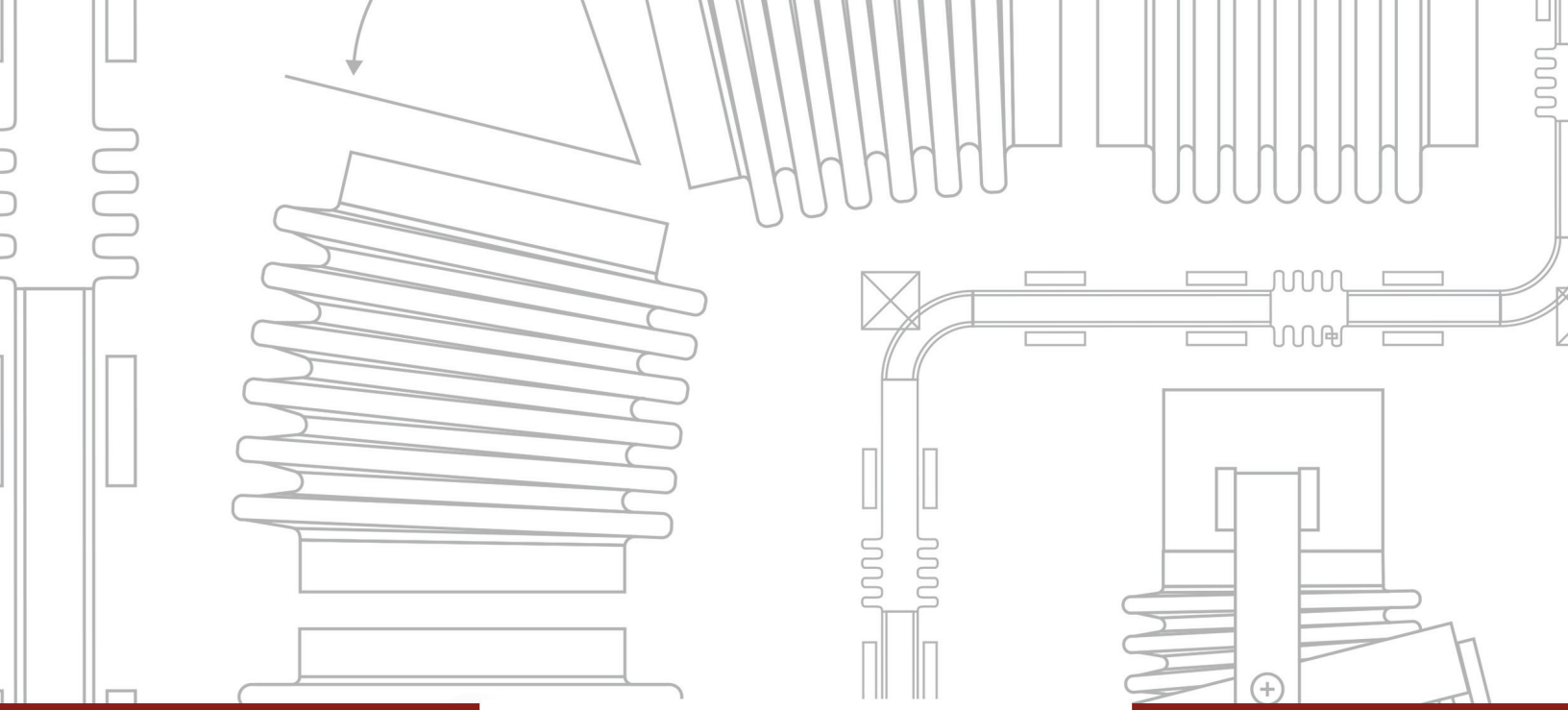


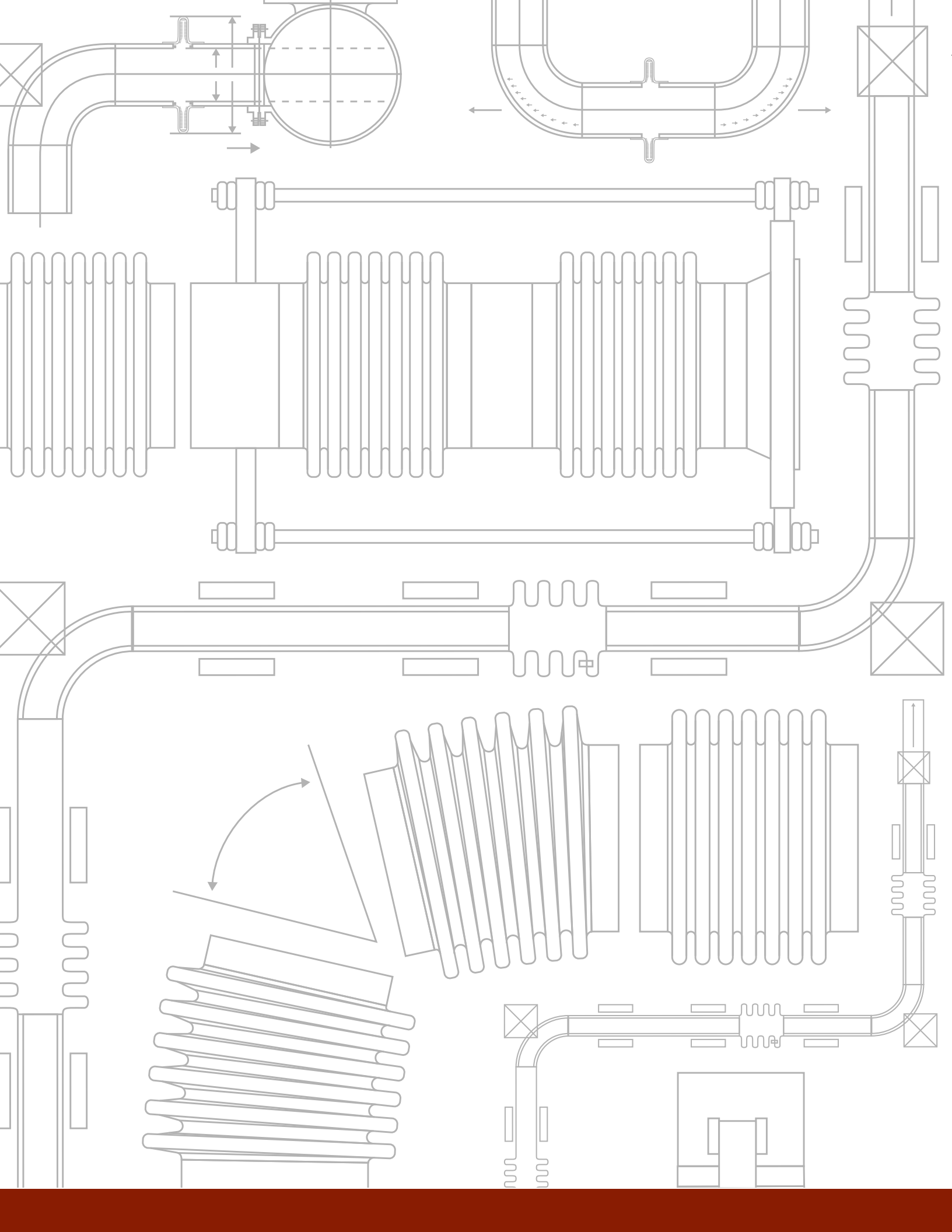
PENFLEX

Metal Bellows Expansion Joints

SPECIFICATION GUIDE

Your Trusted Source Worldwide

www.penflex.com



About Penflex

Founded in 1902, Penflex Corporation has been a pioneer from the very beginning and continues today to be a leader in the design and manufacture of flexible piping solutions. Penflex hoses and expansion joints, known for their durability and superior resistance to corrosion, are used in more than 15 vertical markets by hundreds of companies worldwide.

The Penflex Mission

It is our mission to be the manufacturer of choice by providing customers exceptional value:

- High quality braided flexible metal corrugated hose and metal bellows expansion joints
- Competitive pricing
- On-time delivery
- Superior and personalized customer service
- Cutting-edge industry expertise

Product Offerings

Penflex provides a unique breadth and depth of highly durable products. Penflex products outlast competitive hoses and expansion joints saving time and money in replacement costs and down time. Penflex delivers high quality products that lead the industry in wall thickness, providing for greater durability and improved resistance to chemical corrosion as well as improved reliability in high pressure applications.

- Metal Bellows Expansion Joints
- Corrugated Metal Hose
  - Series: P3, P4, P5, 700, 800, 900, 1400, 400
- Interlocked Metal Hose
  - M100 - Unique pressure capable robust interlocked hose
  - Conveyor Hose
  - Exhaust Hose
- Wire & Synthetic Braids

Penflex also understands that unique applications require unique products and is committed to manufacturing products that customers need. Penflex has the technology and know-how to create standard, off the shelf, and custom hoses and expansion joints that meet specific application requirements.

DS-EN-2000 (01)

Table of Contents

This catalog is intended to serve as a reference. Please visit **www.penflex.com** for more information, including details on the specific Corrosion Resistance of Materials and Alloys Cross-Reference. For additional engineering specifications, please call the factory at (800) 232-3539 or (610) 367-2260. Penflex reserves the right to change specifications without notice.

Locations

In addition to its Gilbertsville, Pennsylvania headquarters and manufacturing plant location, Penflex maintains stocking warehouses across the US. These satellite warehouses permit prompt deliveries to customers. Penflex Vietnam manufactures hose with primary service areas in the Asian markets.

Worldwide Locations

- Gilbertsville, Pennsylvania
- Atlanta, Georgia
- Chicago, Illinois
- Houston, Texas
- Vietnam

Quaity Management System

Penflex is dedicated to providing superior quality in all that we do, from manufacturing high quality products to providing unsurpassed customer service to customers. Our Quality Management System, which complies with the requirements of ISO 9001:2015, is Penflex's commitment to each customer that quality and customer satisfaction come first. Penflex Quality Management System (Penflex QMS) is made up of the following parts:

- Quality Policy
- Quality Objectives
- Manual

The Penflex Team

From last minute shipments and special requests to end-user support and custom orders, Penflex is committed to customer service, satisfaction and success. Penflex handles each customer's needs with a sense of urgency, consideration and professionalism. Penflex customer service professionals are available to answer questions and provide any assistance you may require.

Unmatched Support to Customers

Penflex has developed a set of technical tools to assist end-users and distributors in the selection and use of flexible metal hose products. These tools are available for your use at our website **https://penflex.com** and include online calculators for:

- Building Assemblies
- Hose Assembly Length
- Corrugated Hose Flow Velocity
- Pressure
- Temperature Adjustment Factors
- Corrosion Resistance

For assistance with support for metal bellows expansion joints Penflex has an experienced staff with decades of industry knowledge available to answer your questions.

To better support and serve the needs of our customers, Penflex posts Engineering Bulletins on its website. Engineering Bulletins are issued periodically to inform our customers about new products, changes to existing products, answers to the most common questions received from our customers, as well as relevant improvements to our manufacturing processes, etc. The Engineering Bulletins archive can be viewed on our website **https://penflex.com/bulletins**

DS-EN-2000 (01)

Specifying Part Numbers for Expansion Joints

	Pressure Rating (psi)	Nominal ID (in)	OAL (in)		Number of Plies		
EX	015	10	20	321	5	RW/RW	L

Expansion Joint Type
EX = Exhaust
SE = Single Expansion Joint
DE = Double Expansion Joint
UE = Universal Expansion Joint
HE = Hinged Expansion Joint
GE = Gimballed Expansion Joint
PB = Pressure Balance
DH = Double Hinged
DG = Double Gimballed
HX = Heat Exchanger
PV = Pressure Vessel
SRV - Safety Relief Valve Vent Connector
XP = Externally Pressurized

Alloy
304
316L
321
Inconel® 600
Inconel® 625
Inconel® 825
Incoloy® 800H
Hastelloy® C-22
Hastelloy® C-276
Monel® 400

End Connections
RW = Resistance Weld
F = Forged Flange
P = Plate Flange
W = Pipe End
S = Special
WR = Weld Rings
V = Vanstone

Accessories
D = Drain
L = Liner
S = Shroud
T = Tiered
R = Limit Rod

Data Needed for Metal Expansion Joint Design

To request an expansion joint design for your application, please provide the data requested below to sales@penflex.com.

Company Name * _____
City, State * _____
Inquiry By * _____
Email * _____
Phone _____
Quantity * _____
Application _____
Inside Diameter (in) * _____
Operating Pressure (psig) _____
Test Pressure (psig) _____
Operating Temperature (F) _____
Media _____
Material _____
Velocity _____
Natural Frequency (hz) _____
Axial Compression in) _____
Axial Extension (in) _____

Lateral Offset (in) _____
Angular Offset (deg) _____
Cycle Life _____
Overall Length (in) _____
Spring Rate Axial (lbs/in) _____
Spring Rate Lateral (lbs/in) _____
End Types: Left _____
Right _____
Shroud (Yes or No) _____
Liner (Yes or No) _____
Tie Rods (Yes or No) _____
Design Code (EJMA, B31.3, B31.1) _____
NDE _____
Mass Spec (Range) _____
Visual Inspections (VT) (Yes or No) _____
Liquid Penetrant (PT) (Yes or No) _____
Radiographic (RT) (Yes or No) _____

*** Required Field**

Introduction

Where piping designs are subject to changes in temperature, pressure, vibration, compression extension, cyclical movements or movements required by usage, flexible metal hoses and metal expansion joints, in tandem or alone, are needed to preserve the integrity of the system.

Penflex's Expansion Joint Product Range

Penflex manufactures expansion joints ranging in size from 2-1/2" ID to 120" ID. This size range is constantly expanding with the continual investments we are making to solve our customer's needs. In addition to the mentioned size range we produce expansion joints with single and multiple plies, in a wide range of configurations, in a number of alloys, and with a full complement of end fittings and accessories.

Penflex Expansion Joints are manufactured in accordance with the Expansion Joint Manufacturers Association (EJMA) Standards, 10th Edition, as well as ASTM B31.3, and B31.1. Structural welding is in accordance with ASME Section IX.

Non-Destructive Testing Program

The NDT Program is ASNT compliant and will offer these services to customers as well as perform customer requirements for NDT Inspections. The program has three in-house NDT Methods:

- Visual Inspection (VT)
- Liquid Penetrant Inspection (PT)
- Leak Test Inspection (LT)

SNT-TC-1A Level III oversight of the program's Level II's and testing techniques is part of that program. Two SNT-TC-1A Level II NDE's are qualified in three methods of NDT Inspections as well as comply to ASME Section V Articles 6, 7, 9, and 10. Penflex has a LTA with an A2LA ISO 17025 Accredited Metallurgical testing lab and can provide those services as well.

Welding Qualification and Program

In addition, Penflex has a Welding Program that includes ASME Section IX, PED 287-1, EN ISO 15614 Weld Procedure Qualifications with ISO 3834-2 Welding Coordination compliance in process. The Welding Program includes fulltime staff with in house CWI/CWE for continuous improvement of welding processes as well as ongoing development of Welding Matrixes formatted and maintained in an auditable position. Developing and qualifying Welding Procedures in exotic alloys for customer's requirements can now be done in house. Penflex's CWI, CWE, NDE Level II Inspector has 35 years of experience in the Pressure Vessel, Piping, Structural, Fabrication and Welding industries.

Engineering Qualifications

Penflex Expansion Joints have been meticulously designed, manufactured and tested by an highly skilled staff with decades of combined industry experience.

Design

Expansion joints can be custom made or made in commonly used configurations that are designed to meet a range of needs.

Calculations

All calculations are designed to Expansion Joint Manufacturer's Association (EJMA) Standards, 10th Edition, using ASME Section allowable values.

Quality

Penflex has the latest generation of design of manufacturing equipment.

100% Material Traceability

Design preservation via digital storage from original calculation, through production and on to after shipment requirements for replacement or improvement

Pressure Testing

All expansion joints are pressure tested pneumatically or hydrostatically to 1.3 times the design pressure.

All testing personnel are SNT-TC-1A accredited for Visual Testing (VT), Liquid Penetrant Inspection (PT), and Leak Test Inspection (LT).

Factors Determining the Selection of a Bellows

The selection process for a particular application is influenced by six primary considerations:

- Temperature
- Pressure
- Media
- Size
- End Fittings
- Motion

Temperature

The physical properties of any material varies with temperature. Limits for operating temperature are affected by the working pressure, the type of media being conveyed and the nature of the application. By careful selection of material, it is possible to provide an expansion joint for a wide range of operating temperatures. The choice of type, metal alloy, end fitting and method of fitting attachment determines the temperature limit.

Pressure

The nominal pressure ratings of an expansion joint vary according to type, material and size. Specific pressure ratings for each type of an expansion joint are calculated according to the applicable design specification. Under actual working conditions, pressure is affected by many other factors such as temperature, pulsating conditions, bending stresses, shock, vibration, and external influences.

Media

The type of media being conveyed is an important consideration in the selection process. An expansion joint is subject to corrosion by both the material flowing through it and the outside environment. For almost all applications, an expansion joint can be selected that is resistant to the intended media.

For Corrosion Resistance of Materials to different environment, refer to a chart posted on our website.

Size

The size of an expansion joint is specified by the nominal diameter. The existing piping will normally dictate the size of the metal hose for a particular application. However, flow rate, velocity and pressure drop considerations may also influence the selection of the expansion joint.

End Fittings

The use of an expansion joint is complimented by the extensive range of end fittings that are available. Such end fittings may be male or female pipe threads, unions, flanges, flared tube fittings or other specially designed connectors. End fittings are attached by welding, silver brazing, soldering depending on the type of the expansion joint and the alloy.

Hardware & Accessories

Hardware is designed to met specific customer, application, or code requirements and includes components such as shrouds, and tie-rods.

Motion or Movements Required

An expansion joint is generally used in four types of applications; primarily thermal expansion and contraction, and in addition to the following:

- To correct problems of misalignment.
- To provide flexibility in manual handling operations.
- To compensate for regular or constant movement.
- To absorb vibration.

In all types, careful selection and design of the expansion joint and its installation are important for optimal service life. The flexibility of an expansion joint is determined by its mechanical design and the inherent flexibility of its material.

Flow Rates

Liners are designed normally to EJMA for flow rates specified by the customer.

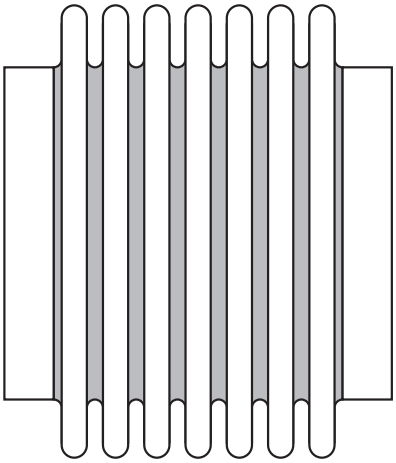
Temperature Adjustment Factors

In general, the strength and therefore the pressure rating of an expansion joint decreases as the temperature increases. Thus, as the operating temperature of an expansion joint increases, the maximum allowable working pressure of the assembly decreases. Elevated service temperatures will decrease these pressure ratings by the factors shown in the following chart. What also must be considered is the maximum working temperature of the end fittings, and other components of the expansion joint.

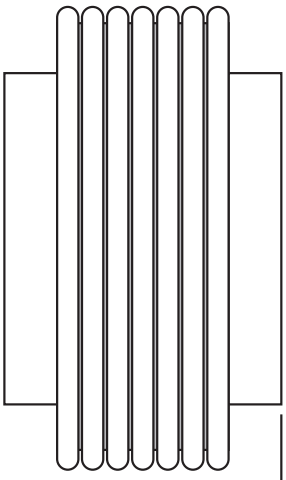
Benefits Offered by a Metal Bellows Expansion Joint

- Compensate for movements and vibration
- Pressure resistant
- Leak Proof without mechanical seals
- Maintenance Free

Axial Movement

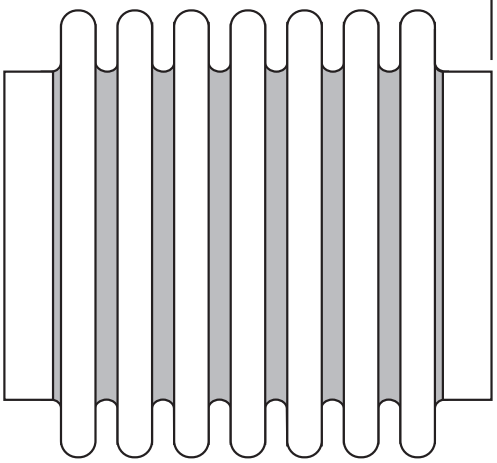


Bellows neutral



Bellows compressed

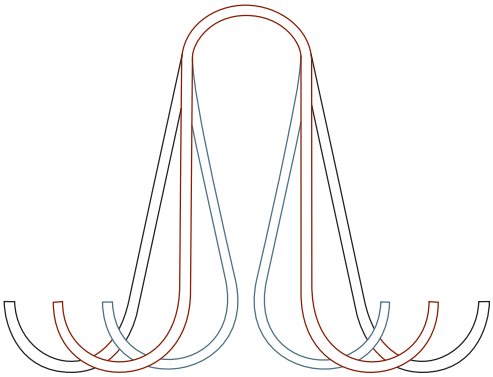
Total Movement



Bellows expanded

Bellow Flexibility

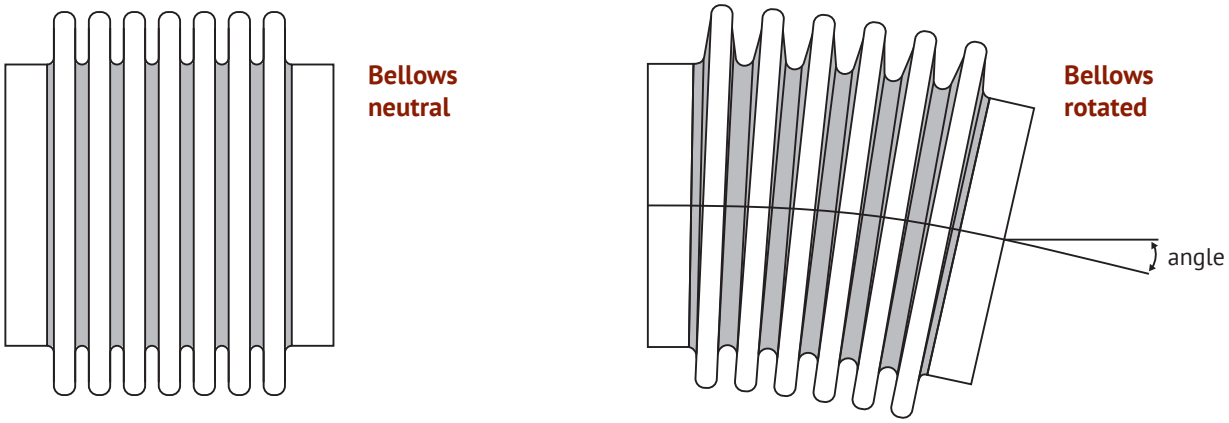
A Bellows consists of one or more convolutions and each convolution can have a position that is neutral, extended or compressed.



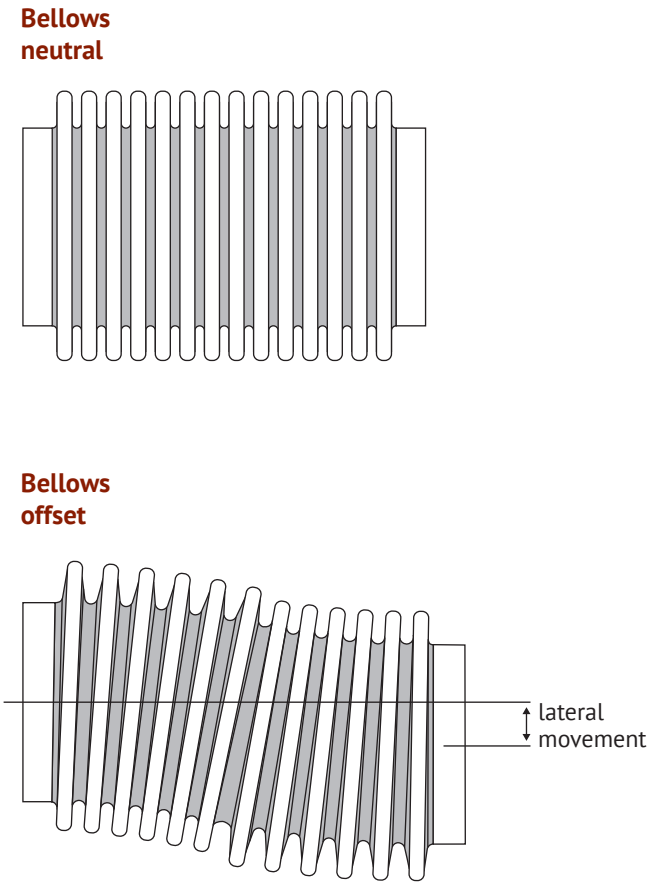
- **Bellows (convolution) in neutral position**
- **Bellows (convolution) in extended position**
- **Bellows (convolution) in compressed position**

When the convolutions are in a sequence, the effect is a piping component that can compensate for a number of movements.

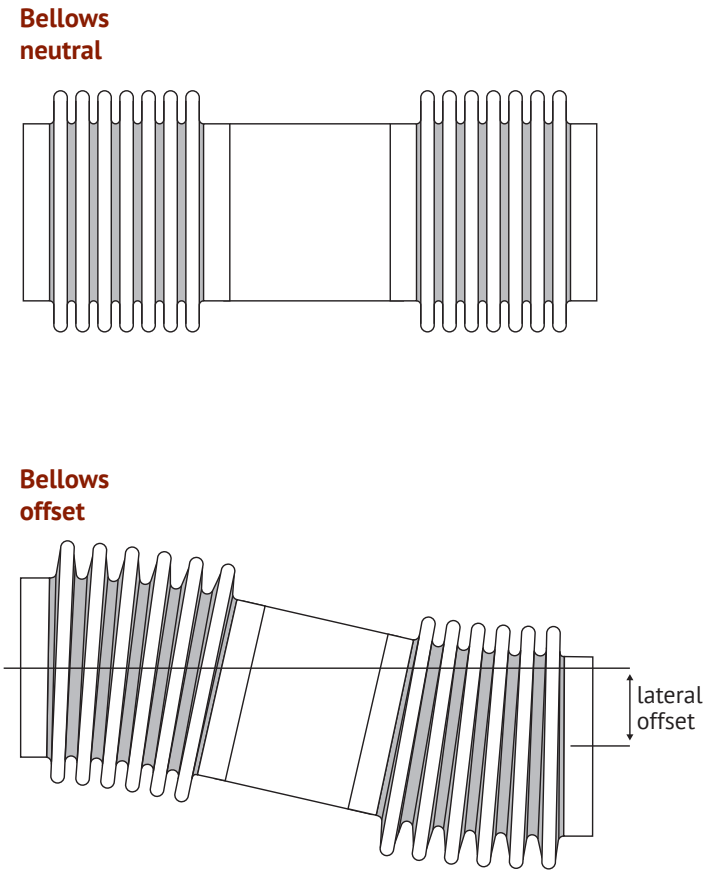
Angular Rotation



Lateral Movement using a Single Bellows



Lateral Movement using a Double or Universal Bellows



Untied Expansion Joints

Most Common Types:

Axial Expansion Joints

Double Expansion Joint

Internally Guided Expansion Joint

Untied Universal Expansion Joints

Pressure Balanced Expansion Joint

Features:

Single or dual bellows with installation fittings only

Commonly used for low pressure service

Simple design = less expensive

All degrees of freedom (axial, lateral, angular)

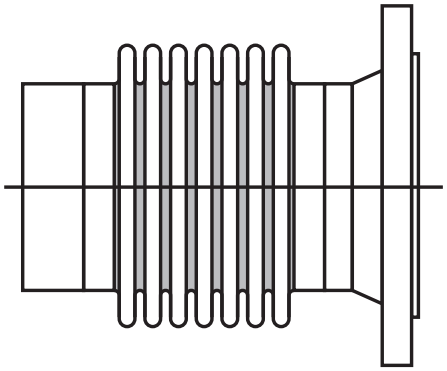
Incur pressure thrust onto pipe

Anchors affected by bellows spring rate **and** pressure thrust = higher force

Basic Expansion Joint Designs

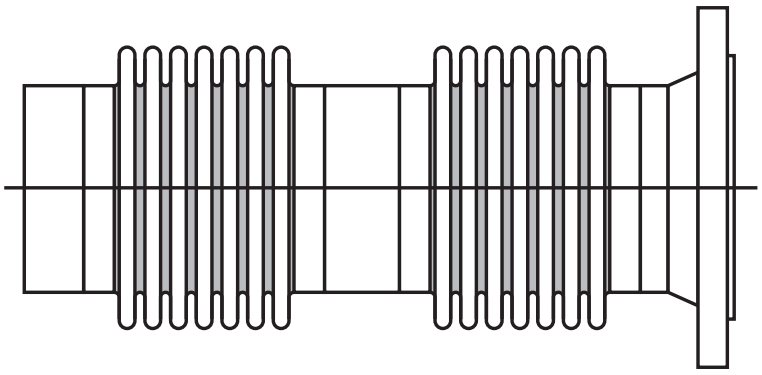
Untied = Pressure Thrust

Single (axial) Expansion Joint



axial, lateral & angular movements

Universal (untied) Expansion Joint



large axial, lateral & (angular) movements

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Tied Expansion Joints

Most Common Types:

Hinged Expansion Joints

In-line pressure Balance Expansion Joint

Gimbaled Expansion Joints

Tied Single & Universal Expansion Joints

Features:

Single or dual bellows with restraining hardware

Typically used for high pressure service

More complex = higher cost for expansion joint*

Limited degrees of freedom

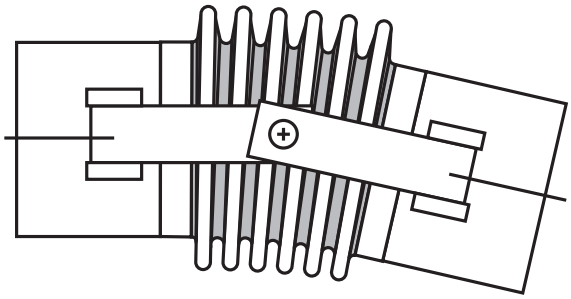
Pressure thrust restrained by hardware

Anchors only affected by bellows spring rate = low force

Expansion Joints Made using a Single or Multiple Bellows

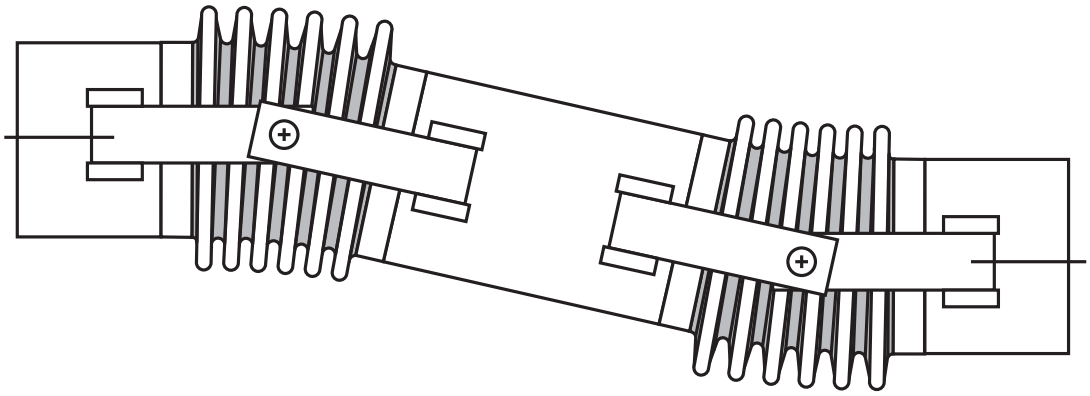
Tied = NO Pressure Thrust

Single-Hinged Expansion Joint *



angular rotation in one plane

Double-Hinged Expansion Joint *

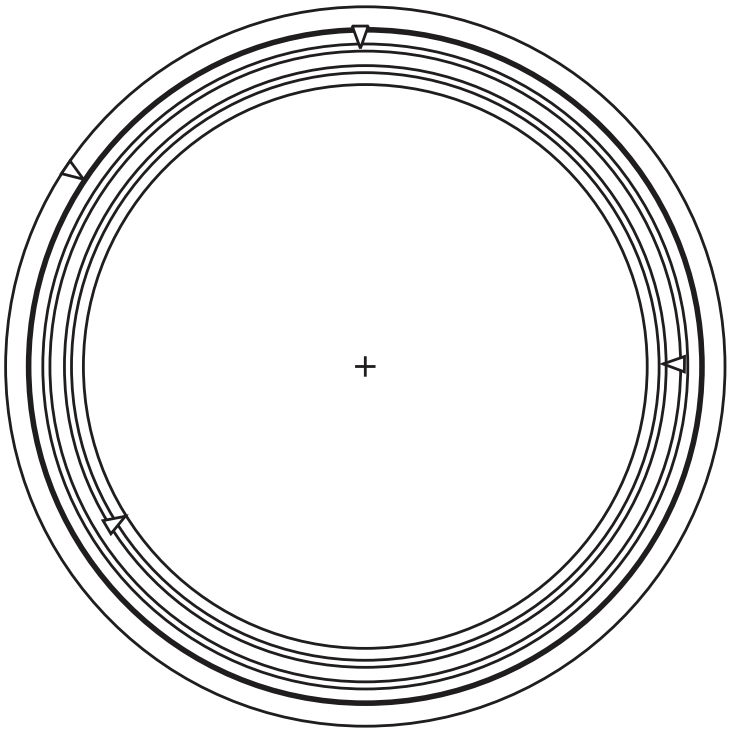


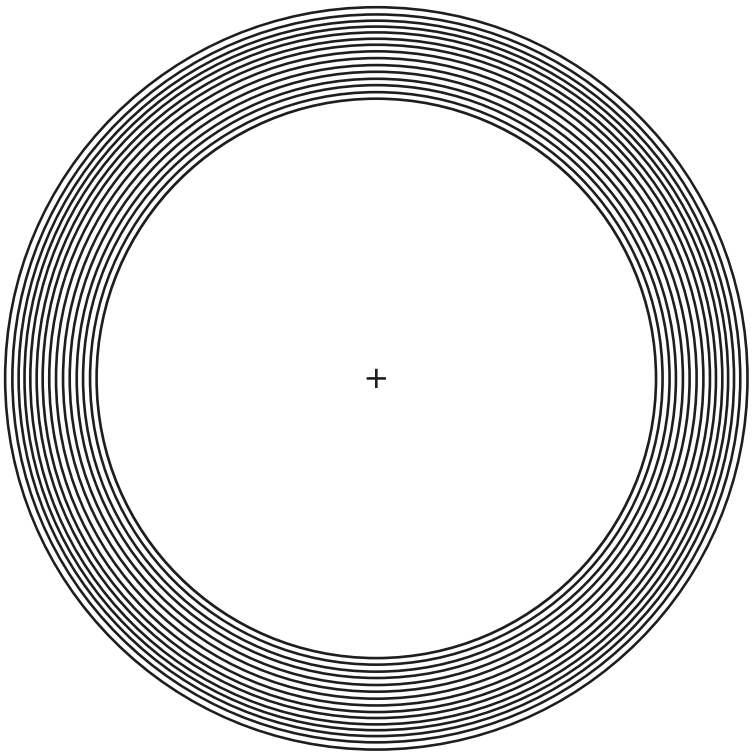
lateral movement in one plane

* Option for slotted hinged joints.

Multi-Ply

- Each ply made from welded tube
- Each ply leak proof
- Wetted ply can be made of different (higher alloy) material for enhanced corrosion resistance
- Allowance for weep holes



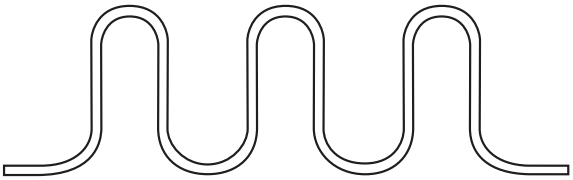


Multi-Ply (Spiral)

- Inner/Outer plies welded
- No sudden leak
- Wetted ply can be made of different (higher alloy) material for enhanced corrosion reisitance

Characterisitcs of Bellows Designs

Single Ply



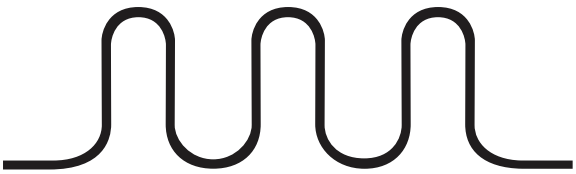
Typical Application

- Shell and tube heat exchangers
- Clamshell bellows
- Penetration seals
- HVAC piping

Characteristics

- One ply
- Relatively thick
- Robust
- Higher spring rate
- High lateral stiffness
- Relatively cheap
- Good NDE when installed
- Weld attachment simple
- Weld repair (temporarily) possible

Multi-Ply



Typical Application

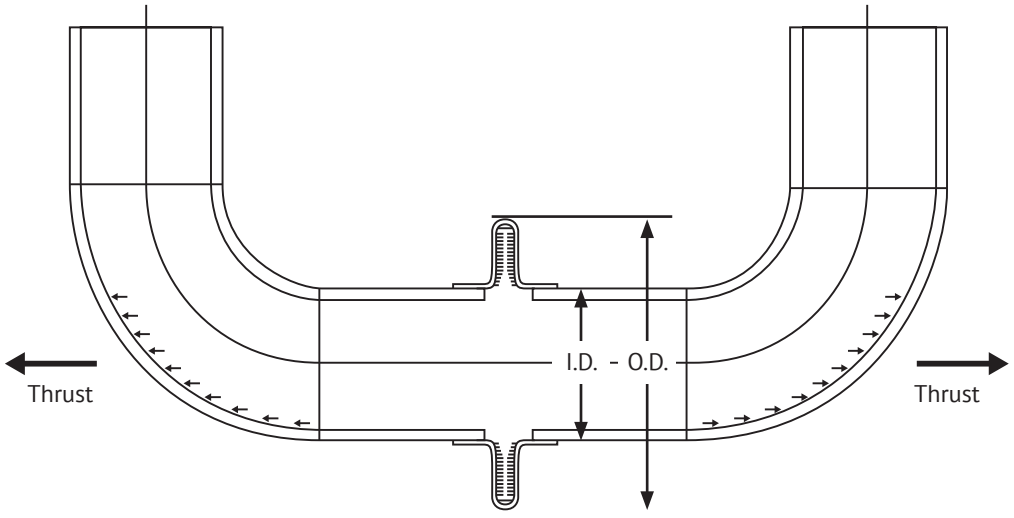
- HT & HP steam & process piping
- Equipment connections
- Vibration dampening

Characteristics

- Between 2 and >5 plies
- Individual plies relatively thin
- Total wall thickness = thick
- Extremely flexible in all directions
- Excellent vibration damper
- Very short compared to single ply with similar flexibility
- Leak monitoring possible
- No sudden leaks

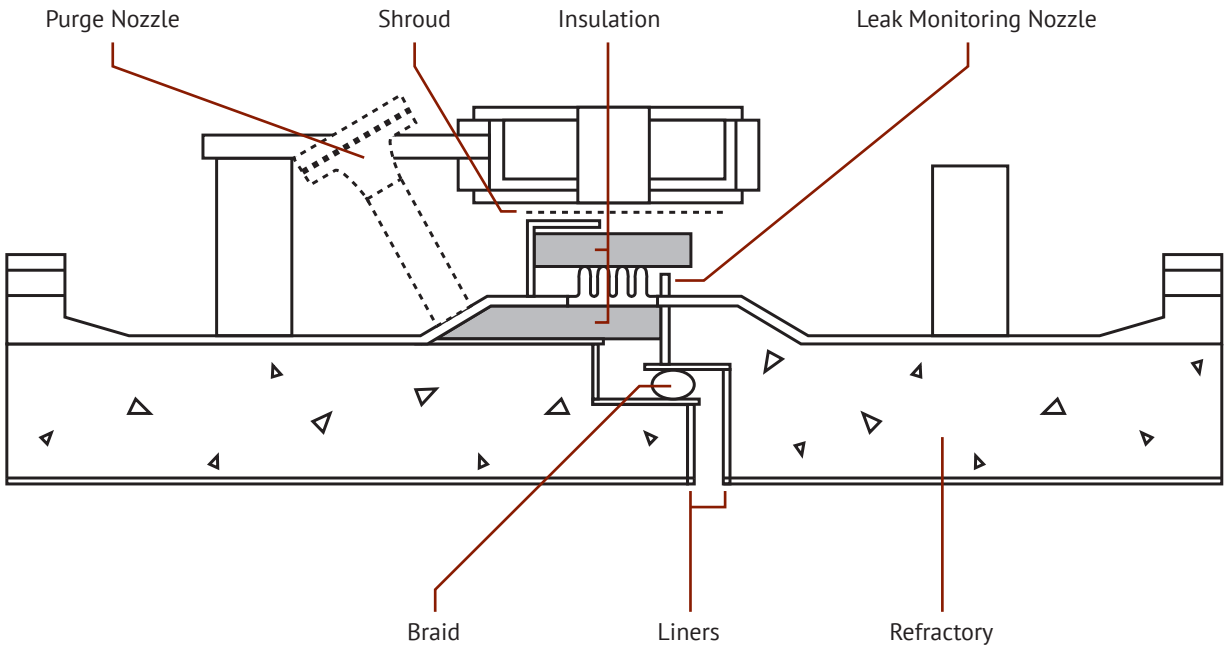
Pressure Thrust

Thrust = Bellows Area x Pressure
[Lb.] [sq. in.] [psig]



Examples of Expansion Joint Attachments

Attachment:	Purpose:
Purge Nozzle	Keep annulus clean
Shroud	Protect bellows externally
Insulation	Control bellows temperature
Leak Monitoring	Provide warning in case of bellows leak
Braid	Avoid removal of packing from bellows
Liners	Protect bellows inside & support refractory
Refractory	Provide resistance against erosion and temp. insulation



Temperature Adjustment Factors

In general, the strength and therefore the pressure rating of a bellows decreases as the temperature increases. Thus, as the operating temperature increases, the maximum allowable working pressure decreases. Elevated service temperatures will decrease these pressure ratings by the factors shown in the following chart for the alloy used braid wire. What also must be considered is the maximum working temperature of the end fittings, and their method of attachment.

Temperature Adjustment Factors

Temperature (°F)	304/304L Stainless Steel	316L Stainless Steel	321 Stainless Steel	Inconel 625™	Monel	Hastelloy C276™
70	1.00	1.00	1.00	1.00	1.00	1.00
150	.95	.93	.97	----	.93	----
200	.91	.89	.94	.96	.90	----
250	.88	.86	.92	----	.87	----
300	.85	.83	.88	----	.83	----
350	.81	.81	.86	----	.82	----
400	.78	.78	.83	.93	.79	.87
450	.77	.78	.81	----	.77	----
500	.77	.77	.78	----	.73	----
600	.76	.76	.77	.91	.72	.96
700	.74	.76	.76	----	.71	----
800	.73	.75	.68	.88	.70	.82
900	.68	.74	.62	----	----	----
1,000	.60	.73	.60	.85	----	----
1,100	.58	.67	.58	----	----	----
1,200	.53	.61	.53	.84	----	----
1,300	.44	.55	.46	----	----	----
1,400	.35	.48	.42	.63	----	----
1,500	.26	.39	.37	----	----	----
1,600	----	----	----	.37	----	----
1,800	----	----	----	.18	----	----

Saturated Steam Pressure To Temperature (PSIG)

Saturated Steam (PSIG)	Temp (°F)	Saturated Steam (PSIG)	Temp (°F)	Saturated Steam (PSIG)	Temp (°F)
0	212	150	366	450	460
10	238	175	377	475	465
20	259	200	388	500	470
30	274	225	397	550	480
40	287	250	406	600	489
50	298	275	414	700	505
60	307	300	422	800	520
75	320	325	429	900	534
80	324	350	436	1000	546
90	331	375	442	1250	574
100	338	400	448	1500	606
125	353	425	454	2500	669

Saturated Steam Pressure To Temperature (Hg)

Saturated Steam Vacuum (in. of Hg)	Temp (°F)
----	0
29.84	20
29.74	32
29.67	40
29.39	60
28.89	80
27.99	100
26.48	120
24.04	140
20.27	160
15.20	180
6.46	200

Glossary

Abrasion: External damage to an expansion joint caused by its being rubbed on, by or against a foreign object.

Ambient or Atmospheric Conditions: The surrounding conditions, such as temperature, pressure and corrosion, to which an expansion joint is exposed.

Amplitude of Vibration and/or Lateral Movement: The distance an expansion joint deflects laterally to one side from its normal position, when this deflection occurs on both sides of the centerline.

Anchor: A restraint applied to a pipeline to control its motion caused by thermal growth.

a. Main – A main anchor is designed to withstand the full bellows thrust produced by spring forces, pressure, flow and other loads.

b. Intermediate – An intermediate anchor is designed to withstand the same thrust as the main anchor with the exception of the thrust due to pressure.

The magnitude, and direction of the forces and movements that are going to be imposed on an anchor must be identified to ensure an expansion joint is designed for a specific application.

Angular: The displacement of the longitudinal axis of an expansion joint from its straight line position into a circular arc.

Annular: Refers to the convolutions on an expansion joint that are a series of complete circles or rings located at right angle to the longitudinal axis of the bellows.

Application: The service conditions that determine how an expansion joint will be used.

Attachment: The method of fixing end fittings to an expansion joint typically by welding, brazing, or soldering.

Axial Movement: Compression or elongation of an expansion joint along its longitudinal axis.

Bellows: A metal tube of one or more thicknesses that has been formed with one or more convolutions allowing it to become flexible axially and laterally.

Bend Radius: The radius of a bend measured to the centerline.

Brazing: A process of joining metals using a non-ferrous filler metal, which melts above 800°F, yet less than the melting of the "parent metals" to be joined.

Butt Weld: A process in which the edges or ends of metal sections are butted together and joined by welding.

Collar: A ring made from tube or metal strip placed over the ends of an expansion joint.

Combined Movements: The sum of all the axial, lateral and angular movements that an expansion joint is subject to simultaneously.

Controlled Flexing: Controlled flexing occurs when an expansion joint is being flexed regularly, as in connections to moving components.

Convolution: The annular flexing member or members in an expansion joint.

Corrosion: The chemical or electro-chemical attack of a media upon an expansion joint.

Cover or Shroud: An exterior accessory of an expansion joint that prevents external abrasion.

Cycle: A single full range movement of an expansion joint from one extreme position to another and back.

Cycle Life: The total number of cycles that an expansion joint is designed to complete.

Cycle-Motion: The movement from normal to extreme position and return.

Deflection: The force required to create a lateral movement in an expansion joint.

Developed Length: The length of an expansion joint plus fitting (overall) required to meet the conditions of a specific application.

Dye Penetrant Inspection or Test: A method for detecting surface irregularities, such as cracks, voids, porosity, etc. The surface to be checked is coated with a red dye that will penetrate existing defects. Dye is removed from surface and a white developer is applied. If there is a defect in the surface being checked, the red dye remaining in it causes the white developer to be stained, thereby locating the defective area.

Displacement: The amount of motion applied to an expansion joint defined as inches for parallel offset and degrees for radial misalignment.

Dog-Leg Assembly: Two expansion joints joined by a common elbow.

Effective Thrust Area: The cross-sectional area described by the outside diameter (at the tops of the convolutions) less two times the metal thickness of the bellows.

Erosion: The wearing away of the inside convolutions of an expansion joint caused by the flow of the media conveyed, such as wet steam, abrasive particles, etc.

Exposed Length: The amount of active (exposed) bellows in an assembly. Does not include the length of fittings and ferrules.

Fatigue: Failure of the metal structure associated with, or due to, the flexing the bellows.

Fitting: A loose term applied to the nipple, flange, union, etc., attached to the end of an expansion joint.

Flow Rate: Pertains to a volume of media being conveyed in a given time period, e.g., cubic feet per hour, pounds per second, gallons per minute, etc.

Galvanic Corrosion: Corrosion that occurs on the less noble of two dissimilar metals in direct contact with each other in an electrolyte, e.g., water, sodium chloride in solution, sulphuric acid, etc.

Guide (For Piping): A device that supports a pipe radially in all directions, but allows free longitudinal movement.

Hardware: A loose term used to describe accessory parts supplied with an expansion joint for installation, such as nuts, bolts, gaskets etc.

Inside Diameter: This refers to the internal free cross section of the expansion joint and (in most cases) is identical to the nominal diameter.

Installation: Referring to the installed geometry of an expansion joint.

Lap Weld (LW): Type of weld in which the ends or edges of the metal overlap each other and are welded together.

Liner: Flexible or fixed sleeve used to line the inside of an expansion joint when the velocity of media is excessive.

Medium (Singular)/Media (Plural): The substance(s) being conveyed through a piping system.

Misalignment: A condition in which two points, intended to be connected, will not mate due to their being laterally out of line with each other.

Natural Frequency: The rate of vibration or flexure of an expansion joint in a given time period, e.g., cycles per second (CPS), cycles per minute (CPM), cycles per day (CPD), etc.

Nominal Diameter: A term used to define the dimensions of a component. It indicates the approximate inside diameter.

Offset – Lateral, Parallel, & Shear: The amount that the ends of an expansion joint are displaced laterally in relation to each other as the result of connecting two misaligned terminations in a piping system, or intermittent flexure required in an application.

Operating Conditions: The pressure, temperature, motion, media, and environment that an expansion joint is subjected to.

Outside Diameter: This refers to the external diameter of an expansion joint, measured from the top of the corrugation.

Penetration (Weld): The percentage of wall thickness of the two parts to be joined that is fused into the weld pool in making a joint. Our standard for penetration of the weld is 100 percent, in which the weld goes completely through the parent metal of the parts to be joined and is visible on the opposite side from which the weld was made.

Pipe Gap: The open space between adjacent ends of two pipes in which an assembly may be installed.

Pitch: The distance between the two peaks of adjacent corrugation.

Ply, Plies: The number of individual thicknesses of metal used in the construction of the wall of an expansion joint.

Pressure: Usually expressed in pounds per square inch (PSI) and, depending on service conditions, may be applied internally or externally to an expansion joint.

a. *Absolute Pressure* – A total pressure measurement system in which atmospheric pressure (at sea level) is added to the gauge pressure, and is expressed as PSIA.

b. *Atmospheric Pressure* – The pressure of the atmosphere at sea level which is 14.7 PSI, or 29.92 inches of mercury.

c. *Burst Pressure* (Actual And Rated)

1. Actual – Failure of the expansion joint determined by the laboratory test in which expansion joint ruptures due to the internal pressure applied. This test is usually conducted at room temperature with the expansion joint in a straight line, but for special applications, can be conducted at elevated temperatures and various configurations.
2. Rated – A burst value which may be theoretical, or a percentage of the actual burst pressure developed by laboratory test. It is expected that, infrequently, due to manufacturing limitations, an assembly may burst at this pressure, but would most often burst at a pressure greater than this.

d. *Deformation Pressure (Collapse)* – The pressure at which the corrugations of expansion joint are permanently deformed due to fluid pressure applied internally, or, in special applications, externally.

e. *Feet of Water or Head Pressure* – Often used to express system pressure in terms of water column height. A column of water 1 ft. high exerts a .434 PSI pressure at its base.

f. *Test Pressure* – The maximum internal pressure which expansion joint can be subjected to without either deforming the corrugations, or exceeding 50 percent of the burst pressure. When expansion joint is tested above 50 percent of its burst pressure, there often is a permanent change in the overall length of the assembly, which may be undesirable for certain applications.

g. *PSIA* – Pounds per square inch absolute.

h. *PSIG* – Pounds per square inch gauge.

i. *Pulsating Pressure* – A rapid change in pressure above and below the normal base pressure, usually associated with reciprocating type pumps.

j. *Shock Pressure* – A sudden increase of pressure in hydraulic or pneumatic system, which produces a shock wave. This shock can cause severe permanent deformation of the corrugations in expansion joint as well as rapid failure of the assembly due to metal fatigue.

k. *Static Pressure* – A non-changing constant pressure.

l. *Working Pressure* - The pressure, usually internal, but sometimes external, imposed on expansion joint during operating conditions.

Profile: Used in reference to the contour rolled into strip during the process of manufacturing expansion joint, or the finished shape of a corrugation; formed from a tube by either the "bumpout," "sink" or roll forming processes, used in making expansion joint.

Random Motion: The non-cyclic uncontrolled motion of expansion joint, such as occurs in manual handling.

Rods:

a. *Limit Rods* – These are rods or bars that are attached to the expansion joint that restrict the movement range of the bellows. The range includes axial, angular and lateral movement during operation. They are also used to prevent axial compression or extension beyond the designed range of movement, as well as retraining the full pressure load and dynamic forces generated if there is an anchor failure.

b. *Tie Rods* – These are rods or bars that are attached to the expansion joint that restrict the movement range of the bellows. During normal operation tie rods retrain the full bellows pressure thrust while permitting only lateral deflection.

c. *Control Rods* – These are rods or bars that are attached to the expansion joint that distribute the movement between two bellows of a universal expansion joint. They are not designed to restrain bellows thrust pressure.

Safety Factor: The relationship of working pressure to burst pressure.

Scale: Generally refers to the oxide in expansion joint brought about by surface conditions or welding.

Squirm: A form of failure in which the expansion joint is deformed into an "S" or "U" bend as the result of excessive internal pressure being applied.

Stress Corrosion: A form of corrosion in stainless steel normally associated with chlorides.

Tangents: The tube ends on either side of a bellows used to weld into piping system or end fittings.

Thrust Area: *See Effective Thrust Area Definition.*

Tig Weld: The tungsten inert gas welding process sometimes referred to as shielded arc. The common trade name is heliarc.

Torsion: A force that produces, or tends to produce, rotation of or torsion through one end of an expansion joint while the other end is fixed.

Velocity: The speed at which the medium flows through the expansion joint, usually specified in feet per second.

Velocity Resonance: The sympathetic vibration of convolutions due to buffeting of high velocity gas or air flow.

Vibration: Low amplitude motion occurring at high frequency.

Welding: The process of localized join of two or more metallic components by means of heating their surfaces to a state of fusion, or by fusion with the use of additional filler materials.

Notes:

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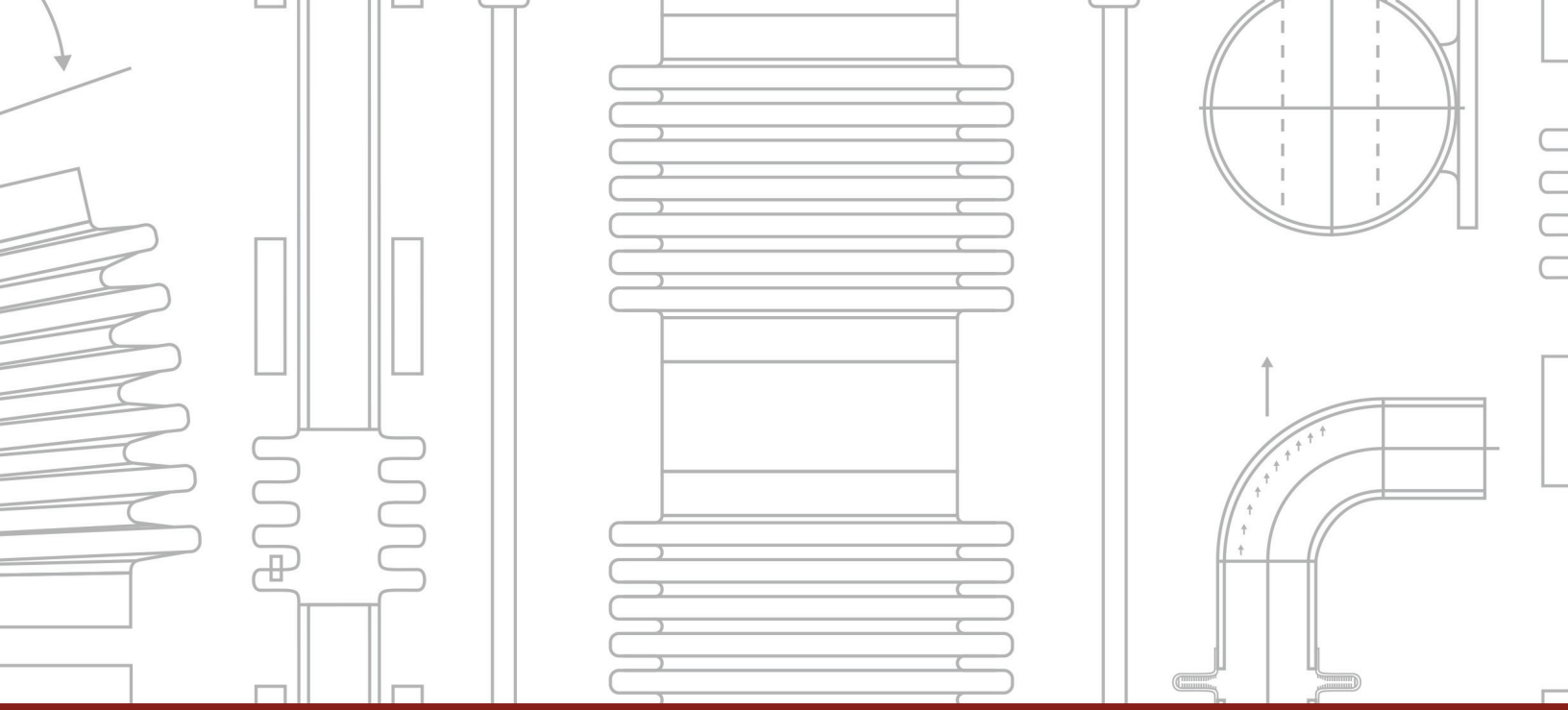

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