

Expansion Joints

Installation and Maintenance Manual



Garlock
SEALING TECHNOLOGIES®

an EnPro Industries company

Garlock Sealing Technologies

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Elastomeric Expansion Joints

Definition and Function

1. **Flexible Connector** - An elastomeric expansion joint is a specially designed section of pipe inserted within a rigid piping system to provide flexibility.
2. **Stress Relief** - Pipe stress caused by thermal expansion/contraction or foundation settlement can be handled by expansion joints.
3. **Minor Misalignment** - Standard expansion joints can withstand a minimal amount of existing lateral, torsional, angular or concurrent misalignment. Contact the manufacturer for specifics.
4. **Isolate/Reduce Vibration** - Oscillating movement around the axis of the expansion joint can be effectively dampened, eliminating the transmission of this vibration - preventing equipment damage/failure.
5. **Dampen Sound Transmission** - Using rubber flanges, expansion joints can lower the transmission of undesirable noises.
6. **Multiple Arch Type** - Expansion joints with up to four arches may be manufactured to handle greater movements than a single arch. The movement capability of a multiple arch expansion joint is typically that of a single arch type multiplied by the number of arches. (See Figures 1, 2 & Table I)
7. **Natural/Synthetic Elastomer** - A wide variety of elastomers are available to meet specific demands of industrial applications.
8. **Fabric/Metal Reinforced** - The strength in an elastomeric expansion joint is derived from design features, combined with rubber impregnated layers of fabric and internal metal reinforcement. (See Figures 1 & 2)
9. **Fabric Reinforcement** - In these styles, wide flowing arch (Figure 3) and U-type (Figure 4), fabric is used to effectively handle design parameters outlined.
10. **Resistance To Corrosive Media** - Special elastomeric liners and covers may be utilized to prolong life of the expansion joint when corrosives are present.
11. **Resistance To Abrasive Media** - Abrasive media may be handled more effectively if a special tube/liner is used; ie: gum rubber, increasing thickness of layers (rubber), steel flow liner, etc.
12. **Temperature Capability** - Depending on the elastomer selected, elastomeric expansion joints can handle a range of -40°F (-40°C) to 400°F (205°C).

Construction Details

Elastomeric expansion joints are constructed of three basic elements: the tube, the body or carcass, and the cover. The construction details are shown in Figures 1-4 and each element is defined as follows:

1. **Tube** - Consists of a protective, leakproof lining which may be made of synthetic or natural rubber, depending on operating conditions. The tube is seamless and it extends through the bore of the joint to the outside edges of the flanges. Its purpose is to eliminate the possibility of the materials being handled from penetrating the carcass and weakening the fabric. Tubes can be designed to handle a wide range of service conditions for chemical, petroleum, sewage, gaseous, and abrasive materials. When evaluating a specific application, the media will dictate the type of elastomer needed; ie: fluoroelastomer (VITOn[®]), FEP fluorocarbon, nitrile, EPDM, HyPALOn[®], chlorobutyl, gum rubber, or neoprene elastomers are frequently specified. FDA- approved materials such as white neoprene or white EPDM elastomers are also available.
2. **Body or Carcass** - Consists of fabric/metal reinforcement. Expansion joints with a combination of fabric and metal reinforcement are shown in Figures 1 & 2. The expansion joints in Figures 3 & 4 have fabric reinforcement only.
 - a. **Fabric Reinforcement** - The flexible and supporting member between the tube and cover. Standard constructions normally utilize high qual-

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Construction Details (cont'd)

ity synthetic fabric such as polyester, nylon tire cord or fiberglass/KEVLAR®. natural fabrics are also used depending on temperature and pressure requirements. All fabric plies are impregnated with a compatible elastomer in order to maintain a superior bond as well as flexibility.

- b. **Metal Reinforcement** - Consists of solid steel rings imbedded in the carcass of the expansion joint. The steel rings reinforce the expansion joint and provide the dimensional stability needed for pressure or vacuum service. They are formed from AISI 1018 or other high strength materials and are either round or rectangular (see Figures 1 & 2).
3. **Cover** - A homogeneous layer of rubber compound bonded to the exterior of the expansion joint. The prime function of the cover is to protect the carcass from outside damage. Special elastomers can be supplied to resist chemicals oils, sunlight, acid, fumes, and ozone. Environmental conditions will dictate the exterior of the expansion joint for additional protection.

Design Types

The design types of elastomeric expansion joints are shown in Figures 1 thru 4. The benefits of each type are described:

Open Arch Expansion Joint

Figure 1 shows a standard spool type expansion joint. The joint has one open abrupt arch, which is utilized to absorb movements in piping systems. The flanges of the expansion joint are integral with the body and are drilled to conform to the bolting pattern of the metal flanges of the pipe line. This type of rubber faced flange is of sufficient thickness to form a leakproof seal against the metal flanges without the use of gaskets.

Expansion joints with two or more arches may be manufactured to accommodate greater movement. Multiple arch expansion joints are capable of handling the movements of a single arch expansion joint multiplied by the number of arches.

Therefore, movement dictates the number of arches required, subsequently the number of arches dictates face-to-face allowance. See Appendix, Table I for added information on face-to-face dimensions and typical movement capabilities of open arch expansion joints.

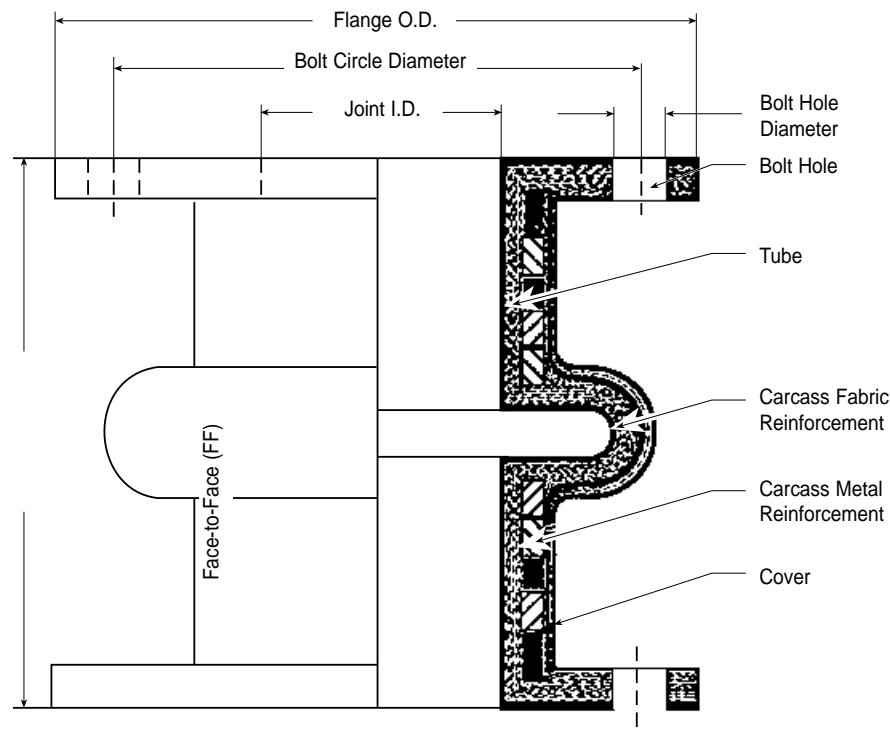


Figure 1
Cross sectional view of single open arch expansion joint.

Design Types (cont'd)

The expansion joint is reinforced with fabric plies and round or rectangular body rings. The number of fabric plies and metal rings is directly proportional to the pressure rating of the expansion joint. Utilization of metal body rings provides the dimensional stability needed for vacuum and pressure service. Typical pressure and vacuum ratings of expansion joints in Figure 1 are listed in Appendix, Table V. Service temperature of the expansion joint depends on the materials of construction.

Expansion joints constructed of polyester fabric and chlorobutyl are rated for temperatures up to 250°F (121°C). EPDM and fiberglass/KEVLAR® fabric allows for up to 300°F (149°C) service. When constructed of fiberglass/KEVLAR® fabric and fluoroelastomer they can withstand temperatures up to 400°F (204°C).

Always contact the manufacturer before specifying and purchasing expansion joints for your specific application.

Filled Arch Expansion Joint

The open arch design of Figure 1 may be modified to reduce turbulence and to prevent the entrapment of solids. Shown in Figure 2 is a standard arch type elastomeric expansion joint manufactured with a bonded, lower durometer rubber arch filler to provide a smooth interior bore. Filled arches built as an integral part of the carcass decrease the flexibility of the joint and should be used only when necessary. Using a filled arch expansion joint reduces movement capabilities by 50%.

Filled arch expansion joints can be constructed to handle the same temperature, pressure and vacuum requirements as open arch expansion joints. For typical pressure and vacuum capabilities, refer to Appendix, Table V.

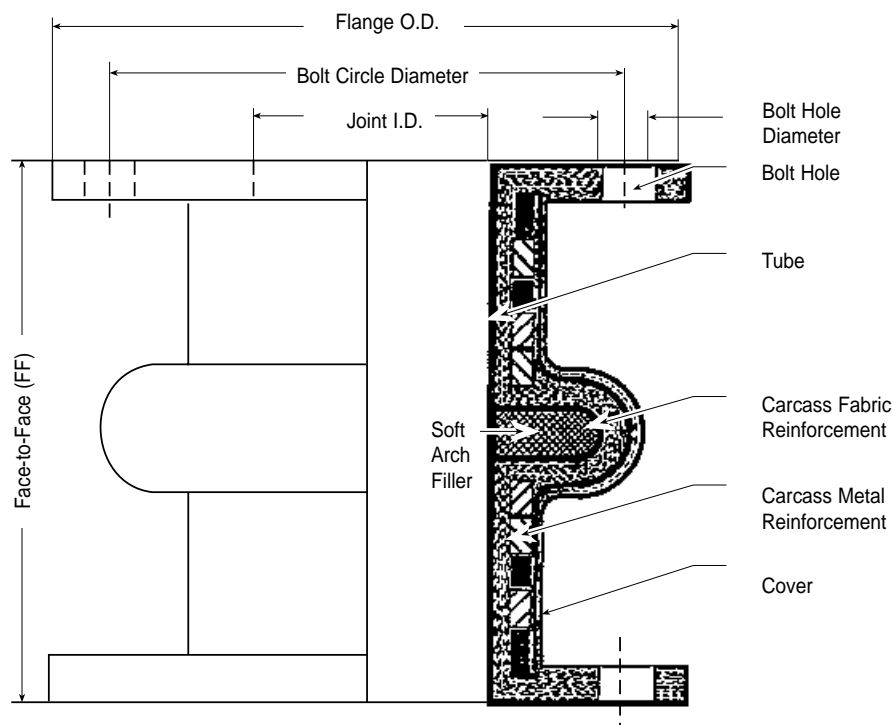


Figure 2
Cross sectional view of filled arch expansion joint.

Design Types (cont'd)

Flowing Arch Expansion Joint

Figure 3 shows a self-flushing or flowing arch expansion joint. The streamlined flowing arch reduces turbulence and allows smooth, quiet flow. There is no possibility of sediment build-up and no need to fill the arch, so movement is not restricted.

The expansion joint is constructed of high strength nylon tire cord without any metal reinforcement. As a result, the expansion joint is very flexible, with up to 30% greater ability to absorb compression movement over the open arch expansion joint. For added information on movement capabilities of the flowing arch expansion joints, refer to Appendix, Table I.

The nylon tire cord fabric provides an exceptionally high temperature range of -40°F (-40°C) to 250°F (121°C). The high-strength fabric also produces an expansion joint with an exceptional burst pressure rating; however, without metal reinforcement, its vacuum rating is reduced. See Appendix, Table V for typical pressure and vacuum ratings of flowing arch expansion joints.

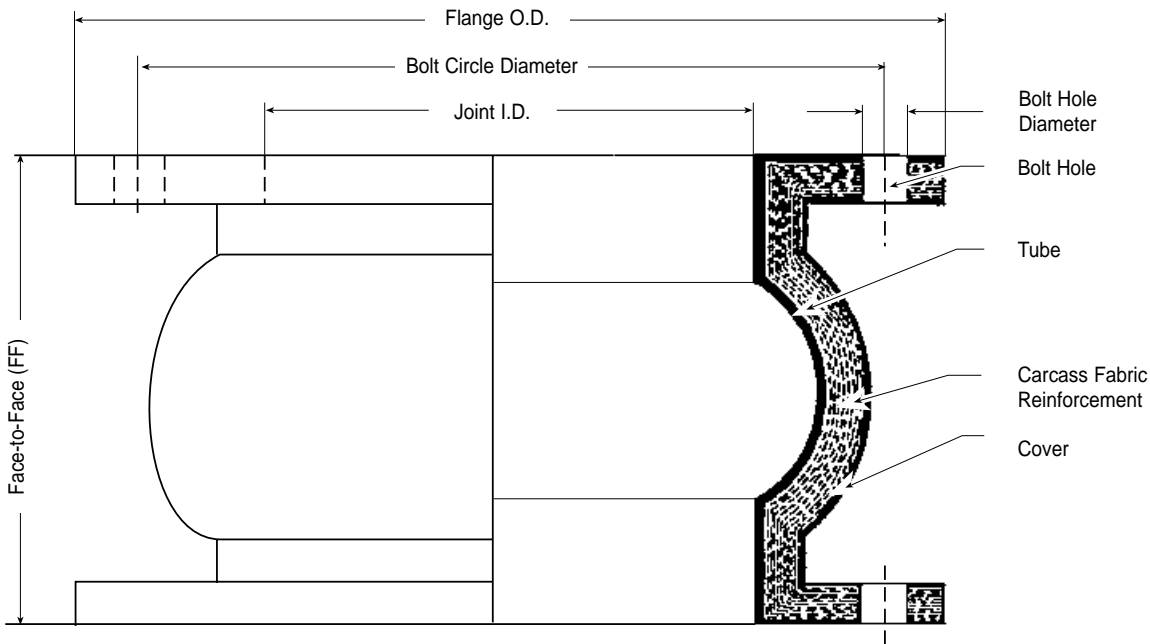


Figure 3
Cross sectional view of flowing arch expansion joint.

Design Types (cont'd)

U-Type Expansion Joint

The U-type expansion joints, as shown in Figure 4, are primarily designed for full vacuum service with a maximum pressure rating of 25 psig (1.7 bar) and temperature of 250°F (121°C). These joints are constructed of several plies of polyester fabric and rubber without metal reinforcement.

Without an arch, the expansion joints have limited movement capability and are primarily recommended for the reduction of vibration and noise. They can be furnished with narrow face-to-face dimensions and often require staggered bolt hole drilling. Typical movement capabilities of U-type expansion joints are listed in Appendix, Table II.

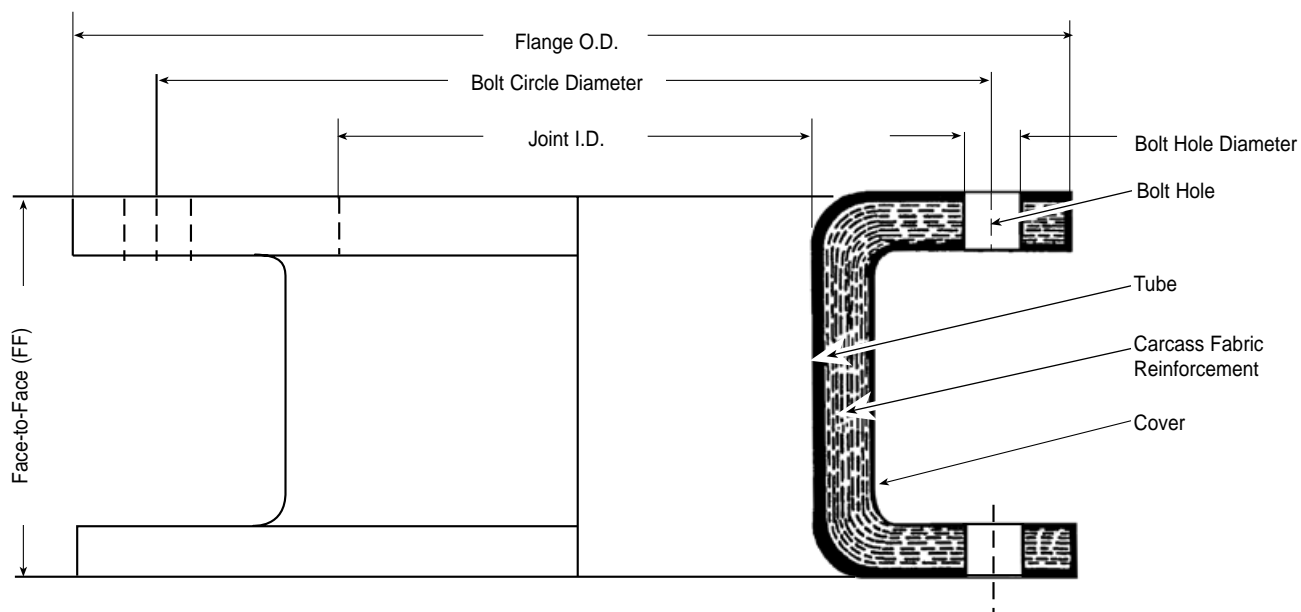


Figure 4
Cross sectional view of U-type expansion joint.

Control Units

Definition and Purpose

A control unit is a system of two or more control rod (tie rod) assemblies placed across an expansion joint from flange to flange to prevent possible damage to the expansion joint caused by excessive motion of the pipeline. Control units are always recommended since this excessive pipe motion could be caused by failure of an anchor or some other piece of equipment in the pipeline and would result in a catastrophic failure of the expansion joint if not used.

Control units are not designed to replace recommended anchoring of a pipeline, but they must be used when proper anchoring cannot be provided. By restraining the piping system, the control unit will adequately protect the expansion joint from excessive elongation and compression movements caused by static pressure thrust or any other load.

Rubber expansion joints are not designed to take end thrusts. In all cases where such are likely to occur, control units must be used to restrain the piping system. The control rod assemblies are set at the maximum allowable expansion and/or contraction of the expansion joint. When used in this manner, they are an additional safety factor, preventing catastrophic failure of the expansion joint and minimizing possible damage to the equipment.

Standard Design

Figure 5 shows the proper assembly of an expansion joint with standard design control units. The control unit system consists of a minimum of two tie rods with triangular plates and hex nuts with spherical washers. The exact number and diameter of the tie rods and the thickness of the triangular plates is selected on the basis of the actual design/test pressure and other load requirements the system may be subjected to. Always specify all load requirements when ordering control unit assemblies.

The tie rods are usually fabricated from high-strength ASTM A193-B7 alloy bolts. They are set for the maximum allowable elongation of an expansion joint and are designed to accept the static pressure thrust in addition to other external loads which would cause the joint to over-elongate.

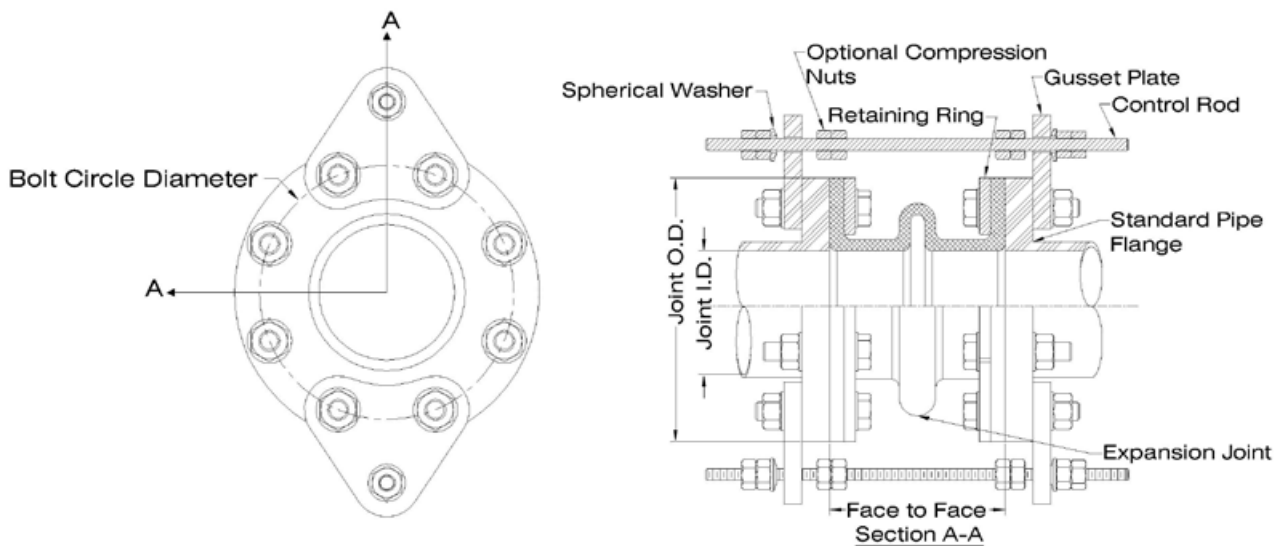


Figure 5
Expansion joint with assembly of standard control unit components.

Standard Design (cont'd)

The maximum elongation setting "E" shown in Figure 5 is based on each expansion joint's design and will vary for different manufacturers. Refer to Table I for typical elongation requirements for single or multiple arch expansion joints.

Overcompression of expansion joints is controlled by installing additional nuts over the tie rods. The compression nuts are the same as the external nuts. The placement of the compression nuts should be such that the expansion joint cannot be compressed beyond its maximum allowable capabilities. This allowable movement is the setting "C" of Figure 5 and is based on design requirements stated by the expansion joint manufacturer. Table I lists typical compression movements for single or multiple arch expansion joints.

note: The control unit settings E and C are based on the expansion joint installed at neutral manufactured length "FF" with pipe flange alignment of $\pm 1/8$ " (0.125mm) maximum.

The triangular plates for control units are usually fabricated from ASTM A-36 plates or other high-strength plate materials. The plates are drilled with three holes, two of which are used for bolting the plate to the pipe flange. The third hole is for the tie rod which connects the plate on each end of the expansion joint.

Once the control units are installed and set, it is critical that the setting is not altered during the service life of the joint. Vibration of the piping system can often loosen and gradually turn the hex nuts, changing the critical setting of the control units. To prevent the turning of the hex nuts, periodic inspections are recommended.

1. Control units do not protect the expansion joints against lateral offsets. Piping must be anchored and supported.
2. Do not use control units with non-metallic flanges which do not have sufficient strength.

Special Design

Figure 6 shows an expansion joint with an assembly of control unit components with spherical washers. This special design is suitable for applications where greater control of piping movements is required.

As shown in Figure 6, the movement of the pipe flanges is restricted to transverse deflection only. This is made possible by the spherical washers on both sides of the triangular plates. By tightening the spherical washers against the plate at both ends of the tie rods, compression and elongation of the expansion joint is eliminated. The elimination of axial movement may be required to control stress in the pipeline or equipment.

If, in another application, axial movement of the pipe flanges must be provided, then the hex nuts are adjusted to allow the expansion joint to compress and elongate as required. The inner hex nuts are set to control compression of the expansion joint. The outer hex nuts are set to control elongation of the expansion joint. Once the hex nuts are set, the nuts are locked together and then the control units function in the same manner as the control units of Figure 5.

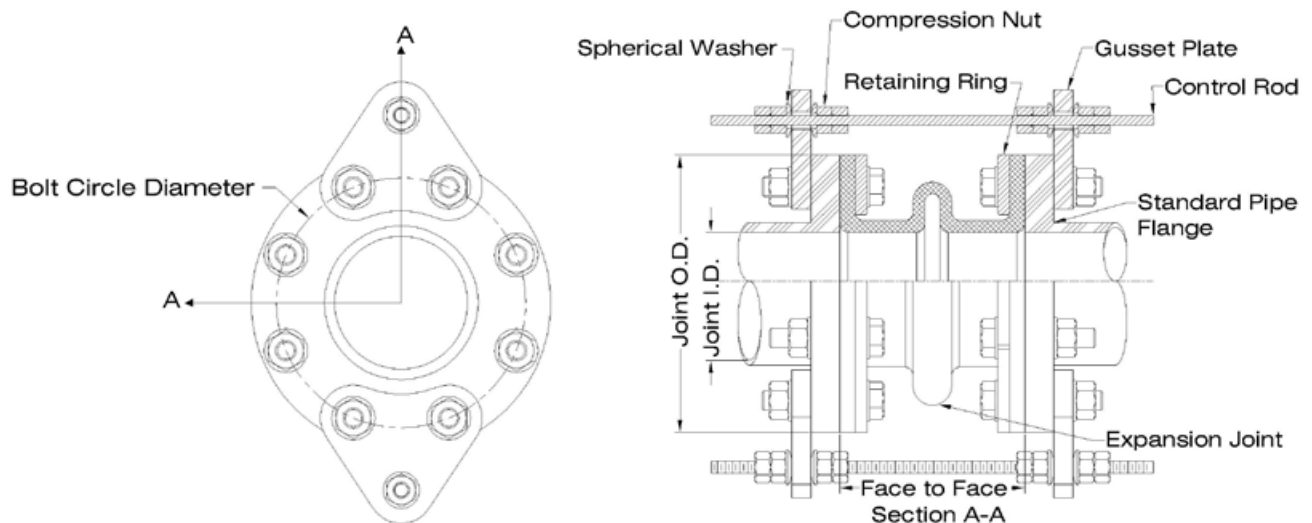


Figure 6
Expansion Joint with assembly/installation of control unit components with spherical washers.

Measuring and Evaluating Misalignment

Before any expansion joints are to be replaced, dimensions must be verified. As a result of settlement, misalignment or improper design, many elastomeric expansion joints are overstressed beyond their performance limitations. It is critical, therefore, that all measurements (flange-to-flange, lateral, torsional, and angular misalignment) be double-checked against original specifications/drawings.

Maximum allowable misalignment is listed in Appendix, Table IV; however, greater tolerances may be permitted. It is advisable to check with the manufacturer before exceeding this industry standard.

Flange-to-Flange Dimensions (also known as face-to-face or FF)

This measurement is taken from the inside of one mating metal flange to the inside of the other – the actual opening where the expansion joint is to be inserted. This is typically the dimension most likely to be variable. For example, if the original expansion joint measured 8" FF, but the current opening measures 9-1/2" FF, it is necessary to build the expansion joint at the new FF dimension. Most elastomeric expansion joints are rated for a minimal amount of elongation (1/4-1/2") and, therefore, the expansion joint would be overstressed if installed at 1-1/2" more than the manufactured dimension. This stress would begin internally as the vulcanized fabric plies began to tear apart. Evidence of such stress would be cracking/tearing at the base of the elastomeric flanges and delamination of fabric plies under pressure/vacuum. Subjecting an expansion joint to this type of condition will shorten its life expectancy and may cause premature failure.

Conversely, if an expansion joint is manufactured at 8" FF, and the actual opening between the mating metal-flanges is 7-1/4" FF, it is practically impossible to precompress the joint without incurring damage. Elastomeric expansion joints are designed to handle gradual axial movements as a result of thermal expansion and contraction. Forcing an expansion joint in place puts an unnatural stress on the elastomeric flanges causing internal damage, especially along the back of the flange area and the arch.

The flange-to-flange dimension becomes a critical factor when replacing an expansion joint, but also, when measured accurately, may enhance the life expectancy of the product. When measured incorrectly, it may greatly

reduce the performance of the expansion joint and may even contribute to a premature/catastrophic failure.

Angular Misalignment

When measuring the flange-to-flange dimension, it is necessary take a minimum of four dimensions; on larger I.D. expansion joints (over 24") six to eight measurements are recommended. If measuring in four areas, they should be spaced equally around the circumference of the expansion joint (in opposing quadrants). Any variation in the dimensions taken are indicative of angular misalignment – the non-parallelism of the mating metal flanges.

There are other important notations to make, if angular misalignment is present. Since one of the main difficulties in installing an expansion joint (especially on 24" I.D. and larger) is accessibility, it is valuable to indicate on the measurements taken where the access point would be. If the access point is dramatically smaller than the opposing side, the expansion joint face-to-face must be built to the access point measurement. However, the expansion joint must have the ability to extend beyond the longest face-to-face flange dimension without damage. There are other ways to handle this angular misalignment; i.e. using tapered metal spacers, and realigning the piping. Be sure to contact the manufacturer for their recommendations (see Figure 7 for illustration).

Angular Misalignment (cont'd)

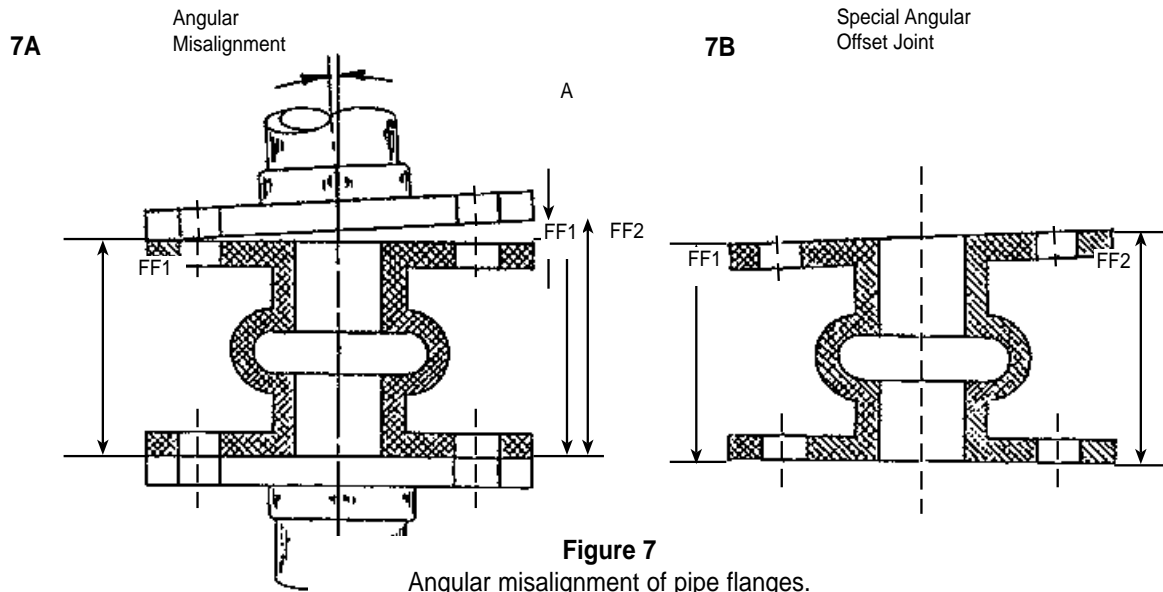


Figure 7
Angular misalignment of pipe flanges.

Lateral Misalignment

This condition is apparent when pipe center lines are not aligned. Inadequate pipe support or settling of equipment is typically the cause for this condition.

When measuring for lateral misalignment, a level and a rule are needed. Place the level on the outside of one of the metal flanges across to the other and measure the difference between them. As in the case of angular misalignment, a minimum of four measurements is recommended on smaller joints. Expansion joints with larger inside diameters (over 24") require six to eight measurements taken equally spaced around the outside circumference of the flange.

Minor amounts of lateral misalignment can be corrected with standard expansion joints (see Appendix, Table IV for limitations and Figure 7 for illustration). For lateral misalignment beyond recommended limitations, special expansion joints can be manufactured to facilitate installation. Another option for correcting lateral misalignment is to realign the pipe. Be sure to contact the manufacturer for their recommendations.

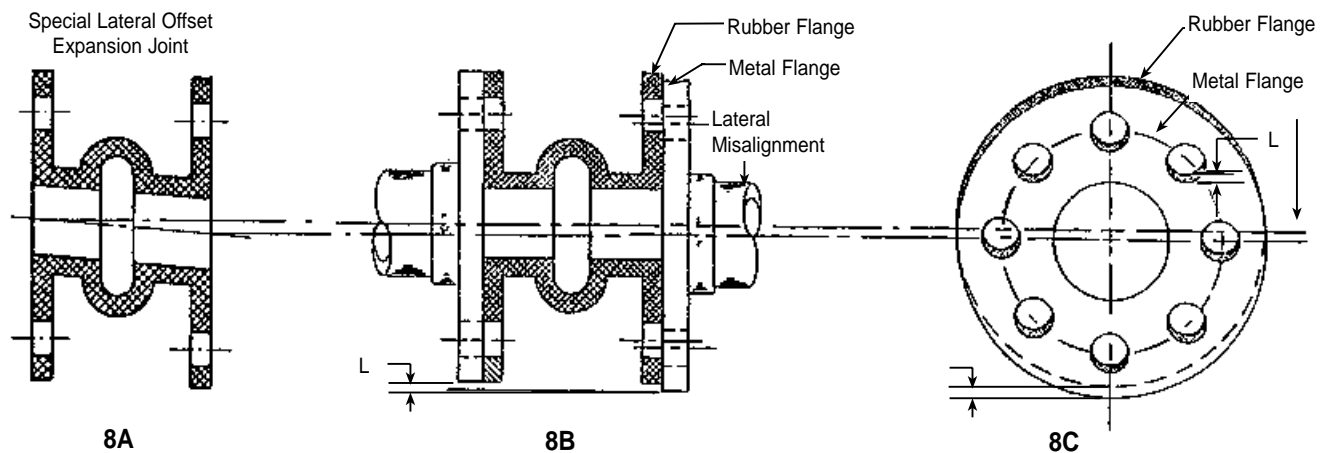


Figure 8
Lateral misalignment of pipe flanges.

Torsional Misalignment

This condition occurs when rotation of the pipe flange causes bolt holes to be out of line (see Figure 9 for illustration). Minor torsional misalignment can be handled using a standard expansion joint; however, severe torsional misalignment requires an expansion joint with the degree of torsional offset built-in (see Appendix Table IV for limitations and Figure 9 for illustration). As an alternative, realign the pipe flanges or drill the expansion joint on-site. Contact the manufacturer for tooling and instructions.

Concurrent Misalignment

Special expansion joints are required for combinations of severe lateral and angular misalignment. This condition requires exact measurements along with the location of the misalignment measured. To best accommodate this situation, drawings that detail these measurements should be provided with the order. If assistance is required, contact the manufacturer for a survey of the expansion joints.

When ordering offset expansion joints, they must be properly identified with a customer equipment number. The manufacturer must also mark the center line of the flange face as well as the back of the joint flange. This will ensure proper location and ease of installation.

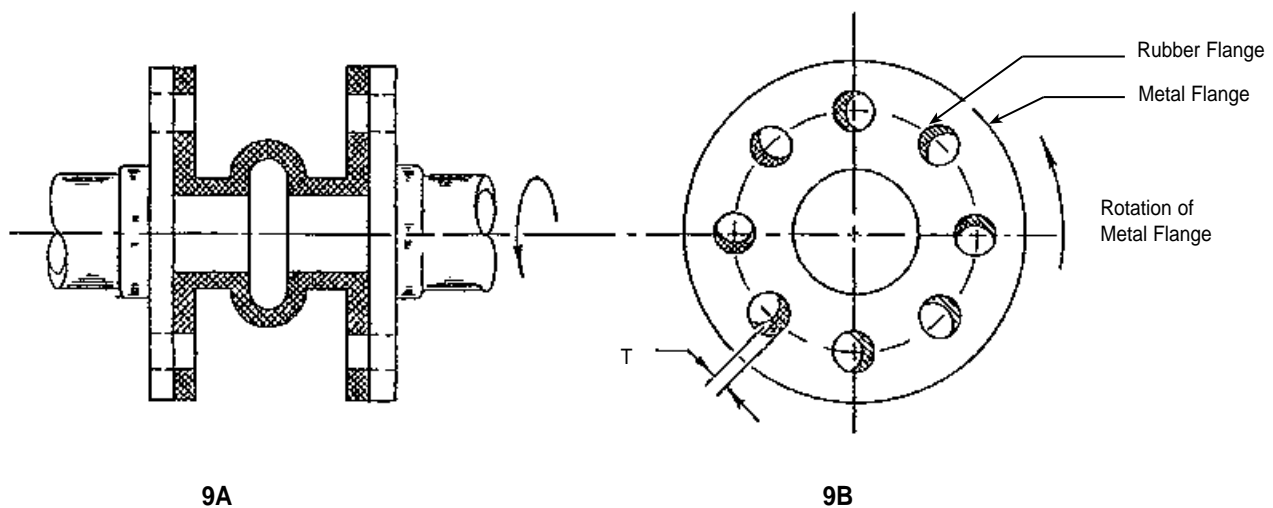


Figure 9
Torsional misalignment of metal flanges

Installation Procedures

Removal of Old Expansion Joints

1. **Measurements** - Prior to removing old expansion joints, accurate measurements of the system should be taken. Measure the face-to-face dimension of the expansion joint and check the flanges for any misalignment such as lateral, torsional and/or angular. Refer to pages 8 thru 10 for measuring and evaluating misalignment.
2. **Pipe Anchors/Supports** - Carefully inspect pipe anchors and flange supports before removing old expansion joints. Over the years pipe supports and anchors may become loose and the expansion joint may actually be supporting the pipe.
3. **Breaking Seal** - With elastomeric joints it is important to break the seal of both flanges before the joint is removed. Forced removal with an unbroken seal may result in damage to the metal flange. To break the seal, drive small wooden wedges between the rubber flange of the joint and mating metal flange.

Joint Handling and Transporting

1. **Expansion Joint Storage** - An elastomeric expansion joint should be stored in a cool, dry and dark place. Expansion joints can be stacked only when individually packaged in boxes or crates of sufficient strength. Expansion joints should always be positioned so that they are not resting or standing upright on their flange edges.
2. **Transportation of Large I.D. Joints** - Care must be taken when transporting large expansion joints from a storage area to the job site. Expansion joints should never be rolled on their flanges or pulled with a cloth sling looped through the I.D. Large expansion joints should always be transported crated or on a platform laying in a horizontal position to prevent any possible damage. Once at the job site, the joints should always be laid flat on the floor and protected against damage.

Preparation for Installation

1. **Area Accessibility** - Installation of large I.D. expansion joints requires a lot of manpower and an open, accessible area. Machinery or equipment which could complicate the installation must be removed. Sharp objects or rough surfaces which may damage the sealing surface of rubber flanges should be taped or removed ahead of time.
2. **Bolts/Fasteners** - Used bolts and fasteners should be sand-blasted and inspected for damage. Corroded or damaged bolts should be replaced. Garlock also recommends the use of flat steel washers where joining retaining ring segments.
3. **Retaining Rings** - Used split retaining rings must be checked for rust and warping. Rusted or corroded retaining rings should be corrected. Warped retaining rings should be replaced, since flatness of rings is critical for achieving and maintaining a seal.
4. **Mating Metal Flanges** - Elastomeric expansion joints must be mated against clean, smooth metal flanges. The mating metal flanges should be carefully examined for reasonable smoothness. Gouged or pitted flanges should be resurfaced or repaired. A suitable repair compound is Belzona "Super Metal" cement.
5. **Joint/Bolt Lubricants** - The recommended lubricant for use with Garlock expansion joints is a solution of graphite in water or glycerine. Another suitable expansion joint lubricant is Dow Corning DC-111, a silicone-based material. Any other joint lubricants must be approved by Garlock to insure chemical compatibility.

Joint Installation

1. **Horizontal/Vertical Installation** - Expansion joints installed where metal flanges are in a horizontal position are first brought to the level of the flanges, then slid into place. Flanges may be lubricated to aid in sliding the expansion joints into place.

Large expansion joints to be installed where metal flanges are in a vertical position will require hoisting into place. Hoisting of the joint can be accomplished with cloth slings. The joint must be looped on the outside with a separate loop formed on each side of the arch to prevent expansion joint damage.

Joint Installation (cont'd)

2. **Piping Misalignment** - Installation of expansion joints may sometimes be complicated due to misalignment of the piping system.

The allowable piping misalignments are shown in Appendix, Table IV. Figure 10 shows a method for installing standard expansion joints with minor lateral and torsional misalignment of the metal flanges.

The methods shown in Figures 9 thru 11 can be used for lateral and torsional misalignment of 1/4" for up to 46" I.D. joints and 1/4" - 3/8" for larger I.D. joints. Greater lateral and torsional misalignments will require special expansion joints. Expansion joints can be built with lateral offset of flanges and they can be either special drilled or supplied with one flange undrilled for torsional misalignment problems. Garlock can provide the tooling and drilling procedures needed to drill elastomeric expansion joints on-site.

Angular misalignment of metal flanges is shown in Table V. The angular misalignment is determined from the smallest and the largest flange opening dimension FF 1 & FF 2 (Figure 7). Standard expansion joints can be installed in flanges with minor misalignment; refer to Table IV. When ordering standard expansion joints, the face-to-face of the expansion joint must be specified such that the expansion joint will fit into the smaller dimension FF 1.

Substantial angular misalignment of the metal flanges will require a special expansion joint built as shown in Figure 7.

3. **Bolting Sequence** - Garlock expansion joints are supplied with segmented retaining rings. Bolting of the retaining rings and torquing of the bolts in each ring segment should be in the sequence illustrated in Figure 11. The objective is to bolt the entire retaining ring segment evenly and to compress the rubber flanges as uniformly as possible. The use of flat steel washers will help obtain an effective seal where the retaining rings are split.

All bolts should be "snug" tight before they are torqued. Torquing should then be accomplished in steps gradually and as evenly as possible.

The bolts are not considered torqued and "lock on" until the edges of the expansion joint bulge out or extrude slightly. In many cases, especially on the

larger sizes (I.D.'s), the flange portion may indent slightly.

4. **Maintaining Seal** - Check bolt tightness at least one week after going on-line and periodically thereafter. As any rubberlike material takes a "set" after a period of compression, the bolts may loosen and require retorquing. It is particularly important to check bolts during temperature cycles or during shut-down times.

Control Unit Installation

Control units should be evenly distributed around the bolt circle of the expansion joint. The triangular plate of the control unit is bolted to the outside of the steel pipe flange using bolts equal to 1/8" - 1/4" diameter smaller than the lower holes in the control unit plate.

Insert control rods with spherical washer and (2) hex nuts through the top hole of the first triangular plate. Place (4) internal compression nuts (if required) over control rod. Insert control rod through second triangular plate. See Figure 5. Place spherical washer and (2) hex nuts on end of control unit rod.

The control unit rod setting is equal to the combined dimensions of the expansion joint face-to-face, two pipe flange thicknesses, two thicknesses of control unit plates, two washer thicknesses, plus maximum elongation of the expansion joint. See Appendix, Table I.

After control units are fully assembled, lock the (2) nuts from each location to one another in order to prevent loosening or movement.

Installation Procedures

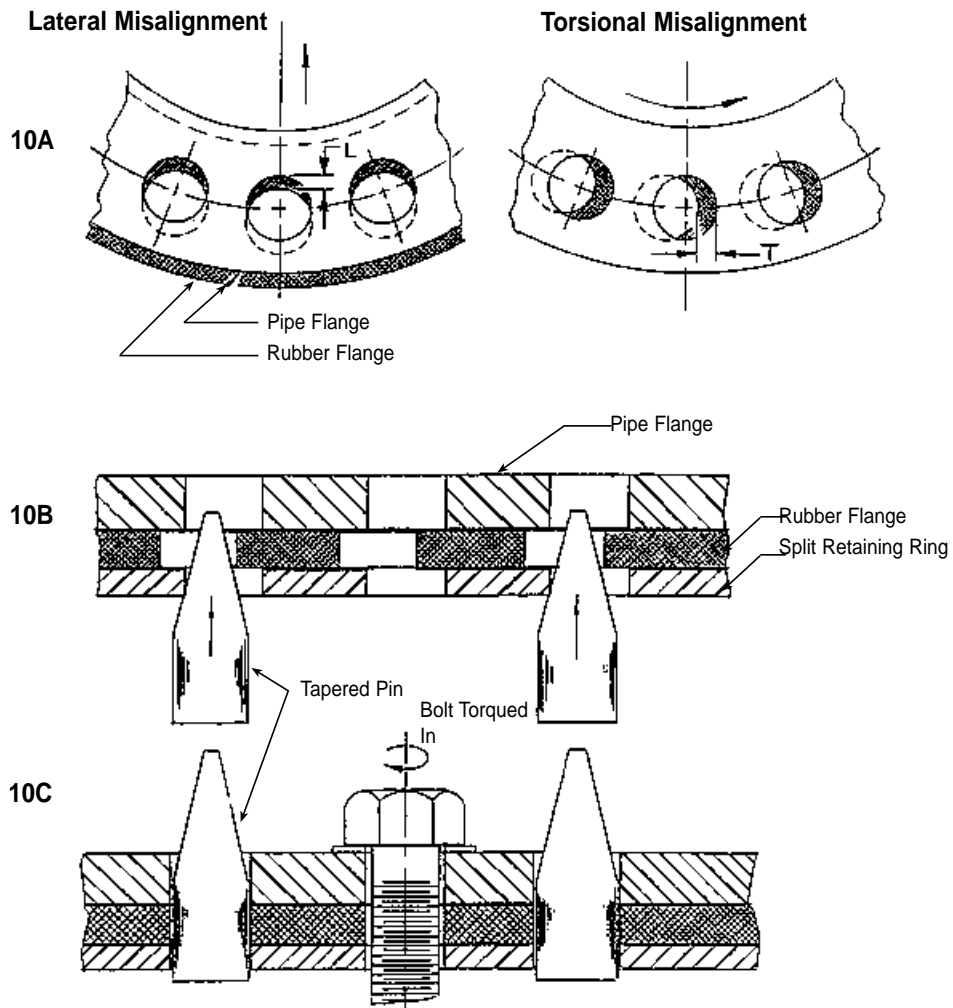
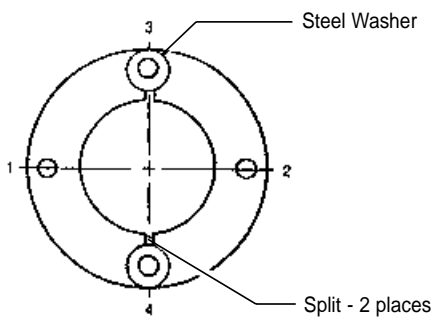


Figure 10

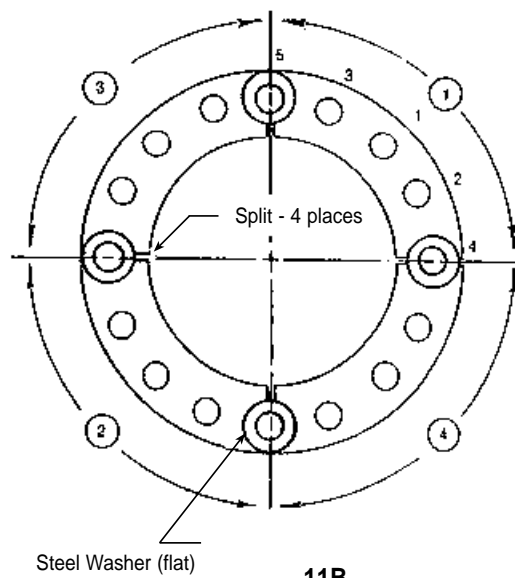
Installing rubber expansion joints with minor lateral and torsional misalignment of pipe flanges.

Small Diameter Expansion Joint
Two segments of retaining rings per flange



11A

Large Diameter Expansion Joint
Four segments of retaining rings per flange



11B

Figure 11

Bolting sequence for elastomeric expansion joints.

Maintenance Procedures

Visual and Physical Inspection of Expansion Joints

Maintenance programs for elastomeric expansion joints should consist of visual as well as physical inspections. These inspections will yield information pertaining to the condition of the expansion joints. Rubber expansion joints will exhibit definite symptoms of premature failure which could be caused by unnatural stress placed on the expansion joint, typically the result of pipe misalignment. External inspections will assist in determining the mode of failure. Internal inspections also contribute to evaluations, when possible, during outages or when the expansion joint is removed for equipment repairs.

Inspection Criteria

1. **Inspection of the tube (internal)** - The tube portion is the most critical part of the expansion joint, as this material comes in direct contact with the media. Any expansion joint which has a damaged tube must be replaced.
 - a. The joint as a whole may feel soft and spongy. Typically there is a break in the tube area and the media has saturated the fabric.
 - b. Visual examination of the tube may also show thin areas or even exposed fabric, where the rubber has been worn away by the flow. This is indicative of an abrasion problem.
 - c. Cracking or hardened rubber on the inside usually indicates excessive temperature. Check temperature rating of material.
2. **External Inspections**
 - a. **Leaking at the flange** - Upon initial installation, rubber will set and bolts may need retightening. If leakage persists, double check the mating flange for gouges or voids which may affect a seal. note: be sure to mate rubber expansion joints with full face flat flanges.
 - b. **Cracking on the outside cover** - The cover portion of the joint is rubber and can be changed if needed to provide compatibility with the environment. Surface cracking on the outside of the joint could be the result of environmental attack or old age.

- c. **Cracking at the base of the flange** - The most frequent causes of failure are over-elongation and lateral misalignment. Both are indicated by cracking at the base of the flange, which is the most critical stress point. Look carefully to determine severity. The fabric of the joint will be exposed and broken in the most severe cases.

This is an extremely critical situation and the joint should be replaced immediately. Measure the face-to-face and lateral misalignment, order the proper size (face-to-face) and build-in offset.

- d. **Delamination** - Ply separation is a typical reaction of materials subjected to unnatural or excessive movement. This condition is evident by soft spots. Torsional misalignment and/or movement are usually the causes for this condition. Expansion joints which show signs of delamination should be watched carefully and replaced as soon as possible.
- e. **Broken body rings** - When an expansion joint has been subjected to pressure surges beyond its capabilities, the metal body rings inside may break. A slight bulge can be felt between the arch and the flange area, where the rings are located. The expansion joint should be replaced, since the structural integrity and dimensional stability of the joints is suspect under these circumstances, and some expansion joints do not contain metal body rings. These joints will tend to balloon under excessive pressure situations and should be replaced.

Troubleshooting Control Units

The control unit assembly is an added safety feature which is used to prevent over-elongation and overcompression of the expansion joint (see description of control units, pages 6 thru 7). If there are signs the gusset plates or threaded rods are bent or distorted, this is a condition of elongation or overcompression. Consult the manufacturer for assistance. Environmental attack may cause corrosion on the metal surface of the control unit. Be sure to order materials compatible with the atmosphere.

Life Expectancy of Elastomeric Joints

The life expectancy of an elastomeric expansion joint is based on many factors.

1. Service Conditions

- a. Temperature
- b. Pressure
- c. Movement
- d. number of Cycles
- e. Environmental Conditions
- f. Media - Abrasive, Chemical
- g. Flow Rate

2. Presence of Misalignment

3. Proper Installation

4. Proper Storage

If the service conditions are not severe, no misalignment is present, the expansion joints are stored and installed properly, the estimated life expectancy of an elastomeric expansion joint is approximately five years.

As stated in this manual, if, however, expansion joints are subjected to harsh service conditions, severe misalignment, installed or stored improperly or any combination thereof, this predicted life will decrease proportionately.

Storage Instructions

In order to obtain complete shelf life, elastomeric expansion joints must be stored properly.

1. Store in a cool, dry area.
2. Store lying on one flange face.
3. Protect the flange faces and tube from nicks, cuts, dents, etc.
4. Do not expose to greases, oils or solvents in liquid or vapor form.
5. Prevent exposure to ultraviolet (UV) light from sunlight or strong fluorescent lights.
6. Do not store near devices which produce ozone (O₃).
7. Do not place other objects on the top flange of the expansion joint.
8. Following extended storage, CAREFULLY inspect the joint for damage.
9. If in doubt concerning any of the above provisions, consult the manufacturer.

Shelf Life

Based on ideal storage conditions, the shelf life of an elastomeric expansion joint is five years from the date of manufacture.

If this time period is exceeded, some degenerative processes may take place; i.e. embrittlement, cracking, restriction of movement capabilities, etc.

Should expansion joints be stored at less than ideal conditions, this five year shelf life must be reduced proportionately. (See storage instructions.) Shelf life must be taken into consideration when predicting the life expectancy of elastomeric expansion joints – if stored in less than ideal conditions, the expected service life would decrease accordingly.

Replacement Schedule

Since the typical life expectancy of an elastomeric expansion joint is five years, preventive maintenance schedules should be enacted accordingly.

If, however, excessive misalignment is present, causing the expansion joint to undergo significant stress, this schedule must be adjusted.

When the expansion joints are subjected to extreme or harsh conditions, i.e. high pressure, excessive movement/cycling, abrasion, etc., inspection procedures need to be done at more timely intervals, beginning at the end of the first year in service and continuing on an ongoing basis. If the service is critical, an accelerated inspection schedule is suggested.

If the expansion joint demonstrates signs of fatigue, replace it as soon as possible. If no physical/visible signs of distress are present, the expansion joint should be replaced every five years. The strength of the expansion joint is in the internal structuring of its layers; deterioration of these strengthening plies is not always apparent.

Appendix

Table I Typical Dimensions and Movement Capabilities for Rubber Expansion Joints

Joint Size (Inside Dia.) ¹	1	1 1/4	1 1/2	2	2 1/2	3	4	5	6	8	10	12	14	16	18	20	22	24	26	28	30	34	36
Flange Outside Dia.	4 1/4	4 5/8	5	6	7	7 1/2	9	10	11	13 1/2	16	19	21	23 1/2	25	27 1/2	29 1/2	32	34 1/4	36 1/2	38 3/4	43 3/4	46
Bolt Circle Dia.	3 1/8	3 1/2	3 7/8	4 3/4	5 1/2	6	7 1/2	8 1/2	9 1/2	11 3/4	14 1/4	17	18 3/4	21 1/4	22 3/4	25	27 1/4	29 1/2	31 3/4	34	36	40 1/2	42 3/4
Number Bolt Holes	4	4	4	4	4	4	8	8	8	8	12	12	12	16	16	20	20	20	24	28	28	32	32
Diameter Bolt Holes	5/8	5/8	5/8	3/4	3/4	3/4	3/4	7/8	7/8	7/8	1	1	1 1/8	1 1/8	1 1/4	1 1/4	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8
Single Arch Std FF	6	6	6	6	6	6	6	6	6	6	8	8	8	8	8	8	10	10	10	10	10	10	10
Dimensions Fig. Thk. A	9/16	9/16	9/16	9/16	9/16	9/16	9/16	9/16	5/8	3/4	3/4	3/4	7/8	7/8	7/8	1	1	1	1	1	1	1	1
200, 200HP, Body Thk. B	1/2	1/2	5/8	3/4	3/4	3/4	7/8	7/8	7/8	7/8	1	1 1/16	1 1/16	1 1/16	1 1/16	1 1/4	1 1/4	1 1/4	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8
204HP Arch Ht. C	1	1	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2	2	2	2	2 1/4	2 1/4	2 1/4	2 1/4	2 1/4
Arch Width D	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	3/4	3/4	3/4	3/4	3/4	3/4	7/8	7/8	7/8	1	1	1	1	1
Std Double Arch FF	10	10	10	10	10	10	10	10	10	10	12	12	12	12	12	14	14	14	14	14	14	14	14
Std Triple Arch FF	14	14	14	14	14	14	14	14	14	14	16	16	16	16	16	18	18	18	18	18	18	18	18
Retaining Ring Thk. R	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8
204, 204HP, 200, 200HP Max. Axial Compression	1/4	1/4	1/4	1/2	1/2	1/2	1/2	1/2	1/2	3/4	3/4	3/4	3/4	3/4	3/4	7/8	7/8	7/8	1	1	1	1	1
Max. Lateral Deflection	1/4	1/4	1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Max. Axial Elongation	1/8	1/8	1/8	1/4	1/4	1/4	1/4	1/4	1/4	3/8	3/8	3/8	3/8	3/8	3/8	7/16	7/16	7/16	1/2	1/2	1/2	1/2	1/2
Dimensions Fig. Thk. A	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	5/8	5/8	5/8	5/8	5/8
206 EZ-FLO®, 204 G306 EZ-FLO® Body Thk. B	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	9/16	9/16	5/8	5/8	5/8	5/8	5/8	5/8	5/8	13/16	13/16	13/16	13/16	13/16	13/16
206 EZ-FLO® Max. Axial Compression	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	1	1	1	1	1	1	1	1 1/8	1 1/8	1 1/8	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4
Max. Lateral Deflection	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Max. Axial Elongation	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2

Joint Size (Inside Dia.) ¹	40	42	48	50	54	60	66	72	78	84	90	96	108	120
Flange Outside Dia.	50 3/4	53	59 1/2	61 3/4	66 1/4	73	80	86 1/2	93	99 3/4	106 1/2	113 1/4	126 3/4	140 1/4
Bolt Circle Dia.	47 1/4	49 1/2	56	58 1/4	62 3/4	69 1/4	76	82 1/2	88 3/4	95 1/2	102	108 1/2	120 3/4	132 3/4
Number Bolt Holes	36	36	44	44	44	52	52	60	60	64	68	68	72	76
Diameter Bolt Holes	1 5/8	1 5/8	1 5/8	1 7/8	2	2	2	2	2 1/8	2 1/4	2 3/8	2 1/2	2 1/2	2 1/2
Single Arch Std FF	10	12	12	12	12	12	12	12	12	12	12	12	12	12
Dimensions Fig. Thk. A	1	1 3/16	1 3/16	1 3/16	1 3/16	1 3/16	1 3/16	1 3/16	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 3/8
200, 200HP, Body Thk. B	1 3/8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 13/16	1 13/16	1 13/16	1 13/16	1 13/16	2
204HP Arch Ht. C	2 1/4	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2
Arch Width D	1	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8
Std Double Arch FF	14	16	16	16	16	16	16	16	18	18	18	18	18	18
Std Triple Arch FF	18	20	20	20	20	20	20	20	22	22	22	22	22	22
Retaining Ring Thk. R	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8
204, 204HP, 200, 200HP Max. Axial Compression	1	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8
Max. Lateral Deflection	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Max. Axial Elongation	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Dimensions Fig. Thk. A	5/8	7/8	7/8	7/8	7/8	7/8	7/8	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 3/8
206 EZ-FLO®, 204 G306 EZ-FLO® Body Thk. B	1 3/16	1	1	1	1	1	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 1/2
206 EZ-FLO® Max. Axial Compression	1 1/4	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8
Max. Lateral Deflection	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Max. Axial Elongation	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2

Notes:

- Pipe sizes through 1 1/2" are supplied with a filled arch (Style 204, 204HP), and movements have been reduced accordingly. Open-arch construction is available on special order.
- Pressure/vacuum ratings are for standard FF dimensions only. Consult Garlock for non-standards.
- For shorter "FF" dimensions, consult Garlock.
- Forces to compress, deflect and elongate elastomeric expansion joints are based on ambient temperature and zero pressure in the pipeline. These forces should be considered only as approximate and may vary with the elastomers and fabric used in construction. To convert force in pounds to kilograms, divide by 2.205.
- Movement of multiple-arch joints can be determined by multiplying the number of arches by the single-arch values in the table above.
- For filled-arch joints, reduce the axial compression, elongation and transverse deflection value by 50%.
- Rated movements are non-concurrent.
- Control units are recommended for most applications.

Table II**Typical Movement Capabilities for U-type Expansion Joints (Figure 4, pg 5)**

		Movement Capabilities					
in.	I.D.	Compression		Elongation		Lateral	
	mm	in.	mm	in.	mm	in.	mm
2 - 20	50-500	1/2	12	1/4	6	1/2	12
22 & up	550 & up	3/4	19	1/4	6	1/2	12

nOTES:

- U-Type expansion joints can be drilled to the same specifications as expansion joints of Table I.
- U-Type expansion joints are typically rated for full vacuum (30" Hg) and 25 psig (1.7 bar) maximum.

Table III**Typical Tolerances for Rubber Expansion Joints (All measurements in inches)**

Nominal Pipe Size Exp. Jt. I.D.	Exp. Jt. I.D. ¹	Non-Critical Flange O.D. ¹	Bolt Line	Face-to-Face Length "F" ²				Number of Measurements to be Averaged
				0 to 6	7 to 12	14 to 18	20 & Up	
0 to 10	± 3/16	± 1/4	± 3/16	± 3/16	± 3/16	± 3/16	+ 3/16 - 1/4	4
12 to 22	± 1/4	± 3/8	± 1/4	± 3/16	± 3/16	± 3/16	+ 3/16 - 1/4	4
24 to 46	± 3/8	± 1/2	± 5/16	± 3/16	± 3/16	+ 3/16 - 1/4	± 1/4	4
48 to 70	+ 3/8 - 1/2	+ 3/4 - 1/2	± 3/8	± 1/4	± 3/8	± 3/8	± 3/8	6
72 & Up	+ 3/8 - 5/8	+ 1 - 3/4	± 1/2	± 1/4	± 3/8	± 3/8	± 3/8	6

nOTES:

- All diameters to be measured with a "Pi" tape.
- All linear dimensions to be measured with a steel rule and averaged.

Table IV**Allowable Pipe Misalignment for Rubber Expansion Joints**

Nominal Pipe Size Expansion Joint I.D.		Pipe Misalignment					
		Angular (A)		Lateral (L)		Torsional (T)	
in.	mm	in.	mm	in.	mm	in.	mm
0 - 10	0 - 250	1/8	3	1/8	3	1/8	3
12 - 22	300 - 550	1/8	3	1/8	3	1/8	3
24 - 46	600 - 1150	3/16	5	1/4	6	1/4	6
48 - 70	1200 - 1750	1/4	6	3/8	10	3/8	10
72 & Up	1800 & up	1/4	6	3/8	10	3/8	10

nOTES:

- Applies to single open arch expansion joints.
- Torsional misalignment "T" is as measured at bolt circle of flanges.
- Misalignments are for ± conditions.

Table V

Pressure and Vacuum Rating for Rubber Expansion Joints

Style 204 / GUARDIAN® 200

Pressure and vacuum service

Pipe Size I.D.		Pressure		Vacuum	
Inches	mm	psi	bar	In. Hg	mm Hg
1/2-4	13-100	165	11	29.9	750
5-12	125-300	140	10	29.9	750
14	350	85	6	29.9	750
16-24	400-600	65	4.5	29.9	750
26-66	650-1650	55	3.8	29.9	750
68-96	1700-2400	45	3	29.9	750
98-108	2450-2700	40	2.8	29.9	750
110-120	2750-3000	30	2	29.9	750

Style 204HP / GUARDIAN® 200HP

High pressure and vacuum service

Pipe Size I.D.		Pressure		Vacuum	
Inches	mm	psi	bar	In. Hg	mm Hg
1/2-4	13-100	200	14	29.9	750
5-12	200-300	190	13	29.9	750
14	350	130	9	29.9	750
16-20	400-500	110	8	29.9	750
22-24	550-600	100	7	29.9	750
26-40	650-1000	90	6	29.9	750
42-66	1050-1650	80	5.5	29.9	750
68-96	1700-2400	70	5	29.9	750
98-108	2450-2700	60	4	29.9	750
110-120	2750-3000	50	3.5	29.9	750

Style 206 EZ-FLO®

High pressure service

Pipe Size I.D.		Pressure		Vacuum	
Inches	mm	psi	bar	In. Hg	mm Hg
2-10	50-250	250	17	26	650
12	300	250	17	12	300
14	350	130	9	12	300
16-20	400-500	110	8	12	300
22-24	550-600	100	7	12	300
26-40	650-1000	90	6	12	300
42-66	1050-1650	80	5.5	12	300
68-96	1700-2400	70	5	12	300
98-108	2450-2700	60	4	12	300
110-120	2750-3000	50	3.5	12	300

Notes:

1. Pressure and vacuum ratings at neutral FF dimension. Extended face-to-face dimensions result in reduced pressure and vacuum ratings for Style 206 EZ-FLO® expansion joints.

Style 306 EZ-FLO®

High pressure service

Pipe Size I.D.		Pressure		Vacuum	
Inches	mm	psi	bar	In. Hg	mm Hg
3-10	75-250	250	17	26	650
12	300	250	17	17	425
14	350	130	9	17	425
16-20	400-500	110	8	15	375

Notes:

1. Pressure and vacuum ratings at neutral FF dimension. Extended face-to-face dimensions result in reduced pressure and vacuum ratings for Style 306 EZ-FLO® expansion joints.

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WARNING:

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