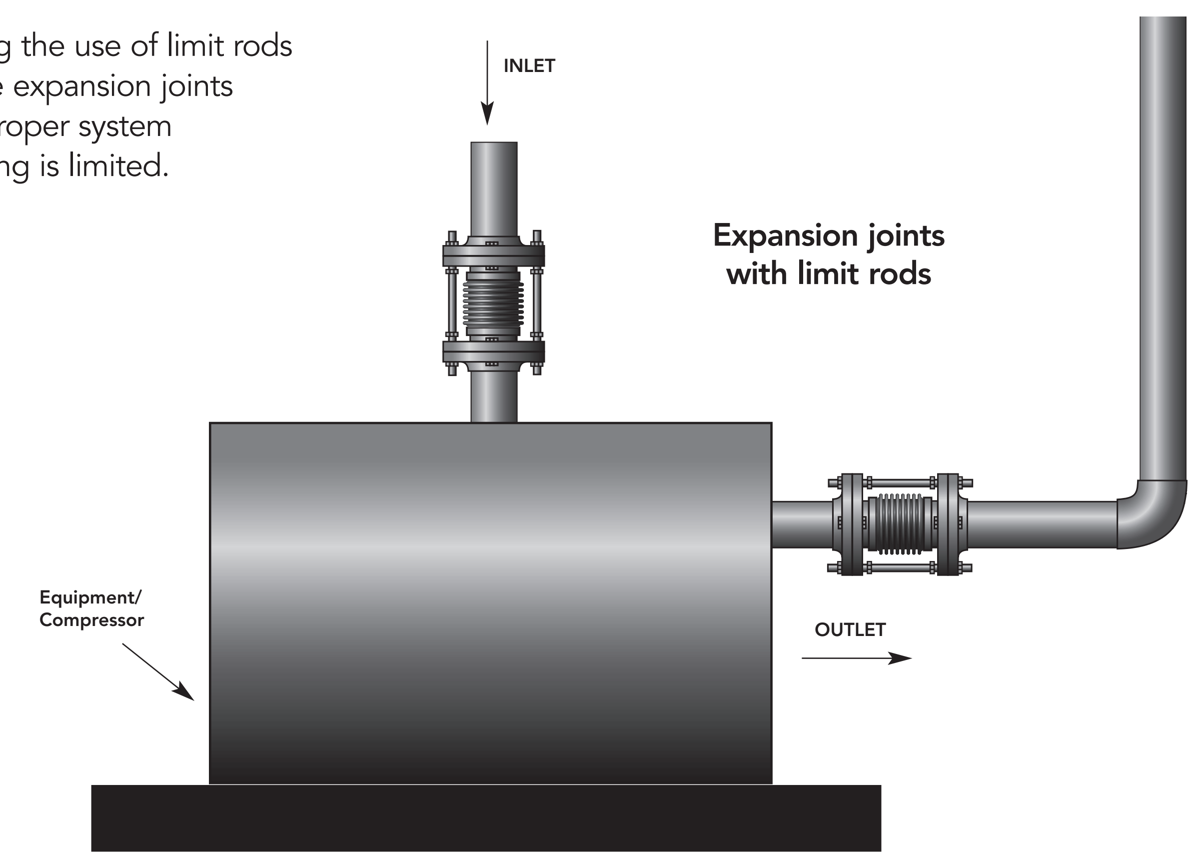
The pressure thrust force acts on the piping system as show. The amount of force varies directly with pressure in the line. The pipe must be anchored to react to the pressure thrust force for the maximum test pressure.

Typical Piping Layout

Showing the use of unrestrained expansion joints when proper system anchoring is limited.



Showing the use of limit rods with the expansion joints when proper system anchoring is limited.



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Flex-Hose State-of-the-Art Technology - Low Corrugation

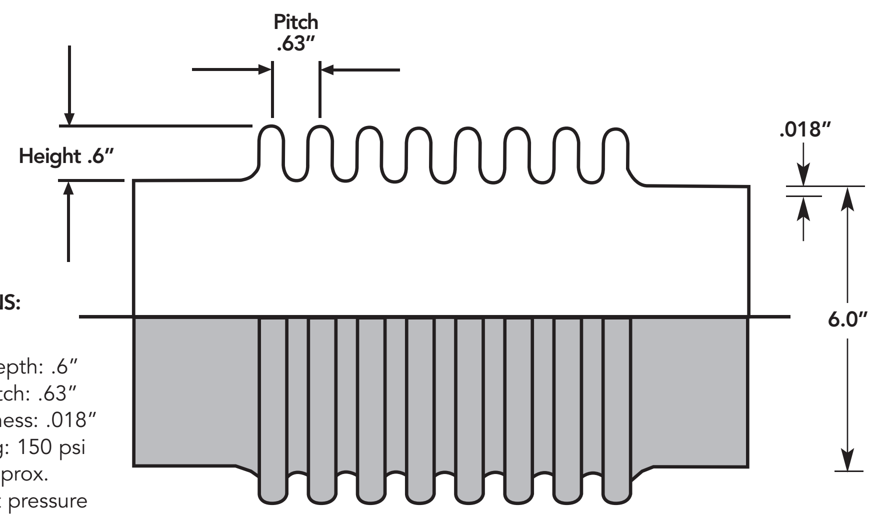
Flex-Hose Co. state-of-the-art low corrugation technology (Figure A) reduces the corrugation height and pitch. This limits the pressure stresses on the corrugations cross section. The low profile design incorporates the correct number of convolutions to acheive the desired movement of the bellows. The smaller outer diameter also saves valuable space. Over 60 percent smaller effective area of the bellows substantially reduces the size of the anchors, the structure to which the pipe guides are attached, and lowering the overall cost while simplifying installation.

Old Technology - High Corrugation

High corrugation (Figure B) is old technology. It must use reinforcing rings to acheive higher working pressure over 50 psi. The extreme height and pitch of the convolutions cause the expansion joint to have very little hoop strength, requiring external structure such as root rings or reinforcing rings for pressures greater than 50 spi.

The increased effective area of the bellows significantly increases the over all cost of a project by creating the need for larger anchors and structure to attach the pipe guides to.

Low Corrugation vs. High Corrugation



SPECIFICATIONS:

Pipe SIze: 6.0"
Corrugation Depth: .6"
Corrugation Pitch: .63"
Material Thickness: .018"
Pressure Rating: 150 psi
A margin of approx.
4 to 1 for burst pressure

By reducing the corrugation height and pitch, we limit the pressure stresses on the corrugation cross-section. The low profile design incorporates the correct number of convolutions to achieve the desired movement of the bellows.

FEATURES:

- No ring reinforcement required
- Lower rod and hinge hardware costs
- Over 60% smaller effective area reduces anchoring costs
- Extension allowance normally eliminates precompression at installation site
- Lighter weights reduce shipping costs and simplify installation

Figure A. - Low Corrugation
State-of-the art low corrugation expansion joint would have an effective area of 34.5 in².
Pressure thrust force = (150 psig)(34.5 in².) = 5176 lbs.

SPECIFICATIONS:

Pipe SIze: 6.0"
Corrugation Depth: 2.5"
Corrugation Pitch: 2.3"
Material Thickness: .125"
Pressure Rating: 50 psi*

*To go to higher pressures, reinforcing rings must be used. The net effect is the rings form the structure and the bellows form the seal.

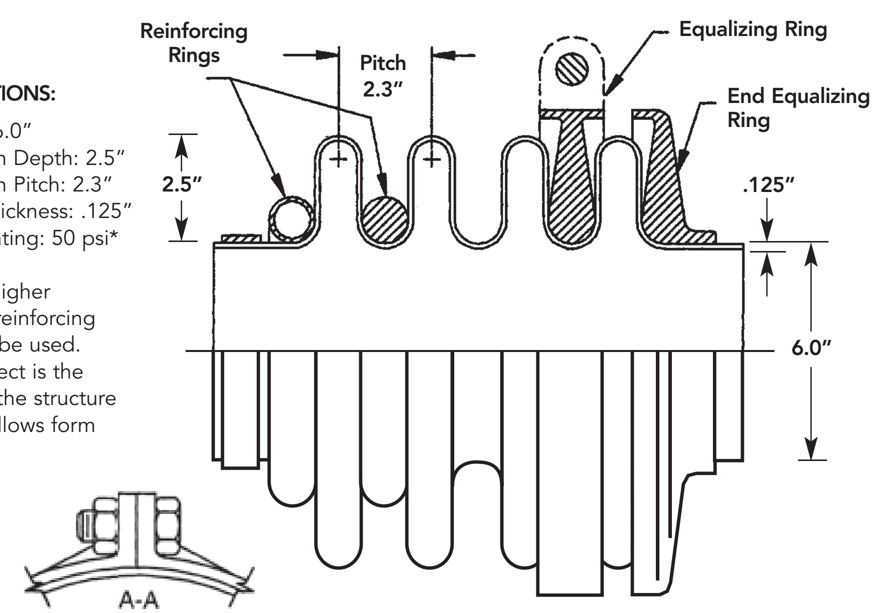
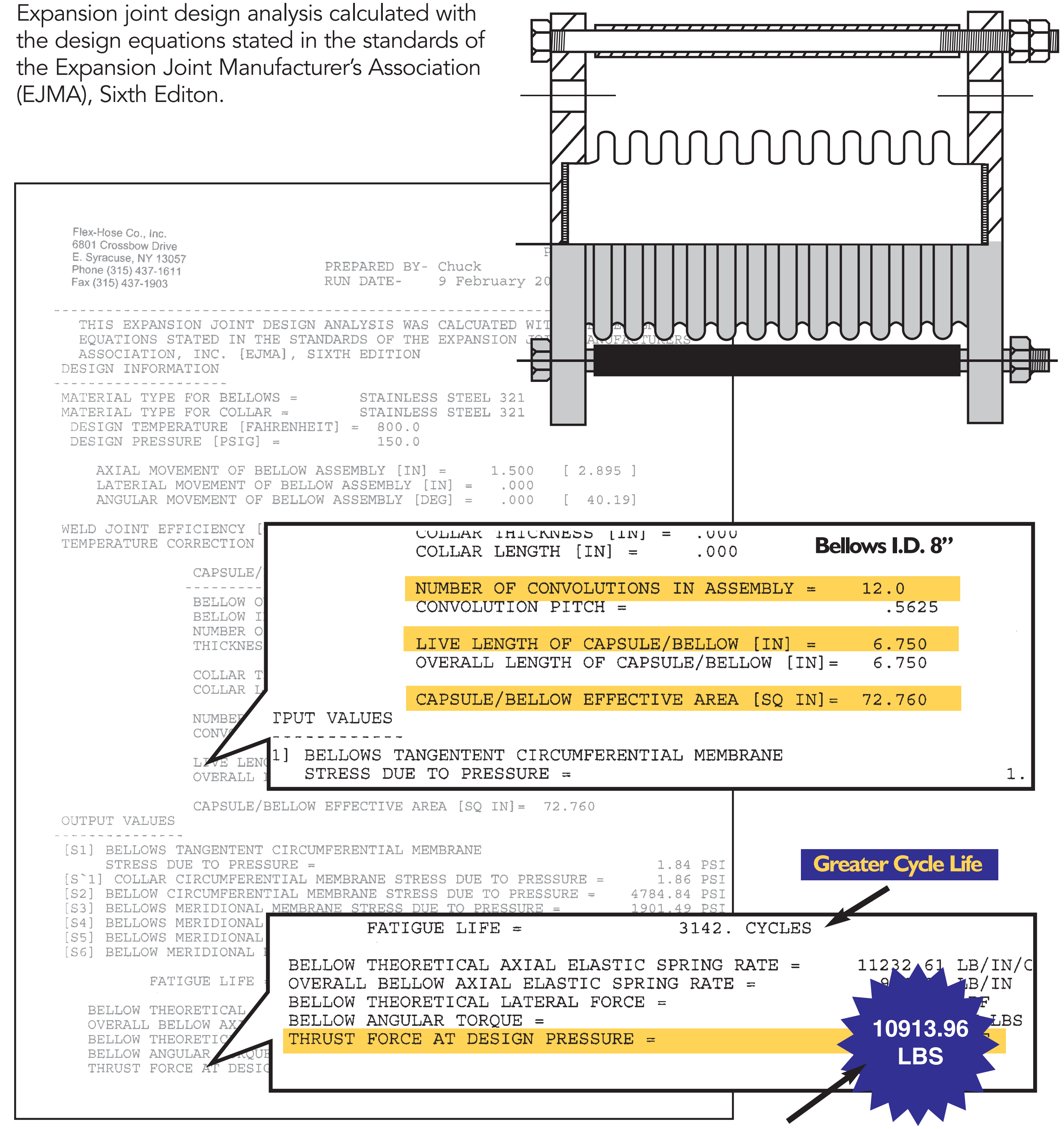


Figure B. - High Corrugation
High corrugation expansion joint would have an effective area of 56.7 in².
Pressure thrust force = (150 psig)(56.7 in².) = 8505 lbs.

EJMA Calculations - Low Corrugation
New Technology utilized by Flex-Hose Co., Inc. minimizes stress loads

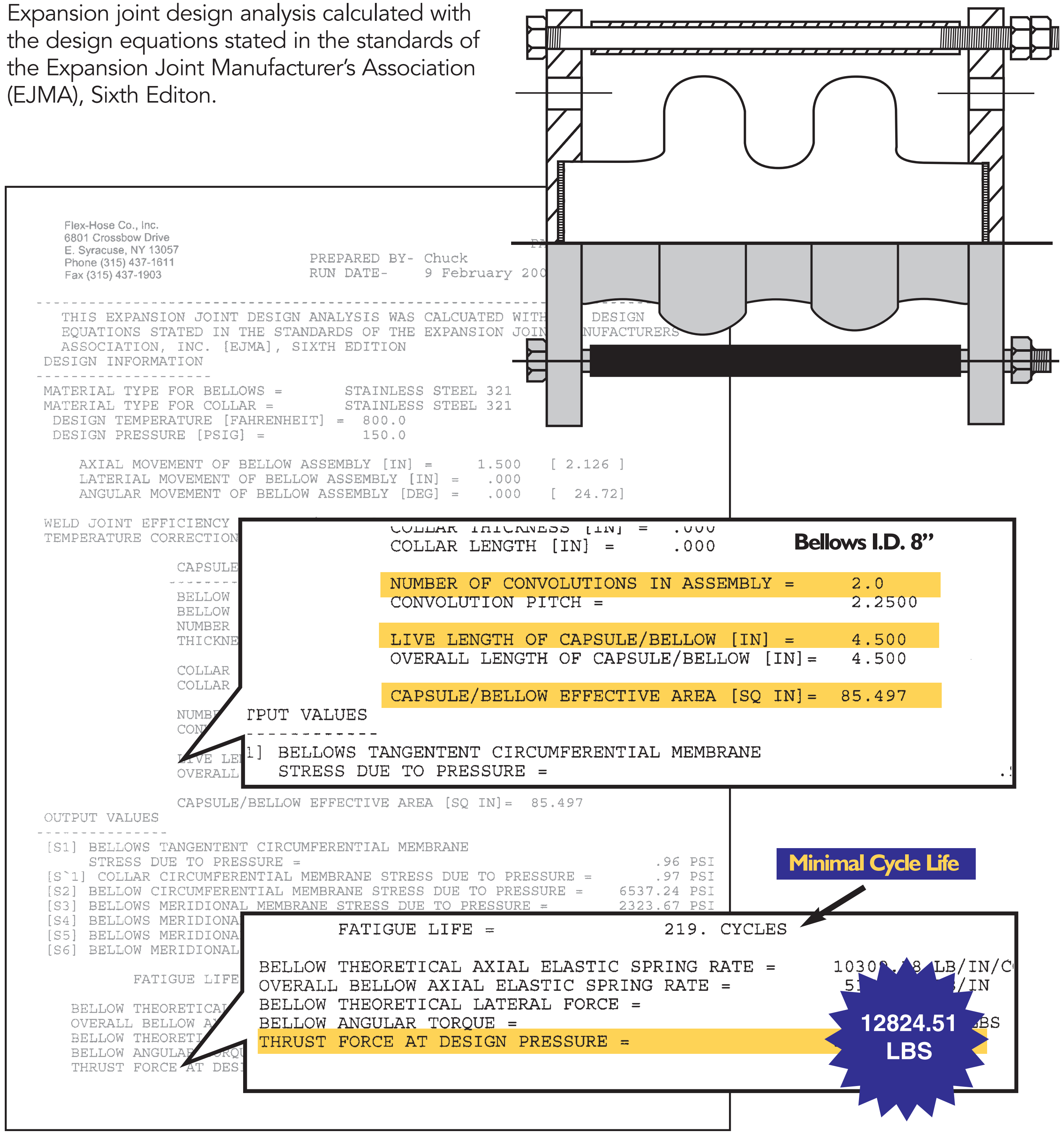
Expansion joint design analysis calculated with the design equations stated in the standards of the Expansion Joint Manufacturer's Association (EJMA), Sixth Editon.

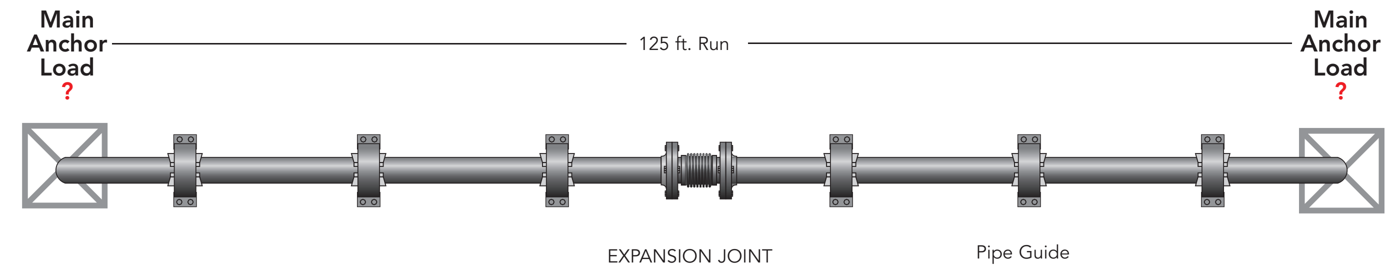


Flex-Hose's new low corrugation technology reduces stress loads resulting in lower anchor requirements than that of old high corrugation technology

EJMA Calculations - High Corrugation
Old Technology produces higher stress loads

Expansion joint design analysis calculated with the design equations stated in the standards of the Expansion Joint Manufacturer's Association (EJMA), Sixth Editon.





Main Pipe Anchors

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 on the main line
4. Where a shut-off or pressure-reducing valve is installed in a pipe run
5. At a capped end of pipe

How much force is at the anchors?

A main pipe 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 a pipe section containing one or more expansion joints, this will consist of the sum of: the pressure thrust at maximum pressure, plus force required to deflect the expansions joints full rated movement plus the frictional forces due to the pipe alignment guides.

Note: The maximum pressure thrust exerted by the expansion joints are during cold water hydrostatic testing*. The main anchors must be designed to absorb the pressure thrust forces created by the test pressure. If the pressure thrust forces that are created by the expansion joint design are too great to be absorbed by main anchors in the piping system the following can be utilized as alternate designs:

- Tied expansion joints (if the rods are always in tension)
- Pressure-balanced expansion joints
- Hinged expansion joints
- Gimbal expansion joints

Determining How Much Force is at the Anchors:

Application: 75# Steam

Example:
An 8" steel pipe line is 125 feet long. Maximum temperature the line will encounter is 320°F. Lowest temperature is 40°F.

Calculation:
125/100 x 2.23 = 2.79" thermal growth
Effective Area = 72.8
Axial Spring Rate = 936.05 lbs/in

Expansion Joint Specified:
Flex-Hose Bellowsflex Single-Ply BF/150-FxF

What are the forces on the anchors and guides?
1) operating conditions
2) *coldwater hydrostatic test at 1.5 x design

Expansion joint forces acting upon anchors:
Where:
Fs = The static pressure thrust due to internal pressure - lbs
= (Effective area) (Design line pressure)
= (72.8 in^2) (115 psi)
= 8,372 lbs
F = The force required to deflect the expansion joint
= (Spring rate) (Axial deflection)
= (936.05 lb/in) (2.79 in)

Solution to forces acting on main anchors:
Fx = -Fs - F
Fx = -8,372 - 2,611.60
Fx = 10.983.60 lbs

Maximum lateral forces acting on pipe alignment guides are:
Force acting on main anchor x 0.15
Maximum lateral force = 10,983.60 x 0.15
Maximum lateral force = 1,647.54 lbs

Internally and Externally Pressurized Expansion Joints

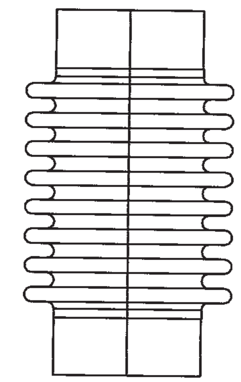
Internally Pressurized Bellows
Bellows Stability
An internally pressurized expansion joint will eventually buckle at some internal pressure loading. This buckling is called squirm. Squirm is detrimental to bellows performance in that it can greatly reduce both cycle life and pressure capacity.

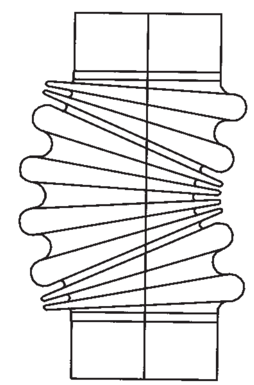
Every internally pressurized bellows will squirm if the pressure is increased to a high enough level. For a given diameter bellows, the greater the convoluted length the lower the pressure required to cause squirm.

For a giving pressure, the larger the diameter, the greater the convoluted length can be before the bellows will squirm. Therefore, the smaller diameter bellows will have a shorter convoluted length and a reduced ability to absorb motion when compared to a larger diameter bellows.

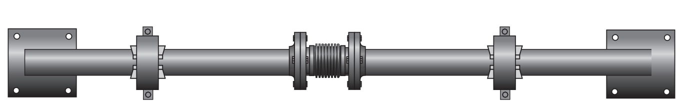
Externally Pressurized Bellows
Bellows Stability
External pressure does not produce squirm no matter how long the convoluted length.

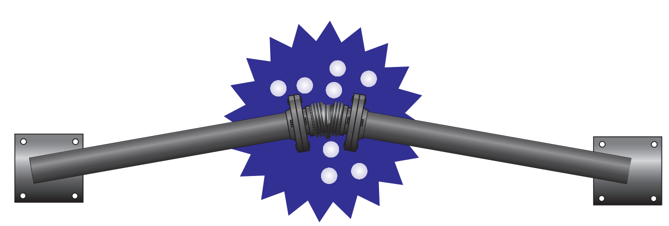
Expansion joints designed with externally pressurized bellows can accommodate greater axial movements even in small diameters.


NORMAL


SQUIRM

Why Pipe Guides?

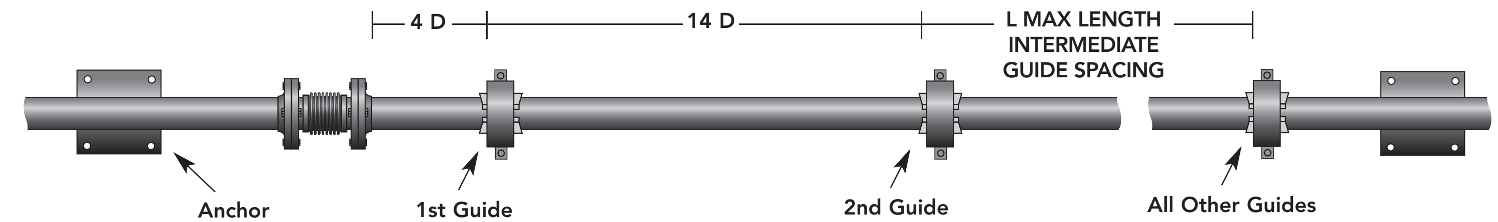

GUIDED


NOT GUIDED

A **pipe alignment guide** is a form of sleeve fastened 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. Pipe alignment guides are designed primarily for use in applications involving axial movement only.

NOTE: Proper guiding and anchoring is essential to an installation of an expansion joint to prevent buckling or squirming of the pipeline.

Intermediate Pipe Guided Spacing



NOTE: First pipe guide must be located within a distance no greater than four pipe diameters from the end of the bellows and the second guide must be located within a distance no greater than fourteen pipe diameters from the first guide.

Nom. Pipe Size (In.)	Maximum Distance from Expansion Joint to 1st Guide or Anchor	Approx. Distance Between 1st and 2nd Guide	Approximate Distance Between Additional Pipe Guides (Ft.)							
			@ 50 PSI	@ 100 PSI	@ 150 PSI	@ 200 PSI	@ 250 PSI	@ 300 PSI	@ 350 PSI	@ 400 PSI
.75	3.00″	10.00″	11.00	7.50	6.00	5.00	5.50	5.00	5.00	5.00
1.00	4.00″	1′-2.00′″	15.00	11.00	8.50	7.50	6.50	6.00	5.50	5.0
1.25	5.00″	1′-5.00″	17.00	13.00	11.00	9.00	8.00	7.25	7.00	6.50
1.50	6.00″	1′-9.00″	22.00	16.00	13.00	11.00	10.00	9.00	8.50	8.00
2.00	8.00″	2′-4.00″	25.00	18.00	14.00	13.00	12.00	11.00	9.50	9.00
2.50	10.00″	2′-11.00″	32.00	23.00	17.00	16.00	14.00	13.00	12.00	11.00
3.00	1′-0″	3′-6.00″	38.00	27.00	22.00	19.00	17.00	16.00	15.00	14.00
4.00	1′-4.00″	4′-8.00″	52.00	37.00	31.00	27.00	24.00	22.00	20.00	18.00
5.00	1′-8.00″	5′-10.00″	62.00	45.00	37.00	32.00	28.00	27.00	24.00	23.00
6.00	2′-0″	7′-0″	67.00	47.00	39.00	34.00	32.00	28.00	26.00	24.00
8.00	2′-8.00″	9′-4.00″	86.00	62.00	51.00	44.00	40.00	36.00	34.00	32.00
10.00	3′-4.00″	11′-8.00″	109.00	76.00	63.00	55.00	48.00	45.00	42.00	38.00
12.00	4′-0″	14′-0″	117.00	84.00	68.00	60.00	54.00	47.00	45.00	42.00
14.00	4′-8.00″	16′-4.00″	120.00	88.00	72.00	62.00	55.00	51.00	46.00	44.00
16.00	5′-4.00″	18′-8.00″	133.00	95.00	78.00	67.00	62.00	55.00	52.00	48.00
18.00	6′-0″	21′-0″	151.00	105.00	87.00	75.00	67.00	62.00	58.00	54.00
20.00	6′-8.00″	23′-4.00″	160.00	107.00	93.00	81.00	72.00	65.00	62.00	57.00
24.00	8′-0″	24′-0″	181.00	130.00	105.00	92.00	85.00	75.00	70.00	65.00

NOTE: The recommendations given for pipe anchors and guides represent the minimum requirements for controlling pipelines which contain expansion joints and are intended to protect the expansion joint and pipe system from abuse and failure. However, additional **pipe supports** are often required between the pipe guides in accordance with accepted piping practices.

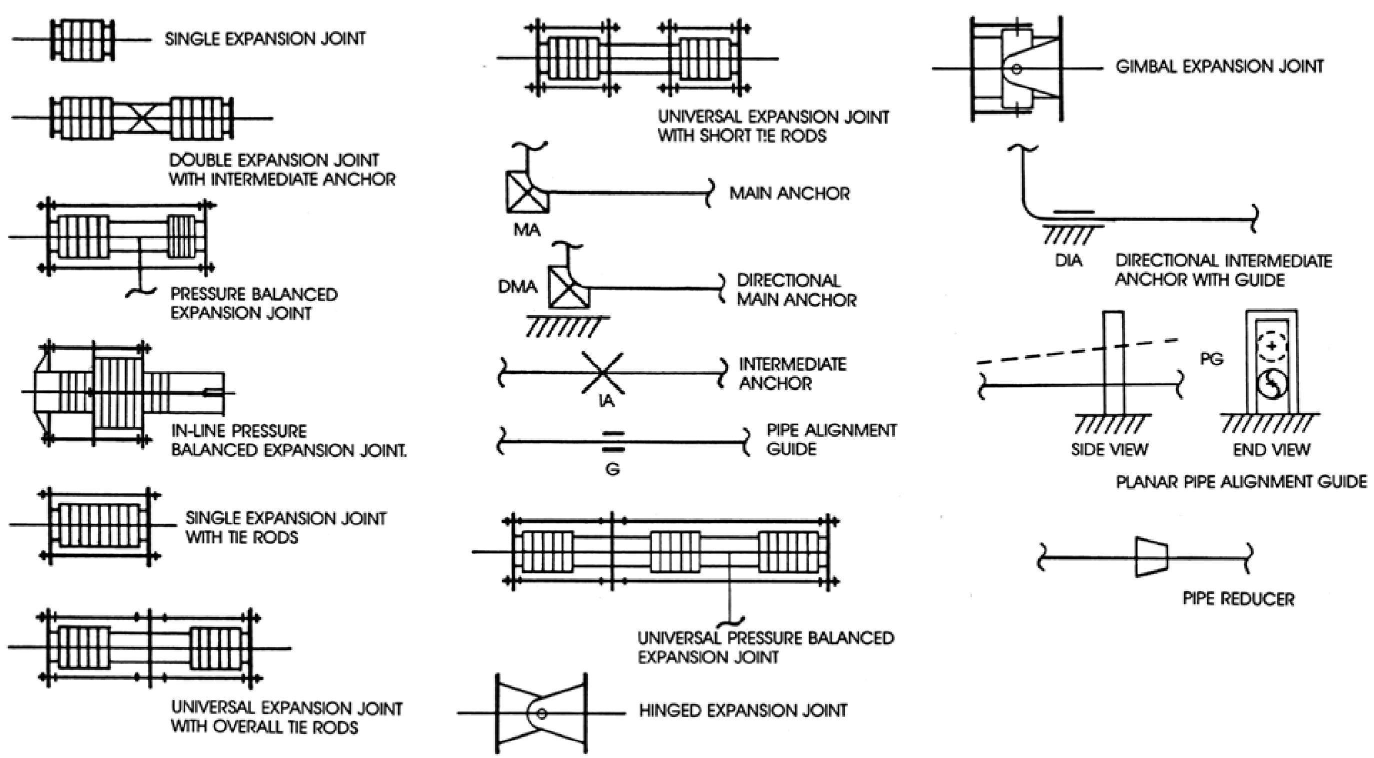
A **pipe support** is any device which permits free movement of the piping and carries the total weight of in line equipment such as valves, meters, expansion joints, and the weight of the contained fluid. Pipe supports cannot be substituted for pipe alignment guides. Pipe rings, U-bolts, roller supports, and spring hangers are some examples of conventional pipe supports.

Additional pipe supports are usually required between guides in accordance with standard piping practices.

Understanding the Customers Intent (Application)

- New Installation
- Replacement of current expansion joint in service
  A. Manufacturer's part number
  B. Overall length in service
  C. Overall length when system is down
  D. Is system hot or cold?
- Pipe diameter
- Space restrictions:
  Overall length if dimension is critical
- Temperature:
  - maximum operating
  - minimum ambient temperature
- Working pressure
- System test pressure
- Media being conveyed
- Alloy of piping system
- Mating pipe end connections

Symbols/Key Guide



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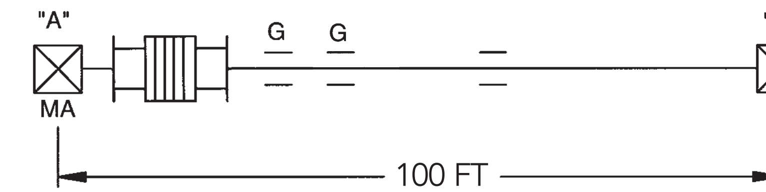
Most Frequent Axial Motion Application

Expansion on a piping run due to an elevated operating temperature (axial motion)

Assumptions:

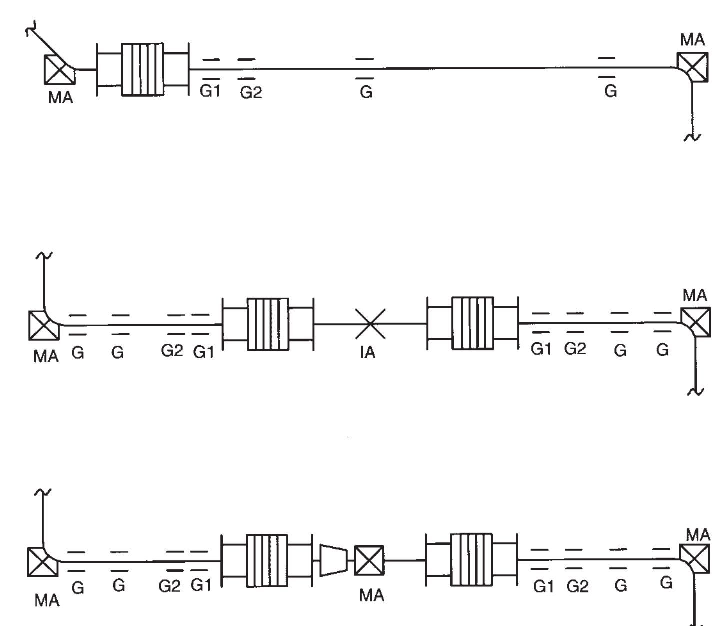
- The piping system is properly supported and guided.
- The weight of the piping system and the fluid being conveyed is carried by properly designed supports and hangers and is, therefore, not included.

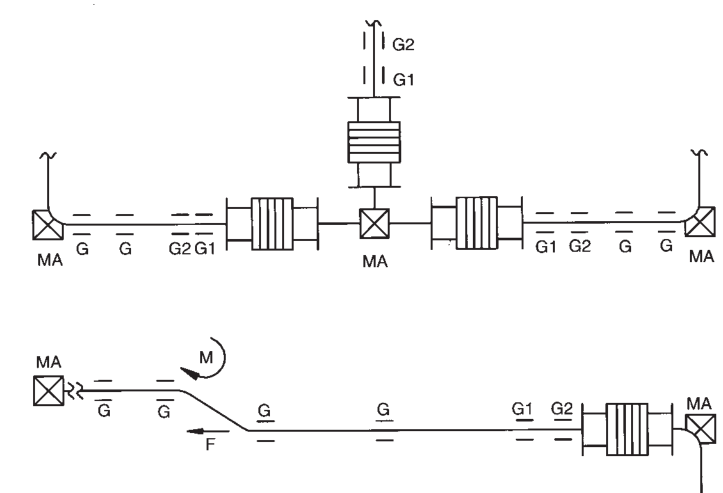


Reduce installation costs by locating the expansion joint to the main anchor no greater than a distance of 4 times the diameter of the pipe, this eliminates the need for a pipe guide.

MA = Main Anchor G = Guide

Axial Motion Applications





Slight directional change in piping system where offset length is no greater than intermediate guide requirements.

NOTE: Guides should be installed near both ends of the offset to minimize the effects of the bending movement in the piping system.

MA = Main Anchor G = Guide

Bellowsflex™ Metal Bellows Expansion Joints

The standard bellows element is manufactured with various 300 series stainless steel alloys. Maximum system test pressure 1.5 times maximum working pressure.
Bellowsflex can also be supplied with accessories such as tie rods, limit rods, flow liners, and protective covers/shrouds.

Standard sizes
2 to 24" I.D.
Custom sizes available to 60"

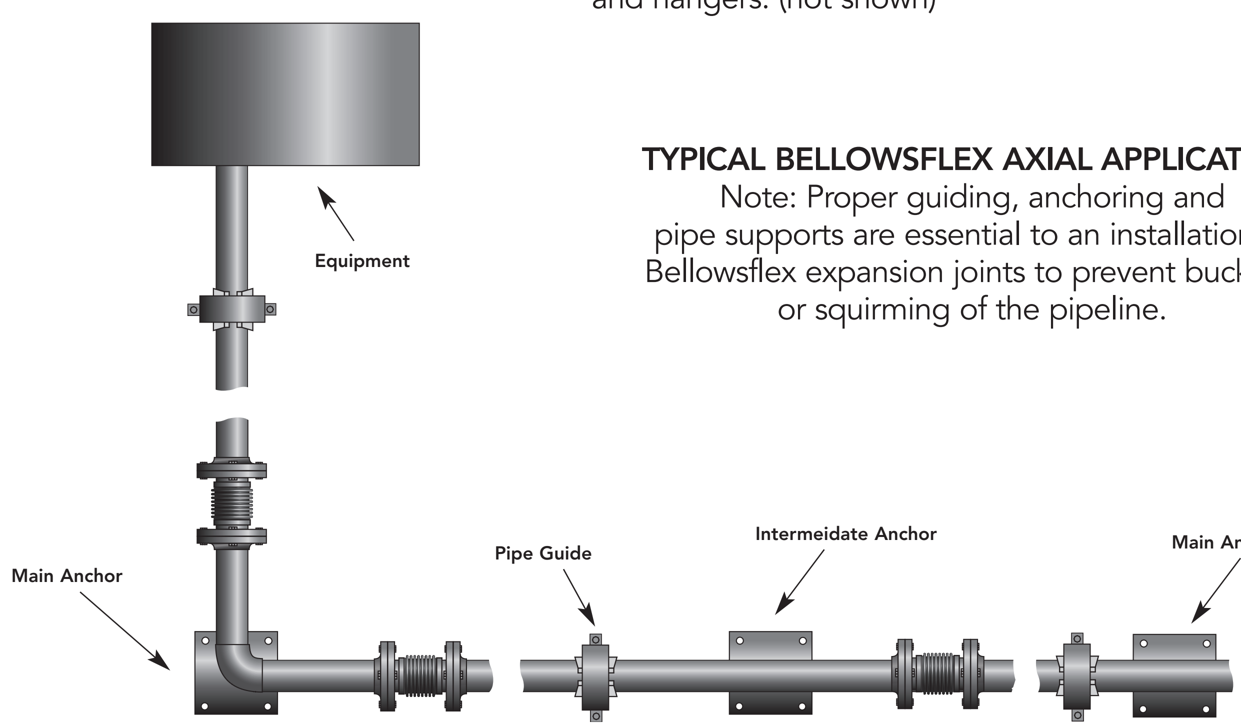
Design Pressure 50, 150, 300, 600 PSIG

Most Frequent Axial Motion Application

Expansion on a piping run due to an elevated operating temperature (axial motion)

Assumptions:

- The piping system is properly supported and guided
- The weight of the piping system and the fluid being conveyed is carried by properly designed supports and hangers. (not shown)



TYPICAL BELLOWSFLEX AXIAL APPLICATION
Note: Proper guiding, anchoring and pipe supports are essential to an installation of Bellowsflex expansion joints to prevent buckling or squirming of the pipeline.

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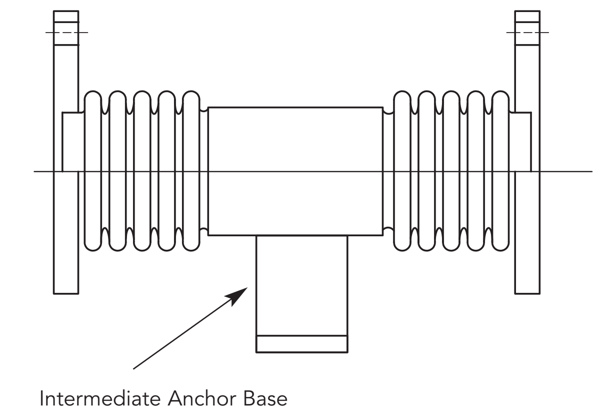
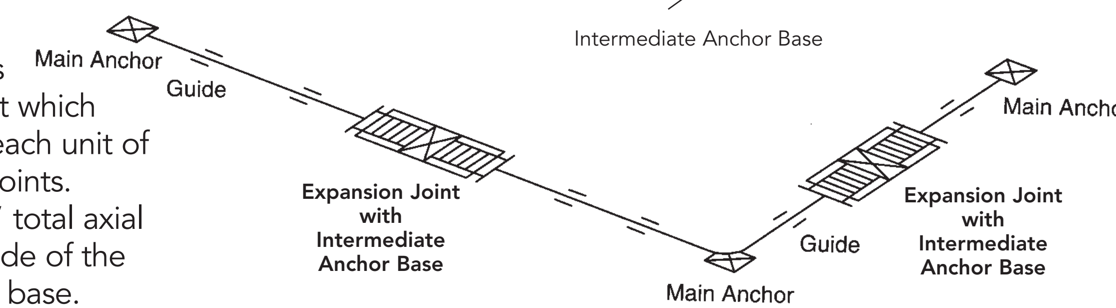
Bellowsflex Dual Metal Bellows Expansion Joints

Dual Bellows Expansion Joint with Intermediate Anchor Base

Main Anchor Piping System
By using a dual unit with an intermediate anchor at the center of a long run of pipe, movement is limited to an amount which can be handled by each unit of the dual expansion joint.



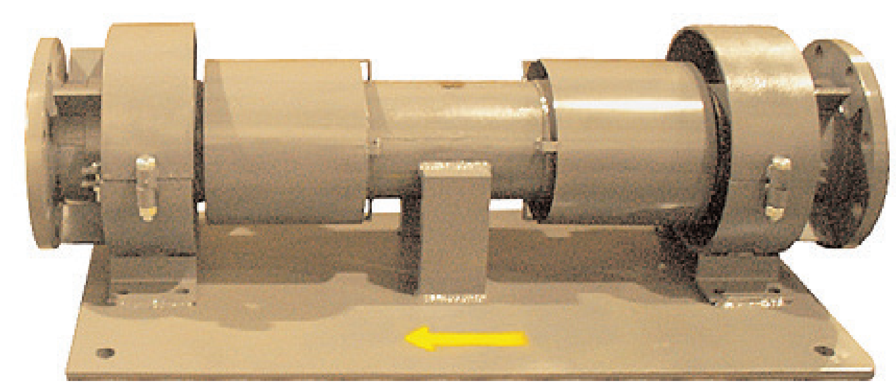
NOTE: Movement is limited to an amount which can be handled by each unit of the dual expansion joints.
i.e.: Unit rated for 6" total axial travel, 3" axial per side of the intermediate anchor base.



Assumptions:

- The piping system is properly supported and guided
- The weight of the piping system and the fluid being conveyed is carried by properly designed supports and hangers. (not shown)

Bellowsflex Dual Series with Factory Assembled Intermediate Anchor Base and Pipe Alignment Guide

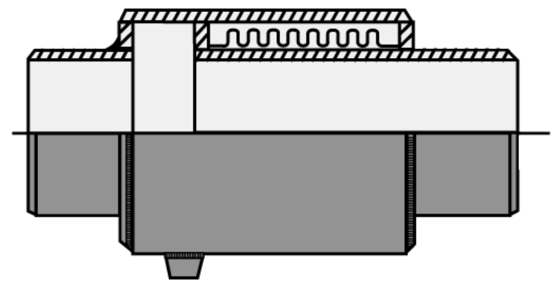


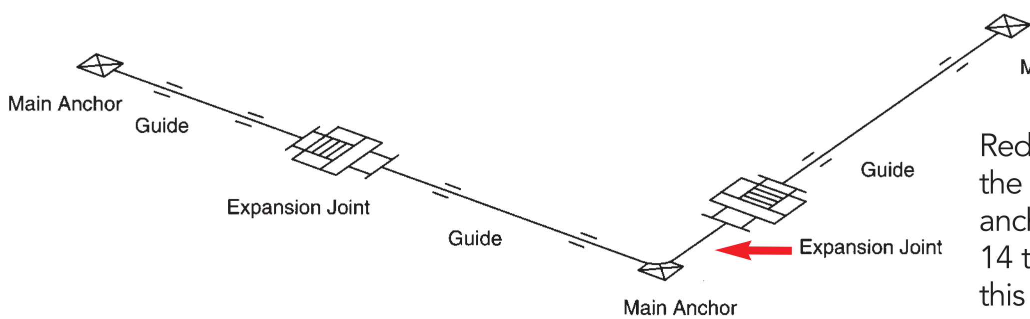
Main Anchor Piping System
Save installation time/cost with first set of guides included - Ready to install

Flexpress™ Externally Pressurized Guided Expansion Joints

Flexpress FPS-Single

Main Anchor Piping System
For movement up to 8″ axial travel
Externally pressurized guided expansion joints reduce the number of pipe guides in a piping system. EJXP internal guide ring eliminates the first set of pipe guides required (4″ pipe dia.)

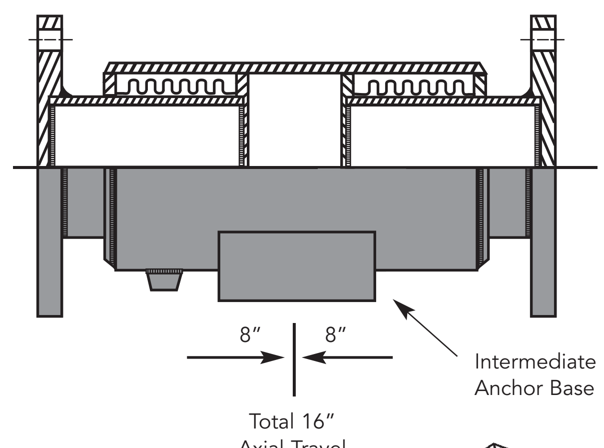




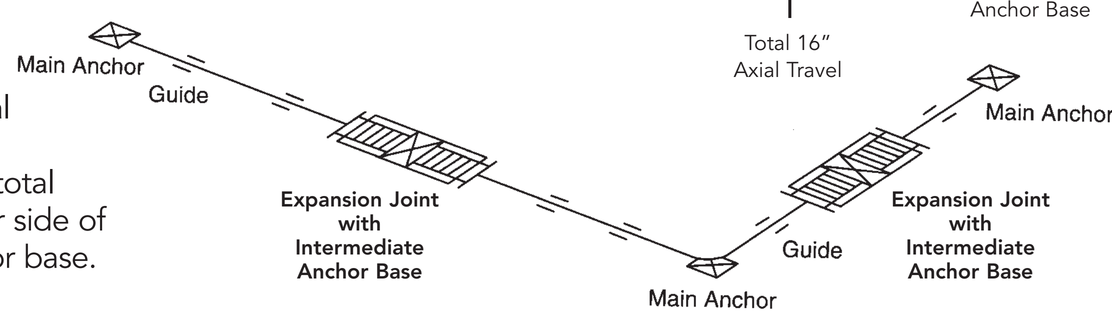
Reduce installation costs by locating the expansion joint to the main anchor no greater than a distance of 14 times the diameter of the pipe, this eliminates the need for a pipe guide.

Flexpress FPD-Dual

Main Anchor Piping System
For movement up to 16″ axial travel
By using a dual unit with an intermediate anchor at the center of a long run of pipe, movement up to 16″ can be handled by the expansion joint.



NOTE: Movement is limited to an amount which can be handled by each unit of the dual expansion joints.
i.e.: Unit rated for 16″ total axial travel, 8″ axial per side of the intermediate anchor base.



Assumptions:

- The piping system is properly supported and guided
- The weight of the piping system and the fluid being conveyed is carried by properly designed supports and hangers. (not shown)

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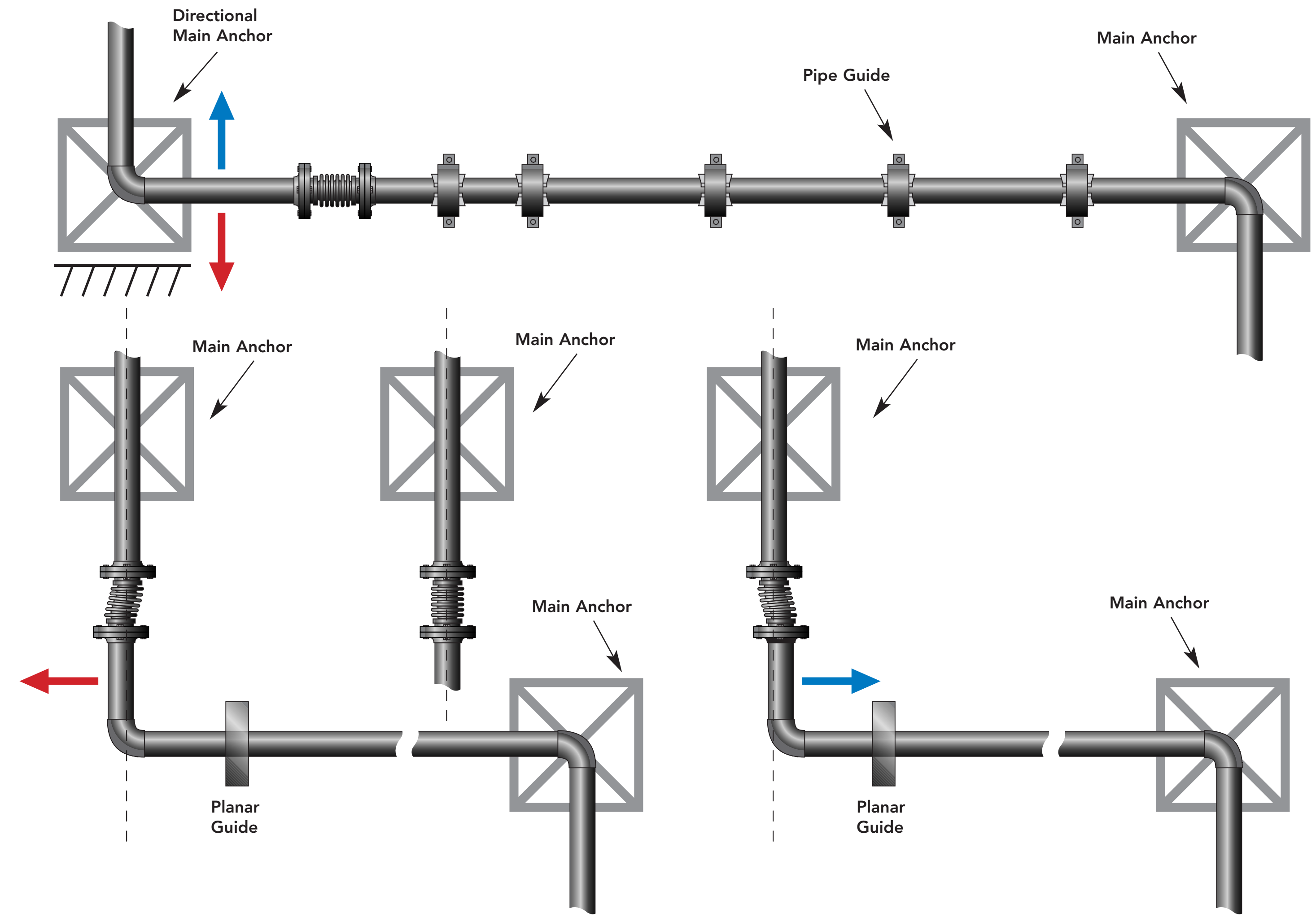
Lateral Movement Applications



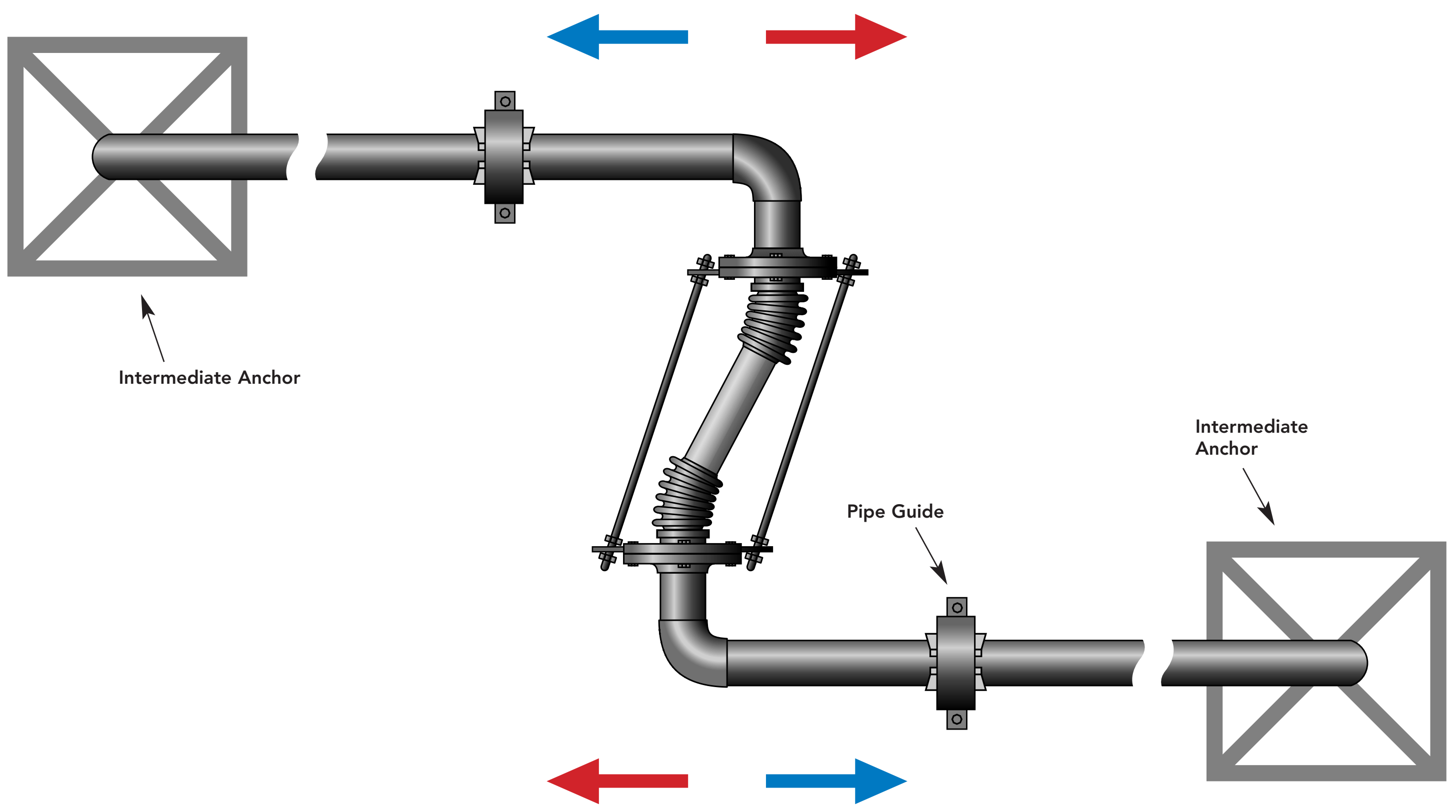
Assumptions:

- The piping system is properly supported and guided
- The weight of the piping system and the fluid being conveyed is carried by properly designed supports and hangers. (not shown)

Single expansion joints have very limited lateral capability

A **directional anchor (DMA)**, or sliding anchor, is one which is designed to absorb loads in one direction while permitting motion in another. It may be either a main or intermediate anchor, depending upon the application considered. When designing a directional anchor, an effort should be made to minimize the friction between its moving or sliding parts, since this will reduce the loading on the pipe and equipment, and will ensure proper function of the anchor.

Universal Tied Expansions Joints



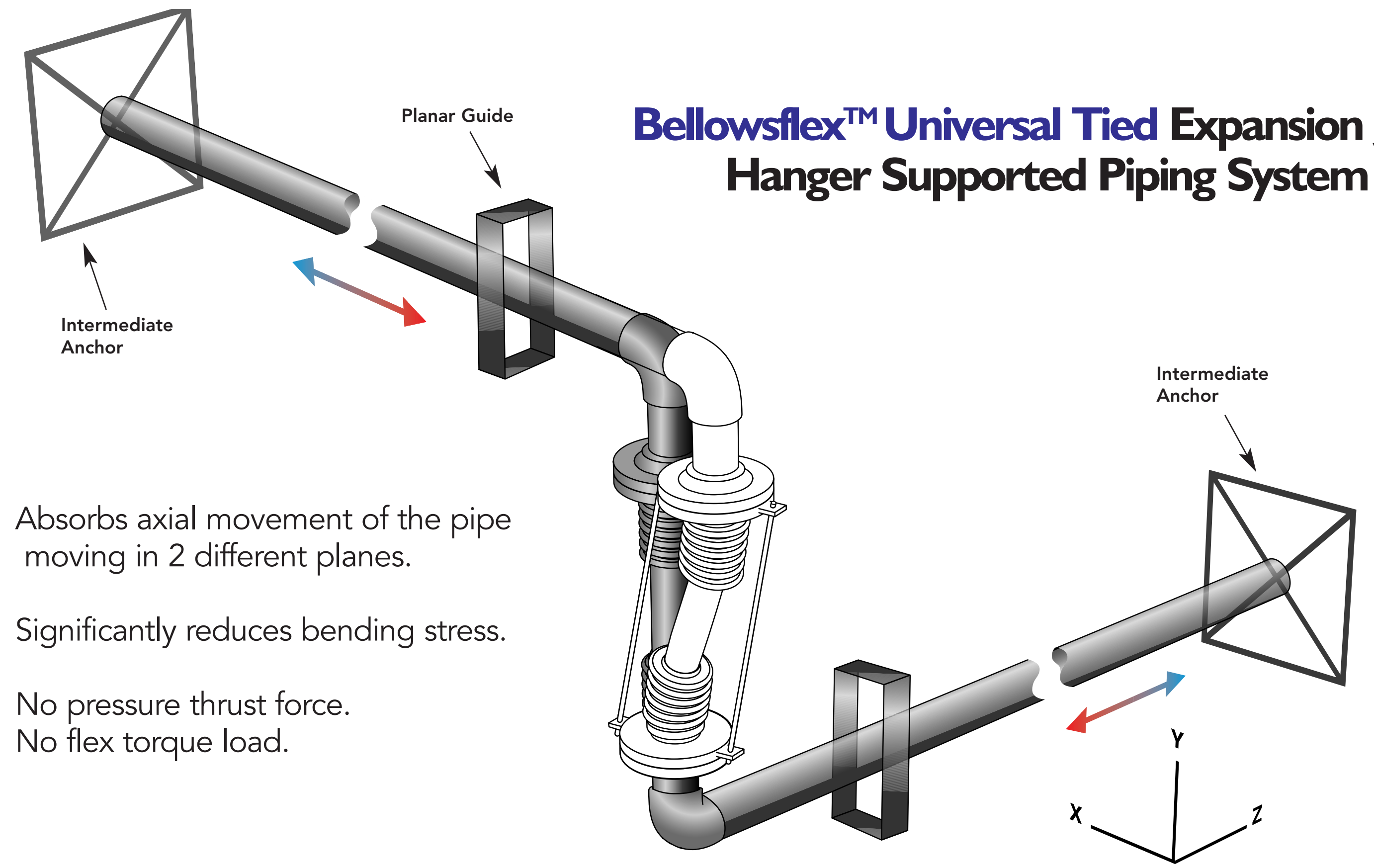
The universal expansion joint is capable of absorbing large lateral motions in any direction.

Control rods are attached to the universal expansion joint with the primary function of distributing movement between the two bellows elements. Control rods are not typically designed to restrain bellows pressure thrust.

Universal expansion joints will not transmit pressure thrust to the piping system when experiencing lateral motion only as the control rods will be in constant tension. However, if the universal expansion joint will see concurrent motions involving axial deflection than the anchor requirements will change to main anchors as a result of the control rods no longer remain in tension.

Universal Tied Expansion Joint for 2-Plane Movement

Bellowsflex™ Universal Tied Expansion Joint Hanger Supported Piping System

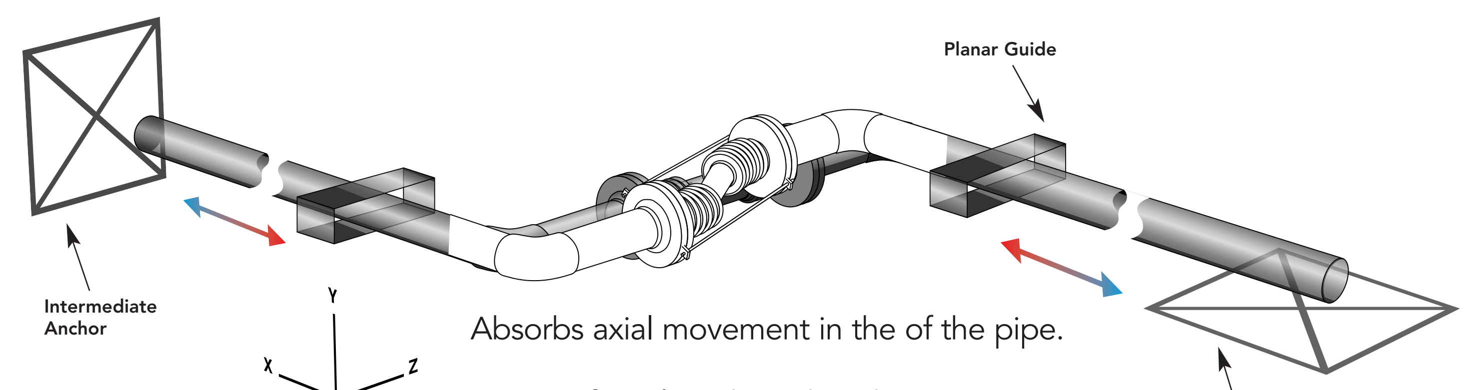


Absorbs axial movement of the pipe moving in 2 different planes.

Significantly reduces bending stress.

No pressure thrust force.
No flex torque load.

Universal Tied Expansion Joint "Dog Leg" System



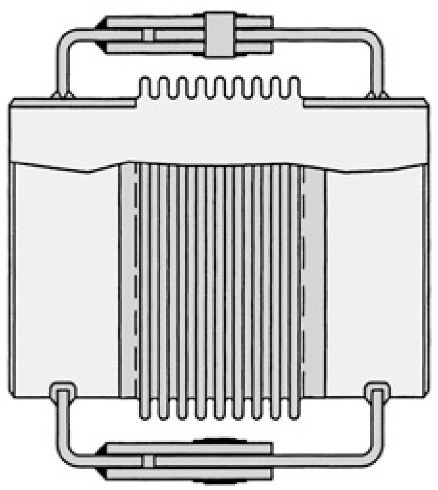
Absorbs axial movement in the of the pipe.

Significantly reduces bending stress.
No pressure thrust force.
No flex torque load.

Assumptions:

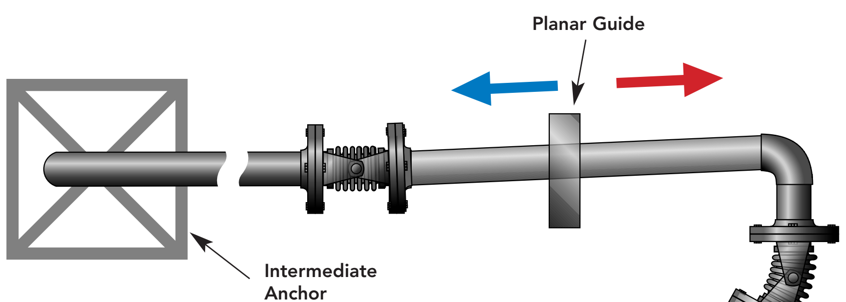
- The piping system is properly supported and guided
- The weight of the piping system and the fluid being conveyed is carried by properly designed supports and hangers. (not shown)

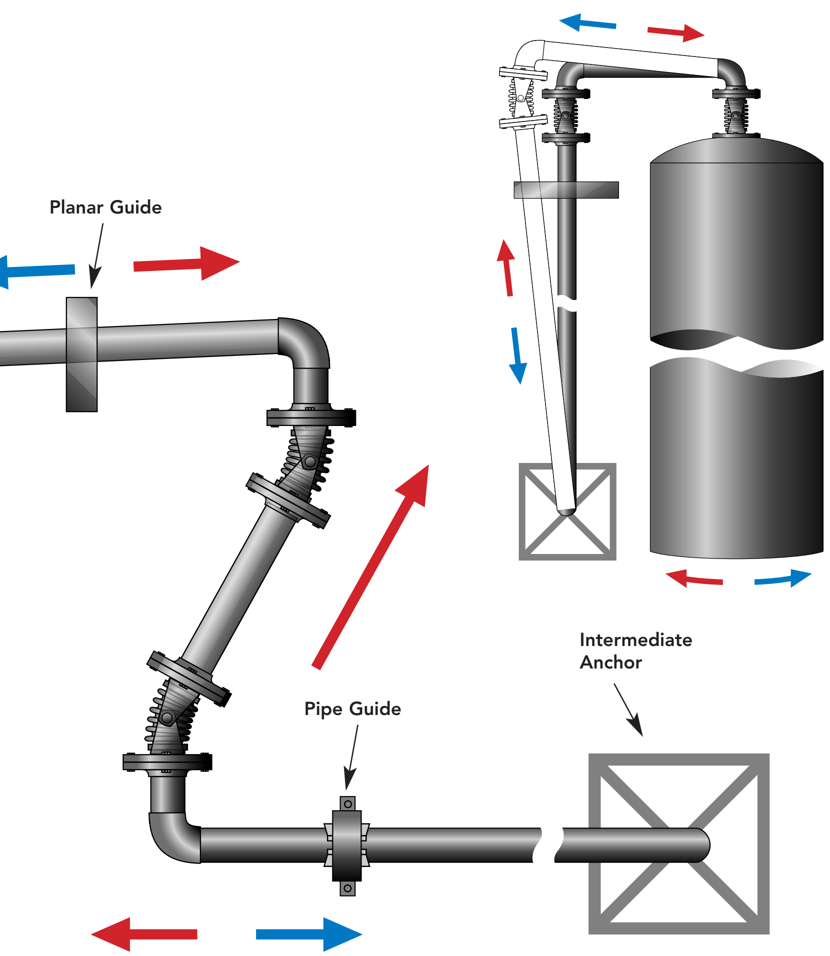
Hinged Expansion Joints



Features:
- Angular motion in one plane only
- Positive control over movement
- Eliminates pressure thrust forces
- Transmits external loads
- Supports dead weight
- Prevents torsion on bellows
- No main anchors required
- Minimum guiding required
- Low forces on piping system

Benefits:
- Compact in size
- Great rigidity & strength
- Can be used in irregular and complex piping systems, simplifying the integration of the expansion joints layout.
- Hinge structure can transmit loads



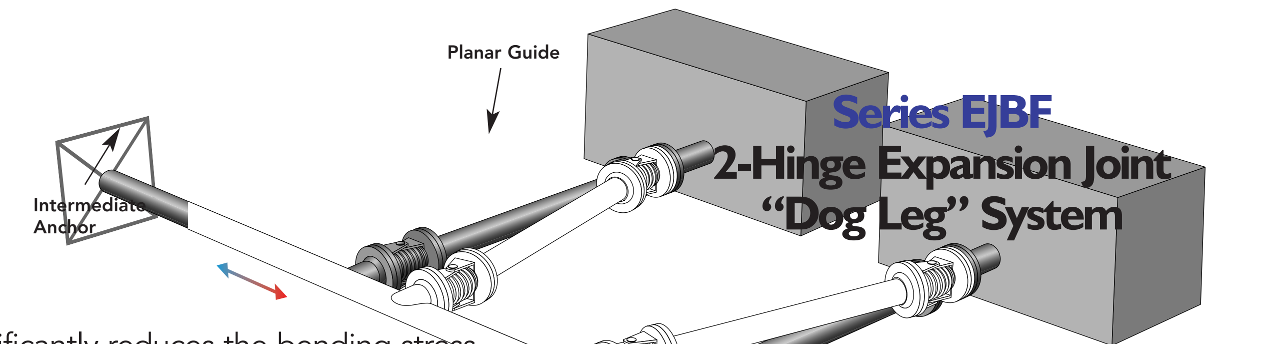


Used in sets of two or three to absorb lateral deflection in one or more directions in a single plane piping system.

Each expansion joint is restricted to pure angular rotation by its hinges. When the joints are separated by a segment of piping they will act like a universal expansion joint in a single plane applications.

Assumptions:
- The piping system is properly supported and guided
- The weight of the piping system and the fluid being conveyed is carried by properly designed supports and hangers (not shown)

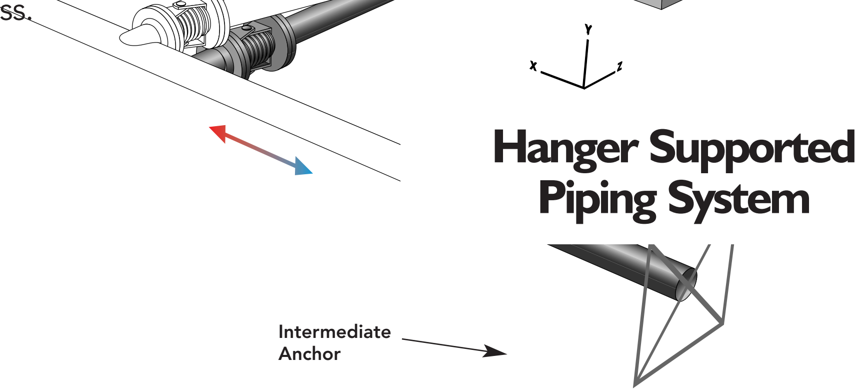
Hinged Expansion Joints



Significantly reduces the bending stress.

Absorbs the equivalent movement of several rigid Dog Leg offsets.

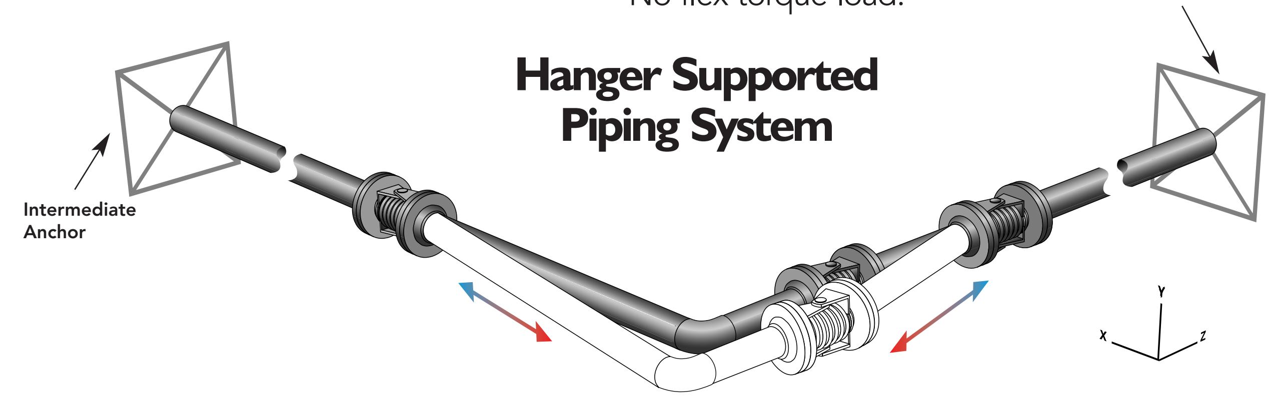
No pressure thrust force.
No flex torque load.



Series EJBF
3-Hinge Expansion Joint "Dog Leg" System

Absorbs axial movement in both legs of pipe.

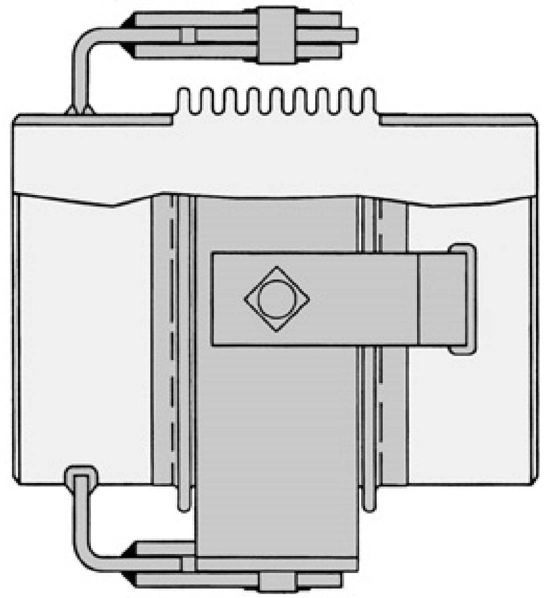
Eliminates bending stress.
No pressure thrust force.
No flex torque load.

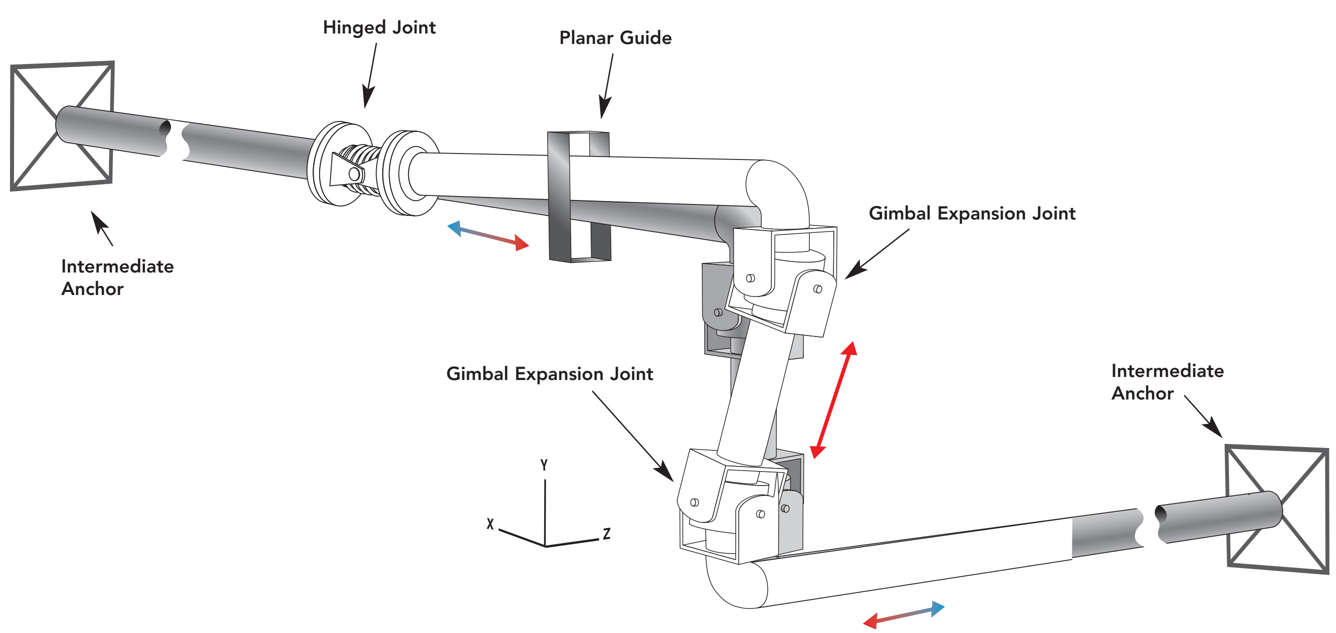


Assumptions:
- The piping system is properly supported and guided
- The weight of the piping system and the fluid being conveyed is carried by properly designed supports and hangers. (not shown)

Gimbal Expansion Joints

Features
- Angular motion in all planes
- Positive control over movement
- Eliminates pressure thrust forces
- Transmits external loads
- Supports dead weight
- Prevents torsion on bellows
- No main anchors required
- Minimum guiding required
- Low forces on piping system





Used in sets of two (occasionally more) to absorb lateral deflection in multi-plane systems. Advantages are similar to hinged expansion joint systems except they are not restricted to single plane systems.

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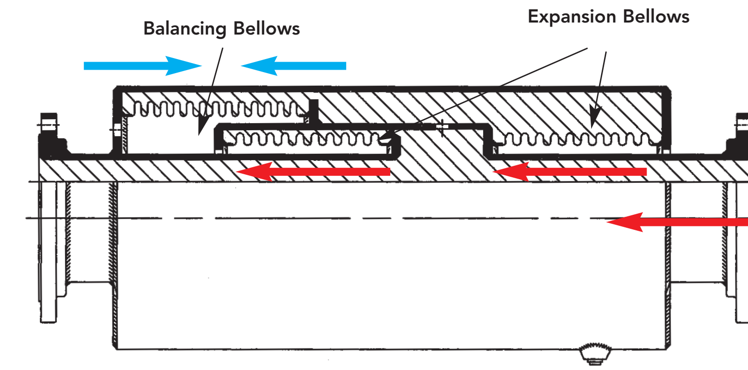
Flexpress™ Pressure Balanced Externally Pressurized Guided Expansion Joint

For up to 8" of movement

Flexpress pressure balanced externally pressurized guided expansion joint eliminates the requirements for main anchors. The inline pressure balanced expansion joint utilizes a balancing bellows to absorb the pressure thrust within the expansion joint itself.



Flexpress pressure balanced externally pressurized guided expansion joint provides a reliable means of absorbing high axial motions. It offers a totally enclosed, externally pressurized stainless steel bellows that is protected from external damage by and external cover. The carbon steel pipe integral liner is designed to prevent bellows impingement or fatigue due to flow induced vibration. The internal guide ring maintains the longitudinal centerline of the expansion joint and eliminates the first set of pipe guides required on each side of the expansion joint saving material and labor.

Assumptions:

- The piping system is properly supported and guided
- The weight of the piping system and the fluid being conveyed is carried by properly designed supports and hangers. (not shown)

Determining How Much Force is at the Anchors:

Application: 75# Steam

Example: An 8" steel pipe line is 275 feet long. Maximum temperature the line will encounter is 320°F. Lowest temperature is 40°F.

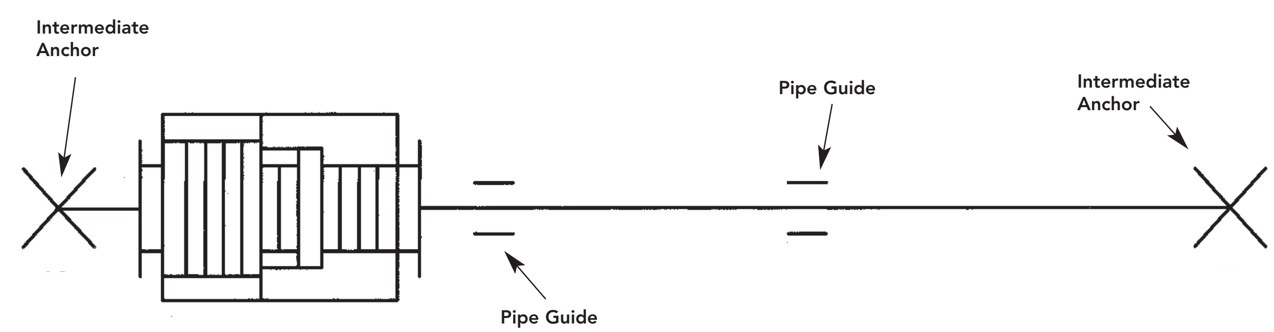
Calculation: 275/100 x 2.23 = 6.13" thermal growth

Expansion Joint Specified:
Flex-Hose Flexpress Pressure Balanced
Externally Pressurized Guided Expansion Joint

What are the forces on the anchors and guides?
1) operating conditions
2) *coldwater hydrostatic test at 1.5 x design

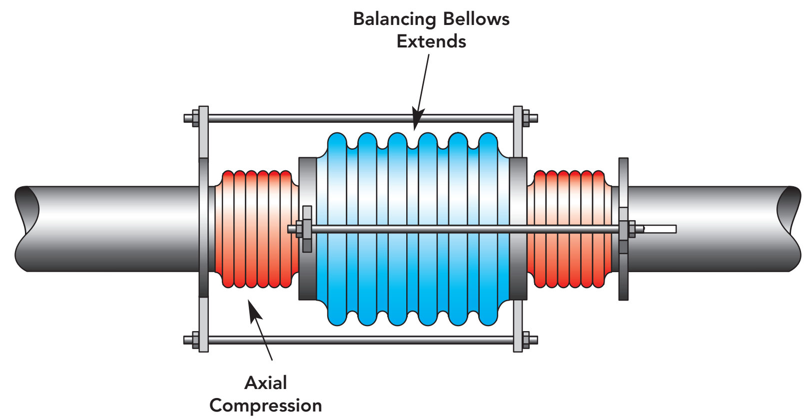
Expansion joint forces acting upon anchors:
Where:
F = The force required to deflect the expansion joint
= (Spring rate) (Axial deflection)
= (1,166 lb/in) (6.13 in)
***Solution to forces acting on main anchors:* Fx = 7,148 lbs**

Maximum lateral forces acting on pipe alignment guides are:
Force acting on main anchor x 0.15
Maximum lateral force = 7,148 x 0.15
Maximum lateral force = 1,072.2 lbs

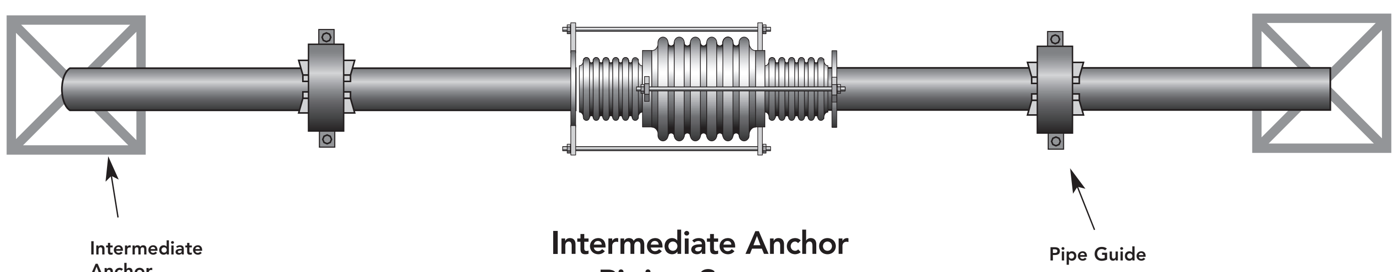


In-Line Pressure Balanced Expansion Joint

Pressure balanced expansion joints contain the pressure thrust forces in the expansion significantly reducing anchor requirements. This is accomplished by utilizing a balancing bellows. The bellows taking the thermal expansion is compressed and the balancing bellows then extends, resulting in the thrust rods always in tension. This design allows the balancing bellows to absorb the pressure thrust. The expansion joint can accept axial compression, axial extension, and lateral movements.



In-Line pressure balanced expansion joints consist of single or double (universal) bellows to accept the piping thermal movement induced for small to medium aixal motion, lateral and angular movements. The larger bellows creates a pressure chamber that produces thrust forces which, by tying to each end of the joint, balance the pressure thrust. They are typically used in straight pipe runs between intermediate anchors.



Intermediate Anchor Piping System

Assumptions:

- The piping system is properly supported and guided
- The weight of the piping system and the fluid being conveyed is carried by properly designed supports and hangers. (not shown)

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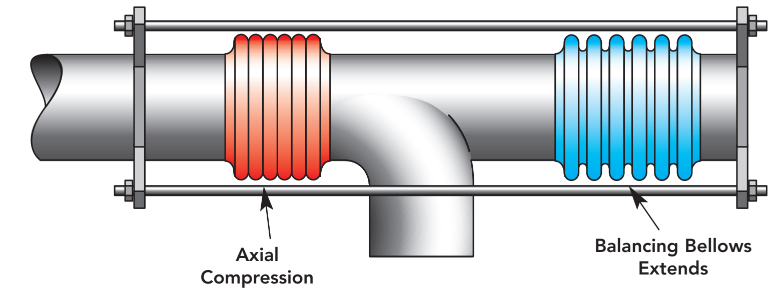
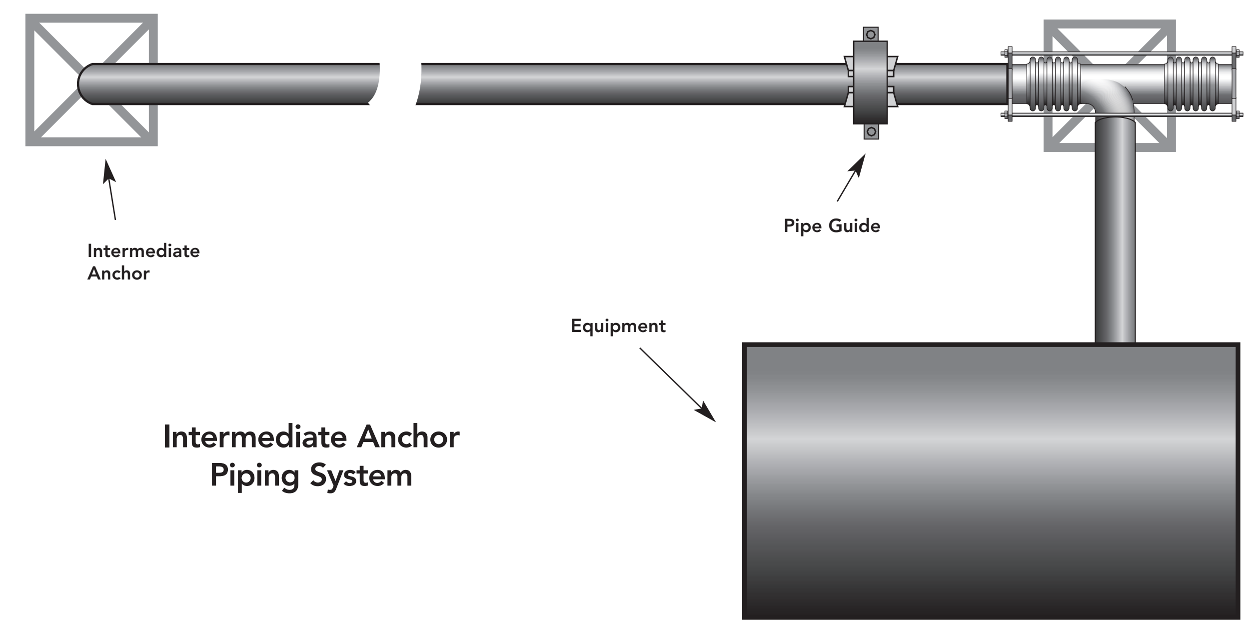
Universal Pressure Balanced Expansion Joint Elbow Assembly

Pressure balanced expansion joints contain the pressure thrust forces in the expansion joint to the piping system anchors. This is accomplished by utilizing a balancing bellows. The bellows taking the thermal expansion is compressed and the balancing bellows then extends, resulting in the thrust rods always in tension. This design allows the balancing bellows to absorb the pressure thrust. The expansion joint can accept axial compression, axial extension, and lateral movements.



Pressure balanced elbows are expansion joints which can consist of a single (depicted above) or double (universal) bellows, but they also contain an elbow which has attached to its outer elbow a balancing bellows and blind flange to the opposite end of the expansion joint and under pressure these tie rods balance the pressure thrust. This expansion joint can accept axial compression and extension and lateral movements.



Intermediate Anchor Piping System

Absorbs both axial and lateral movement but does not impose pressure thrust forces on critical equipment

Assumptions:

- The piping system is properly supported and guided
- The weight of the piping system and the fluid being conveyed is carried by properly designed supports and hangers. (not shown)

Expansion Joint Glossary of Terms

Angular Rotation
Bending about the longitudinal centerline of the expansion joint.

Axial Extension
Extension of the bellows length due to pipe contraction when piping system is anchored properly.

Axial Compression
Compression of the bellows length due to pipe expansion when piping system is anchored properly.

Bellows
The flexible element of an expansion joint consisting of one or more convolutions.

Bellows Expansion Joint
Any device containing one or more bellows used to absorb directional changes, such as those caused by thermal expansion or contraction of a pipeline, duct or vessel.

Concurrent Movement
Simultaneous movement axially, laterally and angularly.

Control Rod
Devices attached to the expansion joint with the primary function of distributing movement between the two bellows of a universal joint.

Convolution or Corrugation
The smallest flexible unit of a bellows, with total movement of a bellows being proportional to the number of convolutions.

Cycle
A cycle is one complete movement from initial position to operating position and back.

Cycle Life
Also known as fatugie life expectancy, is affected by various factors including (but mot limited to): operating pressure, operating temperature, bellows material, and bellows design/profile. Change to any of these factors will change cycle life.

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

External Cover/Shroud
Expansion joints require careful handling and must be protected from any impact, weld spatter, etc. Before insulating an expansion joint, care must be taken that foreign material is not trapped in the corrugations. It is suitable to install a metal cover over the flanges and then wrap the insulation around it.

Flow Liner
Installed in the inlet bore of the expansion joint to protect the bellows from erosion damage due to abrasive media or resonant vibration due to turbulent flow or excessive velocities.

Intermediate Anchor
Am intermediate anchor is one which divides a pipeline into individual expanding pipe sections containing multiple expansion devices of the same pipe size. 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 one or more bellows units, these forces will consist of forces and/or moments required to deflect the bellows unit plus the frictional forces due to the pipe moving over its guides. The pressure thrust is absorbed by the other anchors or devices on the bellows unit such as limit rods, tie rods, hinged restraints, etc.

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Lateral Offset
Motion which is perpendicular to the plane of the pipe with the expansion joint fittings remaining parallel.

Limit Rod
Devices with the primary function of restricting the bellows movement range. The limit rods are designed to prevent bellows over-extension or over-compression while restraining the full pressure thrust in the event of a main anchor failure.

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 onto the main line
4) Where a shut-off or pressure-reducing valve is installed in a pipe run between two bellows units
5) At a capped 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 pressure thrust, the force required to deflect the bellows unit, and the frictional force due to the pipe moving over its guides.

Pipe Alignment Guide
A pipe alignment guide is a form of sleeve fastened 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. Pipe alignment guides are designed primarily for use in applications involving axial movement only.

Pipe Support
A pipe support is any device which permits free movement of the piping and carries the total weight of in line equipment such as valves, meters, expansion joints, and the weight of the contained fluid. Pipe supports cannot be substituted for pipe alignment guides. Pipe rings, U-bolts, roller supports, and spring hangers are some examples of conventional pipe supports.

Planar Guide
A directional pipe planar guide is a pipe alignment guide modified to permit limited movement and/or bending of the pipe in one plane. It is used only in applications involving lateral deflection or angular rotation resulting from 2- or 3-hinge piping configurations.

Pressure Thrust
Extension of the bellows due to line pressure. This pressure thrust must then be absorbed by some means or the line pressure will cause the bellows to over extend and tear itself apart.

Spring Rate
In very low pressure application the more significant force may be the spring rate which is expressed in pounds per inch of motion. Thus, as the pipe grows due to increasing temperature, the bellows will resist compression by the force noted in the spring rate.

Squirm
Strut instability caused by internal pressure on the bellows.

Thermal Movement
Expansion and contraction due to temperature changes. In a piping or ducting system, these thermal changes can produce stress on the system at fixed points such as vessels and rotaing equipment as well as the piping or duct work system itself.

Tie Rod
Devices with the primary function to restrain the bellows pressure thrust.

Torsion
Twisting about the longitudinal axis of a metal expansion joint when it is located at any point in a piping system that would impose torque as a result of thermal change or building seismic joints imposing torque.

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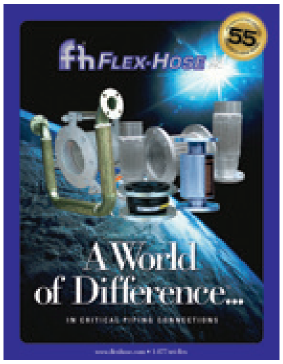
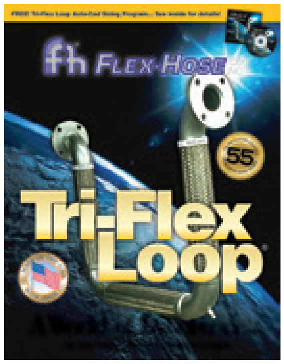
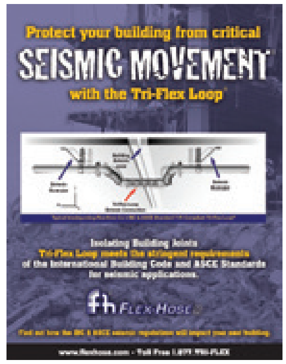


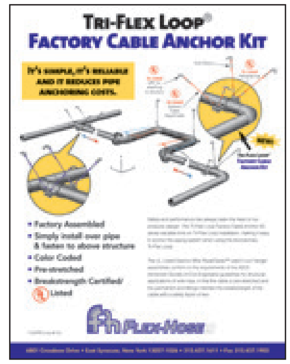
Product Overview



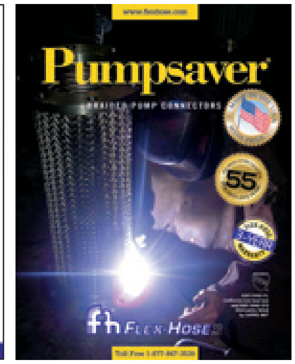
Flexible Pipe Loop



IBC Compliant Seismic Connections

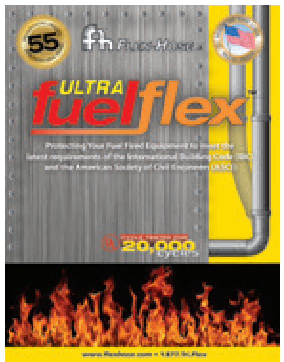


Flexible Pipe Loop Hanger Kit & Accessories

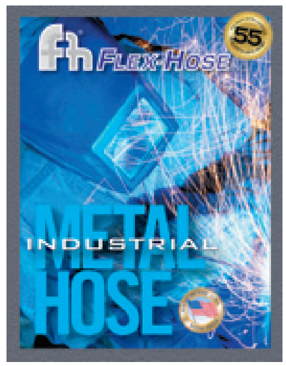


Braided Metal Pump Connectors

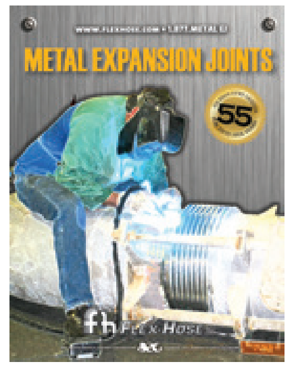
Expansion Joint Application Guide



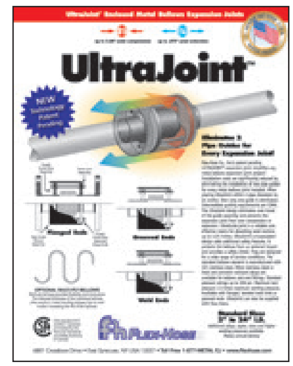
Flexible Gas Connection



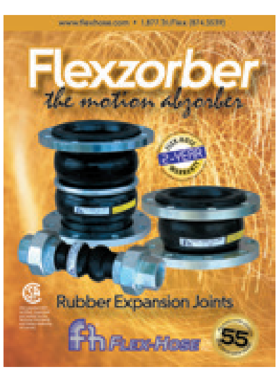
Industrial Metal Hose



Metal Bellows Expansion Joints

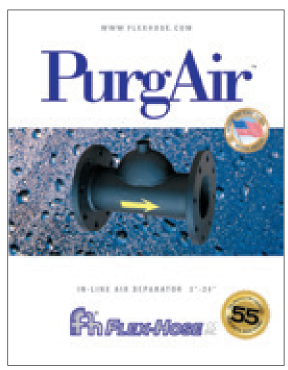


Enclosed Metal Bellows Expansion Joints



Rubber Expansion Joints

Expansion Joint Control Assemblies



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