ThorburnFlex

Clean Power Generation

Petrochemical Processing

Hydro/Pyro Metallurgical Processing

METALLIC EXPANSION JOINTS

Engineered Solutions for Pipe & Duct Motion

www.thorburnflex.com

ThorburnFlex

Thorburn Flex is an innovative manufacturer of specialized engineered flexible piping systems (i.e. custom hose assemblies and expansion joints). Since 1954, Thorburn's corporate mission evolution and business philosophy have been customer driven and targeted to select niche applications where Thorburn can achieve clear positions of sustainable technological and market share leadership. Thorburn is committed to a policy of continuous development and research to provide engineered solutions for pipe motion that set the industry standards for quality, safety, environmental protection, durability and value.

European Conformity	ISO 9001	B31.1, B31.3	ASME "NPT" Sec. III Class 1	ASME "U" Sec. VIII Div. 1	N285.0, B51 CGA CR96-001	97/23/EC Module H	UL 536

ISCIR Romania | CNCAN Romania | EN 13480-2002 | HAF 604 China | TSG China

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Edition 07/10/2025

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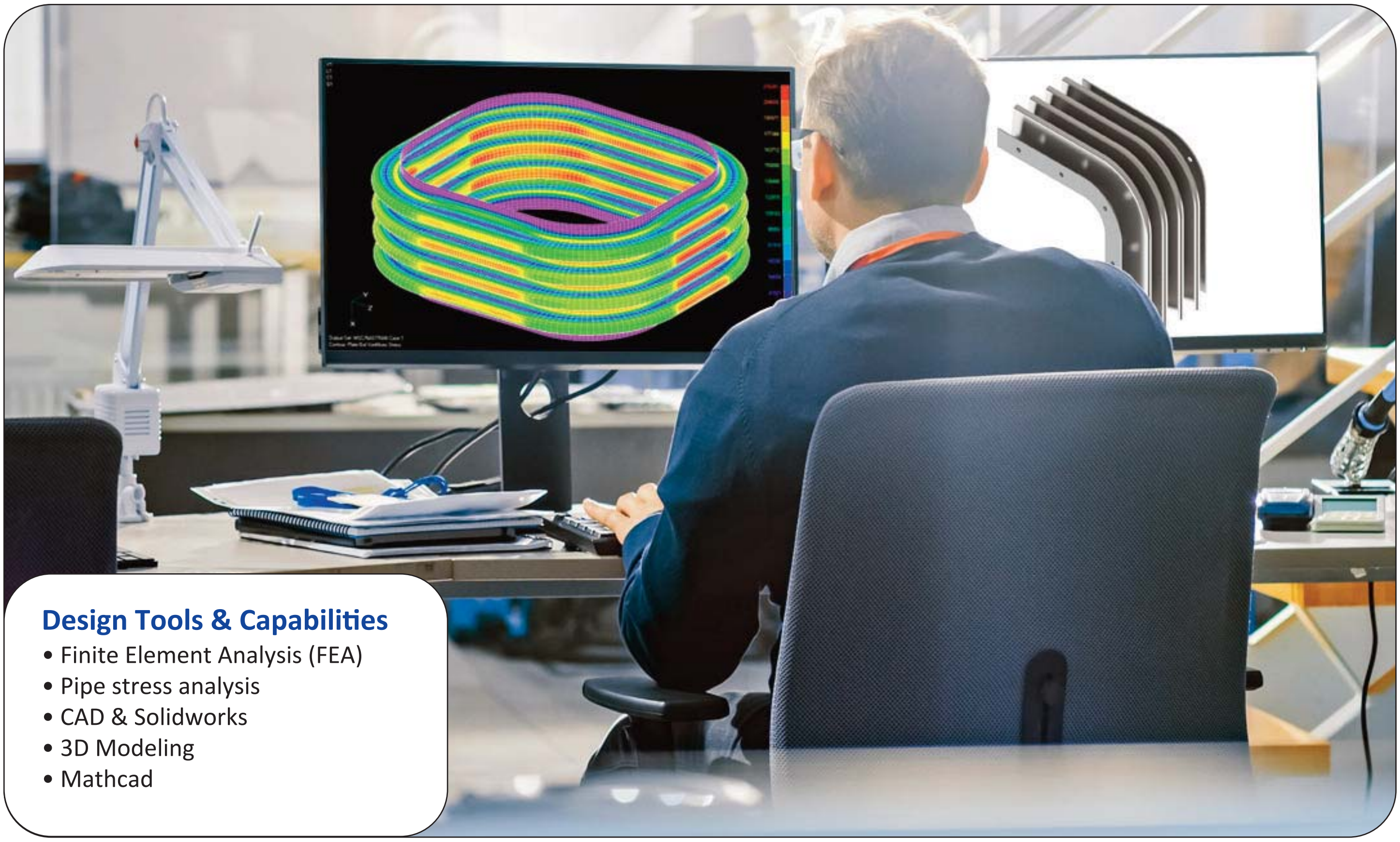


Design Tools & Capabilities
- Finite Element Analysis (FEA)
- Pipe stress analysis
- CAD & Solidworks
- 3D Modeling
- Mathcad

Engineered Solutions for Pipe & Duct Motion
Thorburn's metallic bellows are a flexible element that are used to absorb movements and provide a seal in piping and ducting systems. The movement sources are caused by changes in temperature, pressure, ground settling and vibration. Thorburn bellows must also seal the media flow speed while transporting it under pressure or vacuum.

Thorburn's Global Presence
Thorburn flex is the only company which posseses a nuclear licence for design and manufacture in the USA, Canada, Europe and China. Thorburn's role as a technological leader provides comprehensive knowledge with the broadest range of expansion joints in the industry. We have developed innovative solutions for flexible seals to transport media, vibration dampening and compensation of thermal movements.

Engineering Capabilities & Experience
Thorburn's design engineering expertise is supported by advanced FEA software that offers powerful and complete solutions for both routine and sophisticated engineering problems. Thorburn's engineers can analyse and provide innovative solutions for pipe and duct motion problems including dynamic vibration, nonlinear static, linear static, thermal gradient through material wall thickness, acoustic impedance and fatigue using a common model data structure and integrated solver technology.

Bellows Manufacturing Capabilities

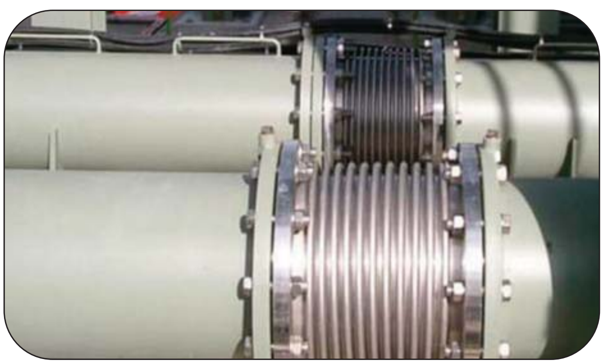
Welding and Fabrication Capabilities

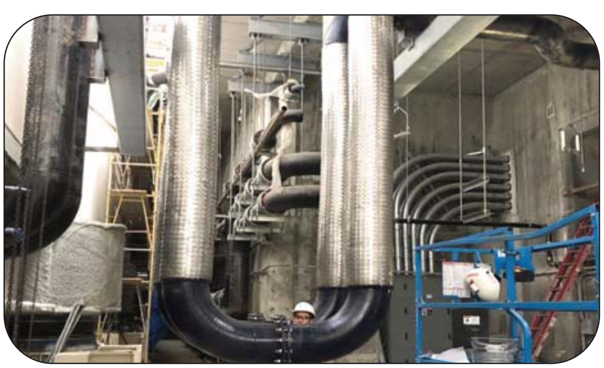
- Arc, pulse arc, TIG, micro TIG, micro plasma, MIG, core wire, laser
- Tube welding, automated and track welding, automated flame cutting and hydro cutting
- Rolls, positioners and turntables
- Automated fitting to end joints welding DIN 6mm (1/4”) to DIN 300mm (12”)
- Automated hydro-forming convolution heights DIN 25mm (1”) to DIN 600mm (24”)
- Spinning lens style forming convolution heights up to 600mm (24”)
- Hydro-forming lens style convolution heights (with no crest weld) up to 250mm (10”)
- Mechanical forming convolution heights DIN 25mm (1”) to DIN 9000mm (360”)

NDT/NDE Programs & Design Verification Testing

- Weld X-Ray to 300KV-5MA / welds dye penetrant to ASME Sec V
- Vacuum testing 760mm (29.9") HG and hydrostatic or nitrogen pressure testing to 1,000 bar (15,000 psi)
- Destructive design verification testing to 4000 bar (60,000 psi)
- Impulse Testing to 680 bar (10,000 psi) at 204°C (400°F).
- Burst testing up to 10,000 bar (150,000 psi)
- Pliability fatigue and deflection testing ISO 10380:2012
- Seismic and vibration analysis in acceptance with ASME Sec III
- Helium mass spectrometer leak testing

Why Use A Metallic Bellows Expansion Joint





All piping or ducting systems are subjected to changes in their geometry due to various factors, some of which are:

Thermal

- Startup to operating temperature
- Variations in ambient temperature
- Emergency or fault conditions

Pressure

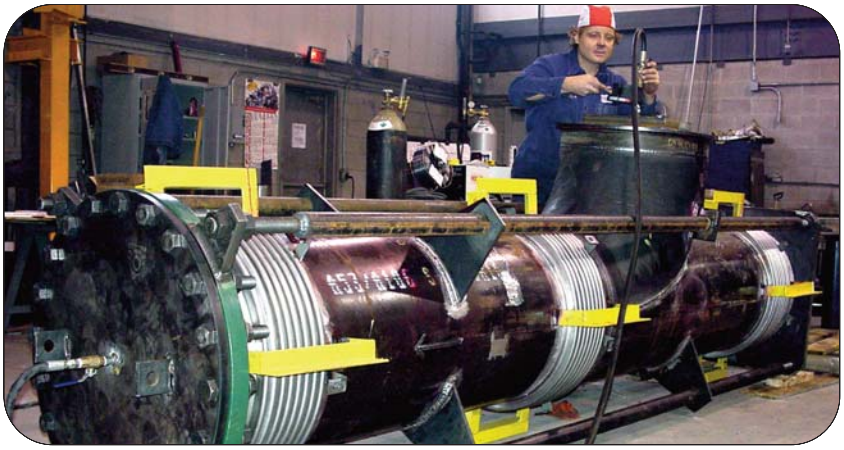
- Deformation due to constant pressure
- Deformation due to pulsating pressure
- Deformation due to vibration

Mechanical

- Movement of other equipment
- Thermal growth in other equipment

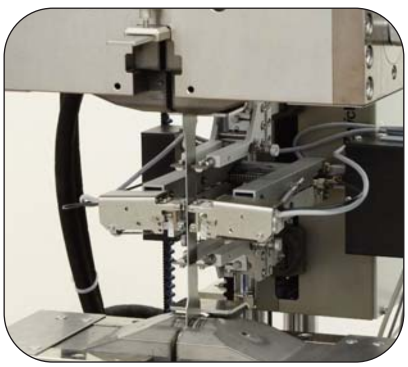
Expansion Loops: The "loop" is the oldest method of dealing with pipe movement and probably the most expensive when one considers today's high costs of material and labour. In addition, pressure drops, heat loss, high anchor loading together with the large space requirement, can make this method economically unsound for the relatively small amount of movements that can be accommodated with the pipe loop.

Thorburn Quality Control System



Helium leak testing

Hot-Flex expansion joint PTFE liner undergoing a 10,000 Volt spark test to detect pin holes



Tensile testing on sheet metal

Charpy V notch impact testing on sheet metal

Metal bellows cyclic fatigue testing

Quality Certifications For Design & Fabrication

Commercial

- ISO 9001

Piping & Pressure Vessel

- ASME Section VIII Div 1 (“U” Stamp)
- ASME B31.1, B31.3, B31.5 (USA)
- CSA B.51 (Categories A & D) (Canada)
- EN 14917 PED 2014 | 60| VE Model H
- TSG (China)

Nuclear

- CSA N299.1 (CANDU Nuclear Family)
- ASME Section III NPT, Class 1 (USA)
- CSA N285.0 (Canada)
- HAF 604 (China)
- CNCAN (Romania)
- ISCIR (Romania)

Destructive & Non-Destructive Testing Capabilities

- Acoustical impedance/noise emission testing
- Large diameter pipe simulating testing
- Radiography, dye penetrant, ultrasonic, magnetic particles
- Burst testing up to 10,000 BAR
- Bellows fatigue & deflection testing
- Seismic and vibration analysis
- Impulse testing up to 680 bar at 204°C
- Helium mass spectrometer leak testing

Thorburn Site Services

Inspection

- Perform inspections, verifications and measurements
- Provide a monitoring plan (one for each unit) expansion joints during unit operating conditions and planed outages
- Measurable acceptance criteria is based on internationally recognized standards

On Site Equipment & Services

- Provide all tooling for expansion joint inspections, verifications, and measurements
- Perform on site maintenance repairs, replacements of expansion joints and delivery of spares

Planned Preventative Maintenance Programs

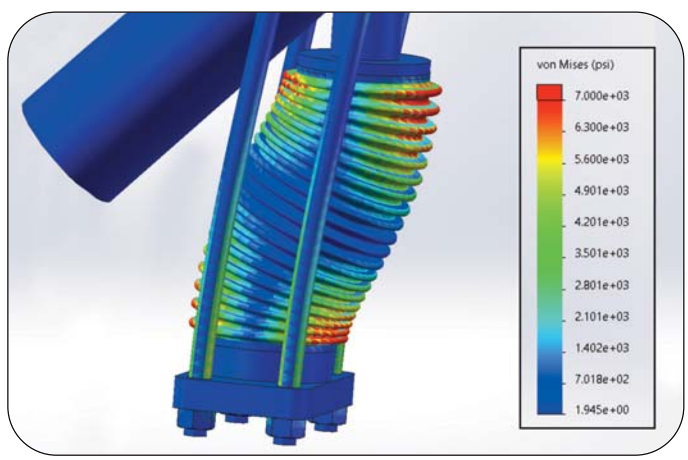
- After each Planned Outage or annual inspection, prepare a "Fitness for Service" report including inspection results, trends, conclusion and recommendations

24/7 Technical Support & Emergency Assistance

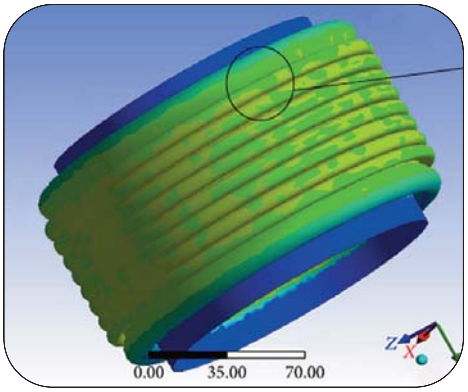
- Provide analysis and evaluation of emergency response during a framework agreement period
- Issue recommendations, forensic and failure mode analysis, counter measure recommendations

Failure Investigations, Analysis & Recommendations

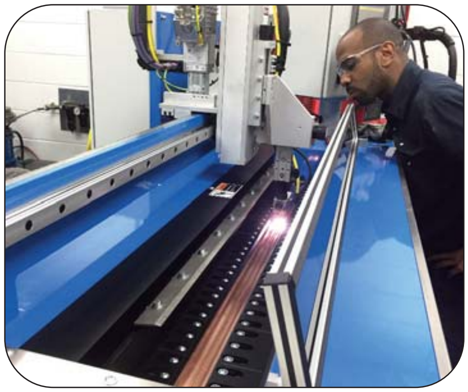
Thorburn's engineers use advanced software to support its designs and identify thermal and mechanical stresses found in flexible piping & ducting systems. Thorburn's Engineers can provide on-site engineering services such as failure mode investigation analysis. FEA and other software tools can measure the results against the actual failure mode and Thorburn can recommend the appropriate counter measures



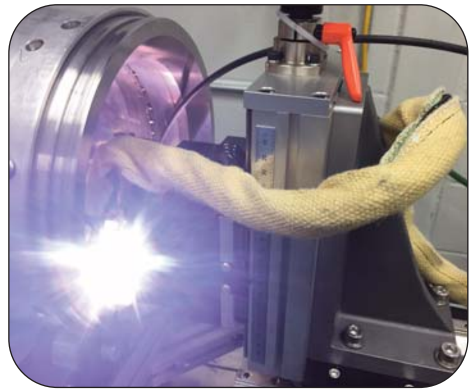
Building Metallic Bellows



Finite Element Analysis (FEA) of a bellows expansion joint design



Robotic fusion seam welding metal sheets into tubes with ASME Section II, 2014/68/EU PED materials conforming to ASME Section III Design



Automatic micro GMT welding as low as 0.1 mm

Mechanical forming metal tubes into bellows from sizes 50mm to over 4m

Hydro-forming metal tubes into bellows from sizes 25mm to over 4m

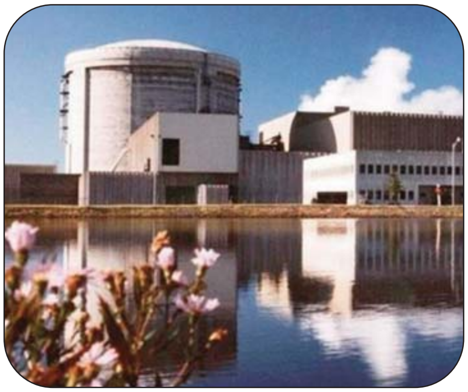
Roll forming metal tubes into large diameter bellows up to 10m in size

Finished bellows conforming to EJMA B31.1, B31.3 and ASME Sections III, VIII, PED

Welding flanges to bellows to ASME sections III, VIII, IX and PED procedures

Finished metallic bellows expansion joint ready for shipping

Typical Bellows Expansion Joint Applications



Clean Nuclear Power Generation

Clean Combined Cycle Power Generation

Petro-Chemical Processing

Biofuels Processing

Hydro/pyro metallurgical Processing

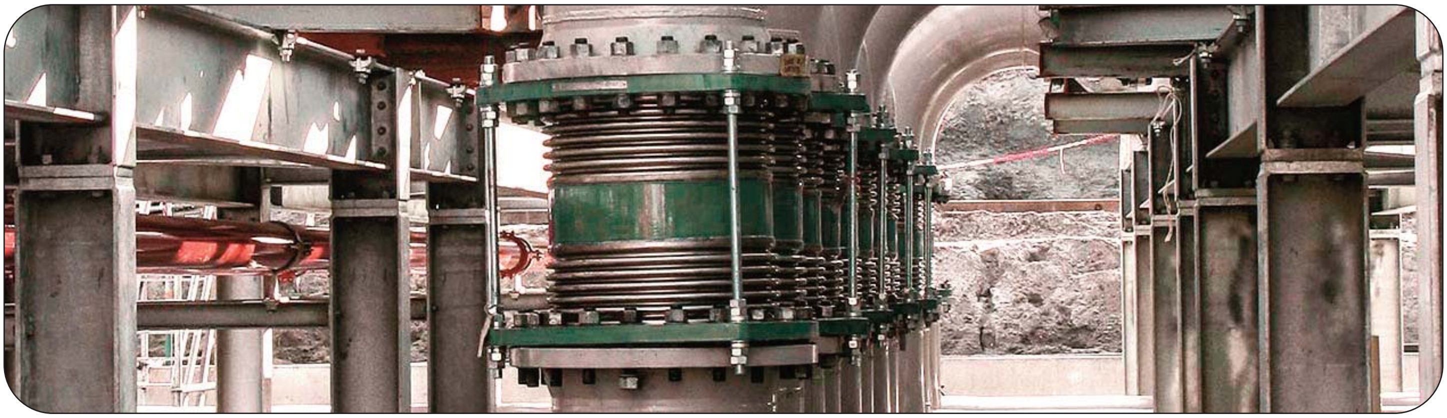
Copper Smelting Acid Plants

Marine & Offshore

Pulp & Paper Processing

Aluminum Processing

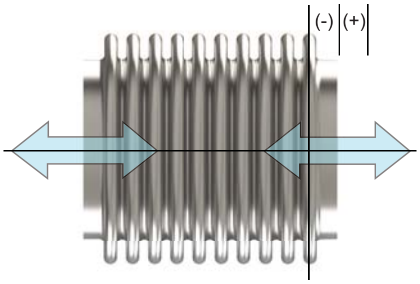
How a Thorburn Metallic Bellows Works



Thorburn's metallic bellows is a flexible seal. The convoluted portion of an expansion joint is designed to flex when thermal or mechanical movements occur in the piping system. The number of convolutions depends upon the amount of movement the bellows must accommodate or the force that must be used to accomplish this deflection. There are four basic movements in a piping system that can be applied to a bellows. These movements are Axial, Lateral, Angular and Torsional. Bellows behave like springs in a piping system and when they are compressed, the bellows resist the movement the same as a spring would.

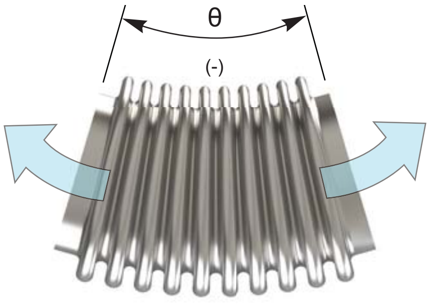
Axial Movement

is the change in dimensional length of the bellows from its free length in a direction parallel to its longitudinal axis. Compression is always expressed as negative (-) and extension as positive (+).



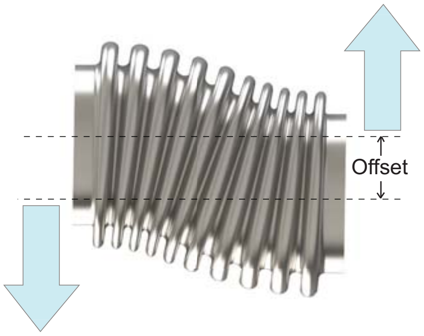
Angular Movement

is the rotational displacement of the longitudinal axis of the bellows toward a point of rotation. The convolutions at the inner most point are in compression (-) while those furthest away are in extension (+).



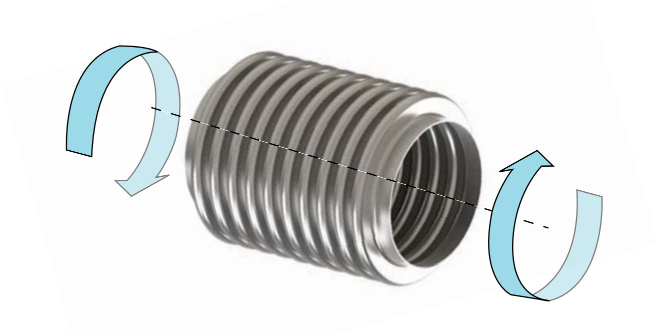
Lateral Movement

is the relative displacement of one end of the bellows to the other end in a direction perpendicular to its longitudinal axis (shear).



Torsional Movement

is the rotation about the axis through the center of a bellows (twisting). Torsional movement destabilizes a bellows reducing its ability to contain pressure and absorb movement. Hinge and gimbal attachments are recommended for this type of movement.

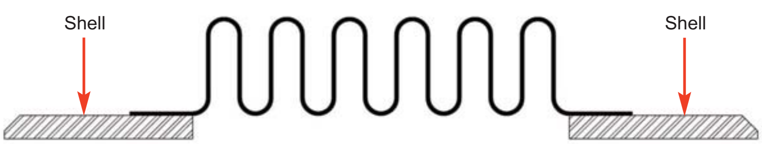


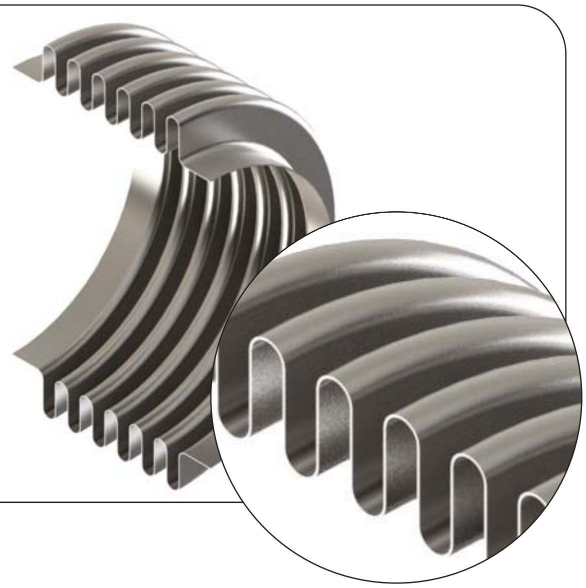
Thorburn Metallic Bellows Convolution Types

Bellows convolutions may be either U-shaped, Omega shaped or toroidal shaped. The U-shaped bellows provides greater deflection but has a lower pressure capacity for the same material thickness. Toroidal bellows is limited to a small deflection but has the highest pressure capacity. The use of external reinforcement of the U-shape can provide a combination of great deflection and higher internal pressure capacity. The pressure capacity of U-shaped bellows can also be increased by the use of multi-ply construction or by increasing the material thickness of the bellows. Thorburn's U-shaped bellows is our most popular bellows profile. The Omega-shaped bellows has limited applications because of its lower pressure capacity than toroidal bellows and smaller deflection capabilities compared to U-shaped bellows.

High Corrugation "U" Type Bellows

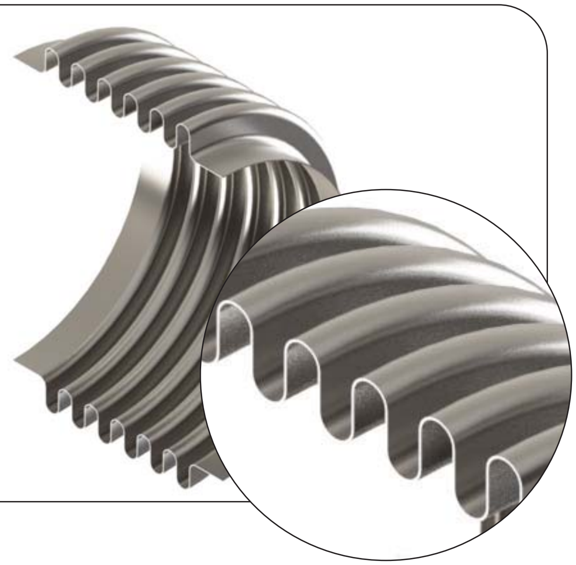
- Excellent flexibility comes from the high convolution and long fatigue life.
- Bellows forming method : Hydro-forming & hydraulic mandrel mechanical forming





Middle Corrugation "U" Type Bellows

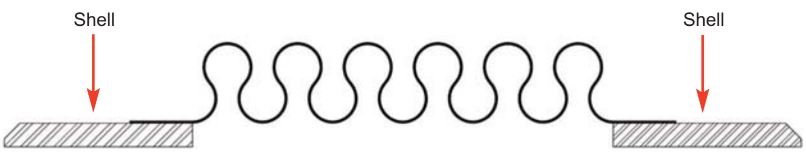
- Less flexible and higher pressures
- Bellows Forming Method : Hydro-forming & hydraulic mandrel mechanical forming

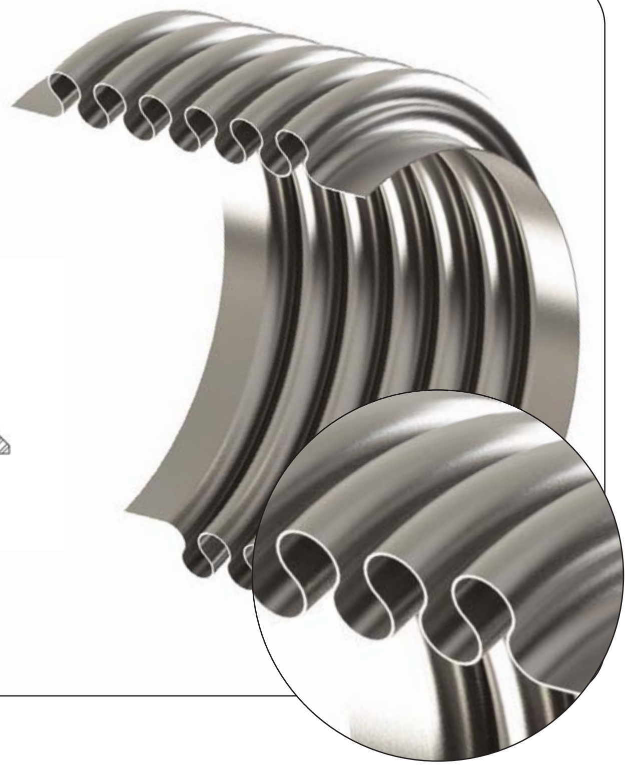


Thorburn Metallic Bellows Convolution Types

Omega Bellows

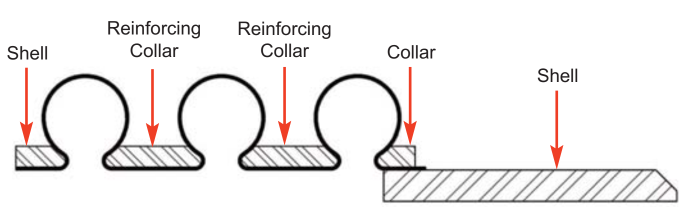
- Omega bellows has low movements and higher pressures for even thickness compared to U-shaped bellows
- Bellows Forming Method: Hydro-forming





Toroidal Bellows

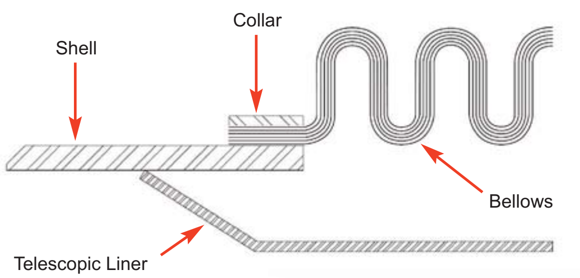
- Toroidal Bellows are mainly designed for the highest pressure applications where there is a need for only small amounts of movement.
- Bellows Forming Method: Hydro-forming



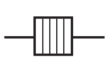
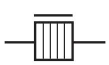
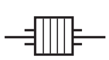
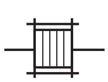
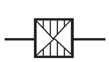
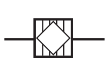
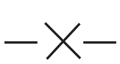
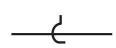
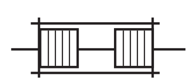
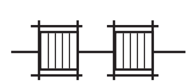
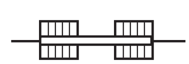
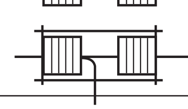
Thorburn Metallic Bellows Convolution Types

Multi-Ply Bellows

- Multi-Ply Bellows can be made up to 6 layers of thin metal layered sheets which provide the flexibility of a thin sheet and the pressure containment of a thick sheet
- Bellows Forming Method : Hydro-forming & Hydraulic mandrel mechanical Forming



Expansion Joint Standard Symbols

-  Single
-  Single externally guided
-  Single internally guided
-  Single with tie rods (T) or limit rods (L)
-  Hinged
-  Gimbal
-  Single with intermediate anchor
-  Single with main anchor
-  Intermediate anchor
-  Main anchor
- Alignment guide
-  1- Roller supports
-  2- Spring hangers
-  Double
-  Universal
-  Universal with individual tie or limit rods
-  Swing
-  Pressure balanced

Thorburn Metallic Bellows Expansion Joint Types

Single Unrestrained Bellows | Single Flex Bellows PG 31-44

Consists of a single bellows element welded to end fittings, normally flange or pipe ends. The single bellows can absorb small amounts of axial, lateral and angular movement with ease. Anchors and guides must be used.

- Thorburn's most economical expansion joint
- Will not absorb pressure thrust forces
- Generally used where axial movement is required and where anchoring is not a problem to install

Thorburn Single Flex™

Tied Single Bellows | Single Flex Bellows PG 31-44

The addition of tie rods to a Single Bellows Assembly adds design flexibility to a piping system. The tie rods are attached to the pipe or flange with lugs that carry the pressure thrust of the system, eliminating the need for main anchors.

- With the assembly tied, the ability to absorb axial growth is lost.
- Lateral and angular movement can only be absorbed with the tied bellows.

Thorburn Single Flex™ Tied

Hinged Bellows | Single Flex Bellows PG 31-44

Movement of a hinged bellows is limited to angulation in one plane. Hinged bellows are used in sets of two or three to absorb large amounts of expansion in high pressure piping systems.

- Angular motion in only one plane
- Positive control over bellows 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
- Maximum bellows cycle life
- To be used in sets of two or three where piping changes direction. The hinge pins absorb internal pressure thrust, permitting the use of light anchors

Thorburn Hinge Flex™

Gimbal Bellows | Single Flex Bellows PG 31-44

Designed to absorb system pressure thrust and torsional twist while allowing angulation in any plane. Gimbal Assemblies, when used in pairs or with a Single Hinged unit, have the advantage of absorbing movements in multi-planer piping systems.

- Angular motion in all planes
- Positive control over bellows movement
- Eliminates pressure thrust forces
- Transmits external loads
- Supports dead weight
- Prevents torsion on bellows
- No main anchors required
- Maximum bellows cycle life
- Used in sets of two or three to absorb motion in any plane

Thorburn Gimbal Flex™ Tied

Thorburn Metallic Bellows Expansion Joint Types

Dual Flex™ Unrestrained Universal Bellows | Dual Flex Bellows PG 45-60

Consists of two bellows connected by a center spool piece with flange or pipe ends. Universal bellows allow greater axial, lateral and angular movements than a single flex bellows. Increasing the center spool length provides increased lateral movement capability. Anchors and guides must be used.

- Used when axial and/or lateral concurrent movement requirements exceed Thorburn's single unrestrained bellows
- Lack of control devices demands careful anchoring and guidance of connecting pipe

Thorburn Dual Flex™ Universal

Dual Flex™ In-Line Unrestrained Bellows | Dual Flex Bellows PG 45-60

Consists of two bellows joined by a common spool which is achored to a support base (intermediate anchor) directly to the structure.

- Use in-line on long pipe runs of straight piping to absorb major axial movement up to 12" (300mm)
- Joint is anchored in the center of the line, therefore two pipe guides must be placed on each side of the Dual Flex in-line expansion joint.

Thorburn Dual Flex™ In-Line

Dual Flex™ Tied Universal Bellows | Dual Flex Bellows PG 45-60

Consists of two bellows connected by a center spool piece with flange or pipe ends. Tie rods absorb pressure thrust and limit movements to lateral deflection (in the case of when only two tie rods are used) and angular deflection. Large angular and lateral deflection are possible by increasing the distance between the two bellows.

- Used in a change in direction of piping to absorb axial expansion in both directions laterally
- Absorbs large amounts of lateral movement in any direction
- Absorbs thermal growth of the piping between tie rod attachments
- Can support dead weight and center spool

Thorburn Dual Flex™ Tied

Extra Flex™ Series EFS & EFD Externally Pressurized Bellows | PG 61-72

Absorbs large amount of axial movement in high pressure steam piping systems. Extra Flex™ can transfer pressure outside of the bellows that eliminates the possibility of pressure imbalance.

Series EFS (Single bellows) up to 200mm movement
Series EFD (Dual bellows) up to 400mm movement

- Sizes 50mm (2") | DN50 to 900mm (36") | DN900
- Long axial movements
- Standard pressures full vacuum up to 300 psi (20 bar) - Higher pressures available
- Self-draining convolutions
- Integral cover and liner
- Leakproof/No packing

Thorburn Extra Flex™

Thorburn Metallic Bellows Expansion Joint Types

Comp Flex™ Series HPC & CTC Externally Pressurized Bellows | PG 73-75

Small diameter multi-convoluted bellows that are fully shrouded. Specifically designed to absorb expansion and dimensional changes in anchored small diameter straight pipe runs.

- Minimizes pressure drop by eliminating multiple bends to absorb pipe motion
- Prevents pipe buckling and pipe expansion noise
- Sizes 12.7mm (1/2”) | DN20 to 100mm (4”) | DN100

Thorburn Comp Flex™

Duct Flex™ Round Ducting Expansion Joints | PG 76-82

Absorbs vibration, thermal movement and misalignment in air handling systems such as precipitators, turbines, condensers and other gas systems.

- Used for low pressure and negative pressure applications
- Deep convolutions allow for large movement and low spring rates

Thorburn Duct Flex™ Round

Duct Flex™ Rectangular Ducting Expansion Joints | PG 83-90

Isolates and absorbs duct motion problems found in scrubbers, precipitators, condensers and other gas or large off-gas systems.

- Used for dust collection and fume extraction ductwork systems
- used in diesel exhaust systems where high temperature and low pressures are in conflict

Thorburn Duct Flex™ Rectangular

High-Core Lens Style Bellows Series AF Expansion Joints | PG 91-94

Characterized by a higher bellows convolution and a thicker ply construction than traditional bellows. Used in acid plant piping systems and fixed tube sheet heat exchangers.

- Bellows are hydro-formed in one piece or fabricated by spinning
- Bellows thickness provide longer protection against corrosive media attack

Thorburn’s Model AFS is made by joining two thick spun "S" shaped halves welded at the belows crest. Up to 24" convolution height
Thorburn’s Model AFU is made by hydro-forming a thick tube into high profile "U" shaped belows with no crest weld. Up to 8" convolution height

Thorburn Hi-Core™ Model AFS Bellows

Thorburn Metallic Bellows Expansion Joint Types

Toroidal Series TB Expansion Joints | PG 95-96

Toroidal bellows are hydraulically formed with very high pressure presses. Designed for use in heat exchangers and very high pressure applications.

- The low convolution hight reduces the pressure thrust on the tubular plates of the heat exchangers
- Circular shaped bellows increases its stability for use in very high pressure applications

Thorburn Toroidal TB™ Bellows

Series IPBU Universal In-Line Pressure Balanced Expansion Joints | PG 97

Balancing bellows with twice the effective area as the line bellows is tied in the expansion joint through a series of tie rods. The opposing pressure forces cancel each other leaving only the low spring reaction forces generated from the bellows deflection.

- Conserves space & eliminates main anchors
- Eliminates pressure thrust

Thorburn In-Line IPBU™ Universal

Series EXIPB™ Externally Pressurized In-Line Pressure Balanced Expansion Joints | PG 98

The opposing force balancing theory is similar to the In-Line Pressure Balanced Assembly except the opposing forces are generated from pressure acting on the outside of the bellows.

Model EXIPBS (Single Bellows) up to 200mm movement
Model EXIPBU (Dual bellows) up to 400mm movement

- Eliminates main anchors
- Eliminates pressure thrust forces
- Self-draining convolutions
- Long axial movements at high pressure
- Integral cover and liner
- Leakproof - Packless

Thorburn Externally Pressurized In-Line EXIPB™

Pressure Balanced Elbow Expansion Joints | PG 99-101

Used in applications where space limitations preclude the use of main anchors. Pressure thrust acting on the line bellows (bellows in the media flow) is equalized by the balancing bellows through a system of tie rods or linkages.

Series PBES (Single bellows)
Series PBEU (Universal bellows)
- Absorbs axial and lateral movements while still restraining pressure thrust forces
- Eliminates main anchors & minimum guiding required

Thorburn Pressure Balanced Elbow PBEU

Thorburn Metallic Bellows Expansion Joint Types

Fluid Catalytic Cracking Unit (FCCU) Expansion Joints | PG 102-104

FCCU is used to convert the high-boiling point, high-molecular weight hydrocarbon fractions of petroleum crude oils into more valuable gasoline, olefinic gases, and other products. Thorburn's FCCU expansion joints requires the addition of refractory lining to protect against gradual deterioration of the expansion joint.

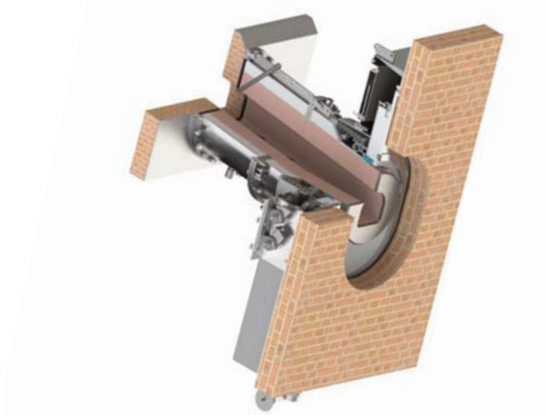
- Withstands abrasive media such as powder catalyst entrained in hydrocarbon flow
- Designed for high temperature, high pressure & high movement applications

Thorburn Series FCCU Expansion Joint

High Temperature Bed Transfer Expansion Joints | PG 105

Installed between the CFB furnace wall and the stripper cooler wall providing high temperature service. Bed Transfer expansion joints are specifically designed with proprietary ash sealing capabilities and refractory lining to protect the bellows and the sliding wall from abrasion caused by abrasive particles suspended in the media in a combustible environment.

- Minimal stripper cooler outlet opening with tertiary sealing system to prevent fly-ash build-up
- Guide ring support self aligning & self sealing
- Large amounts of lateral & axial movement
- Temperature range up to 2100°F (1149°C) in combustion fly ash environments



Thorburn Series BT-CFB™ Bed Transfer Expansion Joint

High Temperature Loop Seal Expansion Joints | PG 106

Used in extremely high temperature CFB boiler applications and are designed to withstand extreme environments. Refractory lining protects the bellows from abrasion caused by the flow of abrasive particles suspended in the media in a combusting environment.

- Refractory lining can reduce the pipe wall temperature to 300-450°F
- Supplied with purge nipples to provide an external positive pressure to enhance sealing
- Protective insulating covers and special thermical packing for extreme fly ash.
- Sliding refractory liner to block accumulation of fly ash into the bellows cavity
- Absorbs large amounts of axial movement
- Available in a "Zero-Gap" Loop Seal design which can absorb large amounts of axial and lateral movement while the liners remain in contact with each other

Thorburn Series LS-CFB™ Loop Seal Expansion Joint

Penetration Seal Bellows | PG 109

Used to allow tubes or pipes to thermally expand and contract without damaging the surrounding shell or pressure casing. Provides good insulation between the boiler wall and the attachment ring.

- Reduces stress in penetration pipe and boiler wall
- Improved boiler efficiency through reduced heat loss

Thorburn Series PSB™ Penetration Seal Bellows

Thorburn Metallic Bellows Expansion Joint Types

Clamshell Retrofit Seal Bellows | PG 110-111

Used when a bellows is leaking or damaged in a pipe line or if a bellows has to be changed with a minimum down time. Performs the same service as standard penetration seals, but consist of two sections of a single bellows that are field welded around the pipe.

- Turnkey removal of old seals and replacement with new seals
- Custom designed bellows to suit application
- Can be built over an existing failed bellows to keep the system running

Thorburn Series CRS™ Retrofit Seal Bellows

Thorburn Series RLB Rubber Lined Metallic Expansion Joints | PG 112-113

Designed to address pipe movement requirements in high pressure applications that exceed the capabilities of Thorburn's 42HPXX Series rubber expansion joints.

- Used in tailing preparation plant piping systems & high pressure piping delivery systems with an abrasive media
- Provides smooth unobstructed flow, resistant to fine & coarse media

Thorburn Rubber Lined RLB™ Bellows

Hot-Flex Series HF PTFE Lined Metallic Expansion Joints | PG 114-115

designed to provide high pressure and temperature transfer containment of highly corrosive media that could not be safely handled by a conventional metallic, elastomeric or molded PTFE expansion joints.

- Protects against start-up & surge forces
- No pigments or additives to the PTFE liner
- Isolates mechanical vibration & reduces system noise

Thorburn Hot Flex™ Expansion Joint

Metallic Braided Flex Connectors| PG 119-121

Designed to provide isolation of the equipment from line stress and permit limited lateral offset which may be created by pipeline agitation or thermal induced movement.

- Absorbs and isolates troublesome pipeline vibrations
- Smooths out force-pump system pulsations
- Tranquillizes jittering compressor pipelines

Thorburn Series PC-96™ Braided Flex Connectors

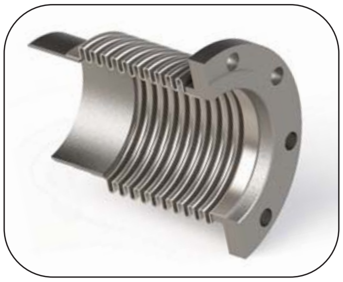
Thorburn Typical Expansion Joint End Connections

Fixed Flange Ends (**FF**)

Vanstone Flange Ends (**VV**)

Weld Ends (**WW**)

Vanstone Flange End / Fixed Flange End (**VF**)



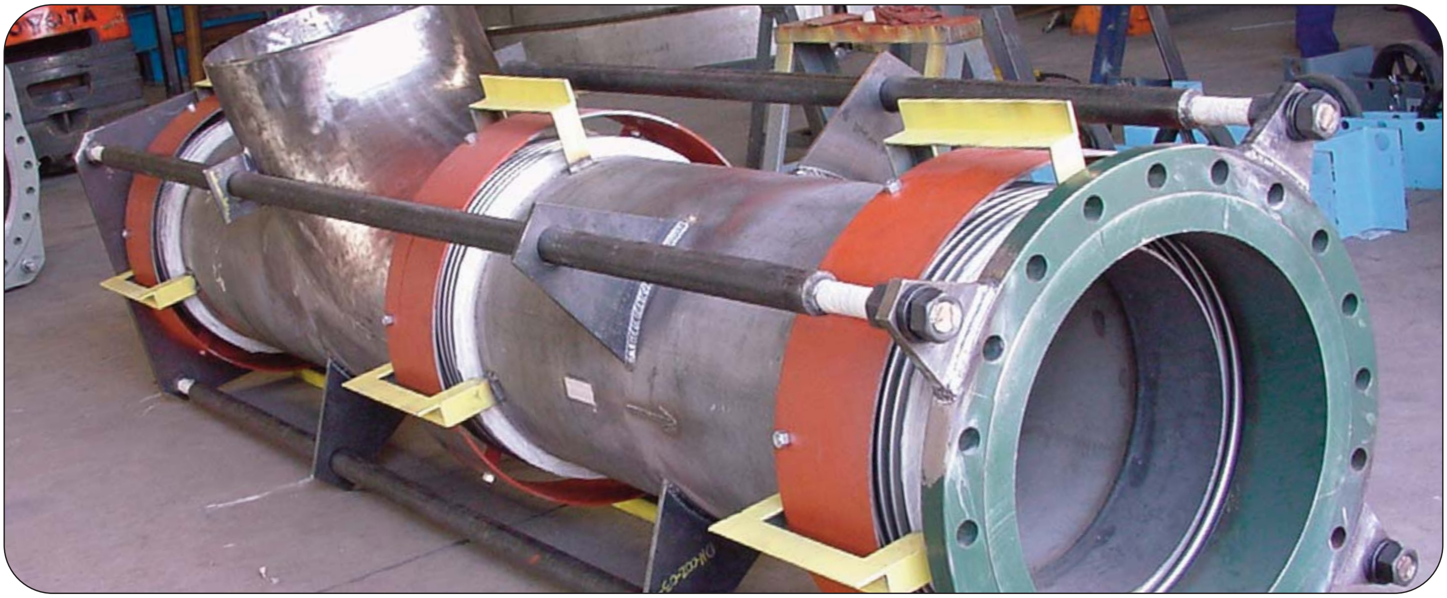
Fixed Flange End / Weld End (**FW**)

Vanstone Flange End / Weld End (**VW**)

Collar Ends (**CC**)

Victaulic Groove Ends (**GG**)

Thorburn's Bellows Expansion Joint Attachments



Thorburn Tie Rod Systems

Ties rods are devices, usually in the form of bars or threaded rods, attached to the expansion joint assembly and are designed to absorb pressure loads and other extraneous forces like dead weight. When used on a Single or Universal Style Expansion Joint, the ability to absorb axial movement is lost.

Single-Tied

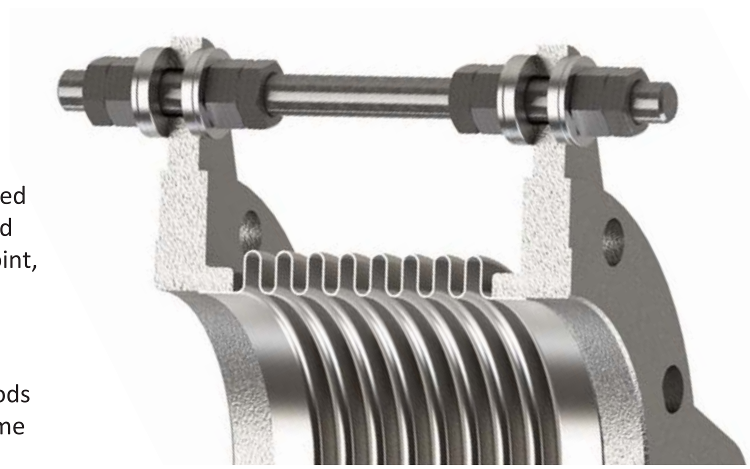
With a single-tied expansion joint, the attachment of the tie rods eliminates axial movement and constantly holds the ends. Some lateral movement is available.

Universal-Tied

For applications that need more lateral movement, universal-tied expansion joints are essential. Each element tilts to accommodate lateral offsets but also creates a low lateral spring rate. Universal-tied expansion joints are ubiquitous throughout many industries.

Benefits of Thorburn Tie Rod Systems

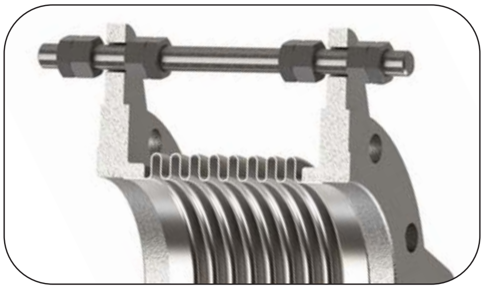
• A straightforward design that contains pressure thrust
• Engineered with a low lateral spring rate and high lateral movement ability
• Highly versatile in all industries
• Has two degrees of movement for single-tied designs
• Has three degrees of movement for universal-tied designs



Thorburn standard tie rod assemblies allow for lateral deflection or angular deflection (in the case of only two tie rods)

Thorburn's installed "In-Place" control rod assembly allows for lateral movement and axial compression movement

Bellows Expansion Joint Attachments



Limit rods

Thorburn Limit Rods

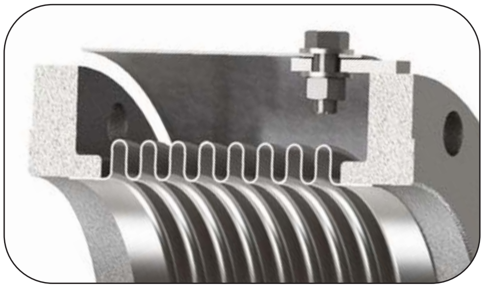
Thorburn's Limit Rods are used to protect the bellows from movements in excess of design that occasionally occurs due to plant malfunction or the failure of an anchor. Limit rods do not contain the pressure thrust during normal operation. Limit rods are designed to prevent bellows over-extension or over-compression and upon request can be designed to restrain the full pressure loading and dynamic forces generated by an anchor failure. During normal operation the rods have no function.

Spherical washers

Thorburn Spherical Washers

Thorburn's Spherical Washers are designed to create an exact, parallel plane between the bolt head and the face of the nut. These washers automatically adjust and compensate for the angular deviation between the planes and prevent the bolt from bending.

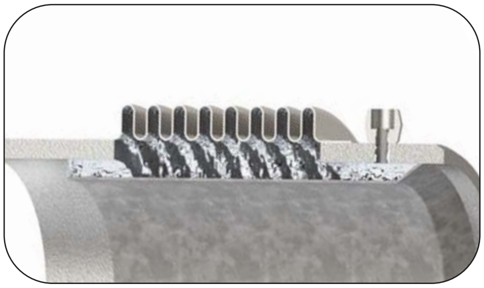
Thorburn Protective Bellows Covers



Weld end expansion joint with liner

Thorburn's Protective Bellows Covers are used to prevent damage during installation and operation or when welding is going to be performed in the immediate vicinity. If the expansion joint is going to be externally insulated, a cover should be considered. Thorburn Flex always recommends covers to protect the bellows on any expansion joint.

Covers can be provided either fixed or removable. Fixed types are used where high velocity external steam conditions exist such as in condenser heater connections. The removable type cover permits periodic in service inspection.

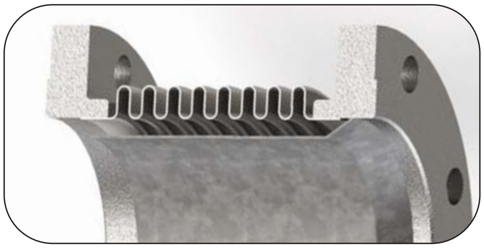


Air Or Steam Purge Under Bellows

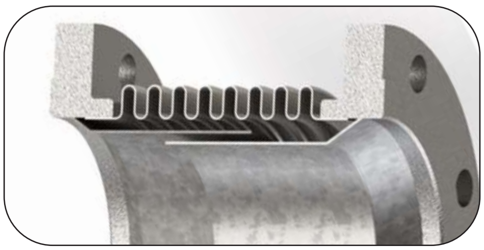
Thorburn Purge Connectors

Thorburn's Purge Connectors are used in conjunction with internal liners to lower the skin temperature of the bellows in high temperature applications such as catalytic cracker bellows. The purge media can be air or steam which helps flush out particulate matter between bellows and the liner. This also prevents the build up of harmful solids in the convolutions that may stop the bellows from performing.

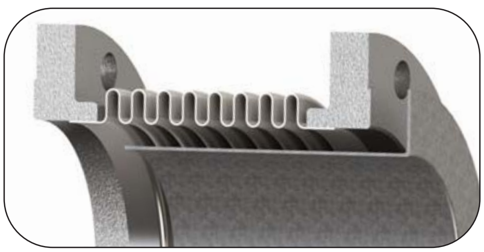
Bellows Expansion Joint Attachments



Flanged end expansion joint with liner



Flanged end expansion joint with telescopic liner



Drop in flow liner

Thorburn Liners - Internal Sleeves

Liner (Internal Sleeves) are used when any of the following conditions exist:

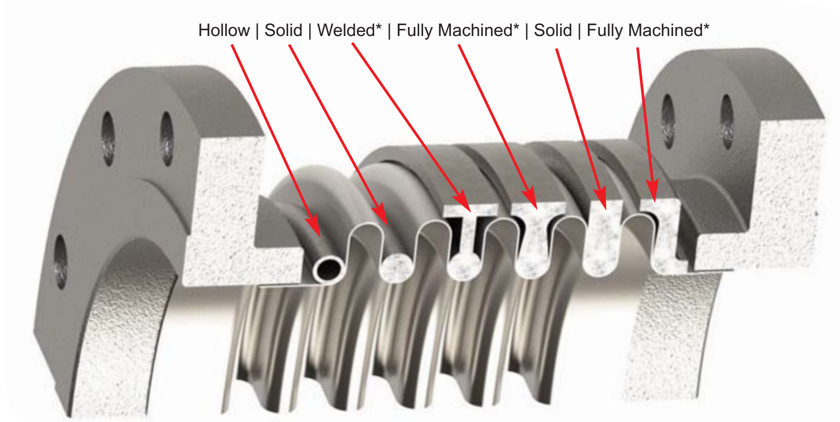
- When pressure drop must be minimized and smooth flow is essential.
- When turbulent flow is generated upstream of the expansion joint by changes in flow direction.
- When it is necessary to protect the bellows from media carrying abrasive materials such as catalyst or slurry.
- In high temperature applications to reduce the temperature of the bellows. The liner permits the anchoring of insulation which provides a thermal barrier between the media and the bellows.
- Where an internal sleeve is not provided the allowable flow velocities shall not be greater than: 25 ft/sec (7.6 m/sec) for liquids
  65 ft/sec (19.8 m/sec) for gases.
- Drain holes should be provided for vertical installations where liquid could become trapped inside the sleeve.
- The internal sleeve material should normally be the same as the bellows material. Other materials may be used provided they are suitable for the application.

Drop-In flow Liners

Sometimes called a top-hat liner, a drop-in flow liner can be removed and replaced when worn thus extending the life of the expansion joint. This type of liner can also be furnished in a telescoping configuration. Gaskets are required on both sides of liner face to effect a seal.

Thorburn Reinforcing Rings

As an expansion joint's design pressure, diameter and temperature increase, convolutions often require reinforcement to contain the hoop stress in the thin-walled bellows. These reinforcing members are known as reinforcing rings (or root rings). Reinforcing rings come in many forms and materials depending on the design conditions. The figure below shows several styles of Thorburn custom reinforcing rings.



** supports the convolution OD with its "T" or "L" shaped over the convolution crest*

Pipe Anchors

Thorburn's bellows expansion joints are sections of flexible pipe that are specifically designed to absorb piping movement. Correct alignment of the adjoining pipe is of vital importance in the proper functioning of Thorburn's expansion joint system.

Although Thorburn expansion joints are designed and built for long and satisfactory life, maximum service will be obtained only when the pipeline has the recommended number of guides and is anchored and supported in accordance with good engineering piping practice.

Pipe Anchors

Pipe anchors divide pipelines into individually expanding sections. The pipe anchors must be designed to withstand all the forces and movements imposed upon them. One Thorburn expansion joint system must be designed to provide adequate flexibility between the anchors of the pipe sections. **Warning:** Do not install more than one single Thorburn expansion joint between the same two anchors in any straight pipe section.

Main Anchors

A main pipe anchor must absorb the full line force due to internal pressure thrust, spring force to deflect Thorburn's bellows expansion joint, friction of pipe moving and the weight of piping acting on the anchor.

Main anchors must be installed:
a) at a change in direction of flow
b) between two Thorburn expansion joints of different sizes
c) at a side branch line containing a Thorburn expansion joint
d) where shut-off valve or pressure relief valve is installed in a pipe run between two Thorburn expansion joints
e) blind end of a pipe

Main Anchor

Intermediate Anchors

Intermediate anchors must be designed to withstand forces and movements imposed upon them which include:
a) the force to deflect bellows
b) friction force of the piping due to guides and supports

Special note: The intermediate anchor is not intended to absorb pressure thrust as it is normally an anchor between a Thorburn Dual Flex bellows where the pressure thrust forces are balanced.

Intermediate Anchor

Directional Anchors

Directional anchors permit movement in one direction only. Similar to a Planar Guide, the movement is often parallel to the direction of the lateral movement in installations where combinations of axial and lateral movements are present in a piping system to direct a pipe's movement away from buildings, structures, or pieces of equipment.

Spring Loaded Directional Anchors

Pipe Supports and Pipe Guides

Pipe Supports

Pipe Alignment Guide

Planar Guide

Pipe Supports

A pipe support permits free movement of the piping and supports only the weight of pipe and fluid. Pipe rings, U-bolts, spring hangers and rollers are examples of pipe supports but cannot be classified as pipe guides. Proper support of the pipeline is required not only for live and dead loads imposed on the pipe but also provides support for Thorburn's expansion joints at each of its attachments on the pipeline.

Pipe Guides And Guiding

Pipe guides are necessary to ensure proper application of movement to Thorburn's expansion joint and to prevent buckling of the line. Buckling may be caused by a combination of two things:

a) Wrong information provided resulting in inadequate flexibility of Thorburn's expansion joint
b) Internal pressure loads on the pipe which causes it to act like a column loaded by the pressure thrust of Thorburn's expansion joint.

Pipe Alignment Guide

Pipe alignment guides are primarily designed for applications involving only axial extension and compression and have a sleeve or other framework rigidly mounted to positively restrict pipeline movement to compression and extension only. The first two alignment guides immediately adjacent to each side of Thorburn's expansion joints are circumferential to the pipe. As in the case with pipe anchors, alignment guides can be subjected to lateral forces as high as 15% of the total axial force.

Planar Guide

Planar guides are used to restrict movement in one plane and permit movement in another plane. Such restraint is a necessary for stability of most single and universal tied joints when subject to internal pressure.

Pipe Guide Design

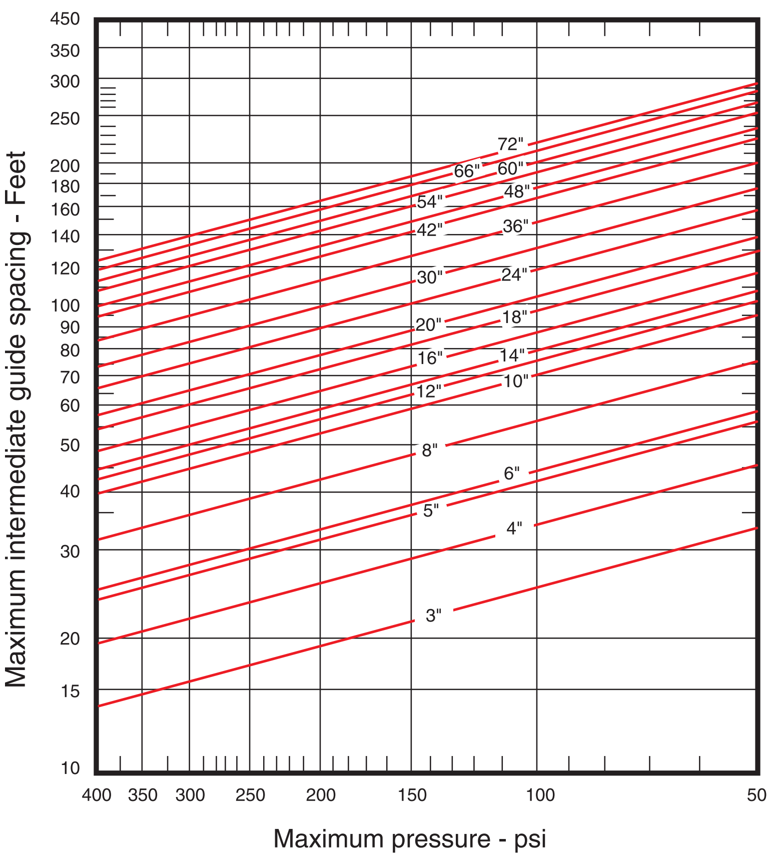
Proper design of both pipe alignment guides and planar pipe guides should allow sufficient clearance between the fixed and moving parts of the alignment guide to insure proper guiding without introducing excessive frictional forces.

Materials from which pipe alignment guides and planar pipe guides are made must provide strength and rigidity under design operating conditions and be sufficiently resistant to corrosion and wear to prevent eventual malfunction of the guide.

The first two alignment guides immediately adjacent to each side of Thorburn's expansion joint should be circumferential to the pipe. Planar pipe guides must be designed with additional clearance in one direction to permit the intended lateral deflection and/or bending of the pipe to take place.

As in the case of pipe anchors, alignment guides can be subjected to lateral forces as high as 15% of the total axial force, and the system designer must assure himself that the guide, guide attachment and the structure to which it is attached are all designed to conservative stress levels. The design of the total guiding system must assure that no relative shifting of alignment guides and Thorburn expansion joint will occur from ground settlement or other environmental conditions.

Pipe Guide Spacing Table



Thorburn recommends that for its single bellows expansion joints the first guide be located within four (4) pipe diameters from the expansion joint and the second guide be located within a distance of fourteen (14) pipe diameters from the first guide. The remaining guides are to be in accordance with the table on the right.

Maximum intermediate guide spacing for any pipe material or thickness may be calculated using the following formula:

$$L = 0.131\sqrt{\frac{EI}{PA \pm \Delta Ra}}$$

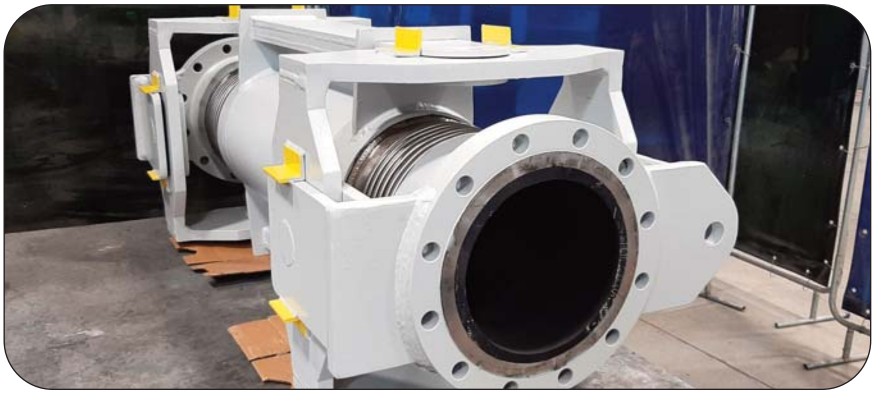
Where L = Maximum intermediate guide spacing (ft)
E = Modulus of elasticity of pipe material (psi)
I = Moment of inertia of pipe (in^4)
P = Design pressure (psi)
A = Bellows effective area (in^2)
Δ = Axial stroke of expansion joint (in.)
R_a = Axial spring rate of bellows (lbs/in)

Notes:

1: When bellows is compressed in operation, use (+) ΔRa; When extended, use (-) ΔR_a

2: Dead weight of the pipe should also be considered for guide spacing

Thorburn Expansion Joints In Piping Systems



In selecting the proper Thorburn metal expansion joint to satisfy system requirements, it is essential that all the operating parameters be fully considered. The following section is presented as a guide for the piping system designer in evaluating the most significant operating requirements and how to apply them in selecting Thorburn metallic bellows expansion joints.

Typical Forces In Piping Systems

The following formulas are presented so that the significant forces created in piping sections containing Thorburn metallic expansion joints can be calculated and evaluated.

STRAIGHT PIPE SECTIONS (See Fig. 1)
$F_{MA\,1} = F_P + F_{EJ} + F_F)$

STRAIGHT PIPE SECTION WITH REDUCER (See Fig. 2)
$F_{MA\,1} = (F_{PX} - F_{PY}) + (F_{EJX} - F_{EJY}) + (F_{FX} - F_{FY})$

CURVED PIPE SECTION (See Fig. 3)
In the case of anchors located at pipe bends or elbows, it is necessary to consider the forces imposed by the pipe sections on both sides of the anchor. These forces must be added vectorially. In addition, the effect of centrifugal force due to flow must be considered as follows:

$$F_{MA\,(FLOW)} = \frac{2A\rho V^2}{g} \sin \frac{\theta}{2}$$

FORCES ON INTERMEDIATE PIPE ANCHORS (See Fig. 4)
An intermediate anchor is designed to absorb forces due to expansion joint deflection and friction only. It is generally considered good practice to design the immediate anchor to resist the forces on the larger force side.

$F_{IA} = F_{EJ} = F_F$

LATERAL DEFLECTION (See Fig. 5 and 6)
For lateral deflection requirements it is necessary to consider, in addition to the other applicable forces, the lateral force and bending moment imposed on connecting pipe and/or equipment.

ROTATIONAL DEFLECTION (see Fig. 7)
For rotational deflection requirements it is necessary to consider, in addition to the other applicable forces, the bending moment imposed on the connecting pipe and/or equipment.

DEFINITIONS OF ACRONYMS

F_{MA}	=	force on main anchor (lbs)
F_{IA}	=	force on intermediate anchor (lbs)
F_P	=	force due to pressure (lbs) (bellows effective area x maximum pressure)
F_{EJ}	=	force due to expansion joint deflection (lbs) (axial spring rate x deflection)
F_F	=	force due to support and guide friction (lbs) (data available on request)
A	=	bellows effective area (in2)
ρ	=	density of flowing media (lbs/in3)
V	=	velocity of flowing media (in/sec)
g	=	acceleration due to gravity (386 in/sec2)
θ	=	angle of pipe curve (degrees)

Note: Deflection forces, bending moments and effective areas are listed in the Expansion Joint Selection Chart (based on ANSI 321 stainless steel at 343°C (650°F)).

Thorburn Expansion Joints In Piping Systems

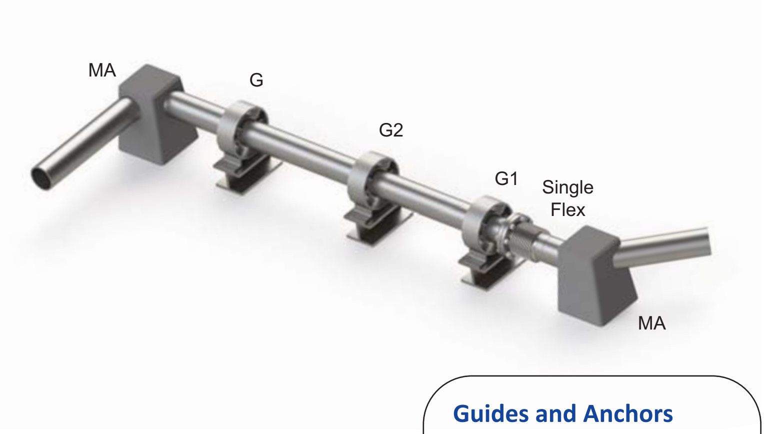
Thorburn Single Flex Unrestrained Installations

Figures 1 through 4 show typical applications of expansion joints to absorb axial pipeline expansion. Note the relative positions of the expansion joints, anchors and guides to achieve proper control of operating conditions.

Figure 1

Illustrates the most basic application for Thorburn's Single Flex Series SF expansion joints.

- One Thorburn Single Flex between two main anchors (MA). The location should be as close as possible to the main anchor.
- Main anchors are used where piping systems have a change in direction.
- Space first pipe alignment guide (G) within four times the pipe diameters of the expansion joint.
- The remaining guides should be spaced at fourteen times the pipe diameter from the first guide.

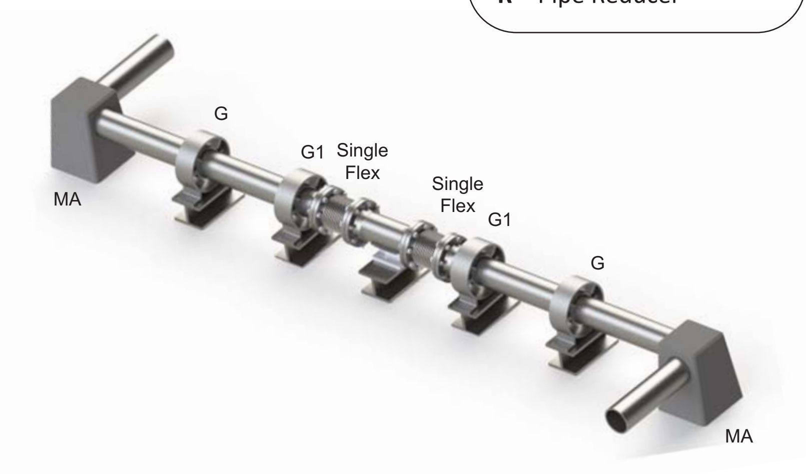


Guides and Anchors
MA = Main Anchor
G = Pipe Alignment Guide
PG = Planar Guide
IA = Intermediate Anchor
R = Pipe Reducer

Figure 2

Illustrates when the thermal movement between two main anchors exceeds the capacity of a Thorburn Single Flex expansion joint.

- The pipe system is divided an intermediate anchor (IA).
- The IA is located between two Thorburn Single Flex bellows.
- Intermediate anchors are not main anchors and are designed to only withstand the spring rates or reaction forces of Thorburn's Single Flex expansion joint.
- Pressure Thrust is cancelled out at the IA juncture because the bellows effective areas are equal.
- Pipe alignment guides are spaced according to guides established in Figure 1

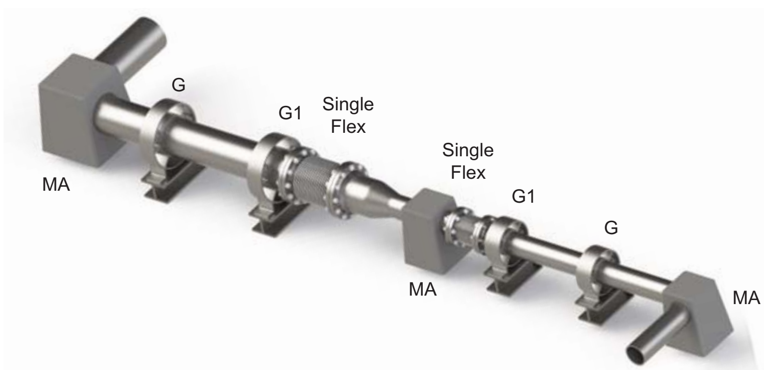


Thorburn Expansion Joints In Piping Systems

Figure 3

Illustrates a piping system with two different pipe diameters joined by a reducer.

- The pressure thrusts are not equal. In this case, the anchor dividing Thorburn's expansion joint must be a main anchor.
- The inline main anchor must be able to withstand the full pressure thrust forces generated by the different sized expansion joints.
- Pipe alignment guides (G1), intermediate guide (G2) and pipe guide must follow proper piping practices illustrated in the illustration and noted in figure 1.

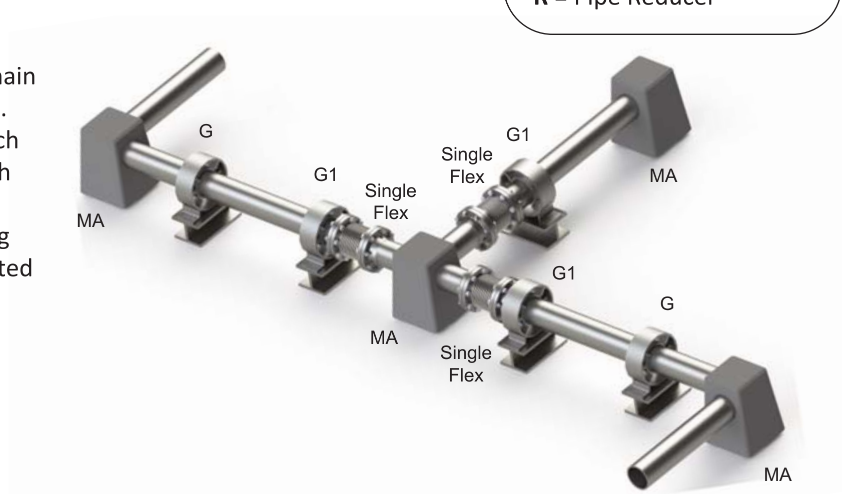


Guides and Anchors
MA = Main Anchor
G = Pipe Alignment Guide
PG = Planar Guide
IA = Intermediate Anchor
R = Pipe Reducer

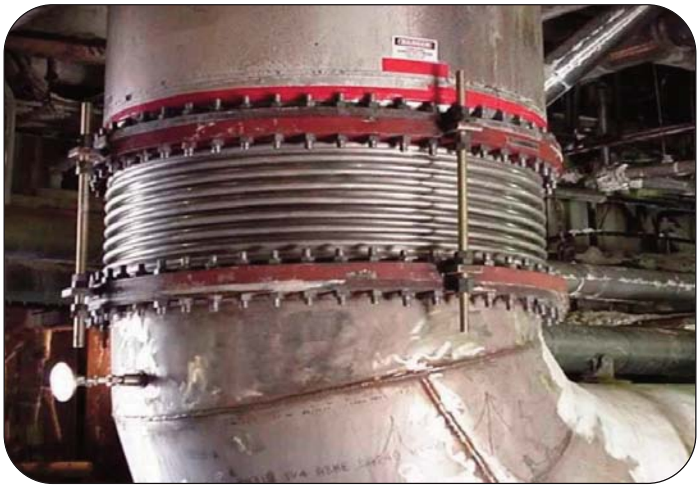
Figure 4

Illustrates when three pipe systems intersect.

- The "T" section in the piping intersection must be a main anchor (MA) and absorb all the pressure thrust forces.
- Thorburn's Single flex expansion joint is located in each pipe run and is designed to absorb the thermal growth of each pipe section.
- Pipe alignment guides, intermediate guides and piping guides should follow proper piping practice as illustrated and noted in Figure 1.



Thorburn Expansion Joints In Piping Systems



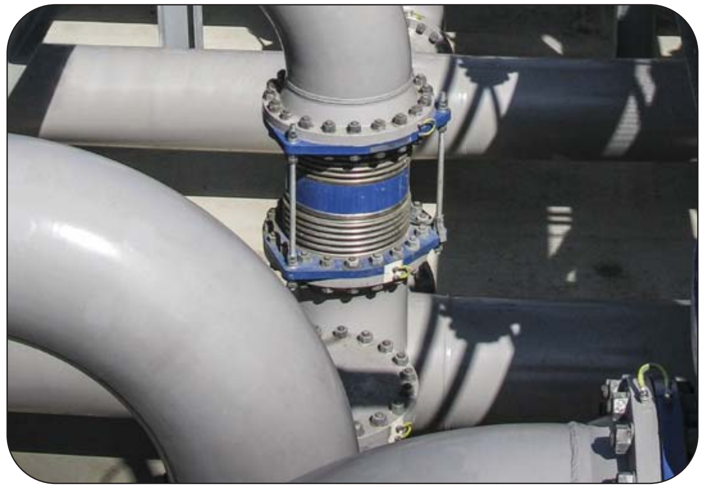


Figure 5

Thorburn Tied Single flex expansion joints are used to protect rotating equipment from thermal effects of the piping system.

- The tie rods can absorb the full pressure thrust which allow for intermediate anchors to be used rather than main anchors.
- A planar pipe guide or spring support hanger is used to allow the thermal growth in the vertical leg to be absorbed by the long horizontal pipe run.

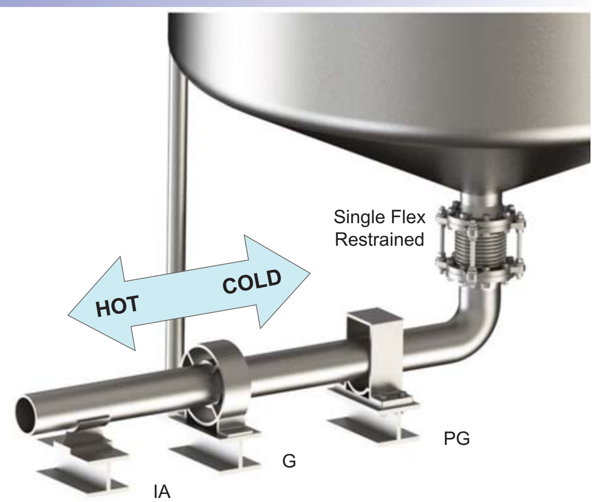
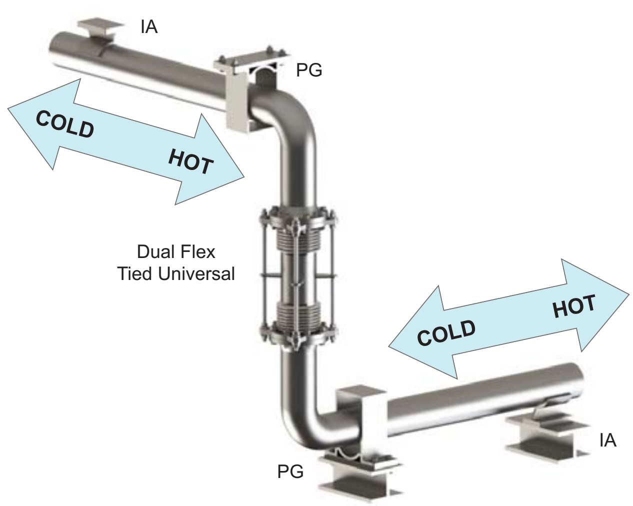


Figure 6

There are many applications where thermal movement in the piping system is too great for a Thorburn Tied Single assembly. In these cases, a Thorburn tied universal expansion joint is the necessary choice.

- Thorburn expansion joint assembly should be designed to fill the offset leg as shown so that axial movement within this pipe leg is absorbed by the bellows assembly.
- It is good practice to keep the maximum distance possible between the bellows. This results in low offset forces on adjacent equipment and structures.
- The center spool is usually supported by the tie rods or spring hangers when center spools are long and diameters large.



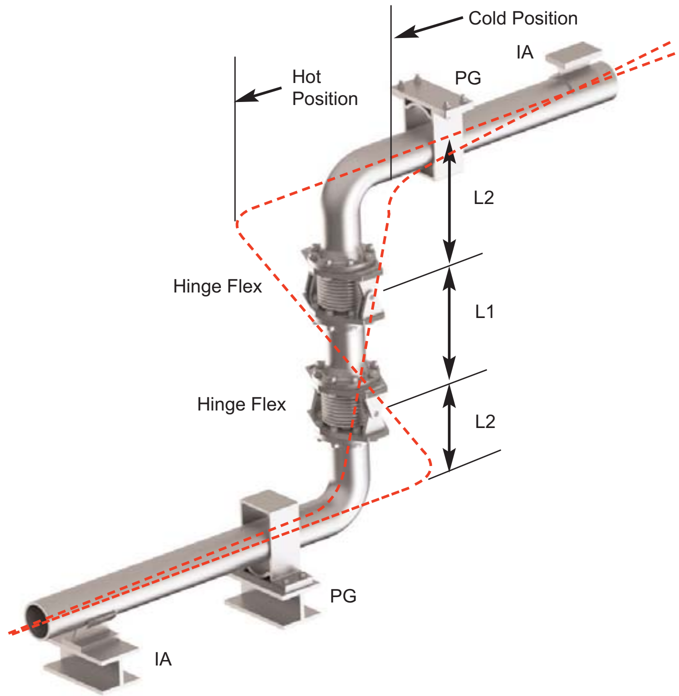
Thorburn Expansion Joints In Piping Systems

Figure 7

Hinged Bellows Assemblies

Thorburn Hinge Flex expansion joints are designed to absorb movement angularly in one plane only. When two Thorburn Hinge Flex expansion joints are installed in a “Z” piping configuration, they can absorb large amounts of horizontal leg movement in a piping system. To maximize movement capability, Thorburn Hinge Flex expansion joints should be preset in the opposite position to the required movement.

- Pressure thrust is contained by the hinge restraint
- Planar pipe guides should permit the offset to move through its movement arc.
- The distance “L” should be maximum distance where “L2” is a minimum distance



Guides and Anchors
MA = Main Anchor
G = Pipe Alignment Guide
PG = Planar Guide
IA = Intermediate Anchor
R = Pipe Reducer

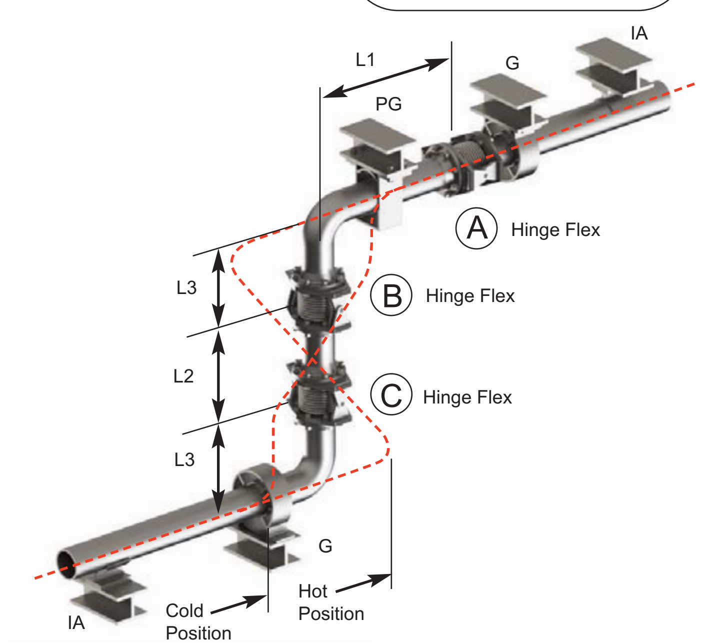
Figure 8

Rotational Deflection Applications

Illustrates a typical arrangement in which Thorburn's hinged expansion joints are installed in a "Z" type plane so that the pipeline expansion is absorbed in both horizontal and vertical legs. Note that the thrust absorbing hinges eliminate the need for main anchors and that Thorburn's expansion joint "B" must be capable of absorbing the sum of the rotation of expansion joints "A" and "C".

The location of the expansion joint should be as follows...

- “L” and “L2” distance should be maximum and “L3” minimum.
- Thorburn hinge restraints are designed to absorb the pressure thrust forces and weight of the pipe between the two hinge units.
- Equipment connections are reduced to friction forces allowing for intermediate anchors (IA)
- Adequate guiding is necessary to maintain single plane deflection.



Thorburn Expansion Joints In Piping Systems

Figure 9

U-Bend Piping System Applications

In a long piping system, the number of expansion joints can be reduced by incorporating four Thorburn Hinged assemblies in a "U" bend system as shown. Pressure drop in the system is kept to a minimum, and pipe supports reduced in number when compared to a system using pipe loops. An intermediate anchor at the "U" bend Divides the system in two equal expanding pipe sections. Cold springing is used to increase the movement capability of the Thorburn expansion joints.

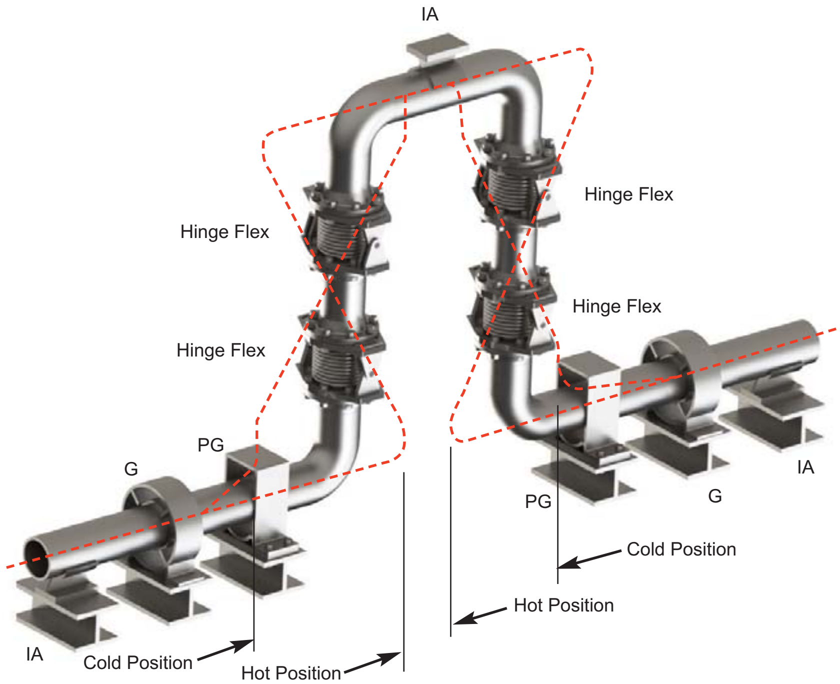
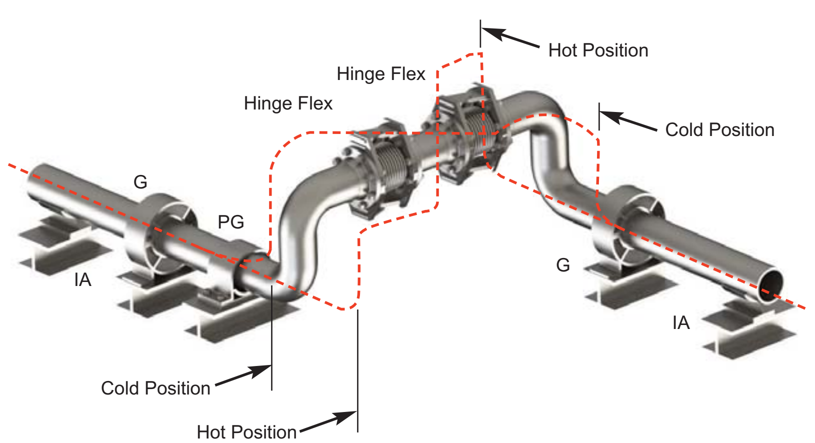


Figure 10

Bridge & Trellis Piping System Applications

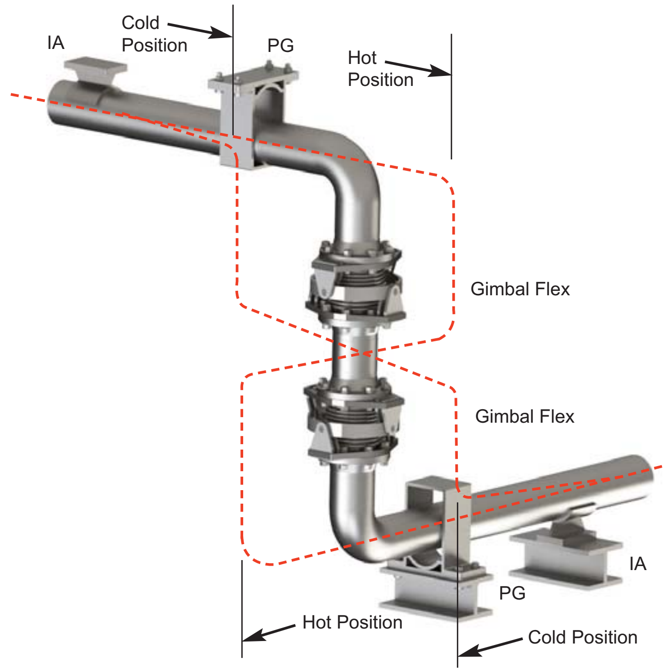
The Thorburn Two-Hinged Bellows assembly system shown is often used where a pipeline crosses a roadway or rail line that is supported by a pipe bridge or trellis. Thorburn's hinge restraint is designed to support the center spool between Thorburn's expansion joints in addition to the pressure thrust generated by the system pressure. Thorburn's Hinged Assemblies can be cold sprung, which further increases the overall movement capability of Thorburn's expansion joints. Offset forces are usually low, hence loads on the bridge structure are kept to a minimum.



Thorburn Expansion Joints In Piping Systems

Figure 11

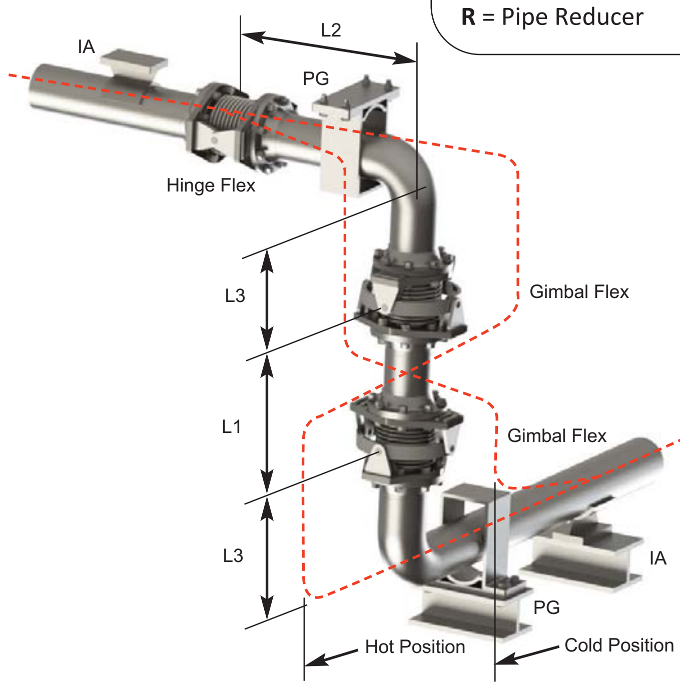
In a multi-planer piping system the use of two Thorburn Gimbal Bellows assemblies in a multi-plane "Z" bend is the best solution. Thorburn gimbal restraint allows thermal expansion in two planes as shown, while still absorbing the pressure thrust. The thermal expansion in the offset leg is taken by the flexibility in the long horizontal pipe runs. The planer pipe guides shown control the direction of this vertical movement. Intermediate anchors are used to contain the resultant low offset forces.



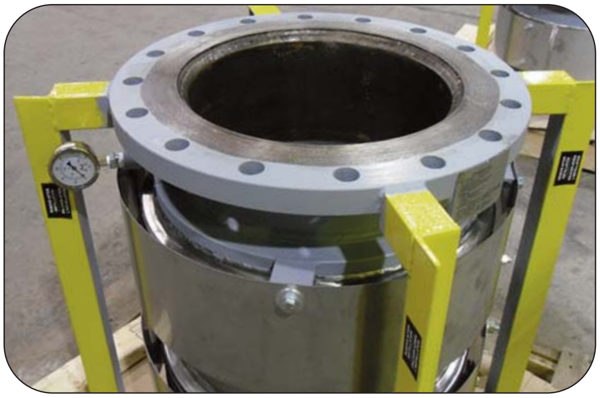
Guides and Anchors
MA = Main Anchor
G = Pipe Alignment Guide
PG = Planar Guide
IA = Intermediate Anchor
R = Pipe Reducer

Figure 12

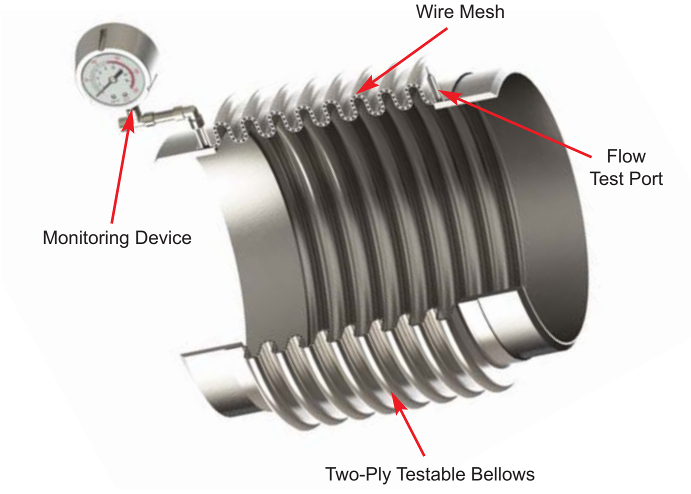
There are many applications in a multiplaner piping system where the horizontal pipe leg is not flexible enough to absorb the thermal expansion in the offset leg. To accommodate this movement, a Thorburn Single Hinged Bellows assembly is used in conjunction with the two Thorburn Gimbal Bellows Assemblies in the locations shown. It is good practice to make (L1) and (L2) the maximum possible with (L3) a minimum. A regular pipe guide must be used on the lower pipe leg, while a planer pipe guide is used on the upper leg.



Thorburn Single Flex™ Bellows Series SF



Thorburn Single Flex™ expansion joints with cover installed and a bellows monitoring device attached



Thorburn's Single Flex™ metallic bellows are specifically designed for piping applications requiring limited absorption of axial and lateral movements. Where small thermal movements are involved and proper anchoring and guiding is feasible, Thorburn's Single-Flex™ expansion joint system provides the most economical installation. Single Flex™ is the base member of Thorburn metal expansion joint family, consisting of a bellows element and end fittings.

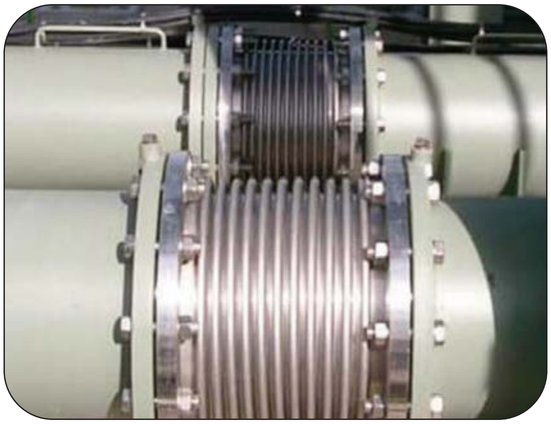
Thorburn Multi Ply Belows

Multi-ply bellows in themselves allow the bellows designer to design for higher movements combined with high pressure and still achieve good cycle life. In laymen's terms the thicker the bellows wall thickness the lower the cycle life for a given movement. By using two plies of a thinner material the cycle life will increase for the same movement without a dramatic drop in pressure capability. A simple two ply bellows is designed to use the strength of both plies to ensure pressure capability. Redundant ply bellows are designed so that each ply is strong enough to withstand the operating conditions even after one ply fails. These types of multi-ply designs are usually monitored to alert the user when one ply fails.

Thorburn Normal Two-Ply Monitoring

Monitoring a normal two-ply design still offers great advantages for the operator. A very small leak through the inner ply will normally not cause a catastrophic failure. The indicator will show the leak and the unit can be shut down for repairs without a total failure of the unit.

Thorburn Single Flex™ Bellows Series SF



Thorburn Single Flex™ expansion joints installed in a piping system

Applications

Thorburn's Single Flex™ is the most simple expansion joint available and comes with one bellows section and end connections. Single Flex™ expansion joints require the most control of the adjacent piping in regards to anchors and guiding. It is usually applied in applications of either straight axial extension or axial compression; however, a combination of axial, with limited amounts of lateral and angular rotation can be accommodated.

Thorburn's Single Flex™ should be placed near one anchor and guides should be used to assume proper alignment and movement control. Each anchor must be designed to restrain the full pressure thrust of the expansion joint.

Thorburn Single Flex™ tied expansion joint

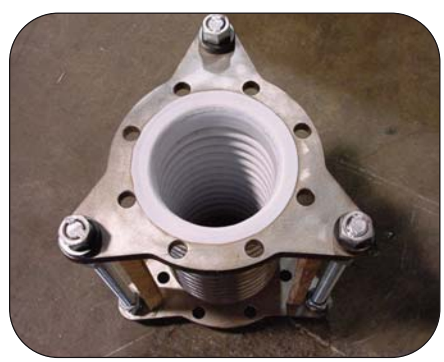
Thorburn Single Flex™ Tied Expansion Joints

Thorburn's Single Flex™ tied expansion joints are identical to Thorburn's single unrestrained expansion joints except that it is supported with tie rods. When tie rods are added to the expansion joint, it constrains the bellows, eliminating overextension. The tie rods contain all the pressure thrust from the bellows, preventing it from being applied to the pipe and anchors. This allows for the bellows to be used without thrust bearing anchors at each end of the pipeline. Stops are set to allow axial movement for their intended design and motion. Where lateral deflection is imposed upon the expansion joint, some shortening of the expansion joint results from the displacement of the tie rods. The amount of the deflection can be minimized by cold springing the expansion joint in the lateral direction. The allowable lateral deflection is directly proportional to the ratio of convoluted length to diameter that, in turn, is restricted by considerations of stability and manufacturing limitations.

Thorburn Single Flex™ Bellows Series SF - Applications

Single Flex™ bellows with control rods installed on a pumping station

Single Flex™ bellows with control rods installed on an exhaust piping system



PTFE lined Single Flex™ Series HF bellows used for corrosive media

Thorburn Single Flex™ Series SFH Hinge Style Bellows

Thorburn Single Flex™ Hinge Type expansion joint with bellows reinforcing rings installed

Thorburn Single Flex™ Hinge Type expansion joints are designed for absorption of thermal expansion and wind loads.

Thorburn's Single-Flex™ hinge type expansion joints are designed to absorb angular rotation in one plane only by the use of a pair of pins through hinge plates attached to the expansion bellows. They are typically used in sets of two or three, to absorb pipe movement in one or more directions in a single plane piping system. Each individual joint in the system is restricted to pure angular rotation by its hinges. However, each pair of hinged joints, separated by a section of piping, will act together to absorb lateral deflection in much the same manner as Thorburn's Dual-Flex universal expansion joint in a single plane application.

Thorburn's Single-Flex™ hinges are designed to restrain the full pressure thrust of the expansion joint and may be designed to support the weight of piping and equipment, absorb thermal loads, wind loads and other external forces. Thorburn Hinge-Flex system permits large movements to be absorbed with minimal anchor forces.

Features

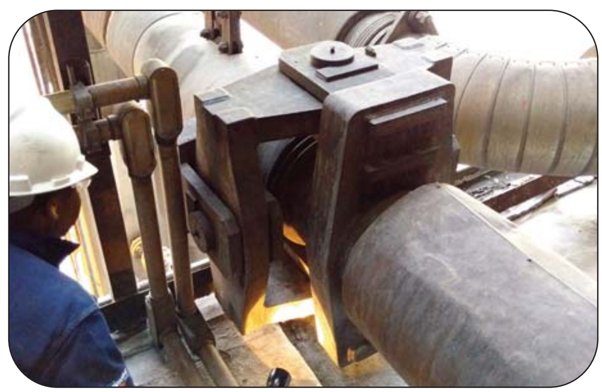
- Angular motion in one plane only
- Positive control over movement
- Eliminates pressure thrust forces
- Transmits external loads
- Supports dead weight
- Prevents torsion on bellows
- No main anchors required
- Minimum guiding required
- Low forces on piping system

Thorburn Single Flex™ Series SFG Gimbal Style Bellows

Thorburn's Single-Flex™ gimbal type is the most reliable expansion joint. It is capable of absorbing angular motion in all planes. The construction of a gimbal type expansion joint incorporates a pair of hinges connected to a common floating gimbal ring. This type of construction provides for close control of the movement imposed upon the bellows and at the same time can support the dead weight of the system.

Wind loading and shear loads are also transmitted through the gimbal structure. Other advantages include low forces and elimination of pressure thrust on adjacent equipment. Thorburn's gimbal type expansion joints are either used in pairs or in combination with a Thorburn hinge type expansion joint to absorb complex multi-plane motion in a piping system.

Final assembly of a Thorburn Single Flex™ Series GF large diameter, Ultra High Pressure (300mm10,000 Kpa Design / 15,000 Kpa), expansion joint ready for crating and shipping



Thorburn Single Flex™ Series GF gimbal type expansion joint installed in a high pressure steam piping system

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 anchor required
- Minimum guiding required
- Low forces on piping system

Thorburn Single Flex™ Series SF Bellows - Styles

Unrestrained

Code "U"

Hinge

Code "H"

Gimbal

Code "G"

Tied Single

Code "T"

Intermediate Anchor

Code "I"

Thorburn Single Flex™ Series SF Bellows - End Connectors

Weld End

Code "WW"

Flange

Code "FF"

Van Stone Flange

Code "VV"

Van Stone/Weld

Code "VW"

Flange/Weld

Code "FW"

Collar Bellows

Code "CC"

Victaulic Grooved

Code "GG"

Van Stone/Flange

Code "VF"

How To Order Thorburn Single Flex™ Series SF Bellows

Nominal Size	Model	Style	Series or Cons	Plies (#)	Ends	Pressure (PSI)	Bellows Material	Ends Material	Liner Material	Cover Material	Resraint & Anchor Material	O.A.L (in)	Option
24	SF	T	L	2P	FF1	300	B5	E1	L5	C0	T0	22	HF
24" I.D.	Single Flex	Tie Rod	Long Series	2 Plies	Flange	300 psi	321SS	304SS	321SS	Carbon Steel		22"	Hot Flex
DN600					ANSI B16.5	21 bar						559mm	

Thorburn Material Code					ASTM/ASME(S) Material Designation	Material Type
Bellows (B)	Liner (L)	End (E)	Spool (S)	Cover (C)		
B-0	L-0	E-0	S-0	C-0	(S)A36/44W	Carbon Steel
B-1	L-1	E-1	S-1	C-1	(S)A-240	SS304
B-2	L-2	E-2	S-2	C-2	(S)A-240	SS304L
B-3	L-3	E-3	S-3	C-3	(S)A-240	SS316
B-4	L-4	E-4	S-4	C-4	(S)A-240	SS316L
B-5	L-5	E-5	S-5	C-5	(S)A-240	SS321
B-6	L-6	E-6	S-6	C-6	(S)A-240	SS309
B-7	L-7	E-7	S-7	C-7	(S)A-240	SS310
B-8	L-8	E-8	S-8	C-8	(S)B-127	Monel 400
B-9	L-9	E-9	S-9	C-9	(S)B-168	Inconel 600
B-10	L-10	E-10	S-10	C-10	(S)B-443	Inconel 625
B-11	L-11	E-11	S-11	C-11	(S)B-409	Incoloy 800
B-12	L-12	E-12	S-12	C-12	(S)B-424	Incoloy 825
B-14	L-14	E-14	S-14	C-14	(S)B-409	Incoloy 800HT
B-15	L-15	E-15	S-15	C-15	(S)B-162	Nickel 201
B-16	L-16	E-16	S-16	C-16	(S)B-575	Inco C276
B-17	L-17	E-17	S-17	C-17	(S)B-364	Tantalum
B-18	L-18	E-18	S-18	C-18	(S)B-265	Titanium Gr. 1
B-19	L-19	E-19	S-19	C-19	(S)B-551	Zirconium Gr. 702
B-20	L-20	E-20	S-20	C-20	(S)A-285	Carbon Steel
B-21	L-21	E-21	S-21	C-21	(S)A-570	Carbon Steel
B-22	L-22	E-22	S-22	C-22	(S)B-588	Carbon Steel
B-23	L-23	E-23	S-23	C-23	(S)A-606	Corten A
B-24	L-24	E-24	S-24	C-24	(S)A516	Carbon Steel
B-25	L-25	E-25	S-25	C-25	(S)A240	304H
B-26	L-26	E-26	S-26	C-26	(S)A240	316H
B-27	L-27	E-27	S-27	C-27	(S)A240	253MA
B-28	L-28	E-28	S-28	C-28	(S)A240	Duplex SS 2205
B-29	L-29	E-29	S-29	C-29	(S)A240	Super Duplex SS 2507
B-30	L-30	E-30	S-30	C-30	SA204 Gr. B	Carbon Steel
B-31	L-31	E-31	S-31	C-31	SA516-60	Carbon Steel
B-32	L-32	E-32	S-32	C-32	(S)A387	Carbon Steel
B-X	L-X	E-X	S-X	C-X	-	Special - Specify

Model:
SF = Single Flex Bellows

Style:
U = Unrestrained
H = Hinge
G = Gimbal
T = Tied Restrained
I = Intermediate Anchor

****Flange Drilling Type:**
FF1 = ANSI B16.5 Cl 150
FF2 = ANSI B16.5 Cl 300
FF3 = PN10, **FF4** = PN16
FF5 = PN25, **FF6** = PN40
FFS = Special Specify
(Add prefix "P" before "FF" type for plate flange)

Series or Number of Convolutions
S = Small, **M** = Medium, **L** = Large

1C = 1 Conv. **6C** = 6 Conv.
2C = 2 Conv. **7C** = 7 Conv.
3C = 3 Conv. **8C** = 8 Conv.
4C = 4 Conv. **9C** = 9 Conv.
5C = 5 Conv. **10C** = 10 Conv.
for additional convolutions specify number followed by suffix "C"

Number of Plies:
1P = 1 Ply **4P** = 4 Plies
2P = 2 Plies **5P** = 5 Plies
3P = 3 Plies **6P** = 6 Plies

End Type:
WW = Weld/Weld
FFX = Flange/Flange**
VVX = Van Stone Flange/Van Stone Flange
WVX = Weld/Van Stone Flange**
WFX = Weld/Flange**
CC = Collar/Collar
GG= Victaulic Grooved/Victaulic Grooved
VFX = Van Stone Flange/Flange**

Option:
HF = Hot Flex PTFE Lined Bellows
RLB = Rubber Lined Bellows
TC = Tantalum Coated Bellows

Special notes

1) Use of material codes as a suffix in the catalogue part number designate the bellows (B), liner (L), end connectors (E), spool (S) and Cover (C).

2) Special note for flanges and pipes: when forged flanges or scheduled pipe are used, the same nomenclature symbols are used (i.e.: E2 or S6).

3) ASTM, ASME "SA" or "SB" materials are standard but other material grades are available upon request.

4) All bellows material purchased by Thorburn are "mill annealed" in accordance with "A", "SA" or "SB" specifications. Thorburn does not perform any other heat treating operations before welding, after welding, before forming convolutions or after forming convolutions unless specified by purchaser. Heat treatment of bellows after forming convolutions can lower bellows' spring rate, "squirm" pressure and cycle life. Thorburn will cooperate with purchasers requiring heat treatment after forming to arrive at what effect the heat treatment will have on published bellows data.

NOTES

1. Rated cycle life is 2000 cycles for any one movement tabulated minimum per EJMA.
2. To combine axial, lateral or angular movements the sum of each must not exceed 100%. Refer to the specifications on pages 40 to 47.
3. To obtain greater movements or cycle life contact Thorburn.
4. Rated axial movement shown is for both compression or extension.
5. Maximum test pressure: 1-1/2 x rated working pressure.
6. Catalogue pressure ratings are based upon a design temperature range of - 20°F to 800°F (-29°C to 427°C). Actual operating temperature should always be specified.
7. For higher pressure temperature, movement and cycle ratings, contact Thorburn with your application details for fast action.

Thorburn Single Flex™ Series SF Bellows Specifications

Design Details				Non-Concurrent Movement			Spring Rate			Overall Length and Weight					
Size	Pressure	Series	Effective Area	Axial	Lateral	Angular	Axial	Lateral	Angular	WW		FF VV FV		FW VW	
										OAL	Weight	OAL	Weight	OAL	Weight
in	psi	-	in²	in	in	deg	lbs/in	lbs/in	in. lbs/deg	in	lbs	in	lbs	in	lbs
2	25	S	6.12	0.50	0.13	20	981	2376	17	8.20	12.14	4.20	10.33	6.20	11.24
		M	6.12	0.79	0.32	30	624	612	11	9.45	12.29	5.45	10.49	7.45	11.39
		L	6.12	1.37	0.88	40	382	140	6	11.65	12.57	7.65	10.76	9.65	11.66
	150	S	6.12	0.49	0.16	20	859	1592	15	8.51	12.18	4.51	10.37	6.51	11.27
		M	6.12	0.73	0.30	20	624	612	11	9.45	12.29	5.45	10.49	7.45	11.39
		L	6.07	0.88	0.60	20	842	305	14	11.65	12.79	7.65	10.98	9.65	11.89
	300	S	6.09	0.38	0.11	16	1658	3084	28	8.51	12.29	4.51	10.49	6.51	11.39
		M	6.09	0.58	0.25	19	1105	914	19	9.77	12.49	5.77	10.69	7.77	11.59
		L	6.07	0.69	0.33	20	1243	749	21	10.40	12.60	6.40	10.79	8.40	11.69
2.5	25	S	8.92	0.54	0.11	19	994	4370	25	7.97	14.56	4.21	16.36	6.09	15.46
		M	8.92	1.00	0.45	38	497	546	12	9.94	14.84	6.18	16.64	8.06	15.74
		L	8.92	1.63	1.00	50	331	162	8	11.91	15.13	8.15	16.93	10.03	16.03
	150	S	8.96	0.39	0.08	17	994	4370	25	7.97	14.68	4.21	16.48	6.09	15.58
		M	8.96	0.79	0.31	20	950	1047	24	9.94	15.06	6.18	16.86	8.06	15.96
		L	8.84	1.00	0.56	21	774	430	19	11.51	15.33	7.76	17.12	9.63	16.22
	300	S	8.99	0.28	0.06	10	4332	19195	108	7.97	14.80	4.21	16.60	6.09	15.70
		M	8.99	0.60	0.23	20	2166	2399	54	9.94	15.28	6.18	17.08	8.06	16.18
		L	8.97	0.84	0.45	22	1584	893	39	11.51	15.65	7.76	17.45	9.63	16.55
3	25	S	13.26	0.80	0.08	8	662	2577	24	8.55	17.98	4.92	18.52	6.73	18.25
		M	13.26	1.75	0.68	10.25	331	322	12	11.10	18.41	7.47	18.96	9.28	18.69
		L	13.26	2.60	1.27	12.5	221	95	8	13.65	18.85	10.02	19.39	11.83	19.12
	150	S	13.34	0.50	0.06	7	2820	11051	105	8.55	18.34	4.92	18.88	6.73	18.61
		M	13.34	1.00	0.36	9	1410	1381	52	11.10	19.08	7.47	19.62	9.28	19.35
		L	13.55	1.35	0.67	11	1863	818	70	13.68	19.82	10.05	20.36	11.86	20.09
	300	S	13.55	0.36	0.04	405	5589	22075	210	5.56	18.34	4.93	18.89	6.74	18.61
		M	13.55	0.78	0.33	6.75	2795	2759	105	11.12	19.08	7.49	19.62	9.30	19.35
		L	13.60	1.20	0.63	9	2513	1106	95	13.68	20.08	10.05	20.62	11.86	20.35
3.5	25	S	16.73	0.65	0.09	8	1649	8042	77	8.56	20.86	5.07	22.80	6.81	12.83
		M	16.73	1.23	0.51	10.25	687	582	32	12.14	21.80	8.65	23.73	10.40	22.77
		L	16.73	1.82	0.94	12.5	550	298	26	13.68	22.20	10.19	24.13	11.93	23.16
	150	S	16.82	0.54	0.07	7	1461	7164	68	8.56	20.66	5.07	22.60	6.81	21.63
		M	16.82	0.98	0.39	9.25	731	896	34	11.12	21.16	7.63	23.10	9.37	22.13
		L	16.92	1.41	0.71	11.5	1096	600	51	13.68	22.20	10.19	24.13	11.93	23.16
	300	S	17.01	0.38	0.04	4.7	6332	31393	299	8.56	21.07	5.07	23.01	6.81	22.04
		M	17.01	0.78	0.32	7.1	3166	3924	150	11.12	21.91	7.63	22.85	9.37	22.88
		L	17.06	1.19	0.60	9.5	2851	1575	135	13.68	23.06	10.19	25.00	11.93	24.03

Thorburn Single Flex™ Series SF Bellows Specifications

Design Details				Non-Concurrent Movement			Spring Rate			Overall Length and Weight					
Size	Pressure	Series	Effective Area	Axial	Lateral	Angular	Axial	Lateral	Angular	WW		FF VV FV		FW VW	
										OAL	Weight	OAL	Weight	OAL	Weight
in	psi	-	in²	in	in	deg	lbs/in	lbs/in	in. lbs/deg	in	lbs	in	lbs	in	lbs
4	25	S	22.09	0.70	0.10	8.5	232	1491	14	8.56	23.36	5.19	26.70	6.87	25.03
		M	22.11	1.35	0.57	10.5	179	289	11	11.12	24.19	7.75	27.53	9.43	25.86
		L	22.16	2.00	1.04	12.5	274	197	17	13.68	25.66	10.31	29.00	11.99	27.33
	150	S	22.48	0.54	0.07	7.5	3199	20957	200	8.56	24.05	5.19	27.39	6.87	25.72
		M	22.48	0.97	0.38	10	1599	2620	100	11.12	25.25	7.75	28.59	9.43	26.92
		L	22.54	1.41	0.69	12.5	1452	1060	91	13.68	26.87	10.31	30.21	11.99	28.54
	300	S	22.23	0.40	0.05	5.4	4985	32295	308	8.56	24.15	5.19	27.49	6.87	25.82
		M	22.23	0.83	0.34	7.95	2493	4037	154	11.12	25.43	7.75	28.77	9.43	27.10
		L	22.23	1.26	0.63	10.5	1917	1837	118	12.66	26.20	9.28	29.54	10.97	27.87
6	25	S	45.67	1.04	0.12	8	194	1210	25	9.74	35.01	6.87	39.29	8.30	37.15
		M	45.70	1.96	0.72	10.25	165	318	21	12.73	36.31	9.86	40.59	11.29	38.45
		L	45.77	2.88	1.33	12.5	246	228	31	15.72	38.60	12.85	42.87	14.29	40.74
	150	S	46.23	0.85	0.08	5.95	2457	15506	315	9.74	36.27	6.87	40.54	8.30	38.40
		M	46.23	1.57	0.46	8.725	1228	1938	158	13.48	38.52	10.61	42.79	12.04	40.66
		L	45.60	2.29	0.85	11.5	1574	1095	199	17.19	40.30	14.32	44.57	15.75	42.43
	300	S	46.57	0.49	0.05	3.85	5168	33034	668	9.73	36.52	6.86	40.79	8.29	38.65
		M	46.57	1.07	0.39	6.925	2584	4129	334	13.46	39.00	10.59	43.27	12.02	41.13
		L	45.72	1.64	0.70	10	2654	3284	337	14.40	39.57	11.53	43.84	12.96	41.70
8	25	S	72.80	1.21	0.13	9	364	3619	74	9.74	46.10	7.25	61.97	8.49	54.03
		M	72.80	2.39	0.73	10.75	182	452	37	13.48	47.85	10.99	63.72	12.23	55.78
		L	73.28	3.57	1.33	12	541	601	110	17.22	51.41	14.73	67.27	15.97	59.34
	150	S	73.47	0.87	0.07	5.55	3138	31482	641	9.74	47.44	7.25	63.30	8.49	55.37
		M	73.47	1.64	0.45	8.275	1569	3935	320	13.48	50.37	10.99	66.23	12.23	58.30
		L	72.20	2.41	0.84	11	1545	2265	310	15.70	51.59	13.20	67.45	14.45	59.52
	300	S	72.83	0.50	0.04	3.55	8215	93289	1662	9.50	47.54	7.01	63.40	8.25	55.47
		M	73.74	1.10	0.35	6	3404	8569	697	13.48	50.93	10.99	66.80	12.23	58.87
		L	73.14	1.70	0.66	9.5	2762	4018	561	15.80	53.08	13.31	68.95	14.55	61.01
10	25	S	108.49	1.45	0.16	8	440	6521	133	9.74	57.65	7.47	88.45	8.60	73.05
		M	108.49	2.97	1.05	9.5	200	612	60	14.23	60.27	11.95	91.06	13.09	75.67
		L	108.84	4.50	1.90	12.5	293	484	89	17.22	62.01	14.95	92.81	16.08	77.41
	150	S	109.31	0.95	0.10	5.15	3872	57784	1176	9.74	59.31	7.47	90.11	8.60	74.71
		M	109.31	1.96	0.72	7.825	1613	4180	490	14.98	64.43	12.70	95.23	13.84	79.83
		L	109.89	2.95	1.20	10	1933	3223	590	17.22	66.62	14.95	97.42	16.08	82.02
	300	S	109.63	0.62	0.06	3.5	8454	126544	2575	9.74	59.69	7.47	90.49	8.60	75.09
		M	108.89	1.40	0.57	6.45	3165	5228	957	17.22	67.24	14.95	98.04	16.08	82.64
		L	108.89	2.40	0.90	8	3165	5228	957	17.22	67.24	14.95	98.04	16.08	82.64

Thorburn Single Flex™ Series SF Bellows Specifications

Design Details				Non-Concurrent Movement			Spring Rate			Overall Length and Weight					
Size	Pressure	Series	Effective Area	Axial	Lateral	Angular	Axial	Lateral	Angular	WW		FF VV FV		FW VW	
										OAL	Weight	OAL	Weight	OAL	Weight
in	psi	-	in²	in	in	deg	lbs/in	lbs/in	in. lbs/deg	in	lbs	in	lbs	in	lbs
		S	157.60	1.30	0.10	6	454	4193	199	11.71	69.61	10.07	132.00	10.89	100.81
	25	M	158.16	2.88	0.91	9	594	612	261	23.13	84.64	21.49	147.03	22.31	115.84
		L	158.16	4.47	1.73	11	637	753	280	21.98	83.41	20.35	145.80	21.17	114.60
		S	154.37	0.80	0.06	4.2	3517	31819	1508	11.71	72.35	10.07	134.74	10.89	103.54
12	150	M	159.10	2.02	0.60	6.35	1796	4186	794	17.42	79.92	15.78	142.30	16.60	111.11
		L	159.10	3.23	1.14	8.5	1796	4186	794	17.42	79.92	15.78	142.30	16.60	111.11
		S	154.09	0.60	0.05	2.9	13672	342967	5852	9.43	70.23	7.79	132.61	8.61	101.42
	300	M	154.09	1.61	0.52	5.45	5127	18086	2195	15.13	76.79	13.50	139.18	14.32	107.99
		L	154.09	2.62	1.00	8	3729	6957	1596	18.56	80.74	16.92	143.12	17.74	111.93
		S	186.33	1.17	0.09	5.15	641	10934	332	10.57	76.86	9.07	184.77	9.82	130.81
	25	M	186.33	2.81	0.84	10	285	960	147	16.28	82.22	14.78	190.13	15.53	136.18
		L	186.49	4.45	1.60	26.05	372	602	193	20.84	90.27	19.35	198.18	20.10	144.23
		S	182.89	0.80	0.05	3.9	3899	41769	1981	11.71	79.44	10.22	187.35	10.96	133.40
14	150	M	182.89	1.93	0.54	10.35	1949	5224	990	17.42	86.13	15.92	194.04	16.67	140.08
		L	180.74	3.06	1.02	12	2011	3698	1009	19.70	87.85	18.21	195.76	18.95	141.81
		S	182.58	0.67	0.05	3.7	9106	97438	4618	11.71	79.99	10.21	187.90	10.96	133.94
	300	M	182.58	1.68	0.51	10.25	4553	12180	2309	17.42	87.15	15.92	195.06	16.67	141.10
		L	181.86	2.69	0.97	12	4079	7547	2060	19.70	89.66	18.21	197.57	18.95	143.61
		S	237.86	1.28	0.09	5.35	581	7088	384	12.10	89.14	11.10	218.75	11.60	153.95
	25	M	237.86	2.85	0.78	8.925	291	886	192	18.20	95.36	17.20	224.96	17.70	160.16
		L	238.04	4.43	1.48	12.5	421	760	278	21.87	103.43	20.87	233.04	21.37	168.24
		S	237.59	0.79	0.06	3.75	4536	55268	2993	12.10	92.58	11.10	222.19	11.60	157.38
16	150	M	237.59	2.06	0.52	6.375	2268	6908	1497	18.20	101.93	17.20	231.53	17.70	166.73
		L	232.29	3.34	0.97	9	2495	3792	1610	23.09	106.33	22.09	235.94	22.59	171.14
		S	233.45	0.77	0.04	3.6	10466	125251	6784	12.10	91.48	11.10	221.09	11.60	156.29
	300	M	233.35	1.55	0.50	4.175	5233	15656	3392	18.20	99.73	17.20	229.34	17.70	164.54
		L	232.13	3.35	0.95	4.75	4489	7905	2894	21.87	104.03	20.87	233.63	21.37	168.83
		S	295.67	1.24	0.08	4.7	635	9622	521	12.10	100.29	11.47	267.59	11.78	183.94
	25	M	295.67	2.94	0.73	8.35	317	1203	261	18.20	107.28	17.57	274.58	17.89	190.93
		L	295.87	4.64	1.37	12	433	837	356	23.09	118.12	22.45	285.43	22.77	201.77
		S	296.03	0.82	0.05	3.65	4079	61931	3354	12.10	101.97	11.47	269.28	11.78	185.62
18	150	M	296.03	2.16	0.49	6.325	2040	7741	1677	18.20	110.48	17.57	277.79	17.89	194.14
		L	293.30	3.5	0.94	9	2426	4655	1977	23.09	118.44	22.45	285.75	22.77	202.09
		S	290.43	0.8	0.04	3.5	12729	189607	10269	12.10	103.12	11.47	270.42	11.78	186.77
	300	M	290.43	1.67	0.45	6.25	6365	23701	5135	18.20	112.57	17.57	279.88	17.89	196.22
		L	288.62	3.34	0.85	9	5264	9939	4220	23.09	119.04	22.45	286.35	22.77	202.70

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Design Details				Non-Concurrent Movement			Spring Rate			Overall Length and Weight					
Size	Pressure	Series	Effective Area	Axial	Lateral	Angular	Axial	Lateral	Angular	WW		FF VV FV		FW VW	
										OAL	Weight	OAL	Weight	OAL	Weight
in	psi	-	in^2	in	in	deg	lbs/in	lbs/in	in. lbs/deg	in	lbs	in	lbs	in	lbs
20	25	S	359.77	1.27	0.08	4.45	692	12762	691	12.10	111.59	11.85	338.44	11.97	225.01
		M	359.77	2.94	0.67	7.725	346	1595	346	18.20	119.35	17.95	346.20	18.08	232.78
		L	359.99	4.62	1.26	11	474	1116	474	23.09	131.40	22.83	358.25	22.96	244.82
	150	S	358.26	0.82	0.05	2.9	5936	109064	5907	12.10	115.64	11.85	342.48	11.97	229.06
		M	358.26	2.15	0.47	5.45	2968	13633	2954	18.20	127.07	17.95	353.91	18.08	240.49
		L	356.25	3.49	0.90	8	2409	5615	2384	23.09	135.03	22.83	361.88	22.96	248.46
	300	S	353.85	0.79	0.04	2.75	16413	297865	16133	12.10	115.24	11.85	342.08	11.97	228.66
		M	353.85	2.06	0.42	5.375	8206	37233	8066	18.20	126.19	17.95	353.04	18.08	239.61
		L	358.86	3.33	0.80	8	4809	11289	4793	23.09	135.03	22.83	361.88	22.96	248.46
22	25	S	430.15	1.29	0.08	4.3	750	16547	896	12.10	123.56	12.37	379.28	12.23	251.42
		M	430.15	2.95	0.61	7.65	375	2068	448	18.20	132.10	18.47	387.82	18.34	259.96
		L	430.39	4.40	1.14	11	481	1180	575	24.31	147.50	24.57	403.22	24.44	275.36
	150	S	428.13	0.82	0.05	2.65	6610	145151	7862	12.10	127.94	23.37	383.65	12.23	255.79
		M	428.13	1.75	0.43	5.325	3305	18144	3931	18.20	140.43	18.47	396.15	18.34	268.29
		L	427.76	3.48	0.82	8	2411	6747	2865	23.09	150.21	23.35	405.93	23.22	278.07
	300	S	435.13	0.79	0.04	2.55	13389	298792	16183	12.10	129.82	12.37	385.54	12.23	257.68
		M	434.94	2.06	0.38	5.275	6760	37702	8168	18.20	144.03	18.47	399.74	18.34	271.88
		L	434.94	3.30	0.73	8	4829	13740	5834	23.09	155.42	23.35	411.14	23.22	283.28
24	25	S	506.81	1.31	0.07	4.15	808	21007	1138	12.10	134.04	12.61	450.12	12.35	292.08
		M	506.81	2.96	0.58	7.325	404	2626	569	18.20	143.35	18.71	459.44	18.46	301.39
		L	507.07	4.60	1.09	10.5	557	1846	784	23.09	157.80	23.59	473.89	23.34	315.84
	75	S	503.43	0.79	0.05	3	7656	197678	10707	12.10	138.56	12.61	454.64	12.35	296.60
		M	503.43	1.90	0.41	5.25	3747	24208	5245	18.20	152.10	18.71	468.18	18.46	310.14
		L	504.22	3.48	0.77	7.5	2621	8644	3671	23.09	163.10	23.59	479.19	23.34	321.14
	150	S	511.81	0.79	0.04	2.4	14851	389830	21114	12.10	140.77	12.61	456.86	12.35	298.81
		M	511.81	1.75	0.35	4.95	7425	48729	10557	18.20	156.27	18.71	472.35	18.46	314.31
		L	511.41	3.32	0.66	7.5	5410	18098	7685	23.09	168.41	23.59	484.49	23.34	326.45
26	25	S	634.57	1.25	0.07	4	954	26439	1682	14.61	198.53	16.11	617.80	15.36	408.17
		M	634.57	1.00	0.09	7.3	545	4933	961	19.57	211.06	21.07	630.33	20.32	420.69
		L	634.57	4.60	1.03	8.5	424	2321	748	22.88	219.41	24.38	638.68	23.63	429.04
	75	S	637.38	1.12	0.06	4.0	3235	90019	5728	14.61	204.48	16.11	623.75	15.36	414.11
		M	637.38	0.88	0.06	6.3	1849	16797	3273	19.57	221.18	21.07	640.46	20.32	430.82
		L	637.38	4.35	0.91	8.5	1438	7903	2546	22.88	232.32	24.38	651.59	23.63	441.96
	150	S	623.15	0.81	0.05	2.9	6844	186181	11846	14.61	201.63	16.11	620.90	15.36	411.27
		M	623.15	0.75	0.06	5.2	3911	34739	6769	19.57	216.20	21.07	635.47	20.32	425.84
		L	623.15	3.47	0.73	7.5	3042	16345	5265	22.88	225.92	24.38	645.19	23.63	435.55

ThorburnFlex

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Design Details				Non-Concurrent Movement			Spring Rate			Overall Length and Weight					
Size	Pressure	Series	Effective Area	Axial	Lateral	Angular	Axial	Lateral	Angular	WW		FF VV FV		FW VW	
										OAL	Weight	OAL	Weight	OAL	Weight
in	psi	-	in^2	in	in	deg	lbs/in	lbs/in	in. lbs/deg	in	lbs	in	lbs	in	lbs
		S	727.01	1.39	0.06	4.0	1016	32251	2052	14.61	214.08	16.49	709.17	15.55	461.62
	25	M	727.01	1.00	0.085	6.8	581	6018	1173	19.57	227.56	21.45	722.66	20.51	475.11
		L	727.01	4.59	0.96	8.7	542	2831	912	22.88	236.55	24.76	731.65	23.82	484.10
		S	730.02	1.27	0.055	4.0	3461	110322	7020	14.61	220.48	16.49	715.57	15.55	468.03
28	75	M	730.02	0.88	0.055	6.0	1978	20585	4011	19.57	238.47	21.45	733.56	20.51	486.01
		L	730.02	4.34	0.84	8.0	1538	9685	3120	22.88	250.46	24.76	745.55	23.82	498.01
		S	714.63	0.88	0.04	2.5	7338	228940	14567	14.61	217.39	16.49	712.48	15.55	464.94
	150	M	714.63	0.75	0.05	5.0	4193	42718	8324	19.57	233.06	21.45	728.15	20.51	480.61
		L	714.63	3.30	0.67	7.5	3261	20099	6474	22.88	243.51	24.76	738.60	23.82	491.05
		S	825.73	1.42	0.06	3.9	1080	38948	2478	14.61	229.62	17.37	820.54	15.99	525.08
	25	M	825.73	73.285	0.435	6.7	617	7267	1416	19.57	244.07	22.33	834.99	20.95	539.53
		L	825.73	5.16	0.810	8.5	480	3419	1101	22.88	253.70	25.64	844.62	24.26	549.16
		S	828.94	1.29	0.055	3.9	3687	133440	8490	14.61	236.48	17.37	827.40	15.99	531.94
30	75	M	828.94	3.10	0.373	5.9	2107	24898	4852	19.57	255.75	22.33	846.67	20.95	551.21
		L	810.57	3.10	0.690	8.0	2592	18119	5836	22.88	261.21	25.64	852.13	24.26	556.67
		S	812.19	0.88	0.035	2.4	7877	279321	17773	14.61	233.10	17.37	824.02	15.99	528.56
	150	M	812.19	0.75	0.050	4.9	5252	82762	11848	17.92	244.26	20.68	835.18	19.30	539.72
		L	811.93	3.52	0.490	7.5	3525	24683	7951	22.88	244.22	16.58	1030.96	14.89	637.59
		S	973.36	1.41	0.065	3.7	1051	72360	2842	22.88	260.90	25.64	851.82	24.26	556.36
	25	M	973.94	3.28	0.413	6.6	854	21176	2311	16.66	261.07	20.04	1047.82	18.35	654.44
		L	973.94	5.15	0.760	9.5	610	7717	1650	20.13	275.59	23.51	1062.34	21.82	668.96
		S	972.67	1.29	0.060	3.7	5232	359856	14135	13.20	254.30	16.58	1041.05	14.89	647.67
32	75	M	972.67	3.09	0.370	5.9	3139	77729	8481	16.66	273.62	20.04	1060.36	18.35	666.99
		L	972.67	4.90	0.680	8.0	2242	28327	6058	20.13	292.93	23.51	1079.68	21.82	686.30
		S	966.23	0.88	0.04	2.2	16848	1151206	45220	13.20	269.92	16.58	1056.67	14.89	662.29
	150	M	966.23	0.75	0.045	4.9	10109	248661	27132	16.66	298.87	20.04	1085.62	18.35	692.24
		L	966.23	3.52	0.460	7.5	7220	90620	19380	20.13	327.82	23.51	1114.56	21.82	721.19
		S	1087.18	1.44	0.055	3.7	1163	89454	3514	13.20	260.05	16.96	1102.62	15.08	681.34
	25	M	1087.18	3.35	0.393	6.1	698	19322	2108	16.66	274.16	20.42	1116.73	18.54	695.44
		L	1087.18	5.26	0.730	7.6	499	7042	1506	20.13	288.26	23.89	1130.83	22.01	709.55
		S	1063.41	1.32	0.05	3.2	4208	316421	12429	13.20	259.28	16.96	1101.85	15.08	680.56
34	75	M	1063.41	3.16	0.340	4.8	2525	68347	7458	16.66	272.76	20.42	1115.33	18.54	694.05
		L	1063.41	5.01	0.630	6.5	1208	16688	3569	20.13	286.24	23.89	1128.81	22.01	707.53
		S	1026.91	0.85	0.110	2.0	5878	240109	16767	14.93	264.90	18.69	1107.47	16.81	686.19
	150	M	1026.91	0.75	0.045	4.6	7018	183486	20021	16.66	271.29	20.42	1113.86	18.54	692.57
		L	1026.91	2.90	0.445	7.0	3359	44802	9581	20.13	284.06	23.89	1126.63	22.01	705.35

Thorburn Single Flex™ Series SF Bellows Specifications

Design Details				Non-Concurrent Movement			Spring Rate			Overall Length and Weight					
Size	Pressure	Series	Effective Area	Axial	Lateral	Angular	Axial	Lateral	Angular	WW		FF VV FV		FW VW	
										OAL	Weight	OAL	Weight	OAL	Weight
in	psi	-	in^2	in	in	deg	lbs/in	lbs/in	in. lbs/deg	in	lbs	in	lbs	in	lbs
36	25	S	1207.21	1.44	0.06	3.5	1227	104745	4114	13.20	275.56	17.58	1303.95	15.39	789.76
		M	1207.21	2.94	0.38	6.0	736	22625	2469	16.66	290.49	21.04	1318.89	18.85	804.69
		L	1207.21	4.45	0.71	8.5	681	10683	2285	20.13	310.48	24.51	1338.87	22.32	824.67
	75	S	1180.93	1.32	0.05	3.0	4529	378236	14857	13.20	274.60	17.58	1302.99	15.39	788.80
		M	1180.93	2.76	0.33	5.3	2717	81699	8914	16.66	288.78	21.04	1317.18	18.85	802.98
		L	1180.93	4.20	0.61	7.5	1941	29774	6367	20.13	302.97	24.51	1331.36	22.32	817.16
	150	S	1143.53	0.75	0.04	2.1	12338	997755	39192	13.20	273.91	17.58	1302.31	15.39	788.11
		M	1142.93	2.00	0.23	2.7	5028	146299	15963	16.66	287.29	21.04	1315.69	18.85	801.49
		L	1142.63	3.00	0.43	7.0	5397	80101	17130	20.13	300.65	24.51	1329.05	22.32	814.85
38	25	S	1260.37	1.44	0.06	3.35	1088	54692	3809	14.92	284.16	19.30	1458.38	17.11	871.27
		M	1260.37	3.35	0.28	5.925	870	28002	3047	16.65	288.44	21.03	1462.66	18.84	875.55
		L	1260.37	5.26	0.56	8.5	622	10205	2177	20.11	296.99	24.49	1471.21	22.30	884.10
	75	S	1263.84	1.32	0.05	2.85	4218	212603	14807	14.92	291.52	19.30	1465.75	17.11	878.63
		M	1263.84	3.16	0.25	3.0	3374	108853	11846	16.65	297.51	21.03	1471.73	18.84	884.62
		L	1263.84	5.01	0.50	7.5	2410	39669	8461	20.11	309.49	24.49	1483.71	22.30	896.60
	150	S	1261.44	0.75	0.04	1.95	8448	425052	29604	14.92	290.75	19.30	1464.98	17.11	877.86
		M	1261.44	1.60	0.10	4.475	8448	425052	29604	16.65	296.54	21.03	1470.77	18.84	883.65
		L	1261.44	2.70	0.42	7.0	4828	79310	16917	20.11	308.12	24.49	1482.35	22.30	895.23
40	25	S	1389.36	1.44	0.05	3.25	1136	62933	4383	14.92	299.31	19.80	1569.35	17.36	934.33
		M	1389.36	3.50	0.20	5.625	909	32222	3507	16.65	303.81	21.53	1573.85	19.09	938.83
		L	1389.36	5.26	0.50	8.0	649	11743	2505	20.11	312.81	24.99	1582.85	22.55	947.83
	75	S	1393.00	1.32	0.05	2.75	4411	245095	17070	14.92	307.05	19.80	1577.10	17.36	942.08
		M	1393.00	3.16	0.20	4.875	3529	125489	13656	16.65	313.36	21.53	1583.40	19.09	948.38
		L	1393.00	5.01	0.40	7.0	2521	45732	9755	20.11	325.96	24.99	1596.01	22.55	960.98
	150	S	1390.13	0.88	0.03	1.9	12241	678786	47276	14.92	306.55	19.80	1576.59	17.36	941.57
		M	1389.14	1.75	0.21	4.45	10000	354614	38591	16.65	312.53	21.53	1582.57	19.09	947.55
		L	1388.48	3.00	0.39	7.0	7243	130988	27939	20.11	324.61	24.99	1594.66	22.55	959.64
42	25	S	1524.64	1.44	0.05	3.15	1183	71955	5011	14.92	314.45	20.42	1800.32	17.67	1057.38
		M	1524.64	3.35	0.20	6.575	947	36841	4009	16.65	319.17	22.15	1805.04	19.40	1062.11
		L	1524.64	5.26	0.49	8.0	676	13426	2864	20.11	328.62	25.61	1814.50	22.86	1071.56
	75	S	1528.44	1.32	0.04	3.15	4605	280710	19551	14.92	322.58	20.42	1808.45	17.67	1065.52
		M	1528.44	3.16	0.23	6.075	3684	143724	15641	16.65	329.20	22.15	1815.07	19.40	1072.13
		L	1528.44	5.01	0.45	9.0	2631	52377	11172	20.11	342.43	25.61	1828.31	22.86	1085.37
	150	S	1525.12	0.85	0.03	1.8	9349	568698	39609	14.92	321.62	20.42	1807.49	17.67	1064.56
		M	1524.57	1.75	0.20	4.4	7565	294394	32037	16.65	327.89	22.15	1813.76	19.40	1070.82
		L	1524.57	2.50	0.38	7.0	5403	107287	22884	20.11	340.59	25.61	1826.46	22.86	1083.53

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Size	Pressure	Series	Effective Area	Axial	Lateral	Angular	Axial	Lateral	Angular	WW		FF VV FV		FW VW	
										OAL	Weight	OAL	Weight	OAL	Weight
in	psi	-	in^2	in	in	deg	lbs/in	lbs/in	in. lbs/deg	in	lbs	in	lbs	in	lbs
44	25	S	1666.19	1.44	0.05	3.05	1231	81792	5697	14.92	329.59	20.92	2001.29	17.92	1165.44
		M	1666.19	3.35	0.33	5.9	985	41877	4557	16.65	334.54	22.65	2006.24	19.65	1170.39
		L	1666.19	5.26	0.61	8.75	703	15261	3255	20.11	344.44	26.11	2016.14	23.11	1180.29
	75	S	1670.17	1.32	0.04	3.05	4798	319588	22259	14.92	338.11	20.92	2009.81	17.92	1173.96
		M	1670.17	2.35	0.15	5.375	3838	163629	17807	16.65	345.04	22.65	2016.74	19.65	1180.89
		L	1670.17	3.38	0.27	7.7	2742	59632	12719	20.11	358.91	26.11	2030.60	23.11	1194.76
	150	S	1665.97	0.88	0.03	2.55	9877	656279	45708	14.92	336.99	20.92	2008.69	17.92	1172.84
		M	1665.25	1.88	0.20	4.025	8015	340688	37075	16.65	343.50	22.65	2015.20	19.65	1179.35
		L	1665.25	2.88	0.37	5.5	8457	183062	39047	20.11	356.74	26.11	2028.44	23.11	1192.59
48	25	S	1968.15	1.44	0.04	2.9	1325	104049	7247	14.92	359.87	22.04	2393.22	18.48	1376.55
		M	1968.15	2.54	0.18	5.85	1060	53273	5797	16.65	365.27	23.77	2398.62	20.21	1381.95
		L	1968.15	3.63	0.33	8.8	757	19414	4141	20.11	376.07	27.23	2409.42	23.67	1382.75
	75	S	1972.48	1.15	0.03	2.9	5182	407688	28395	14.92	369.17	22.04	2402.51	18.48	1385.84
		M	1972.48	2.20	0.11	5.95	4146	208736	22716	16.65	376.73	23.77	2410.08	20.21	1393.40
		L	1972.48	3.25	0.19	9.0	2961	76070	16226	20.11	391.73	27.23	2425.20	23.67	1408.53
	150	S	1967.13	0.60	0.02	2.9	10820	848930	59126	14.92	367.83	22.04	2401.17	18.48	1384.50
		M	1966.34	1.30	0.06	5.05	8780	440713	47961	16.65	374.90	23.77	2408.24	20.21	1391.57
		L	1966.34	1.90	0.11	5.8	6272	160610	34258	20.11	389.28	27.23	24.22.62	23.67	1405.95
52	25	S	2394.37	2.03	0.08	2.5	1688	161202	11227	14.92	414.62	11.92	999.62	13.42	707.12
		M	2384.84	3.24	0.25	6.1125	1493	90910	9893	16.65	424.62	13.65	1009.61	15.15	717.11
		L	2384.84	4.45	0.43	8.5	1067	33130	7067	20.11	447.48	17.11	1032.48	18.61	739.98
54	25	S	2570.97	1.33	0.03	2.45	1751	179564	12506	14.92	430.71	11.92	1051.53	13.42	741.12
		M	2570.97	3.76	0.20	6.225	1401	91937	10005	16.65	442.95	13.65	1063.77	15.15	753.36
		L	2570.97	6.00	0.39	7.0	1001	33505	7146	20.11	467.44	17.11	1088.26	18.61	777.85
60	25	S	3138.47	1.32	0.02	2.3	1909	143811	16642	16.92	481.10	14.42	1339.40	15.67	910.25
		M	3138.47	3.74	0.26	9.5	1527	73631	13314	19.15	495.25	16.65	1353.55	17.90	924.40
		L	3138.47	6.16	0.50	7.0	1091	26833	9510	23.61	523.53	21.11	1381.83	22.36	952.68
64	25	S	3548.21	1.32	0.02	2.25	2022	172231	19931	20.92	738.44	14.42	1489.36	17.67	1113.90
		M	3548.21	3.73	0.25	6.125	1618	88182	15945	23.15	753.52	16.65	1504.45	19.90	1128.98
		L	3548.21	6.14	0.48	7.0	1156	32136	11389	27.61	783.69	21.11	1534.62	24.36	1159.15

Thorburn Single Flex™ Series SF Bellows Specifications

Design Details				Non-Concurrent Movement			Spring Rate			Overall Length and Weight					
Size	Pressure	Series	Effective Area	Axial	Lateral	Angular	Axial	Lateral	Angular	WW		FF VV FV		FW VW	
										OAL	Weight	OAL	Weight	OAL	Weight
in	psi	-	in²	in	in	deg	lbs/in	lbs/in	in. lbs/deg	in	lbs	in	lbs	in	lbs
66	25	S	3762.51	1.81	0.06	3.15	2079	187736	21726	20.92	761.68	14.42	1565.34	17.67	1163.51
		M	3762.51	3.12	0.20	5.9375	1663	96121	17381	23.15	777.24	16.65	1580.90	19.90	1179.07
		L	3762.51	4.41	0.35	8.725	1188	35030	12415	27.61	808.35	21.11	1612.01	24.36	1210.18
70	25	S	4209.95	1.31	0.06	3.15	2191	221459	25628	20.92	808.16	14.42	1703.30	17.67	1255.73
		M	4209.95	3.72	0.20	5.9375	1753	113387	20503	23.15	8244.66	16.65	1719.80	19.90	1272.23
		L	4209.95	6.13	0.35	8.725	1252	41322	14645	27.61	857.66	21.11	1752.79	24.36	1305.23
72	25	S	4443.10	2.00	0.02	3.15	2248	239726	27742	20.92	831.40	14.42	1771.28	17.67	1301.34
		M	4443.10	3.20	0.32	5.9375	1798	122740	22194	23.15	848.37	16.65	1788.25	19.90	1318.31
		L	4443.10	4.41	0.62	8.725	1284	44730	15853	27.61	882.31	21.11	1822.19	24.36	1352.25
80	25	S	5438.52	1.99	0.05	2.8	2472	322740	37349	20.92	924.37	14.92	2313.19	17.92	1618.78
		M	5438.52	3.19	0.19	5.5	1978	165243	29879	23.15	943.22	17.15	2332.05	20.15	1637.63
		L	5438.52	4.39	0.33	8.2	1413	60220	21342	27.61	980.93	21.61	2369.76	24.61	1675.34
84	25	S	5972.48	1.99	0.05	2.8	1907	273406	31640	20.92	962.53	14.92	2574.83	17.92	1768.68
		M	5972.48	3.19	0.19	5.5	1526	139984	25312	23.15	980.35	17.15	2592.65	20.15	1786.50
		L	5972.48	4.39	0.33	7.3	1090	51015	18080	27.61	1015.98	21.61	2628.28	24.61	1822.13
96	25	S	7712.16	1.99	0.05	2.4	2381	440743	51005	20.92	1098.40	15.42	3583.13	18.17	2340.76
		M	7712.16	3.18	0.18	5.2	1905	225661	40804	23.15	1118.16	17.65	3602.89	20.40	2360.53
		L	7712.16	4.38	0.31	7.8	1360	82238	29146	27.61	1157.69	22.11	3642.41	24.86	2400.05
108	25	S	9693.09	1.98	0.04	2.4	2662	619464	71687	20.92	1236.36	22.11	3642.41	24.86	2400.05
		M	9693.09	3.18	0.16	4.925	2130	317166	57350	23.15	1258.59	16.15	4469.75	19.65	2864.17
		L	9693.09	4.37	0.29	7.45	1521	115585	40964	27.61	1303.06	20.61	4514.21	24.11	2908.63
120	25	S	11923.51	2.00	0.04	2.3	3639	1041453	120522	20.92	1389.19	14.42	5810.77	17.67	3599.98
		M	11923.51	3.20	0.17	4.7875	2911	533224	96417	23.15	1417.47	16.65	5839.05	19.90	3628.26
		L	11923.51	4.40	0.29	7.275	2079	194324	68870	27.61	1474.02	21.11	5895.60	24.36	3684.81
144	25	S	17020.85	1.99	0.04	2.8	4334	1770605	204903	20.92	1668.09	15.42	9242.52	18.17	5455.30
		M	17020.85	3.19	0.16	4.84	3467	906550	163922	23.15	1702.02	17.65	9276.45	20.40	5489.23
		L	17020.85	4.40	0.28	6.88	2476	330375	117087	27.61	1769.88	22.11	9344.31	24.86	5557.10
158	25	S	20300.85	1.98	0.02	3.35	4725	2302551	266462	8.92	0.75	0.286	495.22	31.5	155.98
		M	20300.85	3.24	0.21	6.05	3780	1178906	213169	11.15	0.75	0.286	495.22	39.0	193.11
		L	20300.85	4.50	0.40	8.75	2700	429630	152264	15.61	0.75	0.286	495.22	53.9	267.38

Dual Flex™ Series DFU Unrestrained Universal Bellows

If large amounts of lateral movements are required in a piping system, Thorburn's Dual Flex™ Series DFU unrestrained universal expansion joints are used. This type of expansion joint will also result in lower forces on the anchors.

Thorburn's Dual Flex™ Series DFU consists of two bellows joined by a common connector called a "pipe spool". However, unlike Thorburn's double joint Series DFP, this connector is not anchored to the structure. This permits Thorburn's unrestrained universal expansion joint Series DFU to absorb any combination of three basic movements: axial, lateral and angular. Series DFU is used where these combinations or single direction movements are too great to be handled by Thorburn's Single Flex™ single joint.

Features

- Absorbs large amounts of lateral movement in any direction
- Eliminates pressure thrust loads
- Designed to accommodate up to 10" of axial movement
- Eliminates main anchors

Additional points that must be considered before specifying Thorburn's Dual-Flex DFU

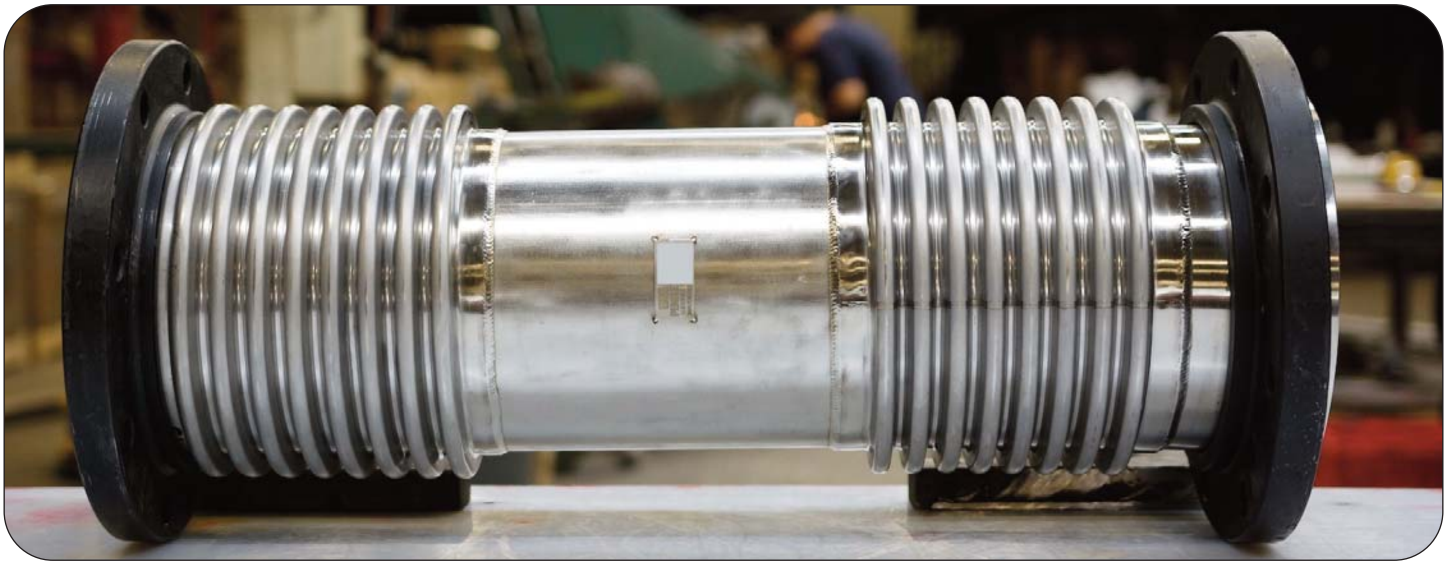
1. For a very long expansion joint, the center spool may have to be supported. In vertical installations, the bellows or related hardware support the mass of the center spool. In horizontal installations, the bellows or related hardware are required to support the center spool mass as well as the weight of the fluid in the center spool. Therefore, it is important to specify the orientation of the universal assembly and the media when specifying Thorburn's Dual Flex™ Series DFU.

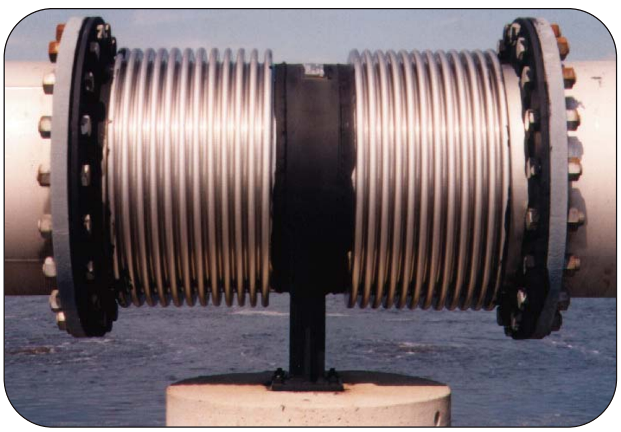
2. Specify the direction of flow for expansion joints requiring liners if the end fittings are not identical before specifying Thorburn's Dual Flex™ Series.

3. Pressure thrust is a very important design consideration. For Thorburn's Dual Flex™ Series DFU, the pressure thrust force will be equal to the "Bellows Area" times the "Operating Pressure".

4. Without properly designed directional main anchors, Thorburn's Dual Flex™ Series DFU is not recommended and Thorburn's Dual Flex™ Series DFT tied universal should be used.

Dual Flex™ Series DFP In-Line Double Restrained Bellows





Thorburn's Dual Flex™ Series DFP in-line double expansion joint, with support foot and intermediate anchor system

Thorburn's Dual Flex™ Series DFP in-line double restrained expansion joint system is typically installed in long pipe runs where the axial movement exceeds the capability of Thorburn's Single Flex™ (Single bellows) expansion joint, where each bellows functions independently as a single unit.

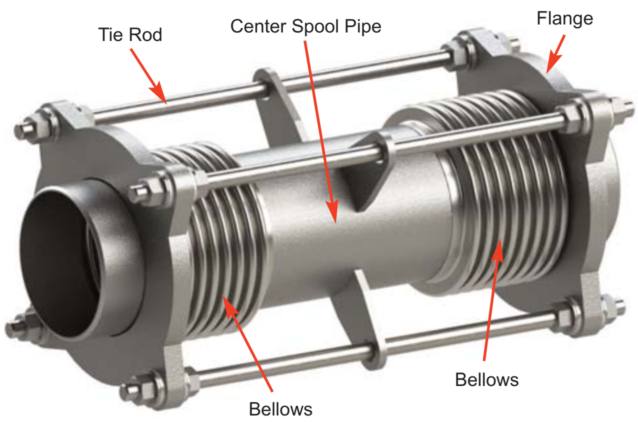
Series DFP consists of two single joints joined by a common spool which is anchored to a support base (intermediate anchor) directly to the structure. The intermediate anchor on the center spool divides this movement between each bellows which should have the same number of convolutions.

It is good practice to use an intermediate anchor in conjunction with two main anchors to divide the pipeline into individual expanding sections. This ensures there is only one expansion joint between any two anchors.

Features

- Designed for long pipe runs of straight piping to absorb major axial movement up to 12"
- Expansion Joint is anchored in the center of the line and two pipe guidesare placed on each side of the unit.

Dual Flex™ Series DFT Tied Universal Bellows



Thorburn's Dual Flex™ Series DFT expansion joint is made up from two single expansion joints connected by a piece of pipe called the center spool. Dual Flex™ Series DFT is constructed with either two sets of short tie rods, one set over each bellows, or with overall tie rods. A unit with the two sets of short rods is designed primarily to limit movement and stabilize the connecting pipe section. A unit with overall tie rods is designed to absorb full pressure thrust, to stabilize the connecting pipe section, and to absorb all external loads which are present, such as wind loads and weight of center pipe nipple where unit is exceptionally long.

The most common application for Thorburn's Dual Flex™ Series DFT tied universal expansion joint system is the "Z" shape piping system. In this case, the expansion joint absorbs the thermal growth of the horizontal piping as lateral deflection.

Features

- •Absorbs large amounts of lateral movement in any direction
- •Eliminates pressure thrust loads
- •Absorbs thermal growth of piping between the tie rods
- •Eliminates main anchors
- •Can support dead weight of the center spool
- •Sizes up to 4.7m (180”)

Thorburn Dual Flex™ Series DFT ready for shipping

Dual Flex™ Series DFT Tied Universal Bellows

An important advantage found in Thorburn's Dual Flex™ Series DFT is that the piping system does not have to be in one plane. The two horizontal legs may lie at any angle in the horizontal plane.

Where dimensionally feasible, Thorburn's Dual Flex™ Series DFT is designed to fill the extra offset leg so that its expansion is absorbed within the tie rods as axial movement. If this is not possible, the growth of the vertical piping leg outside the tied rods must be absorbed by bending in the horizontal legs. To eliminate this deflection, Thorburn can supply its tied universal expansion joints with two 90° elbows.

The tie rod attachments are then located at the centerline of each elbow, therefore the bellows can now absorb the total amount of thermal growth in the vertical leg of the piping system. Please refer to the sketch below for demonstration.

Thorburn's Dual Flex™ Series DFT-EE is a tied universal expansion joint with elbow end connections designed to fill the entire offset leg so that its expansion is absorbed within the tie rods as axial movement. The movements in the horizontal lines are absorbed as lateral deflectors by Thorburn's Dual Flex™ Series DFT-EE expansion joint system.

Tied double universal expansion joint

Tied double elbow universal expansion joint

Thorburn Dual Flex™ Bellows - Styles

In-Line Double

Code “P”

Unrestrained Universal

Code “U”

Tie Rod Universal

Code “T”

Intermediate Anchor

Code “I”

Hinge Support

Code “H”

Gimbal Support

Code “G”

Thorburn Dual Flex™ Bellows - End Connectors

Weld

Code “WW”

Flange

Code “FF”

Van Stone Flange

Code “VV”

Elbow

Code “EE”

How To Order Dual Flex Bellows

Nominal Size	Model	Style	Series or Cons	Plies (#)	Ends	Pressure (PSI)	Bellows Material	Ends Material	Liner Material	Spool Material	Cover Material	Resraint & Anchor Material	O.A.L (in)	Option
24 -	DF -	T -	M -	2P -	WW -	150 -	B5 -	E1 -	L5 -	S2 -	C0 -	T0 -	35 -	TC
24" I.D.	Dual Flex	Tie Rod	Medium	2 Plies	Weld Ends	150 psi	321SS	304SS	321SS	304LSS	Carbon Steel	Carbon Steel	35"	Tantalum Coated
DN600						10 bar							889mm	

Thorburn Material Code					ASTM/ASME(S) Material Designation	Material Type
Bellows (B)	Liner (L)	End (E)	Spool (S)	Cover (C)		
B-0	L-0	E-0	S-0	C-0	(S)A36/44W	Carbon Steel
B-1	L-1	E-1	S-1	C-1	(S)A-240	SS304
B-2	L-2	E-2	S-2	C-2	(S)A-240	SS304L
B-3	L-3	E-3	S-3	C-3	(S)A-240	SS316
B-4	L-4	E-4	S-4	C-4	(S)A-240	SS316L
B-5	L-5	E-5	S-5	C-5	(S)A-240	SS321
B-6	L-6	E-6	S-6	C-6	(S)A-240	SS309
B-7	L-7	E-7	S-7	C-7	(S)A-240	SS310
B-8	L-8	E-8	S-8	C-8	(S)B-127	Monel 400
B-9	L-9	E-9	S-9	C-9	(S)B-168	Inconel 600
B-10	L-10	E-10	S-10	C-10	(S)B-443	Inconel 625
B-11	L-11	E-11	S-11	C-11	(S)B-409	Incoloy 800
B-12	L-12	E-12	S-12	C-12	(S)B-424	Incoloy 825
B-14	L-14	E-14	S-14	C-14	(S)B-409	Incoloy 800HT
B-15	L-15	E-15	S-15	C-15	(S)B-162	Nickel 201
B-16	L-16	E-16	S-16	C-16	(S)B-575	Inco C276
B-17	L-17	E-17	S-17	C-17	(S)B-364	Tantalum
B-18	L-18	E-18	S-18	C-18	(S)B-265	Titanium Gr. 1
B-19	L-19	E-19	S-19	C-19	(S)B-551	Zirconium Gr. 702
B-20	L-20	E-20	S-20	C-20	(S)A-285	Carbon Steel
B-21	L-21	E-21	S-21	C-21	(S)A-570	Carbon Steel
B-22	L-22	E-22	S-22	C-22	(S)B-588	Carbon Steel
B-23	L-23	E-23	S-23	C-23	(S)A-606	Corten A
B-24	L-24	E-24	S-24	C-24	(S)A516	Carbon Steel
B-25	L-25	E-25	S-25	C-25	(S)A240	304H
B-26	L-26	E-26	S-26	C-26	(S)A240	316H
B-27	L-27	E-27	S-27	C-27	(S)A240	253MA
B-28	L-28	E-28	S-28	C-28	(S)A240	Duplex SS 2205
B-29	L-29	E-29	S-29	C-29	(S)A240	Super Duplex SS 2507
B-30	L-30	E-30	S-30	C-30	SA204 Gr. B	Carbon Steel
B-31	L-31	E-31	S-31	C-31	SA516-60	Carbon Steel
B-32	L-32	E-32	S-32	C-32	(S)A387	Carbon Steel
B-X	L-X	E-X	S-X	C-X	-	Special - Specify

Model:
DF = Dual Flex Bellows

Style:
U = Unrestrained **G** = Gimbal
P = Inline Restrained **H** = Hinge
T = Tied Universal **I** = Intermediate Anchor

Series or Number of Convolutions (C):
S = Small, **M** = Medium, **L** = Large

1C x 1C **6C x 6C**
2C x 2C **7C x 7C**
3C x 3C **8C x 8C**
4C x 4C **9C x 9C**
5C x 5C **10C x 10C**
for additional convolutions specify number X number followed by suffix "C"

Number of Plies:
1P = 1 Ply **3P** = 3 Plies
2P = 2 Plies **4P** = 4 Plies

End Type:
WW = Weld/Weld
FFX= Flange/Flange**
VVX = Van Stone Flange/Van Stone Flange**
VFX = Van Stone Flange/Fixed Flange**
EE = Elbow/Elbow

Option:
HF = Hot Flex PTFE Lined Bellows
RLB = Rubber Lined Bellows
TC = Tantalum Coated Bellows

**** Flange Drilling Type:**
FF1 = ANSI B16.5 Cl 150 **FF5** = PN25
FF2 = ANSI B16.5 Cl 300 **FF6** = PN40
FF3 = PN10 **FFS** = Special Specify
FF4 = PN16 (Add prefix "P" before "FF" type for plate flange)

Special notes

1) Use of material codes as a suffix in the catalogue part number designate the bellows (B), liner (L), end connectors (E), spool (S) and Cover (C).

2) Special note for flanges and pipes: when forged flanges or scheduled pipe are used, the same nomenclature symbols are used (i.e.: E2 or S6).

3) ASTM, ASME "SA" or "SB" materials are standard but other material grades are available upon request.

4) All bellows material purchased by Thorburn are "mill annealed" in accordance with "A", "SA" or "SB" specifications. Thorburn does not perform any other heat treating operations before welding, after welding, before forming convolutions or after forming convolutions unless specified by purchaser. Heat treatment of bellows after forming convolutions can lower bellows' spring rate, "squirm" pressure and cycle life. Thorburn will cooperate with purchasers requiring heat treatment after forming to arrive at what effect the heat treatment will have on published bellows data.

NOTES

1. Rated cycle life is 2000 cycles for any one movement tabulated minimum per EJMA.
2. To combine axial, lateral or angular movements the sum of each must not exceed 100%. Refer to the specifications on pages 40 to 47.
3. To obtain greater movements or cycle life contact Thorburn.
4. Rated axial movement shown is for both compression or extension.
5. Maximum test pressure: 1-1/2 x rated working pressure.
6. Catalogue pressure ratings are based upon a design temperature range of - 20°F to 800°F (-29°C to 427°C). Actual operating temperature should always be specified.
7. For higher pressure temperature, movement and cycle ratings, contact Thorburn with your application details for fast action.

Dual Flex Bellows Specifications

Design Details				Non-Concurrent Movement		Spring Rate		Overall Length			Approximate Weight		Added Lateral Movement, Inches per Additional Inch of Spool
								End Style			End Style		
Size	Pressure	Series	Effective Area	Axial	Lateral	Axial	Lateral	FF	WW	EE	FF	WW	
in	psi	-	in^2	in	in	lbs/in	lbs/in	in	in	in	lbs	lbs	
2	25	S	6.1	1.25	3	315	18	12.4	16.4	14.4	12.4	4.2	0.43
		M	6.1	1.5	4	245	12	13.7	17.7	15.7	12.5	4.3	0.54
		L	6.1	1.875	5	200	8	14.9	18.9	16.9	12.7	4.5	0.51
	150	S	6.1	0.8	1.875	572	35	12.4	15.8	13.8	16.4	4.2	0.28
		M	6.2	1	2.25	978	56	13.0	16.4	14.4	16.5	4.3	0.32
		L	6.2	1.125	2.75	855	45	13.7	17.0	15.0	16.6	4.4	0.38
	300	S	6.3	0.7	1.625	2259	131	13.0	16.4	14.4	16.7	4.5	0.23
		M	6.3	0.81	1.875	1977	105	13.7	17.0	15.0	16.8	4.6	0.26
		L	6.3	0.9	2.25	1757	87	14.3	17.7	15.7	16.9	4.7	0.31
2.5	25	S	8.9	1.625	3.125	355	25	13.8	17.5	16.5	19.8	6.7	0.43
		M	8.9	2	4.25	276	16	15.4	19.1	18.1	20.1	6.9	0.54
		L	8.9	2.375	5.375	226	11	16.9	20.7	19.7	20.3	7.2	0.63
	150	S	9.0	1	2	825	66	13.7	16.7	15.7	23.7	6.6	0.28
		M	9.1	1.125	2.25	1611	118	14.5	17.5	16.5	24.1	7.0	0.31
		L	9.1	1.25	2.625	1410	94	15.3	18.3	17.3	24.3	7.2	0.31
	300	S	9.1	0.75	1.5	2256	201	12.9	15.9	14.9	23.8	6.7	0.22
		M	9.1	0.875	1.875	1880	151	13.7	16.7	15.7	24.0	6.9	0.27
		L	9.1	1	2.125	1611	118	14.5	17.5	16.5	24.1	7.0	0.29
3	25	S	13.3	2.25	4.5	236	17	16.5	20.2	20.2	23.8	9.6	0.51
		M	13.3	2.375	5	406	24	18.6	22.2	22.2	24.7	10.5	0.52
		L	13.3	2.875	5	332	17	20.6	24.3	24.3	25.2	11.0	0.57
	150	S	13.5	1.5	2.875	1213	99	16.5	19.1	19.1	32.0	9.8	0.34
		M	13.5	1.75	3.5	1040	77	17.5	20.2	20.2	32.3	10.0	0.40
		L	13.5	1.625	3.375	1715	115	18.6	21.2	21.2	33.0	10.8	0.37
	300	S	13.5	0.875	1.375	3431	355	14.5	17.1	17.1	31.9	9.6	0.18
		M	13.5	1	1.875	2745	253	15.5	18.1	18.1	32.2	9.9	0.23
		L	13.5	1.125	2.5	2287	189	16.5	19.1	19.1	32.5	10.2	0.30

Dual Flex Bellows Specifications

Design Details				Non-Concurrent Movement		Spring Rate		Overall Length			Approximate Weight		Added Lateral Movement, Inches per Additional Inch of Spool
								End Style			End Style		
Size	Pressure	Series	Effective Area	Axial	Lateral	Axial	Lateral	FF	WW	EE	FF	WW	
in	psi	-	in²	in	in	lbs/in	lbs/in	in	in	in	lbs	lbs	
3.5	25	S	16.7	2.375	4.25	262	24	16.7	20.2	21.2	28.9	11.4	0.48
		M	16.7	2.375	4.5	458	34	18.7	22.2	23.2	30.0	12.5	0.47
		L	16.7	2.75	5.5	375	23	20.8	24.3	25.3	30.5	13.0	0.53
	150	S	16.9	1.5	2.5	1370	141	16.6	19.1	20.1	41.2	11.7	0.30
		M	16.9	1.625	2.75	1174	109	17.7	20.2	21.2	41.4	12.0	0.31
		L	17.0	1.625	2.875	1943	163	18.7	21.1	22.2	42.3	12.8	0.31
	300	S	17.0	1	1.625	3109	360	15.6	18.1	19.1	41.3	11.8	0.20
		M	17.0	1.125	2	2591	268	16.6	19.1	20.1	41.6	12.2	0.24
		L	17.0	1.375	2.375	2221	207	17.7	20.2	21.2	42.0	12.5	0.27
4	25	S	20.8	2.625	5	263	22	19.2	22.6	24.6	35.4	15.0	0.49
		M	20.8	2.75	5.375	443	30	21.9	25.0	27.0	36.7	16.3	0.48
		L	20.8	3.375	6.5	362	21	24.1	27.5	29.5	37.3	16.9	0.53
	150	S	21.0	1.75	3.25	1361	123	19.7	21.9	23.9	56.7	15.3	0.32
		M	20.7	1.875	3.625	1369	108	21.0	23.3	25.3	57.0	15.6	0.34
		L	21.1	2.1	4	1879	132	22.8	25.0	27.0	58.2	16.8	0.36
	300	S	21.1	1.25	2.125	3007	300	18.6	20.9	22.9	56.9	15.5	0.22
		M	21.1	1.375	2.625	2506	221	20.0	22.2	24.2	57.3	15.9	0.26
		L	20.7	1.5	2.875	2731	210	21.4	23.6	25.6	57.6	16.2	0.27
6	25	S	45.8	4.125	5.5	227	34	21.6	24.5	30.5	57.5	29.0	0.48
		M	43.8	4.375	6	295	34	24.4	27.2	33.2	58.1	29.5	0.48
		L	44.8	6	10	404	37	28.2	31.1	37.1	59.7	31.2	0.71
	150	S	46.2	2.5	3.125	1208	212	20.7	22.5	28.9	97.2	28.7	0.29
		M	45.2	2.625	3.5	1293	196	22.2	24.1	30.1	97.7	29.9	0.31
		L	45.6	2.875	3.625	1550	207	24.0	25.8	31.8	99.7	31.1	0.30
	300	S	45.6	1.875	2.375	2923	550	19.7	21.5	27.5	96.1	27.6	0.23
		M	45.6	2.125	3	2339	384	21.3	23.2	29.2	97.0	28.4	0.27
		L	44.3	2.25	3.25	2768	388	22.9	24.8	30.8	97.3	28.8	0.28

Dual Flex Bellows Specifications

Design Details				Non-Concurrent Movement		Spring Rate		Overall Length			Approximate Weight		Added Lateral Movement, Inches per Additional Inch of Spool
								End Style			End Style		
Size	Pressure	Series	Effective Area	Axial	Lateral	Axial	Lateral	FF	WW	EE	FF	WW	
in	psi	-	in²	in	in	lbs/in	lbs/in	in	in	in	lbs	lbs	
8	25	S	72.9	4	5	290	60	23.0	25.5	35.5	90.7	44.9	0.40
		M	72.7	4.5	5.75	264	49	24.4	26.9	36.9	91.5	45.7	0.45
		L	71.6	4.75	6	289	48	25.7	28.2	38.2	91.9	46.1	0.45
	150	S	73.5	2.375	2.75	1540	370	22.4	23.6	33.6	146.3	44.5	0.24
		M	73.5	2.75	3.375	1284	275	23.9	25.1	35.1	174.4	45.6	0.28
		L	71.8	2.875	3.5	1521	286	25.5	26.6	36.6	147.8	46.1	0.27
	300	S	72.3	1.75	1.875	3985	1020	21.4	22.5	32.5	144.7	42.9	0.17
		M	72.3	2.125	2.5	3188	719	23.1	24.2	34.2	145.8	44.0	0.21
		L	72.1	2.5	3	2785	555	24.7	25.8	35.8	146.8	45.0	0.24
10	25	S	108.6	4	4	357	110	23.4	25.5	39.5	128.3	62.4	0.24
		M	108.6	4.625	4.75	312	87	24.8	26.9	40.9	129.4	63.6	0.16
		L	108.0	4.875	5	306	77	26.1	28.2	42.2	130.3	64.4	0.12
	150	S	109.3	2.625	2.5	1581	505	24.3	25.1	39.1	205.2	63.4	0.20
		M	108.2	2.75	3	1605	455	25.8	26.6	40.6	206.2	64.3	0.22
		L	106.8	2.875	3.25	1766	446	27.3	28.1	42.1	206.8	65.0	0.23
	300	S	108.0	1.625	1.5	4701	1799	21.8	22.5	36.5	201.9	60.1	0.13
		M	108.0	2	2	3761	1268	23.4	24.2	38.2	203.3	61.4	0.17
		L	108.1	2.5	2.375	3087	923	25.1	25.8	39.8	204.7	62.8	0.19
12	25	S	155.7	6.125	5.625	366	110	29.6	31.2	49.2	186.4	83.1	0.38
		M	157.2	6.5	5.875	420	111	31.9	33.5	51.5	192.5	89.2	0.38
		L	154.7	6.75	6	472	109	34.1	35.7	53.7	193.6	90.3	0.36
	150	S	154.9	3.5	3	1822	685	27.4	27.7	45.7	285.2	79.9	0.23
		M	152.2	3.625	3.375	2014	639	29.8	30.0	48.0	286.6	81.2	0.24
		L	153.6	4.75	4.5	2459	643	33.1	33.4	51.4	289.5	84.1	0.29
	300	S	150.8	2.125	1.875	5902	2443	25.7	25.9	43.9	281.3	76.0	0.15
		M	150.8	2.625	2.375	4722	1647	28.2	28.4	46.4	283.5	78.2	0.18
		L	150.3	3.125	3	4208	1248	30.6	30.9	48.9	285.5	80.2	0.21

Dual Flex Bellows Specifications

Design Details				Non-Concurrent Movement		Spring Rate		Overall Length			Approximate Weight		Added Lateral Movement, Inches per Additional Inch of Spool
								End Style			End Style		
Size	Pressure	Series	Effective Area	Axial	Lateral	Axial	Lateral	FF	WW	EE	FF	WW	
in	psi	-	in²	in	in	lbs/in	lbs/in	in	in	in	lbs	lbs	
14	25	S	186.5	5.75	5	395	163	27.5	29.0	51.0	242.4	89.6	0.36
		M	184.6	6.5	5.5	398	142	29.7	31.2	53.2	244.2	91.4	0.38
		L	186.6	7	6	441	139	32.0	33.5	55.5	251.2	98.3	0.38
	150	S	183.2	2.875	2.125	906	880	25.3	25.3	47.3	387.8	84.9	0.17
		M	183.2	3.375	2.75	2065	918	27.7	27.7	49.7	390.5	87.7	0.21
		L	181.4	3.75	3.125	2050	775	30.0	30.0	52.0	392.5	89.7	0.22
	300	S	179.3	1.625	1.125	8449	5000	23.4	23.4	45.4	384.0	81.2	0.10
		M	179.3	2.25	1.625	6337	3117	25.9	25.9	47.9	386.5	83.6	0.13
		L	179.3	2.875	2.375	5070	2102	28.4	28.4	50.4	388.9	86.1	0.18
16	25	S	237.9	5.375	3.625	285	166	26.5	27.5	53.5	277.3	96.4	0.28
		M	238.0	5.75	4.5	446	222	29.0	30.0	56.0	283.8	102.9	0.32
		L	238.2	4.75	6	568	243	31.4	32.4	58.4	290.3	109.5	0.40
	150	S	234.7	2.875	1.875	2807	1802	26.5	26.0	52.0	486.5	97.6	0.15
		M	234.7	3.5	2.5	2246	1214	29.0	28.5	54.5	489.8	100.9	0.18
		L	232.3	3.75	2.875	2302	1050	31.5	31.0	57.0	491.9	103.0	0.20
	300	S	229.9	0.875	1.25	5666	2862	29.7	29.2	55.2	487.7	98.9	0.09
		M	229.9	1	1.5	4722	2023	32.3	31.8	57.8	490.6	101.7	0.10
		L	226.5	1.4	2	5706	2067	35.0	34.5	60.5	491.6	102.8	0.12
18	25	S	295.7	5	3.75	314	181	28.9	29.5	59.5	345.3	120.4	0.25
		M	295.9	5.75	4.5	495	247	31.4	32.0	62.0	352.6	127.7	0.28
		L	296.0	6	4.75	631	276	33.8	34.4	64.4	360.0	135.1	0.28
	150	S	291.7	2.5	2	3207	2007	29.0	28.0	58.0	592.5	121.7	0.14
		M	291.7	3	2.5	2566	1380	31.5	30.5	60.5	596.2	125.3	0.16
		L	291.7	3.75	3.125	2138	998	34.0	33.0	63.0	599.8	128.9	0.19
	300	S	290.9	0.875	1.25	7671	4564	29.7	28.7	58.7	593.8	123.0	0.08
		M	290.9	1.125	1.625	6137	3113	32.4	31.4	61.4	597.8	126.9	0.10
		L	290.9	1.375	2.125	5114	2235	35.1	34.1	64.1	601.7	130.8	0.13

Dual Flex Bellows Specifications

Design Details				Non-Concurrent Movement		Spring Rate		Overall Length			Approximate Weight		Added Lateral Movement, Inches per Additional Inch of Spool
								End Style			End Style		
Size	Pressure	Series	Effective Area	Axial	Lateral	Axial	Lateral	FF	WW	EE	FF	WW	
in	psi	-	in^2	in	in	lbs/in	lbs/in	in	in	in	lbs	lbs	
20	25	S	359.8	3.875	3.5	344	137	35.3	35.5	69.5	464.1	173.2	0.17
		M	360.0	4	4.125	543	194	37.7	38.0	72.0	472.2	181.3	0.19
		L	360.0	7	5	465	151	40.1	40.3	74.3	476.0	185.1	0.23
	150	S	354.6	2.625	3	2969	1117	38.0	36.5	70.5	769.1	178.3	0.24
		M	354.6	3.25	3.75	2474	837	40.5	39.0	73.0	773.1	182.2	0.17
		L	354.6	4.25	4	2855	864	43.2	41.7	75.7	780.5	189.6	0.18
	300	S	358.7	1.875	2.125	10847	3959	38.9	37.4	71.4	785.9	195.0	0.10
		M	358.7	2.25	2.625	9039	2947	41.6	40.1	74.1	793.0	202.1	0.12
		L	358.7	2.625	3	7748	2269	44.3	42.8	76.8	800.0	209.2	0.13
22	25	S	430.4	5	4	709	336	35.9	37.6	73.6	522.4	209.8	0.20
		M	430.4	6	5	591	253	38.2	40.0	76.0	526.6	241.1	0.24
		L	430.4	7	6	507	197	40.6	42.3	78.3	530.8	218.3	0.27
	150	S	427.5	2.75	2.25	4609	2324	36.1	36.1	72.1	892.1	209.6	0.11
		M	427.5	3.25	2.75	3687	1661	38.6	38.6	74.6	897.2	214.7	0.13
		L	427.5	4	3.5	3072	1242	41.1	41.1	77.1	902.3	219.8	0.16
	300	S	429.0	0.625	1.125	9913	3865	42.1	42.1	78.1	919.5	237.0	0.05
		M	429.0	0.75	1.375	8497	2975	44.8	44.8	80.8	927.2	244.7	0.06
		L	429.0	1	2	7435	2349	47.5	47.5	83.5	935.0	252.5	0.08
24	25	S	507.1	6	4.75	775	364	40.1	41.6	81.6	608.0	230.7	0.29
		M	507.1	7	6	646	268	43.3	44.8	84.8	612.9	235.7	0.26
		L	507.1	8.25	7	554	204	46.4	47.9	87.9	617.8	240.6	0.29
	75	S	503.9	1.375	2.125	4940	2549	39.7	39.3	79.3	1147.7	230.5	0.10
		M	503.9	1.625	2.75	3952	1774	43.0	42.6	82.6	1153.6	236.4	0.12
		L	503.9	2	3.5	3293	1297	46.3	45.9	85.9	1159.6	242.4	0.15
	150	S	510.6	1.25	0.75	29631	13050	43.8	43.4	83.4	1173.8	256.6	0.03
		M	510.6	1.75	1	24693	9498	47.3	46.9	86.9	1183.5	266.3	0.04
		L	510.6	3	2	21165	7165	50.7	50.4	90.4	1193.2	276.0	0.08

Dual Flex Bellows Specifications

Design Details				Non-Concurrent Movement		Spring Rate		Overall Length			Approximate Weight		Added Lateral Movement, Inches per Additional Inch of Spool
								End Style			End Style		
Size	Pressure	Series	Effective Area	Axial	Lateral	Axial	Lateral	FF	WW	EE	FF	WW	
in	psi	-	in²	in	in	lbs/in	lbs/in	in	in	in	lbs	lbs	
26	25	S	595.3	6.5	5.5	656	313	40.2	43.6	87.6	360.9	269.0	0.23
		M	595.3	7.5	6.5	547	232	43.4	46.8	90.8	366.6	274.7	0.26
		L	595.3	8	7	693	262	46.6	50.0	94.0	378.7	286.8	0.27
	75	S	596.7	5.25	4.25	1651	875	37.6	41.0	85.0	355.5	263.6	0.19
		M	596.7	6.5	5.5	1321	617	40.9	44.3	88.3	361.2	269.3	0.23
		L	597.1	7	6	1621	667	44.3	47.7	91.7	372.6	280.7	0.24
	150	S	598.6	3.75	3.75	3660	1891	45.1	41.7	85.7	999.6	267.7	0.16
		M	598.6	4.5	5	2928	1326	48.5	45.2	89.2	1006.3	274.4	0.21
		L	593.2	6	5	3072	1217	52.0	48.6	92.6	1010.5	278.6	0.20
28	25	S	684.9	5.75	5	697	383	40.5	43.6	91.6	386.6	290.0	0.21
		M	684.9	7.5	5.5	581	284	43.6	46.8	94.8	392.7	296.1	0.22
		L	685.2	8	6	737	321	46.9	50.0	89.0	405.7	309.2	0.23
	75	S	686.4	5.25	3.75	1749	1067	37.9	41.0	89.0	380.7	284.1	0.16
		M	686.4	6.25	4.75	1399	752	41.1	44.3	92.3	389.9	290.3	0.20
		L	686.8	6.75	5.25	1722	815	44.5	47.7	95.7	399.1	302.5	0.21
	150	S	688.5	2.5	3.375	3883	2308	45.5	41.7	89.7	1115.1	288.6	0.15
		M	688.5	3	4.25	3107	1818	48.9	45.2	93.2	1122.3	295.8	0.18
		L	682.7	4.75	6	3258	1485	52.4	48.6	96.6	1126.8	300.3	0.24
30	25	S	780.9	6.5	4.5	738	462	40.7	43.9	95.6	412.2	311.0	0.19
		M	780.9	7.75	5.5	615	343	43.9	46.8	98.8	418.8	317.5	0.22
		L	781.1	8	5.75	781	388	47.1	50.0	102.0	432.7	331.5	0.22
	75	S	782.9	4.5	3	2734	1891	38.3	41.2	93.2	410.4	309.1	0.13
		M	782.9	5.5	4	2187	1331	41.9	44.4	96.4	418.0	316.7	0.17
		L	782.9	6.5	5	1823	983	44.8	47.1	99.7	425.7	324.4	0.20
	150	S	784.7	1.375	2	4106	2782	46.2	41.7	93.7	1330.7	309.4	0.09
		M	784.7	1.75	2.5	3285	1950	49.6	45.2	97.2	1338.4	317.1	0.10
		L	778.5	5.25	4.5	3443	1790	53.0	48.6	100.6	1343.2	322.0	0.18

Dual Flex Bellows Specifications

Design Details				Non-Concurrent Movement		Spring Rate		Overall Length			Approximate Weight		Added Lateral Movement, Inches per Additional Inch of Spool
								End Style			End Style		
Size	Pressure	Series	Effective Area	Axial	Lateral	Axial	Lateral	FF	WW	EE	FF	WW	
in	psi	-	in²	in	in	lbs/in	lbs/in	in	in	in	lbs	lbs	
32	25	S	883.1	6.5	4.25	779	552	41.1	43.5	99.6	457.9	331.9	0.18
		M	883.1	7	9	649	409	44.3	46.8	102.8	464.9	338.9	0.20
		L	883.3	8	5.5	825	463	47.5	50.0	106.0	479.8	353.8	0.21
	75	S	885.2	4.5	2.875	2885	2256	38.7	41.2	97.2	455.9	329.9	0.13
		M	885.2	5.5	3.75	2308	1588	41.9	44.4	100.4	464.0	338.1	0.16
		L	885.2	6.5	4.75	1923	1173	45.2	47.7	103.7	472.2	346.2	0.19
	150	S	884.5	1.75	2.25	4734	3615	47.0	41.7	97.7	1615.4	329.4	0.10
		M	884.5	2.25	3	3787	2534	50.4	45.2	101.2	1623.4	337.5	0.12
		L	880.5	3.75	4.25	3628	1233	53.8	48.6	104.6	1629.6	343.7	0.17
34	25	S	991.5	6.25	4	820	652	41.4	43.9	103.6	483.9	352.9	0.17
		M	991.5	7.5	5	683	483	44.5	46.8	106.8	491.0	360.3	0.20
		L	991.5	8	6	585	371	47.5	49.9	109.9	498.4	367.8	0.23
	75	S	993.8	4.375	2.75	3035	2665	38.9	41.2	101.2	481.4	350.8	0.12
		M	993.8	5.5	3.5	2428	1876	42.2	44.4	104.4	490.1	359.4	0.15
		L	993.8	6.5	4.375	2024	1385	45.5	47.7	107.7	498.7	368.1	0.17
	150	S	993.0	0.875	1.125	4975	4266	47.3	41.7	101.7	1760.9	350.2	0.05
		M	993.0	1.125	1.375	3980	2991	50.8	45.2	105.2	1769.4	358.8	0.06
		L	988.9	2.375	3	3812	2518	54.2	48.6	108.6	1776.0	365.3	0.12
36	25	S	1113.7	6.5	4	695	621	42.4	43.6	107.6	571.7	376.4	0.17
		M	1113.7	7.5	5	579	460	45.5	46.8	110.8	580.1	384.8	0.20
		L	1114.0	8	5.5	738	523	48.8	50.0	114.0	597.9	402.5	0.21
	75	S	1116.1	5	2.75	2577	2541	39.9	41.2	105.2	569.2	373.9	0.12
		M	1116.1	6	3.75	2062	1789	43.2	44.4	108.4	579.0	383.7	0.16
		L	1116.1	7	4.5	1718	1321	46.5	47.7	111.7	588.8	393.5	0.18
	150	S	1119.7	4.25	2.375	6796	6471	48.4	42.1	106.1	1969.5	384.2	0.10
		M	1119.7	5.25	3.25	5437	4525	51.9	45.6	109.6	1981.6	396.3	0.13
		L	1119.7	6.5	4	4531	3320	55.4	49.2	113.2	1993.8	408.4	0.16

Dual Flex Bellows Specifications

Design Details				Non-Concurrent Movement		Spring Rate		Overall Length			Approximate Weight		Added Lateral Movement, Inches per Additional Inch of Spool
								End Style			End Style		
Size	Pressure	Series	Effective Area	Axial	Lateral	Axial	Lateral	FF	WW	EE	FF	WW	
in	psi	-	in^2	in	in	lbs/in	lbs/in	in	in	in	lbs	lbs	
38	25	S	1235.1	7	4.25	728	630	44.6	49.6	113.6	642.5	472.5	0.17
		M	1235.1	7.5	5	607	470	47.8	52.8	116.8	651.4	481.3	0.19
		L	1235.4	8	5.75	774	539	51.0	56.0	120.0	670.1	500.1	0.21
	75	S	1237.7	4.75	3	2700	2560	42.2	47.2	111.2	639.9	469.9	0.12
		M	1237.7	6	3.75	2160	1819	45.4	50.4	114.4	650.2	480.2	0.15
		L	1237.7	7	4.75	1800	1353	48.7	53.7	117.7	660.5	490.5	0.18
	150	S	1241.4	4	2.5	7120	6536	51.2	48.1	112.1	2160.7	480.7	0.10
		M	1241.4	5.25	3.25	5696	4613	54.8	51.6	115.6	2173.5	493.5	0.12
		L	1241.4	6.25	4	4746	3413	58.3	55.2	119.2	2186.3	506.3	0.15
40	25	S	1363.2	6	3.5	1136	1081	45.0	49.7	117.7	687.2	505.2	0.14
		M	1363.2	7	4.5	947	807	48.1	52.9	120.9	697.9	515.9	0.17
		L	1363.2	8	5.5	811	623	51.2	56.0	124.0	708.7	526.6	0.20
	75	S	1365.5	4.5	2.75	2822	2952	42.4	47.2	115.2	676.9	494.9	0.11
		M	1365.5	5.75	3.5	2258	2097	45.7	50.4	118.4	687.7	505.7	0.14
		L	1365.5	7	4.5	1881	1561	49.0	53.7	121.7	698.6	516.5	0.17
	150	S	1369.5	4	2.375	7445	7540	51.7	48.1	116.1	2328.3	506.2	0.10
		M	1369.5	5	3	5956	5321	55.3	51.6	119.6	2341.7	519.7	0.11
		L	1369.5	6	3.75	4963	3937	58.8	55.2	123.2	2355.2	533.2	0.14
42	25	S	1505.8	6.75	4	977	904	47.2	51.7	123.7	765.7	561.7	0.15
		M	1505.8	8	5	814	680	50.4	54.9	126.9	777.7	573.6	0.18
		L	1505.8	9	6	698	529	53.5	58.0	130.0	789.7	585.6	0.21
	75	S	1509.4	4.5	2.625	4333	4347	44.9	49.4	121.4	766.1	562.1	0.10
		M	1509.4	5.75	3.5	3466	3107	48.3	52.8	124.8	780.9	576.9	0.13
		L	1509.4	6.75	4.25	2888	2325	51.6	56.1	128.1	795.7	591.7	0.15
	150	S	1512.4	1.5	1.875	6417	6298	54.2	50.1	122.1	2666.8	562.7	0.07
		M	1512.4	1.875	2.25	5134	4481	57.8	53.6	125.6	2681.8	577.7	0.08
		L	1512.4	2.375	2.75	4278	3340	61.3	57.2	129.2	2696.7	592.7	0.09

Dual Flex Bellows Specifications

Design Details				Non-Concurrent Movement		Spring Rate		Overall Length			Approximate Weight		Added Lateral Movement, Inches per Additional Inch of Spool
								End Style			End Style		
Size	Pressure	Series	Effective Area	Axial	Lateral	Axial	Lateral	FF	WW	EE	FF	WW	
in	psi	-	in²	in	in	lbs/in	lbs/in	in	in	in	lbs	lbs	
44	25	S	1646.5	6.75	3.875	1021	1034	48.0	51.7	127.7	874.7	588.6	0.14
		M	1646.5	8	4.75	851	777	51.1	54.9	130.9	887.3	601.2	0.17
		L	1646.5	9	5.75	729	604	54.2	58.0	134.0	899.8	613.7	0.19
	75	S	1650.2	4.5	2.625	4530	4969	45.6	49.4	125.4	875.1	589.0	0.10
		M	1650.2	5.625	3.25	3624	3552	49.0	52.8	128.8	890.6	604.6	0.12
		L	1650.2	6.75	4	3020	2658	52.4	56.1	132.1	906.2	620.1	0.14
	150	S	1644.4	2.5	2.375	8151	8697	55.0	50.1	126.1	2882.3	586.3	0.09
		M	1644.4	3	2.875	6521	6188	58.5	53.6	129.6	2897.2	601.1	0.10
		L	1644.4	3.75	3.75	5434	4612	62.0	57.2	133.2	2912.0	615.9	0.13
46	25	S	1802.9	7.5	4.25	885	871	50.2	53.7	133.7	957.7	649.6	0.15
		M	1802.9	9	5	738	659	53.4	56.9	136.9	971.6	663.5	0.16
		L	1802.9	10	6	632	515	56.5	60.0	140.0	985.4	677.3	0.19
	75	S	1806.8	5	2.875	3933	4172	47.9	51.4	131.4	958.1	650.0	0.10
		M	1806.8	6.25	3.75	3147	3003	51.3	54.8	134.8	975.2	667.1	0.13
		L	1806.8	7.5	4.5	2622	2262	54.6	58.1	138.1	992.3	684.2	0.15
	150	S	1791.3	1.75	2	8503	8741	57.6	52.1	132.1	3401.5	643.4	0.07
		M	1791.3	2.25	2.625	6802	6264	61.1	55.6	135.6	3417.0	658.9	0.09
		L	1791.3	2.625	3.25	5669	4699	64.7	59.2	139.2	3432.5	674.4	0.10
48	25	S	1956.5	7	4	922	984	50.5	53.7	137.7	1028.2	678.1	0.14
		M	1956.5	9	5	768	745	53.6	56.9	140.9	1042.7	692.5	0.16
		L	1956.5	10	6	659	582	56.8	60.0	144.0	1057.1	707.0	0.19
	75	S	1960.6	5	2.75	4097	4715	48.2	51.4	135.4	1028.6	678.4	0.10
		M	1960.6	6.25	3.5	3278	3394	51.5	54.8	138.8	1046.4	696.3	0.12
		L	1960.6	7.5	4.25	2731	2556	54.9	58.1	142.1	1064.3	714.2	0.14
	150	S	1944.5	1.125	1.25	8855	9881	57.7	52.1	136.1	3631.7	671.6	0.04
		M	1944.5	1.375	1.625	7084	7081	61.3	55.6	139.6	3647.9	687.8	0.05
		L	1944.5	1.75	2	5903	5312	64.8	59.2	143.2	3664.1	703.9	0.06

Dual Flex Bellows Specifications

Design Details				Non-Concurrent Movement		Spring Rate		Overall Length			Approximate Weight		Added Lateral Movement, Inches per Additional Inch of Spool
Size	Pressure	Series	Effective Area	Axial	Lateral	Axial	Lateral	End Style			End Style		
								FF	WW	EE	FF	WW	
in	psi	-	in^2	in	in	lbs/in	lbs/in	in	in	in	lbs	lbs	
50	25	S	2282.7	6	4.375	667	667	54.8	57.7	145.7	1154.6	772.5	0.15
		M	2282.7	7.75	5.25	829	761	58.0	60.9	148.9	1169.7	787.5	0.17
		L	2282.7	9	6.25	711	600	61.1	64.0	152.0	1184.7	802.6	0.2
	50	S	2469.3	7.5	4.25	2148	2498	55.6	58.4	146.4	1159.4	777.2	0.14
		M	2469.3	9	5	1719	1821	58.8	61.7	149.7	1175.3	793.2	0.16
		L	2469.3	10	6	1228	1092	62.1	65.0	153.0	1191.3	809.2	0.19
	75	S	3029.6	6.25	3.75	2825	3602	56.3	59.2	147.2	1160.0	777.9	0.11
		M	3029.6	7.5	4.75	2354	2737	59.7	62.6	150.6	1176.1	794.0	0.14
		L	3029.6	9	5.5	2018	2147	63.1	66.0	154.0	1192.2	810.1	0.15
52	25	S	3425.8	6.75	3.25	1840	2748	55.4	57.9	149.9	1241.6	827.4	0.1
		M	3425.8	8	4	1533	2100	58.6	61.1	153.1	1261.8	847.6	0.12
		L	3425.8	9.25	4.75	1314	1655	16.7	64.2	156.2	1282	867.8	0.14
	50	S	3641.1	6.75	3.25	3744	5799	56.3	58.8	150.8	1242.7	828.5	0.1
		M	3641.1	8	4	3120	4415	59.6	62.1	154.1	1263.0	848.9	0.12
		L	3641.1	9.5	4.75	2674	3468	63.0	65.5	157.5	1283.4	869.3	0.13
	75	S	4083.7	2.5	2.25	3273	5625	56.7	59.2	151.2	1223.4	809.2	0.07
		M	4083.7	3.25	2.75	2728	4275	60.1	62.6	154.6	1240.1	825.9	0.08
		L	4083.7	4.5	4	2338	3353	63.5	66.0	158.0	1256.9	842.7	0.11
54	25	S	4306	6.5	2.875	2062	3870	55.8	57.9	153.9	1325.7	859.5	0.09
		M	4306	8	3.5	1718	2957	58.9	61.1	157.1	1346.6	880.4	0.1
		L	4306	9.25	4.125	1473	2331	62.1	64.2	160.2	1367.6	901.4	0.12
	50	S	5292.4	6.75	2.5	4507	10148	56.6	58.8	154.8	1326.7	860.5	0.08
		M	5292.4	8	3.25	3856	7725	60.0	62.1	158.1	1347.9	881.7	0.09
		L	5292.4	9	3.75	3220	6069	63.3	65.5	161.5	1369.1	902.9	0.11
	75	S	20165.5	3.75	1.875	9291	48583	68.4	70.5	166.5	1528.4	1062.2	0.04
		M	20165.5	4.5	2.375	7743	37458	72.1	74.2	170.2	1554.3	1088.1	0.05
		L	20165.5	5.5	2.75	6637	29777	75.8	77.9	173.9	1580.2	1113.9	0.06

Extra Flex™ Series EFS and EFD Externally Pressurized Bellows

Fully assembled Thorburn Extra-Flex™ Series EFD

Advantages

Full thickness cover
Thorburn's Extra-Flex™ cover contains the full line pressure of the system, thus if bellows failure were to occur, the media could not escape radially outward and harm personnel in the area.

Self draining
Thorburn's Extra-Flex™ convolutions make it impossible for media collection in the bellows to cause any corrosive attack on the bellows element. The sediment or residue collects at the bottom of the casing for easy venting.

Purge and drain connector
Thorburn's Extra-Flex™ vent to assure fluid filled line and allow draining of any sediment.

Reduce installation costs
Thorburn's Extra-Flex™ bellows element is completely enclosed and there are no critical surfaces that require special precautions when handling the expansion joint during installation.

None of the slip joint disadvantages
Thorburn Extra-Flex™ does not require maintenance or need lubrication or repacking, therefore making it ideal in areas where accessibility is limited.

Thorburn's Extra Flex™ externally pressurized bellows expansion joints are used to absorb large amount of axial movement in high pressure piping systems. The unique feature of Extra Flex is the transfer of pressure outside of the bellows, which eliminate the possibility of pressure imbalance due to high pressure that can occur on internally pressurized bellows. The bellows is incased into a larger pressure retaining shell that protects the flexible element from possible damages.

- Absorbs up to 400 mm of axial movement
- Pressures up to 50 BAR
- Temperatures up to 816°C
- Sizes - 25 mm to 1500 mm
- Ideal for long steam pipe run – high pressure/steam containment with lots of axial movement
- Superior alternate to slip joints

Features

- High cycle life movement and pressure.
- Intermediate anchor base
- Drain connector to remove water
- Leak proof – no packing
- Maintenance free
- Can be direct buried
- Self guiding

Applications

- Replaces costly equalizing expansion joint system
- Replaces space confining pipe loop
- Replaces maintenance required slip joints
- Ideal for long pipe run steam lining that require high pressure/temperature containment with lots of axial movement

Extra Flex™ Single Bellows Style EFS

Extra Flex™ Double Bellows Style EFD

Extra Flex™ Series EFS and EFD Externally Pressurized Bellows

Thorburn's Extra Flex™ Series EFS single expansion joint is normally located near an anchor at one end of a long piping run. Model EFS expansion joint should be placed with the fixed end adjacent to the anchor.

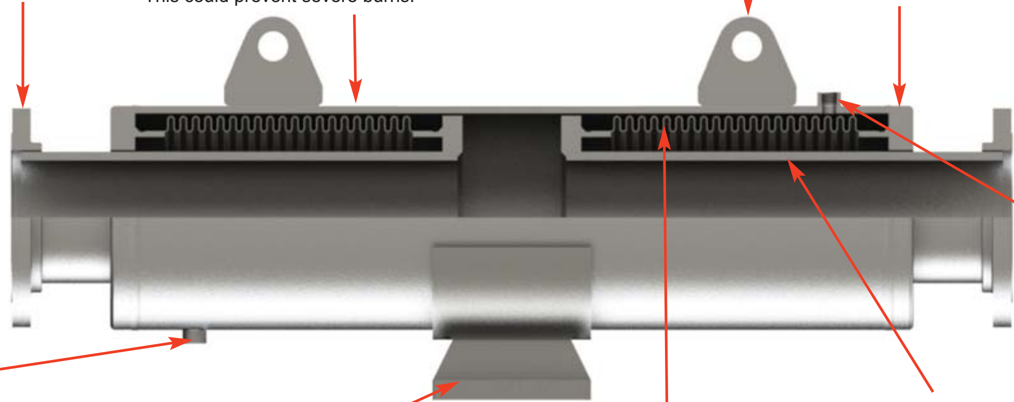
Thorburn's Extra Flex™ Series EFD double bellows may be considered as two single "EFS" expansion joints mounted back-to-back and connected by a common casing. Thorburn Model EFD is installed in the center of a long piping run and is supplied with a support foot which acts as an intermediate anchor.

Flanges
Standard design incorporates raised face slip-on type flanges manufactured to ANSI B16.5 requirements. Carbon steal is standard material. Other materials can also be used for corrosive or extremely high temperature service.

Shroud
An integral, dual purpose component engineered to maintain full system pressure. The shroud will suppress the rapid escapement of hot gases should the bellows suddenly fail. This could prevent severe burns.

Lifting Lugs
Use only designated lifting lugs to lift expansion joints during instalation.

Guides
Both internal and external function as a means to accurately allow bellows to accept thermal expansion or contraction. Additionally maintains bellows stability and prevents abrasive contact between belows and shroud.



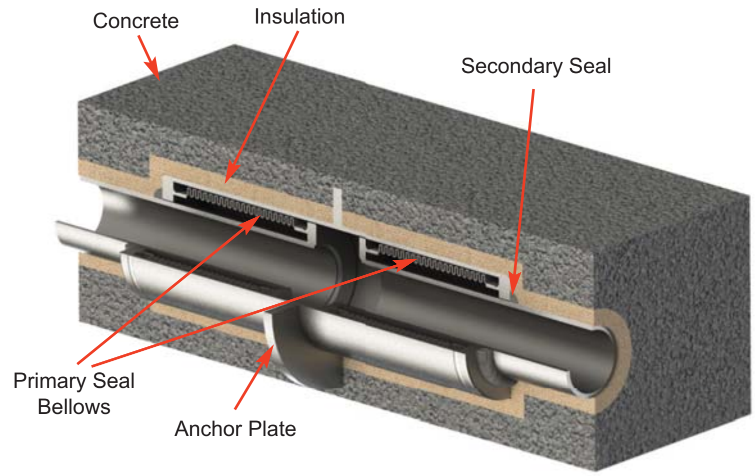
Drain
Optional device used to remove fluids when the system is down. A similar device called a purge port can be located on top of the shroud and used in conjuction with the drain to flush out the expansion joint or to purge trapped gasses.

Base
Designed for use as an intermediate anchor or support, it is a standard and integral part on a double expansion joint and optional on single units. The base can be designed to function as a main anchor if necessary.

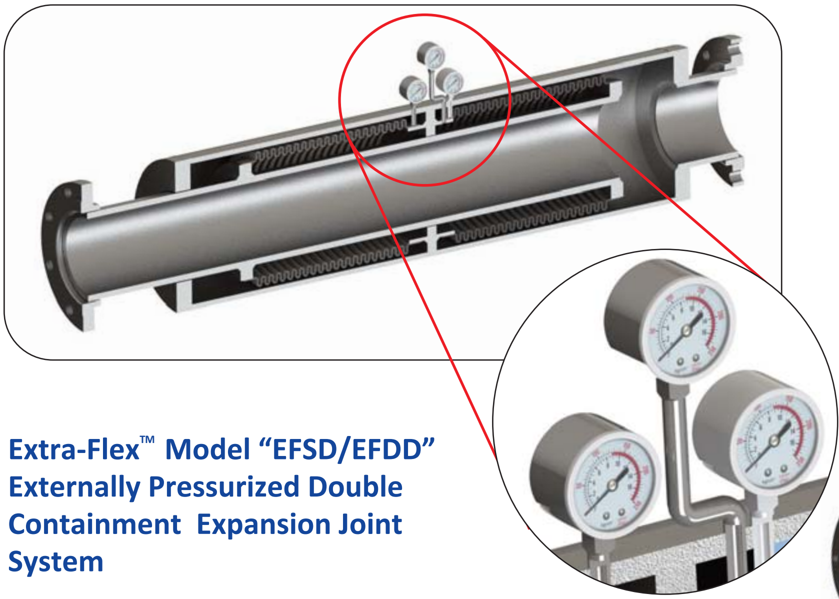
Bellows
Highly engineered design incorporating the use of a multi-ply construction using A240T321 stainless steel as a design standard. Bellows can be manufactured from a wide selection of materials to meet the corrosive, pressure and temperature demands of any system.

Internal Liner
Provided as a standard, it controls flow-induced vibration and functions as the working leg of the Extra-Flex expansion joint as the piping system creates thermal expansion or contraction. Flow is possible from either direction and makes the Extra-Flex expansion joint highly suitable for reverse flow piping systems.

Extra Flex™ - Direct Buried
Thorburn Extra Flex™ expansion joints can be directly buried in steam and condensated service. This eliminates the need for maintenance man-ways which are inconvenient to locate and expensive to build. Years of dependable maintenance free buried service have proven that man-ways are not always required nor are they cost effective. Choose Extra Flex™ money saving approach when comparing the total installed cost of slip joints versus Thorburn Extra Flex™.



Extra Flex™ Series EFSD and EFDD Externally Pressurized Bellows



Extra-Flex™ Model “EFSD/EFDD” Externally Pressurized Double Containment Expansion Joint System

Thorburn’s Extra Flex™ Series EFSD/EFDD is designed to transfer lethal medias where failure of the expansion joint would have serious consequences.

The main bellows is externally pressurized and acts as flexible pressure containment seal. A secondary bellows seals the opening between the inlet pipe line and the bellows outer cover shield. Each bellows seal has an additional secondary ply that can contain the full design conditions of pressure, temperature and media.

Thorburn’s Extra Flex™ Series EFSD/EFDD expansion joint system incorporates an external leak detector systems so that failure of the first bellows sealing ply will be detected immediately. This failure will not result in any media exposure outside the expansion joint system. Three additional containment systems with separate monitoring devices supports the expansion joint and allows the system to continue operating without any risk of injury.

Thorburn’s Extra Flex™ Series EFSD/EFDD expansion joint system can be monitored in this state and used indefinitely with upmost security or until a scheduled shutdown of the system allowing for orderly replacement.

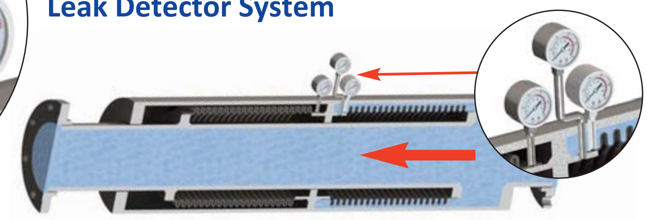
Features

- Absorbs up to 400 mm of axial movement
- Pressures up to 50 BAR
- 4 separate pressure containment compartments
- Leak detection system
- Sizes - 25 mm to 1500 mm

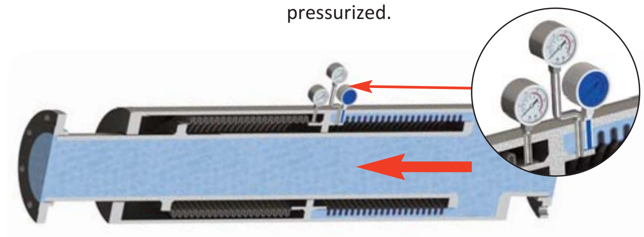
How Thorburn Extra Flex™ EFSD/EFDD Works

Thorburn’s Extra Flex™ Series EFSD/EFDD external pressurized bellows expansion joints are used to absorb large amount of axial movement in high pressure piping systems. The unique feature of this type of expansion joint is the transfer of pressure outside of the bellows, which eliminate the possibility of pressure imbalance due to high pressure that can occur on internal pressurized bellows. The bellows it is incased into a larger pressure retaining shell that protects the flexible element from possible damages.

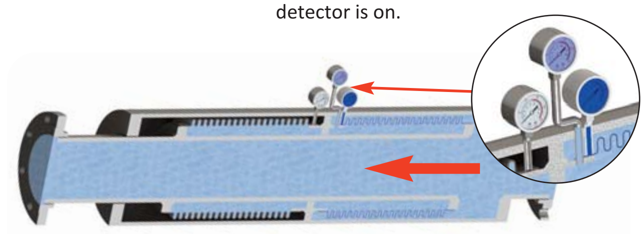
Leak Detector System



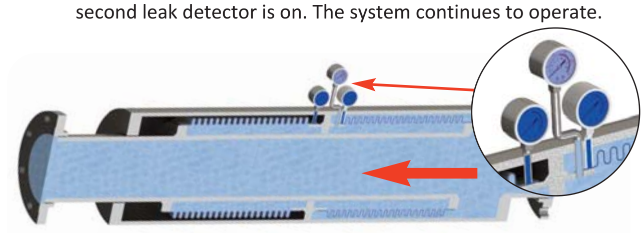
Normal operating conditions: Main bellows is externally pressurized.



First Safety Shield: If the main bellows outer ply develops a leak. Pressure is contained by bellows second ply. The first leak detector is on.



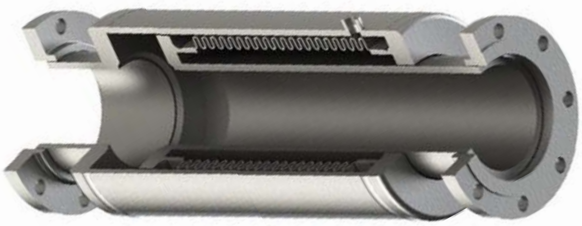
Second First Safety Shield: If both plies of the main bellows are leaking, pressure is contained by secondary 2 ply bellows. the second leak detector is on. The system continues to operate.



Third Safety Shield: If the secondary seal bellows first ply is leaking, pressure is contained by the second ply of the secondary bellows. Third leak detector on. The system continues to operate without external leakage.

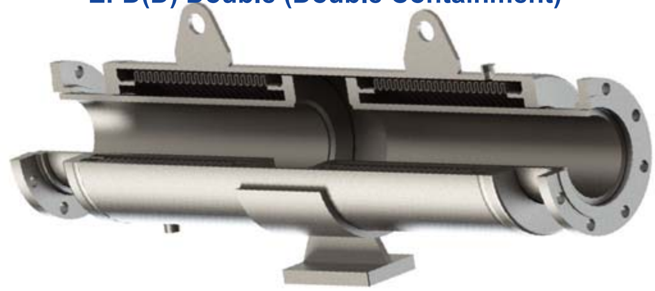
Thorburn Extra Flex™ - Styles

EFS(D) Single (Double Containment)



Codes “EFS” “EFSD”

EFD(D) Double (Double Containment)



Code “EFD” “EFDD”

Thorburn Extra Flex™ - Ends

Flange/Flange Ends

Code “FF”

Flange/Weld Ends

Code “FW”

Weld/Weld Ends

Code “WW”

Thorburn Extra Flex™ Optional Features

Drain With Plug Connector

1/2” NPT Coupling

Code “D”

Purge With Plug Connector

1/2” NPT Plug

Code “P”

Extra Anchor Base

Code “IB”

How To Order Thorburn Extra Flex™

Nominal Size	Model	Series	Ends	Pressure (PSI)	Axial Movement	Bellows Material	Ends Material	Spool/Shell Material	Anchor Material	Length	Option
2	- EFS	- L	- WW	- 300	- 4	- B5	- E1	- S1	- A1	- 39	- D
2" I.D.	Extra Flex Single	Long Series	Weld End	300 PSI	4"	321SS	304SS	304SS	304SS	39"	Drain With
DN50				20 bar	100 mm					991 mm	Connector Plug

Thorburn Material Code				ASTM/ASME(S) Material Designation	Material Type
Bellows (B)	Liner (L)	End (E)	Spool (S)		
B-0	L-0	E-0	S-0	(S)A36/44W	Carbon Steel
B-1	L-1	E-1	S-1	(S)A-240	SS304
B-2	L-2	E-2	S-2	(S)A-240	SS304L
B-3	L-3	E-3	S-3	(S)A-240	SS316
B-4	L-4	E-4	S-4	(S)A-240	SS316L
B-5	L-5	E-5	S-5	(S)A-240	SS321
B-6	L-6	E-6	S-6	(S)A-240	SS309
B-7	L-7	E-7	S-7	(S)A-240	SS310
B-8	L-8	E-8	S-8	(S)B-127	Monel 400
B-9	L-9	E-9	S-9	(S)B-168	Inconel 600
B-10	L-10	E-10	S-10	(S)B-443	Inconel 625
B-11	L-11	E-11	S-11	(S)B-409	Incoloy 800
B-12	L-12	E-12	S-12	(S)B-424	Incoloy 825
B-14	L-14	E-14	S-14	(S)B-409	Incoloy 800HT
B-15	L-15	E-15	S-15	(S)B-162	Nickel 201
B-16	L-16	E-16	S-16	(S)B-575	Inco C276
B-17	L-17	E-17	S-17	(S)B-364	Tantalum
B-18	L-18	E-18	S-18	(S)B-265	Titanium Gr. 1
B-19	L-19	E-19	S-19	(S)B-364	Zirconium Gr. 702
B-20	L-20	E-20	S-20	(S)A-551	Carbon Steel
B-21	L-21	E-21	S-21	(S)A-570 / (S)A-516-70	Carbon Steel
B-22	L-22	E-22	S-22	(S)B-588	Carbon Steel
B-23	L-23	E-23	S-23	(S)A-606	Corten A
B-24	L-24	E-24	S-24	(S)A516	Carbon Steel
B-25	L-25	E-25	S-25	(S)A240	304H
B-26	L-26	E-26	S-26	(S)A240	316H
B-27	L-27	E-27	S-27	(S)A240	253MA
B-28	L-28	E-28	S-28	(S)A240	Duplex SS 2205
B-29	L-29	E-29	S-29	(S)A240	Super Duplex SS 2507
B-30	L-30	E-30	S-30	SA204 Gr. B	Carbon Steel
B-31	L-31	E-31	S-31	SA516-60	Carbon Steel
B-32	L-32	E-32	S-32	(S)A387	Carbon Steel
B-X	L-X	E-X	S-X	-	Special - Specify

Model:
EFS = Extra Flex™ Single Bellows
EFD = Extra Flex™ Dual Belows
EFSD = Extra Flex™ Single Bellows Double Containment
EFDD = Extra Flex™ Dual Bellows Double Containment

Series:
S = Small, **M** = Medium, **L** = Large

End Type:
WW = Weld / Weld
FFX = Flange / Flange**
WFX = Weld / Flange**

****X = Flange Drilling Type:**
FF1 = ANSI B16.5 Cl 150
FF2 = ANSI B16.5 Cl 300
FF3 = PN10
FF4 = PN16
FF5 = PN25
FF6 = PN40
FFS = Special Specify
P = Plate Flange
(Add prefix "P" before "FF" type)

Options:
D = Drain With Plug Connector, 1/2" NPT Coupling
P = Purge With Plug Connector, 1/2" NPT Plug
IB = Intermediate Base Support

Special notes

1) Use of material codes as a suffix in the catalogue part number designate the bellows (B), liner (L), end connectors (E), spool (S) and Cover (C).

2) Special note for flanges and pipes: when forged flanges or scheduled pipe are used, the same nomenclature symbols are used (i.e.: E2 or S6).

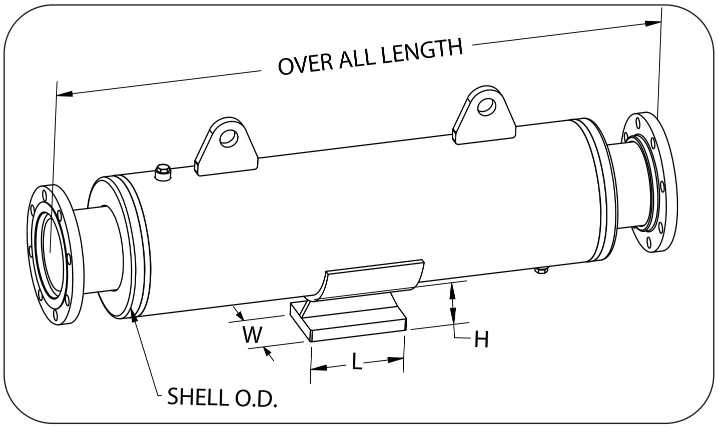
3) ASTM, ASME "SA" or "SB" materials are standard but other material grades are available upon request.

4) All bellows material purchased by Thorburn are "mill annealed" in accordance with "A", "SA" or "SB" specifications. Thorburn does not perform any other heat treating operations before welding, after welding, before forming convolutions or after forming convolutions unless specified by purchaser. Heat treatment of bellows after forming convolutions can lower bellows' spring rate, "squirm" pressure and cycle life. Thorburn will cooperate with purchasers requiring heat treatment after forming to arrive at what effect the heat treatment will have on published bellows data.

NOTES

1. Rated cycle life is 2000 cycles for any one movement tabulated minimum per EJMA.
2. To combine axial, lateral or angular movements the sum of each must not exceed 100%. Refer to the specifications on pages 40 to 47.
3. To obtain greater movements or cycle life contact Thorburn.
4. Maximum test pressure: 1-1/2 x rated working pressure.
5. Catalogue pressure ratings are based upon a design temperature range of - 20°F to 800°F. Actual operating temperature should always be specified.
6. For higher pressure temperature, movement and cycle ratings, contact Thorburn with your application details for fast action.

Thorburn Extra Flex™ Specifications



Size	Design Details: Type	Design Details: Pressure	Design Details: Series	Effective Area	Non-Concurrent Movement: Compress	Non-Concurrent Movement: Extended	Spring Rate	Overall Length, End Style: WW	Overall Length, End Style: FF	Overall Length, End Style: FW	Approximate Weight, End Style: WW	Approximate Weight, End Style: FF	Approximate Weight, End Style: FW	Shell	Base Dimension
in		psi	#	in²	in	in	lbs/in	in	in	in	lbs	lbs	lbs	O.D. in	in
2	EFS	150	S	6.206	4	0.5	272	22.6	24.6	23.6	70.7	71.8	72.8	6.625	Length 4.5
			M	6.206	6	0.75	184	30.2	32.2	31.2	92.4	94.3	95.3	6.625	
			L	6.206	8	1	136	36.4	38.4	37.4	110.2	112.0	113.1	6.625	
		300	S	6.206	2.75	0.5	672	25.6	27.6	26.6	83.5	85.3	86.6	6.625	
			M	6.206	4	0.75	474	30.8	32.8	31.8	98.5	100.4	101.6	6.625	Width 2.25
			L	6.180	5.95	1	322	39.0	41.0	40.0	122.5	124.4	125.7	6.625	
	EFD	150	S	6.206	8	1	272	45.2	47.2	46.2	141.5	143.6	145.6	6.625	
			M	6.206	12	1.5	184	60.4	62.4	61.4	184.8	188.5	190.6	6.625	
			L	6.206	16	2	136	72.8	74.8	73.8	220.3	224.1	226.1	6.625	Height 2
		300	S	6.206	5.5	1	672	51.2	53.2	52.2	166.9	170.7	173.2	6.625	
			M	6.206	8	1.5	474	61.6	63.6	62.6	197.0	200.7	203.3	6.625	
			L	6.180	11.9	2	322	78.0	80.0	79.0	245.1	248.8	251.4	6.625	
2 1/2	EFS	150	S	9.023	4	0.5	303	22.6	26.6	23.6	111.0	114.0	115.5	8.625	Length 4.5
			M	9.023	6	0.75	205	30.2	32.2	31.2	145.0	148.0	149.6	8.625	
			L	9.090	8	1	151	36.4	38.4	37.4	171.8	174.8	176.4	8.625	
		300	S	9.090	2.55	0.5	826	24.8	26.8	25.8	131.4	134.4	136.3	8.625	
			M	8.973	4	0.75	505	32.0	34.0	33.0	163.0	166.0	167.9	8.625	Width 2.25
			L	9.136	5.8	1	364	39.0	41.0	40.0	194.6	197.6	199.5	8.625	
	EFD	150	S	9.023	8	1	303	45.192	47.2	46.2	222.1	228.0	231.1	8.625	
			M	9.023	12	1.5	205	60.456	62.5	61.5	290.1	296.0	299.1	8.625	
			L	9.090	16	2	151	72.744	74.7	73.7	343.7	349.6	352.7	8.625	Height 2
		300	S	9.090	5.1	1	826	49.6	51.6	50.6	262.8	268.7	272.6	8.625	
			M	8.973	8	1.5	505	64.0	66.0	65.0	326.0	331.9	335.8	8.625	
			L	9.136	11.6	2	364	78.0	80.0	79.0	389.2	395.1	399.0	8.625	

Thorburn Extra Flex™ Specifications

Size	Design Details			Effective Area	Non-Concurrent Movement		Spring Rate	Overall Length			Approximate Weight			Shell	Base Dimension
	Type	Pressure	Series		Compress	Extended		End Style WW	End Style FF	End Style FW	End Style WW	End Style FF	End Style FW		
in	psi	psi	#	in²	in	in	lbs/in	in	in	in	lbs	lbs	lbs	O.D. in	In
3	EFS	150	S	13.39	4	0.5	400	22.1	24.1	23.1	110.3	114.1	115.9	8.625	Length 5
			M	13.39	6	0.75	259	30.2	32.2	31.2	148.9	152.8	154.6	8.625	
			L	13.39	8	1	191	36.4	38.4	37.4	177.5	181.4	183.2	8.625	
		300	S	13.27	2.45	0.5	1271	22.0	24.0	23.0	121.9	125.7	128.4	8.625	
			M	13.27	4	0.75	747	31.2	33.2	32.2	166.1	170.0	172.6	8.625	Width 2.5
			L	13.27	5.8	1	529	38.3	40.3	39.3	200.3	204.2	206.8	8.625	
	EFD	150	S	13.39	8	1	400	44.2	46.2	45.2	220.5	228.3	231.9	8.625	
			M	13.39	12	1.5	259	60.4	62.4	61.4	297.8	305.6	309.2	8.625	
			L	13.39	16	2	191	72.8	74.8	73.8	355.0	362.8	366.4	8.625	Height 2
		300	S	13.27	4.9	1	1271	44.0	46.0	45.0	243.7	251.5	256.7	8.625	
			M	13.27	8	1.5	747	62.4	64.4	63.4	332.2	340.0	345.3	8.625	
			L	13.27	11.6	2	529	76.6	78.6	77.6	400.6	408.3	413.6	8.625	
4	EFS	150	S	22.10	4	0.5	780	88.4	90.4	89.4	157.2	162.8	165.4	10.750	Length 6
			M	22.10	6	0.75	390	120.8	122.8	121.8	238.9	244.5	247.1	10.750	
			L	22.10	8	1	344	145.6	147.6	146.6	257.2	262.7	265.3	10.750	
		300	S	22.08	2.55	0.5	1702	88	90.0	89.0	192.2	197.7	202.3	10.750	
			M	22.08	4	0.75	1277	124.8	126.8	125.8	228.9	234.4	239.0	10.750	Width 3
			L	22.08	6	1	912	153.2	155.2	154.2	266.5	272.0	276.6	10.750	
	EFD	150	S	22.10	8	1	780	176.8	178.8	177.8	314.5	325.5	330.7	10.750	
			M	22.10	12	1.5	390	241.6	243.6	242.6	477.9	488.9	494.1	10.750	
			L	22.10	16	2	344	291.2	293.2	292.2	514.4	525.5	530.7	10.750	Height 2
		300	S	22.08	5.1	1	1702	176	178.0	177.0	384.3	395.3	404.5	10.750	
			M	22.08	8	1.5	1277	249.6	251.6	250.6	457.8	468.9	478.1	10.750	
			L	22.08	12	2	912	306.4	308.4	307.4	533.1	544.1	553.3	10.750	
6	EFS	150	S	46.23	4	0.5	967	23.3	25.3	24.3	215.9	225.6	229.2	12.750	Length 7.5
			M	46.23	6	0.75	639	32.3	34.3	33.3	289.7	299.4	302.9	12.750	
			L	46.23	8	1	451	39.8	41.8	40.8	348.5	358.2	361.8	12.750	
		300	S	45.12	2.55	0.5	3197	22.6	24.6	23.6	251.7	261.4	268.6	12.750	
			M	45.12	4	0.75	2078	30.8	32.8	31.8	322.7	332.4	339.7	12.750	Width 3.75
			L	45.12	6	1	1385	38.3	40.3	39.3	385.9	395.6	402.9	12.750	
	EFD	150	S	46.23	8	1	967	46.6	48.6	47.6	431.9	451.3	458.4	12.750	
			M	46.23	12	1.5	639	64.6	66.6	65.6	579.4	598.8	605.9	12.750	
			L	46.23	16	2	451	79.6	81.6	80.6	697.1	716.5	723.6	12.750	Height 2
		300	S	45.12	5.1	1	3197	45.2	47.2	46.2	503.3	522.7	537.3	12.750	
			M	45.12	8	1.5	2078	61.6	63.6	62.6	645.5	664.9	679.5	12.750	
			L	45.12	12	2	1385	76.6	78.6	77.6	771.9	791.3	805.8	12.750	

Thorburn Extra Flex™ Specifications

Size	Design Details: Type	Design Details: Pressure	Design Details: Series	Effective Area	Non-Concurrent Movement: Compress	Non-Concurrent Movement: Extended	Spring Rate	Overall Length, End Style: WW	Overall Length, End Style: FF	Overall Length, End Style: FW	Approximate Weight, End Style: WW	Approximate Weight, End Style: FF	Approximate Weight, End Style: FW	Shell	Base Dimension
in	psi	psi	#	in²	in	in	lbs/in	in	in	in	lbs	lbs	lbs	O.D. in	In
8	EFS	150	S	73.09	4	0.5	1120	24.3	26.3	25.3	321.1	335.8	341.4	16.000	Length 8.5
			M	73.34	6	0.75	738	34.0	36.0	35.0	426.7	441.3	446.9	16.000	
			L	73.34	8	1	565	40.0	42.0	41.0	488.5	503.1	508.7	16.000	
		300	S	74.30	4	1	2585	28.6	30.6	29.6	452.5	467.1	478.2	16.000	
			M	74.30	6	1.5	1723	45.1	47.1	46.1	571.4	586.0	597.2	16.000	Width 4.25
			L	74.30	8	2	1292	46.6	48.6	47.6	654.1	668.7	679.8	16.000	
	EFD	150	S	109.10	8	1	1120	48.6	50.6	49.6	642.3	671.5	682.7	16.000	
			M	109.04	12	1.5	738	68	70.0	69.0	853.4	882.6	893.8	16.000	
			L	109.04	16	2	565	80	82.0	81.0	977.0	1006.2	1017.4	16.000	Height 2
		300	S	110.31	8	2	2585	57.2	59.2	58.2	904.9	934.2	956.4	16.000	
			M	110.31	12	3	1723	90.2	92.2	91.2	1142.9	1172.1	1194.3	16.000	
			L	110.31	16	4	1292	93.2	95.2	94.2	1308.2	1337.5	1359.7	16.000	
10	EFS	150	S	109.10	4	1	1900	22.0	24.0	23.0	358.1	376.4	384.2	18.000	Length 10.5
			M	109.10	6	1.5	1222	30.7	32.7	31.7	482.6	503.3	511.1	18.000	
			L	109.10	8	2	855	37.6	39.6	38.6	571.5	592.2	599.9	18.000	
		300	S	110.31	4	1	3229	30.0	32.0	31.0	557.9	578.6	594.1	18.000	
			M	110.31	6	1.5	2055	42.1	44.1	43.1	720.4	741.1	756.6	18.000	Width 5.25
			L	110.31	8	2	1615	49.0	51.0	50.0	808.4	829.1	844.6	18.000	
	EFD	150	S	109.10	8	2	1900	44	46.0	45.0	716.2	752.9	768.4	18.000	
			M	109.10	12	3	1222	61.4	63.4	62.4	965.2	1006.7	1022.2	18.000	
			L	109.10	16	4	855	75.2	77.2	76.2	1142.9	1184.4	1199.9	18.000	Height 2
		300	S	110.31	8	2	3229	60	62.0	61.0	1115.8	1157.2	1188.2	18.000	
			M	110.31	12	3	2055	84.2	86.2	85.2	1440.8	1482.3	1513.3	18.000	
			L	110.31	16	4	1615	98	100.0	99.0	1616.8	1658.3	1689.3	18.000	
12	EFS	150	S	159.11	4	1	2065	22.4	24.4	23.4	445.4	472.8	485.4	20.000	Length 11.5
			M	159.11	6	1.5	1327	31.1	33.1	32.1	586.5	613.9	626.4	20.000	
			L	159.11	8	2	1032	35.7	37.7	36.7	655.7	683.1	695.6	20.000	
		300	S	152.78	4	1	3432	31.5	33.5	32.5	556.3	583.7	607.0	18.000	
			M	152.78	6	1.5	2340	42.5	44.5	43.5	720.7	748.1	771.3	18.000	Width 5.75
			L	152.78	8	2	1716	51.6	53.6	52.6	849.3	876.7	899.9	18.000	
	EFD	150	S	159.11	8	2	2065	44.8	46.8	45.8	890.8	945.6	970.8	20.000	
			M	159.11	12	3	1327	62.2	64.2	63.2	1173.0	1227.8	1252.9	20.000	
			L	159.11	16	4	2032	71.4	73.4	72.4	1311.3	1366.1	1391.2	20.000	Height 2
		300	S	152.78	8	2	3432	63	65.0	64.0	112.6	1167.4	1213.9	18.000	
			M	152.78	12	3	2340	85	87.0	86.0	1441.4	1496.2	1542.7	18.000	
			L	152.78	16	4	1716	103.2	78.6	104.2	1698.5	1753.3	1799.8	18.000	

Thorburn Extra Flex™ Specifications

Size	Design Details			Effective Area	Non-Concurrent Movement		Spring Rate	Overall Length			Approximate Weight			Shell	Base Dimension
	Type	Pressure	Series		Compress	Extended		End Style			End Style				
								WW	FF	FW	WW	FF	FW		
in	psi	psi	#	in²	in	in	lbs/in	in	in	in	lbs	lbs	lbs	O.D. in	In
14	EFS	150	S	188.28	4	1	2332	23.3	25.3	24.3	641.0	668.9	684.9	24.000	Length 12.5
			M	188.28	6	1.5	1499	32.4	34.4	33.4	806.6	834.6	850.5	24.000	
			L	188.28	8	2	1166	37.3	39.3	38.3	890.6	918.5	934.5	24.000	
		300	S	180.91	2	1	6116	28.2	30.2	29.2	614.2	642.1	674.8	20.000	
			M	180.91	3	1.5	5537	37.3	39.3	38.3	759.5	787.4	820.2	20.000	Width 6.25
			L	180.91	6.8	2	3692	47.0	49.0	48.0	912.4	940.3	973.0	20.000	
	EFD	150	S	188.28	8	2	2332	46.6	48.6	47.6	1282.0	1337.9	1369.8	24.000	
			M	188.28	12	3	1499	64.8	66.8	65.8	1613.3	1669.1	1701.1	24.000	
			L	188.28	16	4	1166	74.6	76.6	75.6	1781.2	1837.1	1869.0	24.000	Height 3
		300	S	180.91	4	2	6116	56.4	58.4	57.4	1228.3	1284.2	1349.6	20.000	
			M	180.91	6	3	5537	74.6	76.6	75.6	1519.0	1574.9	1640.3	20.000	
			L	180.91	13.6	4	3692	94	96.0	95.0	1824.8	1880.7	1946.1	20.000	
16	EFS	150	S	240.06	4	1	2504	23.7	25.7	24.7	646.8	689.1	708.3	24.000	Length 13.5
			M	240.06	6	1.5	1610	32.8	34.8	33.8	840.8	883.2	902.3	24.000	
			L	240.06	8	2	1252	37.6	39.6	38.6	936.0	978.3	997.5	24.000	
		300	S	230.12	4	1	4674	34.7	36.7	35.7	1040.4	1082.7	1123.7	24.000	
			M	227.43	6	1.5	3116	47.4	49.4	48.4	1312.1	1354.5	1395.5	24.000	Width 6.75
			L	232.27	8	2	2337	57.2	59.2	58.2	1508.5	1550.9	1591.9	24.000	
	EFD	150	S	240.06	8	2	2504	47.4	49.4	48.4	1293.6	1378.3	1416.6	24.000	
			M	240.06	12	3	1610	65.6	67.6	66.6	1681.7	1766.4	1804.7	24.000	
			L	240.06	16	4	1252	75.2	77.2	76.2	1872.0	1956.7	1995.0	24.000	Height 3
		300	S	230.12	8	2	4674	69.4	71.4	70.4	2080.7	2165.4	2247.4	24.000	
			M	227.43	12	3	3116	94.8	96.8	95.8	2624.2	2708.9	2790.9	24.000	
			L	232.27	16	4	2337	114.4	116.4	115.4	3017.0	3101.8	3183.8	24.000	
18	EFS	150	S	293.90	4	1	2969	24.1	26.1	25.1	765.3	818.9	841.5	26.000	Length 14.75
			M	293.90	6	1.5	1853	34.2	36.2	35.2	1023.6	1077.2	1099.7	26.000	
			L	293.90	8	2	1441	39.0	41.0	40.0	2135.0	1188.6	1211.2	26.000	
		300	S	298.34	4	1	5181	35.0	37.0	36.0	1204.3	1257.8	1307.3	26.000	
			M	298.34	6	1.5	3454	48.8	50.8	49.8	1549.2	1602.8	1652.2	26.000	Width 7.38
			L	298.34	8	2	2590	58.6	60.6	59.6	1775.3	1828.9	1878.3	26.000	
	EFD	150	S	293.90	8	2	2969	48.2	50.2	49.2	1530.7	1637.8	1682.9	26.000	
			M	293.90	12	3	1853	68.4	70.4	69.4	2047.2	2154.3	2199.4	26.000	
			L	293.90	16	4	1441	78	80.0	79.0	2270.1	2377.2	2422.3	26.000	Height 3
		300	S	298.34	8	2	5181	70	72.0	71.0	2408.5	2515.7	2614.5	26.000	
			M	298.34	12	3	3454	97.6	99.6	98.6	3098.4	3205.5	3304.4	26.000	
			L	298.34	16	4	2590	117.2	119.2	118.2	3550.6	3657.7	3756.6	26.000	

Thorburn Extra Flex™ Specifications

Size	Design Details			Effective Area	Non-Concurrent Movement		Spring Rate	Overall Length			Approximate Weight			Shell	Base Dimension
	Type	Pressure	Series		Compress	Extended		End Style			End Style				
								WW	FF	FW	WW	FF	FW		
in	psi	psi	#	in²	in	in	lbs/in	in	in	in	lbs	lbs	lbs	O.D. in	In
20	EFS	150	S	361.70	4	1	2879	27.6	29.6	28.6	914.5	998.5	1028.2	28.000	Length 16
			M	362.21	6	1.5	1800	39.0	41.0	40.0	1236.5	1320.5	1350.2	28.000	
			L	362.21	8	2	1440	43.8	45.8	44.8	1361.1	1445.1	1474.8	28.000	
		300	S	362.71	3.6	1	6498	35.0	37.0	36.0	1448.8	1532.8	1594.5	28.000	
			M	362.71	5.6	1.5	4135	48.7	50.7	49.7	1920.7	2004.7	2066.4	28.000	Width 8
			L	362.71	7.1	2	3249	56.1	58.1	57.1	2155.0	2239.0	2300.7	28.000	
	EFD	150	S	361.70	8	2	2879	55.2	57.2	56.2	1829.0	1997.0	2056.4	28.000	
			M	362.21	12	3	1800	78	80.0	79.0	2472.9	2641.0	2700.4	28.000	
			L	362.21	16	4	1440	87.6	89.6	88.6	2722.2	2890.2	2949.6	28.000	Height 3
		300	S	362.71	7.2	2	6498	70	72.0	71.0	2897.5	3065.6	3188.9	28.000	
			M	362.71	11.2	3	4135	97.4	99.4	98.4	3841.4	4009.4	4132.8	28.000	
			L	362.71	14.2	4	3249	112.2	114.2	113.2	4310.0	4478.0	4601.4	30.000	
22	EFS	150	S	432.45	4	1	3240	27.8	29.8	28.8	1023.5	1120.9	1154.0	30.000	Length 17.25
			M	432.45	6	1.5	2314	36.7	38.7	37.7	1313.8	1411.2	1444.3	30.000	
			L	432.45	8	2	1620	44.0	46.0	45.0	1521.1	1618.5	1651.6	30.000	
		300	S	433.37	4	1	6597	40.1	42.1	41.1	1780.0	1877.4	1950.5	30.000	
			M	433.37	6	1.5	4241	56.3	58.3	57.3	2337.2	2484.5	2557.7	30.000	Width 8.63
			L	433.37	8	2	3299	66.0	68.0	67.0	2730.2	2827.5	2900.7	30.000	
	EFD	150	S	432.45	8	2	3240	55.6	57.6	56.6	2047.1	2241.8	2308.0	30.000	
			M	432.45	12	3	2314	73.4	75.4	74.4	2627.6	2822.4	2888.6	30.000	
			L	432.45	16	4	1620	88	90.0	89.0	3042.2	3236.9	3303.6	30.000	Height 3
		300	S	433.37	8	2	6597	80.2	82.2	81.2	3560.0	3754.8	3901.1	30.000	
			M	433.37	12	3	4241	112.6	114.6	113.6	4774.4	4969.1	5115.4	30.000	
			L	433.37	16	4	3299	132	134.0	133.0	5460.3	5655.1	5801.4	30.000	
24	EFS	150	S	508.50	4	1	2771	32.8	34.8	33.8	1495.3	1612.2	1653.2	32.000	Length 18.75
			M	508.50	6	1.5	2078	41.7	43.7	42.7	1839.8	1956.7	1997.8	32.000	
			L	508.50	8	2	1385	51.6	53.6	52.6	2176.7	2293.6	2334.7	32.000	
		300	S	506.71	4	1	8634	34.3	36.3	35.3	1860.3	1977.2	2069.7	32.000	
			M	506.71	6	1.5	5551	46.5	48.5	47.5	2401.9	2518.8	2611.4	32.000	Width 9.38
			L	506.71	8	2	4317	53.2	55.2	54.2	2672.0	2788.9	2881.4	32.000	
	EFD	150	S	508.50	8	2	2771	65.6	67.6	66.6	2990.6	3224.4	3306.5	32.000	
			M	508.50	12	3	2078	83.4	85.4	84.4	3679.6	3913.4	3995.5	32.000	
			L	508.50	16	4	1385	103.2	105.2	104.2	4363.5	4587.3	4669.4	32.000	Height 3
		300	S	506.71	8	2	8634	68.6	70.6	69.6	3720.5	3954.3	4139.4	32.000	
			M	506.71	12	3	5551	93	95.0	94.0	4803.9	5037.7	5222.7	32.000	
			L	506.71	16	4	4317	106.4	103.4	107.4	5344.0	5577.8	5762.8	32.000	

Thorburn Extra Flex™ Specifications

Size	Design Details			Effective Area	Non-Concurrent Movement		Spring Rate	Overall Length			Approximate Weight			Shell	Base Dimension
	Type	Pressure	Series		Compress	Extended		End Style			End Style				
								WW	FF	FW	WW	FF	FW		
in	psi	psi	#	in²	in	in	lbs/in	in	in	in	lbs	lbs	lbs	O.D. in	In
26	EFS	150	S	616.94	4	1	5312	27.0	29.0	28.0	1406.5	1454.5	1502.5	34.000	Length 19.5
			M	616.94	6	1.5	3795	30.3	32.3	31.3	1503.7	1551.7	1599.7	34.000	
			L	616.94	7.9	2	29.8	33.6	35.6	34.6	1601.2	1649.2	1697.2	34.000	
		300	S	612.68	4	1	8602	35.5	37.5	36.5	1983.4	2104.0	2224.6	34.000	
			M	612.68	6	1.5	5530	49.8	51.8	50.8	2416.7	2537.3	2657.9	34.000	Width 9.75
			L	612.68	8	2	4301	56.4	58.4	57.4	2660.3	2780.9	2901.5	34.000	
	EFD	150	S	616.94	8	2	5312	54	56.0	55.0	2812.9	2908.9	3004.9	34.000	
			M	616.94	12	3	3795	60.6	62.6	61.6	3007.4	3103.4	3199.4	34.000	
			L	616.94	15.8	4	29.8	67.2	69.2	68.2	3202.5	3298.5	3394.5	34.000	Height 4
		300	S	612.68	8	2	8602	71	73.0	72.0	3966.9	4208.1	4449.3	34.000	
			M	612.68	12	3	5530	99.6	101.6	100.6	4833.5	5074.7	5315.9	34.000	
			L	612.68	16	4	4301	112.8	114.8	113.8	5320.7	5561.9	5803.1	34.000	
28	EFS	150	S	708.13	4	1	5637	27.4	29.4	28.4	1548.4	1603.2	1658.0	36.000	Length 21
			M	708.13	6	105	4026	30.7	32.7	31.7	1652.1	1707.0	1761.8	36.000	
			L	708.60	7.8	2	3078	34.0	36.0	35.0	1754.5	1809.3	1864.2	36.000	
		300	S	705.92	4	1	9332	36.3	38.3	37.3	2211.3	2358.0	2504.8	36.000	
			M	705.92	6	1.5	5999	50.5	52.5	51.5	2672.9	2819.7	2966.4	36.000	Width 10.5
			L	705.92	8	2	4666	57.2	59.2	58.2	2932.4	3079.2	3225.9	36.000	
	EFD	150	S	708.13	8	2	5637	54.8	56.8	55.8	3096.7	3206.4	3316.0	36.000	
			M	708.13	12	3	4026	61.4	63.4	62.4	3304.3	3413.9	3523.5	36.000	
			L	708.60	15.6	4	3078	68	70.0	69.0	3509.1	3618.7	3728.3	36.000	Height 4
		300	S	705.92	8	2	9332	72.6	74.6	73.6	4422.6	4716.1	5009.6	36.000	
			M	705.92	12	3	5999	101	103.0	102.0	5345.9	5639.4	5932.9	36.000	
			L	705.92	16	4	4666	114.4	116.4	115.4	5864.9	6158.4	6451.9	36.000	
30	EFS	150	S	805.61	4	1	5799	28.5	30.5	29.5	1757.3	1819.3	1881.2	38.000	Length 22
			M	805.61	6	1.5	4142	32.0	34.0	33.0	1872.3	1934.2	1996.2	38.000	
			L	805.00	8	2	2900	43.2	45.2	44.2	2156.9	2218.8	2280.7	38.000	
		300	S	802.74	4	1	8843	45.5	47.5	46.5	2695.0	2863.8	3032.7	38.000	
			M	802.74	6	1.5	6317	52.4	54.4	53.4	2982.2	3151.0	3319.9	38.000	Width 11
			L	802.74	8	2	4913	59.3	61.3	60.3	3272.7	3441.6	3610.4	38.000	
	EFD	150	S	805.61	8	2	5799	57	59.0	58.0	3514.7	3638.6	3762.4	38.000	
			M	805.61	12	3	4142	64	66.0	65.0	3744.6	3868.5	3992.3	38.000	
			L	805.00	16	4	2900	86.4	88.4	87.4	4313.7	4437.6	4561.4	38.000	Height 4
		300	S	802.74	8	2	8843	91	93.0	92.0	5389.9	5727.6	6065.3	38.000	
			M	802.74	12	3	6317	104.8	106.8	105.8	5964.3	6302.0	6639.7	38.000	
			L	802.74	16	4	4913	118.6	120.6	119.5	6545.4	6883.1	7220.8	38.000	

Thorburn Extra Flex™ Specifications

Size	Design Details: Type	Design Details: Pressure	Design Details: Series	Effective Area	Non-Concurrent Movement: Compress	Non-Concurrent Movement: Extended	Spring Rate	Overall Length, End Style: WW	Overall Length, End Style: FF	Overall Length, End Style: FW	Approximate Weight, End Style: WW	Approximate Weight, End Style: FF	Approximate Weight, End Style: FW	Shell	Base Dimension
in	psi	psi	#	in²	in	in	lbs/in	in	in	in	lbs	lbs	lbs	O.D. in	In
32	EFS	150	S	910.43	4	1	6197	28.7	30.7	29.7	1888.0	1964.6	2041.2	40.000	Length 23
			M	910.43	6	1.5	4491	32.2	34.2	33.2	2009.4	2086.0	2162.5	40.000	
			L	910.43	8	2	3144	43.4	45.4	44.4	2310.5	2387.1	2463.6	40.000	
		300	S	906.32	4	1	9659	45.8	47.8	46.8	2904.4	3100.0	3295.6	40.000	
			M	906.32	6	1.5	6899	52.8	54.8	53.8	3208.0	3403.6	3599.2	40.000	Width 11.5
			L	906.32	8	2	5366	59.7	61.7	60.7	3515.1	3710.7	3906.3	40.000	
	EFD	150	S	910.43	8	2	6197	57.4	59.4	58.4	3776.1	3929.2	4082.4	40.000	
			M	910.43	12	3	4491	64.4	66.4	65.4	4018.8	4172.0	4325.1	40.000	
			L	910.43	16	4	3144	86.8	88.8	87.8	4621.0	4774.1	4927.2	40.000	Height 4
		300	S	906.32	8	2	9659	91.6	93.6	92.6	5808.8	6200.0	6591.3	40.000	
			M	906.32	12	3	6899	105.6	107.6	106.6	6415.9	6807.2	7198.4	40.000	
			L	906.32	16	4	5366	119.4	121.4	120.4	7030.2	7421.4	7812.6	40.000	
34	EFS	150	S	1019.97	4	1	6603	29.7	31.7	30.7	2132.5	2214.5	2296.5	42.000	Length 24
			M	1019.40	6	1.5	4716	33.1	35.1	34.1	2260.9	2342.9	2424.9	42.000	
			L	1019.40	8	2	3302	44.3	46.3	45.3	2578.8	2660.7	2742.7	42.000	
		300	S	1015.05	3	1	15025	35.0	37.0	36.0	2721.5	2943.6	3165.7	42.000	
			M	1015.05	6	1.5	7512	53.1	55.1	54.1	3443.8	3665.9	3887.9	42.000	Width 12
			L	1015.05	8	2	5843	60.1	62.1	61.1	3767.5	3989.5	4211.6	42.000	
	EFD	150	S	1019.97	8	2	6603	59.4	61.4	60.4	4265.0	4428.9	4592.9	42.000	
			M	1019.40	12	3	4716	66.2	68.2	67.2	4521.8	4685.7	4849.7	42.000	
			L	1019.40	16	4	3302	88.6	90.6	89.6	5157.5	5321.5	5485.4	42.000	Height 4
		300	S	1015.05	6	2	15025	70	72.0	71.0	5443.1	5887.2	6331.3	42.000	
			M	1015.05	12	3	7512	106.2	108.2	107.2	6887.7	7331.8	7775.9	42.000	
			L	1015.05	16	4	5843	120.2	122.2	121.2	7535.0	7979.1	8423.2	42.000	
36	EFS	150	S	1135.73	4	1	7446	33.3	35.3	34.3	1910.7	2003.1	2095.5	44.000	Length 25.25
			M	1135.73	6	1.5	4948	36.7	38.7	37.7	2047.5	2139.9	2232.3	44.000	
			L	1135.73	8	2	3510	47.9	49.9	48.9	2381.6	2478.0	2566.5	44.000	
		300	S	1129.94	2.5	1	19937	37.6	39.6	38.6	2353.4	2601.5	2849.5	44.000	
			M	1129.94	5.9	1.5	8439	57.5	59.5	58.5	3195.9	3443.9	3691.9	44.000	Width 12.63
			L	1129.94	7.7	2	6564	64.4	66.4	65.4	3535.5	3783.5	4031.6	44.000	
	EFD	150	S	1135.73	8	2	7446	66.6	68.6	67.6	3821.4	4006.2	4191.1	44.000	
			M	1135.73	12	3	4948	73.4	75.4	74.4	4094.9	4279.8	4464.7	44.000	
			L	1135.73	16	4	3510	95.8	97.8	96.8	4763.2	4948.1	5133.0	44.000	Height 4
		300	S	1129.94	5	2	19937	75.2	77.2	76.2	4706.9	5202.9	5699.0	44.000	
			M	1129.94	11.8	3	8439	115	117.0	116.0	6391.8	6887.8	7383.9	44.000	
			L	1129.94	15.4	4	6564	128.8	130.8	129.8	7071.0	7567.1	8063.1	44.000	

Thorburn Comp Flex™ Compensators

What are Thorburn Comp Flex™ Compensators?

Thorburn's Comp-Flex™ compensators are small diameter multi-convoluted bellows. They are fully shrouded and specifically designed to absorb expansion and dimensional changes in anchored small diameter straight pipe runs.

Features

- Operating temperature up to 750°F
- Operating pressure up to 175 psi
- Available with flanged and welded ends

Advantages

- Ends pipe expansion noise - Uncontrolled expansion in piping systems causes unpleasant noises. Thorburn's Comp-Flex compensators eliminate this problem.
- Minimize pressure drop - Straight line Thorburn Comp-Flex compensators minimize pressure drop by eliminating multiple bends to absorb pipe motion.
- Prevents pipe buckling - When the pipeline is properly aligned, guided and anchored, all pipe movement is absorbed in the Thorburn Comp-Flex compensator.
- Durable and maintenance-free - Thorburn's Comp-Flex's lifetime design permits the unit to outlast most piping systems, maintenance-free.
- Broad range sizes, end connections and material - Thorburn Comp-Flex are available in standard sizes from 3/4" to 4" for copper tube, steel and stainless steel pipe; available connections are threaded, welded or flanged.

Applications

- Heating and air conditioning piping systems
- Steam, hot water and chilled water piping systems
- Replacement of pipe-loops-slip joints
- Sanitary systems
- Return and supply lines

Compare Thorburn Comp Flex™

Narrow wall construction Thorburn's Comp Flex™ way

Thick wall construction the old fashioned way

Extra piping eliminated the Thorburn's Comp Flex™ way

Pipe loop method the old fashioned way

How To Order Thorburn Comp Flex™ Compensators

Model		Size
HPC-505	-	**48**
Comp Flex™ Fixed Flanges		3 inch

HPC-503: Male Pipe Threads	**CTC-509:** Copper Male Threaded Tube
HPC-504: Beveled For Welding	**CTC-510:** Copper Male Threaded/Female Tube
HPC-505: Fixed Flanges	**CTC-511:** Copper Female Tube/ Female Threaded
	CTC-512: Copper Female Threaded/ Female Threaded

08 = 1/2"	(DIN15)	**20** = 1 1/4"	(DIN32)	**40** = 2 1/2"	(DIN65)
12 = 3/4"	(DIN20)	**24** = 1 1/2"	(DIN40)	**48** = 3"	(DIN80)
16 = 1"	(DIN25)	**32** = 2"	(DIN50)	**64** = 4"	(DIN100)

Thorburn Comp Flex™ Compensators

Construction

1 Internal guide ring maintains alignment of inner pipe and housing and prevents contact of the bellows and housing
2 Traveling pipe or tube isolates belows from internal flow
3 Installation clip
4 2-ply bellows for longer cycle life
5 Anti-torque device on threaded models
6 Shroud provides external protection for bellows
7 Fixed pipe or tube end

Thorburn Comp Flex™ HPC Series Compensators

Male Pipe Threads

HPC-503

Beveled For Welding

HPC-504

Fixed Flange

HPC-505

HPC-503 / HPC-504 / HPC-505 Specifications

Size	Nominal Size	Max. OD	Spring Rate	Effective Area	Tabulated Force (pounds) for Individual Pressure							Overall Length	Approx. Weight HPC-503 HPC-504	Approx. Weight HPC-505
					50	75	100	125	150	175	250			
	NPS	in	lb/in	in²	psi	psi	psi	psi	psi	psi	psi	in	lbs	lbs
12	0.75	5.563	111	1.5	76	114	152	190	228	265	379	27.1	2	6
16	1.00	5.563	95	2.0	103	155	207	258	310	317	517	27.1	3	7
20	1.25	5.563	91	3.3	165	248	330	413	495	578	825	27.1	4	10
24	1.50	5.563	89	4.3	215	323	430	538	645	753	1,075	27.1	5	11
32	2.00	6.625	70	6.0	313	470	627	783	940	1,097	1,567	22.8	7	17
40	2.50	6.625	150	8.8	438	658	877	1,096	1,315	1,535	2,192	22.8	11	25
48	3.00	6.625	150	13.1	653	979	1,306	1,632	1,959	2,285	3,265	24.0	14	30
56	3.50	8.625	213	16.5	823	1,234	1,645	2,056	2,467	2,879	4,112	23.0	18	40
64	4.00	8.625	255	20.8	1,039	1,558	2,077	2,597	3,116	3,635	5,194	21.6	22	48

Design Details

Expansion: 2”
Contraction: 0.5”
EJMA Cycle Life: 2,000

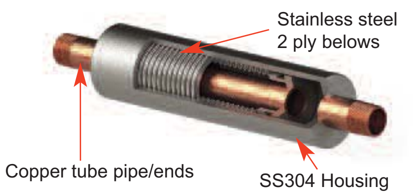
Test Pressure: 262 psi
Working Pressure: 175 psi
Temperature Range: -40°F to 750°F

Standard Materials:

Stainless Steel 2 Ply Belows, Carbon Steel Housing
Schedule 40 A106 Carbon Steel Pipe
Flat Face A36/44W Carbon Steel Flange per ANSI B16.5 150#
See Page 68 for ordering information

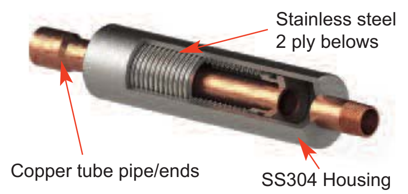
Comp Flex™ CTC Series Compensators With Copper Tube Ends

Copper
Male Threaded Tube Ends



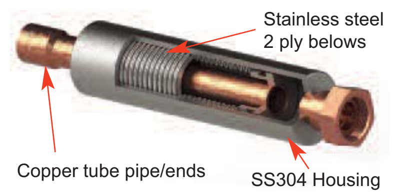
CTC-509

Copper
Female Tube/Male Threaded Tube Ends



CTC-510

Copper
Female Tube/Female Threaded Tube Ends



CTC-511

Not Shown: CTC-512 (Copper female threaded tube/female threaded tube ends

CTC-509 / CTC-510 Specifications

Size	Copper Tube Nominal Size	Actual Tube O.D.	Axial Spring Rate	Casing Outside Dia.	Effective Area	Tabulated Force (pounds) for Individual Pressure							CTC-509/ CTC-510 Overall Length	Approx. Weight
						50	75	100	125	150	175	250		
	in	in	lb/in	in	in^2	psi	psi	psi	psi	psi	psi	psi	in	lbs
12	0.75	0.875	118	4.500	1.1	55	82	109	137	164	191	274	27.1	0.7
16	1.00	1.125	101	4.500	1.7	86	129	172	215	258	301	430	27.1	1.0
20	1.25	1.375	95	4.500	2.4	121	181	242	302	363	428	605	27.1	1.5
24	1.50	1.625	90	4.500	3.2	162	243	324	405	485	566	809	27.1	2.0
32	2.00	2.125	140	6.625	5.1	256	385	513	641	769	897	1,282	22.8	2.4
40	2.50	2.625	128	6.625	7.6	378	568	757	947	1,136	1,325	1,893	22.8	3.6
48	3.00	3.125	158	6.625	10.6	528	791	1,055	1,319	1,583	1,846	2,638	24.0	4.0
56	3.50	3.625	186	8.625	16.9	845	1,268	1,690	2,114	2,536	2,959	4,227	23.0	4.5
64	4.00	4.125	373	8.625	17.9	897	1,347	1,795	2,243	2,692	3,140	4,486	21.6	6.0

CTC-511 / CTC-512 Specifications

Size	Copper Tube Nominal Size	Actual Tube O.D.	Axial Spring Rate	Casing Outside Dia.	Effective Area	Tabulated Force (pounds) for Individual Pressure							CTC-511/ CTC-512 Overall Length	Approx. Weight
						50	75	100	125	150	175	250		
	in	in	lb/in	in	in^2	psi	psi	psi	psi	psi	psi	psi	in	lbs
12	0.75	0.875	118	4.500	1.1	55	82	109	137	164	191	274	27.1	1.00
16	1.00	1.125	101	4.500	1.7	86	129	172	215	258	301	430	27.1	1.40
20	1.25	1.375	95	4.500	2.4	121	181	242	302	363	428	605	27.1	2.10
24	1.50	1.625	90	4.500	3.2	162	243	324	405	485	566	809	27.1	3.80
32	2.00	2.125	140	6.625	5.1	256	385	513	641	769	897	1,282	22.8	4.80

Design Details

Expansion: 2”
Contraction: 0.5”
Working Pressure: 175 psi

Test Pressure: 262 psi
Temperature Range: -320°F to 400°F
Cycle Life: 2,000 full stroke cycles

Standard Materials:

Stainless Steel S240T321 2 Ply Belows
Stainless Steel A304SS Housing
Copper Tube Ends
See Page 68 for ordering information

Thorburn Duct Flex™ Round Ducting Expansion Joints

Thorburn Duct Flex™ Series SDF 22 ft (6.7 m) diameter expansion joint bellows for the Tuxpan combined cycle power plant located in Veracruz, Mexico

Thorburn Duct Flex™ round ducting expansion joints are used to absorb vibration, thermal movement and misalignments in flue gas ducting systems such as precipitators, turbines, condensers, boiler breeching and other gas systems. Thorburn Duct Flex™ Metallic joints are needed where quality, security, and fire resistance is of upmost importance as opposed to rubber or fabric duct expansion joints.

Thorburn Duct Flex™ expansion joints are designed in accordance with the latest Editions of the Standards of the Expansion Joint Manufacturers Association (E.J.M.A.) and ASME for use in dust collection and fume extraction duct systems. Pressure ranges are ±3 psi (21 kpa) and temperatures to 1800°F (982°C) depending on materials.

The bellows are precision formed from cylinders of deep draw quality annealed sheets conforming to ASTM/ASME specifications. Bellows have a minimum of longitudinal seams, the same thickness as parent material, to insure uniform stress distribution and long service life.

Thorburn Duct Flex™ expansion joints are available in sizes from 48" (1200mm) I.D. to 394" (10m) I.D. and can be supplied with lining purge nipples protective/insulating covers and special thermical packing for dust application.

Applications

- low-pressure and negative-pressure applications
- Scrubbers
- Precipitators
- Blower fan systems
- Flue ducts
- Ventilation systems

Thorburn Duct Flex™ - Series

Single Bellows
Single bellows design

Code "SDF"

Dual Bellows
Dual bellows design

Code "DDF"

Thorburn Duct Flex™ - Ends

Weld/Weld Ends
1/4" thick and 3" wide with beveled ends designed to be butt welded to duct. Carbon steel is standard. Other alloys furnished if specified.

Code "WW"

Flange Ends
Standard carbon steel angle flanged ends are dimensioned on page 75. Companion flanges will be furnished when specified. Other alloys and sizes available upon request.

Code "FF"

Flange/Weld Ends
1/4" thick X 1-1/2 wide collars are designed to slip over duct and connect with a fillet weld. Carbon steel is standard. Other alloys furnished if specified.

Code "FW"

How To Order Duct Flex™ Round Ducting Series SDF & DDF

Nominal Size	Model	Style	Ends	Pressure +/- (PSI)	Series or Cons	Number of Plies	Temp. °F	Bellows Material	End Material	Liner Material	Cover Material	O.A.L. (in)
48	**- SDF**	**- U**	**- FF3**	**- 3**	**- 7**	**- 3P**	**- 800**	**- B5**	**- E3**	**- L5**	**- C0**	**- 18**
48" I.D.	Duct Flex™	Un-restrained	Flange	3 PSI	7 Cons	3 Plies	800°F	321SS	304SS	316SS	Carbon Steel	18 inches
DN1200	Single Round		PN10	21 kPa			427°C					460 mm

Thorburn Material Code					ASTM/ASME(S) Material Designation	Material Type
Bellows (B)	Liner (L)	End (E)	Spool (S)	Cover (C)		
B-0	L-0	E-0	S-0	C-0	(S)A36/44W	Carbon Steel
B-1	L-1	E-1	S-1	C-1	(S)A-240	SS304
B-2	L-2	E-2	S-2	C-2	(S)A-240	SS304L
B-3	L-3	E-3	S-3	C-3	(S)A-240	SS316
B-4	L-4	E-4	S-4	C-4	(S)A-240	SS316L
B-5	L-5	E-5	S-5	C-5	(S)A-240	SS321
B-6	L-6	E-6	S-6	C-6	(S)A-240	SS309
B-7	L-7	E-7	S-7	C-7	(S)A-240	SS310
B-8	L-8	E-8	S-8	C-8	(S)B-127	Monel 400
B-9	L-9	E-9	S-9	C-9	(S)B-168	Inconel 600
B-10	L-10	E-10	S-10	C-10	(S)B-443	Inconel 625
B-11	L-11	E-11	S-11	C-11	(S)B-409	Incoloy 800
B-12	L-12	E-12	S-12	C-12	(S)B-424	Incoloy 825
B-14	L-14	E-14	S-14	C-14	(S)B-409	Incoloy 800HT
B-15	L-15	E-15	S-15	C-15	(S)B-162	Nickel 201
B-16	L-16	E-16	S-16	C-16	(S)B-575	Inco C276
B-17	L-17	E-17	S-17	C-17	(S)B-364	Tantalum
B-18	L-18	E-18	S-18	C-18	(S)B-265	Titanium Gr. 1
B-19	L-19	E-19	S-19	C-19	(S)B-551	Zirconium Gr. 702
B-20	L-20	E-20	S-20	C-20	(S)A-285	Carbon Steel
B-21	L-21	E-21	S-21	C-21	(S)A-570	Carbon Steel
B-22	L-22	E-22	S-22	C-22	(S)B-588	Carbon Steel
B-23	L-23	E-23	S-23	C-23	(S)A-606	Corten A
B-24	L-24	E-24	S-24	C-24	(S)A516	Carbon Steel
B-25	L-25	E-25	S-25	C-25	(S)A240	304H
B-26	L-26	E-26	S-26	C-26	(S)A240	316H
B-27	L-27	E-27	S-27	C-27	(S)A240	253MA
B-28	L-28	E-28	S-28	C-28	(S)A240	Duplex SS 2205
B-29	L-29	E-29	S-29	C-29	(S)A240	Super Duplex SS 2507
B-30	L-30	E-30	S-30	C-30	SA204 Gr. B	Carbon Steel
B-31	L-31	E-31	S-31	C-31	SA516-60	Carbon Steel
B-32	L-32	E-32	S-32	C-32	(S)A387	Carbon Steel
B-X	L-X	E-X	S-X	C-X	-	Special - Specify

Model:
SDF = Single Bellows
DDF = Dual Belows

Style:
U = Unrestrained **T** = Tied Universal
H = Hinge **I** = Intermediate Anchor
G = Gimbal

Series or Number of Convolutions:
S = Small, **M =** Medium, **L =** Large

Number of Convolutions (Single or Dual):

Single	Dual
1C = 1 Conv.	**1C + 1C** = 1 Conv.
2C = 2 Conv.	**2C + 2C** = 2 Conv.
3C = 3 Conv.	**3C + 3C** = 3 Conv.
4C = 4 Conv.	**4C + 4C** = 4 Conv.
5C = 5 Conv.	**5C + 5C** = 5 Conv.
6C = 6 Conv.	**6C + 6C** = 6 Conv.
7C = 7 Conv.	**7C + 7C** = 7 Conv.

Number of Plies:
1P = 1 Ply **4P** = 4 Plies
2P = 2 Plies **5P** = 5 Plies
3P = 3 Plies **6P** = 6 Plies

End Type:
WW = Weld / Weld
FFX = Flange / Flange**
WFX = Weld / Flange **
VVX = Van Stone Flange/Van Stone Flange**
VFX = Van Stone Flange/Fixed Flange**

****Flange Drilling Option:**
Plate or Angle Flange are standard.
FF1 = ANSI B16.5 Cl 150 **FF5** = PN25
FF2 = ANSI B16.5 Cl 300 **FF6** = PN40
FF3 = PN10 **FFS** = Other
FF4 = PN16

Special notes

1) Use of material codes as a suffix in the catalogue part number designate the bellows (B), liner (L), end connectors (E), spool (S) and Cover (C).

2) Special note for flanges and pipes: when forged flanges or scheduled pipe are used, the same nomenclature symbols are used (i.e.: E2 or S6).

3) ASTM, ASME "SA" or "SB" materials are standard but other material grades are available upon request.

4) All bellows material purchased by Thorburn are "mill annealed" in accordance with "A", "SA" or "SB" specifications. Thorburn does not perform any other heat treating operations before welding, after welding, before forming convolutions or after forming convolutions unless specified by purchaser. Heat treatment of bellows after forming convolutions can lower bellows' spring rate, "squirm" pressure and cycle life. Thorburn will cooperate with purchasers requiring heat treatment after forming to arrive at what effect the heat treatment will have on published bellows data.

NOTES

1. Rated cycle life is 2000 cycles for any one movement tabulated minimum per EJMA.
2. To combine axial, lateral or angular movements the sum of each must not exceed 100%. Refer to the specifications on pages 40 to 47.
3. To obtain greater movements or cycle life contact Thorburn.
4. Rated axial movement shown is for both compression or extension.
5. Maximum test pressure: 1-1/2 x rated working pressure.
6. Catalogue pressure ratings are based upon a design temperature range of - 20°F to 800°F (-29°C to 427°C). Actual operating temperature should always be specified.
7. For higher pressure temperature, movement and cycle ratings, contact Thorburn with your application details for fast action.

Thorburn Duct Flex™ Round Ducting Series SDF - Specifications

Design Details				Non-Concurrent Movement			Spring Rate			Overall Length / Weight					
										End Style					
										WW		FF		FW	
Size	Effective Area	Pressure	Series	Axial	Lateral	Angular	Axial	Lateral	Angular	O.A.L.	Weight	O.A.L.	Weight	O.A.L.	Weight
in	in²	psi		in	in	in	lbs/in	lbs/in	lbs/in	in	lbs	in	lbs	in	lbs
48	1968.2	15	S	1.44	0.040	2.90	1,325	53,273	7,247	11.92	126	12.92	148	12.42	137
			M	2.54	0.183	5.85	1,060	19,414	5,797	13.65	136	14.65	159	14.15	147
			L	4.00	0.325	8.80	757	70,553	4,141	17.11	158	18.11	180	17.61	169
50	2220.6	15	S	2.03	0.080	2.50	797	36,123	4,914	11.92	167	12.92	190	12.42	178
			M	3.50	0.250	6.11	637	13,164	3,931	13.65	187	14.65	209	14.15	198
			L	4.50	0.430	8.00	455	78,803	2,808	17.11	226	18.11	249	17.61	238
52	2390.0	15	S	2.03	0.080	2.50	826	78,803	5,488	11.92	174	12.92	197	12.42	185
			M	3.23	0.250	6.11	661	40,347	4,391	13.65	194	14.65	218	14.15	206
			L	4.45	0.428	8.00	472	14,704	3,136	17.11	235	18.11	259	17.61	247
54	2567.3	15	S	1.33	0.028	2.45	857	87,715	6,109	11.92	180	12.92	205	12.42	192
			M	3.76	0.200	6.23	685	44,910	4,887	13.65	202	14.65	226	14.15	214
			L	6.00	0.390	7.00	490	16,367	3,491	17.11	245	18.11	269	17.61	257
60	3134.0	15	S	1.32	0.015	2.30	942	70,882	8,203	13.92	204	14.92	231	14.42	218
			M	3.74	0.258	9.50	754	36,292	6,562	16.15	229	17.15	256	16.65	242
			L	6.16	0.500	7.00	538	13,226	4,687	20.61	279	21.61	305	21.11	292
64	3543.9	15	S	1.32	0.015	2.25	997	84,844	9,819	13.92	218	14.92	246	14.42	232
			M	3.73	0.245	6.13	798	43,440	7,855	16.15	245	17.15	272	16.65	259
			L	6.14	0.475	7.00	570	15,831	5,611	20.61	298	21.61	325	21.11	312
66	3758.1	15	S	1.81	0.058	3.15	1,025	92,460	10,700	13.92	225	14.92	253	14.42	239
			M	3.11	0.201	5.94	820	47,339	8,560	16.15	252	17.15	281	16.65	267
			L	4.41	0.345	8.00	586	17,252	6,114	20.61	307	21.61	335	21.11	321
70	4205.2	15	S	1.31	0.058	3.15	1,080	109,018	12,616	13.92	239	14.92	269	14.42	254
			M	3.72	0.201	6.00	864	55,817	10,093	16.15	268	17.15	298	16.65	283
			L	6.13	0.345	8.00	617	20,342	7,209	20.61	326	21.61	356	21.11	341

Thorburn Duct Flex™ Round Ducting Series SDF - Specifications

Design Details				Non-Concurrent Movement			Spring Rate			Overall Length / Weight					
										End Style					
										WW		FF		FW	
Size	Effective Area	Pressure	Series	Axial	Lateral	Angular	Axial	Lateral	Angular	O.A.L.	Weight	O.A.L.	Weight	O.A.L.	Weight
in	in^2	psi		in	in	in	lbs/in	lbs/in	lbs/in	in	lbs	in	lbs	in	lbs
72	4438.3	15	S	2.00	0.023	3.15	1107	117985	13654	13.92	246	14.92	276	14.42	261
			M	3.20	0.321	6.00	886	60408	10923	16.15	276	17.15	306	16.65	291
			L	4.41	0.620	8.00	633	22015	7802	20.61	335	21.61	366	21.11	351
80	5433.2	15	S	1.99	0.053	2.80	1217	158721	18368	13.92	273	14.92	306	14.42	290
			M	3.19	0.189	5.50	974	812265	14694	16.15	307	17.15	340	16.65	323
			L	4.39	0.325	8.00	695	29616	10496	20.61	373	21.61	405	21.11	390
84	5968.3	15	S	1.99	0.053	3.00	1272	182176	21082	13.92	287	14.92	322	14.42	304
			M	3.19	0.189	6.00	1017	93274	16866	16.15	322	17.15	357	16.65	339
			L	4.39	0.325	8.00	727	33992	12047	20.61	382	21.61	427	21.11	409
96	7707.5	15	S	2.00	0.048	2.60	1587	293692	33987	13.92	324	14.92	362	14.42	343
			M	3.20	0.180	5.20	1270	150370	27190	16.15	363	17.15	401	16.65	382
			L	4.40	0.310	7.80	907	54800	19421	20.61	441	21.61	479	21.11	460
108	9687.9	15	S	2.00	0.043	2.40	1775	412804	47772	13.92	365	14.92	407	14.42	386
			M	3.20	0.164	4.90	1420	211356	38217	16.15	409	17.15	451	16.65	430
			L	4.40	0.290	7.45	1014	77025	27298	20.61	496	21.61	539	21.11	518
120	11894.8	15	S	2.00	0.043	2.30	1962	560256	64835	13.92	406	14.92	452	14.42	429
			M	3.00	0.170	4.80	1643	299960	54239	16.15	451	17.15	498	16.65	474
			L	4.40	0.290	7.30	1643	299960	54239	20.61	543	21.61	589	21.11	566
144	16963.1	15	S	2.00	0.038	2.80	2559	1041949	120579	13.92	481	14.92	536	14.42	508
			M	3.20	0.160	4.90	2047	533478	96463	16.15	538	17.15	593	16.65	565
			L	4.40	0.280	6.90	1462	194416	68902	20.61	652	21.61	707	21.11	679
158	20220.2	15	S	2.00	0.018	3.35	2841	1379899	159688	13.92	522	14.92	581	14.42	551
			M	3.00	0.185	6.05	2383	740127	133830	16.15	583	17.15	642	16.65	612
			L	4.50	0.300	8.75	1702	269726	95593	20.61	705	21.61	765	21.11	735

Thorburn Duct Flex™ Round Ducting Series DDF - Specifications

Design Details				Non-Concurrent Movement			Spring Rate			Overall Length / Weight						Added Lateral Movement Inches per Additional Inch of Spool
										End Style						
										WW		FF		FW		
Size	Effective Area	Pressure	Series	Axial	Lateral	Angular	Axial	Lateral	Angular	O.A.L.	Weight	O.A.L.	Weight	O.A.L.	Weight	
in	in²	psi		in	in	in	lbs/in	lbs/in	lbs/in	in	lbs	in	lbs	in	lbs	
48	1995.8	15	S	6.0	1.625	7.5	558	2041	3092	26.280	394.57	24.280	418.50	25.280	406.54	0.11
			M	7.5	2.125	10.0	446	1368	2474	27.850	403.09	25.850	427.03	26.850	415.06	0.13
			L	10.5	3.250	15.0	319	712	1757	30.990	420.15	28.990	444.09	29.990	432.12	0.17
50	2157.3	15	S	6.0	1.500	7.5	580	2294	3477	26.280	394.57	24.280	418.50	25.280	406.54	0.10
			M	7.5	2.125	10.0	464	1538	2782	27.850	403.09	25850	427.03	26.850	415.06	0.13
			L	10.5	3.250	15.0	332	801	1987	30.990	420.15	28.990	444.09	29.990	432.12	0.17
52	2325.1	15	S	6.0	1.500	7.5	603	2568	3892	26.280	427.72	24.280	452.56	25.280	440.14	0.10
			M	7.5	2.000	10.0	482	1721	3113	27.850	436.95	25.850	461.80	26.850	449.38	0.12
			L	10.5	3.125	15.0	344	896	2224	30.990	455.43	28.990	480.27	29.990	467.85	0.16
54	2499.2	15	S	6.0	1.500	7.5	625	2863	4338	26.280	444.29	24.280	469.59	25.280	456.94	0.10
			M	7.5	1.875	10.0	500	1919	3471	27.850	453.88	25.850	479.18	26.850	466.53	0.11
			L	10.5	3.000	15.0	357	999	2479	30.990	473.07	28.990	498.36	29.990	485.72	0.16
60	3059.1	15	S	6.0	1.250	7.5	692	3880	5879	26.280	494.02	24.280	520.67	25.780	507.34	0.08
			M	7.5	1.750	10.0	553	2600	4703	27.850	504.57	25.850	531.33	26.850	518.00	0.10
			L	10.5	2.750	15.0	395	1354	3360	30.990	526.99	28.990	552.64	29.990	539.32	0.14
64	3450.8	15	S	6.0	1.250	7.5	854	5400	8183	30.280	637.67	24.280	552.71	27.280	595.19	0.08
			M	7.5	1.625	10.0	683	3619	6546	31.850	684.53	25.850	563.58	28.850	606.05	0.10
			L	10.5	2.625	15.0	488	1884	4676	34.990	670.26	28.990	585.30	31.990	627.78	0.14
66	3662.2	15	S	6.0	1.125	7.5	879	5903	8946	30.280	657.72	24.280	569.68	27.280	613.70	0.07
			M	7.5	1.625	10.0	704	3956	7157	31.850	668.93	25.850	580.88	28.850	624.90	0.10
			L	10.5	2.500	15.0	503	2060	5112	34.990	691.33	28.990	603.29	31.990	647.31	0.13
70	4103.8	15	S	8.0	1.625	7.5	881	5304	10047	32.280	700.35	26.280	606.12	29.280	653.23	0.01
			M	10.0	2.250	10.0	705	3442	8038	34.350	712.86	28.350	618.63	31.350	665.74	0.12
			L	13.5	3.500	15.0	504	1705	5741	38.490	737.87	32.490	643.65	35.490	650.76	0.16

Thorburn Duct Flex™ Round Ducting Series DDF - Specifications

Design Details				Non-Concurrent Movement			Spring Rate			Overall Length / Weight						Added Lateral Movement Inches per Additional Inch of Spool
										End Style						
										WW		FF		FW		
Size	Effective Area	Pressure	Series	Axial	Lateral	Angular	Axial	Lateral	Angular	O.A.L.	Weight	O.A.L.	Weight	O.A.L.	Weight	
in	in^2	psi		in	in	in	lbs/in	lbs/in	lbs/in	in	lbs	in	lbs	in	lbs	
72	4334.0	15	S	8.00	1.625	7.5	905	5752	10897	32.280	720.47	26.280	623.15	29.280	671.81	0.10
			M	10.0	2.125	10.0	724	3733	8717	34.350	733.34	28.350	636.02	31.350	684.68	0.11
			L	14.0	3.500	15.0	517	1849	6227	38.490	759.07	32.490	661.75	35.490	710.41	0.16
80	5317.8	15	S	6.00	1.375	7.5	1000	7797	14770	32.280	800.99	26.280	691.30	29.280	746.14	0.08
			M	7.50	1.875	10.0	800	5059	11816	34.350	815.28	28.350	705.60	31.350	760.44	0.10
			L	10.5	3.125	15.0	571	2506	8440	38.490	843.87	32.490	734.19	35.490	789.03	0.14
84	5847.4	15	S	4.25	1.375	7.5	1047	8979	17008	32.280	841.24	26.280	725.37	29.280	783.31	0.08
			M	5.25	1.875	10.0	383	2826	13607	34.350	856.25	28.350	740.38	31.350	798.32	0.10
			L	7.50	3.000	15.0	598	2886	9719	38.490	886.27	32.490	770.40	35.490	828.34	0.13
96	7629.9	15	S	5.75	0.750	6.75	1755	24750	37199	30.378	998.35	24.378	863.94	27.378	931.14	0.05
			M	9.50	1.500	10.0	1053	9557	22320	34.630	1065.91	28.630	931.49	31.630	998.70	0.08
			L	13.5	2.500	15.0	752	4735	15943	38.882	1133.46	32.882	999.05	35.882	1066.26	0.11
108	9600.8	15	S	5.50	0.625	6.0	1963	34831	52350	30.378	1123.66	24.378	970.69	27.378	1047.18	0.04
			M	9.625	1.375	10.0	1178	13450	314410	34.630	1199.65	28.630	1046.69	31.630	1123.17	0.07
			L	13.5	2.250	14.0	841	6663	22436	38.882	1275.65	32.882	1122.68	35.882	1199.16	0.10
120	11798.0	15	S	5.75	0.625	5.25	2170	47319	71120	30.378	1248.96	24.378	1077.45	27.378	1163.21	0.04
			M	9.5	1.250	9.0	1302	18272	42672	34.630	1333.39	28.630	1161.88	31.630	1247.64	0.07
			L	13.5	2.000	12.5	930	9052	30480	38.882	1417.83	32.882	1246.32	35.882	1332.07	0.09
144	16870.9	15	S	5.75	0.500	4.5	2583	80835	121047	30.378	1499.57	24.378	1290.96	27.378	1395.27	0.03
			M	9.5	1.125	7.5	1550	31099	72628	34.630	1600.88	28.630	1392.27	31.630	1496.58	0.06
			L	13.5	1.625	10.5	11007	15407	51877	38.882	1702.19	32.882	1493.58	35.882	1597.89	0.07
158	20137.1	15	S	5.75	0.500	4.0	2816	104785	157490	30.378	1641.58	24.378	1411.95	27.378	1526.77	0.03
			M	9.5	1.000	6.75	1689	40462	94494	34.630	1752.46	28.630	1522.83	31.630	1637.64	0.05
			L	13.5	1.625	9.5	1207	20045	67496	38.882	1863.33	32.882	1633.70	35.882	1748.52	0.07

Duct Flex™ Rectangular Expansion Joints

Thorburn Johannesburg South Africa work shop team manufactured two 6m X 20m Duct Flex™ expansion joint for Eskom's 4800MW Medupi power station located west of Lephalale in Limpopo province, South Africa

Duct Flex™ round corner expansion joints at Thorburn's workshop in Johannesburg South Africa

Thorburn Duct Flex™ 316SS round corner expansion joint for use on a power plant steam generator

Thorburn Malaysia transporting a series of large diameter Duct Flex™ expansion joints to the Manjung power station

Thorburn's Malaysian team welding a Duct Flex™ expansion joint for the Tanjung Bin power station in Johor Pontian Malaysia

Duct Flex™ Rectangular Expansion Joints

Thorburn Duct Flex™ Series DFRV dual mitered corner rectangular ducting expansion joint

Thorburn Duct Flex™ Series SFRU single round corner rectangular ducting expansion joint destined for a power plant in Jimha Malaysia

Thorburn Duct Flex™ rectangular expansion joints are designed in accordance with the Sixth (6th) edition of the standards of the Expansion Joint Manufacturers Association (E.J.M.A.). Thorburn Duct Flex expansion joints are specifically designed to isolate, absorb or compensate for duct motion problems found in ducting systems (i.e. thermal growth, vibration and agitation).

Features

- Unmatched Corner Fabrication and Welding Capabilities
- 200 mm High Corners
- Large Movement
- Low Spring Rates
- High cycle life

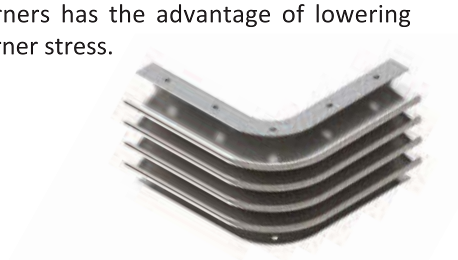
Applications

- Dust collection and fume extraction ductwork systems
- Turbine condenser ducting
- Ducting systems to scrubbers, precipitators, condensers, boiler breaching and other gas or large "off-gas" systems

Corner Configurations

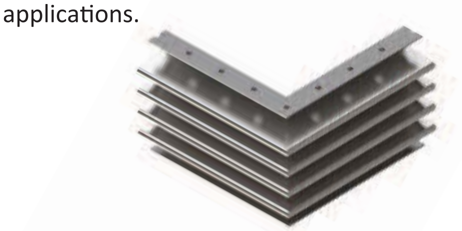
Rounded Corner

Used in applications where vibration and cycle life are important factors. Rounded corners has the advantage of lowering corner stress.



Single Miter Corner

The most common and economical type used to compensate for thermal expansion and used in low cycle and vibration free applications.



Camera Corner

Used on low pressure applications. Camera corners are more accessible for on-site welding. Thorburn does not recommend this configuration.

Duct Flex™ Series SFRV Single Mitered Corner Expansion Joints

Features

- Lowest spring rate.
- Lowest cost for given amount of movement.
- Can be used for gas turbine service if thoroughly insulated internally and externally.
- Can be used for vacuum service (condenser necks) where cost is the primary consideration.

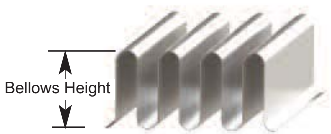
Benefits

- Can be made with 8”(200mm) high convolutions with 0.6 mm thickness
- Short face-to-face applications, axial movements, Ultra low spring rates

Bellows Corner

Outside view of mitered corner construction

Panel Profile



SFRV “U” type bellows profile
SFRV4 - 4" high x 3" pitch
SFRV8 - 8" high x 4" pitch

Series SFRV (Single Bellows) Specifications

Series	Convolution Corner Shape	Convolution Profile Pressure/Temperature	Number of Cons	Axial Compression	Spring Rate (Perimeter)	Overall Length – End Style: FF	Overall Length – End Style: WW	Overall Length – End Style: FW
			#	in	lbs/in/in	in	in	in
SFRV4 (Standard)	V	4" high x 3" pitch ± 100" H_2O at 800ºF	1	1.38	7.48	9.00	11.00	10.00
			2	2.75	3.74	12.00	14.00	13.00
			3	4.13	2.49	15.00	17.00	16.00
			4	5.50	1.87	18.00	20.00	19.00
SFRV8	V	8" high x 4" pitch ± 100" H_2O at 800ºF	1	1.75	12.90	10.00	12.00	11.00
			2	3.50	6.45	14.00	16.00	15.00
			3	5.25	4.30	18.00	20.00	19.00
			4	7.00	3.23	22.00	24.00	23.00

Duct Flex™ Series DFRV Dual Mitered Corner Expansion Joints

Features

- Lowest spring rate and designed for lateral deflection
- Lowest cost for given amount of movement.
- Can be used for gas turbine service if thoroughly insulated internally and externally.
- Can be used for vacuum service (condenser necks) where cost is the primary consideration.

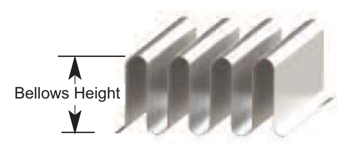
Benefits

- Can be made with 200 mm high cons with 0.6 mm thickness
- Short face-to-face applications, large axial movements, Ultra low spring rates

Bellows Corner

Outside view of mitered corner construction

Panel Profile



DFRV "U" type bellows profile
DFRV4 - 4" high x 3" pitch
DFRV8 - 8" high x 4" pitch

Series DFRV (Dual Bellows) Specifications

Series	Convolution Corner Shape	Convolution Profile Pressure/Temperature	Number of Cons	Axial Compression	Spring Rate (Perimeter)	Overall Length – End Style FF	Overall Length – End Style WW	Overall Length – End Style FW
			#	in	lbs/in/in	in	in	in
DFRV4 (Standard)	V	4" high x 3" pitch ± 100" H_2O at 800ºF	1+1	2.75	3.74	52.00	51.00	10.00
			2+2	5.50	1.87	58.00	54.00	13.00
			3+3	8.25	1.25	64.00	57.00	16.00
			4+4	11.00	0.94	70.00	60.00	19.00
DFRV8	V	8" high x 4" pitch ± 100" H_2O at 800ºF	1+1	3.50	6.45	50.00	52.00	11.00
			2+2	7.00	3.23	54.00	56.00	15.00
			3+3	10.50	2.15	58.00	60.00	19.00
			4+4	14.00	1.61	62.00	64.00	23.00

Duct Flex™ Series SFRU Round Corner Expansion Joints

Thorburn Duct Flex Series SFRU single bellows round corner rectangular ducting expansion joint

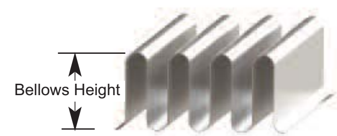
Features

- 3"X2.5" convolution profile can be made with 12" inside radius round corner to eliminate stress risers that exist in the corners of mitered or camera corner rectangular expansion joints.
- Highest pressure capacity for axial movement only
- Best design for gas turbine applications because bellows will heat up at a uniform rate to minimize thermal shock.
- The best design for vacuum service (condenser necks). Lower stress due to pressure.
- Bellows will be close to the flue gas temperature at all times, providing that the bellows is insulated externally. Will minimize condensate and sulfur base acids forming in the convolutions.

Bellows Corner

Outside view of round corner construction

Panel Profile



SFRU "U" type bellows profile
SFRU3 - 3" high x 2" pitch
SFRU4 - 4" high x 3" pitch
SFRU8 - 8" high x 5" pitch

Benefits

- 100 mm high convolutions, 175 mm radius
- Best design for vacuum service
- Highest pressure capacity (max. 175 KPA)

Series SFRU (Single Bellows) Specifications

Series	Convolution Corner Shape	Convolution Profile Pressure/Temperature	Number of Cons	Axial Compression	Spring Rate (Perimeter)	Overall Length End Style FF		
						FF	WW	FW
			#	in	lbs/in/in	in	in	in
SFRU3 (Standard)	Round	3" high x 2" pitch ± 100" H_2O at 800ºF	1	1.13	16.74	8.50	10.50	9.50
			2	2.25	8.37	11.00	13.00	12.00
			3	3.38	5.58	13.50	15.50	14.50
			4	4.50	4.19	16.00	18.00	17.00
SFRU4	Round	4" high x 3" pitch ± 100" H_2O at 800ºF	1	1.38	7.48	9.00	11.00	10.00
			2	2.75	3.74	12.00	14.00	13.00
			3	4.13	2.49	15.00	17.00	16.00
			4	5.50	1.87	18.00	20.00	19.00
SFRU8	Round	8" high x 5" pitch ± 100" H_2O at 800ºF	1	3.50	7.36	13.25	15.25	14.25
			2	7.00	3.68	20.50	22.50	21.50
			3	10.50	2.45	27.75	29.75	28.75
			4	14.00	1.84	35.00	37.00	36.00

Duct Flex™ Series DFRU Dual Round Corner Expansion Joints

Thorburn Duct Flex Series DFRU dual bellows round corner rectangular ducting expansion joint

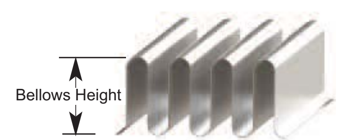
Features

- 3"X2.5" dimensional profile can be made with 12" inside radius round corner to eliminate stress risers that exist in the corners of mitered or camera corner rectangular expansion joints.
- Highest pressure capacity and designed for lateral and axial deflection
- Best design for gas turbine applications because bellows will heat up at a uniform rate to minimize thermal shock.
- The best design for vacuum service (condenser necks). Lower stress due to pressure.
- Bellows will be close to the flue gas temperature at all times, providing that the bellows is insulated externally. Will minimize condensate and sulfur base acids forming in the convolutions.

Bellows Corner

Outside view of dual round corner construction

Panel Profile



DFRU "U" type bellows profile
DFRU3 - 3" high x 2" pitch
DFRU4 - 4" high x 3" pitch
DFRU8 - 8" high x 5" pitch

Benefits

- 100 mm high convolutions, 175 mm radius
- Best design for vacuum service
- Highest pressure capacity (max. 175 KPA)

Series DRFU (Dual Bellows) Specifications

Series	Convolutions	Convolution Profile Pressure/Temperature	Number of Cons	Axial Compression	Spring Rate (Perimeter)	Overall Length End Style FF	Overall Length End Style WW	Overall Length End Style FW
			#	in	lbs/in/in	in	in	in
DFRU3 (Standard)	Round	3" high x 2" pitch ± 100" H_2O at 800ºF	1+1	2.25	8.37	51.00	53.00	9.50
			2+2	4.50	4.19	56.00	58.00	12.00
			3+3	6.75	2.79	61.00	63.00	14.50
			4+4	9.00	2.09	66.00	68.00	17.00
DFRU4	Round	4" high x 3" pitch ± 100" H_2O at 800ºF	1+1	2.75	3.74	52.00	51.00	10.00
			2+2	5.50	1.87	58.00	54.00	13.00
			3+3	8.25	1.25	64.00	57.00	16.00
			4+4	11.00	0.94	70.00	60.00	19.00
DFRU8	Round	8" high x 5" pitch ± 100" H_2O at 800ºF	1+1	7.00	3.68	53.25	55.25	14.25
			2+2	14.00	1.84	60.50	62.50	21.50
			3+3	21.00	1.23	67.75	69.75	28.75
			4+4	28.00	0.92	75.00	77.00	36.00

Thorburn Duct Flex™ Series

SFRU - Single Round Corner Bellows

DFRU - Dual Round Corner Bellows

SFRV - Single Mitered Corner Bellows

DFRV - Dual Mitered Corner Bellows

Typical Thorburn Duct Flex™ Rectangular Ends

Weld Flange Ends - Code "WF"

Flange Ends - Code "FF"

Weld Ends - Code "WW"

How To Order Duct Flex™ Rectangular Expansion Joints

Nominal Size	Model	Ends	Temp. (°F)	Pressure (psi)	Pressure Type	Con Height & Pitch	Number of Cons	Installed Position	Bellows Material	Liner Material	Cover Material	End Material	O.A.L. (in)
60X96 -	DFRV -	FF -	800 -	1 -	P -	2HP -	3CX3C -	H -	B5 -	L5 -	C0 -	E0 -	22
60"X96"	Dual Flex	Flanged Ends	800°F	1 psi	Positive	4"X3"	3 Cons X	Horizontal	SS321	SS321	Carbon Steel	Carbon Steel	22 inches
1500mm X2400mm	"V" Shape Corner		427°C	7 kPa		102mm X80mm	3 Cons						559mm

Thorburn Material Code					ASTM/ASME(S) Material Designation	Material Type
Bellows (B)	Liner (L)	End (E)	Spool (S)	Cover (C)		
B-0	L-0	E-0	S-0	C-0	(S)A36/44W	Carbon Steel
B-1	L-1	E-1	S-1	C-1	(S)A-240	SS304
B-2	L-2	E-2	S-2	C-2	(S)A-240	SS304L
B-3	L-3	E-3	S-3	C-3	(S)A-240	SS316
B-4	L-4	E-4	S-4	C-4	(S)A-240	SS316L
B-5	L-5	E-5	S-5	C-5	(S)A-240	SS321
B-6	L-6	E-6	S-6	C-6	(S)A-240	SS309
B-7	L-7	E-7	S-7	C-7	(S)A-240	SS310
B-8	L-8	E-8	S-8	C-8	(S)B-127	Monel 400
B-9	L-9	E-9	S-9	C-9	(S)B-168	Inconel 600
B-10	L-10	E-10	S-10	C-10	(S)B-443	Inconel 625
B-11	L-11	E-11	S-11	C-11	(S)B-409	Incoloy 800
B-12	L-12	E-12	S-12	C-12	(S)B-424	Incoloy 825
B-14	L-14	E-14	S-14	C-14	(S)B-409	Incoloy 800HT
B-15	L-15	E-15	S-15	C-15	(S)B-162	Nickel 201
B-16	L-16	E-16	S-16	C-16	(S)B-575	Inco C276
B-17	L-17	E-17	S-17	C-17	(S)B-364	Tantalum
B-18	L-18	E-18	S-18	C-18	(S)B-265	Titanium Gr. 1
B-19	L-19	E-19	S-19	C-19	(S)B-551	Zirconium Gr. 702
B-20	L-20	E-20	S-20	C-20	(S)A-285	Carbon Steel
B-21	L-21	E-21	S-21	C-21	(S)A-570	Carbon Steel
B-22	L-22	E-22	S-22	C-22	(S)B-588	Carbon Steel
B-23	L-23	E-23	S-23	C-23	(S)A-606	Corten A
B-24	L-24	E-24	S-24	C-24	(S)A516	Carbon Steel
B-25	L-25	E-25	S-25	C-25	(S)A240	304H
B-26	L-26	E-26	S-26	C-26	(S)A240	316H
B-27	L-27	E-27	S-27	C-27	(S)A240	253MA
B-28	L-28	E-28	S-28	C-28	(S)A240	Duplex SS 2205
B-29	L-29	E-29	S-29	C-29	(S)A240	Super Duplex SS 2507
B-30	L-30	E-30	S-30	C-30	SA204 Gr. B	Carbon Steel
B-31	L-31	E-31	S-31	C-31	SA516-60	Carbon Steel
B-32	L-32	E-32	S-32	C-32	(S)A387	Carbon Steel
B-X	L-X	E-X	S-X	C-X	-	Special - Specify

Model:
SFRU = Single Round Corner
DFRU = Dual Round Corner
SFRV = Single Mitered "V" Corner
DFRV = Dual Mitered "V" Corner

Number of Convolutions (Single or Dual):

Single	Dual
1C = 1 Conv.	**1C + 1C** = 1 Conv.
2C = 2 Conv.	**2C + 2C** = 2 Conv.
3C = 3 Conv.	**3C + 3C** = 3 Conv.
4C = 4 Conv.	**4C + 4C** = 4 Conv.
5C = 5 Conv.	**5C + 5C** = 5 Conv.
6C = 6 Conv.	**6C + 6C** = 6 Conv.
7C = 7 Conv.	**7C + 7C** = 7 Conv.
8C = 8 Conv.	**8C + 8C** = 8 Conv.

Installed Position
H = Horizontal
V = Vertical

End Type:
Single Bellows
WF = Weld Flange
FF = Flange Plate or Angle Flange are standard.
(Specify Flange Drilling)
WW = Weld

Pressure Type
P = Positive
N = Negative
P/N = Positive/Negative

Con Height & Pitch
1HP = 3"X2" (80mm X 51mm)
2HP = 4"X3" (102mm X 80mm)
3HP = 8"X4" (203mm X 102mm)
4HP = 8"X5" (203mm X 127mm)

Special notes

1) Use of material codes as a suffix in the catalogue part number designate the bellows (B), liner (L), end connectors (E), spool (S) and Cover (C).

2) Special note for flanges and pipes: when forged flanges or scheduled pipe are used, the same nomenclature symbols are used (i.e.: E2 or S6).

3) ASTM, ASME "SA" or "SB" materials are standard but other material grades are available upon request.

4) All bellows material purchased by Thorburn are "mill annealed" in accordance with "A", "SA" or "SB" specifications. Thorburn does not perform any other heat treating operations before welding, after welding, before forming convolutions or after forming convolutions unless specified by purchaser. Heat treatment of bellows after forming convolutions can lower bellows' spring rate, "squirm" pressure and cycle life. Thorburn will cooperate with purchasers requiring heat treatment after forming to arrive at what effect the heat treatment will have on published bellows data.

NOTES

1. Rated cycle life is 2000 cycles for any one movement tabulated minimum per EJMA.
2. To combine axial, lateral or angular movements the sum of each must not exceed 100%.
3. To obtain greater movements or cycle life contact Thorburn.
4. Rated axial movement shown is for both compression or extension.
5. Maximum test pressure: 1-1/2 x rated working pressure.
6. Catalogue pressure ratings are based upon a design temperature range of - 20°F to 800°F (-29°C to 427°C). Actual operating temperature should always be specified.
7. For higher pressure temperature, movement and cycle ratings, contact Thorburn with your application details for fast action.

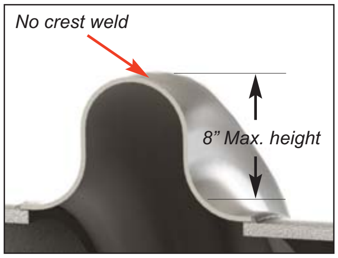
Thorburn Series AF High-Core Bellows Expansion Joints


Thorburn Series AFU High-Core bellows expansion joints fully assembled

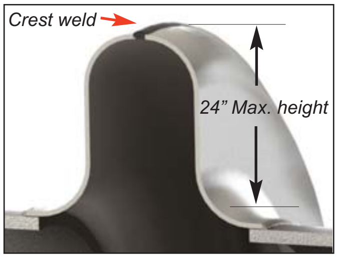

Thorburn's High-Core bellows expansion joints are used in acid plant piping systems


Manufacturing a Thorburn Series AFS single convolution lens High-Core bellows

Thorburn High-Core Bellows Profiles



Thorburn Series AFU hydro-formed bellows



Thorburn Series AFS spun bellows

Series AF High-Core Bellows

Thorburn Series AF High-Core bellows are characterized by a higher convolution profile and a thicker ply construction than traditional bellows expansion joints. Series AF bellows are typically composed of a single or multi-convolution with a bellows height of 80mm (2") to 600mm (24"). Thorburn AF Series bellows are manufactured by a spinning process, referred as lens style bellows (Series AFS) or a hydroforming process (Series AFU). The bellows are made from a single ply thickness from 1.5mm (1/16") to 6mm (1/4"). Available with welded or flanged ends. Thorburn Series AF bellows expansion joints are found mainly in ducting systems in acid plants and fixed tube sheet heat exchangers to accommodate thermal growth. In fixed tube sheet heat exchangers, Thorburn AF bellows are fabricated from steel plate of the same material and thickness as the shell barrel.

Advantages Over Thin Wall Bellows

- Holds up better to mechanical damage
- Facilitates weld repair
- Performs better to corrosive media attack

Industry Applications

- Acid Plants
- Iron and Steel
- Mining
- Chemical
- Power Stations
- Cement Factories

Special Applications

- Heat Exchangers

ASME Sec.VIII, Appendix 5
(circumferential welded convolutions)
ASME Sec.VIII, Appendix 26
(for U-shaped and Omega shaped bellows without circumferential welds)

Thorburn Series AFS High-Core Lens Bellows Expansion Joints

Thorburn Series AFS High-Core bellows expansion joints ready for shipping

Bellows spinning machine forming a Thorburn lens style bellows

Thorburn Series AFS Spun Lens Style Bellows

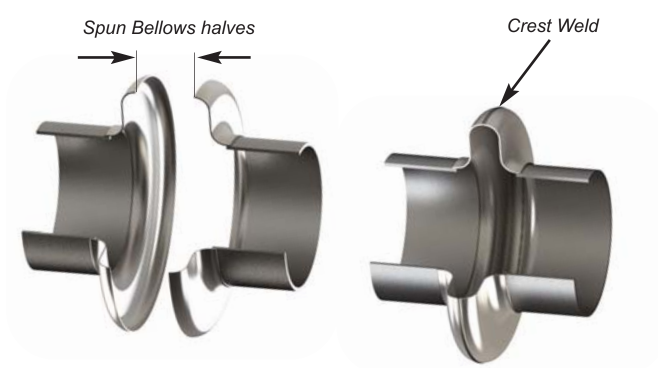
Thorburn AFS bellows are made from welded thick metal disks that are made into donut like shapes. The AFS convolution profile is formed first by spinning the outside edges of the donut in one direction, sometimes refered to as a flange, then spinning the other direction of the donut, which is refered to as a flued. The shape of the profile after spinning resembles the letter"S". The final step in making a Thorburn AFS convolution is done by welding the two "S" halves together. The expansion joint assembly is made by welding a pipe end to the roots of the welded "S" shaped convolution.

Thorburn AFS construction

- Typical convolution height: 80mm (3") to 600mm (24")
- Thickness: 1.5mm (1/16"), 2mm (5/64"), 3mm (1/8"), 5mm (3/16"), 6mm (1/4")
- Materials: 304H, Inconel 625, 316H, 316L, 321

Welding a Thorburn Series AFS single convolution lens High-Core bellows

Thorburn lens bellows installed on a heat exchanger



Lens type bellows consisting of two spun halves joined together with a crest weld

Thorburn Series AFU High-Core Hydro-Formed Bellows

Welding a Thorburn Series AFU Inconel 625 250mm height single convolution bellows expansion joint without crest weld

Thorburn Series AFU High-Core Hydro-Formed Bellows

Series AFU High-Core bellows are manufactured by hydroforming in one piece without a crest weld. Series AFU bellows can be formed with a single convolution or multi-convolution configuration with no root weld. Thorburn's large hydroforming presses (as shown in the photo at right) can make convolutions with materials up to 3mm (1/8") thick and heights up to 250mm (10"). Thorburn AFU bellows can be made with multiple convolutions all in one piece. This process provides greater design flexibility and cycle life and dramatically reduces installation costs. Series AFU High-Core bellows can be supplied with ASME "U" stamp code verification.

In corrosive applications, SS304 or SS316 can be upgraded to alloy 625 to provide better corrosive resistance. When heat exchangers are insulated, Thorburn's AFU bellows can be designed with smaller heights to make it easier to insulate in the field.

Thorburn's large hydroforming press making large multi-convolutions up to 4 meters with convolution heights up to 250mm (10 inches)

Thorburn Series AFU Inconel 625 100mm height multi-convolution expansion joint

Construction Features

- Convolution Height: 50mm (2") to 250mm (10")
- Single Ply (Standard)
- Thickness: 1.5mm (1/16"), 2mm (5/64"), 3mm (1/8")
- Single or multi-convolutions, multi-plies
- Hydro-formed in one piece with no crest weld
- Low spring rates, greater movement
- Low overall cost

How To Order Thorburn High-Core Bellows Expansion Joints

Model	Style	Duct O.D.	Number of Cons	Bellows Height	Bellows Pitch	Bellows Thickness	Bellows Material	Cover Material	Liner Material	End Type	End Material	O.A.L. (in)	Options
AFS -	S -	48 -	3C -	H10 -	P4 -	T3 -	B4 -	C0 -	L0 -	WW -	E3 -	48 -	
High Core	Single Bellows	48”	3 Cons	10”	5”	0.12”	SS316	Carbon Steel	Carbon Steel	Weld End	316SS	48 inches	None
Spun		1200mm		250mm	125mm	3mm						1219mm	

Thorburn Material Code				ASTM/ASME(S) Material Designation	Material Type
Bellows (B)	Liner (L)	End (E)	Spool (S)		
B-0	L-0	E-0	S-0	(S)A36/44W	Carbon Steel
B-1	L-1	E-1	S-1	(S)A-240	SS304
B-2	L-2	E-2	S-2	(S)A-240	SS304L
B-3	L-3	E-3	S-3	(S)A-240	SS316
B-4	L-4	E-4	S-4	(S)A-240	SS316L
B-5	L-5	E-5	S-5	(S)A-240	SS321
B-6	L-6	E-6	S-6	(S)A-240	SS309
B-7	L-7	E-7	S-7	(S)A-240	SS310
B-8	L-8	E-8	S-8	(S)B-127	Monel 400
B-9	L-9	E-9	S-9	(S)B-168	Inconel 600
B-10	L-10	E-10	S-10	(S)B-443	Inconel 625
B-11	L-11	E-11	S-11	(S)B-409	Incoloy 800
B-12	L-12	E-12	S-12	(S)B-424	Incoloy 825
B-14	L-14	E-14	S-14	(S)B-409	Incoloy 800HT
B-15	L-15	E-15	S-15	(S)B-162	Nickel 201
B-16	L-16	E-16	S-16	(S)B-575	Inco C276
B-17	L-17	E-17	S-17	(S)B-364	Tantalum
B-18	L-18	E-18	S-18	(S)B-265	Titanium Gr. 1
B-19	L-19	E-19	S-19	(S)B-551	Zirconium Gr. 702
B-20	L-20	E-20	S-20	(S)A-285	Carbon Steel
B-21	L-21	E-21	S-21	(S)A-570	Carbon Steel
B-22	L-22	E-22	S-22	(S)B-588	Carbon Steel
B-23	L-23	E-23	S-23	(S)A-606	Corten A
B-24	L-24	E-24	S-24	(S)A516	Carbon Steel
B-25	L-25	E-25	S-25	(S)A240	304H
B-26	L-26	E-26	S-26	(S)A240	316H
B-27	L-27	E-27	S-27	(S)A240	253MA
B-28	L-28	E-28	S-28	(S)A240	Duplex SS 2205
B-29	L-29	E-29	S-29	(S)A240	Super Duplex SS 2507
B-30	L-30	E-30	S-30	SA204 Gr. B	Carbon Steel
B-31	L-31	E-31	S-31	SA516-60	Carbon Steel
B-32	L-32	E-32	S-32	(S)A387	Carbon Steel
B-X	L-X	E-X	S-X	-	Special - Specify

Special notes

All bellows material purchased by Thorburn is "mill annealed" in accordance with "A", "SA" or "SB" specifications. Thorburn does not perform any other heat treating operations before welding, after welding, before forming convolutions or after forming convolutions unless specified by purchaser. Heat treatment of bellows after forming convolutions can lower bellows' spring rate, "squirm" pressure and cycle life. Thorburn will cooperate with purchasers requiring heat treatment after forming to arrive at what effect the heat treatment will have on published bellows data.

Model:
AFS = Acid Flex Spun Bellows
AFU = Acid Flex Hydro-formed “U” Type Bellows

Styles:
S = Single Bellows
D = Dual Bellows

Options:
H = Hinge
G = Gimbal
T = Tied
None = Blank

Number of Convolutions:
1C = 1 Conv. **1C + 1C**= 1 Conv.
2C = 2 Conv. **2C + 2C**= 2 Conv.
3C = 3 Conv. **3C + 3C**= 3 Conv.
4C = 4 Conv. **4C + 4C**= 4 Cons

Bellows Height:
H2 = 2” (50mm)
H3 = 3” (80mm)
H4 = 4” (100mm)
H5 = 5” (125mm)
H6 = 6” (150mm)
H8 = 8” (200mm)
H9 = 9” (225mm)
H10 = 10” (250mm)
H12 = 12” (300mm)
H16 = 16” (400mm)
H24 = 24” (600mm)

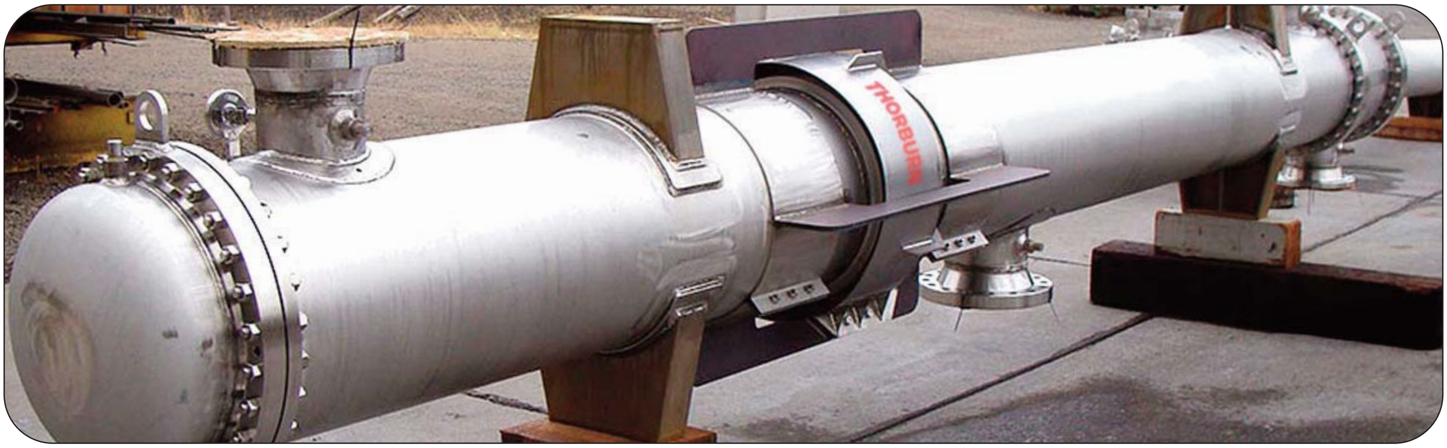
Bellows Pitch:
P1 = 80mm (3”)
P2 = 100mm (4”)
P3 = 112mm (4.5”)
P4 = 125mm (5”)
P5 = 150mm (6”)

Bellows Thickness:
T1 = 1.5mm (.06”)
T2 = 2mm (.08”)
T3 = 3mm (.12”)
T4 = 4mm (.16”)
T5 = 5mm (.20”)
T6 = 6mm (.25”)

End Type:
WW = Weld End/Weld End
EFX = End Flange**
EN = None

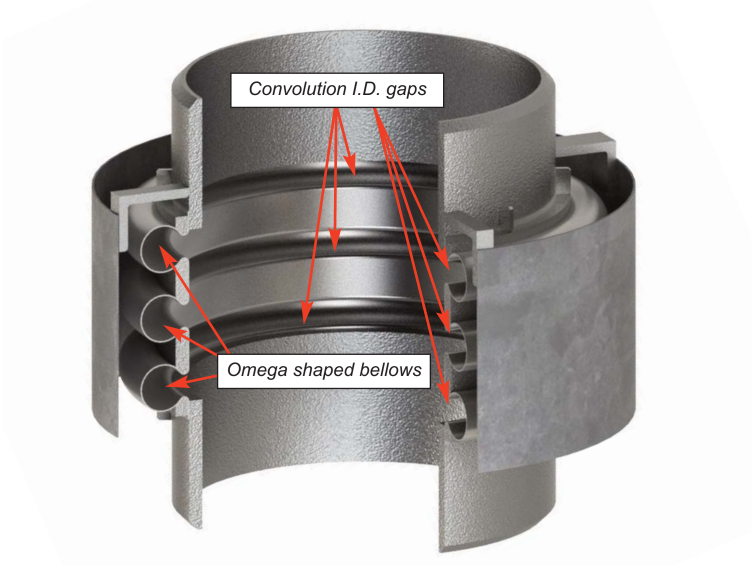
****Flange Drilling Type:**
Plate or Angle Flange are standard.
FF1 = ANSI B16.5 Cl 150 **FF5** = PN25
FF2 = ANSI B16.5 Cl 300 **FF6** = PN40
FF3 = PN10 **FFS** = Special Specify
FF4 = PN16

Series TB Toroidal Bellows Expansion Joints



Thorburn series TB single convolution toroidal bellows installed on a heat exchanger

Cutaway of Thorburn's multi-convolution Omega shaped bellows

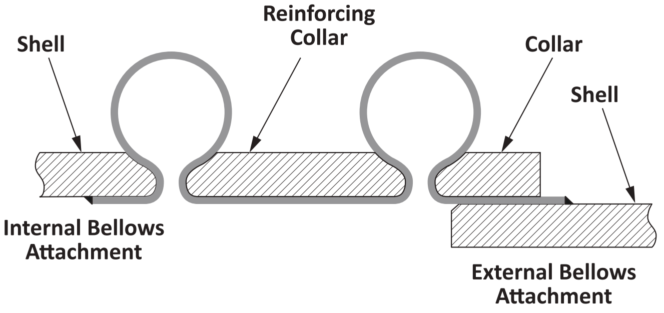


Designed for High Pressure Applications

Thorburn's Series TB toroidal bellows consists of a circular tube wrapped around weld ends or pipe ends having a small gap at the I.D. to permit axial stroke. Thorburn's Series TB toroidal expansion joint bellows are Omega shaped (Ω) and are hydro-formed with very high pressure presses. The Omega shape of the bellows increases its stability in very high pressure applications. Its high pressure resistance is due to the absence of bending stress in the side walls of the bellows, which is the single most the limiting factor for the conventional "U" bellows profile.

Thorburn's Series TB toroidal bellows are hydraulically formed and have a minimum number of longitudinal weld seams which are the same thickness as the parent material and cannot act as a focal point for stresses.

Thorburn's Series TB toroidal bellows are designed for Heat Exchangers in accordance with ASME Sec VIII, Div 1, App. 26. The low convolutions height reduces the pressure thrust on the tubular plates of the exchangers, especially when compared to flanged and flued type bellows.



How To Order Series TB Toroidal Bellows Expansion Joints

Model	Style	Size (in)	Number of Cons	Number of Plies	Ply Thickness	Bellows Material	Liner Material	End Type	End Material	Cover Material	Options
TB -	SF -	8 -	2C -	2P -	T2 -	B25 -	L25 -	WW -	E25 -	C0 -	
Toroidal Bellows	Single Flex	DN200	2 Conv.	2 Plies	.08 in	SS304H	SS304H	Weld End	SS304H	CS A36/44W	None

Thorburn Material Code					ASTM/ASME(S) Material Designation	Material Type
Bellows (B)	Liner (L)	End (E)	Spool (S)	Cover (C)		
B-0	L-0	E-0	S-0	C-0	(S)A36/44W	Carbon Steel
B-1	L-1	E-1	S-1	C-1	(S)A-240	SS304
B-2	L-2	E-2	S-2	C-2	(S)A-240	SS304L
B-3	L-3	E-3	S-3	C-3	(S)A-240	SS316
B-4	L-4	E-4	S-4	C-4	(S)A-240	SS316L
B-5	L-5	E-5	S-5	C-5	(S)A-240	SS321
B-6	L-6	E-6	S-6	C-6	(S)A-240	SS309
B-7	L-7	E-7	S-7	C-7	(S)A-240	SS310
B-8	L-8	E-8	S-8	C-8	(S)B-127	Monel 400
B-9	L-9	E-9	S-9	C-9	(S)B-168	Inconel 600
B-10	L-10	E-10	S-10	C-10	(S)B-443	Inconel 625
B-11	L-11	E-11	S-11	C-11	(S)B-409	Incoloy 800
B-12	L-12	E-12	S-12	C-12	(S)B-424	Incoloy 825
B-14	L-14	E-14	S-14	C-14	(S)B-409	Incoloy 800HT
B-15	L-15	E-15	S-15	C-15	(S)B-162	Nickel 201
B-16	L-16	E-16	S-16	C-16	(S)B-575	Inco C276
B-17	L-17	E-17	S-17	C-17	(S)B-364	Tantalum
B-18	L-18	E-18	S-18	C-18	(S)B-265	Titanium Gr. 1
B-19	L-19	E-19	S-19	C-19	(S)B-551	Zirconium Gr. 702
B-20	L-20	E-20	S-20	C-20	(S)A-285	Carbon Steel
B-21	L-21	E-21	S-21	C-21	(S)A-570	Carbon Steel
B-22	L-22	E-22	S-22	C-22	(S)B-588	Carbon Steel
B-23	L-23	E-23	S-23	C-23	(S)A-606	Corten A
B-24	L-24	E-24	S-24	C-24	(S)A516	Carbon Steel
B-25	L-25	E-25	S-25	C-25	(S)A240	304H
B-26	L-26	E-26	S-26	C-26	(S)A240	316H
B-27	L-27	E-27	S-27	C-27	(S)A240	253MA
B-28	L-28	E-28	S-28	C-28	(S)A240	Duplex SS 2205
B-29	L-29	E-29	S-29	C-29	(S)A240	Super Duplex SS 2507
B-30	L-30	E-30	S-30	C-30	SA204 Gr. B	Carbon Steel
B-31	L-31	E-31	S-31	C-31	SA516-60	Carbon Steel
B-32	L-32	E-32	S-32	C-32	(S)A387	Carbon Steel
B-X	L-X	E-X	S-X	C-X	-	Special - Specify

Model:
TB = Toroidal Bellows

Style:
SF = Single Flex
DF = Dual Flex

Number of Convolutions: (Single and Dual)
1C = 1 Conv. **1C + 1C**= 1 Conv.
2C = 2 Conv. **2C + 2C**= 2 Conv.
3C = 3 Conv. **3C + 3C**= 3 Conv.
4C = 4 Conv. **4C + 4C**= 4 Conv.

Number of Plies:
1P = 1 Ply
2P = 2 Plies
3P = 3 Plies
4P = 4 Plies

Ply Thickness:
T1 = 1.5mm (.06”)
T2 = 2mm (.08”)
T3 = 3mm (.12”)
T4 = 4mm (.16”)
T5 = 5mm (.20”)
T6 = 6mm (.25”)

End Type:
WW = Weld End/Weld End
EF = End Flange (specify flange type)
EN = None (Bellows cuff only)

Options:
H = Hinge
G = Gimbal
T = Tie Rod
Blank = None

Special notes

1) Use of material codes as a suffix in the catalogue part number designate the bellows (B), liner (L), end connectors (E), spool (S) and Cover (C).

2) Special note for flanges and pipes: when forged flanges or scheduled pipe are used, the same nomenclature symbols are used (i.e.: E2 or S6).

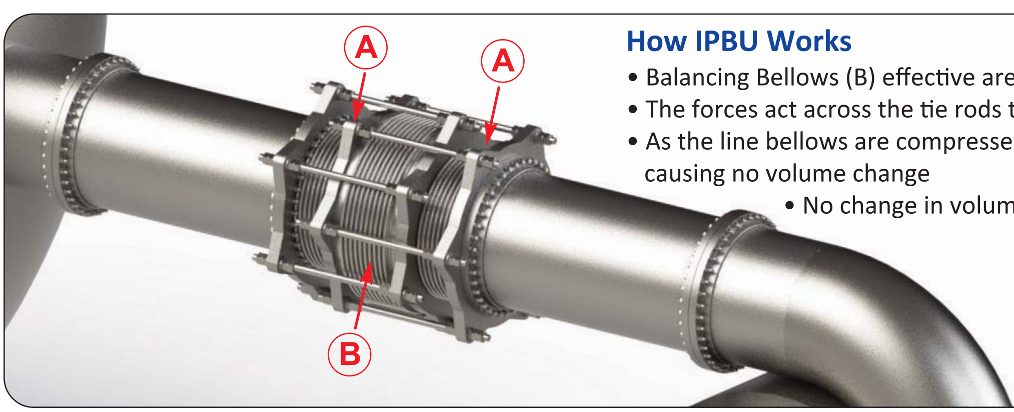
3) ASTM, ASME "SA" or "SB" materials are standard but other material grades are available upon request.

Universal In-Line Pressure Balanced Series IPBU

Thorburn's Model IPBU in-line pressure balanced expansion joint is primarily used to absorb axial thermal growth and restrain pressure thrust in straight piping runs that cannot be anchored. Thorburn's IPBU in-line pressure balanced joint acts as constant volume device. It is this constant volume property in combination with the interlinking hardware that enables the expansion joint to absorb axial movement while simultaneously restraining pressure thrust. The constant volume property of Thorburn's IPBU is created by the addition of an intermediate balancing bellows whose effective area is twice the effective area of the line bellows. The interlinking hardware transmits the thermal movements such that the line bellows and balancing bellows always move in opposite directions to one another e.g. when the line bellows extends, the balancing bellows compresses and vice versa. This ensures that a constant volume is always maintained while pressure thrust is restrained.

Features

- Absorbs axial deflection
- Absorbs lateral deflection independently from the balancing and line bellows
- Neutralizes pressure thrust forces
- Eliminates the requirement for main anchors
- Protects sensitive equipment against detrimental pressure thrust forces
- Main anchors are not required



How IPBU Works

- Balancing Bellows (B) effective area is twice that of the line bellows (A).
- The forces act across the tie rods that are attached to the tie rod plates
- As the line bellows are compressed the balancing bellows is extended causing no volume change
- No change in volume neutralizes pressure thrust loads

Externally Pressurized In-Line Pressure Balanced Series EXIPB

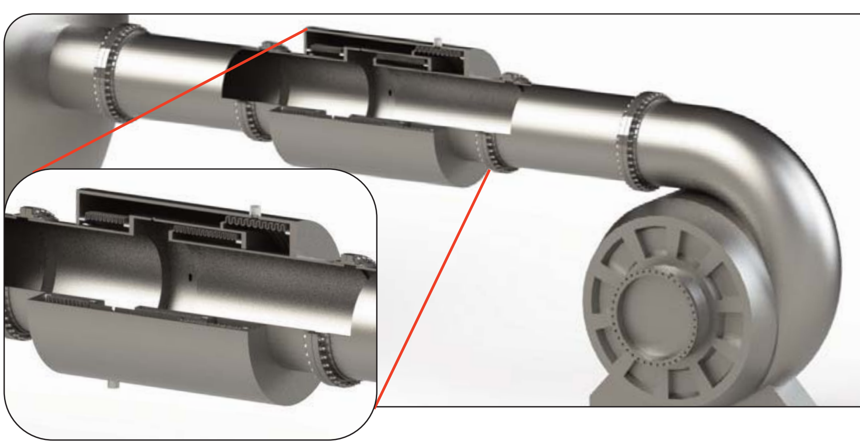
Thorburn Series EXIPB in-line, externally pressurized pressure balanced expansion joint is typically used when:

- the application requires that large axial movements be absorbed.
- the design pressure is high.
- the piping cannot be anchored to restrain the pressure thrust. Thorburn's EXIPB eliminates the need for main anchors.
- a safe enclosure is required to contain hazardous media.
- Convolutions must be self-draining

Thorburn's EXIPB is a constant volume device similar in concept to Thorburn's IPBU. The constant volume property is achieved through the addition of a balancing bellows with an effective area equal to twice the effective area of inner line bellows. Through proper cross-linking, the change in volume of the line bellows is countered by an equal and opposite volume change in the balancing bellows. When a contraction of the pipe (and line bellows) occurs, an equal extension is imposed on the balancing bellows resulting in the expansion joint maintaining constant volume. If no volume change occurs, all pressure thrust forces remain in balance. This unique design also incorporates integral guide rings, a full thickness cover, self-draining convolutions, and insensitivity to flow induced erosion and vibration. Thorburn's EXIPB is both easy to insulate and handle during installation.

Features

- Single Bellows (EXIPBS) up to 8 inches (200mm) movement
- Dual Bellows (EXIPBU) up to 16 inches (400mm) movement
- Up to 400 mm of axial displacement
- Available from 50mm up to 4 m
- Eliminates main anchors & pressure thrust forces
- High pressure up to 50 BAR (750 psi) - Higher pressures available upon request
- Leak proof, pack-less self-draining convolutions
- Self-guiding & maintenance free



How EXIPB Works

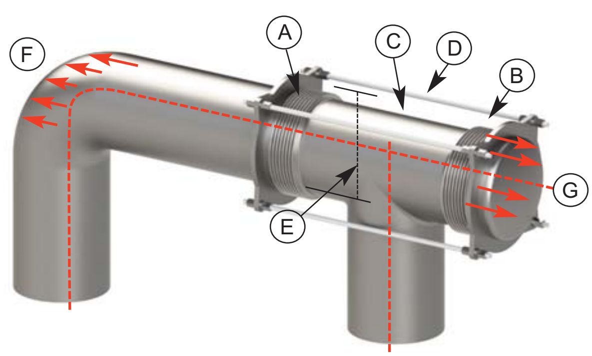
When the Line Bellows contract, an equal but opposite expansion occurs in the balancing bellows resulting in the volume remaining unchanged.

Therefore all forces remain constant and balanced, eliminating axial pressure thrust forces.

Elbow Pressure Balanced Series PBES

How does Thorburn's axial pressure balance work?

Internal pressure causes a pressure thrust on flow bellows **(A)** and against the side outlet (elbow or tee) **(C)**. This thrust is balanced by the identical internal pressure thrust **(G)** pushing on balancing bellows **(B)** that is transmitted back through the tie rods **(D)** counteracting the line pressure thrust **(F)**. The force remaining is the axial spring force required to compress line bellows **(A)** and extend balancing bellows **(B)**, plus whatever friction load is generated by the piping moving through the alignment guides.



A Flow bellows
B Balancing bellows
C Tee or elbow connector
D Tie rods
E Mean diameter of corrugations
F Pressure thrust of the line
G Reaction pressure thrust on the balancing end

Thorburn's custom designed pressure balanced elbow series PBES expansion joints are the ideal flexible piping solution when:

- there is a change in direction of the piping and a main anchor cannot be installed at the change of direction. Thorburn's PBES absorbs the pressure thrust and eliminates the need for a main anchor at the change in direction of the piping e.g. a 45° or 90° elbow.
- the expansion joint must absorb axial movement and a small amount of lateral motion as it has only a single line bellows.

Thorburn's PBES expansion joints are commonly used on load sensitive equipment. For this reason, they are often installed on turbine casing and pump nozzles. Thorburn's PBES expansion joint uses line and balancing bellows that are typically linked with tie rods. The balancing bellows is subjected to the same pressure as the line bellows. When there is thermal growth of the piping, the line bellows compresses. The tie rods transfer this thermal growth to the balancing bellows causing it to extend by an equal amount. Since there is no change in the volume of the system, the pressure thrust forces remain in balance. It should be noted that when the line bellows deflects laterally, there is also no volume change. The reader shall take note that the line bellows can absorb both axial and lateral motion but the balancing can only absorb axial motion.

Typical Applications

Thorburn's pressure balanced expansion joints are used where there is a change in the direction of the pipe line. The most common applications for Thorburn's pressure balanced elbow is adjacent to a piece of equipment such as a turbine, pump or valve where allowable nozzle loads necessitate the elimination of pressure thrust.

Features

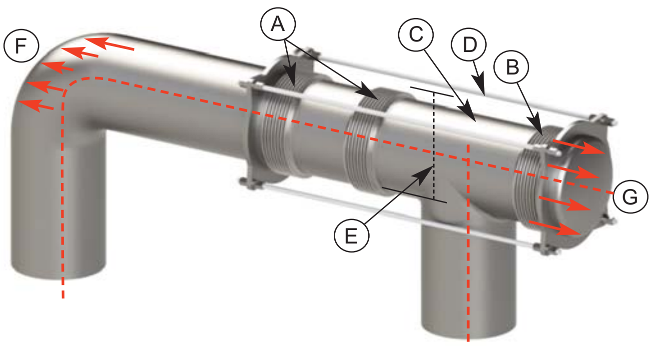
- Absorbs axial and lateral movements without imposing pressure thrust on the turbine nozzles
- Eliminates main anchors, Minimum guiding required

Elbow Pressure Balanced Universal Expansion Joint Series PBEU

Thorburn's pressure balanced elbow Series PBEU functions on the same principle as Thorburn Series PBES except that it has a universal line bellows design. The PBEU design utilizes two line bellows and a single balancing bellows. The PBEU is used when:

- axial movement and large amounts of lateral movement must be absorbed.
- nozzle loads from lateral movement have to be minimized.
- there is a change in direction of the piping and a main anchor cannot be installed at the change of direction. Thorburn's PBES absorbs the pressure thrust and eliminates the need for a main anchor at the change in direction of the piping e.g. a 45° or 90° elbow.

Thorburn's PBEU accomplishes this through the use of universal line bellows and a single balancing bellows. The bellows are joined together by tie rods. These rods pivot at their attachment points to facilitate the lateral deflection. The lateral movement is absorbed by the line bellows in the same manner as it would be for a conventional tied universal expansion joint. The sketch on the right depicts a typical PBEU application requiring absorption of both axial movement and large magnitude lateral deflection. The anchor on the piping run and on the turbine are intermediate anchors and only provide directional guiding.

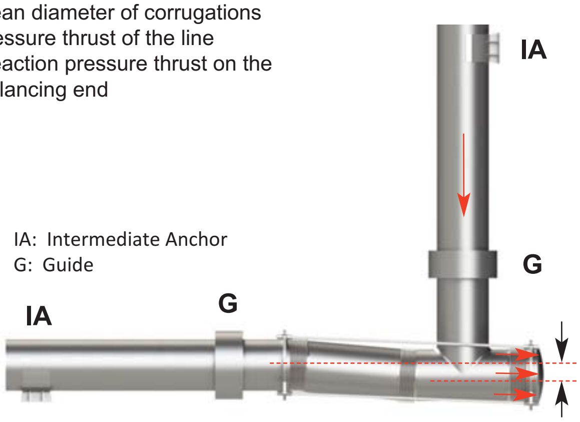


Pressure balanced joint has lateral pipe connection that can move easily between two bellows.

A Flow bellows
B Balancing bellows
C Tee or elbow connector
D Tie rods
E Mean diameter of corrugations
F Pressure thrust of the line
G Reaction pressure thrust on the balancing end

Thorburn crossover pressure balanced expansion joint installation

IA: Intermediate Anchor
G: Guide



Guiding and anchoring construction in a Thorburn PBEU universal pressure balanced expansion joint system

Steam Turbine Crossover Expansion Joints

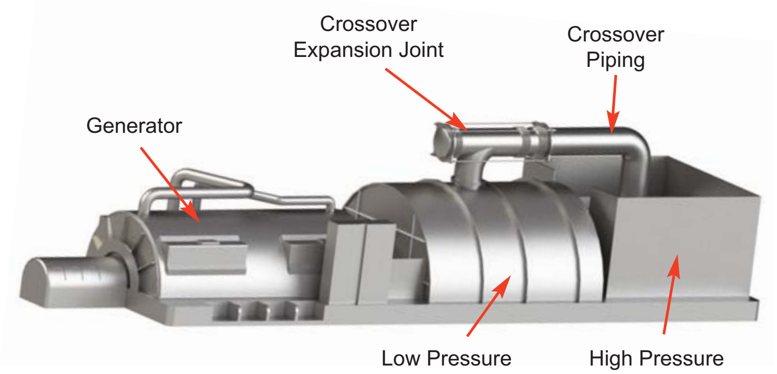
Thorburn's crossover expansion joint installed on a geothermal power plant

Thorburn crossover expansion joint in service on a steam generator

The Advantage of Crossover Bellows

Thorburn's Steam Turbine Crossover Expansion Joints Series STCEJ work in a manner identical to both the PBES and PBEU expansion joints described above though they are typically larger in size and operate at lower pressures. An STCEJ is typically located on the outlet exhaust nozzle of a steam turbine. STCEJ expansion joints can be found in coal fired power generation plants, combined cycle plants, nuclear power generating stations, geothermal thermal power generation facilities etc. Proper STCEJ design results in minimal loadings on the turbine casings which improves the reliability of the critically important steam turbines. It should be noted that STCEJ's commonly operate in high chloride service applications and may require the use of more exotic bellows materials such as Alloy 625 (or Alloy 625 LCF). These materials ensure reliability of the STCEJ and the system it is installed into.

Typical Steam Generator



Custom Fluid Catalytic Cracking Unit (FCCU) Expansion Joints

FCCU hinge type expansion joint

FCCU pressure balanced expansion joint

Fluid catalytic cracking (FCC) is one of the most important conversion processes used in petroleum refineries. It is widely used to convert the high-boiling point, high-molecular weight hydrocarbon fractions of petroleum crude oils into more valuable gasoline, olefinic gases, and other products. Alumina silicate powder is used as a catalyst to produce the cracking of heavy hydrocarbon molecules into lighter molecules.

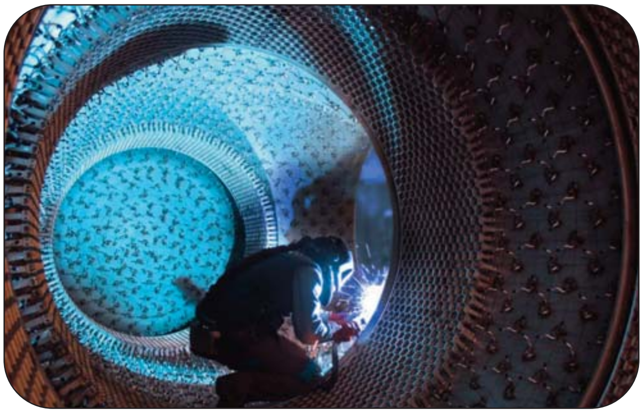
Thorburn's Fluid Catalytic Cracking Unit (FCCU) Expansion Joints are exposed to high temperatures, high pressures, large movement conditions and very aggressive media and are considered highly engineered and one of the most critical and complex types of Thorburn expansion joints we have manufactured. The introduction of abrasive media (catalyst) requires the addition of refractory lining to protect against gradual deterioration of the expansion joint.

Features

- Custom designed to suit application requirements
- Tied universal, hinged, gimbal and pressure balanced types
- Bellows Inconel 625 LCF (Low Cycle Fatigue)
- Abrasive resistant refractory lining
- Free floating structural support permits differential thermal expansion between structural rings and shell
- Designed for high temperature, high pressure and high movement applications
- Typical Operating Conditions: 566°C to 760°C
- Withstands abrasive media such as powder catalyst entrained in hydrocarbon flow

Custom Fluid Catalytic Cracking Unit (FCCU) Expansion Joints

FCCU high temperature expansion joint with pantograph linkages



Pressure balanced cold wall expansion joint with V-anchors and hex mesh used to armour anti-abrasive and anti-corrosion refractory linings

Thorburn FCCU hot wall expansion joint with a gimbal ring that permits lateral deflection in two planes and a pantographic linkages that equalizes the amount of axial compression that each bellows will absorb

Typical Thorburn Expansion Joints Used In FCCU

Due to the high temperatures in the FCC process, different configurations of expansion joints are required for the thermal growth of the piping system.

- Restrained Universal (*See Page 49*)
- Hinged (*See Page 36*)
- Gimbal (*See Page 37*)
- Pressure Balanced (In-line & Elbow) (*See Pages 100-104*)

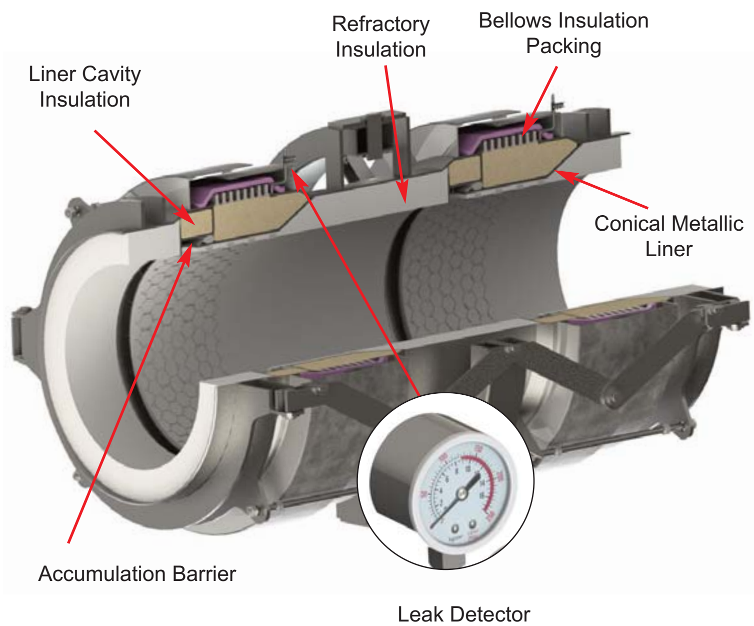
Thorburn FCCU expansion joints are categorized into three groups:

FCCU-CW Cold Wall - Installed in flue gas piping and utilize anchors and high density 125mm thick refractory lining to reduce the shell wall temperatures below 340°C. Internal insulation and liner seal keeps fluid particles out of the liner and bellows cavity. External insulation is used to prevent the bellows from dropping below the acid dew point.

FCCU-HW Hot Wall - Found in flue gas piping and incorporate an abrasion resistant lining made of hex-mesh and refractory. The lining is designed to withstand abrasion from the catalyst flow but is not intended to be used as a thermal barrier and therefore the shell temperature of the expansion joint will rise above allowable temperatures for normal carbon steel.

FCCU-UL Unlined - Used for inlet and outlet ducting systems and can be exposed to very high temperatures and external insulation is required. These joints are designed to accept large movements and have the same hardware as lined expansion joints but do not convey catalyst and therefore do not require lining.

Custom Fluid Catalytic Cracking Unit (FCCU) Expansion Joints



Internal Insulation

Refractory Insulation
Single layer of 5” thick refractory lining type RESCOCAST 110G for the spool pipe and pipe ends.

Conical Metallic Liner
The conical liners are exposed to the full flow temperature and allows radial expansion of the liner without thermal induced stress.

Accumulation Barrier
The gap between the liners is closed with a metallic seal made from SS knitted wire encased in hose wire braid made from Inconel 600.

Bellows Insulation Packing
The bellows convolutions are filled with ceramic/silica fiber insulation blanket to prevent particle accumulation between the convolutions.

Liner Cavity Insulation
The liner cavity is filled with ceramic fiber blanket which provides the equivalent temperature reduction of the refractory insulation.

Hardware

Leak Detector
Should the inner bellows develop a leak the pressure built-up between the plies is noted by the leak detector.

Pantographic Linkage
Connecting the ends and center spool pipe which distributes the axial movement equally between two bellows.

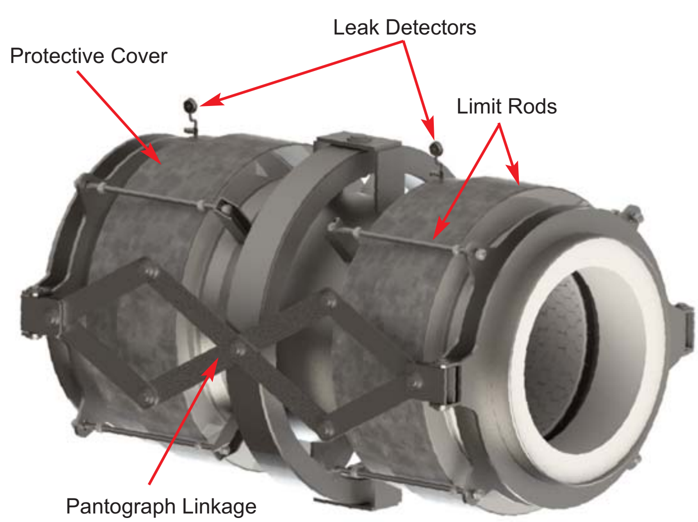
Limit Rods
Prevents bellows from moving beyond the design limit and not meant to restrain the pressure axial thrust load.

Tie Rods
Tie rods are used in universal type expansion joints and are designed to support the full axial pressure thrust load.

Protective Covers
Designed for protection against jet impingement. Can be welded at the end rings and in the middle to the seal bellows.

Hinge
Absorbs angular movement in a single plane and is designed to restrain pressure thrusts and other external loads.

Gimbal
Absorbs angular movement in a all planes and is designed to restrain pressure thrusts and other external loads.



Custom High Temperature Series BT-CFB Bed Transfer Joints

Circulating Fluidized Bed (CFB) Power Plant

CFB Furnace to Stripper Cooler Wall Bed Transfer

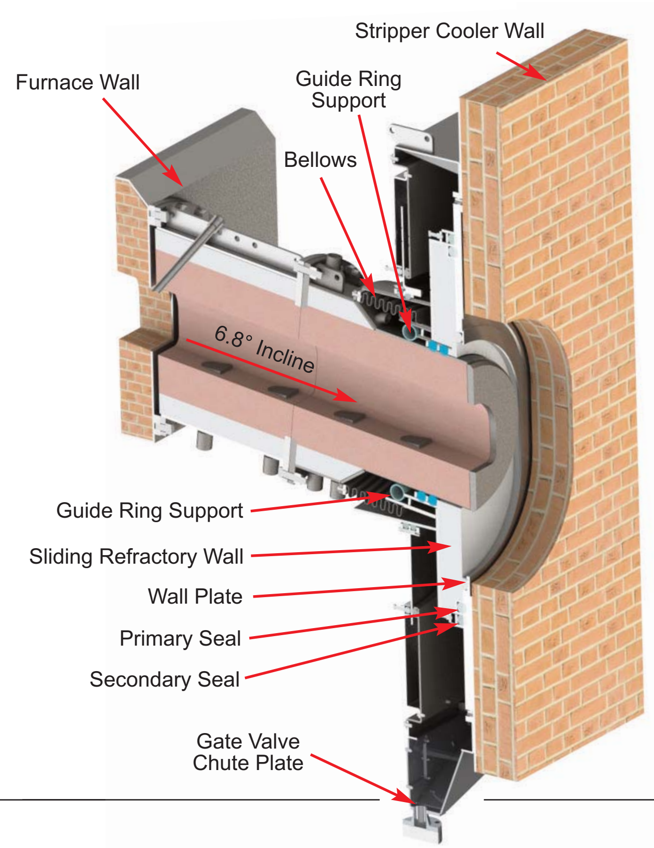
Bed transfer expansion joints are installed between the CFB furnace wall and the stripper cooler wall providing high temperature service. Bed Transfer expansion joints are specifically designed with proprietary ash sealing capabilities and absorbs up to 50mm (2”) of axial movement and ± 200mm (8”) of lateral deflection and are able to withstand abrasive combustible media at temperatures up to 1100°C (2012°F). Bed transfer expansion joints are rebuildable for easy maintenance.

Features

- Facilitates maintenance cleaning & repair
- No furnace wall inlet opening
- Removable nozzle section & inspection access door
- Gate valve and chute plate
- No ash build-up & Abrasion resistant
- No exposed metallic components
- No thermal mechanical stress
- No lateral bellows loads only axial displacement
- Guide ring support self aligning & self sealing
- Minimal stripper cooler outlet opening with tertiary sealing system to prevent fly-ash build-up

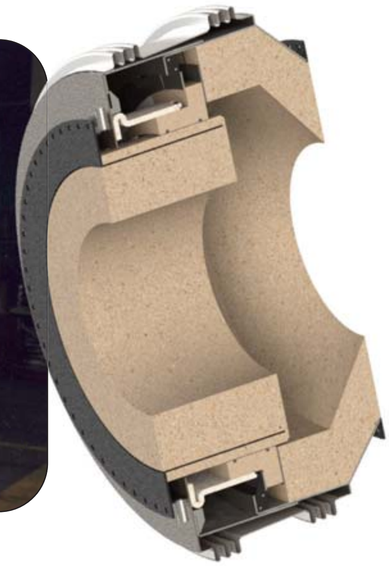
Thorburn Series BT-CFB bed transfer expansion joint ready for inspection

Bed Transfer Expansion Joint Components



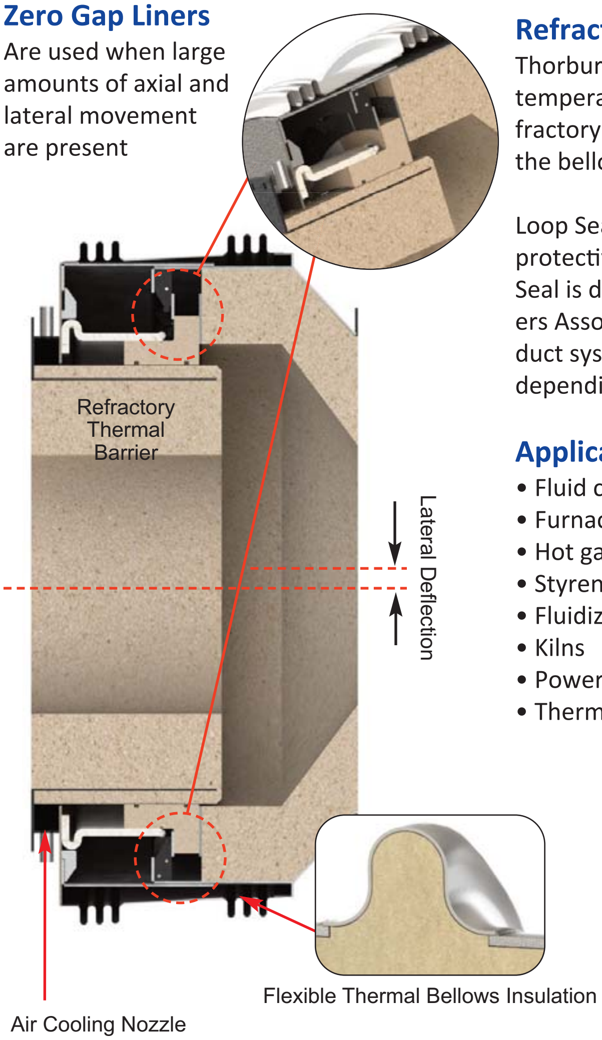
Custom High Temperature Loop Seal Expansion Joints

Thorburn Loop Seal "Zero Gap" expansion joint allows for lateral deflection



Zero Gap Liners

Are used when large amounts of axial and lateral movement are present



Refractory Lined For High Temperature Service

Thorburn's Loop Seal Refractory Lined Expansion Joints are used in extremely high temperature applications and are designed to withstand extreme environments. Refractory lining can reduce the pipe wall temperature to 300-450°F and also protect the bellows from abrasion caused by the flow of abrasive particles.

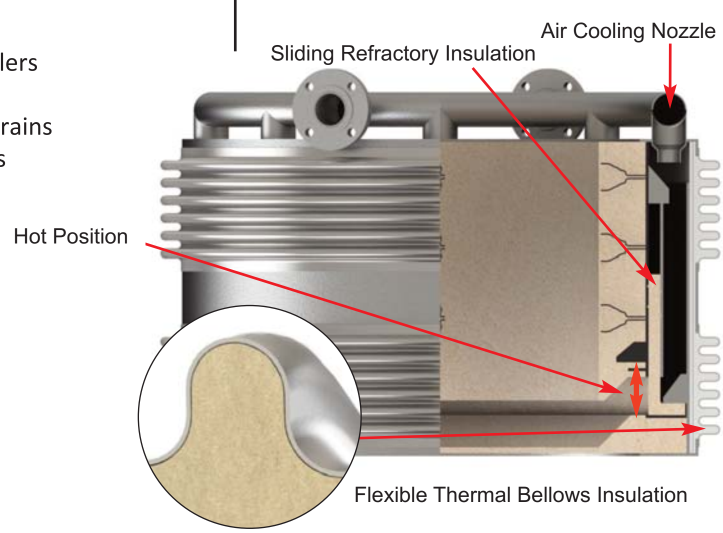
Loop Seal Refractory Lined Expansion Joints can be supplied with lining purge nipples, protective insulating covers and special thermical packing for dust applications. Loop Seal is designed in accordance with the standards of the Expansion Joint Manufacturers Association (E.J.M.A) latest edition for use in dust collection and fume extraction duct systems. The pressure ranges are ±5psi and temperatures up to 1800°F (982°C) depending up on materials.

Applications

- Fluid catalytic cracking Units (FCCU)
- Furnaces
- Hot gas turbines
- Styrene plants
- Fluidized bed boilers
- Kilns
- Power recovery trains
- Thermal oxidizers

Zero Gap Liners

Are used when large amounts of axial and lateral movement are present



Air Cooled Condenser Bellows Expansion Joint Assemblies

Thorburn Series SFH single bellows hinged expansion joint

Thermal Power generation plants such as combined cycle, concentrated solar, coal, biomass, and waste to energy, use air-cooled condensers to return spent steam back into the cycle after the steam has been used to spin the turbine to generate electricity.

An air cooled condenser is made up of modules that are arranged in parallel rows. Each module contains a number of fin tube bundles. A vertical upward flow forces the cooling air across the heat exchange area of the fin tubes.

Tied Universal metal bellows are required at the spent steam risers to the condenser frame. It reduces loads transmitted by differential thermal growth from the expanding duct system and wind loads.

A hinge or gimbal expansion joint is also used to reduce loads created when the tied universal joint causes an angular load on the duct system.

Ordering Information

Please see Single Flex™ (Pg 39), Dual Flex™ (Pg 53), Duct Flex™ (Pg 81)

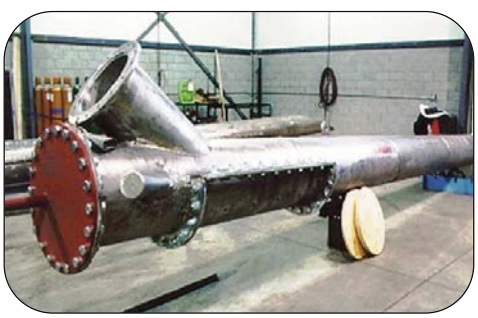
Thorburn Series DFT tied universal expansion joint

SFH hinge and DFT tied universal expansion joints

Specialized Custom CFB Expansion Joints

CFB oxy-fuel technology allowing 100% capture of carbon dioxide, fuel flexible, zero emissions

Center Ash Drain Expansion Joints for a project in Turow Bogatynia, Poland



Fuel Chute Expansion Joints for a power plant in Jacksonville, Florida

Center Ash Drain Bellows Assemblies

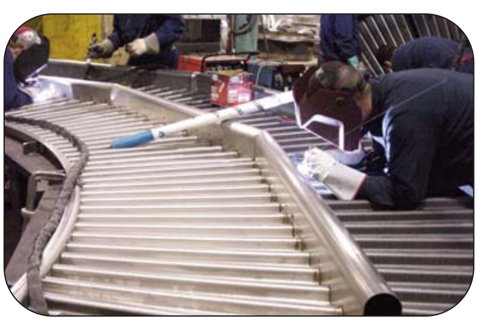
Thorburn engineers have designed complex center ash drain assemblies to absorb thermal movement and mitigate stress while providing a leak tight seal.

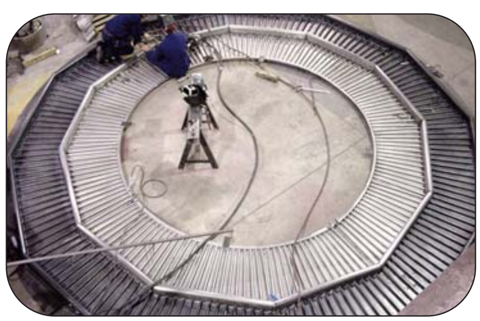
Fuel Chute Expansion Joints

Thorburn engineers have designed fuel chutes to transport abrasive fuels used to fuel a CFB power plant with removable wear plates. Thorburn expansion joints are added to the fuel chutes to isolate vibration, absorb thermal movements and neutralize stress.

Cyclone Roof Seal Expansion Joints

Designed to absorb circumferential radial expansion while maintaining a seal. Built in sections with tight tolerances for site fabrication.





Cyclone Roof Seal Expansion Joints for a JEA Florida Project

Thorburn Series PSB Custom Penetration Seal Bellows

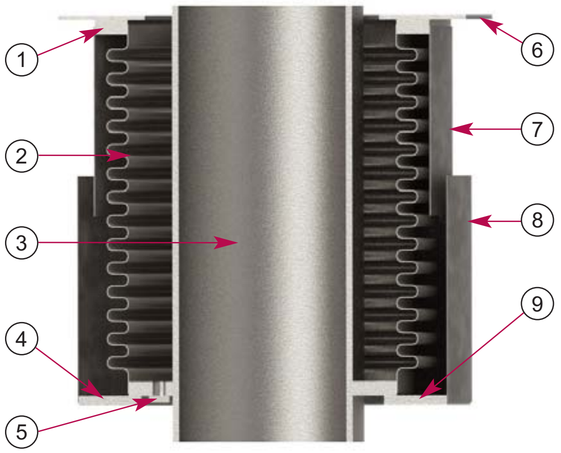
Sidewall and roof penetration seal bellows are found in HRSG power plants

Thorburn's penetration seal bellows ready for shipment to Toshiba power plant in Kanasa City, Missouri

Thorburn custom metallic penetration seal bellows are used to allow tubes or pipes to thermally expand and contract without damaging the surrounding shell or pressure casing. The packing material in this joint is used to help reduce the escape of heat and gas from the boiler. Thorburn penetration seals can operate at flow temperatures up to 1400°F (760°C) and have the longest service life under design conditions and provide good insulation between the boiler wall and the attachment ring.

Advantages

- 100% gas-tight operation
- Accommodates axial, angular, and lateral movements
- Stainless and nickel alloys available for corrosion resistance
- Reduces stress in penetration pipe and boiler wall
- Improved boiler efficiency through reduced heat loss
- Low maintenance
- External insulation options available



Typical Penetration Seal Components

1 Outside ring
2 Bellows
3 Penetration pipe*
4 Inside ring
5 Drain plug (optional)
6 Boiler wall*
7 Inside cover (optional)
8 Outside cover (optional)
9 Cover ring (optional)

* Shown for illustration only.

Thorburn Series CRS Custom Clamshell Retrofit Seal Bellows

Thorburn Series CRS custom clamshell retrofit seal bellows are used when a bellows is leaking or damaged in a pipe line or if a bellows has to be changed with a minimum down time. Thorburn Series CRS custom clamshell retrofit seal bellows perform the same service as standard penetration seals, but consist of two sections of a single bellows that are field welded around the pipe, by a highly skilled TIG welder. A clamshell prevents the cutting of pipe sections during bellows installation.

Clamshell retrofit seal bellows are a two-piece bellow design. The bellows is split in half longitudinally and the halves are match-marked to ensure the bellows halves are aligned correctly. As the clamshell is fitted accurately in position, a purge gas is then set up to minimize oxidizing of the weld to ensure a good quality welding. The clamshell halves are then welded back together.

Advantages

- Turnkey removal of old seals and replacement with new seals
- Experienced ASME Section IX welders & procedures
- Custom designed bellows to suit application


Thorburn site team replaced a failed fabric penetration seal with a series of retrofit seals


Thorburn Series CRS penetration seals were site welded together without cutting the steam pipe

Types of Custom Clamshell Retrofit Seal Bellows

Oversized clamshell retrofit seal bellows

Oversized Clamshell Retrofit Seal Bellows

An oversized clamshell retrofit seal bellows is recommended to seal a leaking bellows while keeping the plant on line. The bellows is installed on top of the current bellows unit while the system operates. The leaking bellows are encapsulated by adding split rings with a larger outside diameter than the leaking bellows on either side.

Same sized clamshell retrofit seal bellows

Same Sized Clamshell Retrofit Seal Bellows

For a same-size clamshell retrofit seal bellows installations, the pipe line must be shut down and the leaking or damaged bellows is removed. The pipe outside diameter where the old bellows was located and welded needs to be ground smooth to obtain a weldable surface for proper installation of the new bellows.

Oversized clamshell retrofit seal components

Thorburn Custom Silencer Seal Bellows

Thorburn Silencer systems are a vital part for power generation to safely direct turbine exhaust to the atmosphere and to provide optimal acoustic and aerodynamics of the gas flow. Metallic silencer bellows are installed to compensate for extreme heat and thermal expansion of the pipeline.

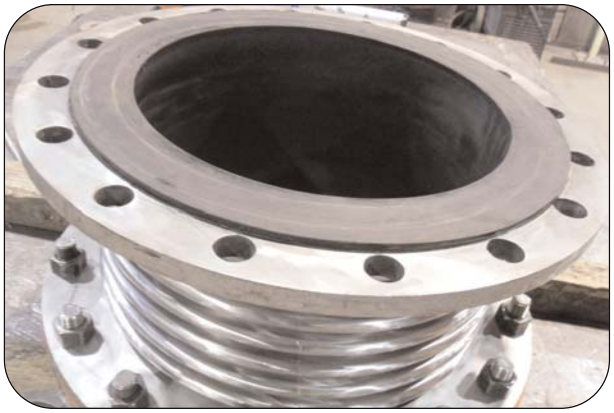
Silencer Bellows Seal Expansion Joint Attached Externally

- Bellows thermal movement absorbed by the silencer expansion joint
- Sound attenuation covers can be supplied
- Bellows designed to take full line inlet pressure
- Bellows made of inconel 625 LCF to address stress corrosion cracking
- Expansion Joint system absorbs pressure thrust

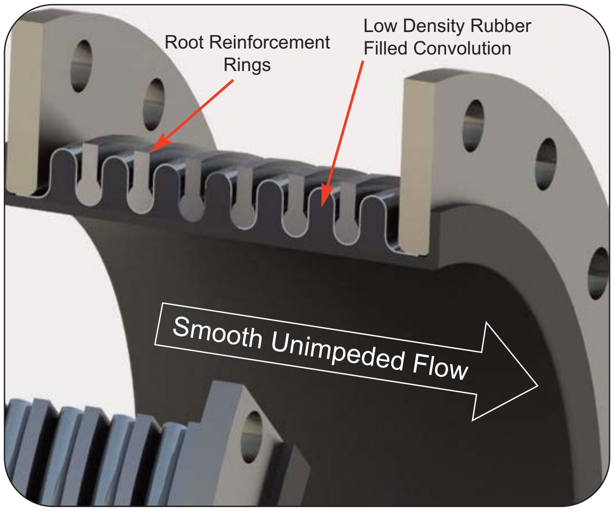
Integrated Bellows Seal

- Integrated expansion joint is more cost effective
- Absorbs large thermal growth of the connecting piping from safety relief vent valves
- Combining silencer EJ into the silencer yields an effective method of absorbing movement without being exposed to the high inlet pressure
- Standard seals are designed to take +/- 25mm
- Axial & +/- 50mm Lateral

Thorburn Series RLB Rubber Lined Metallic Bellows



RLB-SF Rubber Lined Metallic Expansion Joint



Low density rubber filled convolutions & root reinforcement rings

Thorburn Series RLB Rubber Lined Metallic Expansion Joints

Full vacuum to 70 bar (1000psi), Sizes 100mm to 4000mm - CRN (Canada)

Thorburn's RLB Series rubber lined metallic expansion joints are specifically designed to address pipe movement requirements in high pressure applications that exceed the capabilities of Thorburn's 42HPXX Series rubber expansion joints. Thorburn's RLB Series incorporates the security of using ASME code allowable stress values to calculate pressure containment & movement capabilities of a metallic expansion joint while combining the superior abrasion, erosion and corrosion resistance of a rubber expansion joint. This combination yields a superior expansion joint to a stand alone metallic or rubber expansion joint.

RLB Series rubber lined metallic expansion joint uses 3 proven technologies

Lining metal pipes with rubber is a technology that has been in service in mines for over a century to handle abrasion, erosion & corrosion problems. Low density rubber filled arches in rubber expansion joints to provide smooth unimpeded flow is a technology that was perfected in the 1930's. Thorburn's RLB rubber lined metallic expansion joints are an innovation of combining three proven technologies (metallic expansion joints, rubber lining of metallic surfaces & low density rubber filled expansion joint arches) to address high pressure pipe motion problems found in transfering slurry and bitumen to tailing processing facilities.

Thorburn Series RLB Features

- Provides smooth unobstructed flow
- Abrasive resistant to fine & coarse media
- Relieves stress in piping systems
- ASME B31.1 & B31.3 compliant
- CRN for all Canadian Provinces

Thorburn Series RLB Rubber Lined Metallic Bellows

Thorburn's Dual Flex Model RLB-DFT - Tied Universal Rubber Lined Metallic Expansion Joint System for the SUNCOR fort Hills Project. Design pressure 35 bar (550 psi) test pressure 53 bar (800 psi)

Cyclic movement testing (1000x) of Thorburn's Singleflex Model RLB-SF rubber lined metallic expansion joint with low density rubber filled convolutions to prove its dynamic movement capabilities.The metallic expansion joint provides pressure containment while the rubber lining provides abrasion erosion & corrosion resistance. The expansion joints metal surfaces are chemically etched to provide the ideal surface for rubber lining. Adhesion test are performed on the rubber lining to ensure its bonding strength.

Thorburn's Model RLB-SF Cyclic Movement Testing

Media Compatibility

(HNBR/FKM Lining)

Chemically inert & resistant to

- Isopentane,
- N-Pentane solvents,
- Bitumen - Maltene
- Bitumen - Asphaltene
- H_2O & Air

Typical Applications

- Tailing preparation plant piping systems
- High pressure piping delivery systems
- Ore & slurry pipeline transportation systems
- Process water pipeline systems
- In-Plant slurry pipeline systems
- Pump station high pressure piping systems

How To Order Thorburn Seal Bellows

Please see Single Flex ordering information on page 39 and Dual Flex ordering information on page 53

Hot-Flex™ Series HF PTFE Lined Metallic Bellows

Thorburn's Hot-Flex™ high pressure PTFE lined expansion joint system with tangent pipe combines the properties of metal and teflon into the most advanced and versatile expansion joint available in the world today

High Pressure /Temperature & Corrosive Resistant

Thorburn's Hot-Flex™ "HF" Series PTFE lined expansion joint system is designed to provide high pressure and temperature transfer containment of highly corrosive media that could not be safely handled by conventional metallic, elastomeric or PTFE expansion joints. Hot-Flex™ expansion joints combine the high pressure rating of a metallic expansion joint with the high temperature corrosion resistance of PTFE, creating a product that will out-perform them both. Hot-Flex™ PTFE lined expansion joints can be custom engineered to your specific application. Available in hinged, gimbal, pressure balanced or tied universal designs.

Isostatically steam molded PTFE for a perfectly shaped bellows profile

Advantages

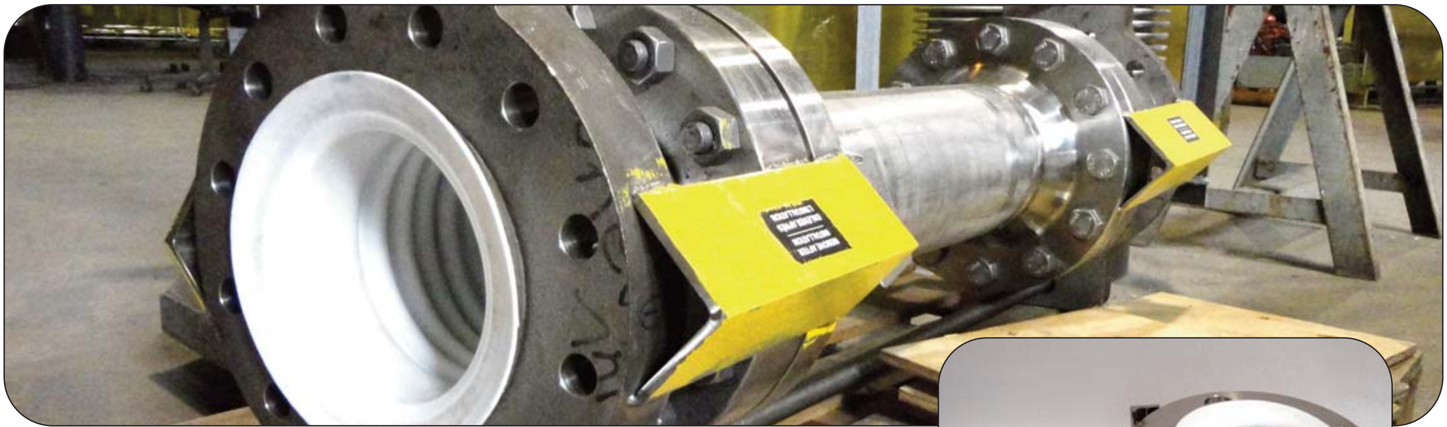
- Protects against start-up & surge forces
- Absorbs pipe movement
- Isolates mechanical vibration
- Reduced System Noise
- Compensates Misalignment

Benefits

- Corrosive resistant & Anti stick
- PTFE Liner covers flange face
- Liners are spark tested
- No pigments or additives to the PTFE liner
- Absorbs pipe movements and stress
- Isolates mechanical vibration
- Reduces system noise
- Sizes from 1" to 96" (DN25 to DN2440)
- Protects against surge forces

Thorburn Model HF-LP high density ETFE (Ethylene tetrafluoroethylene) lined bellows for low permeation

Hot-Flex™ Series HF PTFE Lined Metallic Bellows



Thorburn's Hot-Flex™ with isostatically molded unpigmented PTFE convolutions

Construction

Hot-Flex™: PTFE or FEP teflon tube formed into a stainless steel, inconel, monel or hastelloy corrugated tube.
Flanges: Floating type (150#, 300# or metric). Available in carbon steel, stainless steel or PTFE coated to meet your specific requirements.
Working temperatures: from -300°F to +400°F.
Working pressures: 50 - 150 - 300 psi available (please specify).
Options: Gimbal-hinged-dual-externally pressurized-pressure balanced.

***DANGER:** Thorburn Thor-Shield™ (page 116) must be used at all times in hazardous service to protect against serious personal injury in the event of expansion joint failure. Thorburn internal liners must be used in abrasive service or where sharp-edge solids may be present.*

Hot-Flex™ with Hastelloy C4 Bellows Expansion Joints and Tantalum Coated Vacuum Rings

This unique expansion joint design uses very special materials and offers enhanced performance properties, such as excellent strength and durability, as well as resistance to oxidation, corrosion and deformation at high temperatures or under high pressure for use in Petro-Chemical Plants.

Construction

Bellows Material: Alloy C-4 (2.4610) NiMo16Cr16Ti
Pipes: Alloy C-4 (2.4610) NiMo16Cr16Ti
Backing Rings: Alloy C-4 (2.4610) NiMo16Cr16Ti
Vacuum rings: Tantalum
Lining: PTFE

How To Order Hot Flex™ Expansion Joints

Please see ordering information for Single Flex page 39 and Dual Flex page 53

Tantalum Coated Metallic Bellows

Tantalum Coating

Tantalum coatings (Ta coatings) have unique characteristics which provide a number of benefits in numerous applications. Tantalum coating treatment is a unique solution that can extend the life of metal bellows against a wide range of aggressive chemicals, acids, electrical conductivity at high temperatures and corrosive environments. Tantalum is the most corrosion resistant metal available and the coating treatment process on metal bellows provides superior corrosion resistance for extended service life and reduced maintenance in a wide range of industrial processes and applications.

Features

- Chemically resistant to SCC and pitting in many aggressive media and environments.
- Tantalum layer remains passivated and inert to corrosion under high temperature (>200° C) acidic conditions including concentrated HCl and H_2SO_4.
- Superior corrosion resistance against wet, dry chlorine atmospheres, and other chlorinated environments.

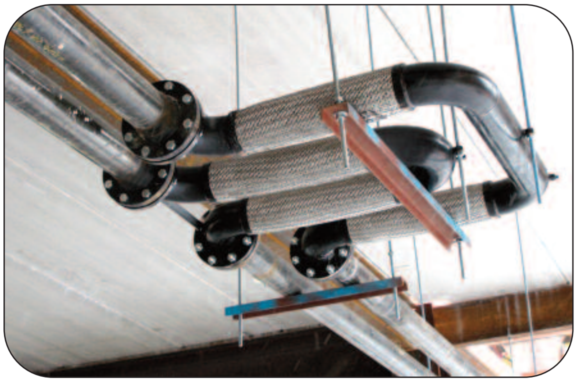
Applications

- Chemical Processing
- Oil & Gas
- Pharmaceutical
- Mining
- Marine

How To Order Tantulum Coatings

Please see Single Flex ordering information on page 39 and Dual Flex ordering information on page 53

Thor-Loop™ Flexible Pipe Loops



Thorburn's Thor-Loop™ Series UL Flexible Pipe Loops

Thor-Loop™ is a custom flexible pipe loop engineered to absorb up to 500 mm (20 in) of movement in all directions, providing superior protection in demanding piping systems.

Features

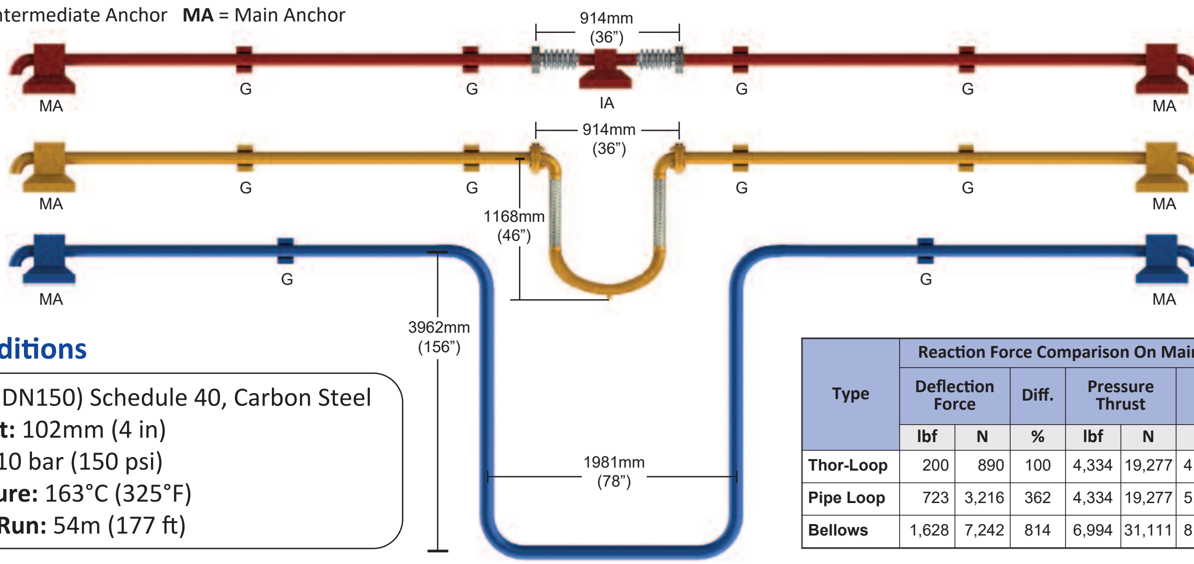
- Absorbs thermal (axial) and seismic movement in all directions - U-type (TL) & V-type (VL)
- UL-listed and CGA-certified, ideal for fire sprinkler and gas-fired equipment systems.
- Protects boilers, chillers, and connected equipment during seismic events.
- Prevents nozzle cracking, shearing, and pipe stress, ensuring long service life.
- Low anchor loads compared to bellows and hard pipe loops for easier installation.
- Versatile configurations, including double-containment, steam-jacketed, or buried loops

Applications

- Nozzle load relief for equipment and tanks
- Fire sprinkler and gas system connections
- Buried or space-restricted piping systems

Thor-Loop™ vs Metallic Bellows vs Hard Pipe Loop Comparison

G = Guide **IA** = Intermediate Anchor **MA** = Main Anchor



Design Conditions

Pipe: 6 in (DN150) Schedule 40, Carbon Steel
Movement: 102mm (4 in)
Pressure: 10 bar (150 psi)
Temperature: 163°C (325°F)
Length of Run: 54m (177 ft)

Type	Reaction Force Comparison On Main Anchors							
	Deflection Force		Diff.	Pressure Thrust		Total Reaction Force		
	lbf	N	%	lbf	N	lbf	N	
Thor-Loop	200	890	100	4,334	19,277	4,534	20,167	
Pipe Loop	723	3,216	362	4,334	19,277	5,057	22,493	
Bellows	1,628	7,242	814	6,994	31,111	8,622	38,353	

How to Order Thorburn Thor-Loop™ Hose Assemblies

Note: Thor-Loop™ hose assemblies installed in any orientation other than hanging down **must** have the 180° return supported. If the 180° return bend is made of different material than the end fittings, please specify.

Thor-Loop	Type	Hose	Size	Pressure	1st End	1st End Material	2nd End	2nd End Material	Dimension A	Dimension B	Accessories
(N)TL	02	S96	32	300	01	S6	40	S6	14	24.5	SB

Thor-Loop:
(N)TL - U-Loop
(N)VL - V-Loop

Type:
01 - Hanging Down
02 - Hanging Up
03 - Hanging Sideways

Hose:
S96
S96Z
S92
S92Z
B96
B96Z

Size:
08 = 1/2" (DIN15)
12 = 3/4" (DIN20)
16 = 1" (DIN25)
20 = 1 1/4" (DIN32)
24 = 1 1/2" (DIN40)
32 = 2" (DIN50)
40 = 2 1/2" (DIN65)
48 = 3" (DIN80)
64 = 4" (DIN100)

1st End / 2nd End:
01 - Elbow Male NPT Nipple
14 - Elbow Weld End
17A(150) - Elbow Flange 150#
17A(300) - Elbow Flange 300#
17(PN10) - Elbow Flange PN10
17(PN25) - Elbow Flange PN25
25 - Lapjoint Flange SS316 150# Stub SS316
26 - Lapjoint Flange CS 150# Stub SS316
40 - Elbow Victaulic
43 - Elbow Female Copper Sweat End

Note: For additional End Connection types, Please see Page 25

End Material:
CS = Carbon Steel
S4 = 304SS
S6 = 316SS
B = Brass

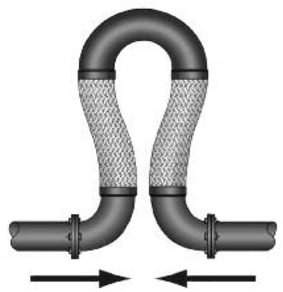
Dimension A / Dimension B:
See Movement Charts on page 57

Accessories:
DP = Drain Plug
SB = Support Bracket
XX = Specify return bend material if different than end material

Notes: Prefix (N) is used for code compliance. When Nuclear Class 2, 3 or 4 is required insert NC2 for Class 2, NC3 for Class 3 & NC4 for Class 4 at the end of the part number. Class 6 use prefix (N) only.

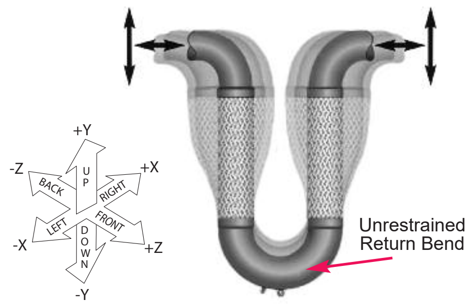
Thor-Loop™ Flexible Pipe Loops

Thermal (Axial) Movement

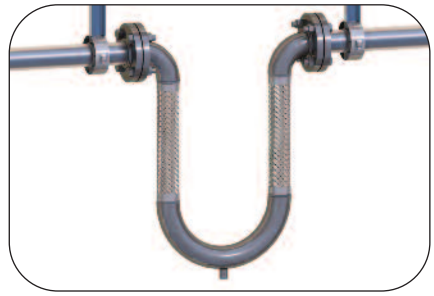


Thor-Loop's flexible elements are designed with sufficient live length with the offset amount never exceeding the elastic limit and therefore will flex indefinitely

Seismic Movement



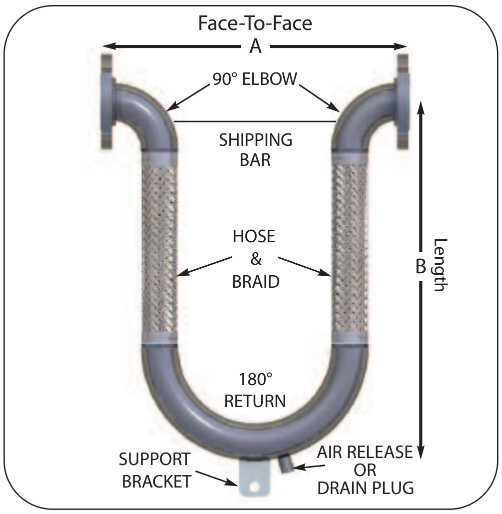
The randomness of movement in an earthquake requires Thor-Loop™ be capable of movement in all directions

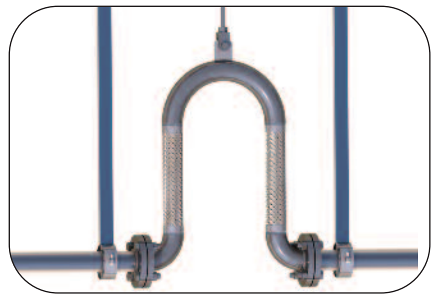


Hanging Down (Code 01)

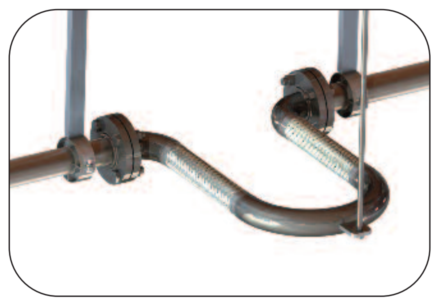
Thor-Loop Series VL "V-Loop"

Thor-Loop Series VL "V-Loop" is a compact design that provides greater movement than Thorburn Series TL "U-Loop" in more compact spaces.





Hanging Up (Code 02)



Hanging Sideways (Code 03)

Thor-Loop™ Movement Selection Charts

Threaded/Welded Ends With Typical OAL Dimensions

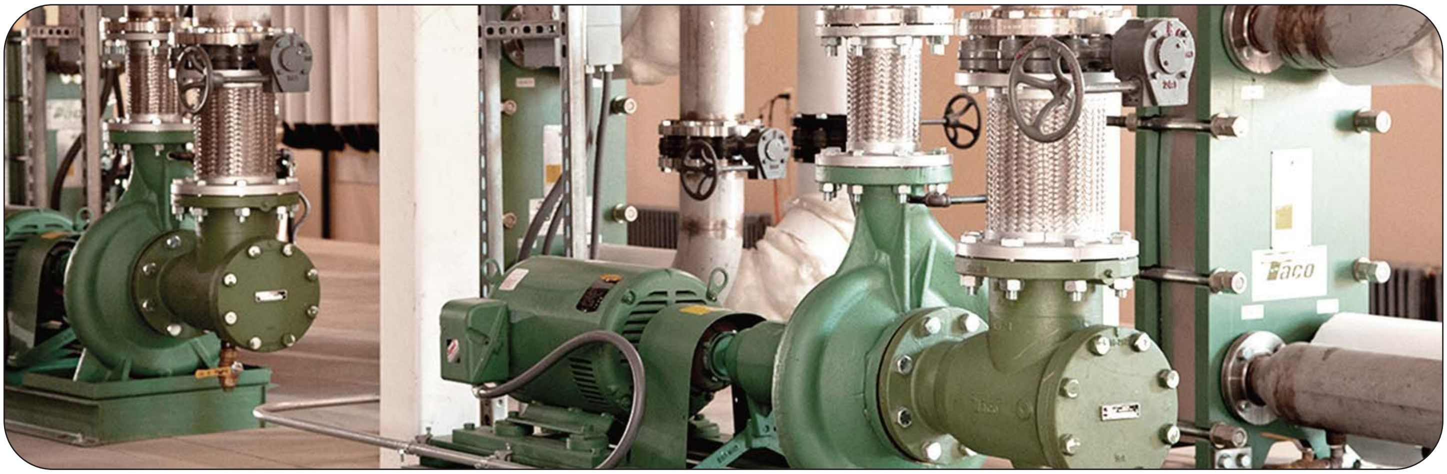
Pipe Size inch (DIN)	Movement inch (mm)	Threaded Face-Face (A) inch (mm)	Welded Face-Face (A) inch (mm)	Length (B) inch (mm)
1/2 (12.7)	±1.5 (38) ±4 (100)	12 (300) 15 (381)	6 (153) 9 (229)	11 (280) 16 (407)
3/4 (20)	±1.5 (38) ±4 (100)	13 (330) 16 (407)	6 (153) 10 (254)	11 (280) 18 (457)
1 (25)	±1.5 (38) ±4 (100)	12 (300) 16 (407)	6 (153) 10 (254)	12 (300) 19 (483)
1 1/4 (32)	±1.5 (38) ±4 (100)	13 (330) 17 (432)	8 (204) 11 (280)	14 (356) 20 (508)
1 1/2 (38)	±1.5 (38) ±4 (100)	15 (381) 18 (457)	9 (229) 12 (305)	15 (381) 22 (559)
2 (50)	±1.5 (38) ±4 (100)	18 (457) 20 (508)	12 (305) 14 (356)	18 (457) 25 (635)
2 1/2 (63.5)	±1.5 (38) ±4 (100)	21 (534) 22 (559)	15 (381) 16 (407)	21 (534) 29 (737)
3 (80)	±1.5 (38) ±4 (100)	26 (661) 28 (712)	18 (457) 20 (508)	24 (610) 30 (762)
4 (100)	±1.5 (38) ±4 (100)	32 (813) 34 (864)	24 (610) 26 (661)	28 (712) 36 (915)

Flanged Ends With Typical OAL Dimensions

Pipe Size inch (DIN)	Movement inch (mm)	Face-Face (A) inch (mm)	Length (B) inch (mm)
2 (50)	±1.5 (38) ±4 (100)	13 (330) 15 (381)	18 (457) 25 (635)
2 1/2 (63.5)	±1.5 (38) ±4 (100)	16 (407) 18 (457)	21 (534) 29 (737)
3 (80)	±1.5 (38) ±4 (100)	19 (483) 21 (534)	24 (610) 30 (762)
4 (100)	±1.5 (38) ±4 (100)	25 (635) 27 (686)	28 (712) 36 (915)
5 (127)	±1.5 (38) ±4 (100)	31 (788) 33 (839)	33 (839) 41 (1042)
6 (153)	±1.5 (38) ±4 (100)	37 (940) 39 (991)	37 (940) 46 (1169)
8 (204)	±1.5 (38) ±4 (100)	49 (1245) 51 (1296)	45 (1143) 54 (1372)
10 (254)	±1.5 (38) ±4 (100)	61 (1550) 63 (1601)	54 (1372) 64 (1626)
12 (305)	±1.5 (38) ±4 (100)	73 (1855) 75 (1906)	62 (1575) 73 (1855)

Note: The dimensions above should be viewed as estimates. Exact dimension are determined by application.

Thorburn Metallic Pump Connectors



Thorburn metallic pipe connectors provide piping systems with the flexibility needed to absorb noise and vibration, compensate for thermal growth, or permit motion of other piping elements. They are designed to be adjacent to mechanical equipment to isolate vibration, absorb small movements and to facilitate installation. Thorburn metallic pipe connectors are made from a standard flexible corrugated 321 stainless steel core hose covered by a 304 SS wire braid and pressure tested 1.5 times their maximum rated working pressure and manufactured with a 4:1 safety factor.

Features

- Compensates for misalignment
- Smooths out force-pump system pulsation
- Controls vibration
- Eliminates piping stress & reduces noise
- All metal construction
- Absorbs thermal growth

Applications

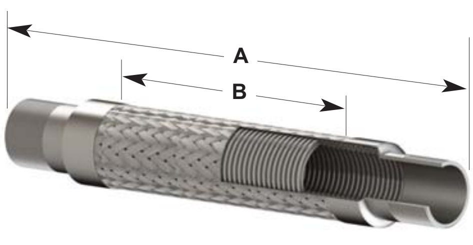
- Boiler systems
- Cooling towers
- Riser connections
- Compressors
- Chillers
- Mechanical rooms
- Pump suction
- Discharge lines

Series PC96-01/PC96-14 NPT Welded Pump Connectors

Thorburn Part Number	Nominal I.D.		Length A		Length B		Pressure @ 21°C (70°F)		Max. Offset		Weight (Approx.)	
	in	mm	in	mm	in	mm	psi	kPa	in	mm	lbs	kg
PC96XX08	0.50	15	13.0	330	7.0	178	850	5860	0.5	12	0.5	0.20
PC96XX12	0.75	20	13.0	330	7.0	178	650	4481	0.5	12	0.75	0.30
PC96XX16	1.00	25	14.0	356	8.0	203	575	3964	0.5	12	1.00	0.40
PC96XX20	1.25	32	14.0	356	8.0	203	450	3102	0.5	12	1.50	0.60
PC96XX24	1.50	40	14.0	356	8.0	203	325	2241	0.5	12	2.00	0.90
PC96XX32	2.00	50	15.0	381	9.0	229	275	1896	0.5	12	2.50	1.10
PC96XX40	2.50	65	16.0	406	10.0	254	200	1379	0.5	12	3.50	1.50
PC96XX48	3.00	80	17.0	432	11.0	279	200	1379	0.5	12	5.00	2.20

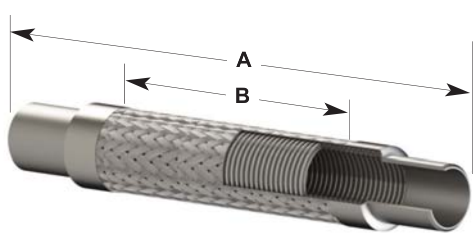
XX = Insert 01 for Male NPT or 14 for Weld Ends

PC96-01



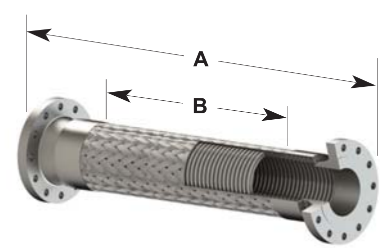
Male NPT Ends (Carbon Steel)

PC96-14



37° Beveled Weld Ends (Carbon Steel)

PC9617P



150# Flange Ends (Carbon Steel)

Series 9617P Flanged Pump Connectors

Thorburn Part Number	Nominal I.D.		Length A		Length B		Pressure @ 21°C (70°F)		Max. Offset		Weight (Approx.)	
	in	mm	in	mm	in	mm	psi	kPa	in	mm	lbs	kg
PC9617P16	1.00	25	11.0	279	8.0	203	200	1379	0.50	12	8	3.60
PC9617P20	1.25	32	11.0	279	8.0	203	200	1379	0.50	12	10	4.50
PC9617P24	1.50	40	11.0	279	8.0	203	200	1379	0.50	12	14	6.40
PC9617P32	2.00	50	12.0	305	9.0	229	200	1379	0.50	12	16	7.27
PC9617P40	2.50	65	14.0	356	10.0	254	200	1379	0.50	12	19	8.60
PC9617P48	3.00	80	14.0	356	11.0	279	200	1379	0.50	12	22	10.00
PC9617P56	3.50	90	14.0	356	11.0	279	200	1379	0.50	12	25	11.30
PC9617P64	4.00	100	15.0	381	12.0	305	200	1379	0.50	12	29	13.10
PC9617P80	5.00	125	20.0	508	16.0	406	200	1379	0.50	12	38	17.30
PC9617P96	6.00	150	21.0	533	17.0	432	200	1379	0.25	6	42	19.00
PC9617P128	8.00	200	23.0	584	19.0	483	200	1379	0.25	6	74	33.60
PC9617P160	10.00	250	25.0	635	21.0	533	150	1034	0.25	6	90	40.90
PC9617P192	12.00	300	27.0	676	23.0	584	150	1034	0.25	6	100	45.50

Standard End Types

Flange

Code “FF”

Welded

Code “WW”

Male NPT

Code “MNPT”

How To Order Thorburn Pump Connectors

Series	Size	1st End (Standard Leave Blank)	1st End Material	2nd End (Standard Leave Blank)	2nd End Material	Overall Length	Fractions	Option
PC9617P -	**32 -**	**FF4 -**	**S6 -**	**FF4 -**	**S6 -**	**64 -**	**06 -**	**-**
	2 inch (DN50)	Fixed Flange PN10	316SS	Fixed Flange PN10	316SS	64 inches	3/8 inch	None
		Standard Leave Blank	CS Standard Leave Blank	Standard Leave Blank	CS Standard Leave Blank	1626mm	(Inches Only)	

Model (Standard):
PC96-01 NPT Welded
PC96-14 NPT Welded
PC9617P Flanged

Flange Drilling Type Codes:
FF1 = ANSI B16.5 Cl 150
FF2 = ANSI B16.5 Cl 300
FF3 = PN10
FF4 = PN16
FF5 = PN25
FF6 = PN40
FFS = Special Specify
P = Plate Flange
(Add prefix “P” before “FF” type)

Sizes:
08 = 1/2” (DN15)
12 = 3/4” (DN20)
16 = 1” (DN25)
20 = 1 1/4” (DN32)
24 = 1 1/2” (DN40)
32 = 2” (DN50)
40 = 2 1/2” (DN65)
48 = 3” (DN80)
64 = 4” (DN100)
96 = 6” (DN150)
128 = 8” (DN200)
160 = 10” (DN250)
192 = 12” (DN300)

Materials:
CS = Carbon Steel (Standard)
S4 = 304SS
S6 = 316SS

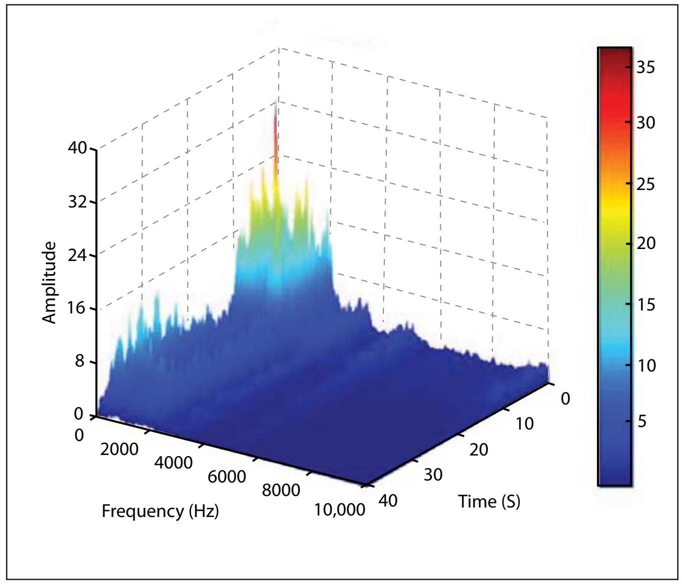
Fractions:
Applies to inches only.
Fractions of an inch in 1/8”

02 = 1/8 (3mm)
04 = 1/4 (6mm)
06 = 3/8 (10mm)
08 = 1/2 (12mm)
10 = 5/8 (16mm)
12 = 3/4 (20mm)
14 = 7/8 (22mm)

Options:
Blank: None
FJ = Fry-Sil Jacket
TS = Thor-Sil
SFS = Saturated Fiberglass Sleeving
UCS = Unsaturated Ceramic Sleeving
CT = Cryo-Therm

Thorburn's Vibration Attenuation Strategy

21% of hydrocarbon leaks are due to vibration induced fatigue failures in piping systems. This situation is compounded by the fact that designers and codes do not consider all the effects of vibrations in piping systems. Thorburn's vibration attenuating expansion joints are an engineered solution.



Lateral Vibration

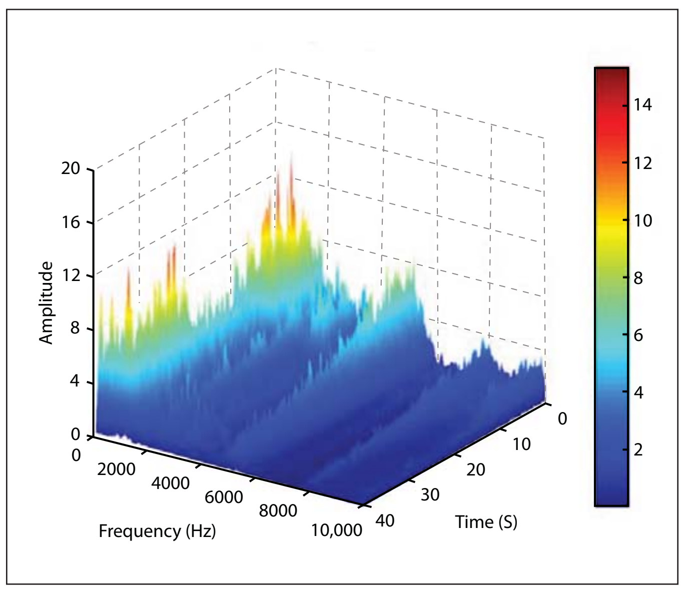
Experts in Bellows Vibration Analysis & Design
In piping applications where temperature precludes the use of a rubber expansion joint , Thorburn can
provide an engineered solution that addresses both thermal growth and severe vibration.

Where does piping vibration come from?
Pulsation: Changes in fluid pressure
Momentum: Changes in fluid density & velocity
Machinery: Unbalanced forces from operating machinery

Thorburn's Vibration Attenuation Strategy
Frequency Selection:
Bellows are tuned to avoid system vibration frequencies to thereby avoiding destructive bellows resonance

Damping:
Increasing the membrane mass of the flexible element dissipates the vibration energy

Low vibration-induced bellows stress:
Keeping bellows stress due to vibration below the plastic range eliminates metal fatigue



Axial Vibration

Thorburn ThermaCover™ - Removable Thermal Insulation Covers

Process piping and equipment left without a properly designed thermal insulation cover can freeze and fail to properly operate.

Thorburn ThermaCover™ Removable thermal insulation covers are a critical component when it comes to site safety and system stability and are used to cover valves, flanges, expansion joints, and process piping. Unlike permanent hard insulation, Thorburn soft insulation covers have the advantage of being removable and reusable, making them the insulation of choice for components that need to be accessed from time to time for maintenance and inspection.

Valves, flanges and expansion joints left uncovered can result in:
- Unnecessary process adjustment due to heat loss.
- False readings or alarms being sent to the control room.
- Equipment failures due to operation outside of normal temperature ranges.
- Degradation of product quality due to improper process temperatures.

Benefits
- Heat retention and freeze protection.
- Personnel protection against burns from hot components.
- Energy savings from reduced heat loss to surrounding environment.
- Sound attenuation.
- Insulation Jackets are easily removable for maintenance & inspection.

Thorburn ThermaCover™ Construction

Material:
Model TCS (Silicone Impregnated Fiberglass)
Temperature Range: -67°F (-55°C) to 500°F (260°C)
Model TCT (PTFE Impregnated Fiberglass)
Temperature Range: -100°F (-73°C) to 500°F (260°C)

Usage: Typical outer cover used in most standard insulation blanket applications. Also used as inner liner for applications < 500°F (260°C) where a fluid barrier or insulation fiber containment is desired.

Special Properties: Flexible; flame retardant; water and oil resistant; mold resistant; chemical resistant. Typically grey or red, but other colors also available.

How To Order Thorburn ThermaCover™

Model		Size
TCS	-	**48**
Silicone Impregnated Fiberglass		3 inch (DN80)

TCS = Silicone Impregnated Fiberglass
TCT= PTFE Impregnated Fiberglass

32 = 2 in (DN50)	**96** = 6 in (DN150)	**224** = 14 in (DN350)
40= 2.5 in (DN65)	**128** = 8 in (DN200)	**256** = 16 in (DN400)
48 = 3 in (DN80)	**160** = 10 in (DN250)	**288** = 18 in (DN450)
64 = 4 in (DN100)	**192**= 12 in (DN300)	**320** = 20 in (DN500)

Thorburn Thor-Shield™ TLFP Spray Shields For Flanges

Safety Spray Shields are used to prevent injury to personnel or damage to equipment

Available with 150 psi (10 bar) & 300 psi (20 bar) rating

Thorburn Flex offers safety spray shields manufactured with a non-porous, 100% PTFE multi-directional TLFP material. Thor-Shield™ TLFP Spray Shields are manufactured with a non-porous, 100% PTFE multi-directional TLFP material and guarantee performance against harmful spray out and leakage regardless of severity and duration of chemical exposure.

Materials such as PTFE coated fiberglass, can be weakened by challenging industrial environments and often require monitoring. The translucent material used in the Thor-Shield™ TLFP Spray Shield allows safe and easy detection of moisture leakage at a flange. If leakage does occur at the flange, Thor-Shield™ can be cleaned and reused without concern for weakening due to chemical attack. Thor-Shield™ can be used in almost all industrial settings such as marine, offshore, pharmaceutical, chemical processing, FDA approved, cryogenic, and clean room applications.

THOR-SHIELD™ TLFP Features

- Temperature range of -340°F (-207°C) to 600°F (316°C)
- pH range of 1-14
- Unaffected by exposure to wet, chemical environments & ultraviolet light
- Fire and tear resistant
- Drawstring is all-PTFE cord
- Custom sizes available
- Translucent material allows leak detection

Thorburn THOR-SHIELD™ Optional Features

pH Indicating Patch

Sensitive pH Indicating Patch

Immediately signals a leak and will change color to red in the presence of acid or green in the presence of alkali. The pH indicating patch is also replaceable which allows continued use of the spray shield.

Clear PTFE Strip & Drain

Clear PTFE Strip & Drain

Clear PTFE strip in center allows for visual inspection of the expansion joint with a drain nipple attached to the bottom of the shield.

How To Order Series Thor-Shield™ TLFP Spray Shields For Flanges

Model	Size	Flange Type	Option
TS -	**192** -	**FL4** -	**PHP**
Thor-Shield	12 inch (DN300)	PN16 Flange	Sensitive pH Indicating Patch
	32 = 2 in (DN50) **40**= 2.5 in (DN65) **48** = 3 in (DN80) **64** = 4 in (DN100) **96** = 6 in (DN150) **128** = 8 in (DN200) **160** = 10 in (DN250) **192**= 12 in (DN300) **224** = 14 in (DN350) **256** = 16 in (DN400) **288** = 18 in (DN450) **320** = 20 in (DN500)	**FL1** = ANSI B16.5, Cl 150 **FL2** = ANSI B16.5, Cl 300 **FL3** = PN10 **FL4** = PN16 **FL5** = PN25 **FL6** = PN40	**PHP** = Sensitive pH Indicating Patch **SD** = Clear PTFE Strip & Drain

Nuclear Power and the Environment

All forms of electricity production generate some level of CO_2 and other greenhouse gasses (GHG), even if they do not burn fossil fuels. Construction of all power generation plants require the use heavy machinery, cement and steel production having its own carbon foot print.

Replacing Coal & Natural Gas With Nuclear Power Generation Will Turn Back The Climate Clock Nearly Two Decades
Nuclear Power is seven times more cost effective than solar, is half the cost of wind and natural gas, but comparable to hydro power.

When considering the extra power generation life cycle, nuclear power generation comes out as one of the cleanest technologies available.

Solar and wind power generation are low carbon sources, yet to power a grid, they require back-up sources more than 80% of the time. The power back-up most often comes from burning natural gas which emits CO_2 in the process.

Replacing coal and natural gas with nuclear power generation will avoid roughly 2.2 billion tonnes of CO_2 emissions annually. This is the same as taking 500 million passenger vehicles off the road, or nearly a third of all the passenger vehicles globally. It is never too late to consider using nuclear power to curb green house gases.

Thorburn Nuclear Business Unit

Thorburn Flex offers unmatched capabilities and expertise in applications engineering, design development and manufacture of flexible piping systems for PHWR, PWR, BWR nuclear power plants. Operating under a strategy of global presence Thorburn Flex has structured and developed a specific Nuclear Business Unit used to service this niche market sector. Through this business unit, our nuclear components consistently meet and exceed all the quality design requirements of our nuclear reactor business partners.

Thorburn Bellows Expansion Joints For Nuclear Service


Bruce Power - The largest nuclear power plant in North America

Thorburn's metallic bellows expansion joints are an integral part of the primary containment pressure boundary in the Bruce Power PHWR 6000MW nuclear power plant. Thorburn's belows alow for thermal expansion and contraction of pipe, vent lines, fuel transfer tubes, steam extraction, coolant piping, turbine crossover, feeder turbine exhaust, condenser seals, and accommodate movement between the containment and other structures, such as a shield wall.

Bruce Power

Bruce Power turns to Thorburn Flex during emergency shut-down

Dear Robert,

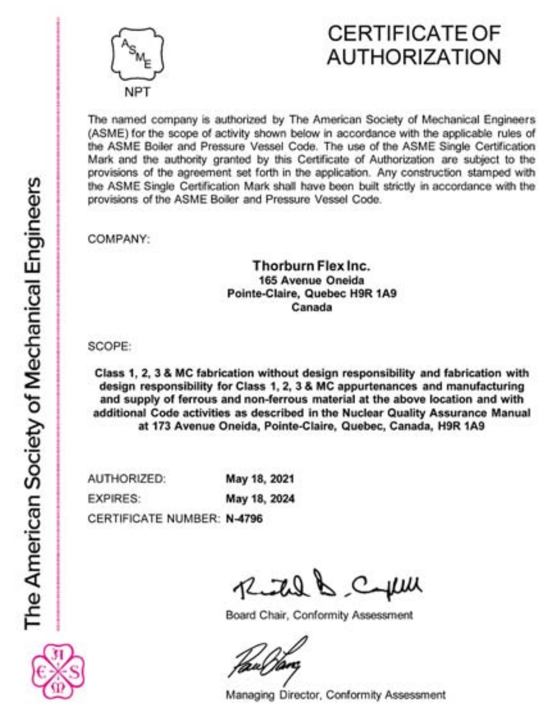
I wanted to personally thank you for the outstanding support THORBURN FLEX Inc. provided Bruce Power in quickly and efficiently supplying 2 Expansion Bellows required as contingency parts for a pressure boundary steam leak that forced Bruce Power Unit 3 off line on September 24th.

When one of our units is forced off-line, this results in a greater than $1.5M daily loss in revenue. Our ability to quickly engage dependable, quality suppliers such as THORBURN FLEX Inc. to meet emerging needs such as this is enormously important to our business and our reputation. As we have become accustom to, your organization quickly responded, pulling out all the stops to supply our requirements in the unbelievably short time of approximately 96 hours.

Please pass on Bruce Power's profound appreciation to all involved for THORBURN FLEX's continuing support to ensure Bruce Powers safe and efficient operations.

Again, sincere thanks.

Harry Hall
Vice President, Supply Chain | Bruce Power


The American Society of Mechanical Engineers

NPT

CERTIFICATE OF AUTHORIZATION

The named company is authorized by The American Society of Mechanical Engineers (ASME) for the scope of activity shown below in accordance with the applicable rules of the ASME Boiler and Pressure Vessel Code. The use of the ASME Single Certification Mark and the authority granted by this Certificate of Authorization are subject to the provisions of the agreement set forth in the application. Any construction stamped with the ASME Single Certification Mark shall have been built strictly in accordance with the provisions of the ASME Boiler and Pressure Vessel Code.

COMPANY:

Thorburn Flex Inc.
165 Avenue Oneida
Pointe-Claire, Quebec H9R 1A9
Canada

SCOPE:

Class 1, 2, 3 & MC fabrication without design responsibility and fabrication with design responsibility for Class 1, 2, 3 & MC appurtenances and manufacturing and supply of ferrous and non-ferrous material at the above location and with additional Code activities as described in the Nuclear Quality Assurance Manual at 173 Avenue Oneida, Pointe-Claire, Quebec, Canada, H9R 1A9

AUTHORIZED: **May 18, 2021**
EXPIRES: **May 18, 2024**
CERTIFICATE NUMBER: **N-4796**

Board Chair, Conformity Assessment

Managing Director, Conformity Assessment

Nuclear Certification & Licences (Design & Fabrication)

USA
- ASME III NPT Class 1
- NCA 4000 (NQA-1)

CANADA
- CSA N285.0
- CSA N299.1 (CANPAC)
- CRN Available

EUROPE
- CNCAN (Romania)
- ISCIR (Romania)

CHINA
- H604

Non-Nuclear Certification & Licences (Design & Fabrication)

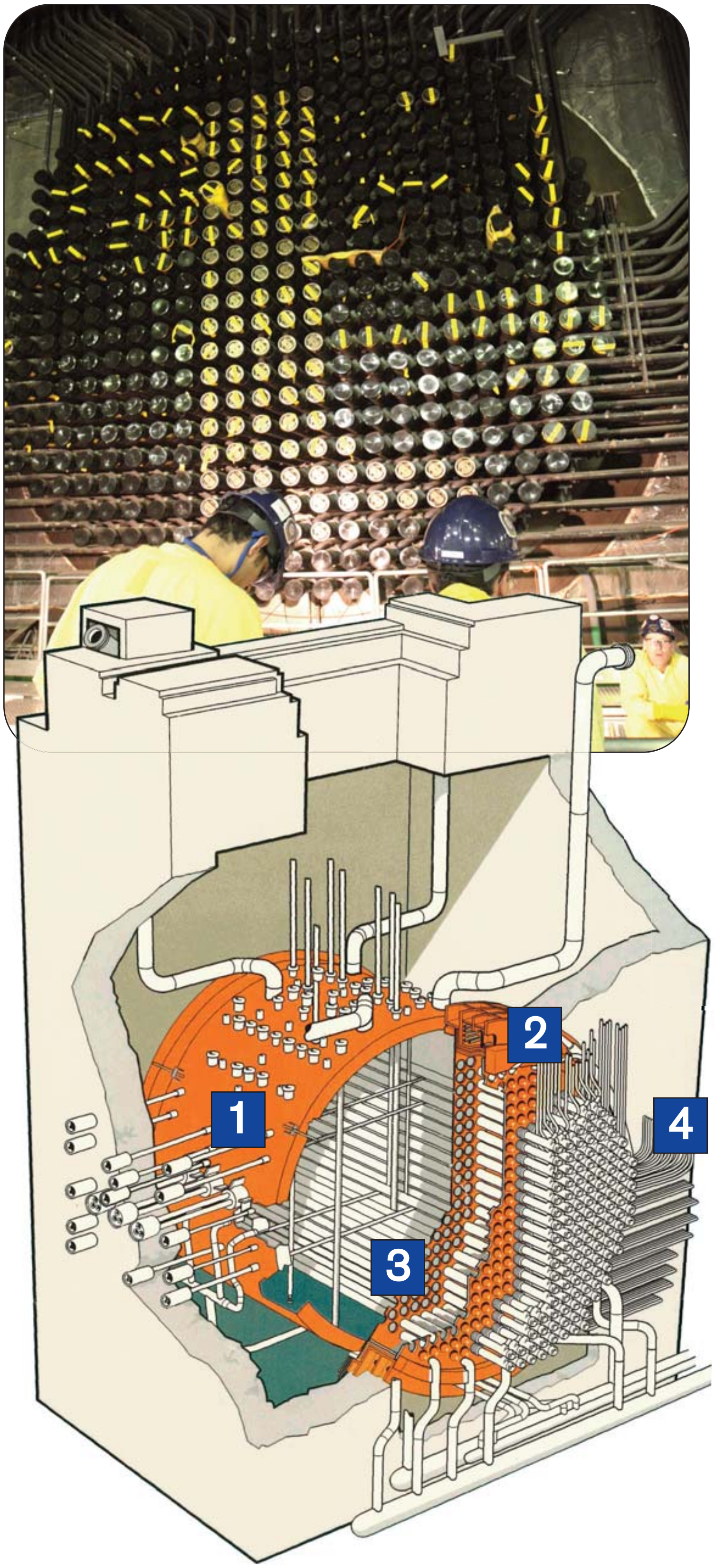
USA
- ASME Sec. VIII Division 1 "U" Stamp
- ASME B31.1, B31.3

CANADA
- CSA B51
- CSA N285.0 Class 6
- ISO 9001: 2015

EUROPE
- PED 97/23/EC - Module H

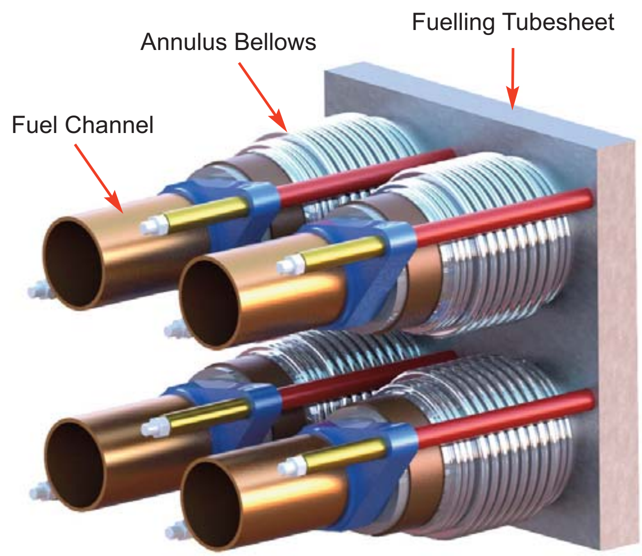
CHINA
- TSG

Thorburn Flex Bellows Found In A Calandria Vault



Calandria Fuel Channel Assembly

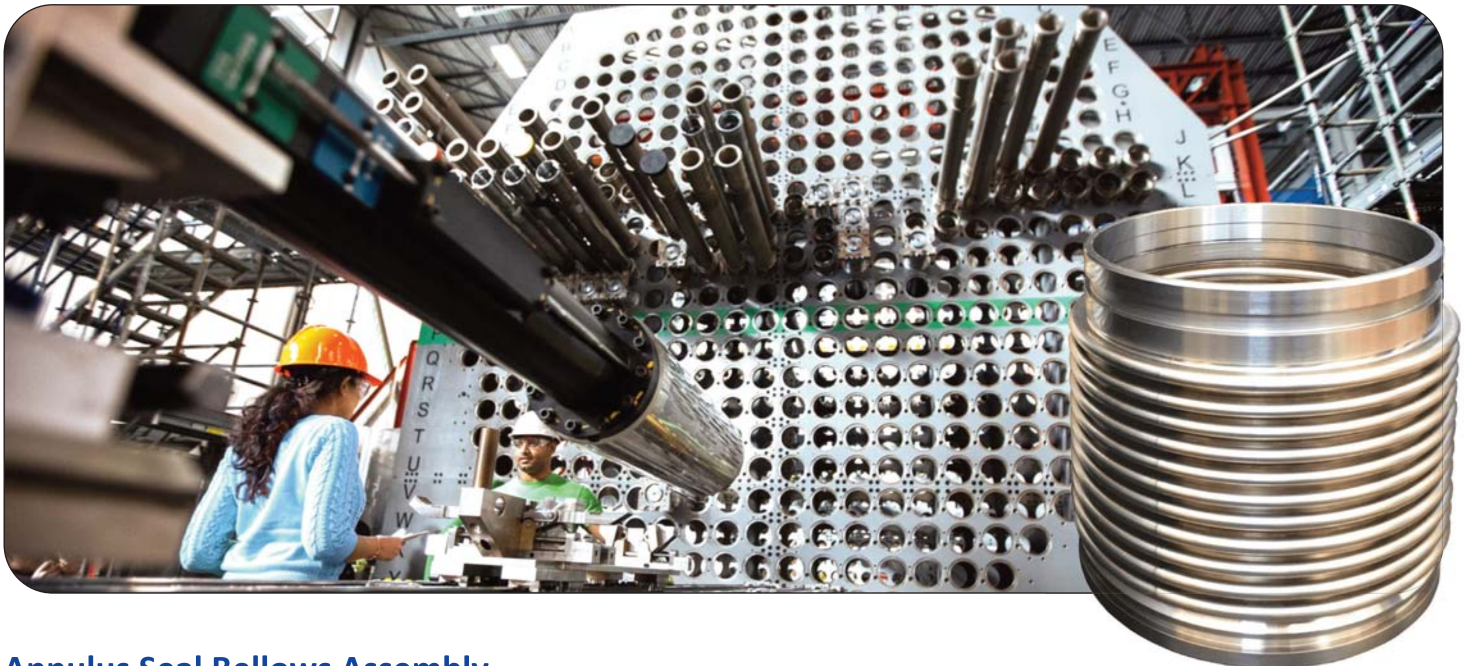
In a PHWR reactor, the high pressure coolant and fuel is contained in several hundred small diameter horizontal channels (Fuel Channels). The Fuel Channels are insulated from the moderator by the gas in the annulus formed between the pressure tube and the concentric calandria tube. The calandria tubes are part of the calandria vessel pressure boundary that is the container for the low pressure, low temperature, heavy water moderator.



Calandria & End Shield Assembly In Reactor Vault

1. Calandria
2. Calandria End Shield
3. Fuel Channel Assemblies
4. Feeder Pipes

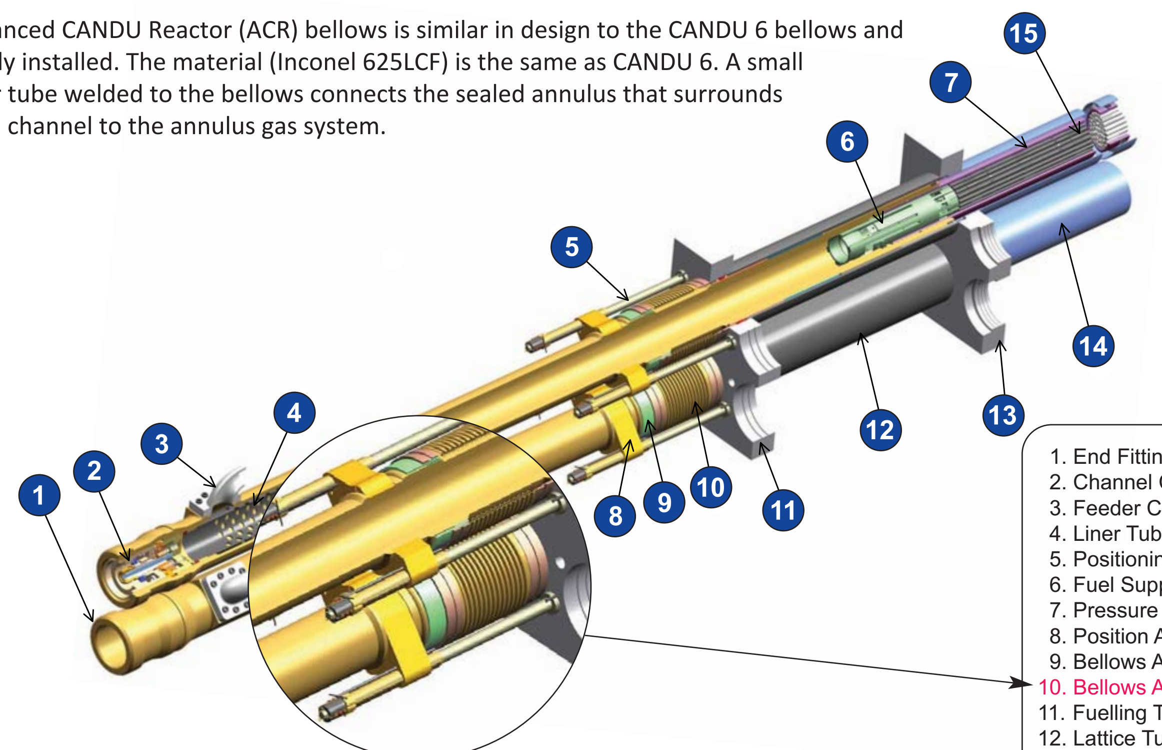
Thorburn Annulus Seal Bellows



Annulus Seal Bellows Assembly

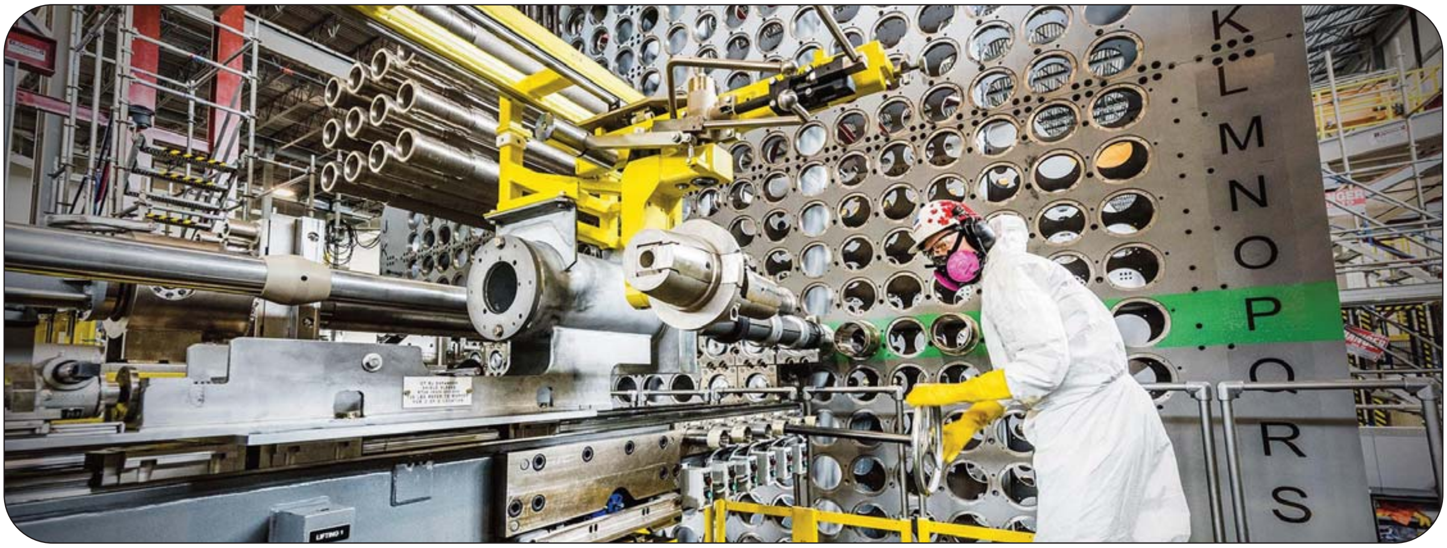
Each end of the annulus between a calandria tube and a pressure tube is sealed by a Thorburn Inconel bellows. The Thorburn bellows assembly allows axial motion of the channels and also supports the torque of the end fitting from the feeder piping.

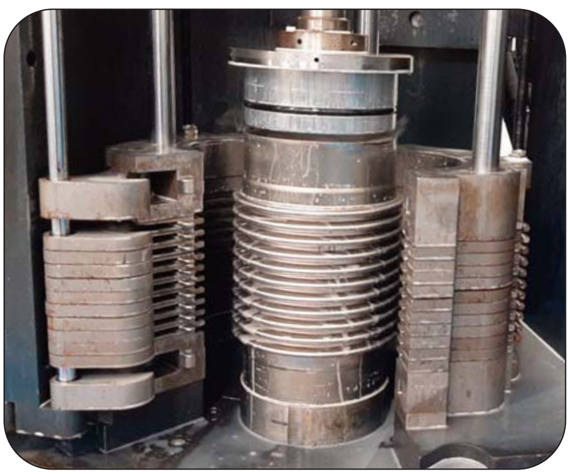
The Advanced CANDU Reactor (ACR) bellows is similar in design to the CANDU 6 bellows and is similarly installed. The material (Inconel 625LCF) is the same as CANDU 6. A small diameter tube welded to the bellows connects the sealed annulus that surrounds each fuel channel to the annulus gas system.



1. End Fitting
2. Channel Closure
3. Feeder Connection
4. Liner Tube
5. Positioning Assembly Stud
6. Fuel Support Plug
7. Pressure Tube
8. Position Assembly Yoke
9. Bellows Attachment Ring
10. Bellows Assembly
11. Fuelling Tubesheet
12. Lattice Tube
13. Calandria Tubesheet
14. Calandria Tube
15. Fuel Bundle

Thorburn Annulus Seal Bellows

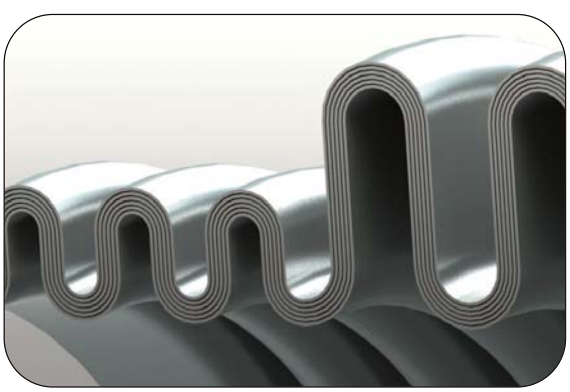




Thorburn's Precision hydro formed bellows manufactured with various ply thicknesses

Thorburn Annulus Seal Bellows

Thorburn's annulus seal metallic bellows assemblies are manufactured with multiple ply Inconel SB443 alloy 625LCF and formed using a proprietary hydro forming process. Thorburn bellows seams are welded using a fusion welding process without filler metals. The collar plies are fused using resistance welding while the collars are welded to the Bellows Attachment Ring and the Fuelling Tubesheet using GTAW or robotically using an orbital welding process. Thorburn's metallic bellows assemblies are designed and manufactured to ASME B31.1, ASME Sec III, Class 2 & 3, as required under nuclear class N285.0, N299.1 and NPT quality assurance programs.



Thorburn's 6 ply bellows with sizes 10mm to 250mm

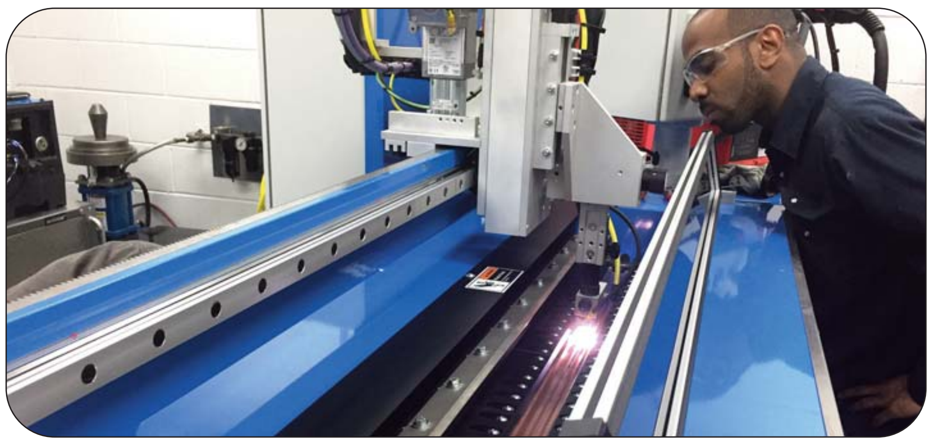
Thorburn Multi-Ply Bellows

Thorburn uses multi-ply bellows for increased cycle life and when lower forces are required while still maintaining the same pressure capacity. The multi-plies act in unison as far as hoop pressure loading is concerned but act individually when cycle life and forces are calculated. Bellows can be designed with various convolution heights to simplify installation.

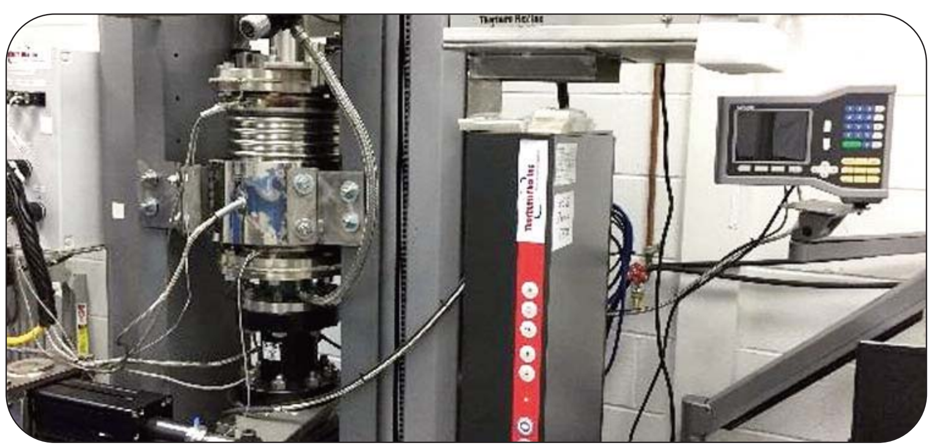
Thorburn In-House Manufacturing Annulus Bellows Capabilities

Thorburn automatic circumferential micro GTAW/PAW welding

Thorburn hydroforming bellows
(all convolutions simultaneously)



Thorburn automatic fusion seam welding



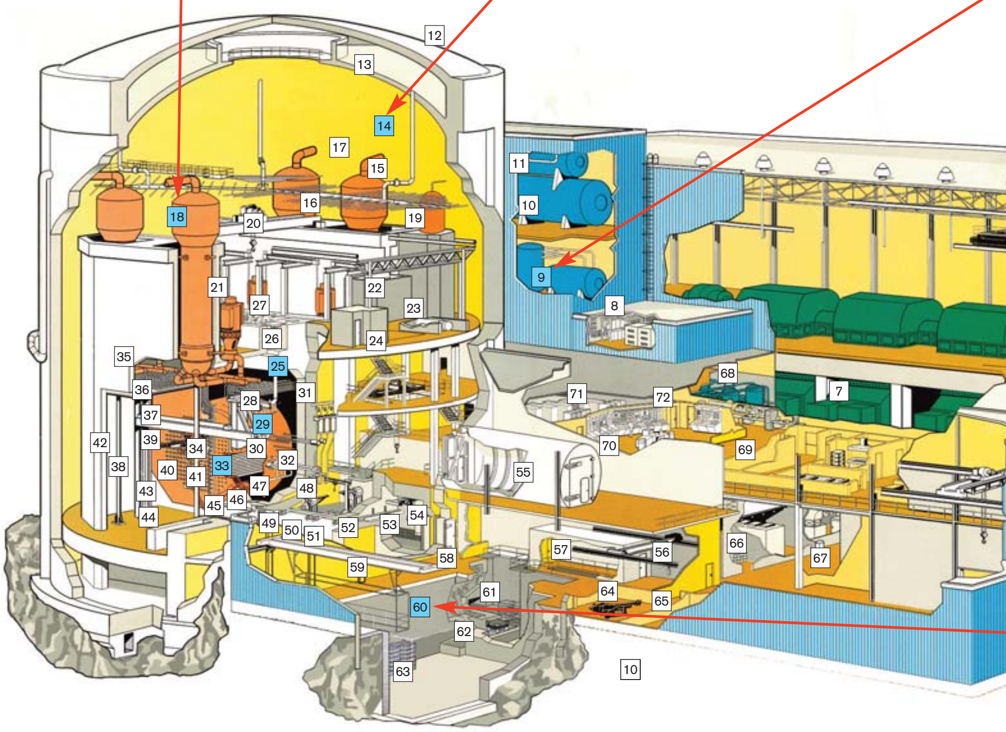
Thorburn cyclic testing (axial and torsional movement) bellows under pressure & temperature

Thorburn Bellows Expansion Joints For PHWR Nuclear Reactors

MAIN STEAM LINES
Gimbal Steam Penetration
Expansion Joint

DOUSING SYSTEM
Hinged Bellows
Expansion Joint

BOILER FEED TANK SYSTEM
Elbow Pressure Balanced
Expansion Joint



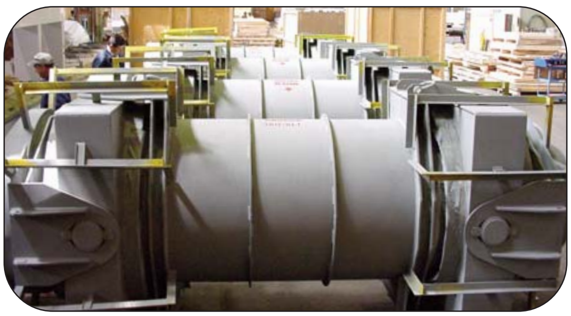
SPENT FUEL BAY
Maintenance Gate
Transfer Canal Tube
Transition Piece
Containment Passage

1. Diesel Room
2. Water Treatment Plant
3. Crane Hall
4. Turbine Building
5. Turbine Building Crane
6. **Steam Generator**
7. Condenser
8. Battery Room
9. **Boiler Feed Water Tanks**
10. Deaerator Storage Tank
11. Deaerator
12. Reactor Building
13. Dousing Tank
14. **Dousing Water Spray Pipes**
15. Dousing Water Valves
16. Dousing Water Spray Nozzles
17. **Main Steam Pipes**
18. **Steam Generators**
19. Pressurizer
20. Crane
21. Heat Transport Pumps
22. Bleed Condenser
23. Bleed Cooler
24. Hatch
25. **Reactor Vault**
26. Pressure Relief Pipes
27. Reactivity Mechanism Deck
28. Reactivity Mechanism Guide Tubes
29. **Calandria**
30. Poison Injection Nozzles
31. Poison Tanks
32. Ion Chambers
33. **Fuel Channel Assemblies**
34. End Shield
35. Headers
36. Feeder Pipes
37. Fuelling Machine Bridge
38. Bridge Support
39. Fueling Machine
40. Fuelling Machine Catenary
41. Fuelling Channel End Fittings
42. Steam Generator Support
43. Feeder Pipe Insulation Cabinet
44. Fueling Machine Shielding Door
45. End Shield Cooling
46. Fuelling Machine Track
47. Moderator Inlet Pipe
48. New Fuel Transfer Mechanism
49. New Fuel Port
50. Fuelling Machine Service Port
51. Rehearsal Facility
52. Spent Fuel Port
53. Spent Fuel Elevator
54. Entrance To Spent Fuel Area
55. Airlock
56. Crane
57. Spent Fuel Shipping Area
58. Spent Fuel Handling Area
59. Spent Fuel Bay Gantry
60. **Spent Fuel Bay**
61. Spent Fuel Storage Trays
62. Storage Tray conveyor
63. Storage Tray Stack
64. Fueling Machine Maintenance
65. Decontamination Room
66. New Fuel Storage
67. Tool Crib
68. Vapour Recovery Equipment
69. Office
70. Control Room
71. Control Equipment Room
72. Computer Room

Thorburn Gimbal Expansion Joints For Main Steam Penetration

Steam generator at Embalse power plant

Thorburn's main steam penetration gimbal belows (ASME Section III Class B) for the Qinshan nuclear power plant



Preparing shipment to Qinshan

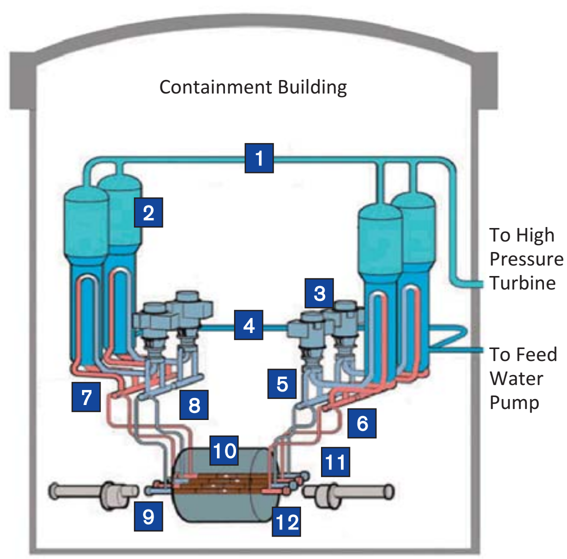
Thorburn gimbal expansion joints for main steam penetration, spent fuel bay interconnecting piping, crossover, steam lines, boiler feed pumps & treated water lines.

Features

- Angular movement in more than one plane
- Eliminates pressure thrust forces
- Transmits external loads
- Supports dead weight
- Prevents torsion on bellows
- Low forces on piping system

Steam Piping System

1. Steam Piping
2. Steam Generators
3. Heat Transport Pumps
4. Feedwater Piping
5. Reactor Inlet Headers
6. Reactor Outlet Headers
7. From Fuel Channels
8. To Fuel Channels
9. Fuel channels
10. Calandria
11. Fuelling Machine
12. Moderator



Thorburn Hinged Expansion Joints For Dousing System

Qinshan multi-unit nuclear power plant in Qinshan Town, Haiyan County, in Jiaxing, Zhejiang province, China

Dousing System

1. Reactor Building
2. Dousing Tank
3. Dousing Water Spray Pipes
4. Dousing Water Valves
5. Dousing Water Spray Nozzles

Ultra High Pressure: 300mm - 10,000 Kpa Design / 15,000 Kpa Test

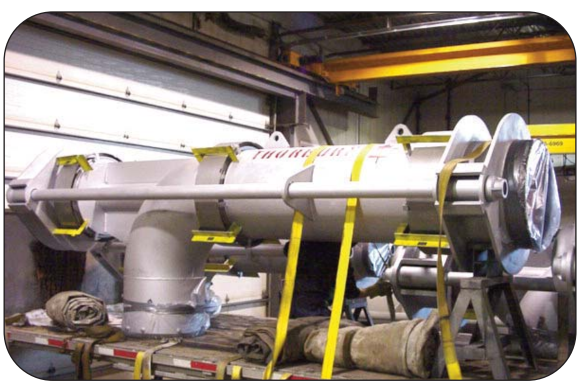
Features

- Angular motion in one plane only
- Eliminates pressure thrust forces
- Positive control over movement
- No main anchors required
- Low forces on piping system
- Prevents torsion on bellow

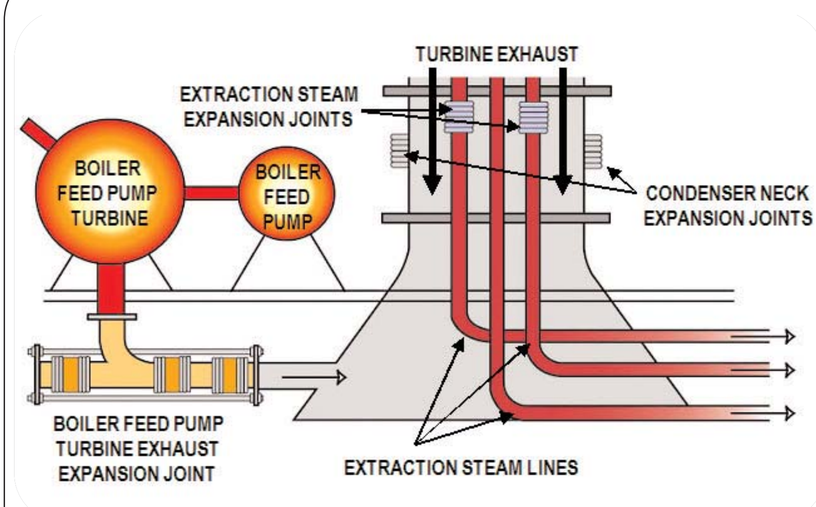
Thorburn's ASME Section III class 2 hinged expansion joints were installed at the qinshan PHWR nuclear reactor's dousing system

Thorburn Pressure Balanced Expansion Joints For Boiler Feed Pump

A Boiler Feed Pump provides high pressure water to the boiler which in turn produces steam to drive the steam turbine



Thorburn designed boiler feed pump pressure balanced expansion joints for a nuclear power plant in Romania



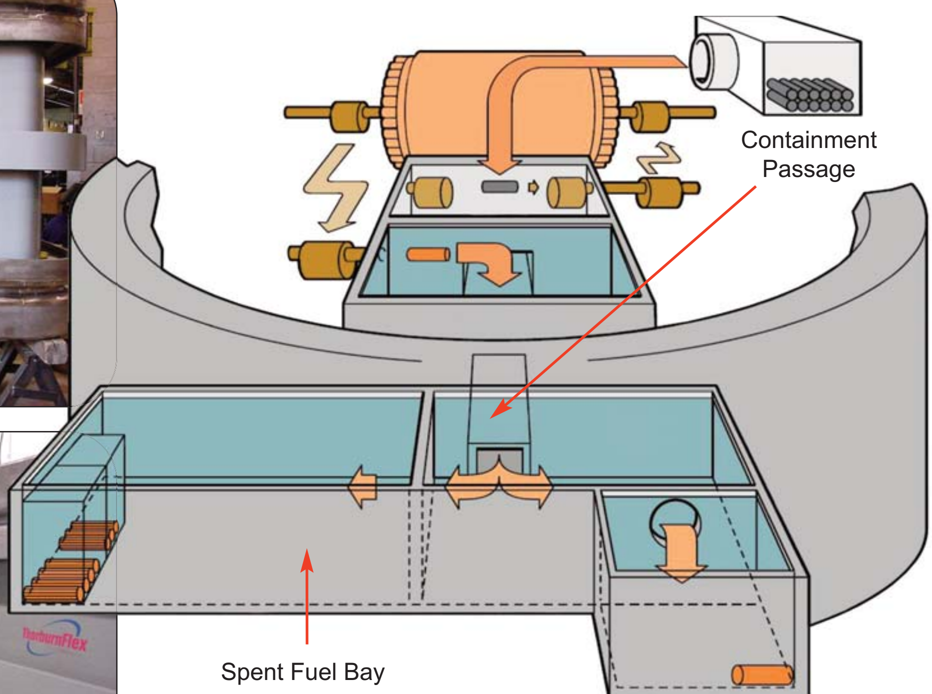
Application

A change in direction in a turbine exhaust system where allowable loads necessitate the elimination of pressure thrust.

Thorburn Rectangular Expansion Joints For Containment Passage

CANDU 6 spent fuel storage bay

Thorburn custom inverted corrugation expansion joint for the Wolsong nuclear power plant in North Gyeongsang province, South Korea



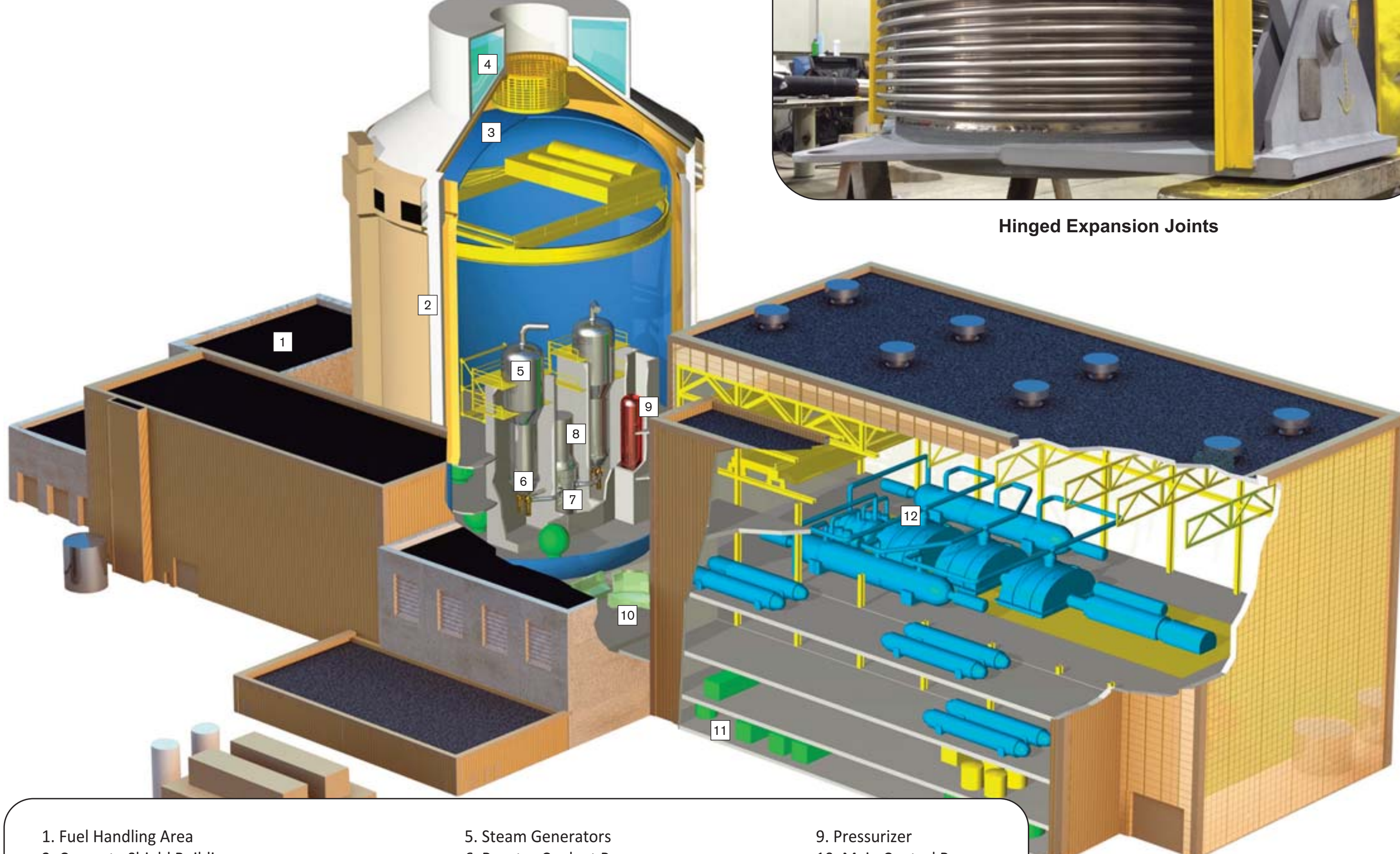
Thorburn's rectangular inverted bellows expansion joints absorbs movement and reduces stress as the irradiated fuel is transfered to the spent fuel storage bay.

Thorburn Bellows Expansion Joints For PWR Nuclear Reactors

Gimbal Expansion Joints

Elbow Pressure Balanced Expansion Joints

Hinged Expansion Joints

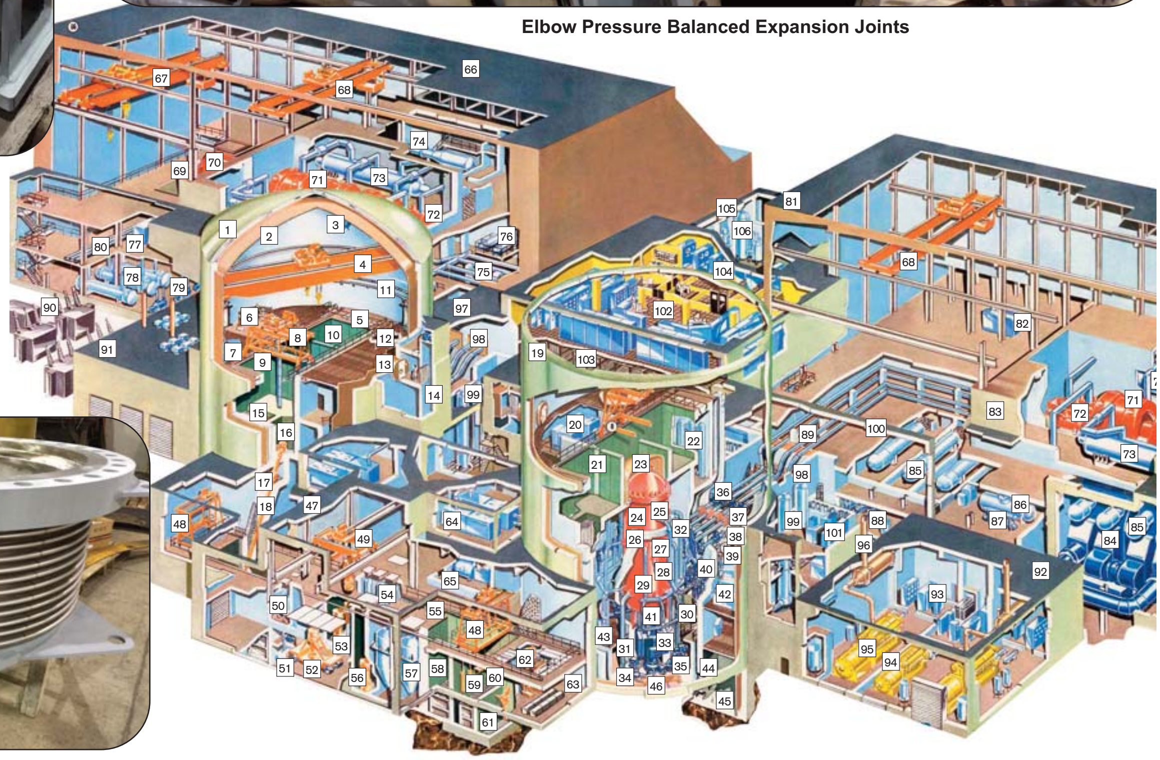


1. Fuel Handling Area
2. Concrete Shield Building
3. Steel containment
4. Passive Containment Cooling Water Tank
5. Steam Generators
6. Reactor Coolant Pumps
7. Reactor Vessel
8. Integrated Head Package
9. Pressurizer
10. Main Control Room
11. Feedwater Pumps
12. Turbine Generator

Thorburn Bellows Expansion Joints For BWR Nuclear Reactors

Gimbal Expansion Joints

Elbow Pressure Balanced Expansion Joints



Hinged Expansion Joints

1. Reactor building No. 2
2. Steel containment building
3. Re-circulation air fans
4. Polar crane
5. Access to water clean up heat exchangers
6. Reactor pressure vessel head tensioner
7. Equipment hatch access area
8. Refuelling platform
9. Steam dryer storage area
10. Steam separator storage area
11. Containment spray piping
12. Service platform
13. Personal lock
14. Elevator building
15. Fuel storage pool
16. Fuel transfer pool
17. Fuel transfer valve room
18. Fuel transfer tube
19. Reactor building No. 1
20. Heating, ventilation & air condition units
21. Fuel transfer gate
22. Reactor water clean up heat exchangers
23. Dry well head
24. Reactor vessel
25. Main steam outlets
26. Reactor Shield wall
27. Low pressure core spray pipes
28. Low pressure core spray inlet
29. Feed water pipes
30. Recirculating pump discharge pipe
31. Recirculating pump suction
32. Main steam isolation valves-outboard
33. Recirculating pump
34. Recirculating loop isolation valve
35. Recirculating loop shutoff valve
36. Main steam isolation valves-inboard
37. Main steam line penetration seals
38. Feedwater
39. Residual heat removal heat exchange lines
40. Main steam safety relief valves
41. Control rod drives
42. Hydraulic control unit modules
43. Master controls - in containment
44. Vent annulus area
45. Pressure suppression pool
46. Equipment hatch
47. Common fuel handling building
48.Refuelling gantry
49. Overhead bridge crane
50. Filter demineralizer
51. Filter demineralizer tank
52. Fuel cask shipping transporter
53. Fuel cask decontamination/ storage area
54. Fuel pool heat exchangers
55. Fuel transfer canal
56. Spent fuel shipping cask pool
57. Skimmer surge tanks
58. Spent fuel pool
59. Fuel preparation machine
60. Storage & rechannelling pool
61. Fuel transfer pool
62. Lift truck-new fuel inspection stand
63. New fuel receiving station
64. Standby gas treatment system
65. Heating & ventilating room
66. Turbine building No. 2
67. Turbine building main crane
68. Turbine building auxiliary crane
69. Alternator
70. Generator
71. Low pressure turbine
72. High pressure turbine
73. Reheater moisture separator
74. Steam seal evaporator
75. Main steam pipes
76. Moisture separator drain tanks
77. Stator winding liquid cooling equipment
78. Turbine building cooling water heat exchangers
79. Turbine building cooling water pumps
80. Generator main leads
81. Turbine building No. 1
82. Charcoal absorber vault refrigeration units
83. Shield wall
84. Condenser
85. Heaters
86. Turbine lubricating oil tank
87. Oil coolers
88. Demineralizer water pumps
89. Main steam pipe chase
90. Transformer yard
91. Diesel generator building No. 2
92. Diesel generator building No.
93. Control panels
94. High pressure core spray generator
95. Diesel generator
96. Exhaust pipes
97. Auxiliary building No. 2
98. Main steam pipe chase panels
99. Residual heat removal exchangers
100. Auxiliarly building No. 1
101. Air conditioning units
102. Common control room
103. Cable laying room
104. Computer room
105. Common radwaste building
106. Waste concentrator

Thorburn Bellows Expansion Joints For SMR Nuclear Reactors

Certified SMR Design Companies

- Westinghouse
- NuScale
- B&W mPower™
- Holtec
- Ultra Safe Nuclear Corporation
- GE Hitachi Nuclear Energy
- KAERI
- KEPCO
- ARC Nuclear
- CNEA
- X-energy
- Rolls-Royce
- U-Battery Consortium
- Moltex Energy

Small Modular Reactors (SMRs) are part of a new generation of nuclear power plant designs being developed in several countries. The objective of these SMRs is to provide a flexible, cost-effective energy alternative. Small reactors are defined by the International Atomic Energy Agency as those with an electricity output of less than 300 MWe, although general opinion is that anything with an output of less than 500 MWe counts as a small reactor. Modular reactors are manufactured at a plant and brought to the site fully constructed. They allow for less on-site construction, increased containment efficiency, and heightened nuclear materials security.

Westinghouse SMR Design

Thermal capacity: 800 MWt
Electrical capacity: > 225 MWe (gross)
Capacity factor: >95 percent
Dimensions: 90' x 32' cylindrical reactor pressure vessel
Weight: modular weight based on crane capacity lifting limits
Transportation: Barge, truck or train
Cost: Numerous advantages due to modular design and manufacturing, 18-24 month construction times, $ / kWh equivalent to GW-sized nuclear plants.
Fuel: Standard LWR fuel in 17 x 17 configuration, 24-month refueling cycle with fuel enriched less than 5%

NuScale SMR Design

Thermal capacity: 160 MWt
Electrical capacity: > 50 MWe (gross)
Capacity factor: >95 percent
Dimensions: 76' x 15' cylindrical containment vessel module containing reactor and steam generator
Weight: ~ 700 tons as shipped from fabrication shop
Transportation: Barge, truck or train
Cost: Numerous advantages due to simplicity, off-the-shelf standard items, modular design, shorter construction times, <$5,000/KW
Fuel: Standard LWR fuel in 17 x 17 configuration, each assembly 2 meters (~ 6 ft) in length; 24-month refueling cycle with fuel enriched less than 4.95 percent

Metallic Expansion Joints For Renewable Power Generation

What is renewable energy?

Renewable energy is energy derived from natural sources that are replenished at a higher rate than they are consumed. Sunlight and wind, for example, are such sources that are constantly being replenished. Renewable energy sources are plentiful and all around us. Many nations around the world already have renewable energy contributing more than 20% of their total energy supply, with some generating over half their electricity from renewables. A few countries generate all their electricity using renewable energy. National renewable energy markets are projected to continue to grow strongly in the 2030's and beyond.

Wind

Wind farms capture the energy of wind flow by using turbines and converting it into electricity. There are several forms of systems used to convert wind energy and each vary.

Solar

Solar energy is derived by capturing radiant energy from sunlight and converting it into heat, electricity, or hot water. Photovoltaic (PV) systems can convert direct sunlight into electricity through the use of solar cells.

Hydroelectric

Dams are what people most associate when it comes to hydroelectric power. Water flows through the dam's turbines to produce electricity, known as pumped-storage hydropower. Run-of-river hydropower uses a channel to funnel water through rather than powering it through a dam.

Geothermal

Geothermal heat is heat that is trapped beneath the earth's crust that can be captured and used to produce geothermal energy by using steam that comes from the heated water pumping below the surface, which then rises to the top and can be used to operate a steam turbine.

Biomass To Energy (BTE) & Waste To Energy (WTE)

BTE is organic matter that comes from recently living plants and organisms. Power generation can be achieved by burning biomass, or harnessing methane gas which is produced by the natural decomposition of organic materials. WTE is considered a bio-mass fuelled power plant and transforms municipal and industrial solid waste into electricity.

Tidal

Tidal energy is a form of hydropower that works by harnessing the kinetic energy created from the rise and fall of ocean tides and currents, also called tidal flows, and turns it into usable electricity.

Metallic Expansion Joints For Wind Power Generation

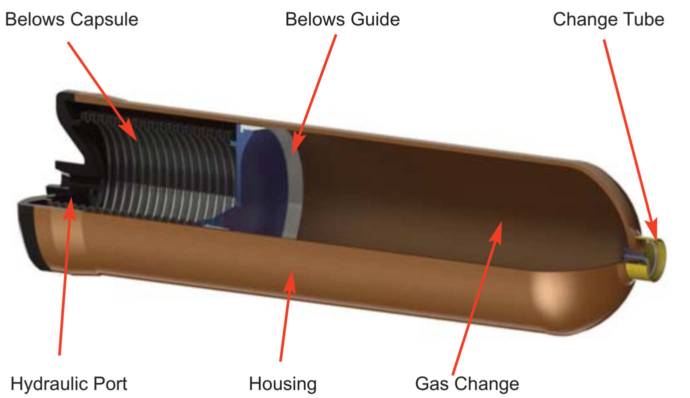
Scandinavia's biggest wind farm: "Kriegers Flak" has a total capacity to cover the electricity consumption of around 600,000 Danish households.

Wind is a domestic source of energy with an abundant and inexhaustible supply. Wind energy has been harnessed for centuries to propel sailing vessels and turn grist mills and water pumps. Today, wind is used increasingly to generate electricity. A wind turbine turns wind energy into electricity using the aerodynamic force from the rotor blades, which work like an airplane wing or helicopter rotor blade.

Thorburn Metal Bellows For Wind Power Generation

Wind turbine pitch, yaw, and brake systems use hydraulic actuation. These hydraulic actuation systems use high-pressure, gas-charged hydraulic accumulators. Thorburn Metal bellows accumulators offer a maintenance-free advantage. Thorburn's accumulator bellows use a metal bellows capsule that forms an internal chamber, which contains the hydraulic fluid and separates it from the precharge gas. The bellows collapses and expands to meet the volume or flow demands of the hydraulic system, including both operating and hydraulic-shutdown modes. The bellows accumulator uses a high-strength stainless steel flow-formed housing.

Thorburn's bellows subassembly consists of the stainless-steel bellows capsule welded at one end to the fixed terminal fitting, and at the other end the movable sweeper fitting. A PTFE guide attaches to the sweeper to ensure smooth motion of the bellows inside the housing with negligible friction. Thorburn's entire bellows subassembly slides into the housing and the end terminal permanently attaches to the housing with a full penetration electron beam weld. At the domed (closed) end of the housing is a small stainless-steel charge tube. Thorburn's metal bellows accumulator completely eliminates use of elastomeric or wearing seals used in traditional bladder or piston accumulators.



Cutaway of a piston accumulator with Thorburn's bellows capsule assembly

Metallic Expansion Joints For Solar Power Generation

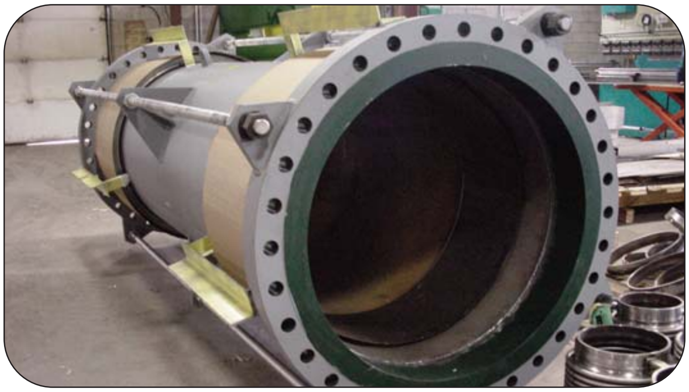
Solar power is the conversion of energy from sunlight into electricity, either directly using photovoltaics, indirectly using concentrated solar power, or a combination of both.

Concentrating Solar Power (CSP) plants use lenses or mirrors and solar tracking systems to focus a large area of sunlight into a small beam to concentrate onto a receiver. The receiver contains a heat-transfer fluid that is heated to 500–1000 °C (773–1,273 K or 932–1,832 °F) and then used as a heat source to drive turbines or engines. Thermal energy can also be stored and used to produce electricity when it is needed, day or night.

Solar Receiver Steam Generator (SRSG)

Thousands of mirrors, known as heliostats, track the sun on two axes and concentrate the solar energy onto the SRSG, located in the heliostat field on top of the tower. The concentrated energy reflected by the heliostats enables the heating of water, which is then transformed into steam to activate a steam turbine and produce electricity.

Solar Receiver Steam Generator (SRSG)



Thorburn tied universal expansion joint for a CSP plant

PBEU universal elbow pressure balanced expansion joint for a SRSG plant

Metallic Expansion Joints For Geothermal Power Generation

Geothermal power plants use high-temperature hydrothermal resources from dry steam or hot water wells. These resources are developed by drilling wells into the ground and driving the steam or hot water to the surface. The hot water or steam drives a turbine that generates electricity. Geothermal energy is considered a renewable and sustainable energy source because the heat extraction is negligible compared to the heat content of the Earth. The greenhouse gas emissions of geothermal electric stations are on average 45 grams of carbon dioxide per kilowatt-hour of electricity, or less than 5 percent of that of conventional coal-fired plants.

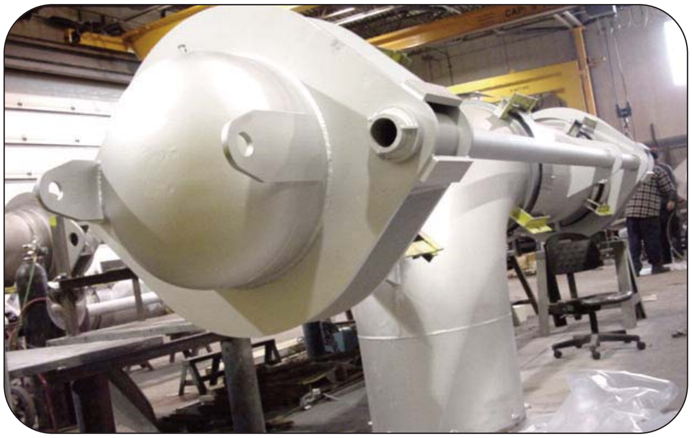
Technologies currently in use include dry steam power stations, flash steam power stations and binary cycle power stations. Geothermal electricity generation is currently used in 26 countries, while geothermal heating is in use in 70 countries.

Steam generator with a crossover expansion joint in a geothermal power plant

Thorburn PBEU universal elbow pressure balanced expansion joint for a steam turbine in a geothermal power plant near Leon, Nicaragua, Central America

Geothermal power plants have much in common with traditional power-generating stations. They use many of the same components, including turbines, generators and other standard power generating equipment. Thermal growth, equipment movement, vibration or pressure pulsation may generate movement in a piping system. When this movement is not absorbed by the piping system itself, Thorburn's expansion joints are the perfect solution.

Metallic Expansion Joints For Biomass Power Generation



Thorburn PBEU universal elbow pressure balanced expansion joint for a biomass power plant

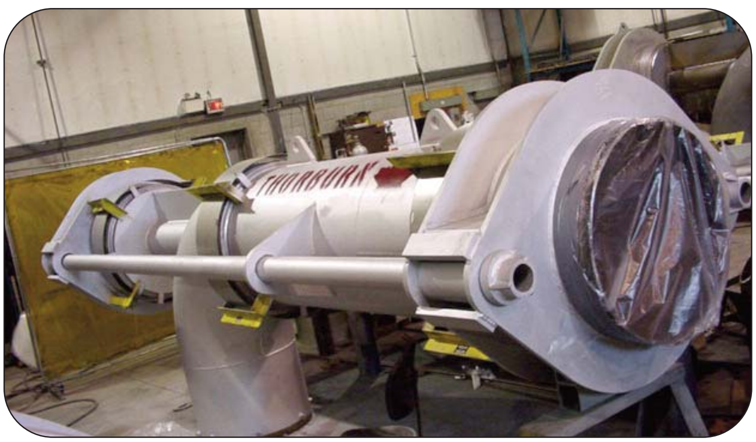
Thorburn DFT tied universal and hinged expansion joints for a biomass power plant

Most biopower plants use direct-fired combustion systems. They burn biomass directly to produce high-pressure steam that drives a turbine generator to make electricity. In some biomass industries, the extracted or spent steam from the power plant is also used for manufacturing processes or to heat buildings.

Biomass is used for facility heating, electric power generation, and combined heat and power. The term biomass encompasses a large variety of materials, including wood from various sources, agricultural residues, and animal and human waste.

Biomass can be converted into electric power through several methods. The most common is direct combustion of biomass material, such as agricultural waste or woody materials. Other options include gasification, pyrolysis, and anaerobic digestion. Gasification produces a synthesis gas with usable energy content by heating the biomass with less oxygen than needed for complete combustion. Pyrolysis yields bio-oil by rapidly heating the biomass in the absence of oxygen. Anaerobic digestion produces a renewable natural gas when organic matter is decomposed by bacteria in the absence of oxygen.

Metallic Expansion Joints For Waste To Energy Power Generation



Thorburn PBEU universal elbow pressure balanced expansion joint for a Montreal, Quebec, Canada WTE plant

Thorburn DFT tied universal expansion joints for a Quebec City, Canada WTE plant

Waste-to-energy (WTE) plants are similar in their design and equipment with other steam-electric power plants, particularly biomass plants. Most waste-to-energy plants burn municipal solid waste, which sorts material before burning it and can co-exist with recycling.

In terms of volume, waste-to-energy plants incinerate 80 to 90 percent of waste. Sometimes, the residue ash is clean enough to be used for some purposes such as raw materials for use in manufacturing cinder blocks or for road construction. In addition, the metals that may be burned are collected from the bottom of the furnace and sold to foundries. Some waste-to-energy plants convert salt water to potable fresh water as a by-product of cooling processes.

Turbine-based electricity operations are inherently prone to high and fluctuating temperatures, which cause thermal damage. Axial, angular, lateral and rotational movement leads to misalignment of components and high vibration that is transmitted along ductwork and can cause damage and misalignment.

Thorburn's Metal bellows expansion joints absorbs the thermal, movement, and vibration damage in large industrial operations and help turbine-based electricity operations like a waste to energy plant operate at peak efficiency for maximum benefit.

Metallic Expansion Joints For Hydro Power Generation

Most hydroelectric power plants have a reservoir of water, a gate or valve to control how much water flows out of the reservoir, and an outlet or place where the water ends up after flowing downward. Water gains potential energy just before it spills over the top of a dam or flows down a hill. The potential energy is converted into kinetic energy as water flows downhill. The water can be used to turn the blades of a turbine to generate electricity, which is distributed to the power plant's customers.

Run-of-the-river hydroelectricity is a type of hydroelectric generation plant whereby little or no water storage is provided. Run-of-the-river power plants may have no water storage at all or a limited amount of storage, in which case the storage reservoir is referred to as pondage. A plant without pondage is subject to seasonal river flows, thus the plant will operate as an intermittent energy source. Conventional hydro uses reservoirs, which regulate water for flood control, displaceable electrical power, and the provision of fresh water for agriculture.

Hydroelectric energy is the most commonly-used renewable source of electricity. China is the largest producer of hydroelectricity. Other top producers of hydropower around the world include the United States, Brazil, Canada, India, and Russia. Approximately 71 percent of all of the renewable electricity generated on Earth is from hydropower.

High Pressure Expansion Joints

Thorburn's high pressure expansion joints use reinforcement or equalizing rings located around the outside of the convolution to prevent the bellows from being forced out of shape due to the high pressures. Equalizing and Reinforcing Rings are devices used on some expansion joints fitting snugly in the roots of the convolutions. The primary purpose of these devices is to reinforce the bellows against internal pressure and equalize the movement among all the corrugations.

Metallic Expansion Joints For Tidal Power Generation

The gravitational pull of the moon and sun along with the rotation of the earth create tides in the oceans. In some places, tides cause water levels near the shore to rise and fall up to 40 feet. People in Europe harnessed this movement of water to operate grain mills more than a 1,000 years ago. Today, there are tidal energy systems that generate electricity. Although not yet widely used, tidal energy has the potential to dominate renewable power generation since tides are more predictable than the wind and the sun. There are four main forms of tidal power generation.

Tidal Stream Generator

Tidal stream generators make use of the kinetic energy of moving water to power turbines, in a similar way to wind turbines that use the wind to power turbines. Some tidal generators can be built into the structures of existing bridges or are entirely submersed, thus avoiding concerns over aesthetics or visual impact. These turbines can be horizontal, vertical, open, or ducted.

Tidal stream generator

Tidal Barrage

A tidal barrage is similar in structure to a dam. Tidal barrages use potential energy in the difference in height (or hydraulic head) between high and low tides. The barrage is installed across an inlet of an ocean bay or lagoon that forms a tidal basin. Sluice gates on the barrage control water levels and flow rates to allow the tidal basin to fill on the incoming high tides and to empty through an electricity turbine system on the outgoing ebb tide. A two-way tidal power system generates electricity from both the incoming and outgoing tides.

Tidal barrage

Dynamic Tidal Power

Dynamic tidal power is a technology under development that exploits the interaction between potential and kinetic energies in tidal flows. Long dams would be built from coasts straight out into the sea or ocean, without enclosing an area such as a bay, lagoon or basin. The technology was demonstrated at the London Bridge in June 2019. Plans for a 30 m, 62.5kwh 'pilot' installation on a tidal estuary shoreline in the Bristol Channel are underway.

Dynamic tidal power

Tidal Lagoon

A new tidal lagoon design option is to construct circular retaining walls embedded with turbines that can capture the potential energy of tides. The created reservoirs are similar to those of tidal barrages, except that the location is artificial and does not contain a pre-existing ecosystem.

Tidal lagoon

Engineered Solutions for Pipe & Duct Motion

Typical Thorburn Design Specifications For Metallic Bellows

Introduction

To provide a sample specification for the fabrication, inspection and shipping of Thorburn metallic bellows type expansion joints. Certain optional procedures are shown and will be followed when specified.

Data Required

Size ____________ Qty ______

Axial Motion (Compression) ____________

Lateral Motion ____________

Angular Motion ____________

Design Pressure (Internal) ____________

Design Temperature ____________ (°F or °C)

Cycle Life ____________

Dimension limits ____________

Extension ____________

(External) ____________

Bellows Element

- Manufactured from large sheets producing longitudinal welds only.
- All welds planished to within 3% of parent metal thickness.
- Material thickness of sheet to be within commercial tolerances.

Materials

- Bellows – T.321 SS is standard. Readily available in T.316, T.304, Monel, Inconel, Incoloy, Hastelloy, etc. in thicknesses to .187".
- Materials shall be free from imperfections that would interfere with the purpose designed. All materials to meet ASTM or ASME Code Section II.

Design

- Expansion joints are designed to meet known requirements of EJMA, ASME B31.3 Appendix X or ASME Section VIII if applicable.
- The expansion joint shall be free of all control devices such as self-equalizing rings.

Drawings

- The approval drawing shall show all principal dimensions including the number, size and thickness of bellows, location and type of welds (optional).
- The drawing shall list the movement, pressure and temperature rating, materials, test pressure, order number and project name (optional).

Typical Design Specifications For Metallic Bellows

Heat Treatment

- When specified, heat treatment will be performed.

Welding

- Unless otherwise specified, the welding procedures and welders shall be qualified to Section IX of the ASME Boiler and Pressure Vessel Code for all pressure containing welds.
- Longitudinal welds in bellows and transition pieces shall conform to ASME Section IX.
- Welding of bellows to transition pieces shall be to Code Case 1177.7 (optional).

Inspection

- The expansion joint is inspected to meet designated requirements.
- A partial data report shall be produced per ASME Section VIII and Code Case 1177.7 (optional).
- All pressure butt welds shall be subjected to a liquid penetrant examination by experienced operators in the presence of an authorized inspector (optional).
- All longitudinal seams of bellows and transition pieces shall be radiographed per ASME Section V (optional).
- Certificate of compliance will be forwarded on completion of project (optional).

Testing

- All pressure welds shall be leak tested by either liquid penetrant examination to ASME Section V or internal pressure test.
- The expansion joint shall be hydrostatically tested to 1.5 times the operating pressure (or design pressure). Hydrostatic tests include the testing of the rods and attachments when they are an integral part of the expansion joint (optional).

Reports And Records

- Applicable records listed below will be kept available for examination by the purchaser's inspector.
  - Welding procedure specifications
  - Operators' welding qualification test results
  - Radiographic films (optional)
  - Certified mill test reports (optional)
  - A partial data report (optional)
- A clear indication of records, reports, inspection and tests required shall be stated at the time of placing purchase order.

Marking

- Each expansion joint will have attached to it the Thorburn stainless steel nameplate, showing our Company name and address, pressure rating and temperature rating.
- Expansion joints with flow liners will have a flow direction arrow painted visibly on the unit.
- Markings indicating P.O. number, project number, part number and customer coding if required must be specified (optional).

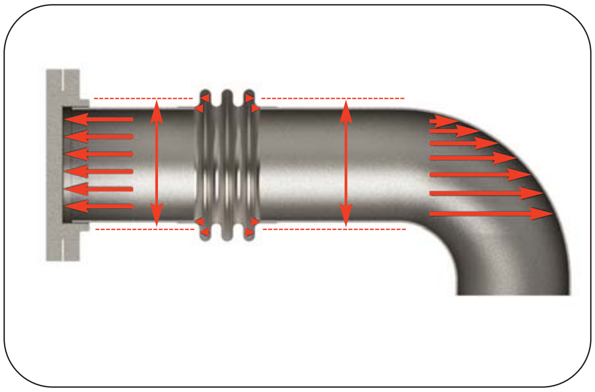
Shipping

- Expansion joints will be supplied with shipping bars and positioning devices for holding the joint in the required installation position during shipping and erection. These will be painted yellow and tagged with instructions for removal after installation.
- Standard protective paint will be applied to all surfaces unless otherwise specified. The bellows shall not be painted.
- Expansion joints will be supplied on skids, or loaded and blocked as deemed necessary for shipping.
- Protective coatings, coverings, end protection and special packaging may be provided as optional.
- The following "Installation Instruction Tag" will be on each expansion joint.

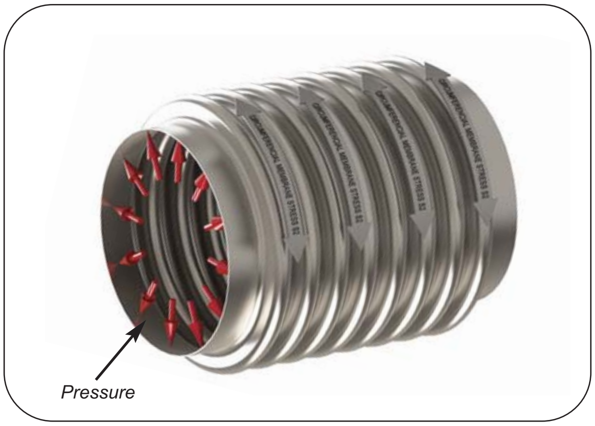
Thorburn's Metal Bellows Design Elements

Pressure Thrust

The spring represents the axial spring rate of the bellows. The hydraulic piston represents the effect of the pressure thrust which the expansion joint can exert on the piping anchors or pressure thrust restraints (hinges, Gimbals, tie rods) which may be part of the expansion joint assembly. The area of the hydraulic cylinder would be the effective area of the bellows. Force on equipment or adjacent piping anchors "F" = (the effective area of the bellows) x (the working pressure) + (the spring rate of the bellows) x (the stroke of the bellows). The pressure thrust force would equal (the working pressure) x (the bellows effective area). The pressure thrust force is typically much higher than the spring force. Expansion joints designed for lateral offset or for angular motion are more complicated to model accurately. However, the effect of pressure thrust is the same.



Working pressure acting on the effective area of the bellows is larger than the pipe diameter

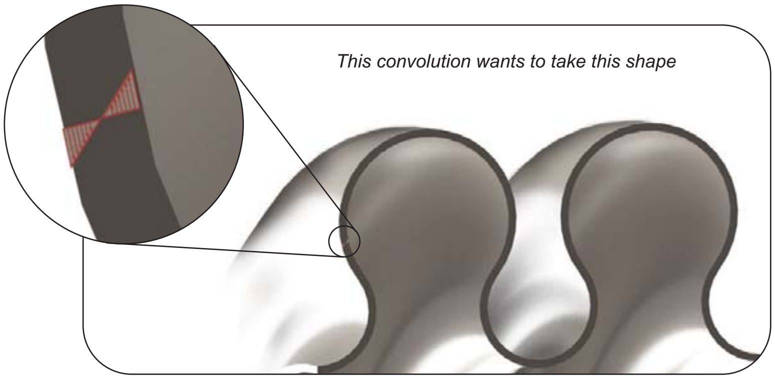


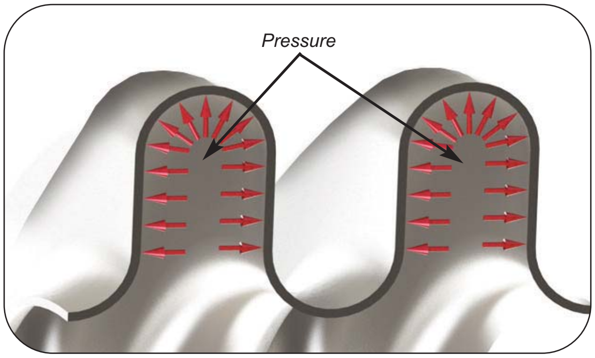
Circumferential Membrane Stress Due to Pressure S_2

The ability of a bellows to carry pressure is measured primarily by hoop stress or S_2 from the standards of the Expansion Joint Manufacturers Association (EJMA). S_2 is the stress which runs circumferentially around the bellows due to the pressure difference between the inside and the outside of the bellows. Hoop stress is what holds a bellows together like the hoops on a barrel. This stress must be held to a code stress level. The user should specify the code to be used.

Meridional Membrane Stress Due to Pressure S_4

The bellows ability to carry pressure is also limited by bulge stress or EJMA stress S_4. This is a stress which runs longitudinal to the bellows center line. More specifically, it is located in the bellows' side wall and it is a measure of the tendency of the bellows' convolutions to become less U-shaped and more spherical. The value of (S_3 + S_4) must be lower than the allowable stress of the bellows' material multiplied by material strength factor which is equal to 3.0 for bellows in the as formed condition (with cold work) and 1.5 bellows in the annealed condition (without cold work). Accommodating a requirement for annealing will often result in the addition of reinforcing rings or a much heavier bellows material and more convolutions. It is Thorburn's standard to not anneal bellows after forming to take advantage of the added performance that is imparted to a bellows through cold work.





Thorburn's Metal Bellows Design Elements

In-plane instability | Column instability

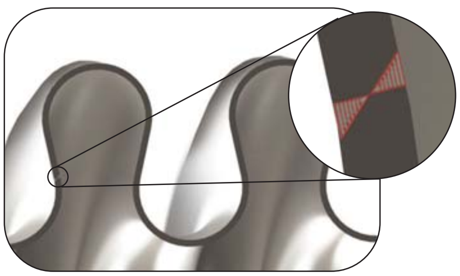
Bellows Stability

Excessive internal pressure may cause a bellows to become unstable and squirm. Squirm is detrimental to bellows performance in that it can greatly reduce both fatigue life and pressure capacity. The two most common forms are column squirm and in-plane squirm. Column squirm is defined as a gross lateral shift of the center section of the bellows. It results in curvature of the bellows centerline. This condition is most associated with bellows which have a relatively large length-to-diameter ratio and is analogous to the buckling of a column under compressive load. In-plane squirm is defined as a shift or rotation of the plane of one or more convolutions such that the plane of these convolutions is no longer perpendicular to the axis of the bellows. It is characterized by tilting or warping of one or more convolutions. This condition is predominantly associated with high meridional bending stress and the formation of plastic hinges at the root and crest of the convolutions. It is most common in bellows which have a relatively small length-to-diameter ratio.

Convolution shape before deflecting. When the bellows compresses, the side walls bend to shorten the bellows

Meridional Bending Stress Due To Deflection S_6

When a bellows deflects, the motion is absorbed by deformation of the side walls of each convolution. The associated stress caused by this motion is the deflection stress or EJMA stress S_6 . This stress runs longitudinal to the bellows' center line. The maximum value of S_6 is located in the side wall of each convolution near the crest or root.



Convolution shape after deflecting

Expansion joints are designed to operate with a value of S_6 which far exceeds the yield strength of the bellows material. This means that most expansion joints will take a permanent set at the rated axial or lateral motions. They are rarely designed to be elastic. This also means that the bellows will eventually fatigue after a finite number of movement cycles. It is important to specify a realistic cycle life as a design consideration when ordering an expansion joint. An overly conservative cycle life requirement can result in a bellows design that is so long and soft that it is subject to squirm failure.

Design Variables As They Affect Metallic Bellows Dynamics

Variation	Stress EJMA S2	Stress EJMA S4	Deflection Stress EJMA S6	Column Squirm Pressure	In-Plane Squirm	Cycle Life	Rated Axial	Rated Lateral	Rated Angular	Axial Spring Rate	Lateral Spring Rate	Angular Spring Rate	Pressure Thrust
Thicker Material	- (1)	- (2)	+ (1)	+ (3)	+ (2)	-	-	-	-	+ (3)	+ (3)	+ (3)	S
Thinner Material	+ (1)	+ (2)	- (1)	- (3)	- (2)	+	+	+	+	- (3)	- (3)	- (3)	S
Higher Convolute	- (1)	+ (2)	- (2)	- (3)	- (2)	+	+	+	+	- (3)	- (3)	- (3)	+
Lower Convolute	- (1)	- (2)	+ (2)	- (3)	+ (2)	-	-	-	-	+ (3)	+ (3)	+ (3)	-
Smaller Pitch	- (1)	+	-	-		+	+	+	+	-	-	-	S
Larger Pitch	+ (1)	-	+	+		-	-	-	-	+	+	+	S
More Plies	-	-	S	+		S	S	S	S	+	+	+	S
Fewer Plies	+	+	S	-		S	S	S	S	-	-	-	S
Larger Diameter	+ (1)	S	S	+		S	S	-	-	+	+	+	+
Smaller Diameter	+ (1)	S	S	-		S	S	+	+	-	-	-	-
More Convolutions	S	S	-	-		+	+	+	+	-	-	-	S
Fewer Convolutions	S	S	+	+		-	-	-	-	+	+	+	S

Legend: **+ :** Increase **- :** Decrease **S:** Same **(#):** Indicates how steeply the variation affects the design variable, i.e., (1) means the change is linear; (2) means the design variable changes by the square of the variable; (3) means the design variable changes by the cube of the variable.

Bellows Design Analysis Documentation

All custom bellows designs should be documented to prove that the design has been analyzed to the proper code, the design is safe and mechanically stable, the cycle life is in accordance with the specification requirements and the important stress values have been satisfied. Thorburn bellows design analysis shows all the critical information in a summary format. This paper is offered to help a customer interpret the information that is shown on Thorburn's bellows design analysis so the information is more meaningful.

ThorburnFlex	Customer:	Project:	File No:	Tag:12" EJ	QTY: 1
INPUT DATA					
Nominal Pipe Size	D:= 12	**Bellows mat. code**	Mat_b:= 10	**Reinforcement (0=Unreinf, 1=Reinf)**	Type:= 0
Design pressure	P:= 50psi	**Number of bellows**	N_b:= 1		
Design temp. (°F)	Temp:= 1000°F	**Spool pipe length**	L_s:= 0 in	**Reinf. ring type (0=Integral,1=Bolt)**	RR:= 1
Bellows inside diameter	D_b:= 12.75 in	**Spool pipe thickness**	t_s:= 0 in		
Number of cons.	N_c:= 14	**Pipe end thickness**	t_e:= 0 in	**Reinf. ring mat. code**	Mat_r:= 2
Convolution pitch	q := 1.17in	**Collar thickness**	t_c:= 0in	**Collar mat. code**	Mat_c:= 2
Convolution height	w := 1.156in	**Collar length**	L_c:= 0 in	**Liner mat. code**	Mat_l:= 2
Thickness of one ply	t:= 0.025 in	**Bellows neck length**	L_t:= 0.5 in	**Bolt mat. code**	Mat_f:= 13
Number of plies	n:= 3	**Spring rate factor**	SR:= 1.7	**Width RR rib**	Wr_r := 0 in
Axial (- comp. + ext.	x:= 2.25 - in	**Code (311,313,8)**	Code:= 313	**Thk RR rib**	tr_r:= 0 in
Lateral deflection	x_l:= 0in	**Fluid density**	ρm:= 62 lb· ft^{-3}	**RR Bolt Diam**	D_f:= 0.5 in
Angular rotation	θ := 0.0 deg	**Flow velocity**	v1:= 20ft sec^{-1}	**Bolt length**	L_f:= 5.0 in
Torsional rotation	ϕ := 0 deg	**Factor for flow media. =1 liquids =2 gases**	K_i:= 1	**Bolt thread pitch**	Tpi:= 13 in^{-1}
Angular rot. preset	$θ_p$:= 0 deg			**No. of gussets per tangent collar**	n_g:= 10
Cold axial preset	x_p:= 2in				
Cold lateral preset	x_{lp} := 0 in			**Bellow actual Yield**	Sy_{mb}:= 60 ksi
CALCULATION					
Tool width: Tw = 0.51 in	**Bellows_Mat:** "Inconel 625 Gr1, SB-443, N06625"		**Temp_C:** = 537.8 °C **Max_Temp:** = 1200°F	**P:** =345 kPa	**Flow_Rate:** 2174 · m³ · hr^{-1}
Material Proprieties		**Room Temp.**	**Design Temp.**	**Bellows Dimensions**	
Allowable stress		$Sa0_b$ = 36700 · psi	Sa_b = 31200 · psi	Bellows eff. area	A_e 153.5 · in2
Yield strength		$Sy0_b$ = 60000 · psi	Sy_b = 42100 · psi	Bellows free length	L_b = 16.38 · in
Moduli of elasticity		$E0_b$ = 30x10⁶ · psi	E_b 25.7x10⁶ · psi	Univ EJ. free length	L_u = 16.38 · in
Convolution factors		C_d = 1.8921 C_f = 1.3361	C_p = 0.5673	Bellows weight	Wb = 37.4 · lb
				Movement /conv.	e_t = 0.3036 · in
Stress Values Eq. C-4.2 of E.J.M.A.				OD reinf ring	od_r = 0 · in
S_1= Tangent circumf. membrane stress due to press.		S_1 = 2524 · psi	**Stress Verification =1 when is "TRUE"**		
S_{11}= Collar circumf. membrane stress due to press.		S_{11} = 0 · psi	S_1 C_{wb} · Sa_b = 1		V_1 = "Pass"
S_{12}= Collar circumf. bending stress due to press.		S_{12} = 0 · psi	S_2 C_{wb} · Sa_b = 1		V_2 = "Pass"
S_2= Circumf. membrane stress due to pressure		S_2 = 2150 · psi	S_3 + S4 · Cm Sa_b = 1		V_{34} = "Pass"
S_{21}= Reinf. ring circumferential stress due to press.		S_{21} = 0 · psi	S_{11} C_{wc} · Sa_c = 1		V_{11} = "Pass"
S_{22} = Fastener Membrane stress due to pressure		S_{22} = 0 · psi	**For reinforced only**		
S_3= Meridional memb.stress due to pressure		S_3 = 404 · psi	S_{11} + S_{12} ≤ K_s · C_{wc} · W_t · Sa_c = 1		V_{1112} = "NA"
S_4= Meridional bending stress due to press.		S_4 = 11084 · psi			V_{21} = "NA"
S_5= Meridional membrane stress due to defl.		S_5 = 1257 · psi	S_{22} < Sa_f = 1		V_{22} = "NA"
S_6= Meridional bending stress due to deflection		S_6 = 143315 · psi	**Pressure Stability**		
S_t= Total stress range for design conditions		S_t = 152613 · psi	PSC Column Squirm	Psc 56 · psi	V_Psc "Pass"
Spring Rates		**Reaction Forces**	Psi In-plane squirm	Psi 141 · psi	V_Psi "Pass"
Axial	f_{wa} 578 · lbf · in^{-1}	F_a = -1301 · lbf	**Dimensions Limitations**		
Lateral	f_{wl} 849 · lbf · in^{-1}	V_l = 0 · lbf	Extension limit		e_e < er_e = 1
Angular	$f_{wθ}$ 247 · lbf · in · deg^{-1}	$M_θ$ = 0 · lbf · in	Compression limit		e_c < er_c = 1
Torsional	$f_{wφ}$ 501x10³· lbf · in · deg^{-1}	$M_φ$ = 0 x 10⁰ · lbf · in	Knuckle radius		(r_m)> 3 · t = 1
Max. velocity for flow induced vibration (no liner)		v_{alw} 6.8 ft s^{-1}	Max. liner OD		ODL = 12.75 · in
$Liner_{chk}$ = "Liner Required"			Min. liner thk		tl = 0.0568 · in
Life Expectancy (cycles) for applicable Code			**Bellows Natural Frequency**		
Nc = 201844	EJMA 10th Ed.		Axial vibration (Hz)		fna - 26
Nc_B313 = 151383	ASME B31.3		Lateral vibration (Hz)		fnl - 45
Nc_VIII = 2021	ASME Sect. VIII, App. 26		Rocking vibration (Hz)		fnr - 31
Nc_III = 410	ASME Section III				

Standard Flange Data

This abbreviated flange data summary is intended to help system designers in selecting the optimum pipe and duct flanges. The working pressure at temperature ratings were obtained from applicable flange specifications. Where elevated temperature data was not available, the rated working pressure at ambient was down rated in accordance with ASME Code strength versus temperature correction factors.

Slip -On Flanges	Nominal I.D.	Working Pressure Rating (psi) at Temperature (°F)							
	(in)	-20° to 100°	200°	300°	400°	500°	600°	700°	800°
Class 125 L.W Forged Steel Mat'l A-105	6 - 12	175	152	134	116	98	80	62	46
AWWA 125 L.W C207-54T Class D Mat'l A-105	14 - 96	150	131	115	99	83	67	51	38
150# Forged Steel ANSI B16.5 Mat'l A-105	1 - 24	275	260	230	200	170	140	110	80
Class 125 Forged Steel Dim. to B16.1 Mat'l A-105	26 - 96	275	240	210	180	150	130	110	80
Class 125 (Class A) Cast Steel B16.1 Mat'l 126A	1 - 12	175	165	140					
Class 125 (Class B) Cast steel B16.1 Mat'l A-126B	1 - 12 14 - 24 30 - 48	200 150 150	190 135 115	165 110 50	140				
Class 300 Forged Steel ANSI B16.5 Mat'l A-105	1 - 24	740	675	655	635	600	550	535	410
Class 400 Forged Steel ANSI B16.5 Mat'l A-105	1 - 24	990	900	875	845	800	730	710	550

Thermal Expansion Of Pipe (inches per 100 feet of pipe)

Temp (°F)	Carbon Steel Carbon-Moly Low-Chrome (thru 3 Cr Mo)	5 Cr Mo thru 9 Cr Mo 18	Austenitic Stainless Steels Cr 8 Ni	12 Cr 17 Cr 27 Cr	25 Cr 20 Ni	Monel 67 Ni 30 Cr	3-1/2 Nickel	Aluminum	Gray Cast Iron	Bronze	Brass	Wrought Iron	70 Cu 30 Ni
-325	-2.37	-2.22	-3.85	-2.04	-3.00	-2.62	-2.22	-4.68		-3.98	-3.88	-2.70	-3.15
-300	-2.24	-2.10	-3.63	-1.92	-2.83	-2.50	-2.10	-4.46		-3.74	-3.64	-2.55	-2.87
-275	-2.11	-1.98	-3.41	-1.80	-2.66	-2.38	-1.98	-4.21		-3.50	-3.40	-2.40	-2.70
-250	-1.98	-1.86	-3.19	-1.68	-2.49	-2.26	-1.86	-3.97		-3.26	-3.16	-2.25	-2.53
-225	-1.85	-1.74	-2.96	-1.57	-2.32	-2.14	-1.74	-3.71		-3.02	-2.93	-2.10	-2.36
-200	-1.71	-1.62	-2.73	-1.46	-2.15	-2.02	-1.62	-3.44		-2.78	-2.70	-1.95	-2.19
-175	-1.58	-1.50	-2.50	-1.35	-1.98	-1.90	-1.50	-3.16		-2.54	-2.47	-1.81	-2.12
-150	-1.45	-1.37	-2.27	-1.24	-1.81	-1.79	-1.38	-2.88		-2.31	2.24	-1.67	-1.95
-125	-1.30	-1.23	-2.01	-1.11	-1.60	-1.59	-1.23	-2.57		-2.06	-2.00	-1.49	-1.74
-100	-1.15	-1.08	-1.75	-0.98	-1.39	-1.38	-1.08	-2.27		-1.81	-1.76	-1.31	-1.53
-75	-1.00	-0.94	-1.50	-0.85	-1.18	-1.18	-0.93	-1.97		-1.56	-1.52	-1.13	-1.33
-50	-0.84	-0.79	-1.24	-0.72	-0.98	-0.98	-0.78	-1.67		-1.32	-1.29	-0.96	-1.13
-25	-0.68	-0.63	-0.98	-0.57	-0.78	-0.77	-0.62	-1.32		-1.25	-1.02	-0.76	-0.89
0	-0.49	-0.46	-0.72	-0.42	-0.57	-0.57	-0.46	-0.97		-0.77	-0.75	-2.56	-0.66
25	-0.32	-0.30	-0.46	-0.27	-0.37	-0.37	-0.30	-0.63		-0.49	-0.48	-0.36	-0.42
50	-0.14	-0.13	-0.21	-0.12	-0.16	-0.20	-0.14	-0.28		-0.22	-0.21	-0.16	-0.19
70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	0.23	0.22	0.34	0.20	0.28	0.28	0.22	0.46	0.21	0.36	0.35	0.26	0.31
125	0.42	0.40	0.62	0.36	0.51	0.52	0.40	0.85	0.38	0.66	0.64	0.48	0.56
150	0.61	0.58	0.90	0.53	0.74	0.75	0.58	1.23	0.55	0.96	0.94	0.70	0.82
175	0.80	0.76	1.18	0.69	0.98	0.99	0.76	1.62	0.73	1.26	1.23	0.92	1.07
200	0.99	0.94	1.46	0.86	1.21	1.22	0.94	2.00	0.90	1.56	1.52	1.14	1.33
225	1.21	1.13	1.75	1.03	1.45	1.46	1.13	2.41	1.08	1.86	1.83	1.37	1.59
250	1.40	1.33	2.03	1.21	1.70	1.71	1.32	2.83	1.27	2.17	2.14	1.60	1.86
275	1.61	1.52	2.32	1.38	1.94	1.96	1.51	3.24	1.45	2.48	2.45	1.83	2.13
300	1.82	1.71	2.61	1.56	2.18	2.21	1.69	3.67	1.64	2.79	2.76	2.06	2.40
325	2.04	1.90	2.90	1.74	2.43	2.44	1.88	4.09	1.83	3.11	3.08	2.29	2.68
350	2.26	2.10	3.20	1.93	2.69	2.68	2.08	4.52	2.03	3.42	3.41	2.53	2.96
375	2.48	2.30	3.50	2.11	2.94	2.91	2.27	4.95	2.22	3.74	3.73	2.77	3.24
400	2.70	2.50	3.80	2.30	3.20	3.25	2.47	5.39	2.42	4.05	4.05	3.01	3.52
425	2.93	2.72	4.10	2.50	3.46	3.52	2.69	5.83	2.62	4.37	4.38	3.25	
450	3.16	2.93	4.41	2.69	3.72	3.79	2.91	6.28	2.83	4.69	4.72	3.50	
475	3.39	3.14	4.71	2.89	3.98	4.06	3.13	6.72	3.03	5.01	5.06	3.74	
500	3.62	3.35	5.01	3.08	4.24	4.33	3.34	7.17	3.24	5.33	5.40	3.99	
525	3.86	3.58	5.31	3.28	4.51	4.61	3.57	7.63	3.46	5.65	5.75	4.25	
550	4.11	3.80	5.62	3.49	4.79	4.90	3.80	8.10	3.67	5.98	6.10	4.50	
575	4.35	4.02	5.93	3.69	5.06	5.18	4.03	8.56	3.89	6.31	6.45	4.76	
600	4.60	4.24	6.24	3.90	5.33	5.46	4.27	9.03	4.11	6.64	6.80	5.01	
625	4.86	4.47	6.55	4.10	5.60	5.75	4.51		4.34	6.96	7.16	5.27	
650	5.11	4.69	6.87	4.31	5.88	6.05	4.75		4.57	7.29	7.53	5.53	
675	5.37	4.92	7.18	4.52	6.16	6.34	4.99		4.80	7.62	7.89	5.80	
700	5.63	5.14	7.50	4.73	6.44	6.64	5.24		5.03	7.95	8.26	6.06	
725	5.90	5.38	7.82	4.94	6.73	6.94	5.50		5.26	8.28	8.64	6.32	
750	6.16	5.62	8.15	5.16	7.02	7.25	5.76		5.50	8.62	9.02	6.59	
775	6.43	5.86	8.47	5.38	7.31	7.55	6.02		5.74	8.96	9.40	6.85	
800	6.70	6.10	8.80	5.60	7.60	7.85	6.27		5.98	9.30	9.87	7.12	
825	6.97	6.34	9.13	5.82	7.89	8.16	6.54		6.22	9.64	10.17	7.40	
850	7.25	6.59	9.46	6.05	8.19	8.48	6.81		6.47	9.99	10.57	7.69	
875	7.53	6.83	9.79	6.27	8.48	8.80	7.08		6.72	10.33	10.96	7.97	
900	7.81	7.07	10.12	6.49	8.87	9.12	7.35		6.97	10.68	11.35	8.26	
925	8.08	7.31	10.46	6.71	9.07	9.44	7.72		7.23	11.02	11.75	8.53	
950	8.35	7.56	10.80	6.94	9.37	9.77	8.09		7.50	11.37	12.16	8.81	
975	8.62	7.81	11.14	7.17	9.66	10.09	8.46		7.76	11.71	12.57	9.08	
1000	8.89	8.06	11.48	7.40	9.95	10.42	8.83		8.02	12.05	12.98	9.36	
1025	9.17	8.30	11.82	7.62	10.24	10.75	8.98			12.40	13.39		
1050	9.46	8.55	12.16	7.95	10.54	11.09	9.14			12.76	13.81		
1075	9.75	8.80	12.50	8.18	10.83	10.43	9.29			13.11	14.23		
1100	10.04	9.05	12.84	8.31	11.12	11.77	9.45			13.47	14.65		
1125	10.31	9.28	13.18	8.53	11.41	12.11	9.78						
1150	10.57	9.52	13.52	8.76	11.71	12.47	10.11						
1175	10.83	9.76	13.86	8.98	12.01	12.81	10.44						
1200	11.10	10.00	14.20	9.20	12.31	13.15	10.78						
1225	11.38	10.26	14.54	9.42	12.59	13.50							
1250	11.66	10.53	14.88	9.65	12.88	13.86							
1275	11.94	10.79	15.22	9.88	13.17	14.22							
1300	12.22	11.06	15.56	10.11	13.46	14.58							
1325	12.50	11.30	15.90	10.33	13.75	14.94							
1350	12.78	11.55	16.24	10.56	14.05	15.30							
1375	13.06	11.80	16.58	10.78	14.35	15.66							
1400	13.34	12.05	16.92	11.01	14.65	16.02							
1425			17.30										
1450			17.69										
1475			18.08										
1500			18.47										

This data is for information purposes only and does not imply that materials are suitable for all the temperatures shown.

Common Flange Dimensions & Drilling Chart

Nominal Pipe Size Expansion Joint ID	25 / 125 / 150 LB. Drilling								250 / 300 LB. Drilling			
	Specifications								Specifications			
	ANSI B16.1 - 1975 Class 25 (B) ANSI B16.1 - 1975 Class 125 (A) ANSI B16.24 - 1971 (A) AWWA C207-07 Tbl 2 & 3 Class D (D) ANSI B16.5 Class 125/150 (C)			AWWA C207-07, Tbl 2 & 3, Class D. Tbl 4, Class E (C) MSS SP-44 1975 Class 150 (A) SS SP-51 1965 MSS 150# (A) 1914 Amor Std for Ranges (E)					ANSI B16.1 - 1975 Class 250 ANSI B16.24 - 1971 300 lb ANSI B16.5 - 1973 Class 300 MSS SP-44 1975 Class 300			
	Common Size			Bolt Hole Size								
				Drilling Column								
	OD	BC	No. Of Holes	A	B	C	D	E	OD	BC	No. Of Holes	Hole Diameter
1/2	3 1/2	2 3/8	4	5/8	•	5/8	•	9/16	3 3/4	2 5/8	4	5/8
3/4	3 7/8	2 3/4	4	5/8	•	5/8	•	•	4 5/8	3 1/4	4	3/4
1	4 1/4	3 1/8	4	5/8	•	5/8	•	•	4 7/8	3 1/2	4	3/4
1 1/4	4 5/8	3 1/2	4	5/8	•	5/8	•	•	5 1/4	3 7/8	4	3/4
1 1/2	5	3 7/8	4	5/8	•	5/8	•	5/8	6 1/8	4 1/2	4	7/8
2	6	4 3/4	4	3/4	•	3/4	•	3/4	6 1/2	5	8	3/4
2 1/2	7	5 1/2	4	3/4	•	3/4	•	3/4	7 1/2	5 7/8	8	7/8
3	7 1/2	6	4	3/4	•	3/4	•	3/4	8 1/4	6 5/8	8	7/8
3 1/2	8 1/2	7	8	3/4	•	3/4	•	•	9	7 1/4	8	7/8
4	9	7 1/2	8	3/4	3/4	3/4	3/4	3/4	10	7 7/8	8	7/8
5	10	8 1/2	8	7/8	3/4	7/8	3/4	7/8	11	9 1/4	8	7/8
6	11	9 1/2	8	7/8	3/4	7/8	3/4	7/8	12 1/2	10 5/8	12	7/8
8	13 1/2	11 3/4	8	7/8	3/4	7/8	3/4	7/8	15	13	12	1
10	16	14 1/4	12	1	3/4	1	3/4	1	17 1/2	15 1/4	16	1 1/8
12	19	17	12	1	3/4	1	3/4	1	20 1/2	17 3/4	16	1 1/4
14	21	18 3/4	12	1 1/8	7/8	1 1/8	7/8	1 1/8	23	20 1/4	20	1 1/4
16	23 1/2	21 1/4	16	1 1/8	7/8	1 1/8	7/8	1 1/8	25 1/2	22 1/2	20	1 3/8
18	25	22 3/4	16	1 1/4	7/8	1 1/4	7/8	1 1/8	28	24 3/4	24	1 3/8
20	27 1/2	25	20	1 1/4	7/8	1 1/4	7/8	1 1/4	30 1/2	27	24	1 3/8
22	29 1/2	27 1/4	20	•	•	1 3/8	7/8	1 3/8	33	29 1/4	24	1 5/8
24	32	29 1/2	20	1 3/8	7/8	1 3/8	7/8	1 3/8	36	32	24	1 5/8
26	34 1/4	31 3/4	24	•	•	1 3/8	7/8	1 3/8	38 1/4	34 1/2	28	1 3/4
28	36 1/2	34	28	•	•	1 3/8	7/8	1 3/8	40 3/4	37	28	1 3/4
30	38 3/4	36	28	1 3/8	1	1 3/8	1	1 1/2	43	39 1/4	28	2*
32	41 3/4	38 1/2	28	•	•	1 5/8	1	1 5/8	45 1/4	41 1/2	28	2
34	43 3/4	40 1/2	32	•	•	1 5/8	1	1 5/8	47 1/2	43 1/2	28	2
36	46	42 3/4	32	1 5/8	1	1 5/8	1	1 5/8	50	46	32	2 1/4*
38	48 3/4	45 1/4	32	•	•	1 5/8	1	1 3/4	56	43	32	1 5/8
40	50 3/4	47 1/4	36	1 5/8	1 1/8	1 5/8	1	1 3/4	48 3/4	45 1/2	32	1 3/4
42	53	49 1/2	36	•	•	1 5/8	1 1/8	1 3/4	57*	52 3/4*	36*	2 1/4*
44	55 1/4	51 3/4	40	•	•	1 5/8	1 1/8	1 3/4	53 1/4	49 3/4	32	1 5/8
46	57 1/4	53 3/4	40	•	•	1 5/8	1 1/8	1 3/4	55 3/4	52	28	2
48	59 1/2	56	44	1 5/8	1 1/8	1 5/8	1 1/8	1 3/4	65*	60 3/4*	40*	2 1/4*
50	61 3/4	58 1/4	44	•	•	1 7/8	1 1/4	1 7/8	60 1/4	56 1/4	32	2 1/8
52	64	60 1/2	44	•	•	1 7/8	1 1/4	1 7/8	62 1/4	58 1/4	32	2 1/8
54	66 1/4	62 3/4	44	2	1 1/8	1 7/8	1 3/8	1 7/8	65 1/4	61	28	2 3/8
56	68 3/4	65	48	•	•	1 7/8	•	1 7/8	67 1/4	63	28	2 3/8
58	71	67 1/4	48	•	•	1 7/8	•	1 7/8	69 1/4	65	32	2 3/8
60	73	69 1/4	52	2	1 1/4	1 7/8	1 3/8	1 7/8	71 1/4	67	32	2 3/8
62	73 3/4	71 3/4	52	•	•	•	•	2				
66	80	76	52	•	•	1 7/8	1 3/8	2				
72	86 1/2	82 1/2	60	2	1 1/4	1 7/8	1 3/8	2				
78*	93	89	64	•	•	2 1/8	1 5/8	•				
84	99 3/4	95 1/2	64	2 1/4	1 3/8	2 1/8	1 5/8	2 1/8				
90*	106 1/2	102	68	•	•	2 3/8	1 7/8	•				
96	113 1/4	108 1/2	68	2 1/4	1 3/8	2 3/8	1 7/8	2 3/8				
102	120	114 1/2	72	•	•	2 5/8	2 1/8	•				
108	126 3/4	120 3/4	72	•	•	2 5/8	2 1/8	•				
120	140 1/4	132 3/4	76	•	•	2 7/8	2 3/8	•				
132	153 3/4	145 3/4	80	•	•	3 1/8	2 5/8	•				
144	167 1/4	158 1/4	84	•	•	3 3/8	2 7/8	•				

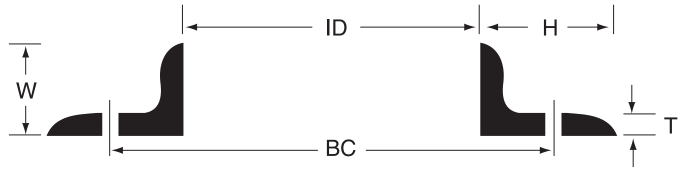
**DIMENSION SHOWN DOES NOT MEET SMM SP-44*
Most manufacturers can furnish products meeting the drilling/flange standards of:
1. British Standard 10:1962
2. EJMA, Tables 2-3-5-5/1962
3. ISO, International Std. 2084
4. ISO, International Std. 2536
5. NBS Product Standard PS 15-69
6. API Standard 605
7. DIN-ND 2501 Tbls 6-10-16
8. SMS 2033
9. DIN 2633
10. RSF 1583
11. NF.E 29-201 PN 6-10-16 and many others.

NOTES: 1. When ordering/specifying: Expansion Joints, Rubber Pipe, Retaining Rings or control Unit Assemblies, always note the mating flange drilling specification or the actual dimensions if specification is unknown. In the absence of this data, these products will be drilled to ANSI B16.1, Class 125 or to the individual manufacturer's printed drilling specification. 2. When products are manufactured to ASTM F1123-87 . They should be drilled to MIL-F- 20042C or ANSI B16.5, Class 150 as specified by the customer. 3. AWS= American War Standard, ASA= American Standards Association, changed to USAS, USAS=United States of America Standards Institute, changed to ANSI, ANSI= American National Standards Institute, AWWA = American Water Works Association, API = American Petroleum Institute 4. Drilling is available, but not shown for the following: 1914—78", 90"; AWWA C207-78-114", 126", 138".

DIN Flange Drilling

Nominal Pipe Size (DIN)	PN-10 EN 1092-1 (BS4504 - DIN 2501)				PN-16 EN 1092-1 (BS4504 - DIN 2501)				PN-25 EN 1092-1 (BS4504 - DIN 2501)				PN-40 EN 1092-1 (BS4504 - DIN 2501)			
	Flange OD (mm)	Bolt Circle (mm)	No. Of Holes (#)	Hole Dia. (mm)	Flange OD (mm)	Bolt Circle (mm)	No. Of Holes (#)	Hole Dia. (mm)	Flange OD (mm)	Bolt Circle (mm)	No. Of Holes (#)	Hole Dia. (mm)	Flange OD (mm)	Bolt Circle (mm)	No. Of Holes (#)	Hole Dia. (mm)
25	115	85	4	14	115	85	4	14	115	85	4	14	115	85	4	14
32	140	100	4	18	140	100	4	18	140	100	4	18	140	100	4	18
40	150	110	4	18	150	110	4	18	150	110	4	18	150	110	4	18
50	165	125	4	18	165	125	4	18	165	125	4	18	165	125	4	18
65	185	145	4	18	185	145	4	18	185	145	8	18	185	145	8	18
80	200	160	8	18	200	160	8	18	200	160	8	18	200	160	8	18
100	220	180	8	18	220	180	8	18	235	190	8	22	235	190	8	22
125	250	210	8	18	250	210	8	18	270	220	8	26	270	220	8	26
150	285	240	8	22	285	240	8	22	300	250	8	26	300	250	8	26
175	315	270	8	22	315	270	8	22	330	280	8	26	350	295	8	30
200	340	295	8	22	340	295	8	22	360	310	12	26	375	320	12	30
250	395	350	12	22	405	355	12	26	425	370	12	30	450	385	12	33
300	445	400	12	22	460	410	12	26	485	430	16	30	515	450	16	33
350	505	460	16	26	520	470	16	26	555	490	16	33	580	510	16	36
400	565	515	16	26	580	525	16	30	620	550	16	36	660	585	16	39
500	670	620	20	26	715	650	20	33	730	660	20	36	755	670	20	42
600	780	725	20	30	780	770	20	36	845	770	20	39	890	795	20	48
700	895	840	24	30	895	840	24	36	960	875	24	42	995	900	24	48
800	1015	950	24	33	1015	950	24	39	1085	990	24	48	1140	1030	24	56
900	1115	1050	28	33	1115	1050	28	39	1185	1090	28	48	1250	1140	28	56
1000	1230	1160	28	36	1230	1170	28	42	1320	1210	28	56	1360	1250	28	56

Duct Flex Mating Angle Flanges



Part Number	Nominal Diameter	Actual I.D.	Angle Thickness (T)	(H)	(W)	Revised Duct Flex (CC) O.A.L.	Weight	Angle Flange Data		
								Bolt Circle	Hole Dia.	No. of Holes
#	in	in	in	in	in	in	lbs	in	in	#
MAF14	14	14.188	0.188	1.50	1.50	+0.5	7.00	15.813	0.406	12
MAF16	16	16.250	0.188	1.75	1.75	+1	9.50	18.125	0.406	16
MAF18	18	18.250	0.188	1.75	1.75	+1	10.50	20.125	0.406	16
MAF20	20	20.250	0.188	1.75	1.75	+1	11.60	22.125	0.406	20
MAF22	22	22.250	0.188	1.75	1.75	+1	12.80	24.125	0.563	20
MAF24	24	24.250	0.188	1.75	1.75	+1	14.00	26.125	0.563	20
MAF26	26	26.250	0.188	2.00	2.00	+1.5	17.30	28.500	0.563	24
MAF28	28	28.250	0.188	2.00	2.00	+1.5	18.50	30.500	0.563	24
MAF30	30	30.250	0.188	2.00	2.00	+1.5	20.00	32.500	0.563	28
MAF32	32	32.250	0.188	2.00	2.00	+1.5	21.30	34.500	0.563	28
MAF34	34	34.250	0.188	2.00	2.00	+1.5	22.50	36.500	0.563	32
MAF36	36	36.250	0.188	2.00	2.00	+1.5	23.80	38.500	0.563	32
MAF38	38	38.250	0.188	2.00	2.00	+1.5	24.60	40.500	0.563	36
MAF40	40	40.250	0.188	2.00	2.00	+1.5	26.20	42.500	0.563	36
MAF42	42	42.250	0.188	2.00	2.00	+1.5	27.50	44.500	0.563	40
MAF44	44	44.250	0.188	2.00	2.00	+1.5	28.80	46.500	0.563	40
MAF46	46	46.250	0.188	2.00	2.00	+1.5	30.00	48.500	0.563	44
MAF48	48	48.250	0.188	2.00	2.00	+1.5	31.50	50.500	0.563	44
MAF50	50	50.250	0.250	3.00	3.00	+3.5	54.00	53.500	0.688	48
MAF52	52	52.250	0.250	3.00	3.00	+3.5	57.00	55.500	0.688	48
MAF54	54	54.250	0.250	3.00	3.00	+3.5	59.70	57.500	0.688	52
MAF60	60	60.250	0.250	3.00	3.00	+3.5	68.20	63.500	0.688	56
MAF66	66	66.250	0.250	3.00	3.00	+3.5	76.70	69.500	0.688	60
MAF72	72	72.313	0.375	3.00	3.00	+3.5	119.30	75.500	0.688	68
MAF84	84	84.313	0.375	3.00	3.00	+3.5	141.90	87.500	0.813	76
MAF96	96	96.313	0.375	3.00	3.00	+3.5	164.50	99.500	0.813	88
MAF108	108	108.375	0.375	3.00	3.00	+3.5	187.30	111.500	0.813	100
MAF120	120	120.375	0.375	3.00	3.00	+3.5	209.90	123.500	0.813	108
MAF132	132	132.375	0.375	3.00	3.00	+3.5	232.50	135.500	0.813	120
MAF144	144	144.375	0.375	3.00	3.00	+3.5	255.10	147.500	0.813	132

Material Standards Comparison

International steel designation				ISO	National designations superseded by EN						
EN	ASTM	UNS	JIS		BS (UK)	DIN (Germany)	NF (France)	SS (Sweden)	BG/PR (China)	KS (Korea)	GOST (Russia)
FERRITIC GRADES											
1.4600						1.4600					
1.4512	406		SUS409		409S19	1.4512	Z3 CT12				
1.4003		S40977		4003-410-77-I		1.4003					
1.4000	410S	S41008	SUS403	4000-410-08-I	403S17	1.4000	Z8 C12	2301			08X13
1.4589		S42035		4589-429-70-E		1.4589					
1.4016	430	S43000	SUS430	4016-430-00-I	430S17	1.4016	Z8 C17	2320	1Cr17	STS 430	12X17
1.4511				4511-430-71-I		1.4511	Z4 CNb17				
1.4520				4520-430-70-I		1.4520					
1.4510	439	S43035	SUS430LX	4510-430-35-I							
1.4509		S43940		4509-439-40-X		1.4509	Z3 CT Nb 18				
1.4607						1.4607					
1.4113	434	S43400		4113-434-00-I	434S17	1.4113					
1.4513		S43600		4513-436-00-J		1.4513					
1.4521	444	S44400	SUS444	4521-444-00-I		1.4521	Z3 CDT 18-02	2326			
MARTENSITIC AND PRECIPITATION HARDENING GRADES											
1.4006	410	S41000	SUS410	4006-410-00-I	410S21	1.4006	Z10 C13	2302	1Cr12	STS 410	12X13
1.4005	416	S41600	SUS416	4005-416-00-I	416S21	1.4005	Z11 CF13	2380	Y1Cr13	STS 416	
1.4021	420	S42000	SUS420J1	4021-420-00-I	420S29	1.4021	Z20 C13	2303	2Cr13	STS 120J1	20X13
1.4031	420	S42000		4031-420-00-I	420S45	1.4031	Z33 C13	2304			
1.4034	420	S42000		4034-420-00-I		1.4034	Z44 C14				
1.4028	420	S42000	SUS420J2	4028-420-00-I	420S45	1.4028	Z33 C13	2304	3Cr13	STS420J2	30X13
1.4313		S41500	SUSTi6NM	4313-415-00-I		1.4313	Z6 CN 13-04	2385			
1.4542	630	S17400	SUS630			1.4542	Z7 CNU 16-04				
1.4116				4116-420-77-E		1.4116	Z5O CD15				
1.4110				4110-420-69-E		1.4110					
1.4568	631	S17700	SUS631			1.4568	Z9 CNA 17-07	2388			
1.4122				4122-434-19-I		1.4122					
1.4574	632	S15700				1.4574					
FERRITIC HIGH TEMPERATURE GRADES											
1.4713						1.4713					
1.4724				4724-405-77-I		1.4724	Z13 C13				10X13CI0
1.4736						1.4736					
1.4742				4742-430-77-I		1.4742	Z12 CAS18				
1.4762				4762-445-72-I		1.4762	Z12 CAS25				
AUSTENITIC HIGH TEMPERATURE GRADES											
1.4948	304H	S30409	SUS304	4948-304-09-I	304S51	1.4948	Z6 CN 18-09	2333	1Cr18Ni9	STS 304	08X18H10
1.4878	321H		SUS321		321S51	1.4878	Z6 CNT 18-10	2337	1Cr18Ni9Ti	STS 321	08X18H10T
1.4818		S30415		4818-304-15-E				2372			
1.4833	309S	S30908	SUS309	4833-309-08-I	309S16	1.4833	Z15 CN 23-13		0Cr23Ni13	STS309S	20X23H13
1.4828			SUH309	4828-305-09-I		1.4828	Z17 CNS 20-12		1Cr20Ni14Si2		08X20H14C2
1.4835		S30815		4835-308-15-U		1.4835		2368			
1.4845	310S	S31008	SUS310S	4845-310-08-E	310S16	1.4845	Z8 CN25-20	2361	0Cr25Ni20		10X23H18
1.4841	314	S31400		4841-314-00-E		1.4841	Z15 CNS 25-20				20X25H2052

Material Standards Comparison

International steel designation				ISO	National designations superseded by EN						
EN	ASTM	UNS	JIS		BS (UK)	DIN (Germany)	NF (France)	SS (Sweden)	BG/PR (China)	KS (Korea)	GOST (Russia)
DUPLEX GRADES											
1.4162		S32101		4162-321-01-E							
1.4362		S32304		4362-323-04-I		1.4362	Z3 CN 23-04 Az	2327			
1.4662		S82441									
1.4662		S32205	SUS 329J3L	4462-318-03-I	318S13	1.4462	Z3 CND 22-05 Az	2377	00Cr22Ni5Mo3N	STS 329J3L	
1.4501		S32760		4501-327-60-I							
1.4410		S32750		4410-327-50-E			Z3 CND 25-06 Az	2328		STS 329J4L	
AUSTENITIC GRADES											
1.4310	301	S30100	SUS 301	4310-301-00-I	301S21	1.4310	Z11 CN 18-08	2331	1Cr17Ni7	STS 301	07X16H6
1.4618				4618-201-76-E		1.4618					
1.4318	301LN	S30153	SUS 301L	4318-301-53-I			Z3 CN 18-07 Az			STS 301L	
1.4376						1.4376					
1.4372	201	S20100	SUS 201	4372-201-00-I	284S16		Z12 CMN 17-07 Az		1Cr17Mn6Ni5N	STS 201	
1.4301	304	S30400	SUS304	4301-304-00-I	304S31	1.4301	Z7 CN 18-09	2333	0Cr18Ni9	STS 304	08X18H10
1.4307	304L	S30403		4307-304-03-I	304S11	1.4307	Z3 CN 18-10	2352	00Cr19Ni10	STS 304L	03X18H11
1.4311	304LN	S30453	SUS304LN	4311-304-53-I	304S61	1.4311	Z3 CN 18-10 Az	2371	00Cr18Ni10N	STS 304LN	
1.4541	321	S32100	SUS 321	4541-321-00-I	321S31	1.4541	Z6 CNT 18-10	2337	0Cr18Ni10Ti	STS 321	08X18H10T
1.4550	347	S34700	SUS 347	4550-347-00-I	347S31	1.4550	Z6 CNNb 18-10	2338	0Cr18Ni11Nb	STS 347	08X18H12Б
1.4305	303	S30300	SUS 303	4305-303-00-I	303S31	1.4305	Z8 CNF 18-09	2346	0Cr18Ni11Nb		12X18H10E
1.4303	305	S30403	SUS305J1	4303-305-00-I	305S19	1.4303	Z1 CN 18-12	2333	0Cr18Ni11Nb	STS 305	06X18H11
1.4306	304L	S30430	SUS304L	4306-304-03-I	304S11	1.4306	Z3 CN 18-10	2352	0Cr18Ni11Nb	STS 304L	03X18H11
1.4567			SUSXM7	4567-304-30-I	304S17	1.4567	Z3 CNU 18-09 FF		0Cr18Ni11Nb		
1.4640						1.4640					
1.4401	316	S31600	SUS 316	4401-316-00-I	316S31	1.4401	Z7 CND 17-11-02	2347	0Cr17Ni12Mo2	STS 316	
1.4404	316L	S31603		4404-316-03-I	316S11	1.4404	Z3 CND 17-11-02	2348	00Cr17Ni14Mo2	STS 316L	03X17H14M2
1.4427											
1.4436	316	S31600	SUS 316	4436-316-00-I	316S33	1.4436	Z7 CND 18-12-03	2343	0Cr17Ni12Mo2	STS 316	
1.4432	316L	S31603		4432-316-03-I	316S13	1.4432	Z3 CND 18-14-03	2353	00Cr17Ni14Mo2	STS 316L	03X17H14M3
1.4406	316LN	S31653	SUS 316LM	4406-316-53-I	316S61	1.4406	Z3 CND 17-11-Az		00Cr17Ni12Mo2N	STS 316LN	
1.4441						1.4441					
1.4429		S31653	SUS316LN	4429-316-53-I	316S63	1.4429	Z3 CND 17-12 Az	2375	00Cr17Ni13Mo2N	STS 316LN	
1.4571	316Ti	S32100	SUS316Ti	4571-316-35-I	320S31	1.4571	Z6 CNDT 17-12	2350	0Cr18Ni12Mo2Ti	STS 316Ti	08X17H13M2T
1.4435	316L		SUS 316L	4435-316-91-I	316S13	1.4435	Z3 CND 18-14-03	2353	00Cr17Ni14Mo2	STS 316L	03X17H14M3
1.3952											
HIGH PERFORMANCE AUSTENITIC GRADES											
1.4438	317L	S31703	SUS 317L	4438-317-03-I	317S12	1.4438	Z3 CND 19-15-04	2367	00Cr19Ni13Mo3	STS 317L	
1.4439	317LMN	S31726		4439-317-26-E		1.4439	Z3 CND 18-14-05-Az				
1.4466		S31050		4466-310-50-E							
1.3964											
1.4539	904L	N08904		4539-089-04-I	904S13	1.4539	Z2 NCDU 25-20	2562		STS 317J5L	
1.4547		S31254	SUS 312L	4547-312-54-I				2378			
1.4529		N08926		4529-089-26-I							
1.4565		S34565		4565-345-65-I		1.4565					
1.4652		S32654		4652-326-54-I							

Installation Instructions

Installation

The following precautions must be taken when installing an expansion joint.

1. Remove any protective covering from the ends of expansion joint. Plywood covers may have been used to protect flanges or weld ends. Check inside expansion joint for desiccant bags or any other material.

2. When a flow liner is installed in the expansion joint, orient the expansion joint with a flow arrow pointing in the direction of the flow.

3. Using lifting lugs, lift joint to desired location and position into pipeline or ducting.

4. Weld end expansion joints:
a) Prior to welding, cover the bellows element with a chloride free fire retardant cloth. This is to prevent arc strikes, weld splatter, etc. from damaging the bellows element.

b) Using the proper electrode, weld the expansion joint to adjacent piping. Do not use bellows to correct for misalignment of piping unless this has been considered in the design of the expansion joint.

5. Flanged end expansion joints:
a) Orient expansion joint flanges so that the bolt holes are aligned with the mating flanges. Do not force the expansion joint to match the bolt holes of the mating flange. This causes torsion on the bellows and will severely reduce the bellows capability during operation and may cause premature failure of the expansion joint. It is good practice to leave one pipe flange loose until the expansion joint is installed or to purchase an expansion joint with a flange that will rotate.

b) Install gaskets and bolt to the required torque recommended by the flange manufacturer.

Thorburn expansion joints are fully inspected at the factory and are packaged to arrive at the job site in good condition. Please, immediately upon receipt at the job site, verify that there is no freight damage (i.e. dents, broken hardware, loose shipping bars, etc.).

Because the bellows expansion joint is required to absorb thermal and/or mechanical movements, the bellows element must be constructed of a relatively thin gauge material. This requires special installation precautions. The following steps should be taken prior to installation of the expansion joint into the pipeline or duct.

1. The opening into which the expansion joint will be installed should be examined to verify that the opening for which the expansion joint was designed does not exceed the installation tolerances designated by the designer and/or purchaser. If the opening exceeds the tolerance, notify Thorburn at once for a disposition.

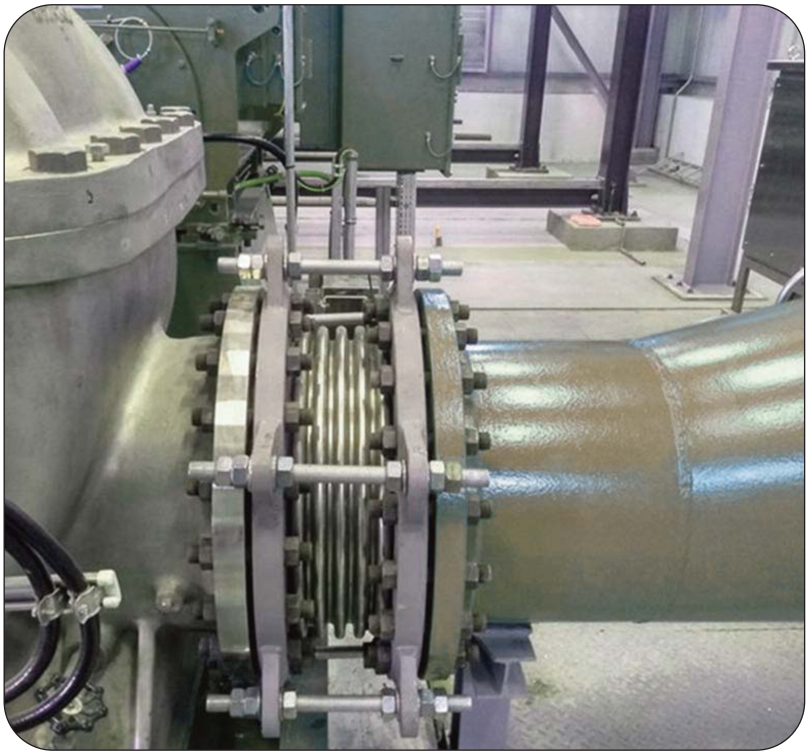
2. The attachment edges of the pipe or duct should be smooth, clean and parallel to each other.

3. The area around the expansion joint should be cleared of any sharp objects or protrusions. If not removable, they should be noted so they can be avoided.

4. Expansion joints provided with lifting lugs should be lifted only by the designated lifting lugs. Shipping bars (painted yellow) are not designed to be lifting devices. Never use a chain or any other handling devices directly on the bellows element or bellows cover. For expansion joints not provided with lifting lugs (i.e. less than 500 lbs.), the best lifting method should be evaluated at the time of installation.

5. The shipping bars are installed on an expansion joint to maintain shipping length and give the expansion joint stability during transit and installation. Do not remove the shipping bars until the installation is complete.

Safety and Design Recommendations



Thorburn expansion joints are employed in piping systems to absorb differential thermal expansion while containing the system pressure. They are being successfully utilized in refineries, chemical plants, fossil and nuclear power systems, heating and cooling systems, and cryogenic transfer systems. Typical service conditions range from pressures from full vacuum to 1000 psi (6500 kPa)and -420°F (-216°C) to +2100°F (+1150°C). Therefore, Thorburn expansion joints fall into the category of a highly engineered product. Thorburn expansion joints cannot and should not be purchased and used as commodity items if they are to perform their intended function safely and reliably. The system operating characteristics and Thorburn's expansion joints design, installation, test and operating procedures must all be considered.

Unlike most commonly used components, Thorburn's expansion joint bellows is constructed of relatively thin gauge material in order to provide the flexibility needed to absorb mechanical and thermal movements expected in service. This requires design, manufacturing quality, handling, installation and inspection procedures which recognize the unique nature of the product.

In general, the most reliable and safe bellows expansion joint installations have always involved a high degree of understanding between the user and Thorburn. With this basic concept in mind, this section was prepared in order to better inform the user of those factors which many years of experience have shown to be essential for the successful installation and performance of piping systems containing bellows expansion joints.

After Installation But Prior To Hydrostatic Test

1. Inspect entire system to insure that anchors, guides and pipe supports are installed in strict accordance with piping system drawings. A pipe guide spacing chart is provided on page 20 to aid in this check.

2. Anchors must be designed for the test pressure thrust loads. Expansion joints exert a force equal to the test pressure times the effective area of the bellows during hydrostatic test. Pressure thrust at design pressure may be found on the individual drawings.

3. If the system media is gaseous, check to determine if the piping and/or the expansion joint may require additional temporary supports due to the weight of water during testing.

4. Remove shipping bars (painted yellow) prior to hydrostatic testing. Shipping bars are not designed for hydrostatic pressure thrust loads.

5. Hydrostatically test pipeline and expansion joint. Only chloride free water should be used for hydrostatic test (published reports indicate chloride attack as low as 3 ppm). Water should not be left standing in the bellows.

General Precautions

1. Cleaning agents, soaps and solvents may contain chlorides, caustics or sulfides and can cause stress corrosion which appears only after a bellows is put into service.

2. Wire brushes, steel wool and other abrasives should not be used on the bellows element.

3. Hydrostatic test pressure should not exceed 1.5 times the rated working pressure unless the expansion joint was specifically designed for this test pressure.

4. Some types of insulation leach chlorides when wet. Only chloride free insulation materials should be used for insulating an expansion joint.

THORBURN'S WARRANTY IS VOID UNLESS THE ABOVE INSTRUCTIONS ARE FOLLOWED

Types Of Corrosion

Thorburn's flexible metal hoses are suitable for the transport of critical fluids if a sufficient resistance is ensured against all corrosive media that may occur during the lifetime of the hose. The flexibility of the hose's corrugated elements require their wall thickness to be considerably thinner than that of all other parts of the piping system. Special attention must be paid to all possible kinds of corrosion, especially pitting corrosion, intergranular corrosion, crevice corrosion and stress corrosion cracking. This leads to the fact that the corrugated flexible element that is exposed to the corrosive fluid has to be chosen from a material with even higher corrosion resistance than those of the piping system parts it is connected to.

According to EN ISO 8044, corrosion is the "physicochemical interaction between a metal and its environment that results in changes in the properties of the metal, and which may lead to significant impairment of the function of the metal, the environment, or the technical system, of which these form a part. This interaction is often of an electrochemical nature". Different types of corrosion may occur, depending on the material and on the corrosion conditions.

Uniform Corrosion

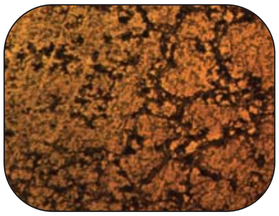
A general corrosion proceeding at almost the same rate over the whole surface. This type of corrosion includes rust which commonly is found on unalloyed steel (e. g. caused by oxidation in the presence of water). Stainless steels can only be affect by uniform corrosion under extremely unfavorable conditions, e.g. caused by liquids, such as acids and salt solutions. The loss in weight is specified in g/m2h or as the reduction in the wall thickness in mm/year.

Pitting Corrosion

A locally limited corrosion attack that may occur under certain conditions, called pitting corrosion on account of its appearance. It is caused by the effects of chlorine, bromine and iodine ions, especially when they are present in hydrous solutions. This selective type of corrosion cannot be calculated, unlike surface corrosion, and can therefore only be kept under control by choosing an adequate resistant material. The resistance of stainless steels to pitting corrosion increases in line with the molybdenum content in the chemical composition of the material.

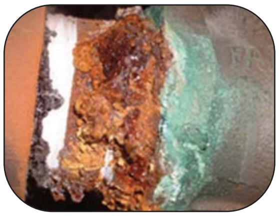
Crevice Corrosion

This type of corrosion is caused by the lack of oxygen in crevices which results in a localized attack on a metal surface at, or immediately adjacent to, the gap or crevice between two joining surfaces. The gap or crevice can be formed between two metals or a metal and non-metallic material. Examples of crevices are gaps and contact areas between parts, under gaskets or seals, inside cracks and seams and spaces filled with deposits.



Intergranular Corrosion

Intergranular corrosion is a local, selective type of corrosion which primarily affects the grain boundaries. It is caused by deposits in the material structure, which lead to a reduction in the corrosion resistance in the regions close to the grain boundaries. In stainless steels this type of corrosion can advance up to the point where the grain composition is dissolved. These deposit processes are dependent on temperature (critical temperature range is between 550°C and 650°C) and time in CrNi alloys. The onset of the deposit processes differs according to the type of steel. Intergranular corrosion can be avoided by using stainless steels with low carbon content (≤ 0,03 % C) or containing elements, such as titanium or niobium. Thin wall flexible elements made of materials such as 1.4541(SA 240 Type 321) or low-carbon qualities like 1.4404 (SA 240 Type 316L) can protect against intergranular corrosion. The resistance of materials to intergranular corrosion can be verified by a standardized test (Monypenny - Strauss test according to ISO 3651-2).



Dezincing

A type of corrosion which occurs primarily in copper-zinc alloys with more than 20% zinc. During the corrosion process the copper is separated from the brass and the zinc either remains in solution or is separated in the form of basic salts above the point of corrosion. The dezincing can be either of the surface type or locally restricted, and can also be found deeper inside. Conditions which encourage this type of corrosion include thick coatings from corrosion products, lime deposits from the water or other deposits of foreign bodies on the metal surface. Water with high chloride content at elevated temperature in conjunction with low flow velocities further the occurrence of dezincing.

Galvanic Corrosion

This type corrosion is an electrochemical process in which one metal corrodes preferentially when it is in electrical contact with another, in the presence of an electrolyte. A similar galvanic reaction is exploited in primary cells to generate a useful electrical voltage to power portable devices. Materials which can be encountered in both the active and passive state must also be taken into account. A CrNi alloy, for example, can be activated by mechanical damage to the surface, by deposits (diffusion of oxygen made more difficult) or by corrosion products on the surface of the material. This may result in a potential difference between the active and passive surfaces of the metal, and in material erosion (corrosion) if an electrolyte is present.

Stress Corrosion Cracking (SCC)

This type of corrosion is observed most frequently in austenitic materials, subjected to tensile stresses and exposed to a corrosive agent. The most common corrosive agents are alkaline solutions and those containing chlorides. The form of the cracks may be either transgranular or intergranular. Whereas the transgranular form only occurs at temperatures higher than 50°C (especially in solutions containing chloride), the intergranular form can be observed already at room temperature in austenitic materials in neutral solutions containing chloride. At temperatures above 100°C, SCC can already be caused by very small concentrations of chloride or lye – the latter always leads to the transgranular form. Stress corrosion cracking takes the same forms in non-ferrous metals as in austenitic materials. Damage caused by intergranular stress corrosion cracking can occur in nickel and nickel alloys in highly concentrated alkalis at temperatures above 400°C, and in solutions or water vapor containing hydrogen sulphide at temperatures above 250°C. A careful choice of materials based on a detailed knowledge of the existing operating conditions is necessary to prevent from this type of corrosion damage.

Common Metallurgical Problems in Bellows		
Failure Mode	**Cause**	**Solution**
Chloride Stress Corrosion Cracking	Chlorides acting on austenitic stainless steel bellows (T-304, T-316, T-321)	Use a high nickel alloy like Inconel-600 or Inconel-625
Carbide Precipitation	Chromium carbides form in unstabilized stainless steels (T-304, T316) at high temperatures (over 700ºF) causing loss of corrosion resistance	Use a stabilized stainless steel (T-321) or low carbon stainless steel (T-304L) or another high alloy material not affected by carbide precipitation
Pitting Corrosion	Galvanic action causing holes to form in a bellows, usually from acids	Use a bellows material containing molybdenum (T-316, I-825, I-625) or one of the specialty materials such as Zirconium, Titanium or Tantalum

Corrosion Resistance Tables

Table Key

Meanings of abbreviations

adp: acid dew point
bp: boiling point
cs: cold-saturated (@ room temp)
dr: dry condition
hy: hydrous solution
me: melted
mo: moist condition
sa: saturated (@ boiling point)

Assessment	Corrosion Behavior	Suitability
A	Resistant	Suitable
B	Uniform corrosion with reduction in thickness of up to 1 mm/year	Restricted suitability
C	Risk of pitting corrosion	
D	Risk of stress corrosion cracking	
E	Hardly resistant, uniform corrosion with reduction in thickness of more than 1 mm/year up to 10 mm/year	Not recommended
F	Not resistant (different forms of corrosion)	Unsuitable

Medium			Materials													
Designation Chemical Formula	Concentration	Temperature		Stainless Steels			Nickel Based Alloys					Copper Based Alloys		Pure Metals		
	%	°C	Non/Low Alloy Steels	409, 410L, 430	SS304, SS321	SS316, SS316L	Incoloy 825 2.4858	Inconel 600 2.4816	Inconel 625 2.4856	Hastelloy-C 2.4610 C276 2.4819	Monel 2.4360	Alloy CuNi 70/30	Bronze	Titanium	Tantalum	Aluminum
Acetanilide (Antifebrine) C_8H_9NO																
Acetic acid CH_3COOH or $C_2H_4O_2$	5 5 50 50 80 96 98	20 bp 20 bp 20 20 bp	F F F F F F F	A F F F F F F	A A A F C F F	A A A A C C F	A A A A A A A	B B B B B B B	A A A A A A A	A A A A A A A	B B B B B B B			A A B A A A A	A A A A A A A	A A F A
Acetic acid vapour	33 100 100	20 >50 <bp		F F F	B F F	B F F	 A A	 B F		 A A	 B F	 F F		 A A		 B F
Acetic aldehyde $CH_3–CHO$	100	bp	B	B	A	A	A	A	A	A	A	A	A	A	A	A
Acetic anhydride $(CH_3–CO)_2O$	all 100 100	20 60 bp	B F F	A	A A A	A A A	A	B F	A	A A A	B	B	A B	A A A	A A A	A B F
Acetic anilide (Antifebrine)		<114	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Acetone CH_3COCH_3	100	bp	B	A	A	A	A	A	A	A	A	A	A	A	A	A
Acetyl chloride CH_3COCl		20	B	B	B	B	B	B	A	A	B	B	B		A	B
Acetylene dr HC=CH dr		20 200	A B	A A	A A	A A	A A	A A	A A	A A	A A	F F	F F	A A	A A	A B
Acetylene dichloride hy $C_2H_2Cl_2$ dr	5 100	20 20	 A	 C	 C	 C	 A	 A	 A		 A					B A
Acetylen tetrachloride $CHCl_2–CHCl_2$	100 100	20 bp bp	A A B	A A	A A	A A				A A				A B		A F F
Adipic acid $HOOC(CH_2)_4COOH$	all	200	A	A	A	A	A	A	A	A	A			A	A	A
Alcohol *see ethyl or methyl alcohol*																

Medium			Materials													
Designation Chemical Formula	Concentration	Temperature		Stainless Steels			Nickel Based Alloys					Copper Based Alloys		Pure Metals		
	%	°C	Non/Low Alloy Steels	409, 410L, 430	SS304, SS321	SS316, SS316L	Incoloy 825 2.4858	Inconel 600 2.4816	Inconel 625 2.4856	Hastelloy-C 2.4610 C276 2.4819	Monel 2.4360	Alloy CuNi 70/30	Bronze	Titanium	Tantalum	Aluminum
Allyl alcohol CH_2CHCH_2OH	100	bp			A	A	A	A	A	B						
Allyl chloride $CH_2=CHCH_2Cl$	100	25				A	A	A	A		A					
Alum KAI $(SO4)_2$ hy hy	100 10 10 sa	20 20 <80	B B B	B A B F	A A A F	A A A B	A	B	A	A B B F		B B B F	B	A A	A A A	B B
Aluminium me Al		750	B	B	B	B					B			B		
Aluminium acetate hy $(CH_3–COO)_2Al(OH)$ hy	3 sa	20	F F	A A	A A	A A				A B				A A	 B	
Aluminium chloride hy $AlCl_3$	5	20	F	F	F	C	B	B	A	A	B	F	B	A	A	F
Aluminium fluoride hy AlF_3	10	25	F	F	F	F				B	B			A	F	B
Aluminium formate $Al(HCOO)_3$			B	A	A	A	A	A	A	A			A	A	A	A
Aluminium hydroxide hy $Al(OH)_3$	10	20	B	F	A	A	A		A	A	F	A	A		A	F
Aluminium nitrate $Al(NO_3)_3$			A	A	A	A	A	A	A	A	A			A	A	B
Aluminium oxide Al_2O_3		20	B	B	A	A	A		A	A	F	A	A		A	F
Aluminium potassium sulphate *see alum*																
Aluminium sulphate hy $Al_2(SO_4)_3$ hy	10 15	<bp 50	F F	F F	F F	A B	A	B B	A B	B B	F B	F B	F B	A A	A A	F F
Ammonia dr NH_3 hy hy hy	10 2 20 sa	20 20 40 bp	A A A A	A A A A	A A A A	A A A A	 A A	A A B F	A A B B	A A B B	B A F F	A F	D D	A A A A	A A A A	A B

Medium: Designation / Chemical Formula		Concentration %	Temperature °C	Non/Low Alloy Steels	Stainless Steels: 409, 410L, 430	Stainless Steels: SS304, SS321	Stainless Steels: SS316, SS316L	Nickel Based Alloys: Incoloy 825 2.4858	Nickel Based Alloys: Inconel 600 2.4816	Nickel Based Alloys: Inconel 625 2.4856	Nickel Based Alloys: Hastelloy-C 2.4610 C276 2.4819	Nickel Based Alloys: Monel 2.4360	Copper Based Alloys: Alloy CuNi 70/30	Copper Based Alloys: Bronze	Pure Metals: Titanium	Pure Metals: Tantalum	Pure Metals: Aluminum
Ammonia bromide NH_4Br	hy	10	25	F	C	C	C	A		A	B					A	B
Ammonium acetate $CH_3–COONH_4$				B	A	A	A									A	A
Ammonium alum $NH_4Al(SO_4)_2$	hy	cs	20			A	A								F	A	
Ammonium bicarbonate (NH)HCO_3	hy			A	A	A	A	B	F			F	F			A	A
Ammonium bifluoride NH_4HF_2	hy hy	10 100	25 20	F F	F F	F A	F A				A A				F F	A A	
Ammonium bromide *see ammonia bromide*																	
Ammonium carbonate $NH_4)_2CO_3$	hy hy	1 50	20 bp	A A	A A	A A	A A	A A	A A	A A	B B	A A				A A	A A
Ammonium chloride NH_4Cl	hy hy hy	1 10 50	20 100 bp	B B B	C C C	C C C	C C C	A A A	A A B	A A A	A A B	A B B	B B B	D D	A A A	A B B	B B B
Ammonium fluoride NH_4F	 hy hy	10 hg 20	25 70 80	B C C	B	A F	A F				A A			 F	B	A A	
Ammonium fluosilicate $(NH_4)_2SiF_6$	hy	20	40	F		B	A	A	A	A	A	A					
Ammonium formate $HCOONH_4$	hy hy	10 10	20 70	B	A	A	A	A	A	A	A	A			A	A A	A A
Ammonium hydroxide NH_4OH		100	20		A	A	A	A	A	A	A	F	F		A	A	B
Ammonium nitrate NH_4NO_3	hy hy	5 100	20 bp	F F	A A	A A	A A	A A	B	A	A A	F F	F	 F		A A	A A
Ammonium oxalate $COONH_4)_2$	hy hy	10 10	20 bp	B F	B F	A B	A A		B B	A A	A	B B	B B		A B	A A	
Ammonium perchlorate NH_4ClO_4	hy	10	20		C	C	C				B				A		
Ammonium persulphate $(NH_4)S_2O_8$	hy hy	5 10	20 25	 F	A B	A B	A B	A	B	A	A A	F F	F F	 F	A A	A	F
Ammonium phosphate $NH_4H_2PO_4$	hy	5	25	A	B	B	A	A	B	A	A	B	B		A	A	B
Ammonium rhodanide NH_4CNS			70		A	A	A								A		A
Ammonium sulphate $(NH_4)_2SO_4$	hy hy hy	1 10 sa	20 20 bp	A A B	A B	A B A	A A	A A	B F	A	A B F	B B E	F F F	 B	A F A	A A A	C C
Ammonium sulphite $(NH_4)_2SO_3$		cs sa	20 bp		B F	A B	A B	F F	F F			F F	F F		A A	A A	
Ammonium sulphocyanate *see ammonium rhodanide*																	
Amyl acetate $CH_3–COOC_5H_{11}$		all 100	20 bp	 B		 B	 B	B	B A	B B	B B	B A	B A			B	B A
Amyl alcohol $C_5H_{11}OH$		100 100	20 bp	A B	A A	A A	A A		A	A	A	A	A	A	 A	A	 B
Amyl chloride $CH_3(CH_2)_3CH_2Cl$		100	bp	B		C	C	A	B	A	A	B	A		A	A	F
Amyl thiol		100	160			A	A				A						
Aniline $C_6H_5NH_2$		100 100	20 180			A B	A B	A	B	A	A	F B	F	F	A		A F
Aniline chloride *see aniline hydrochloride*																	
Aniline hydrochloride $C_6H_5NH_2HCl$	hy hy	5 5	20 100		C C	C C	C C				A A		F		A A	A	F
Aniline sulphite	hy hy	10 cs	20 20				A A		B		A A						
Antifreeze Glysantine			20		A	A	A	A	A	A	A	A			A	A	A

Medium: Designation / Chemical Formula		Concentration %	Temperature °C	Non/Low Alloy Steels	Stainless Steels: 409, 410L, 430	Stainless Steels: SS304, SS321	Stainless Steels: SS316, SS316L	Nickel Based Alloys: Incoloy 825 2.4858	Nickel Based Alloys: Inconel 600 2.4816	Nickel Based Alloys: Inconel 625 2.4856	Nickel Based Alloys: Hastelloy-C 2.4610 C276 2.4819	Nickel Based Alloys: Monel 2.4360	Copper Based Alloys: Alloy CuNi 70/30	Copper Based Alloys: Bronze	Pure Metals: Titanium	Pure Metals: Tantalum	Pure Metals: Aluminum
Antimony Sb	me	100	650	F						A	A				F		F
Antimony trichloride $SbCl_3$	dr hy		20 100	A B	F F	F F	F F										F F
Aqua regia $3HCl+HNO_3$			20	F	F	F	F		F		F		F	F	A	A	
Arsenic As			65 110			A B	A B										
Arsenic acid H_3AsO_4	hy hy	 90	20 110	F	 F	A F	A F		 F				 F				 F
Asphalt			20	A	A	A	A						A	A			A
Azobenzene $C_6H_5–N=N–C_6H_5$			20		A	A	A	A	A	A	A	A			A	A	A
Baking powder	mo			B	A	A	A	A	A	A	A	A					A
Barium carbonate $BaCO_3$			20	F	A	A	A	A		A	A	A	A	A	A	A	B
Barium chloride $BaCl_2$	hy hy	5 25	20 bp		C C	C C	C C	B B	B B	A A	A A	B B	F		A A	A A	F C
Barium hydroxide $Ba(OH)_2$	solid hy hy hy hy	100 all all 100 cs sa 50	20 20 bp 815 20 bp 100	A A A A A A A	A A A A A A A	A A A A A A A	A A A A A A A	A A A A	B B B B		A A B B B	B B B	A A A A	A A A	A A A A A A A		F F A F
Barium nitrate $Ba(NO_3)_2$	hy	all	bp		A	A	A	A	B	A			F	F			
Barium sulphate $BaSO_4$			25	A	A	A	A	A		A		A	A	A	A	A	A
Barium sulphide BaS			25		A	A	A						F	F			
Basic aluminium acetate *see aluminium acetate*																	
Beer		100 100	20 bp	F F	A A	A A	A A	A A	A A	A A	A A	A A	A A	A A	A A	A A	A A
Benzaldehyde $C_6H_5–CHO$	dr		bp		A	A	A					B			B	A	A
Benzene		100 100	20 bp		A A	A A	A A	A	A B	A B	B B	A B	A B	A	A B	A A	A B
Benzenesulfonic acid $C_6H_5–SO_3H$	hy hy	5 5	40 60	F F	A F	A B	A B										
Benzine		100	25		A	A	A	A	A	A	A	A	A	A	A		B
Benzoic acid C_6H_5COOH	hy hy	all all	20 bp	B F	A A	A A	A A	A A	A A	A A	A A	A A	A A	A A	A A	A A	A F
Benzyl alcohol $C_6H_5–CH_2OH$		all	20	B	B	A	A	A	A	A	A	A	A	A	A		
Biphenyl $C_6H_5–C_6H_5$		100 100	20 400	A A	A A	D D	D D	A A	A A	A A	A A	A A	A	A	A A	A A	A A
Blood			20	F	A	A	A	A	A	A	A	A	A	A	A		
Boiled acid			20	B	A	A	A	A	A	A	A	A	A	A	A		A
Borax $Na_2B_4O_7$	hy hy	cs sa		B A	A A	A A	A A						A	A	A A	A A	A B
Boric acid H_3BO_3	hy hy hy	50 50 70	100 150 150	F F F	A B B	A A B	A A B	A A A	B B B	A A A	A A A	B B B	 A	 B	A A A	A A A	B B B
Boron B			20 900	A A	A	A	A										

Corrosion Resistance Tables

Medium				Materials													
Designation Chemical Formula		Concentration %	Temperature °C	Non/Low Alloy Steels	Stainless Steels			Nickel Based Alloys					Copper Based Alloys		Pure Metals		
					409, 410L, 430	SS304, SS321	SS316, SS316L	Incoloy 825 2.4858	Inconel 600 2.4816	Inconel 625 2.4856	Hastelloy-C 2.4610 C276 2.4819	Monel 2.4360	Alloy CuNi 70/30	Bronze	Titanium	Tantalum	Aluminum
Bromine Br	dr mo	100 100	20 20	C C	C C	C C	C C	B	A F	A	A F	A A	 B	A B	F A		F F
Bromine water		0.03 1	20 20		C C	C C	C C										
Bromoform $CHBr_3$	dr mo		20	A F	A A	A A	A A	A A	A A	A A	A A	A A		A A			F F
1,3-Butadiene $CH_2{=}CHCH{=}CH_2$								A	A	A		A					A
Butane C_4H_{10}		100 100	20 120	A	A B	A A	A A	A	A	A	A B	A	A	A			B
Butanol $CH_3{-}CH_2{-}CH_2{-}CH_2OH$		100 100	20 bp	A A	A A	A A	A A	A	A A	A	A A	A A	A	A	A A	A A	A A
Butter			20	F	A	A	A	A	A	A	A						A
Buttermilk			20	F	A	A	A	A		A	A	F		F			A
Butylacetate $CH_3COOC_4H_9$			20 bp	B B	A A	A A	A A	A A		A A	A A	B A	A A	A	A A	A A	A A
Butyric acid $CH_3{-}CH_2{-}CH_2{-}COOH$	hy hy	cs sa	20 bp	F F	A F	A F	A A	B B	F F	A A	A A	B B					A B
Cadmium Cd	me					F	F										
Calcium Ca	me		850	F		F	F										
Calcium bisulphite $CaSO_3$		cs sa	20 bp	F F	F F	A F	A A						B	B	A A		
Calcium carbonate $CaCO_3$			20	B	A	A	A	A	A	A	A	A	A	A	A	A	A
Calcium chlorate $Ca(ClO_3)_2$	hy hy	10 10	20 100		C F	C F	C C	B B	B B	B B	B B	B B	F F			A A	
Calcium chloride $CaCl_2$	hy hy	5 10 cs sa	100 20	F F F F	C C C F	C C C C	C C C C	 A A A	 A A A	 A A A	A A A A	 A B F	 A A A	 B	A A A C	A A A A	F F F F
Calcium hydroxide $Ca(OH)_2$				A	A	A	A	B	B	A	A	B	A	A	A	A	F
Calcium hypochlorite $Ca(OCl)_2$	hy hy	2 cs	20	F F	F F	F F	C	C A	F	A	A B	F	F		A	A A	F F
Calcium nitrate $Ca(NO_3)_2$		 all	20 100	F F	A A	A A	A A	A A	A A	A A	A A	A A			A A		A A
Calcium oxalate $(COO)_2Ca$	mo		20	B	A	A	A	A	A	A	A	A	A	A	A	A	F
Calcium oxide CaO			20	A	A	A	A	A	A	A	A	A	A	A	A		F
Calcium sulphate $CaSO_4$	mo mo		20 bp	B B	A A	A A	A A	A A		A A	A A	A A	A A	A A	A A	A A	B B
Calcium sulphite $CaSO_3$	hy hy	cs sa		A A	A A	A A	A A								A A	A A	B B
Carbolic acid $C_6H_5(OH)$	 hy	 90	20 bp bp	A F F	A F F	A F F	A A A	A	B	A	A B B	B A A	A		A A A	A A A	A F F
Carbon dioxide CO_2	dr dr mo mo	100 100 20 100	<540 1000 25 25	A F B F	B B B	A A A	A A A	A A A	A F A B	A A A	A A A	A A B	 A A	 B	 A	A A A A	 F F
Carbo monoxide CO		100 100	20 <540	A F	A A	A A	A A		A F	A	A A	A B			A A	A A	A B
Caustic-soda solution *see sodium hydroxide*																	
Chilean nitrate *see sodium nitrate*																	
Chloral $CCl_3{-}CHO$			20								A					A	F

Medium				Materials													
Designation Chemical Formula		Concentration %	Temperature °C	Non/Low Alloy Steels	Stainless Steels			Nickel Based Alloys					Copper Based Alloys		Pure Metals		
					409, 410L, 430	SS304, SS321	SS316, SS316L	Incoloy 825 2.4858	Inconel 600 2.4816	Inconel 625 2.4856	Hastelloy-C 2.4610 C276 2.4819	Monel 2.4360	Alloy CuNi 70/30	Bronze	Titanium	Tantalum	Aluminum
Chloramine				F	F	B	A	A		A	A	A					
Chloric acid $HClO_3$	hy		20	F	F	F	F	A			A				A	A	F
Chlorinated lime *see calcium hypochlorite*																	
Chlorine Cl_2	dr dr dr mo mo	100 100 100	200 300 400 20 150	A F F F F	A F F F F	A F F F F	A A F F F	 A	A A A	A A A	A A A A A	A A A	A	A	B A A	A A A	A B B
Chlorine dioxide ClO_2	hy	0.5	20	F	F	F	F				B			F	A	A	
Chloroacetic acid $CH_2Cl{-}COOH$	 hy	all 30	20 80	F F	F F	F F	 F	F	 F	B	B A	F	F	 F	A A	A A	F F
Chlorobenzene C_6H_5Cl	dr mo	 100	 20	A A	A C	A C	A C	 A	 A	 A	A A	 A	 A	 A	 A	 A	 B
Chloroethane C_2H_5Cl - *see ethyl chloride*																	
Chloroform $CHCl_3$	dr mo			B F	B C	B C	B C	A A	A A	A A	A	A A	A	A	A A		A F
Chloronaphthaline $C_{10}H_7Cl$				A	A	A	A	A	A	A	A	A	A	A	A	A	A
Chlorophenol $C_6H_4(OH)Cl$				B	A	A	A				A						
Chlorosulphon acid $HOSO_2Cl$	hy mo	100	20 20	A F	A F	A F	A B	A B	A B	A B	A	A			A F	A A	A F
Chrome alum $KCr(SO_4)_2$	hy	1 cs sa	20	F F F	F F F	A B F	A A F		 A A			B A B			A A A		B F F
Chromic acid Cr_2O_3 (H_2CrO_4)	hy hy hy hy hy hy hy	5 5 10 10 10 50 60	20 90 20 65 bp bp 20	F F F F F F F	F F A F F F F	A F A F F F F	A F A F F F F	B B B F B	F F F F F	A	A B A A A F	F F F F F F F	F F F F F F F	F F F F F F F	A A A A A A A	A A A A A A A	B B F F F
Chromic-acid anhydride *see chromium oxide*																	
Chromium oxide CrO_3				A	A	A	A	A	A	A	A	A	A	A	A	A	A
Chromium sulphate $Cr_2(SO_4)_3$		cs sa		F F	A A	A B	A B		A B	A A	A A	A A					
Cider				F F	A A	A A	A A	A A	A A	A A	A A	A A			A A	A A	B B
Citric acid $C_6H_8O_7$	hy hy	all all	<80 bp	F F	F F	A F	A A		A A		A A						
Combustion gases free from S or H_2SO_4 and Cl with S or H_2SO_4 and Cl			≤400 >adp ≤400	A A	A A	A A	A A				A A						
Copper (II) acetate $CU_2(CH_3COO)_4$	hy hy		20 bp	F F	A A	A A	A A	A	B	A	A	B	F	F F	A A	A	F F
Copper (II) chloride $CuCl_2$	hy hy	1 cs	20	F F	F F	C F	C F	A F	F F		B A	F F	F		A A	A A	F F
Copper (II) nitrate $Cu(NO_3)_2$	hy hy hy	1 50 cs	20 bp		A A A	A A A	A A A	A A	F F F		A B B	F F F	F F		A A A	A F A	F F
Copper (II) sulphate $CuSO_4$	hy hy	cs sa		F F	A B	A A	A A	A A	F F		A A	F F	F		A A	A A	F F
Cresol $C_6H_4(CH_3)OH$		all all	20 bp	F F	B B	A B	A A		A A	A A	 B	A A			A A		A F
Crotonaldehyde $CH_3{-}CH{=}CH{-}CHO$			20 bp	F		A B	A A	A A	A A	A A	A A	A A	A A				A A
Cyclohexane $(CH_2)_6$				A	A	A	A	A	A	A	A	A	A	A	A	A	A

Medium			Materials													
Designation Chemical Formula	Concentration	Temperature		Stainless Steels			Nickel Based Alloys					Copper Based Alloys		Pure Metals		
	%	ºC	Non/Low Alloy Steels	409, 410L, 430	SS304, SS321	SS316, SS316L	Incoloy 825 2.4858	Inconel 600 2.4816	Inconel 625 2.4856	Hastelloy-C 2.4610 C276 2.4819	Monel 2.4360	Alloy CuNi 70/30	Bronze	Titanium	Tantalum	Aluminum
Diammonium phosphate *see ammonium phosphate*																
Dibromethane $CH_2Br–CH_2Br$			B		A	A										F
Dichlorflourmethane dr		bp			A	A	A	A	A	A	A				A	A
CF_2Cl_2 dr		20			A	A	A	A	A	A	A				A	A
mo		20			A	A	A	A	A	A	A				A	A
Dichloroethane dr	100	20	A	C	C	C	B	A				A		A	A	A
$CH_2Cl–CH_2Cl$ mo	100	20		C	C	C									A	
Dichloroethylene *see acethylene dichloride*																
Diethyl ether $(C_2H_5)_2O$			A	A	A	A	A	A	A	B	A	A	A	A	A	A
Ethane $CH_3–CH_3$		20	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Ether *see diethyl ether*																
Ethereal oils		20	B	A	A	A	A	A	A	B	A	A	A	A	A	A
Ethyl alcohol	all	20	A	A	A	A	A	A	A	A	A	A	A	A	A	A
C_2H_5OH	all	bp	B	A	A	A	A	A		A	A	A	A	A	A	A
Ethylbenzene $C_6H_5–C_2H_5$			B	A	A	A	A	A	A	A	A	A	A	A	A	A
Ethyl chloride C_2H_5Cl			A	D	D	D	A	A	A	B	A	A	B		A	B
Ethylene $CH_2=CH_2$		20	A	A	A	A										A
Ethylene dibromide CH_2Br-CH_2Br			B		A	A									F	
Ethylene dichloride dr	100	20	A	C	C	C	B	A				A		A	A	A
CH_2CLCH_2CL mo	100	20		C	C	C									A	
Ethylene glycol $CH_2OH–CH_2OH$	100	20	A	A	A	A	A	B	A	A	B	A	A	A	A	A
Exhaust gases *see combustion gases*																
Fats			A	A	A	A	A	A	A	A	A	A	A	A	A	A
Fatty acid	100	20	A	A	A	A	A	A	A	A	B	B	A	A	A	A
$C_{17}H_{33}COOH$	100	60	F	A	A	A	A	A	A	A	A		B	A	A	B
	100	150	F	F	A	A	A	A	A	A	B		B	A	A	F
	100	180	F	F	F	A	A	A	A	A	B		F	A	A	F
	100	300	F	F	F	A	A	A	A	A			F	A	A	F
Fixing salt *see sodium thiosulphate*																
Flue gases *see combustion gases*																
Fluorine mo		20	F	F	F	F				A	A	F	B	F		F
dr	100	20	A	A	A	A				A	A	A	A	A		F
dr	100	200	A	A	C	C				A	A			A		F
dr	100	500	F							A						F
Fluorosilicic acid	100	20	F	F	C	C				B		B	B			F
$H_2(SiF_6)$	25	20	F	F	F	F	B	B	B	B	F		B	F		F
	70	20	F	F	F	F				B						F
vapour			F	F	F	F				B				E		F
Formaldehyde hy	10	20	F	A	A	A	A	A	A	A	A	A	A	A		B
CH_2O hy	40	20	F	A	A	A	A	A	A	A	A	A	A	A		B
hy	all	bp	F	A	A	A				A				A		F
Formic acid	10	20	F	F	B	A	A	B	A	A	B			A	A	A
HCOOH	10	bp	F	F	F	B	A	B	A	A	B			A		F
	80	bp	F	F	F	F	A	B	A	A	F			F		F
	85	65	F	F	F	F	A	B	A	A	E			F		F

Medium			Materials													
Designation Chemical Formula	Concentration	Temperature		Stainless Steels			Nickel Based Alloys					Copper Based Alloys		Pure Metals		
	%	ºC	Non/Low Alloy Steels	409, 410L, 430	SS304, SS321	SS316, SS316L	Incoloy 825 2.4858	Inconel 600 2.4816	Inconel 625 2.4856	Hastelloy-C 2.4610 C276 2.4819	Monel 2.4360	Alloy CuNi 70/30	Bronze	Titanium	Tantalum	Aluminum
Fuels Benzine		20		A	A	A	A	A	A	A	A		A			A
		bp		A	A	A	A	A	A	A	A		A			A
Benzene		20		A	A	A	A	A	A	A	A		A			A
		bp		A	A	A	A	A	A	A	A		A			A
Benzine-alcohol-mixture		20		A	A	A	A	A	A	A	A		A			A
Diesel oil		20		A	A	A	A	A	A	A	A		A			A
Furfural	100	25	B	B	B	B				A		A	A		A	A
	100	bp	F	B	B	B				A					A	A
Gallic acid hy	1	20	B	A	A	A				A					A	
$C_6H_2(OH)_3COOH$	100	20	F	A	A	A									A	
	100	bp	F	A	A	A		F							A	
Gelatine		20	A	A	A	A		A		A					A	
		80	B	A	A	A		A			A	A	A	A		A
Glacial acetic acid CH_3CO_2H *see acetic acid*																
Glass me		1200	B		B	B										
Glauber salt *see sodium sulphate*																
Gluconic acid $CH_2OH(CHOH)_4–COOH$	100	20	B	A	A	A	A	A	A	A	A	A	A	A		A
Glucose hy $C_6H_{12}O_6$		20		A	A	A						A	A	A		A
Glutamic acid		20	B	C	C	A	A	B	A	A	B					
$HOOC–CH_2–CH_2–CHNH_2$ $–COOH$		80	F	C	C	A		B		B						
Glycerine	100	20	A	A	A	A	A	A	A	A	A	A	A	A	A	A
$CH_2OH–CHOH–CH_2OH$	100	bp	B	B	A	A		A	A	A	A				A	A
Glycol *see ethylene glycol*																
Glycolic acid		20	F	B	B	B				A				A		B
$CH_2OH–COOH$		bp	F	F	F	F				A				A		B
Glysantine *see antifreeze*																
Hexachloroethane $CCl_3–CCl_3$		20			A	A	A	A	A	A	A			A		F
Hexamethylene - hy	20	60	B		A	A				A						
tetramine hy $(CH_2)_6N_4$	80	60	F		A	A				A						
Household ammonia *see ammonium hydroxide*																
Hydrazene $H_2N–NH_2$		20	A		A		F	F			F					B
Hydrazine sulphate hy $(NH_2)_2H_2SO_4$	10	bp	F		F	F										
Hydrobromic acid aqueous solution of hydrogen bromide (HBr)		20	F	F	F	F	F	F	F	F	F	F	F	F	A	F
Hydrochloric acid	0.2	20	F	F	C	C				A				A	A	
HCl	0.5	20	F	F	F	C				A				A	A	
	0.5	bp	F	F	F	F				F				B	A	
	1	20	F	F	F	C	F	F		A	B	F	F	A	A	F
	2	65	F	F	F	F				A				A	A	F
	5	20	F	F	F	F	F	F		A	B	F	B		F	
	15	20	F	F	F	F	F	F		A	F	F		F	A	F
	32	20	F	F	F	F				A				F	A	F
	32	bp	F	F	F	F				F				F	A	F
Hydrochloric-acid gas *see hydrogen chloride*																
Hydrofluoric acid	10	20	F	F	F	F	B	B	A	A	B		F	F	F	F
HF	80	20	B				B	B	B	B	B			F	F	F
	80	bp								B	B			F	F	F
	90	30					B	B			A			F	F	F

ThorburnFlex

Corrosion Resistance Tables

Medium: Designation / Chemical Formula		Concentration %	Temperature ºC	Non/Low Alloy Steels	Stainless Steels: 409, 410L, 430	Stainless Steels: SS304, SS321	Stainless Steels: SS316, SS316L	Nickel Based Alloys: Incoloy 825 2.4858	Nickel Based Alloys: Inconel 600 2.4816	Nickel Based Alloys: Inconel 625 2.4856	Nickel Based Alloys: Hastelloy-C 2.4610 C276 2.4819	Nickel Based Alloys: Monel 2.4360	Copper Based Alloys: Alloy CuNi 70/30	Copper Based Alloys: Bronze	Pure Metals: Titanium	Pure Metals: Tantalum	Pure Metals: Aluminum
Hydrogen H			<300 >300	A F		A A	A A				A A						A A
Hydrogen bromide HBr	dr mo	100 30	20 20	A F	A F	A F	A F								 A		
Hydrogen chloride HCl	dr dr dr dr		20 100 250 500	A A B F	F F F F	B F F F	B F F F	A A A	A A A B	A A A	A A A A			F			B B F F
Hydrogen cyanide HCN	dr hy hy	 20 cs	20 20 20	F F F	A B B	A A A	A A A	A A A	B B A	A A A	A A A	B B F	F F F	F F F	A A A	A A A	A A A
Hydrogen fluoride HF		5 100	20 500	 F	F F	F F	F F	F F	A F	A	A A	A F			F F	F F	F F
Hydrogen peroxide H_2O_2		all	20	F	F	A	A	A	B	A	A	B	F	F	B	F	A
Hydrogen sulphide H_2S	dr dr dr mo	100 100 100	20 100 200 20	B F F F	D D F F	A A A A	A A A A	A	B A	 A	A A	B A	A F	A F	A A	A A	A A A
Hydroiodic acid	dr mo		20 20	A F	A F	A F	A F										
Hypochlorous acid HOCl			20	F	F	F	F								A		F
Indol			20	A	A	A	A	A	A	A	A	A	A	A	A		A
Ink *see gallic acid*																	
Iodine J_2	dr mo mo	100	20 20 bp	A F F	C F F	C F F	C F F				A B B	A F F	F	F	F A		A F F
Iodoform CHJ_3	dr mo		60 20	A F	A F	A C	A C										A
Iron (II) chloride $FeCl_2$	hy hy	10 cs	20	A		C	C	 F	 F		B A	 F	B F	B	A A	A A	F F
Iron (II) sulphate $FeSO_4$	hy	all	bp	A	A	A	A				A	A			A		F
Iron (III) chloride $FeCl_3$	dr hy hy hy	100 5 10 50	20 25 65 20	A F F F	C F B F	C F B F	C F B F	B F	F F F		A A F B	F F	F F F	F F F	A A A A	A A A	B B
Iron (III) nitrate $Fe(NO_3)_3$	hy hy	10 all	20 bp	F F	A A	A A	A A	 F	 F	 F	A F	 F			A		
Iron (II) sulphate $FeSO_4$	hy	all	bp	A	A	A	A				A	A			A		A
Iron (III) sulphate $Fe(SO_4)_3$	hy hy	<30 all	20 bp	F F	A B	A A	A A	A	F		A A	B	F	F	A A	A A	F F
Isatine $C_8H_5NO_2$			20	B	A	A	A	A	A	A	A	A	A	A	A		A
Kalinite *see alum*																	
Ketene $R_2C{=}C{=}O$			20 bp		A A	A A	A A	A A	A A	A A	A A				A A	A A	A A
Lactic acid $C_3H_6O_3$	hy hy hy hy	1 all 10 all	20 20 bp bp	F F F F	F F F F	A B F F	A A F B	A A	 F	A	A A A A	 F	A B	B	A A A A	A A A A	A B B B
Lactose $C_{12}H_{22}O_{11}$	hy		20	A	A	A	A	A	A	A	A	A	A	A	A		A
Lead Pb	me		388 900	F F	B F	B F	B F		A		 A	F			A	A	
Lead acetate $(CH_3–COO)_2Pb$	me			F	A	A	A				A	A		F			F
Lead acide $Pb(N_3)_2$		<20	<30					A	A	A		B					
Lead nitrate $Pb(NO_3)_2$	hy		100	B	A	A	A	A	A	A	A	A			A	A	A
Lime CaO *see calcium oxide*																	
Lithium Li	me		300	A	A	A	A	A	A	A	A	F	F	F	A		F
Lithium chloride LiCl	hy	cs		F	F	F	C	A	A	A	A	B			A		
Lithium hydroxide LiOH	hy	all	20	B	A	A	A	A	A	A		A			A		
Magnesium Mg	me		650		B	F	F	F	F		F	F	F	F	A	A	F
Magnesium carbonate $MgCO_3$	hy hy		20 bp	A A	A A	A A	A A	A A	A A	A A	A A	A A	A A		A A	A A	B B
Magnesium chloride $MgCl_2$	hy hy hy	5 5 50	20 bp bp	F F F	F F F	C F F	C F F	A A	A A	A A	A A A	A A	F F		A A A	A A A	F F F
Magnesium hydroxide $Mg(OH)_2$	hy hy	cs sa		A A		A A	A A	A A	A A	A A	A A	A A	A A	A A	A A	A A	F F
Magnesium nitrate $Mg(NO_3)_2$		cs		A	A	A	A	F	F		F	A	F	A	A	A	B
Magnesium oxide *see magnesium hydroxide*																	
Magnesium sulphate $MgSO_4$	hy hy hy	0.1 5 50	20 20 bp	A F F	B B B	A A A	A A A	 A	 B	 A	A A B	 B	 A	 A	A A A	A A A	F A A
Maleic acid HOOC–HC=CH–COOH	hy hy	5 50	20 100	F F	A A	A A	A A	A	B B	A	A A	B	A				A A
Maleic anhydride		100	285								A						
Mallic acid	hy hy	 50	20 100	F F	F F	A A	A A	A A	B B	A A	A A	B B	F F	 F	A A	A A	A A
Malonic acid $CH_2(COOH)_2$			20 50 100			B	B	B B F	B B F	B B	B B F	B B F			B B F		B
Manganese(II) chloride $MnCl_2$	hy hy	5 50	100 20	F B	C F	C C	C C	B B	B B	B B		B B	F F		A A	A A	
Manganese(II) sulphate $MnSO_4$		cs			A	A	A	A	A	A	A	A			A		
Maritime climate	mo			EC	BC	BC	A	A	A	A	A	A	A	A	A	A	A
Methanol *see methyl alcohol*																	
Menthol $C_{10}H_{19}OH$					A	A	A	A	A	A	A	A	A	A	A	A	A
Mercury Hg	dr	100 all	20 <500	A B	C B	C B	C A		A A	A A	A A	F F	F F	F F	A A	 A	B F
Methane CH_4			200 600	A	A	A	A	A	A	A A	A	A	A	A			A
Methyl acetate CH_3COOCH_3		60 60	20 bp	A A		A A	A A				A A				A A	A A	
Methyl alcohol CH_3OH		<100 100	20 bp	 B	A F	A B	A B	A	A A	A A	A A	A A		 A	A A	B A	 B
Methylamine $CH_3–NH_2$	hy	25	20	B	A	A	A	A		A	A	F	F	F	A		A
Methyl chloride CH_3Cl	dr mo mo		20 20 bp	A F	A C C	A C C	A C C		A A A	A A A	A	A		A	A A A		A F F
Methyldehyde *see formaldehyde*																	
Methylene dichloride CH_2Cl_2	dr mo mo		20 20 bp	A	C C C	C C C	C C C	 A B		 B B	 B B	 B B	A A B		A A A		A B B

Medium			Materials													
Designation Chemical Formula	Concentration %	Temperature °C	Non/Low Alloy Steels	Stainless Steels			Nickel Based Alloys					Copper Based Alloys		Pure Metals		
				409, 410L, 430	SS304, SS321	SS316, SS316L	Incoloy 825 2.4858	Inconel 600 2.4816	Inconel 625 2.4856	Hastelloy-C 2.4610 C276 2.4819	Monel 2.4360	Alloy CuNi 70/30	Bronze	Titanium	Tantalum	Aluminum
Milk of lime $Ca(OH)_2$		20 bp	A A	B B	A A	A A										A A
Milk sugar *see lactose*																
Mixed acids HNO3 H2SO4 H2O % % % 90 10 – 50 50 – 50 50 – 50 50 – 38 60 2 25 75 – 25 75 – 25 75 – 15 20 65 15 20 65 10 70 20 10 70 20 05 30 65 05 30 65 05 30 65 05 15 80		 20 20 90 120 50 50 90 157 20 80 50 90 20 90 bp 134	 A F F F F	 F F F F F F F F F F F F F F	 A A B F A A B F A A A A A A B B	 A A B F A A B F A A A A A A B B					 F		 F	 A A		 B F
Molasses				A	A	A	A	A	A	A	A			A	A	A
Monochloroacetic acid *see chloroacetic acid*																
Naphthaline $C_{10}H_8$	100 100	20 390	A A	A A	A A	A A								A		B
Naphthaline chloride	100 100	45 200								A A						
Naphthaline sulphonic acid $C_{10}H_7SO_3H$	100 100	20 bp	A	 F	A F	A F				A A						
Naphthenic acid hy	100	20		C	C	C	A	A	A		A					A
Nickel (II) chloride hy $NiCl_2$ hy	10 10 tot	20 bp 70	F F	C F	C C	C C A	A	B	A	A A B	B	B	B	A A		
Nickel (II) nitrate hy $Ni(NO_3)_2$ hy	10 <100	25 25	F F	A A	A A	A A	A A	A F	A	A B	F F	F		A A	A A	F F
Nickel (II) sulphate hy $NiSO_4$ hy		20 bp	F F	A A	A A	A A	A	B A	B	B B	B B			A A		
Nitric acid HNO_3	1 1 5 5 10 15 25 50 65 65 99 20 40	20 bp 20 bp bp bp bp bp 20 bp bp 290 200	F F F F F F F F F F F F F	A A A B B B F F A F F F F	A A A A A A A F A F F F F	A A A A A A A B A F F F F	 A A A A	 F F A F F		A B A B B F F F A F F F F	A F F F F F F	B F F F F	F	A A A A A A B B A A A F F	A A A A A A A A A A F A A	 F F B F
Nitrobenzene hy $C_6Hx(NO_2)y$			A	A	A	A	A	A	A	B	A	A	A	A		A
Nitrobenzoic acid hy $C_6H_4(NO_2)COOH$		20	B	A	A	A	A	A	A	A	A	A	A			A
Nitroglycerine hy $C_3H_5(ONO_2)_3$		20	A	A	A	A										A
Nitrogen N	100 100	20 900	A B		A	A		A	A	A	A	A	A	A		A
Nitrous acid HNO_2 *See nitric acid*																

Medium			Materials													
Designation Chemical Formula	Concentration %	Temperature °C	Non/Low Alloy Steels	Stainless Steels			Nickel Based Alloys					Copper Based Alloys		Pure Metals		
				409, 410L, 430	SS304, SS321	SS316, SS316L	Incoloy 825 2.4858	Inconel 600 2.4816	Inconel 625 2.4856	Hastelloy-C 2.4610 C276 2.4819	Monel 2.4360	Alloy CuNi 70/30	Bronze	Titanium	Tantalum	Aluminum
Oleic acid *see fatty acid*																
Oleum *see sulphur trioxide*																
Oxalic acid hy $C_2H_2O_4$ hy hy	all 10 sa	20 bp	F F F	F F F	A F F	A F F	B A B	B B B	A A B	A A B	B B B	B		A F	A A	A F
Oxygen O		500	B	A	A	A					A		F			A
Ozone				A	A	A	A	A	A	A	A			A		A
Paraffin C_nH_{2n+2} me		20 120	A A	A A	A A	A A						 A	 A	A A		A A
Perchlorethane *see hexachlorethane*																
Perchloric acid (60%) $HClO_4$	10 100	20 20	F F	F F	F F	F F								A A		F
Perchlorethylene C_2Cl_4 mo		20 bp	A A F	A B C	A B C	A B C							A B			A F
Perhydrol *see hydrogen peroxide*																
Petroleum		20 bp	A A	A A	A A	A A		A A	A A	A A	A A	A	A A	A A		A A
Petrol *see benzine (benzene)*																
Phenol *see carbolic acid*																
Phloroglucinol $C_6H_3(OH)_3$		20		A	A	A	A	A	A	A	A			A	A	A
Phosgene dr $COCl_2$		20		A	A	A	A	A	A	A	A			A	A	A
Phosphoric acid hy H_3PO_4 hy hy hy hy hy	1 10 30 60 80 80	20 20 bp bp 20 bp	F F F F F F	A F F F F F	A A B F B F	A A B F A F	A	A A A	A A	A A B B A F	B B	F B	 B A B	A A F F F F	A A A A A A	F F
Phosphorous dr P		20		A	A	A	A									
Phosphorous pentachlorite dr PCl_5		20 200 bp	A	 A	A B A	A A A	 A			A A	A A		A		 A	A A
Phtalic acid and phtalic anhydride $C_6H_4(COOH)_2$ dr		20 200 bp	A	 A	A F A	A A A	 A			A A	A A		A		 A	A A
Picric acid hy $C_6H_2(OH)(NO_2)_3$ hy me	3 cs	20 150	F F F	A A A	A A A	A A A	F	F		A	F	F	F	A A A		B A F
Plaster *see calcium sulphate*																
Potash lye *see potassium hydroxide*																
Potassium me K		604 800	A		A A	A A				B B				A A	 B	A A
Potassium acetate me $CH_3–COOK$ hy	100	292 20	B B	 A	A A	A A		 A	 A	 A	 A		 B	A A		
Potassium bisulphate hy $KHSO_4$ hy	5 5	20 90	F F	F F	E F	A F								A F		
Potassium bitartrate hy $KC_4H_5O_6$ hy	cs sa		F F	F F	A F									A A		A A
Potassium bromide hy KBr	5	30	F	C	C	C	A	B	A	A	B	A		A	A	F

Corrosion Resistance Tables

Medium: Designation / Chemical Formula		Concentration %	Temperature °C	Non/Low Alloy Steels	Stainless Steels: 409, 410L, 430	SS304, SS321	SS316, SS316L	Nickel Based Alloys: Incoloy 825 2.4858	Inconel 600 2.4816	Inconel 625 2.4856	Hastelloy-C 2.4610 C276 2.4819	Monel 2.4360	Copper Based Alloys: Alloy CuNi 70/30	Bronze	Pure Metals: Titanium	Tantalum	Aluminum
Potassium carbonate K_2CO_3	hy hy	50 50	20 bp	B F	A F	A A	A A	A A	A A	A A	A A	A A	B	B	A A	A A	F F
Potassium chlorate $KClO_3$	hy hy	5 sa	20	F F	A A	A A	A A	A A	B F	A A	 A	B F	F F	B			
Potassium chloride KCl	hy hy hy hy hy	10 10 30 cs sa	20 <bp bp	F F F F F	F F F C F	C C C C C	C C C C C	A	A	A	A B B B B	A A	A F	 B	 A		B B A
Potassium chromate K_2CrO_4	hy hy	10 10	20 bp	A B		A A	A A	A	A	A	A	B	A	A	A A		A A
Potassium cyanide KCN	hy hy	10 10	20 bp	F F	A A	A A	A A	A	F		A	B	F F	 F		A	F F
Potassium dichromate $K_2Cr_2O_7$	hy hy hy	10 25 25	40 40 bp	F F F	A F F	A A A	A A A	B B	B B	B B	B B B	B B	A F F	 B B	A A A	A A A	A A A
Potassium ferricyanide $K_3(Fe(CN)_6)$	hy hy hy	1 cs sa	20	A F	A A A	A A C	B A A	B	A A A	A	A A A	A A		A A	A A A	A A A	 A A
Potassium ferrocyanide $K_4(Fe(CN)_6)$	hy hy hy	1 25 25	20 20 bp		A A B	A A B	A A A	B A A	B A A	A A A	A A A	A A A	A A A	 A	A A A	A A A	A A A
Potassium fluoride KF	hy hy	cs sa		A B	A A	A A	A A				A A						F
Potassium hydroxide	hy hy hy hy hy hy me	10 20 30 50 50 sa 100	20 bp bp 20 bp 360	 D D D F	A A F A F F F	D D D D F D F	D D D D F D F	B B B B B	B B F B F F	B B B	B B B A B B F	A A A A A	A F F F A		A A F A F F	F F F F F F F	F F F F F F F
Potassium hypochloride KClO	hy hy	all all	20 bp		C C	C C	C C	F F	F F		A B	F F	F F		A A		F F
Potassium iodide KJ	hy hy		20 bp	A A	C F	C C	C C	A A	B B	B B	A A	F F	A A		A A	A A	F F
Potassium nitrate KNO_3	hy hy	all all	20 bp		A A	A A	A A	A	B	B	B B	B			A A		A B
Potassium nitrite KNO_2		all	bp	B	A	A	A	B	A	A	A	A	B	B			
Potassium permanganate $KMnO_4$	hy hy	10 all	20 bp	A F	A B	A B	A B	 A	 B	 B	A B	B B	A A		A A	A A	A A
Potassium persulphate $K_2S_2O_8$	hy	10	50	F	F	A	A		A		A	F		F	A		F
Potassium silicate K_2SiO_3			20	B	A	A	A	A	A	A	A	A	A	A	A		F
Potassium sulphate K_2SO_4	hy hy	10 all	25 bp	F A	A A	A A	A A	A A	A A	A A	A A	A A	A A	A A	A A	A A	A B
Protein solutions			20	B	A	A	A	A	A	A	A	A	A		A	A	A
Pyridine C_5H_5N	dr	all all	20 bp		A A	A A	A A		 A	 A	 A	 A			A A		A A
Pyrogallol $C_6H_3(OH)_3$		all all	20 bp	F F	A A	A A	A A				A B			A A	A A		A A
Quinine bisulphate	dr		20	F	F	F	A	A		A	A	B	A		A	A	
Quinine sulphate	dr		20	F	A	A	A	A		A	A	B	A	A	A	A	
Quinol $HO–C_6H_4–OH$				F		A	A	A	A	A		B					A
Salicylic acid HOC_6H_4COOH	dr mo hy	100 100 cs	20 20	B F F	A	A A A	A A A	A A	B B	A A	A B A	B A A	A A		A A A	A	A B
Salmiac *see ammonium chloride*																	

Medium: Designation / Chemical Formula		Concentration %	Temperature °C	Non/Low Alloy Steels	Stainless Steels: 409, 410L, 430	SS304, SS321	SS316, SS316L	Nickel Based Alloys: Incoloy 825 2.4858	Inconel 600 2.4816	Inconel 625 2.4856	Hastelloy-C 2.4610 C276 2.4819	Monel 2.4360	Copper Based Alloys: Alloy CuNi 70/30	Bronze	Pure Metals: Titanium	Tantalum	Aluminum
Salpetre *see potassium nitrate*																	
Seawater at flow velocity v (m/s) 0 < v ≤ 1.5 1.5 < v < 4.5		20 20	B B	C A	C A	C A	C C	C A	A A	A A	C A	B A					
Siliceous flux acid *see fluorsilicic acid*																	
Silver nitrate $AgNO_3$	hy hy hy hy me	10 10 20 40 100	20 bp 60 20 250	F F F F F	A A A A F	A A A A A	A A A A A	A	B	B	B B	F	F	F	A A A A	A	F
Soap	hy hy hy	1 1 10	20 75 20	A A A	A A A	A A A	A A A		A	A		A A	A A		A A		A A A
Sodium (O2 Ģ 0.005 %) Na	me		200 600	A F	A B	A A	A A								A A		B
Sodium acetate $CH_3–COONa$	hy hy	10 sa	25	A F	A A	A A	A A		A	A	A A	A			A A	A A	A
Sodium aluminate Na_3AlO_3	 hy	100 10	20 25	A A	A A	A A	A A				 B				A A		 F
Sodium arsenate Na_2HAsO_4	hy	cs		A	A	A	A								A		A
Sodium bicarbonate $NaHCO_3$	 hy hy hy	100 10 cs sa	20 20	 A	A A A A	A A A A	A A A A	 A A	 B B	 B A	 B A B	 B B	 A A	 B	A A A A	 A	A A B
Sodium bisulphate $NaHSO_4$	hy hy	all all	20 bp	F F	F F	F F	A B	A A	B B	B B	B B	B B	F F	B B	A A	A A	A B
Sodium bisulphite $NaHSO_3$	hy hy hy	10 50 50	20 20 bp	F F F	F A F	A A F	A A A				B B	 A A		A A	A A A		A
Sodium borate $NaBo_3$ 4 H_2O	hy me	cs		 F	A F	A F	A F	A		A	A F	B	A		A	A	B
Sodium bromide NaBr	hy hy	all all	20 bp	F F	F F	F F	C C				B B				A A		F F
Sodium carbonate Na_2CO_3	hy hy hy me	B all	20 bp 400 900	F F F	A A F F	A A F F	A A F F	A A	B A	A A	A A	A A	A		A A	A A	E F
Sodium chloride NaCl	hy hy hy hy	0.5 2 cs sa	20 20	 F F	C C C F	C C C F	C C C C	A A A A	B B B B	A A A A	A A A B	A A A A	A A A A		A A A A	A A A A	 E F
Sodium chlorite NaClO2	dr hy hy hy	100 5 5 10	20 20 bp 80	F F	C	C F F F	A C F C		A A		 B B				A A A A		
Sodium chromate Na_2CrO_4	hy	all	bp	A	A	A	A	A	A	A	A	A	A	A			A
Sodium cyanide NaCN	me hy	 cs	600	B B	 A	 A	 A					F F	F B	F F	 A		F F
Sodium fluoride NaF	hy hy hy	10 10 cs	20 bp	A A		A A D	A A D							F			A A
Sodium hydrogensulphate see sodium bisulphate																	
Sodium hydrogensulphite see sodium bisulphite																	

Medium				Materials													
Designation Chemical Formula		Concentration	Temperature	Non/Low Alloy Steels	Stainless Steels			Nickel Based Alloys					Copper Based Alloys		Pure Metals		
		%	ºC		409, 410L, 430	SS304, SS321	SS316, SS316L	Incoloy 825 2.4858	Inconel 600 2.4816	Inconel 625 2.4856	Hastelloy-C 2.4610 C276 2.4819	Monel 2.4360	Alloy CuNi 70/30	Bronze	Titanium	Tantalum	Aluminum
Sodium hydroxide	solid	100	all	A	A	A	A		A	A	A	A					
$NaOH$	hy	<10	<60	A	A	A	A		A	A	A						
	hy	<10	<bp	F	F	A	A		A	A	A						
	hy	<20	<60	A	A	A	A		A	A	A						
	hy	<20	<bp	F	F	A	A		A	A	A						
	hy	<40	<60	A	A	A	A		A	A	A						
	hy	<40	<100	F	F	A	A		A	A	A						
	hy	<40	<100	F	F	F	F		A	A	A						
	hy	<50	<<60	A	A	A	A		A	A	A						
	hy	<50	<100	F	F	A	A		A	A	A						
	hy	<50	<100	F	F	F	F		A	A	A						
	hy	<60	<90	F	F	A	A		A	A	A						
	hy	<60	<140	F	F	F	F		A	A	A						
	hy	<60	<140	F	F	F	F		F	A	F						
	hy	<60	<140	F	F	F	F		F	A	F						
Sodium hypochlorite	hy	5	20	F	F	F	C	A	F		A	F	F		A		F
$NaOCl$	hy	10	50	F		C	C		A		B				A		F
Sodium hyposulphite		all	20		F	A	A	A	B	B	B	B	F			A	
$Na_2S_2O_4$		all	bp		F	A	A	A	B	B	B	B	F			A	
Sodium iodide					C	C	C	A	A	A	A						B
NaJ																	
Sodium nitrate	hy	5	20	F	A	A	A	A	A	A	A	B	A		A	A	A
$NaNO_3$	hy	10	20	B	A	A	A	A	A	A	B	B	A	B	A	A	A
	hy	<10	bp	F	A	A	A				A				A	A	F
	hy	30	20	B	A	A	A	A	A	B	B	B	A		A	A	A
	hy	30	bp	B	A	A	A	A	A		F	B			A	A	A
	me		320	F	A	A	A				A				A	A	A
Sodium nitrite	hy		20		A	A	B	A	A	A	A	A			A	A	B
$NaNO_2$																	
Sodium perborate	hy	10	20	F	A	A	A				B				B		
$NaBO_2$	hy	10	bp	F	A	A	A				B				B		
Sodium perchlorate	hy	10	20	F	F	A	A	B			B				A		
$NaClO_4$	hy	10	bp	F		A	A	B			B				A		
Sodium peroxide	hy	10	20	F	B	A	A	B	B	B	B	A	F		F	F	F
Na_2O_2	hy	10	bp	F	F	A	A	B	B	B	B	A	F		F	F	F
	me		460					F	B		F	F					
Sodium phosphate	hy	10	20		A	A	A	A	A	A	A	A	A	B	A	A	A
Na_2HPO_4	hy	10	bp		A	A	A	A	A	A	A	A			A	A	B
	hy	cs			A	A	A	A	A	A	A	A			A	A	A
Sodium salicylate	hy	all	20		A	A	A	A			A				A		A
$C_6H_4(OH)COONa$																	
Sodium silicofluoride	hy	cs		F	F	F	F	A	A	B	B	A					B
$Na_2(SiF_6)$																	
Sodium sulphate	hy	10	20	F	A	A	A	A	A	A	A	A	A	A	A	A	A
Na_2SO_4	hy	cs	20	F	B	A	A	A	B	A	A	B	A		A	A	A
	hy	sa		F	F	A	A	A	A	A	A	A			A	A	B
Sodium sulphide	hy	1	20	F	A	A	A	A	A			B			A		
Na_2S	hy	cs		F	F	F	A	A	B	A	A		F		A	A	B
	hy	sa		F	F	F	B								A		F
Sodium sulphite	hy	10	20	F	B	A	A					A	B	B	A		A
Na_2SO_3	hy	30	bp	F	F	A	A								A		F
Sodium superoxide																	
see sodium peroxide																	
Sodium tetraborate																	
see borax																	
Sodium thiosulphate	hy	1	20	B	A	A	A					A			A		A
$Na_2S_2O_3$	hy	10	20	F	A	A	A								A		A
	hy	25	bp	F	C	C	C								A		B
		cs		F	F	A	A		B			B	F		A	A	A
Spirit of terpentine		100	20	F	A	A	A						A	A	A		A
		100	bp	F	A	A	A						A	A	A		A
Spirits			20	B	A	A	A	A	A	A	A	A					
			bp	F	A	A	A	A	A	A	A	A					
Steam																	
02 < 1 ppm; Cl < 10 ppm			<560	B	B	B	A				A				A		
02 > 1 ppm; Cl < 10 ppm			<315	D	D	D	D				A				A		
02 > 15 ppm; Cl < 3 ppm			>450	D	D	D	D				A				A		

Medium				Materials													
Designation Chemical Formula		Concentration	Temperature	Non/Low Alloy Steels	Stainless Steels			Nickel Based Alloys					Copper Based Alloys		Pure Metals		
		%	ºC		409, 410L, 430	SS304, SS321	SS316, SS316L	Incoloy 825 2.4858	Inconel 600 2.4816	Inconel 625 2.4856	Hastelloy-C 2.4610 C276 2.4819	Monel 2.4360	Alloy CuNi 70/30	Bronze	Titanium	Tantalum	Aluminum
Stearic acid		100	20	B	A	A	A		A	A	A	A	B	B	A		A
$CH_3(CH_2)_{16}COOH$		100	95	F	A	A	A	A	B		A	B	B		A	A	F
		100	180								B				A		F
Succinic acid			bp	B	A	A	A	A	A	A	A	A	A	A			
$HOOC–CH_2–CH_2–COOH$																	
Sulphur	dr	100	60	A	A	A	A				A						
S	me		130	B	A	A	A		A		A	F	F	F	A		
	me		240	F	A	A	A				A				A		
	me		20	F	E	B	A				A	F	F	F	A		
Sulphur dioxide	dr	100	20	A	A	A	A	A	A	A	A	B	A	A	A	A	A
SO_2	dr	100	60	F	F	B	B				A				A		A
	dr	100	400	F	F	F	A				B				A		A
	dr	100	800	F	F	F	F				F				A		A
	mo	100	20	F	F	F	A	A	A	A	A	A	F	B	A	A	F
	mo	100	60	F	F	F	A				A				A		F
	mo	100	70	F	F	F	F				A				A		F
Sulphuric acid		0.05	20	F	B	A	A								A	A	B
H_2SO_4		0.05	bp	F	B	B	A								B	A	F
		0.1	20	F	F	A	A								A	A	B
		0.2	bp	F	F	F	A								B	A	F
		0.8	bp	F	F	F	F								B	A	F
		1	20	F	F	B	A		B	A	A	B	F		A	A	B
		3	bp	F	F	F	F				B		F		B	A	F
		5	bp	F	F	F	F	B	F		F	B	F		F	A	F
		7.5	20	F	F	B	A								B	A	B
		10	bp	F	F	F	F	B	F		F	F	F		F	A	F
		25	20	F	F	F	F				A		F		F	A	B
		25	bp	F	F	F	F				F		F		F	A	F
		40	20	F	F	F	F				A	B	F	F	B	A	B
		40	bp	F	F	F	F				F		F		F	A	F
		50	20	F	F	F	F	B	F		A	F	F		F	A	F
		50	bp	F	F	F	F	F	F		F	F	F		F		F
		60	20	F	F	F	F				A	B		F	F	A	F
		80	20	F	F	B	B				A	B	F	B	F	A	F
		90	20	F	F	B	A				A				F	A	F
		96	20	B	B	B	A				A	F	F		F	A	F
Sulphurous acid	hy	1	20	F	F	A	A		B		A	F				A	B
H_2SO_3	hy	cs		F	F	A	A				A	F			B	A	F
	hy	sa		F	F	B	A				B					A	F
Sulphur trioxide	hy	100	20														F
SO_3	dr	100	20	A				E	F		A	F	E	A		F	A
Tannic acid	hy	5	20	F	A	A	A		A			A	A	A	A		A
$C_{76}H_{52}O_{46}$	hy	25	100	F	F	A	A								A		
	hy	50	bp	F	F	A	A						A		A		
Tar			20	A	A	A	A						A	A	A		B
Tartaric acid	hy	10	20	B	A	A	A	A	B	A	A	B	A	A	A	A	F
	hy	10	bp	F	B	A	A	A	F		B	F	A		B	A	F
	hy	25	20	F	B	A	A		A		A	A	A		A	A	F
	hy	25	bp	F	F	B	A		A		B	B	A		B	A	F
	hy	50	20	F	F	A	A				A		A		A	A	F
	hy	50	bp	F	F	F	F				B		A		F	A	F
Tetrachloroethane																	
see acetylen tetrachloride																	
Tetrachloroethylene	pure	100	20	A	A	A	A				A		A	A	A		A
	pure	100	bp			A	A				A		A	A	A		A
	mo		20	F	F	C	C				A		B	B	A		F
	mo		bp	F	F	C	C				A		B	B	A		F
Tin chloride		5	20	F	F	F	F	F	F		A	B	F		A	A	F
$SnCl_2$; $SnCl_4$		sa		F	F	F	F										
Toluene		100	20	A	A	A	A					A	A	A	A		A
C_6H_5-CH_3		100	bp	A	A	A	A					A	A	A	A		A
Town gas				A	A	A	A	A	A	A	A	B	B	A			
Trichloroacetaldehyde																	
see chloral																	
Trichloroethylene	pure	100	20	A	A	A	A				A		A	A	A		A
$CHCl=CCl_2$	pure	100	bp			A	A				A		A	A	A		A
	mo		20	F	F	C	C				A		B	B	A		F
	mo		bp	F	F	C	C				A		B	B	A		F

Corrosion Resistance Tables

Medium			Materials													
Designation Chemical Formula	Concentration	Temperature		Stainless Steels			Nickel Based Alloys					Copper Based Alloys		Pure Metals		
	%	°C	Non/Low Alloy Steels	409, 410L, 430	SS304, SS321	SS316, SS316L	Incoloy 825 2.4858	Inconel 600 2.4816	Inconel 625 2.4856	Hastelloy-C 2.4610 C276 2.4819	Monel 2.4360	Alloy CuNi 70/30	Bronze	Titanium	Tantalum	Aluminum
Trichloromethane *see chloroform*																
Tricresylphosphate			A	A	A	A	A	A	A	A						
Trinitrophenol *see picric acid*																
Trichloroacetic acid *see chloroacetic acid*																
Urea $CO(NH_2)_2$	100 100	20 150	A F	A	A B	A A		F		A B	A B			A A	A A	A F
Uric acid hy $C_5H_4O_4N_3$ hy		20 100	F F	A A	A A	A A	A A	B B	A A	A A	A A	A A		A A		F F
Vinyl chloride dr CH_2=CHCl		20 <400	A A	A A	A A	A A				A A			A	 A		A
Water vapour *see steam*																
Wine		20 bp	F F	A A	A A	A A		A A					F F		A A	F F
Yeast		20	B	A	A	A	A	A	A	A	A	A	A	A	A	A
Yellow potassium prussiate see potassium ferricyanide																
Zinc chloride hy $ZnCl_2$ hy hy hy hy	5 5 10 20 75	20 bp 20 20 20	F F F F F	C F C C F	C F C C C	C F C C C	A A	B F	A	A B	B F F	F F F	 F	A A A A A	A A A A A	F F A
Zinc sulphate hy $ZnSO_4$ hy hy hy hy	2 20 30 cs sa	20 bp bp	F F F F F	A A F A F	A A A A A	A A A A A	 A	 B	 A	A B B B B	 B	A A		A A A A A	A A A A A	A F F B F

Material Selection At A Glance

Bronze®
Alloy consisting of primarily copper (Cu) and around 12% tin (Sn) alloy

Monel® 400. UNS N04400 / EN 2.4360
A high nickel-copper alloy which offers superior strength and corrosion resistance with a wide range of media including seawater and chlorine.

Inconel® 625. UNS N06625 / EN 2.4856
A nickel-chromium-molybdenum super alloy with an addition of niobium that acts with the molybdenum to stiffen the alloy matrix and provides ultra-high strength without the need for heat treatment. This material provides superior resistance to pitting and crevice corrosion. Thorburn's Inconel 625 UNS NO6625 / EN 2.4856 is compliant with NACE MR0175-2009/ISO 15156-2009

Hastelloy® C-276. UNS N10276 / EN 2.4819
A nickel-chromium-molybdenum super alloy with addition of tungsten designed to have excellent corrosion resistance for severe environments Especially resistant to pitting and crevice corrosion. Resistant to the formation of grain boundary precipitants in the heat affected zone making it suitable for most chemical process applications in an as-welded condition.

T-300 Series Stainless Steel (Austenitic)
Thorburn's metal hose is typically made from austenitic stainless steel, such as, 304, 304L, 316, 316L & 321

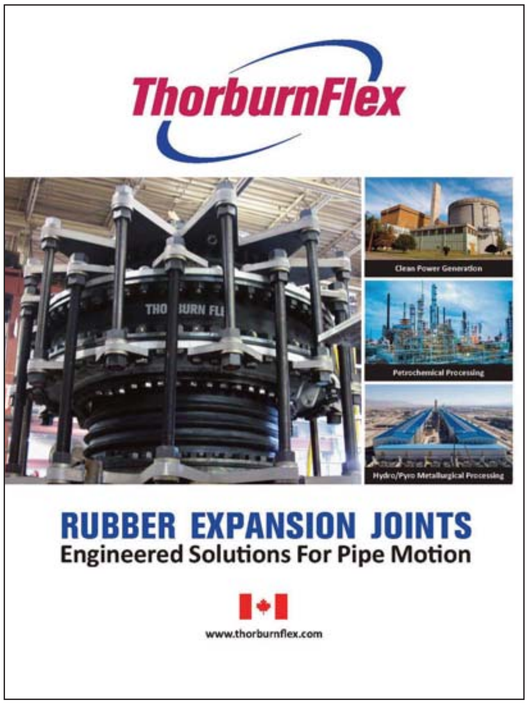
T-304 Stainless Steel UNS S30400 / EN 1.4301
T-304 is the most commonly used stainless in the world and is referred to as 18/8. It is weldable, machinable with the right techniques, and has good corrosion resistance.

T-304L Stainless Steel UNS S30403 / EN 1.4307
T-304L has reduced or low carbon to eliminate carbide precipitation due to welding so the alloy can be used in the "as welded" condition even in severe corrosive conditions.

T-316 Stainless Steel UNS S31600 / EN 1.4401
T316 stainless steel is 18/8 with the inclusion of molybdenum (Mo) in the alloy. To give better overall corrosion resistant properties than Grade 304, particularly higher resistance to pitting and crevice corrosion in chloride environments.

T-316L Stainless Steel UNS S31603 / EN 1.4404
T-316L has reduced or low carbon to eliminates carbide precipitation and offers higher creep, stress to rupture and tensile strength at elevated temperatures.

T-321 Stainless Steel UNS S32100 / EN 1.4541
Type 321 is an austenitic chrome nickel steel stabilized with titanium. This material has similar properties to alloy 304, but its titanium content limits carbide precipitation, making it somewhat easier to machine. This grade is recommended for parts fabricated by welding which cannot be subsequently annealed.



Rubber Expansion Joints Catalog

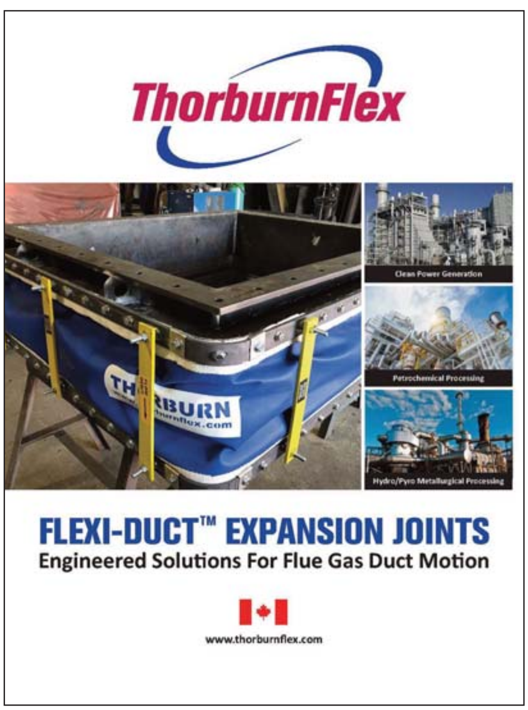
Thorburn Flex is an innovative manufacturer of specialized engineered flexible piping systems (i.e. custom hose assemblies and expansion joints). Since 1954, Thorburn's corporate mission evolution and business philosophy have been customer driven and targeted to select niche applications where Thorburn can achieve clear positions of sustainable technological and market share leadership. Thorburn Flex is committed to a policy of continuous development and research to provide engineered solutions for pipe moon that set the industry standards for quality, safety, environmental protection, durability and value. This catalog provides the reader with engineered solutions for pipe motion.

Applications

Clean Power Generation

Petro-Chemical Processing

Hydro/Pyro Metallurgical Processing



Flexi Duct™ Expansion Joints Catalog

Thorburn's Flexi Duct™ are engineered, custom built expansion joints using the most advanced composite material technology combined with proven expansion joint design. Thorburn's innovative Flexi Duct™ expansion joints places Thorburn in the best position to address thermal, chemical and multi-plane movement requirements in the most challenging flue duct applications. This catalog provides the reader with engineered solutions for flue gas duct motion.

Applications

Clean Power Generation

Petro-Chemical Processing

Hydro/Pyro Metallurgical Processing

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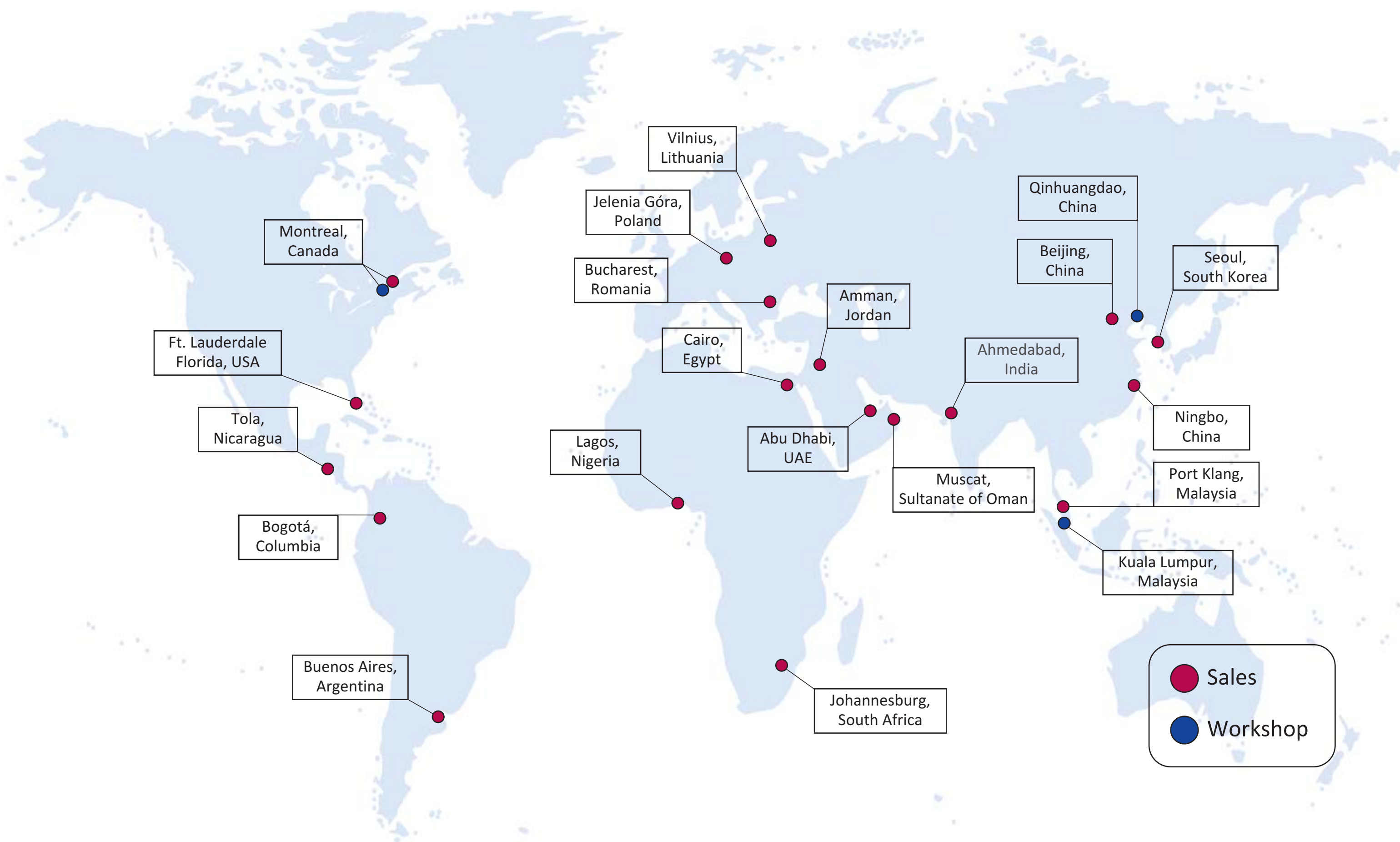
European Conformity | ISO 9001 | B31.1, B31.3 | ASME "NPT" Sec. III Class 1 | ASME "U" Sec. VIII Div. 1 | N285.0, B51 CGA CR96-001 | 97/23/EC Module H | UL 536

ISCIR Romania | CNCAN Romania | EN 13480-2002 | HAF 604 China | TSG China
(CRN for all Canadian Provinces)

Thorburn's Global Presence



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