

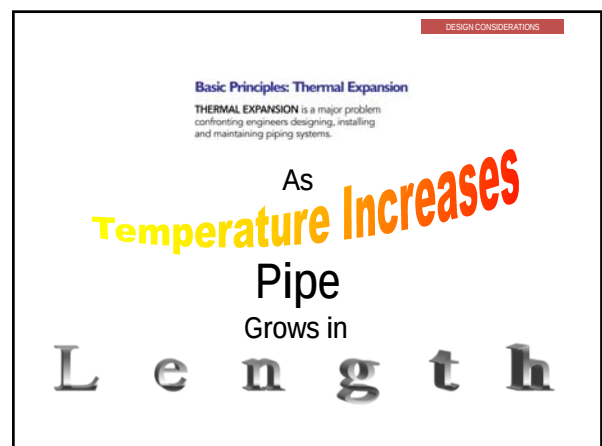
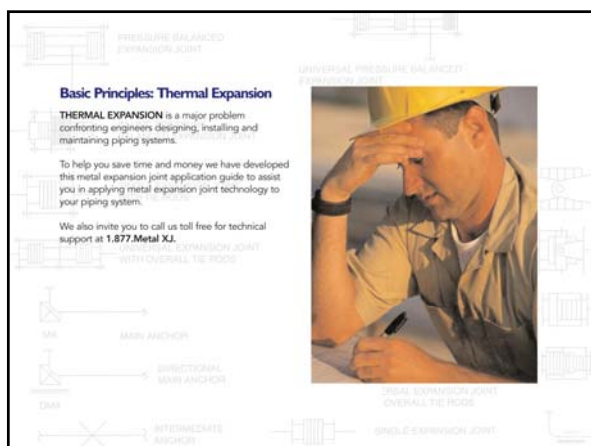
THERMAL EXPANSION IN PIPING SYSTEMS TRAINING-ONE CEU CREDIT

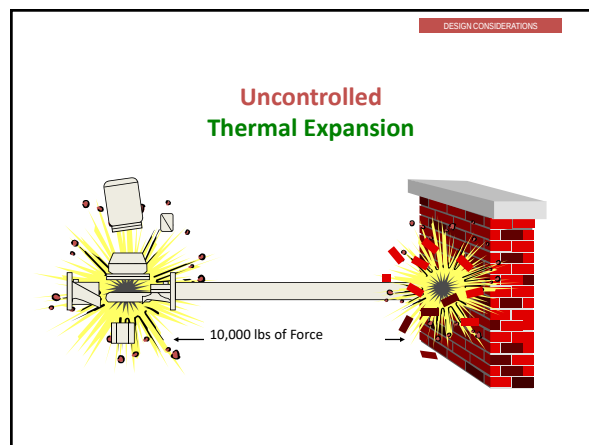
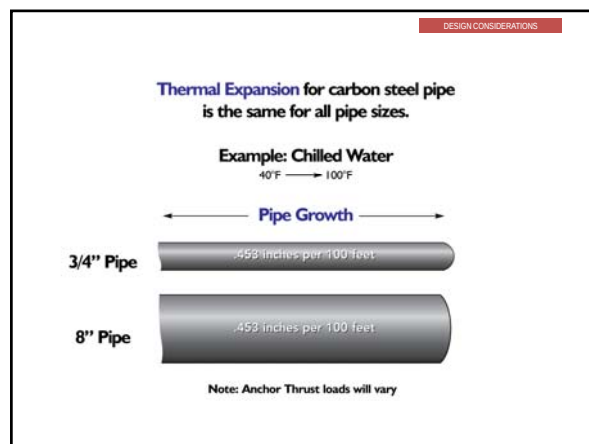
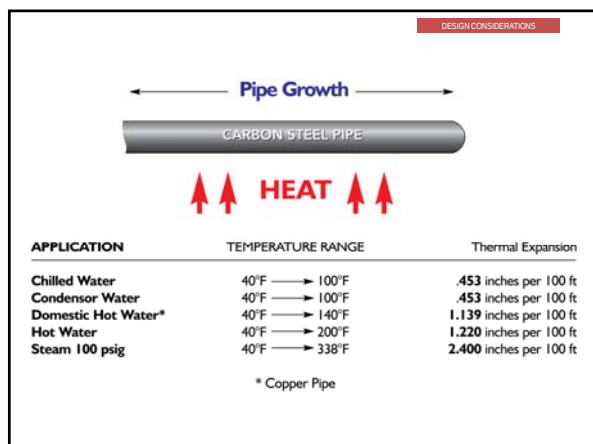


FLEX-HOSE CO., INC. fh

Thermal Expansion In Piping Systems-Course Outline

- Principles and calculations of thermal expansion in piping systems.
- Piping system loads and impact on building systems and structural systems
- Metal Expansion Joint Anatomy and options
- Guidelines and methodology for applying and selecting metal expansion devices for compensation of thermal expansion and equipment connections and isolation





DESIGN CONSIDERATIONS

Thermal Expansion of Metal Pipe

Saturated Steam Pressure, psig	Temperature, °F	Linear Thermal Expansion, in./100 ft.		
		Carbon Steel	Copper	Type 304 Stainless Steel
-10	-10	-0.19	-0.32	-0.30
-20	-20	-0.12	-0.21	-0.20
-10	-10	-0.06	-0.11	-0.10
0	0	0	0	0
10	10	0.08	0.12	0.11
20	20	0.15	0.24	0.22
32	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	0.48	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	1.00	1.50	1.52
-10.0	160	1.12	1.80	1.79
-7.2	180	1.37	2.05	2.02
-3.0	200	1.62	2.30	2.24
0	212	1.82	2.38	2.43
2.5	220	1.89	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
181.3	380	3.05	4.42	4.35
232.8	400	3.23	4.67	4.59
295.1	500	4.15	5.91	5.80
352.8	600	5.13	7.18	7.03
507.9	700	6.18	8.47	8.29
	800	7.23	9.79	9.59
	900	8.36	11.16	10.91
	1000	9.42	12.54	12.27

Calculating Pipe Growth

Application: Heating Hot Water

Example: A 6" 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 = .45" per 100 ft. pipe 40°F = .12" per 100 ft. pipe Difference: 1.40" per 100 ft. pipe 134/100 × 1.40 = 2.48" total length change

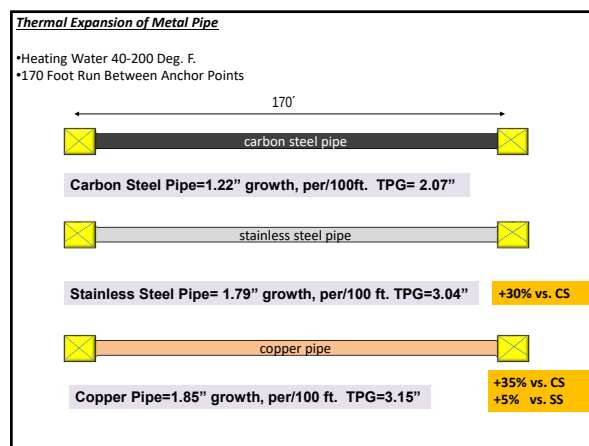
Application: 1100 Steam

Example: A 6" steel pipe line is 132 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 132/100 × 2.82 = 4.29" total length change

Thermal Expansion and Contraction

Application	Temperature Range (°F)	Thermal Expansion (per 100 ft.)
Chilled Water	40° - 100°	.45"
Condenser Water	40° - 140°	.46"
Domestic Hot Water (Copper Pipe)	40° - 140°	1.14"
Hot Water	40° - 200°	1.22"
Steam 100 psig	40° - 338°	2.40"



DESIGN CONSIDERATIONS

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 cold compression/.60 axial extension

DESIGN CONSIDERATIONS

Thermal Movement

Axial compression

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

DESIGN CONSIDERATIONS

Thermal Movement

Axial extension

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

DESIGN CONSIDERATIONS

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, "U" bends and mechanical pipe loops
- Design expansion devices, expansion joints or flexible loop technology

Why Expansion Joints?

- Flow-Hour 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.

DESIGN CONSIDERATIONS

How to Control Thermal Expansion

- Free Floating Pipe
- Pipe Bends
- Pipe Loops
- Externally Pressurized Expansion Joints
- Metal Bellows type Expansion Joints

Clevis Hanger

Spring Cushion Hanger

DESIGN CONSIDERATIONS

How to Control Thermal Expansion

Free Floating Pipe

Clevis Hanger

Spring cushion hanger with roller

DESIGN CONSIDERATIONS

Pipe Bends and Pipe Loops

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

DESIGN CONSIDERATIONS

Pipe Bends

DESIGN CONSIDERATIONS

Designing "L" Bends or 90° Pipe Bends

1. Calculate expansion of longest leg.
2. Find minimum feet required for this amount of expansion from chart. This represents the minimum footage of expansion type pipe supports required EACH side of elbow.

Note: Per 2000 ASHRAE Systems and Equipment Handbook page 41.11 a conservative estimate of force (Anchor Loads) is 500 lb per diameter inch.

Pipe Size	Expansion of Longest Leg									
	1'	1½'	2'	2½'	3'	3½'	4'	4½'	5'	
2½"	9'	12'	14'	16'	17'	18'	19'	21'	22'	
3"	10'	13'	15'	17'	18'	19'	20'	22'	23'	
4"	11'	14'	16'	18'	19'	22'	22'	24'	25'	
5"	12'	15'	17'	19'	21'	23'	25'	27'	28'	
6"	13'	16'	19'	21'	23'	25'	27'	29'	31'	
8"	18'	20'	22'	25'	27'	29'	31'	33'	35'	

DESIGN CONSIDERATIONS

Per 2000 ASHRAE Systems and Equipment Handbook page 41.11 a conservative estimate of force (Anchor Loads) is 500 lb per diameter inch.

DESIGN CONSIDERATIONS

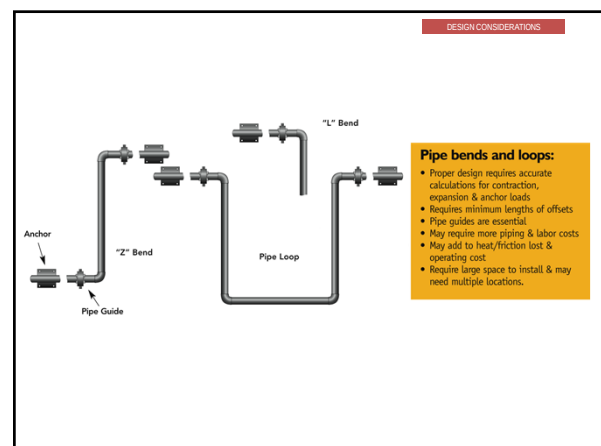
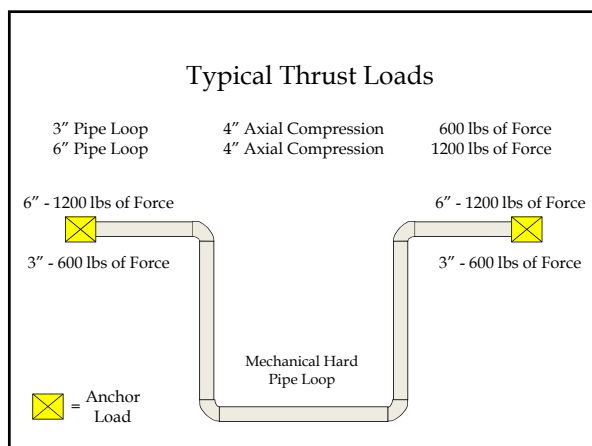
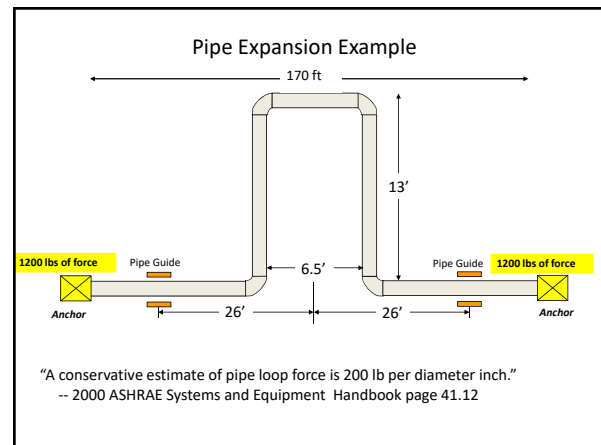
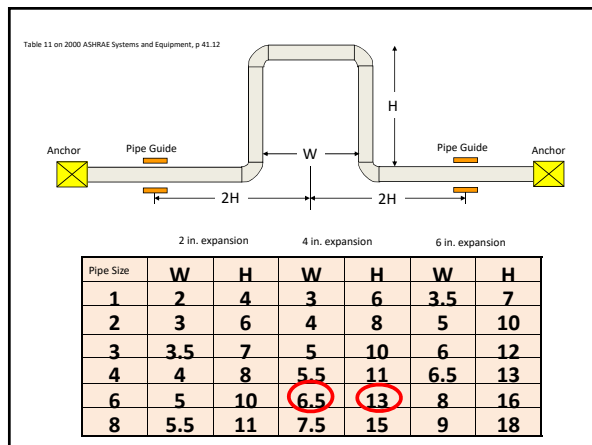
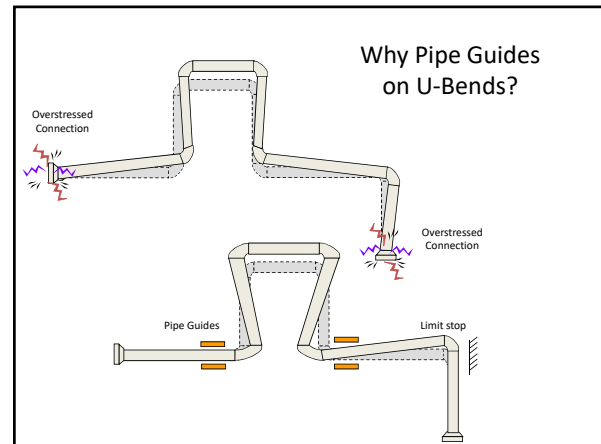
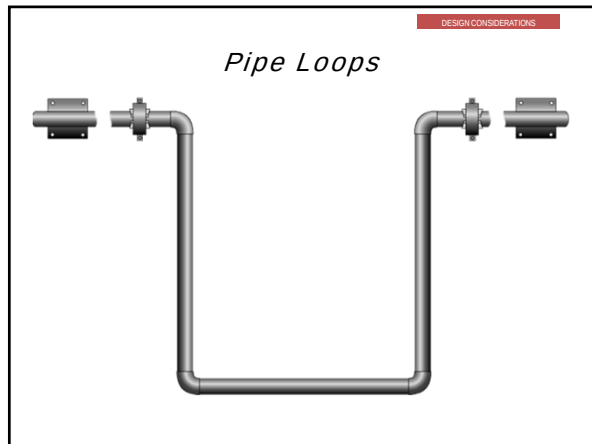
Designing "Z" Bends or Pipe Bends

1. Calculate total expansion anchor to anchor.
2. Find minimum feet required for this amount of expansion from chart. This represents the minimum footage for offset and minimum footage of expansion type pipe supports required for EACH side of "Z" Bend.

Pipe Size	Anchor to Anchor Expansion									
	1'	1½'	2'	2½'	3'	3½'	4'	4½'	5'	
2½"	6'	8'	9'	10'	11'	12'	13'	14'	15'	
3"	7'	9'	10'	12'	13'	14'	15'	16'	17'	
4"	8'	10'	11'	13'	14'	16'	17'	18'	19'	
5"	8'	10'	12'	14'	16'	17'	19'	20'	21'	
6"	9'	11'	13'	15'	17'	19'	20'	22'	23'	
8"	9'	12'	14'	17'	19'	20'	22'	24'	25'	

DESIGN CONSIDERATIONS

From 2000 ASHRAE Systems and Equipment Handbook, p 41.12, the force developed in a Z bend can be calculated with acceptable accuracy as follows:
 $F = CE(D/L)^2$, where F is in lbs, C = 4000 lb/in, D = outside pipe diameter in inches, L = length of offset in ft, E = anchor to anchor expansion in inches.
 $F = CE(D/L)^2 = 4000(4)(6/20)^2 = 1440 \text{ lbs}$



DESIGN CONSIDERATIONS

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



BELLWOSTECHNOLOGY

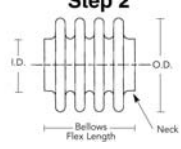
Basic Principles: Bellows Anatomy

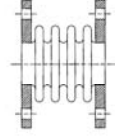
- Bellows formed from a metal cylinder in two steps
- Bellows length approximately one-third the length of original cylinder

Step 1



Step 2



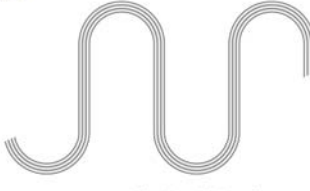


- Adding flanges completes assembly of the single bellows expansion joint

BELLWOSTECHNOLOGY

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

BELLWOSTECHNOLOGY

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 schedules. The bellows is a flexible seal design to contain the media, absorb thermal movement, and pressure 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 bellows 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.

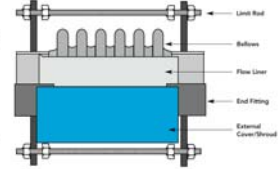
Flexibility of the bellows is achieved through the convolution profile and pitch as multiple convolutions are required to provide the expected expansion and contraction of the piping system.

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. 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.

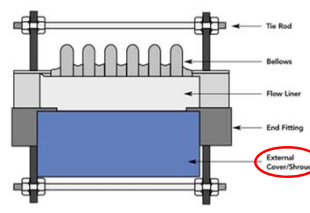
Control Rods
Control rods are devices attached to the expansion joint with the primary function of distributing movement between the two bellows of a universal joint. Control rods are not designed to restrain bellows pressure thrust.

BELLWOSTECHNOLOGY

Accessories

Covers Flow Liners Tie Rods Limit Rods Control Rods

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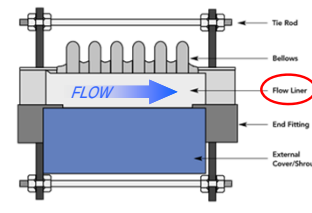


BELLWOSTECHNOLOGY

Accessories

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BELLOWS TECHNOLOGY

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BELLOWS TECHNOLOGY

Accessories

Covers Flow Liners Tie Rods Limit Rods Control 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.

BELLOWS TECHNOLOGY

Accessories

Covers Flow Liners Tie Rods Limit Rods Control Rods

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BELLOWS TECHNOLOGY

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.

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.

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.

Concurrent Movements
Expansion joint movement capacity published in the catalog is maximum capacity for non-concurrent 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%.

BELLOWS TECHNOLOGY

Expansion Joint Movement Capabilities

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

For example:

Expansion Joint design parameters

Non-concurrent	
Axial	1.5"
Lateral	.50"
Angular	10°

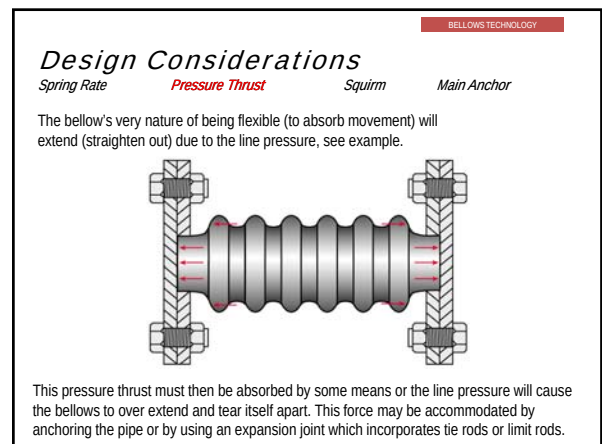
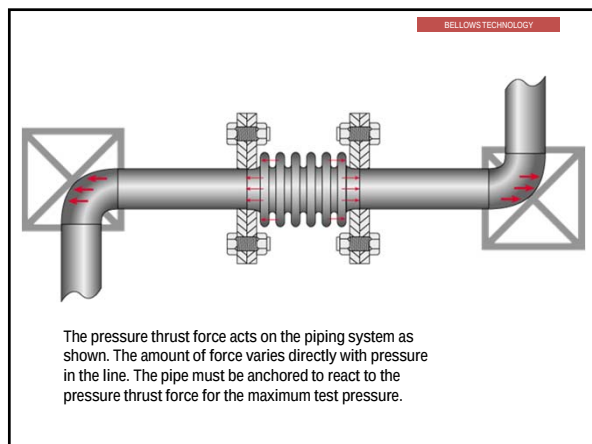
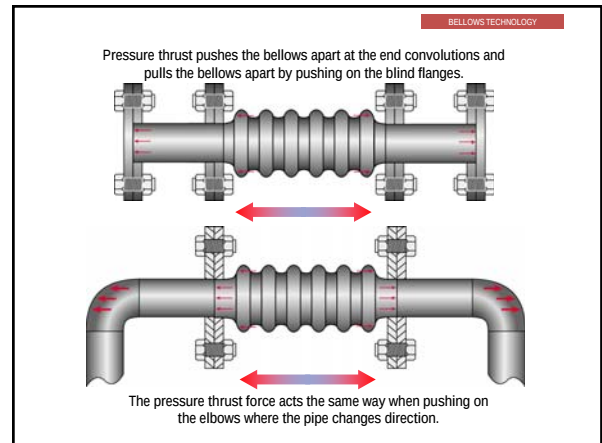
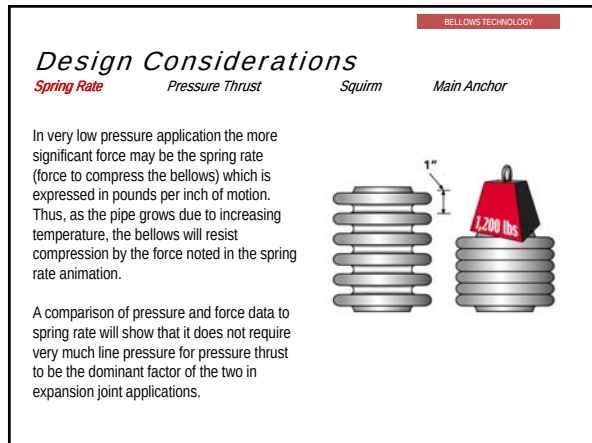
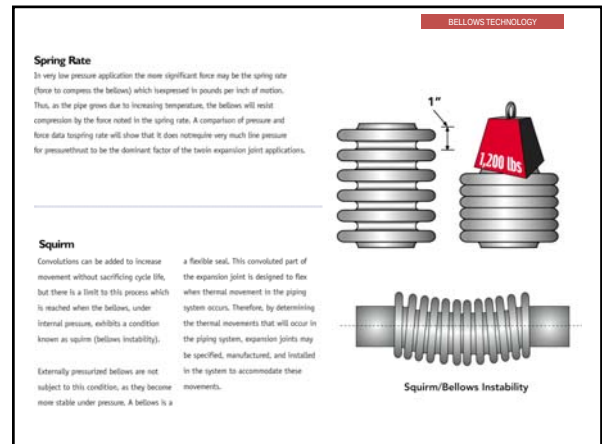
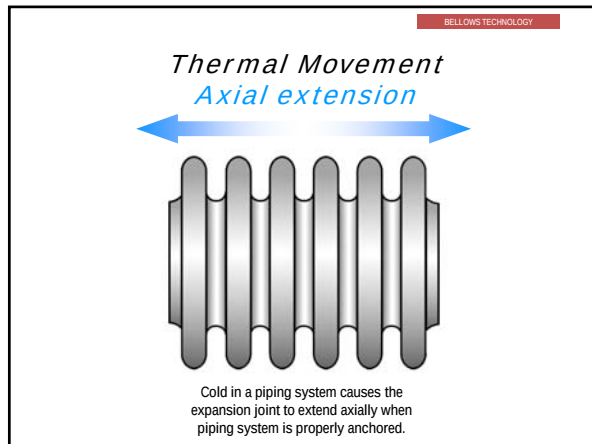
Concurrent	
Axial	.75" = 50%
Lateral	.125" = 25%
Angular	2.5° = 25%
TOTAL	= 100%

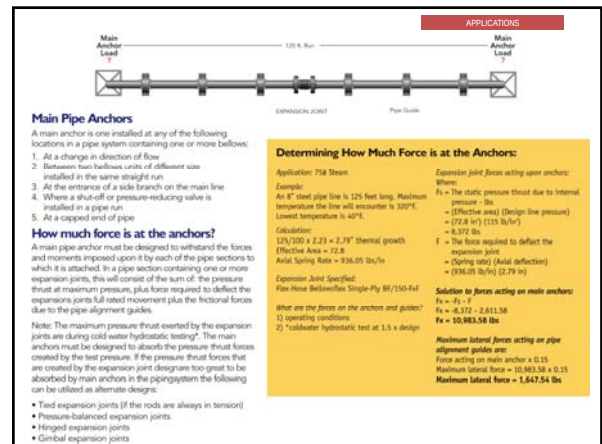
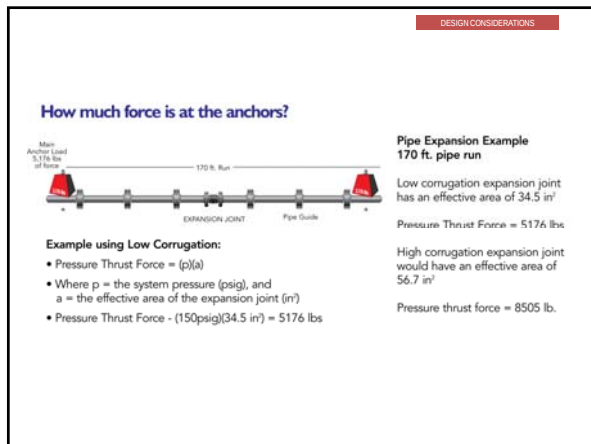
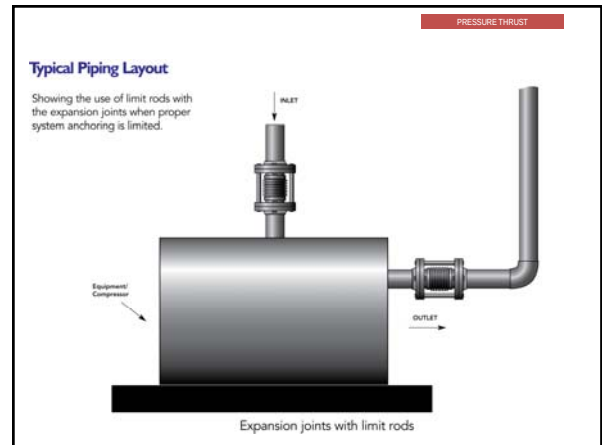
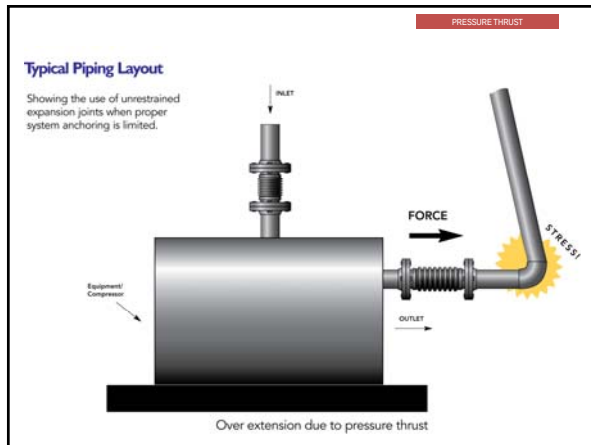
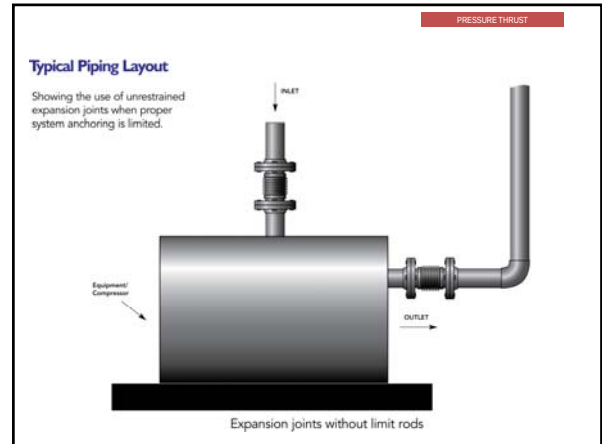
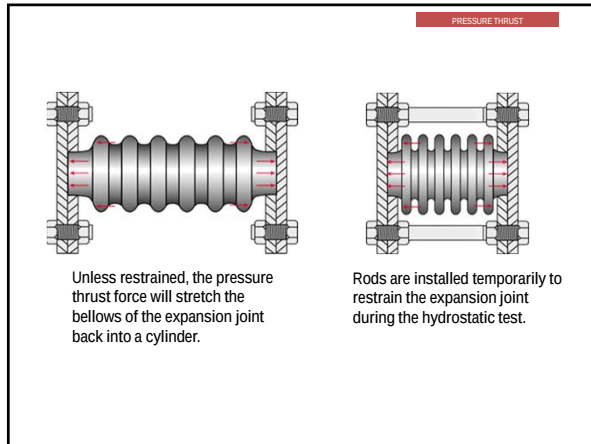
BELLOWS TECHNOLOGY

Thermal Movement

Axial compression

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





DESIGN CONSIDERATIONS

Intermediate Anchor

An 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.

MAIN ANCHOR LOAD = EFFECTIVE AREA x DESIGN LINE PRESSURE

+

SPRING RATE x AXIAL DEFLECTION

INTERMEDIATE ANCHOR LOAD = SPRING RATE x AXIAL DEFLECTION

MAXIMUM LATERAL FORCE (PIPE GUIDE LOAD) = MAIN ANCHOR LOAD x .15

APPLICATIONS

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
- Size 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

APPLICATIONS

Symbols/Key Guide

APPLICATIONS

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.

MA = Main Anchor G = Guide

APPLICATIONS

Axial Motion Applications

MA = Main Anchor G = Guide

APPLICATIONS

Pipe Guides

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.

APPLICATIONS

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 PSIG	@ 100 PSIG	@ 150 PSIG	@ 200 PSIG	@ 300 PSIG	@ 350 PSIG	@ 400 PSIG	
.75	3.00"	10.00"	11.00	7.50	6.00	5.00	5.50	5.00	5.00	1.00
1.00	4.00"	13.00"	15.00	11.00	9.00	7.50	6.50	6.00	5.50	1.50
1.25	5.00"	16.00"	18.00	13.00	11.00	9.00	8.00	7.25	7.00	2.00
1.50	6.00"	19.00"	22.00	16.00	13.00	11.00	10.00	9.00	8.50	2.50
2.00	8.00"	24.00"	28.00	20.00	16.00	13.00	12.00	11.00	10.50	3.00
2.50	10.00"	30.00"	34.00	24.00	19.00	16.00	14.00	13.00	12.00	3.50
3.00	12.00"	36.00"	40.00	28.00	22.00	18.00	16.00	15.00	14.00	4.00
4.00	16.00"	48.00"	54.00	36.00	28.00	22.00	20.00	18.00	17.00	5.00
5.00	20.00"	60.00"	66.00	45.00	34.00	26.00	24.00	22.00	21.00	6.00
6.00	24.00"	72.00"	78.00	54.00	40.00	30.00	28.00	26.00	25.00	7.00
8.00	32.00"	96.00"	104.00	72.00	52.00	38.00	36.00	34.00	33.00	9.00
10.00	40.00"	120.00"	128.00	90.00	64.00	45.00	42.00	40.00	39.00	11.00
12.00	48.00"	144.00"	152.00	108.00	76.00	52.00	48.00	46.00	45.00	13.00
14.00	56.00"	168.00"	176.00	126.00	88.00	60.00	56.00	54.00	53.00	15.00
16.00	64.00"	192.00"	200.00	144.00	100.00	68.00	64.00	62.00	61.00	17.00
18.00	72.00"	216.00"	224.00	162.00	112.00	74.00	70.00	68.00	67.00	19.00
20.00	80.00"	240.00"	248.00	180.00	124.00	80.00	76.00	74.00	73.00	21.00
24.00	96.00"	288.00"	296.00	216.00	148.00	96.00	92.00	90.00	89.00	25.00

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 supports any movement of the piping and carries the total weight of in line equipment such as valves, tees, expansion joints, and the weight of the contained fluid. Pipe supports cannot be substituted for pipe alignment guides. Pipe rings, ladders, roller supports, and spring hangers are some examples of unsuitable pipe supports. Additional pipe supports are usually required between guides in accordance with non-slipping practices.

APPLICATIONS

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

APPLICATIONS

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

TYPICAL BELLOWFLEX INSTALLATION
Note: Proper guiding and anchoring is essential to an installation of Bellowsflex expansion joints to prevent buckling or squirming of the pipeline.

For movement up to 3.5"

APPLICATIONS

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 BELLOWFLEX 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.

BELLOWSTECHNOLOGY

Design Considerations

Low Corrugated vs. **High Corrugated**

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

fh FLEX-HOSE CO. NC

BELLOWS TECHNOLOGY

Design Considerations

Low Corrugated vs. High Corrugated



Old Technology
High Corrugation

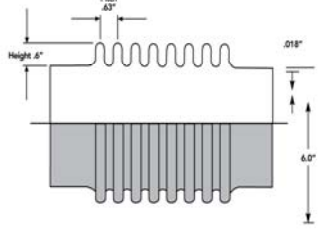
BELLOWS TECHNOLOGY

Low Corrugation vs. High Corrugation

Low Corrugation Features

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

STATE-OF-THE-ART TECHNOLOGY LOW CORRUGATION



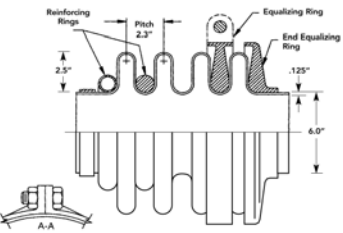
DESIGN CONSIDERATIONS

High corrugation is yesteryear's technology which typically requires reinforcing rings to achieve 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 psi.

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

OLD TECHNOLOGY HIGH CORRUGATION



APPLICATIONS

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.

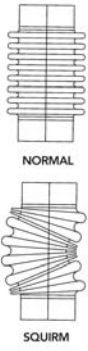
Externally Pressurized Bellows

Bellows Stability

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 given 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.

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



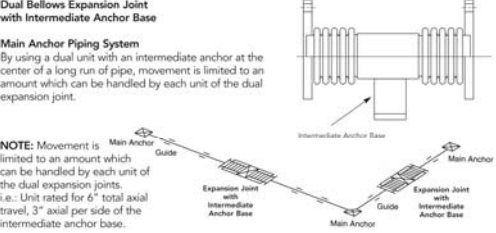
APPLICATIONS

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)

Bellows Pump Connectors/ Expansion Joints

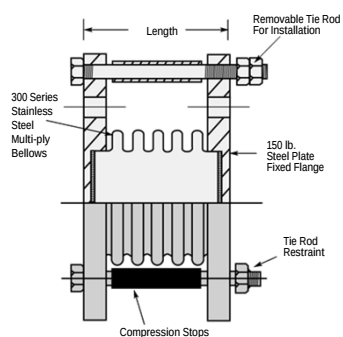
304 series stainless steel bellows construction. Series EJPC has a short face-to-face dimension for compact installations.

.5" axial compression.



Standard Sizes
2" to 12" I.D.
Additional alloys, styles, sizes and higher working pressures available. Please consult factory.

Bellows Pump Connectors/Expansion Joints

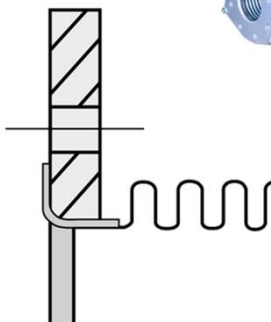


Bellows Pump Connectors/Expansion Joints

OPTIONAL VANSTONE FLANGE

Vanstone flanges provide a cost-effective means of isolating the media from the standard carbon steel flange.

The Vanstone option, without the use of tie rods, allows full rotation of the backup flange to allow for bolt hole alignment.



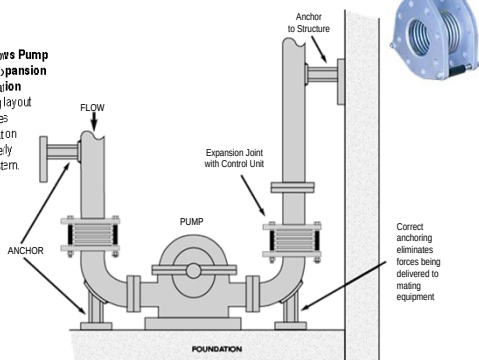
Standard Sizes

2" to 12" I.D.
Additional alloys, styles, sizes and higher working pressures available. Please consult factory.



Bellows Pump Connectors/Expansion Joints

Typical Bellows Pump Connector/Expansion Joint Installation
Typical piping layout showing Series EJPJC installation within a properly anchored system.



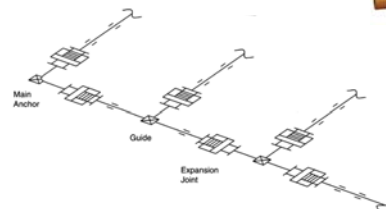
Flexcomp™

Expansion Compensators Main Anchor Piping System – For movement up to 2" axial travel.

Hot water and chilled water piping system (steel)
Domestic hot water piping system (copper)
External cover, assuring safety and reliability.
Standard working pressure ratings up to 200 psi.



Standard Sizes
3/4" to 4" I.D.



Design Considerations

Spring Rate

Pressure Thrust

Squirm

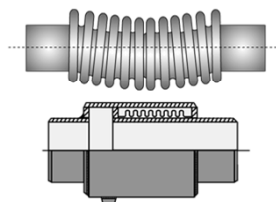
Main Anchor

Flexpress™

Externally Pressurized Expansion Joints

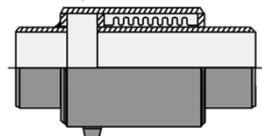
Convolutions can be added to increase movement without sacrificing cycle life, but there is a limit to this process which is reached when the bellows, under internal pressure, exhibits a condition known as squirm (bellows instability).

Flex-Hose Series EJPX externally pressurized bellows are not subject to this condition, as they become more stable under pressure. A bellows is 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.



Flexpress™

Series EJPX (welded ends)
Cut-away side view



Suitable for virtually any axial movement.

Bellows element is completely enclosed to preclude external damage, internal contact with the flow, and containment of the media in the event of bellows rupture.

External pressurization of bellows eliminates squirm or instability — even if over-pressurization occurs.

Internal guides insure alignment

External guiding is necessary but minimized by internal guides in the joint.

Standard Sizes

2" to 24" I.D.

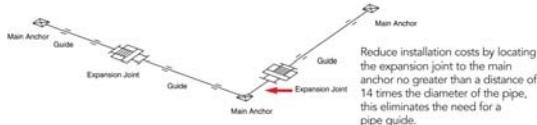
Flexpress™ Externally Pressurized Guided Expansion Joints

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. EJP internal guide ring eliminates the first set of pipe guides required (4" pipe dia.)



Flexpress FPD-Dual

Main Anchor Piping System

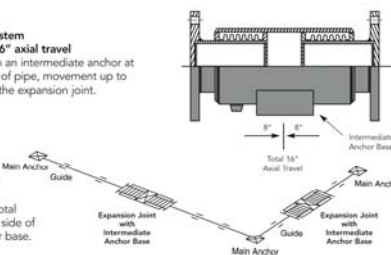
For movement up to 16" axial travel

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)



Bellows Xhaust™

Exhaust Type Expansion Joints

Low pressure (up to 50 psi) and high temperature (1200°F) applications.

Assembly weights have been reduced to permit use in thin wall flue duct systems.

Applications are exhaust connections on diesel, gasoline or gas turbine engine installations

Ducting conveying corrosive gases

Standard Sizes

4" to 48" I.D.

Other corrosion resistant alloys available. Please consult factory.

Design Pressure 50 PSIG



Bellows Xhaust™

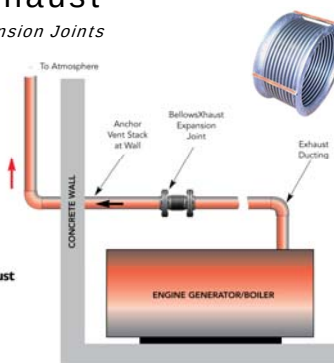
Exhaust Type Expansion Joints

Standard Sizes

4" to 48" I.D.

Other corrosion resistant alloys available. Please consult factory.

Typical BellowsXhaust Flow Diagram



Bellows Xhaust™

Exhaust Type Expansion Joints

OPTIONAL VANSTONE FLANGE

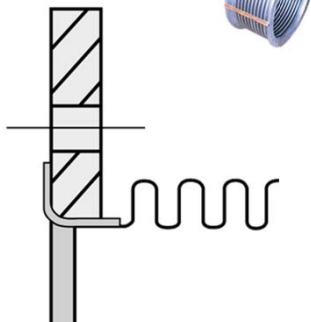
Vanstone flanges provide a cost-effective means of isolating the media from the standard carbon steel flange vs. a bellows exhaust unit with high alloy flanges. The Vanstone design are available for ease of bolt hole alignment.

Standard Sizes

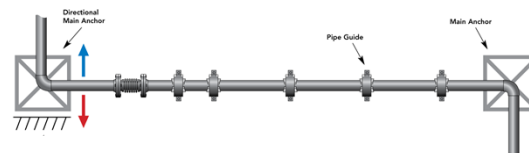
4" to 48" I.D.

Other corrosion resistant alloys available. Please consult factory.

Design Pressure 50 PSIG

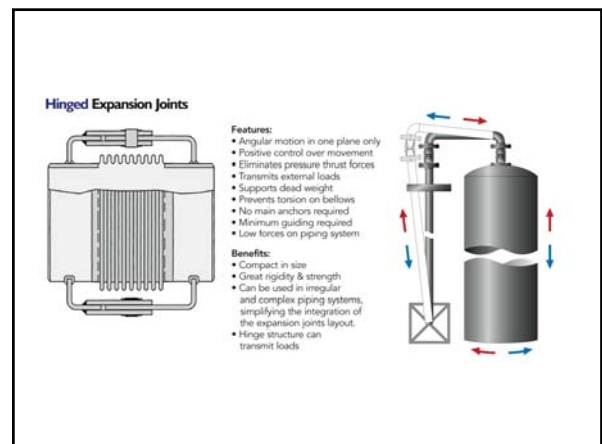
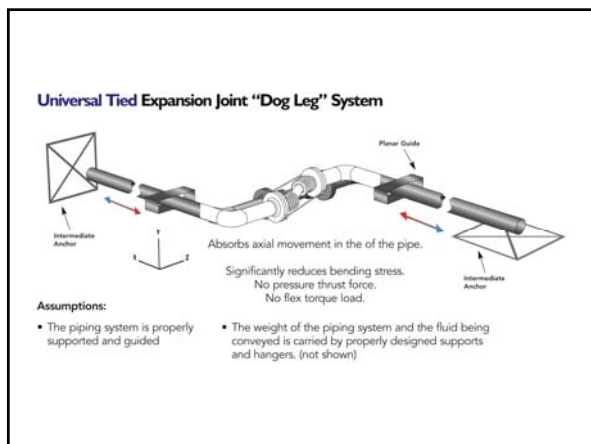
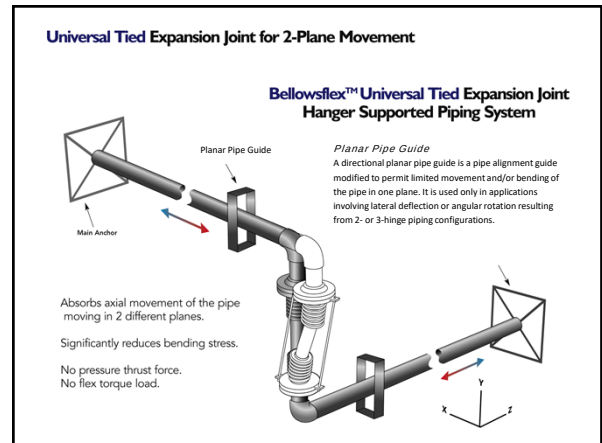
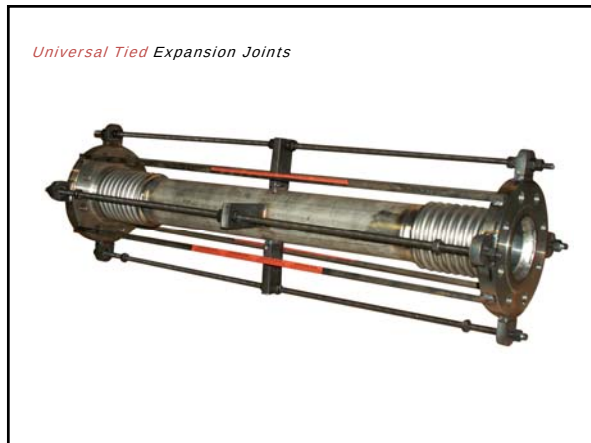
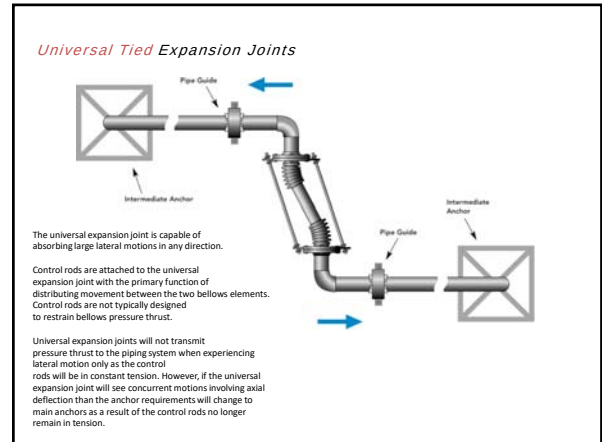
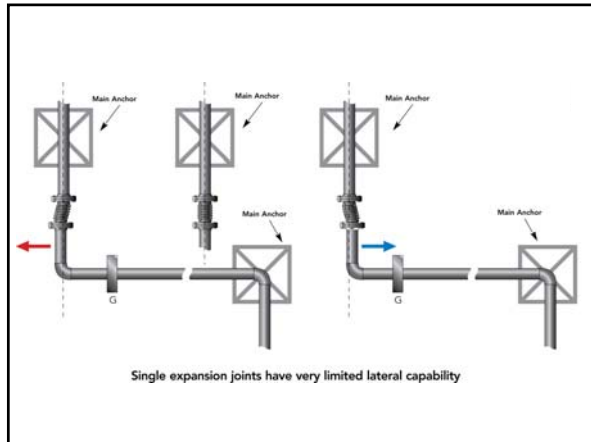


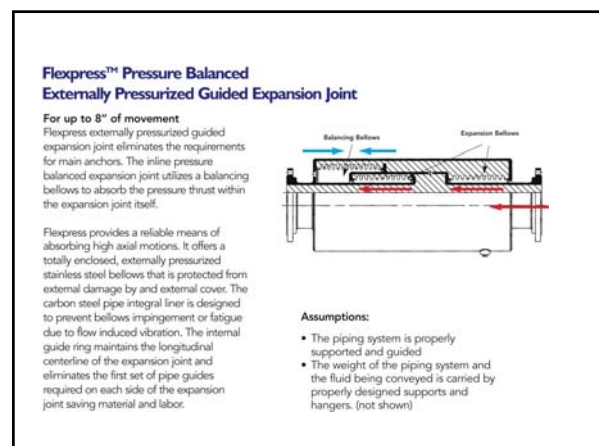
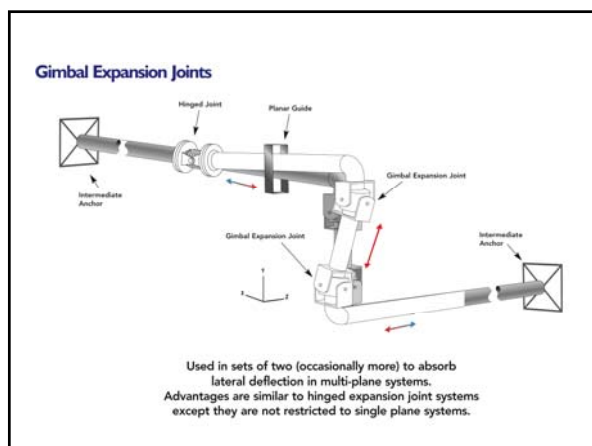
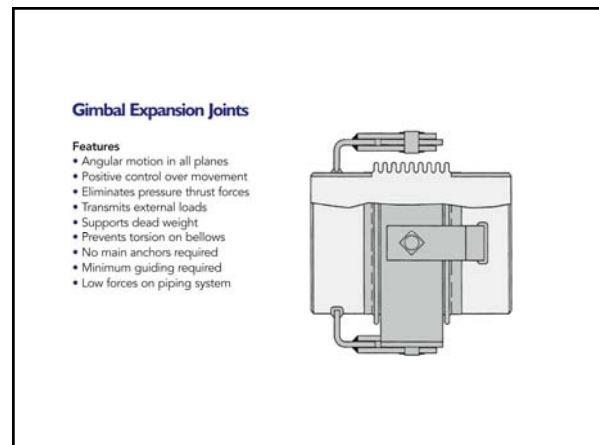
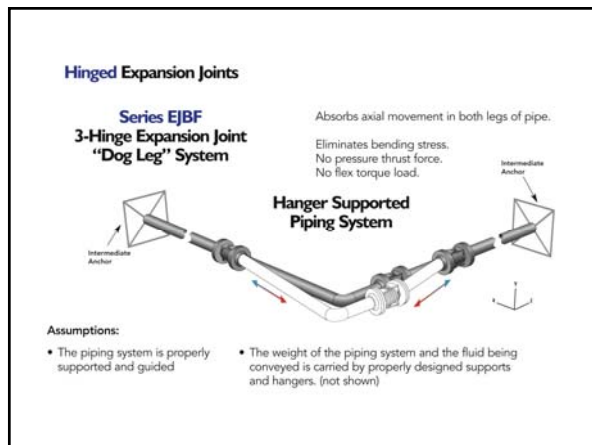
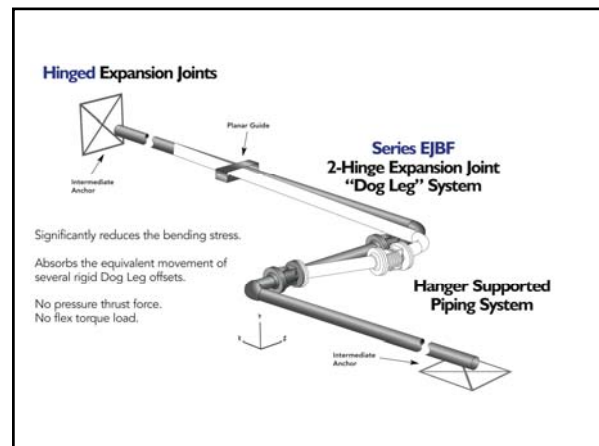
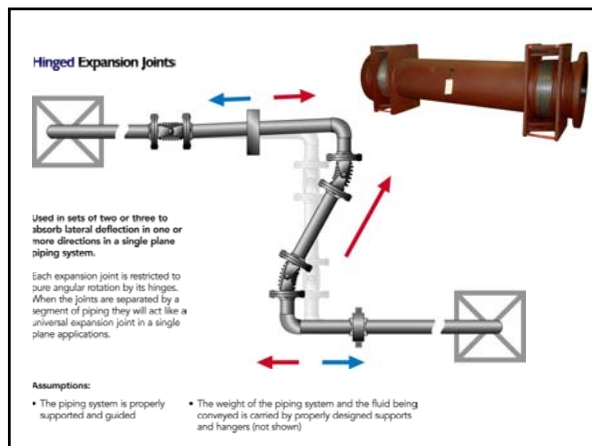
Lateral Movement Applications



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.





Flexpress™ Pressure Balanced Externally Pressurized Guided Expansion Joint

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: $275/100 \times 2.23 = 6.13"$ thermal growth

Expansion Joint Specified:

Flex-Hose Pressurized 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)

$= (1,148 \text{ lb/in}) (0.13 \text{ in})$

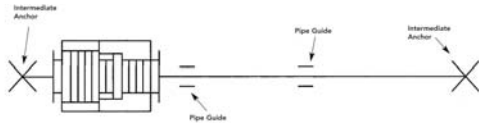
Solution for forces acting on main anchors: $F_x = 7,148 \text{ lbs}$

Maximum lateral forces acting on pipe alignment guides are:

Force acting on main anchor $\times 0.15$

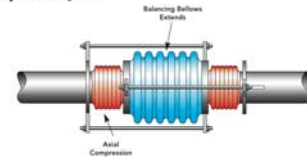
Maximum lateral force $= 7,148 \times 0.15$

Maximum lateral force $= 1,072.2 \text{ lbs}$



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 axial 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.

In-Line Pressure Balanced Expansion Joint

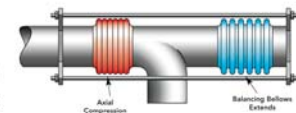


Assumptions:

- 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)

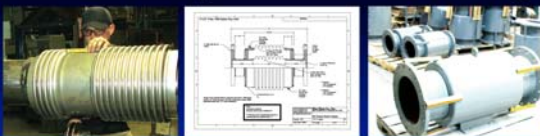
Universal Pressure Balanced Expansion Joint Elbow Assembly

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.

Flex-Hose Expansion Joint Training



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