FLUID SEALING® ASSOCIATION FSA

Expansion Joints PIPING

TECHNICAL HANDBOOK

general rubber

Compliments of General Rubber

8.0 EDITION

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This handbook is a compilation of standards of construction and a guide for specifying and purchasing non-metallic expansion joints. The information set forth is based upon the substantial experience in research, design and application of rubber expansion joints by engineering personnel associated with the member companies of the Expansion Joints-Piping Division of the Fluid Sealing Association.

The purpose of this publication is to provide a handy reference source of pertinent information and factual data for the thousands of engineers whose daily concern is designing piping systems and overseeing installations. No portion of this handbook attempts to establish dictates in modern piping design. This handbook is widely used in customer inquiries as a reference for design and performance standards.

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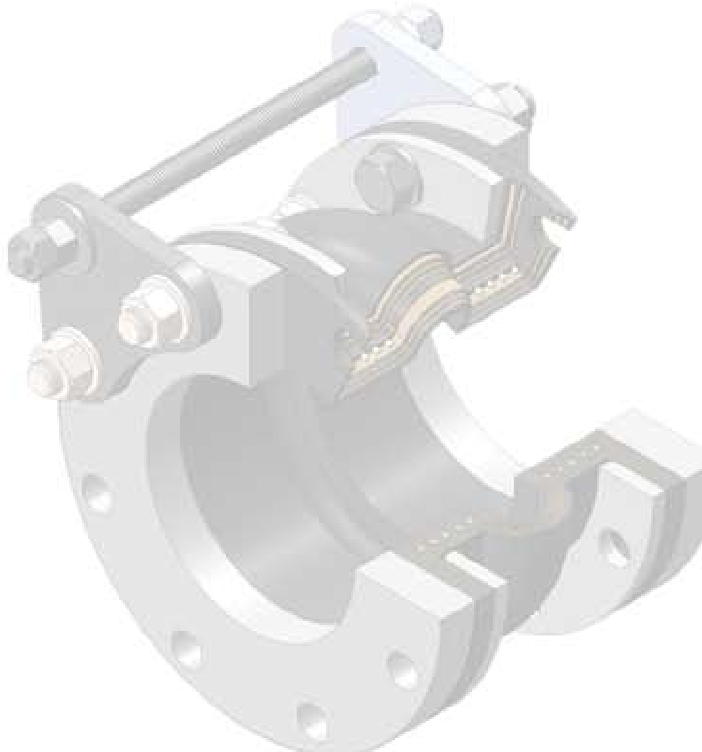


Figure 1: Cross Sectional View Of Standard Spool "Arch" Type Expansion Joint

Careful selection of the expansion joint design and material for a given application, as well as properly engineered installation are important factors in determining performance. These factors should be fully evaluated by every person selecting and applying expansion joints for any application.

†Rubber expansion joints have been specified and used for many years by consulting engineers, mechanical contractors, pressure vessel designers, plant engineers and turn-key construction firms. They are installed to accommodate movement in piping runs, to protect piping from expansion and contraction and to insure efficient and economical on-stream operations.

Rubber expansion joints provide time-tested ways to accommodate pressure loads, relieve movement stresses, reduce noise, isolate vibration, compensate for misalignment after plants go on stream and prolong the life of motive equipment. Rubber expansion joints, designed by engineers and fabricated by skilled craftsmen, are used in all systems conveying fluids under pressure and/or vacuum at various temperatures:

- Air Conditioning, heating and ventilating systems* in commercial and institutional buildings, schools, apartments, stores, hospitals, motels, hotels and aboard ships
- Central and ancillary power-generating stations in communities, factories, buildings and aboard ships.
- Sewage disposal and water-treatment plants.
- Process piping in paper and pulp, chemical, primary metal and petroleum refining plants.

*ASHRAE Handbook and Product Directory, 1984 Systems, Chapter 32.
†"Rubber" in this catalog refers to all types of elastomers, synthetic as well as natural rubber.

A. DEFINITION:

A non-metallic expansion joint is a flexible connector fabricated of natural or synthetic elastomers, fluoroplastics and fabrics and, if necessary, metallic reinforcements to provide stress relief in piping systems due to thermal and mechanical vibration and/or movements.

Noteworthy performance features include flexibility and concurrent movements in either single or multiple arch type construction, isolation of vibration and noise, resistance to abrasion and chemical erosion.

B. FUNCTIONS:

Engineers can solve anticipated problems of vibration, noise, shock, corrosion, abrasion, stresses and space by incorporating rubber expansion joints into designed piping systems.

B.1. *Reduce Vibration.* Rubber expansion joints isolate or reduce vibration caused by equipment. Some equipment requires more vibration control than others. Reciprocating pumps and compressors, for example, generate greater unbalanced forces than centrifugal equipment. However, rubber pipe and expansion joints dampen undesirable disturbances including harmonic overtones and vibrations caused by centrifugal pump and fan blade frequency. This is based on actual tests conducted by a nationally recognized independent testing laboratory. Rubber expansion joints reduce transmission of vibration and protect equipment from the adverse effects of vibration.
See Appendixes F, G and Chapter VII, Section B.

B.2. *Dampen Sound Transmission.* Subsequent to going on stream, normal wear, corrosion, abrasion and erosion eventually bring about imbalance in motive equipment, generating undesirable noises transmitted to occupied areas. Rubber expansion joints tend to dampen transmission of sound because of the steel-rubber interface of joints and mating flanges. Thick-wall rubber expansion joints, compared with their metallic counterparts, reduce considerably the transmission of sound.
See Appendixes F, G and Chapter VII, Section B.

B.3. *Compensate Lateral, Torsional and Angular Movements.* Pumps, compressors, fans, piping and related equipment move out of alignment due to wear, load stresses, relaxation and settling of supporting foundations. Rubber expansion joints compensate for lateral, torsional and angular movements, preventing damage and undue downtime of plant operations.
See Tables V & VI and Chapter VII, Section. A.

B.4. *Compensate Axial Movements.* Expansion and contraction movements due to thermal changes or hydraulic surge effects are compensated for with strategically located rubber expansion joints. They act as helix springs, compensating for axial movements. *See Tables V & VI and Chapter VII, Section A.*

C. ADVANTAGES:

The industry has allied itself with designers, architects, contractors and erectors in designing and fabricating rubber expansion joints under rigid standards to meet present-day operating conditions. The industry has kept abreast of the technological advances in rubber compounding and synthetic fabrics to provide rubber expansion joints having advantages not available in other materials.

C.1. *Minimal Face-to-Face Dimensions.* Minimal face-to-face dimensions in rubber expansion joints offer untold economies, compared with costly expansion bends or loops. The relative cost of the pipe itself may be less or no more than a rubber expansion joint; however, total costs are higher when considering plant space, installation labor, supports and pressure drops.
See Tables V & VI.

C.2. *Lightweight.* Rubber expansion joints are relatively light in weight, requiring no special handling equipment to position, contributing to lower installation labor costs.

C.3. *Low Movement Forces Required.* The inherent flexibility of rubber expansion joints permits almost unlimited flexing to recover from imposed movements, requiring relatively less force to move, thus preventing damage to motion equipment. *See Tables V & VI.*

C.4. *Reduced Fatigue Factor.* Compared to steel, the inherent characteristics of natural and synthetic elastomers are not subject to fatigue breakdown or embrittlement and prevent any electrolytic action because of the steel-rubber interface of the joints and mating flanges. *See Table II.*

C.5. *Reduced Heat Loss.* Rubber expansion joints reduce heat loss, giving long maintenance-free service. The added piping required for loops, contribute to higher operating costs after going on stream due to an increase in heat losses.

C.6. *Corrosion, Erosion Resistant.* A wide variety of natural, synthetic and special purpose elastomers and fabrics are available to the industry. Materials are treated and combined to meet a wide range of practical pressure/temperature operating conditions, corrosive attack, abrasion and erosion. Standard and special sizes of rubber expansion joints are available with PTFE/TFE/FEP liners, fabricated to the configurations of the joint body, as added insurance against corrosive attack. Fluoroplastics possess unusual and unique characteristics of thermal stability, non-sticking surface, extremely low co-efficient of friction and resistance to practically all corrosive fluids and forms of chemical attack. *See Table II.*

C.7. *No Gaskets.* Elastomeric expansion joints are supplied with flanges of vulcanized rubber and fabric integrated with the tube, making the use of gaskets unnecessary. The sealing surfaces of the expansion joint equalize uneven surfaces of the pipe flange to provide a fluid and gas-tight seal. A ring gasket may be required for raised face flanges. Consult manufacturer about specific applications.

C.8. *Acoustical Impedance.* Elastomeric expansion joints significantly reduce noise transmission in piping systems because the elastomeric composition of the joint acts as a dampener that absorbs the greatest percentage of noise and vibration.
See Appendix F.

C.9. *Greater Shock Resistance.* The elastomeric type expansion joints provide good resistance against shock stress from excessive hydraulic surge, water hammer or pump cavitation.

Table I: Maximum Temperature Ratings

Reinforcing Fabric	Tube or Cover Elastomer						
	Pure Gum Rubber	Neoprene	Butyl	Nitrile	CSM	EPDM	FKM
Nylon	180°F/ 82°C	225°F/ 107°C	250°F/ 121°C	210°F/ 99°C	250°F/ 121°C	250°F/ 121°C	250°F/ 121°C
Polyester	180°F/ 82°C	225°F/ 107°C	250°F/ 121°C	210°F/ 99°C	250°F/ 121°C	250°F/ 121°C	250°F/ 121°C
Aramid	180°F/ 82°C	225°F/ 107°C	300°F/ 149°C	210°F/ 99°C	250°F/ 121°C	300°F/ 149°C	400°F/ 204°C

Note: Temperatures listed above are the typical maximum degree ratings for continuous use. All fabrics lose a percentage of their strength in relation to exposure temperature and duration. That being said, higher operating temperatures may be achieved if operation pressures are reduced and sound engineering practices are used during the design and manufacturer of a product.

D. CONSTRUCTION DETAILS:

D.1. *Tube.* A protective, leak-proof lining made of synthetic or natural rubber as the service dictates. This is a seamless tube that extends through the bore to the outside edges of the flanges. Its purpose is to eliminate the possibility of the materials being handled penetrating the carcass and weakening the fabric. These tubes can be designed to cover service conditions for chemical, petroleum, sewage, gaseous and abrasive materials. *See Tables I and II, and Figure 1.*

D.2. *Cover.* The exterior surface of the joint is formed from natural or synthetic rubber, depending on service requirements. The prime function of the cover is to protect the carcass from outside damage or abuse. Special polymers can be supplied to resist chemicals, oils, sunlight, acid fumes and ozone. Also, a protective coating may be applied to the exterior of the joint for additional protection. *See Tables I and II, and Figure 1.*

D.3. *Carcass.* The carcass or body of the expansion joint consists of fabric and, when necessary, metal reinforcement.

D.3.A. *Fabric Reinforcement.* The carcass fabric reinforcement is the flexible and supporting member between the tube and cover. Standard constructions normally utilize high quality synthetic fabric. Natural fabrics can also be used at some pressures and temperatures. All fabric plies are impregnated with rubber or synthetic compounds to permit flexibility between the fabric plies. *See Table 1 and Figure 1.*

D.3.B. *Metal Reinforcement.* Wire or solid steel rings embedded in the carcass are frequently used as strengthening members of the joint. The use of metal sometimes raises the rated working pressure and can supply rigidity to the joint for vacuum service. *See Table IV and Figure 1.*

TABLE II: List of Elastomers Used in Expansion Joints and Rubber Pipes

MATERIAL DESIGNATION		RATING SCALE CODE	ELASTOMER PHYSICAL AND CHEMICAL PROPERTIES COMPARISON							
ANSI/ASTM D1418-77	ASTM-D-2000 D1418-77	7-Outstanding, 3-Fair to good, 6-Excellent, 2-Fair, 5-Very Good, 1-Poor to Fair, 4-Good, 0-Poor, X-Contact Mfg. COMMON NAME CHEMICAL GROUP NAME	ALKALI, CONC. ANIMAL VEG. OIL CHEMICAL WATER	OXYGENATED HYDRO. LACQUERS OIL & GASOLINE ALKALI, DILUTE	ACID DILUTE ACID, CONC. ALPHATIC HYDRO AROMATIC HYDRO	ELE. INSULATION WATER ABSORP RADIATION SWELLING IN OIL	REBOUND-COLD COMP. SET TENSILE STRENGTH DIELECTRIC STR.	ABRASION IMPERMEABILITY DYNAMIC REBOUND-HOT	HEAT COLD FLAME TEAR	OZONE WEATHER SUNLIGHT OXIDATION
CR	BC BE	**NEOPRENE** CHLOROPRENE	4340	4401	2346	4543	5424	5245	4444	5565
NR	AA	**GUM RUBBER** POLYISOPRENE, SYNTHETIC	53XX	X004	0033	0655	6646	6627	5052	4020
IR	AA	**NATURAL RUBBER** POLYISOPRENE, SYNTHETIC	53XX	X004	0033	0655	6646	6226	5052	4020
IIR	AA	**BUTYL** ISOBUTENE-ISOPRENE	5654	4034	0046	0455	5430	5264	4045	6556
CIIR	AA BA	**CHLOROBUTYL** CHLORO-ISOBUTENE-ISOPRENE	5654	4034	0046	0455	5430	5264	4045	6556
NBR	BE BK CH	**BUNA-N/NITRILE** NITRIL-BUTADIENE	4350	4520	4644	5541	0554	4544	3034	4022
SBR	AA	**SBR/GRS/BUNA-S** STYRENE-BUTADIENE	53X2	4004	0033	0655	4544	4425	3053	2020
CSM	CE	**CSM** CHLORO-SULFONYL-POLYETHYLENE	5644	4431	2346	4543	5222	4244	3444	6767
FKM	HK	FLUOROCARBON ELASTOMER	5660	4610	6665	6553	5562	4555	2627	7777
EPR	BA CA DA	**EPDM** ETHYLENE-PROPYLENE-DIENE-TERPOLYMER	5656	6036	0046	0766	7546	6545	4056	6767
AFMU		**PTFE/TFE/FEP** FLUORO-ETHYLENE-POLYYMERS	7777	7777	7777	737X	XXXX	XXX4	XXX7	7777
SI	GE	**SILICONE**	5550	2X02	0026	2566	4036	6020	2267	6666

A. "ARCH" TYPE:

A full face integral flange design is available in both Single Arch and Multiple Arch Types. These basic types can be manufactured to meet the requirements of ASTM F1123-87 (Note: The U.S. Navy previously used MIL-E-15330D, Class A-Type I as its standard specification, but has adopted the ASTM Specification.) These types are available in several construction design series, based on the application pressure requirements. *See Table IV.*

A.1. *Single Narrow Arch Type.* Construction is of fabric and rubber, reinforced with metal rings or wire. The full face flanges are integral with the body of the joint and drilled to conform to the bolt pattern of the companion metal flanges of the pipeline. This type of rubber face flange is of sufficient thickness to form a tight seal against the metal flanges without the use of gaskets. The shortest face-to-face dimensions are available with this type of construction. See Table V and Figure 2A.

Figure 2A: Single Narrow Arch Type Expansion Joint

A.2. *Multiple Arch Type.* Joints with two or more arches may be manufactured to accommodate movements greater than those of which a Single Arch Type joint is capable. Multiple Arch joints of most manufacturers are composites of standard sized arches and are capable of movements of a single arch multiplied by the number of arches. *See Figure 2B.* The minimum length of the joint is dependent upon the number of arches. In order to maintain lateral stability and prevent sagging when the joint is installed in a horizontal position, a maximum number of four (4) arches is recommended. *See Table V, Note 3.*

Figure 2B: Multiple Arch Type Expansion Joint

A.3. *Lightweight Type.* Both the Single Arch and Multiple Arch Types are available in a lightweight series from most manufacturers. Dimensionally the same as the standard product, except for reduced body thickness, this series is designed for lower pressure and vacuum applications. For a No-Arch design see Section H.3, this chapter. Contact the manufacturer for specific information.

A.4. *PTFE Lined.* Spool Arch Type joints are available in many standard pipe sizes with Fluoroplastic liners of TFE and/or FEP. These liners are fabricated as an integral part of the expansion joint during manufacture and cover all wetted surfaces in the tube and flange areas. Fluoroplastic provides exceptional resistance to almost all chemicals within the temperature range of the expansion joint body construction. Filled arches are not available.

A.5. *Wide Arch Type:* This type, similar to the Narrow "Arch" Type, is available in a metallic reinforced and a non-metallic reinforced design. Generally, the Wide Arch Type features greater movements than the Standard Spool "Arch" Type. *See Table VI.*

A.5.A *Non-metallic Reinforced Design.* Constructed similar to the Spool "Arch" Type except the carcass does not contain wire or metal ring reinforcement. Pressure resistance is accomplished through the use of special external flanged retaining rings furnished with the joint. Available also in a "Filled Arch" design. *See Figure 2C.*

Figure 2C: Wide Arch Non-Metallic Reinforced Type Expansion Joint

A.5.B. *Metallic Reinforced Design.* A molded version of the Spool "Arch" Type utilizing solid steel rings in a carcass, at the base of the arch. The reduced body thickness requires special retaining rings available from the manufacturer. *See Figure 2D.*

Figure 2D: Molded Wide Arch Metallic Reinforced Type Expansion Joint

B. REDUCER TYPE: "TAPER":

Reducing expansion joints are used to connect piping of unequal diameters. They may be manufactured as a concentric reducer with the axis of each end concentric with each other or as an eccentric reducer having the axis of each end offset from each other. Tapers in excess of 20 degrees are not desirable. Recommendations concerning the degree of taper and working pressures should be obtained from the manufacturer of your choice. Normally, pressures are based on the larger of the two inside dimensions. Available with or without arches. *See Figures 2E and 2F.*

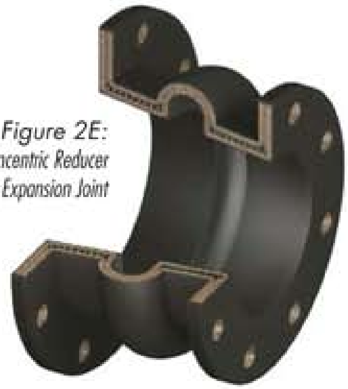


Figure 2E:
Concentric Reducer Type Expansion Joint

Figure 2F:
Eccentric Reducer Type Expansion Joint

C. CUSTOM TYPE:

Offset joints are custom built to specifications to compensate for initial misalignment and non-parallelism of the axis of the piping to be connected. Offset joints are sometimes used in close quarters where available space makes it impractical to correct misalignment with conventional piping. Generally, the industry follows the practice of drilling flanges according to pipe size of flanges when not specified otherwise. It is recommended that complete drawings and specifications accompany inquiries or orders for offset joints. *See Figure 2G.*

Figure 2G:
Custom Type Expansion Joint

D. SLEEVE TYPE:

A sleeve design is available in both single and multiple arch types. Both types are available in several design constructions, based on the application pressure and flexibility requirements. Contact the manufacturer for movement and pressure limitations and type of sleeve ends required.

D.1. *Sleeved Arch Type.* This joint is similar to the "Arch" Type *(See Figures 2A and 2B)* except that the capped sleeve ends have an I.D. dimension equal to the O.D. of the pipe. These joints are designed to slip over the straight ends of the open pipe and be held securely in place with clamps. This type of joint is recommended only for low to medium pressure and vacuum service because of the difficulty of obtaining adequate clamp sealing. *See Figure 2H.*

Figure 2H:
Sleeve Type Expansion Joint

D.2. *Lightweight Type.* Dimensionally the same as the sleeve "Spool Type", except for reduced body thickness. This series is designed for very low pressure and vacuum applications. Joints are available in single and multiple arch types. Consult the manufacturer for the types of clamps available for sealing. This type generally offers greater flexibility than the spool type.

D.3. *Enlarged End Type.* This joint can be manufactured in the same design as the spool type and lightweight type. The sleeve ends on this design are the same dimension as the O.D. of the pipe, while the rest of the joint is the same as the I.D. of the pipe.

E. SPECIAL FLANGE TYPE:

Most of the expansion joint types depicted in this chapter are available with modifications to the flanges. These modifications include enlarged flanges, different drill patterns and weld-end stubs.

E.1. *Enlarged Flange Type.* Expansion joints utilizing a full face integral flange design can be furnished with an enlarged flange on one end. (For example, an 8" (203 mm) expansion joint can be fabricated with a flange to mate to an 8" (203 mm) pipe flange on one end; and a 12" (305 mm) flange on the other end to mate to a 12" (304 mm) pipe flange.) Additionally, drilling of different specifications may be furnished. For example, an expansion joint can be furnished with one end drilled to ANSI B16.5, Class 150, and the other end drilled to MIL-F-20042C. *See Figure 2I.* *Note: Special control rods will be required when needed.*

Figure 2I:
Enlarged Flange Type Expansion Joint

E.2. *Weld-End Type.* Several manufacturers offer an expansion joint with weld-end nipples which allow the unit to be directly welded into place on the job or welded to associated equipment before final installation. The design is basically the Sleeve Type expansion joint bonded to matching steel weld-end nipples. Normally, there are steel band clamps around the periphery of the rubber sleeve end to reinforce the rubber-metal bond.

F. DESIGNS FOR REDUCTION OF TURBULENCE AND ABRASION:

The open-arch design of the Standard Spool Type Expansion Joint may be modified to reduce possible turbulence and to prevent the collection of solid materials that may settle from the solution handled and remain in the archway.

F.1. *Filled Arch Type.* Arch-type expansion joints may be supplied with a bonded-in-place soft rubber filler to provide a smooth interior bore. Filled arch joints also have a seamless tube so the arch filler cannot be dislodged during service. Filled arches, built as an integral part of the carcass, decrease the flexibility of the joint and should be used only when necessary. Movements of expansion joints with filled arches are limited to 50% of the normal movements of comparable size expansion joints with unfilled (open) arches.
See Tables V & VI and Figure 2J.

Figure 2J:
Single Arch Type Expansion Joint with Filled Arch

F.2. *"Top Hat" Liner.* This product consists of a sleeve extending through the bore of the expansion joint with a full face flange on one end. Constructed of hard rubber, metal or Fluoroplastic; it reduces frictional wear of the expansion joint and provides smooth flow, reducing turbulence. This type of sleeve should not be used where high viscosity fluids, such as tars, are being transmitted. These fluids may cause "packing-up or caking" of the open arch or arches, which reduces movements and in turn may cause premature expansion joint failure. Baffles are rarely required on rubber expansion joints. *See Figure 2K.*

Figure 2K:
Top Hat Liner

G. RECTANGULAR WITH ARCH TYPE:

A custom made flexible connector for use with rectangular flanges on low pressure service. The arch design accommodates greater movement than the "U" type joint.
See Figure 2L

Figure 2L:
Arch Type Rectangular

H. "U" TYPE:

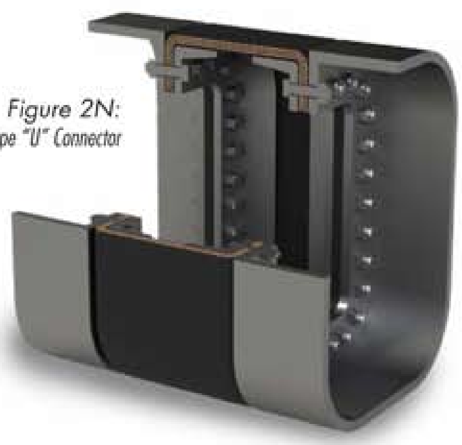
"U" type joints are available for low pressure applications in external and internal flange design and for higher pressure service in a no-arch modification of the single arch type.

H.1. *External Full Face Integral Flange Turbine to Condenser.* This lightweight custom-made flexible joint is generally used between a turbine and condenser. It is constructed of plies of rubber and fabric usually without metal reinforcement. The joint is recommended for full vacuum service or a maximum pressure of 25 PSIG (172 kPa). Flange drilling may be staggered to facilitate installation and tightening of bolts. The joint is securely bolted in place with conventional retaining rings for vacuum service or special support rings for pressure service. The joint may be rectangular, round or oval in shape.
See Figure 2M.

Figure 2M:
External Flange Type "U" Connector

H.2. *Internal Full Face Integral Flange Turbine to Condenser.* This joint is similar to the external flange joint except that conventional retaining rings are used for pressure service and special support rings are used for vacuum service. The joint may be rectangular, round or oval in shape. *See Figure 2N* which depicts a rectangular version with special support rings. Based on installation, field splicing may be necessary.

Figure 2N:
Internal Flange Type "U" Connector



H.3. *No Arch "U" Type.* The construction of this joint is similar to the Single Arch Type, except modified to eliminate the arch. This connector will absorb vibration and sound. A reducer version is shown in Figure 2D.
See Table II for pressures and Figure 2O. For alternate designs, see Chapter V.

Figure 2O:
No-Arch "U" Type Connector

I. BELT "DOGBONE" TYPE:

The belt type or "Dogbone" expansion joint is a commonly specified flexible connection used exclusively in power generating stations, to isolate low pressure steam turbines from condensers. Forming a continuous loop around the connecting ductwork, the Dogbone allows for compressive and lateral movements of the two components, as the equipment heats and expands during operation.

It is initially furnished with specially machined steel clamping fixtures, as a component of the condenser. It is designed to operate under full vacuum and at temperatures up to 250 F. Future replacement typically involves changing of the rubber element only.

Construction of the flexible element, consists of laminated fabric plies, tied to a solid bulb core, all bonded and covered in elastomer and then compression molded. Although different elastomers and fabrics are available for variable operating conditions, the application of neoprene and nylon has proven to be the most reliable and enduring combination. It is best to consult with knowledgeable and experienced manufacturers to specify the most superior materials, whether it is new construction or replacement. As a critical element whose failure will shut down a power plant, careful consideration should be given to specifying high grade materials, with built in safety and reliability features.

All Dogbone joints will require a splice to make endless, at some point. Except in unusual circumstances, only one splice per joint is necessary. For new construction, most Dogbones can be supplied with a factory splice. Subsequent replacements, most often require a field splice, due to added interference within the condenser. In any case, splicing should be done by skilled technicians that work directly for, or are approved by the manufacturer. This insures compatibility of the materials and provides a complete warranty, for the entire expansion joint. *See Figure 2S.*

Figure 2S:
Belt Type Expansion Joint

J. SPHERICAL TYPE:

The design incorporates a long radius arch, providing additional movement capabilities when compared to other types. The arch is self-cleaning, eliminating the need of Filled Arch Type construction.
See Chapter III for Spherical Floating Flange design.

J.1. *Integral Flange Spherical Type.* Basically the same design as the Floating Flange Spherical Type *(See Chapter III)*, except full face flanges are integral with the body of the joint. Pressure-resisting hoop strength is a function of the special weave fabric and its ply placement in the body, as well as the design of the retaining rings. Special retaining rings are sometimes required. Contact the manufacturer for pressure and movement rating. *See Figure 2R.*

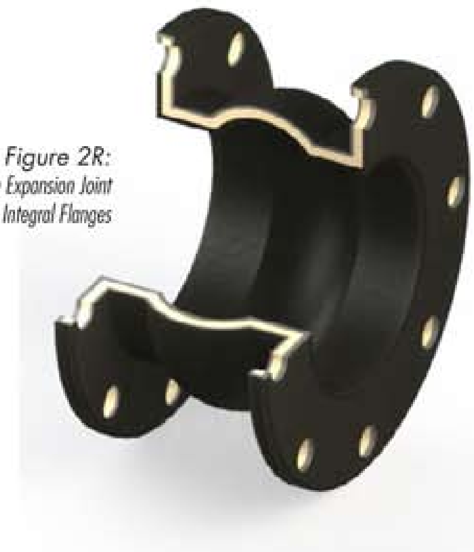


Figure 2R:
Spherical Type Expansion Joint with Integral Flanges

K. FAN CONNECTORS:

Industrial fans and their related ducting frequently require a flexible connector to absorb vibration, reduce noise and provide an easy access to fans when overhaul or cleaning is required. Elastomeric fan connectors have a lighter body and flanges designed to match the specific fan design. Usually their pressure and vacuum ratings are approximately ± 2 PSIG (14 kPa) to match the service. Face-to-face dimension as short as 2-1/2" (63mm) are available. Slip-over fan connectors are also frequently specified. *See Figure 2T.*

Figure 2T:
Rectangular Fan Connector

L. HINGED TYPE:

Hinged type rubber expansion joints are designed to permit angular rotation in one plane. The arrangement consists of a pair of hinge plates connected with pins and attached to the expansion joints' external or internal hardware. The hinge assembly must be designed for the internal pressure thrust forces of the system. Hinged type rubber expansion joints can be used in sets of two or three to absorb lateral movement in one plane. *See Figure 2U.*

Figure 2U:
Hinged Type Joint

M. GIMBAL TYPE:

Gimbal type rubber expansion joints are designed to permit angular rotation in multiple planes. The arrangement consists of two pairs of hinge plates connected with pins to a common gimbal ring and attached to the expansion joints' external or internal hardware. The gimbal assembly must be designed for the internal pressure thrust forces of the system. Gimbal type rubber expansion joints can be used in sets of two, or sets of two with a single hinge type joint to absorb lateral movement in multiple planes. *See Figure 2V.*

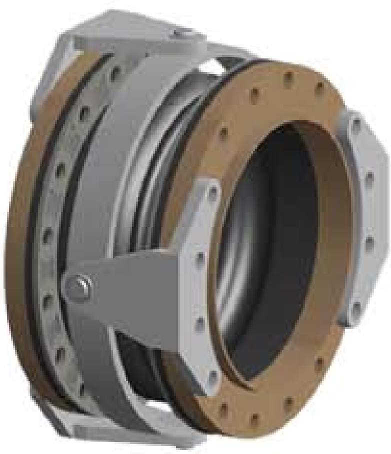


Figure 2V:
Gimbal Type Joint

N. UNIVERSAL TYPE:

Universal type rubber expansion joints are designed to permit extension, compression, lateral and angular movements. The arrangement consists of two rubber expansion joints connected by a center spool with restraint hardware.
See Figure 2W.

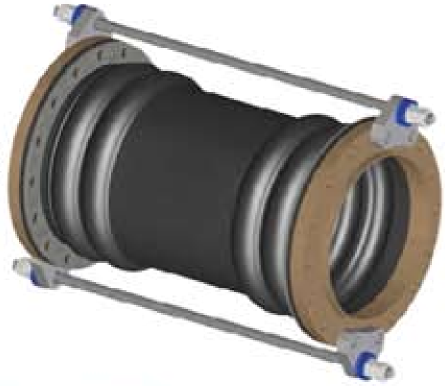


Figure 2W:
Universal Type Joint

O. PRESSURE BALANCED:

Pressure Balanced type rubber expansion joints are designed to absorb compression, lateral and angular movements while restraining the pressure thrust force. The arrangement consists of two or three rubber expansion joints and interconnecting hardware, attached to the external or internal interconnecting hardware.

O.1. *In-line Configuration Type.* This configuration is designed to function in a straight pipeline with no provision for anchors. The balancing rubber expansion joint needs to be twice the effective area as the main rubber expansion joint.
See Figure 2X.

Figure 2X:
In-Line Pressure Balanced Joint

O.2. *Elbow Configuration Type.* This configuration is designed to function with incorporation of an elbow. The balancing rubber expansion joint can be the same effective area as the main rubber expansion joint. *See Figure 2Y.*

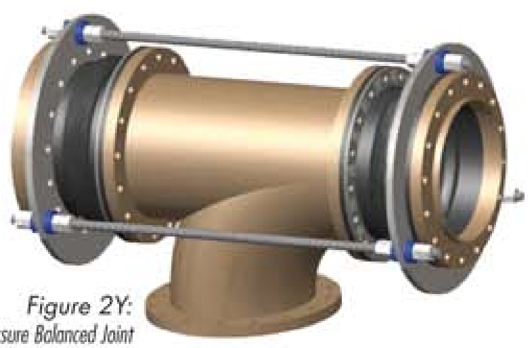


Figure 2Y:
Elbow Pressure Balanced Joint

Table V: Typical Narrow Arch Expansion Joint Movement/Spring Rate Capabilities

Nominal Pipe Size Expansion Joint		Nominal Face-to-Face Minimum Length		MOVEMENTS: AXIAL COMPRESSION		AXIAL EXTENSION		LATERAL DEFLECTION		DEGREES OF ANGULAR MOVEMENT	DEGREES OF TORSIONAL MOVEMENT	SPRING RATES: AXIAL COMPRESSION		AXIAL EXTENSION		LATERAL DEFLECTION		ANGULAR MOVEMENT	
in	mm	in	mm	in	mm	in	mm	in	mm			lbs/in	N/mm	lbs/in	N/mm	lbs/in	N/mm	ft-lbs/ deg	Nm/deg
1*	25	6	150	7/16	11	1/4	6	1/2	13	27.5	3	235	41	304	53	350	61	.04	.05
1-1/4*	32	6	150	7/16	11	1/4	6	1/2	13	22.5	3	294	51	383	67	438	77	.10	.13
1-1/2*	40	6	150	7/16	11	1/4	6	1/2	13	18.5	3	353	62	459	80	524	92	.15	.20
2	50	6	150	7/16	11	1/4	6	1/2	13	14.5	3	423	74	552	97	700	123	.30	.41
2-1/2	65	6	150	7/16	11	1/4	6	1/2	13	11.5	3	530	93	689	121	762	133	.50	.68
3	75	6	150	7/16	11	1/4	6	1/2	13	10.0	3	635	111	828	145	824	144	.80	1.10
3-1/2	88	6	150	7/16	11	1/4	6	1/2	13	8.3	3	742	130	965	169	888	155	1.3	1.8
4	100	6	150	7/16	11	1/4	6	1/2	13	7.5	3	848	148	1104	193	952	167	1.9	2.6
5	125	6	150	7/16	11	1/4	6	1/2	13	6.0	3	1058	185	1376	241	1092	191	3.7	5.0
6	150	6	150	7/16	11	1/4	6	1/2	13	5.0	3	1271	223	1652	289	1234	216	6.4	8.7
8	200	6	150	11/16	18	3/8	10	1/2	13	5.5	3	1412	247	1837	322	1506	264	12.7	17.2
10	250	8	200	11/16	18	3/8	10	1/2	13	4.5	3	1766	309	2296	402	1618	283	24.2	32.8
12	300	8	200	11/16	18	3/8	10	1/2	13	3.75	3	2118	371	2755	482	1896	332	42.1	57.1
14	350	8	200	11/16	18	3/8	10	1/2	13	3.25	2	1853	325	2411	422	2234	391	19.2	80.3
16	400	8	200	11/16	18	3/8	10	1/2	13	2.75	2	2118	371	2755	482	2572	450	76	103
18	450	8	200	11/16	18	3/8	10	1/2	13	2.5	1	2382	417	3101	543	2840	497	106	144
20	500	8	200	13/16	21	7/16	11	1/2	13	2.5	1	2649	464	3440	602	3176	556	152	206
22	550	10	250	13/16	21	7/16	11	1/2	13	2.25	1	2913	510	3785	663	3296	577	205	278
24	600	10	250	13/16	21	7/16	11	1/2	13	2.0	1	3178	557	4130	723	3412	597	274	371
26	650	10	250	15/16	24	1/2	13	1/2	13	2.3	1	3060	536	3980	697	3658	641	292	396
28	700	10	250	15/16	24	1/2	13	1/2	13	2.0	1	3296	577	4286	751	3904	684	382	518
30	750	10	250	15/16	24	1/2	13	1/2	13	2.0	1	3532	619	4594	804	4150	727	437	592
32	800	10	250	15/16	24	1/2	13	1/2	13	1.8	1	3769	660	4899	858	4876	854	555	752
34	850	10	250	15/16	24	1/2	13	1/2	13	1.75	1	4002	701	5602	981	5602	981	645	874
36	900	10	250	15/16	24	1/2	13	1/2	13	1.5	1	4238	742	5512	965	6328	1108	844	1144
38	950	10	250	15/16	24	1/2	13	1/2	13	1.5	1	4475	784	5818	1019	6502	1139	943	1278
40	1000	10	250	15/16	24	1/2	13	1/2	13	1.5	1	4708	824	6124	1072	6676	1169	1042	1413
42	1050	12	300	1-1/16	27	9/16	14	1/2	13	1.5	1	4452	780	5783	1013	6846	1199	1163	1577
44	1100	12	300	1-1/16	27	9/16	14	1/2	13	1.5	1	4664	817	6057	1061	7142	1251	1270	1722
46	1150	12	300	1-1/16	27	9/16	14	1/2	13	1.3	1	4870	853	6339	1110	7436	1302	1680	2278
48	1200	12	300	1-1/16	27	9/16	14	1/2	13	1.25	1	5087	891	6608	1157	7732	1354	1825	2474
50	1250	12	300	1-1/16	27	9/16	14	1/2	13	1.25	1	5300	928	6884	1206	8024	1405	1968	2668
52	1300	12	300	1-1/16	27	9/16	14	1/2	13	1.25	1	5512	965	7166	1255	8314	1456	2138	2899
54	1350	12	300	1-1/16	27	9/16	14	1/2	13	1.25	1	5724	1002	7435	1302	8606	1507	2308	3129
56	1400	12	300	1-1/16	27	9/16	14	1/2	13	1.25	1	5936	1039	7717	1351	8896	1558	2464	3341
58	1450	12	300	1-1/16	27	9/16	14	1/2	13	1.0	1	6148	1076	7992	1400	9184	1608	3310	4488
60	1500	12	300	1-1/16	27	9/16	14	1/2	13	1.0	.5	6360	1114	8268	1448	9472	1659	3537	4795
66	1650	12	300	1-1/16	27	9/16	14	1/2	13	1.0	.5	6996	1225	9095	1593	10216	1789	4288	5813
72	1800	12	300	1-1/16	27	9/16	14	1/2	13	0.9	.5	7632	1337	9922	1738	10954	1918	5681	7702
78	1950	12	300	1-1/16	27	9/16	14	1/2	13	0.9	.5	8268	1448	10748	1882	11902	2084	7022	9520
84	2100	12	300	1-1/16	27	9/16	14	1/2	13	0.8	.5	8904	1559	11575	2027	12850	2250	8641	11715
96	2400	12	300	1-1/16	27	9/16	14	1/2	13	0.70	.5	10176	1782	13228	2317	14750	2538	13441	18223
102	2550	12	300	1-1/16	27	9/16	14	1/2	13	0.66	.5	10812	1893	14056	2462	15700	2749	16967	23003
108	2700	12	300	1-1/16	27	9/16	14	1/2	13	0.62	.5	11448	2005	14883	2606	16652	2916	21855	29630
120	3000	12	300	1-1/16	27	9/16	14	1/2	13	0.56	.5	12720	2228	16537	2896	18550	3249	29871	40498
132	3300	12	300	1-1/16	27	9/16	14	1/2	13	0.51	.5	13992	2450	18190	3185	20288	3553	33547	45481
144	3600	12	300	1-1/16	27	9/16	14	1/2	13	0.47	.5	15264	2673	19843	3475	22026	2857	42902	58164

*Items are normally furnished with "Filled Arch" construction.

NOTES:

A. MOVEMENT CAPABILITY

1. "Filled Arch" construction reduces above movement by 50%.
2. The degree of Angular Movement is based on the maximum extension shown.
3. If greater movements are desired, expansion joints can be supplied with two, three or four arches. Relatively longer "Face-to-Face" length dimensions are incorporated into designs of Multiple Arch Type expansion joints.
4. To calculate approximate movement of Multiple Arch expansion joints, take the movement shown in the above table and multiply by the number of arches.
5. Movements shown above are based on proper installation practice. (See Chapter VIII, Section D).

B. SPRING RATE

1. Forces required to move expansion joints are based on zero pressure conditions and room temperature in the pipe line.
2. These forces should be considered only as approximates which may vary with the elastomers and fabrics used in fabrication and the specific construction design of an individual manufacturer.
3. See Chapter III, Section F for definition of values shown.
4. To calculate the approximate Spring Rate for Multiple Arch Joints, divide the single arch values by the number of arches.
5. For Pressure Thrust Forces see Chapter VIII, Section A.2.

C. FORCE POUNDS

1. Is the force required to move an expansion joint its rated movement.
2. To calculate the force pounds required to move an expansion joint its rated movement: Multiply the rated movement by the corresponding spring rate.

Table VI: Typical Wide Arch Expansion Joint Movement/Spring Rate Capabilities

Nominal Pipe Size Expansion Joint		Nominal Face-to-face Minimum Length		MOVEMENTS								SPRING RATES							
				AXIAL COMPRESSION		AXIAL EXTENSION		LATERAL DEFLECTION		DEGREES OF ANGULAR MOVEMENT	DEGREES OF TORSIONAL MOVEMENT	AXIAL COMPRESSION		AXIAL EXTENSION		LATERAL DEFLECTION		ANGULAR MOVEMENT	
in	mm	in	mm	in	mm	in	mm	in	mm			lbs/in	N/mm	lbs/in	N/mm	lbs/in	N/mm	ft-lbs/ deg	Nm/deg
1*	25	6	150	3/4	19	7/16	11	5/8	16	34.4	3	176	31	228	39	262	46	.03	.04
1-1/4*	32	6	150	3/4	19	7/16	11	5/8	16	28.1	3	220	38	287	50	328	57	.075	.10
1-1/2	40	6	150	3/4	19	7/16	11	5/8	16	23.1	3	265	46	344	60	393	69	.11	.15
2	50	6	150	3/4	19	7/16	11	5/8	16	18.1	3	317	55	414	72	525	92	.22	.30
2-1/2	65	6	150	3/4	19	7/16	11	5/8	16	14.4	3	397	69	517	90	571	100	.375	.51
3	75	6	150	3/4	19	7/16	11	5/8	16	12.5	3	476	83	621	109	618	108	.60	.81
3-1/2	88	6	150	3/4	19	7/16	11	5/8	16	10.4	3	556	97	724	127	666	117	.975	1.32
4	100	6	150	3/4	19	7/16	11	5/8	16	9.4	3	636	111	828	145	714	125	1.425	1.93
5	125	6	150	3/4	19	7/16	11	5/8	16	7.5	3	793	139	1032	181	819	143	3	4
6	150	6	150	3/4	19	7/16	11	5/8	16	6.2	3	953	167	1239	217	925	162	5	7
8	200	6	150	1-3/16	30	11/16	17	5/8	16	6.9	3	1059	185	1378	241	1129	198	10	13
10	250	8	200	1-3/16	30	11/16	17	3/4	19	5.6	3	1324	232	1722	302	1213	212	18	24
12	300	8	200	1-3/16	30	11/16	17	3/4	19	4.7	3	1588	278	2066	362	1422	249	32	43
14	350	8	200	1-3/16	30	11/16	17	3/4	19	4.1	2	1390	243	1808	317	1675	293	14	19
16	400	8	200	1-3/16	30	11/16	17	3/4	19	3.4	2	1588	278	2066	362	1929	338	57	77
18	450	8	200	1-3/16	30	11/16	17	3/4	19	3.1	1	1786	313	2326	407	2130	373	80	108
20	500	8	200	1-7/16	37	3/4	19	3/4	19	3.1	1	1987	348	2580	452	2382	417	114	155
22	550	10	250	1-7/16	37	3/4	19	3/4	19	2.8	1	2185	383	2839	497	2472	433	154	209
24	600	10	250	1-7/16	37	3/4	19	3/4	19	2.5	1	2383	417	3097	542	2559	448	205	278
26	650	10	250	1-5/8	41	1	25	3/4	19	2.9	1	2295	402	2985	523	2743	480	219	297
28	700	10	250	1-5/8	41	1	25	3/4	19	2.5	1	2472	433	3214	563	2928	513	286	388
30	750	10	250	1-5/8	41	1	25	3/4	19	2.5	1	2649	464	3445	603	3112	545	328	445
32	800	10	250	1-5/8	41	1	25	3/4	19	2.2	1	2827	495	3674	643	3657	640	416	564
34	850	10	250	1-5/8	41	1	25	3/4	19	2.2	1	3001	525	4201	736	4201	736	484	656
36	900	10	250	1-5/8	41	1	25	3/4	19	1.9	1	3178	556	4134	724	4746	831	633	926
38	950	10	250	1-5/8	41	1	25	3/4	19	1.9	1	3356	588	4363	764	4876	854	707	959
40	1000	10	250	1-5/8	41	1	25	3/4	19	1.9	1	3531	618	4593	804	5007	877	781	1059
42	1050	12	300	1-7/8	48	1	25	3/4	19	1.9	1	3339	585	4337	759	5134	899	872	1182
44	1100	12	300	1-7/8	48	1	25	3/4	19	1.9	1	3498	613	4543	796	5356	938	952	1291
46	1150	12	300	1-7/8	48	1	25	3/4	19	1.6	1	3652	640	4754	832	5577	977	1260	1708
48	1200	12	300	1-7/8	48	1	25	3/4	19	1.6	1	3815	668	4956	868	5799	1016	1369	1856
50	1250	12	300	1-7/8	48	1	25	3/4	19	1.6	1	3975	696	5163	904	6018	1054	1476	2001
52	1300	12	300	1-7/8	48	1	25	3/4	19	1.6	1	4134	724	5374	941	6235	1092	1603	2173
54	1350	12	300	1-7/8	48	1	25	3/4	19	1.6	1	4293	752	5576	976	6454	1130	1731	2347
56	1400	12	300	1-7/8	48	1	25	3/4	19	1.6	1	4452	780	5787	1013	6672	1168	1848	2505
58	1450	12	300	1-7/8	48	1	25	3/4	19	1.2	1	4611	807	5994	1050	6888	1206	2482	3365
60	1500	12	300	1-7/8	48	1	25	3/4	19	1.2	1	4770	835	6201	1086	7104	1244	2653	3597
66	1650	12	300	1-7/8	48	1	25	3/4	19	1.2	1	5247	919	6821	1194	7662	1342	3216	4360
72	1800	12	300	1-7/8	48	1	25	3/4	19	1.1	.5	5724	1002	7441	1303	8215	1439	4261	5777
78	1950	12	300	1-7/8	48	1	25	3/4	19	1.1	.5	6201	1086	8061	1412	8926	1563	5266	7140
84	2100	12	300	1-7/8	48	1	25	3/4	19	1.0	.5	6678	1169	8681	1520	9637	1688	6481	8787
96	2400	12	300	1-7/8	48	1	25	3/4	19	.87	.5	7632	1337	9921	1737	11062	1937	10081	13668
102	2550	12	300	1-7/8	48	1	25	3/4	19	.82	.5	8109	1420	10542	1846	11775	2062	12725	17253
108	2700	12	300	1-7/8	48	1	25	3/4	19	.77	.5	8586	1503	11162	1955	12489	2187	16391	22223
120	3000	12	300	1-7/8	48	1	25	3/4	19	.70	.5	9540	1670	12403	2172	13912	2436	22403	30374
132	3300	12	300	1-7/8	48	1	25	3/4	19	.64	.5	10494	1838	13642	2389	15216	2665	25160	34112
144	3600	12	300	1-7/8	48	1	25	3/4	19	.59	.5	11448	2005	14882	2606	16519	2893	32176	43625

*Items are normally furnished with "Filled Arch" construction.

NOTES:

A. MOVEMENT CAPABILITY

1. *Filled Arch reduces movement.*
2. *The degree of Angular Movement is based on the maximum extension shown.*
3. *If greater movements are desired, expansion joints can be supplied with two, three or four arches. Relatively longer "Face-to-Face" length dimensions are incorporated into designs of Multiple Arch Type expansion joints.*
4. *To calculate approximate movement of Multiple Arch expansion joints, take the movement shown in the above table and multiply by the number of arches.*
5. *Movements shown above are based on proper installation practice. (See Chapter VIII, Section D).*

B. SPRING RATE

1. *Forces required to move expansion joints are based on zero pressure conditions and room temperature in the pipe line.*
2. *These forces should be considered only as approximates which may vary with the elastomers and fabrics used in fabrication and the specific construction design of an individual manufacturer.*
3. *See Chapter III, Section F for definition of values shown.*
4. *To calculate the approximate Spring Rate for Multiple Arch Joints, divide the single arch values by the number of arches.*
5. *For Pressure Thrust Forces see Chapter VIII, Section A.2.*

C. FORCE POUNDS

1. *Is the force required to move an expansion joint its rated movement.*

Appendix B: Common Flange Dimensions/Drilling Chart *(For: Expansion Joints, Rubber Pipe, Retaining Rings, Control Units)*

25/125/150 LB. DRILLING — 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

250/300 DRILLING — Specifications

ANSI B16.1-1975 Class 250
ANSI B16.24-1971 300 lb
ANSI B16.5-1973 Class300
MSS SP-44-1975 Class 300

NAVY DRILLING — Specifications

MIL-F-20042C - 50 lb.
MIL-F 20042C - 150 lb
BU Ships Drawing B.176

NOMINAL PIPE SIZE EXPANSION JOINT I.D.	25/125/150 LB. DRILLING: COMMON SIZE O.D.	B.C.	No. Of Holes	BOLT HOLE SIZE, Drilling Column A	B	C	D	E	250/300 DRILLING O.D.	B.C.	No. Of Holes	Hole Dia.	NAVY DRILLING O.D.	B.C.	No. Of Holes	Hole Dia.
1/4	2-1/2	1-11/16	4	7/16									3-1/4	2-1/8	3	9/16
3/8	2-1/2	1-11/16	4	7/16				9/16					3-3/8	2-1/4	3	9/16
1/2	3-1/2	2-3/8	4	5/8		5/8		9/16	3-3/4	2-5/8	4	5/8	3-9/16	2-7/16	3	9/16
3/4	3-7/8	2-3/4	4	5/8		5/8			4-5/8	3-1/4	4	3/4	3-13/16	2-11/16	4	9/16
1	4-1/4	3-1/8	4	5/8		5/8			4-7/8	3-1/2	4	3/4	4-1/4	3-1/8	4	9/16
1-1/4	4-5/8	3-1/2	4	5/8		5/8			5-1/4	3-7/8	4	3/4	4-1/2	3-3/8	4	9/16
1-1/2	5	3-7/8	4	5/8		5/8		5/8	6-1/8	4-1/2	4	7/8	5-1/16	3-15/16	6	9/16
2	6	4-3/4	4	3/4		3/4		3/4	6-1/2	5	8	3/4	5-9/16	4-7/16	6	9/16
2-1/2	7	5-1/2	4	3/4		3/4		3/4	7-1/2	5-7/8	8	7/8	6-1/8	5	6	9/16
3	7-1/2	6	4	3/4		3/4		3/4	8-1/4	6-5/8	8	7/8	6-5/8	5-1/2	8	9/16
3-1/2	8-1/2	7	8	3/4		3/4			9	7-1/4	8	7/8	7-3/16	6-1/16	8	9/16
4	9	7-1/2	8	3/4	3/4	3/4	3/4	3/4	10	7-7/8	8	7/8	7-11/16	6-9/16	8	9/16
4-1/2	9-1/4	7-3/4	8					7/8					8-3/16	7-1/16	10	9/16
5	10	8-1/2	8	7/8	3/4	7/8	3/4	7/8	11	9-1/4	8	7/8	9-1/16	7-13/16	10	11/16
5-1/2													9-9/16	8-5/16	10	11/16
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	10-1/8	8-7/8	12	11/16
6-1/2													10-5/8	9-3/8	12	11/16
7	12-1/2	10-3/4	8					7/8					11-5/16	10	12	11/16
7-1/2													11-7/8	10-9/16	12	11/16
8	13-1/2	11-3/4	8	7/8	3/4	7/8	3/4	7/8	15	13	12	1	12-3/8	11-1/16	14	11/16
8-1/2													12-15/16	11-5/8	14	11/16
9	15	13-1/4	12					7/8					13-15/16	12-3/8	14	13/16
9-1/2													14-1/2	12-15/16	14	13/16
10	16	14-1/4	12	1	3/4	1	3/4	1	17-1/2	15-1/4	16	1-1/8	15	13-7/16	15	13/16
11													16-9/16	15	16	13/16
12	19	17	12	1	3/4	1	3/4	1	20-1/2	17-3/4	16	1-1/4	17-5/8	16-1/16	18	13/16
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	19-1/8	17-3/8	19	15/16
15	22-1/4	20	16					1-1/8								
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	21-3/16	19-7/16	20	15/16
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	23-1/4	21-1/2	22	15/16
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	25-13/16	23-13/16	24	1-1/16
22	29-1/2	27-1/4	20			1-3/8	7/8	1-3/8	33	29-1/4	24	1-5/8	27-7/8	25-7/8	26	1-1/16
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	30	28	28	1-1/16
25													31-1/2	29-1/4	29	1-3/16
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	32-9/16	30-6/16	30	1-3/16
28	36-1/2	34	28			1-3/8	7/8	1-3/8	40-3/4	37	28	1-3/4	34-11/16	32-7/16	32	1-3/16
30	38-3/4	36	28	1-3/8	1	1-3/8	1	1-1/2	43	39-1/4	28	2*	36-13/16	34-9/16	35	1-3/16
32	41-3/4	38-1/2	28			1-5/8	1	1-5/8	45-1/4	41-1/2	28	2	39	36-3/4	36	1-3/16
33													40	37-3/4	36	1-3/16
34	43-3/4	40-1/2	32			1-5/8	1	1-5/8	47-1/2	43-1/2	28	2	41	38-3/4	36	1-3/16
35													42-7/8	40-3/8	36	1-5/16
36	46	42-3/4	32	1-5/8	1	1-5/8	1	1-5/8	50	46	32	2-1/4*	43-7/8	41-3/8	36	1-5/16
38	48-3/4	45-1/4	32			1-5/8	1	1-3/4	56	43	32	1-5/8	46-1/8	43-5/8	36	1-5/16
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	48-1/8	45-5/8	36	1-5/16
42	53	49-1/2	36			1-5/8	1-1/8	1-3/4	57*	52-3/4*	36*	2-1/4*	50-1/4	47-3/4	38	1-5/16
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	54-1/2	52	40	1-5/16
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	75-3/4	71-3/4	52					2								
64	78	74	52					2								
66	80	76	52			1-7/8	1-3/8	2								
68	82-1/4	78-1/4	56					2								
70	84-1/4	80-1/2	56					2								
72	86-1/2	82-1/2	60	2	1-1/4	1-7/8	1-3/8	2								
74	88-1/2	84-1/2	60					2								
76	90-3/4	86-1/2	60					2								
784	93	89	64			2-1/8	1-5/8									
80	95-1/4	91	60					2-1/8								
82	97-1/2	93-1/4	60					2-1/8								
84	99-3/4	95-1/2	64	2-1/4	1-3/8	2-1/8	1-5/8	2-1/8								
86	102	97-3/4	64					2-1/8								
88	104-1/4	100	68					2-1/8								
904	106-1/2	102	68			2-3/8	1-7/8									
92	108-3/4	104-1/2	68					2-1/4								
94	111	106-1/4	68					2-1/4								
96	113-1/4	108-1/2	68	2-1/4	1-3/8	2-3/8	1-7/8	2-3/8								
98	115-1/2	110-3/4	68					2-3/8								
100	117-3/4	113	68					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									

*DIMENSIONS SHOWN DO NOT MEET SMM SP-44

NOTICE:
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. NEE 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".

Appendix C: Control Unit Dimensions and Ratings

CONTROL UNIT						Nominal Pipe Size Exp. Jt. ID		MAXIMUM SURGE OR TEST PRESSURE OF THE SYSTEMS				
Plate Thickness		Rod Diameter		Standard Control Unit Assembly of:				Number of Control Rods Recommended				
in.	mm	in.	mm	Rods	Plates	in.	mm	2	3	4	6	8
3/8	10	1/2	13	2	4	1/2	15	1328	•	•	•	•
3/8	10	1/2	13	2	4	3/4	20	1106	•	•	•	•
3/8	10	1/2	13	2	4	1	25	949	•	•	•	•
3/8	10	1/2	13	2	4	1-1/4	32	830	•	•	•	•
3/8	10	1/2	13	2	4	1-1/2	40	510	•	•	•	•
3/8	10	5/8	16	2	4	2	50	661	•	•	•	•
3/8	10	5/8	16	2	4	2-1/2	65	529	•	•	•	•
3/8	10	5/8	16	2	4	3	75	441	•	•	•	•
3/8	10	5/8	16	2	4	3-1/2	88	365	547	729	•	•
3/8	10	5/8	16	2	4	4	100	311	467	622	•	•
3/8	10	5/8	16	2	4	5	125	235	353	470	•	•
1/2	13	5/8	16	2	4	6	150	186	278	371	•	•
1/2	13	3/4	19	2	4	8	200	163	244	326	•	•
3/4	19	7/8	22	2	4	10	250	163	244	325	488	•
3/4	19	1	25	2	4	12	300	160	240	320	481	•
3/4	19	1	25	2	4	14	350	112	167	223	335	•
3/4	19	1-1/8	29	2	4	16	400	113	170	227	340	453
3/4	19	1-1/8	29	2	4	18	450	94	141	187	281	375
3/4	19	1-1/8	29	2	4	20	500	79	118	158	236	315
1	25	1-1/4	32	2	4	22	550	85	128	171	256	342
1	25	1-1/4	32	2	4	24	600	74	110	147	221	294
1	25	1-1/4	32	2	4	26	650	62	93	124	186	248
1-1/4	32	1-3/8	35	2	4	28	700	65	98	130	195	261
1-1/4	32	1-1/2	38	2	4	30	750	70	105	141	211	281
1-1/4	32	1-1/2	38	2	4	32	800	63	94	125	188	251
1-1/2	38	1-5/8	41	2	4	34	850	72	107	143	215	286
1-1/2	38	1-3/4	44	2	4	36	900	69	103	138	207	276
1-1/2	38	1-3/4	44	2	4	38	950	63	94	125	188	251
1-1/2	38	1-1/2	38	3	6	40	1000	42	63	85	127	169
1-1/2	38	1-5/8	41	3	6	42	1050	48	72	96	144	192
1-1/2	38	1-5/8	41	3	6	44	1100	44	66	88	133	177
1-1/2	38	1-5/8	41	3	6	46	1150	41	61	82	122	163
1-1/2	38	1-5/8	41	3	6	48	1200	40	60	81	121	161
1-1/2	38	1-5/8	41	3	6	50	1250	37	56	75	112	150
1-1/2	38	1-5/8	41	3	6	52	1300	35	53	70	105	140
1-1/2	38	2	51	3	6	54	1350	43	64	86	128	171
1-1/2	38	2	51	3	6	56	1400	40	60	80	120	160
1-1/2	38	2	51	3	6	58	1450	38	56	75	113	150
1-3/4	44	2	51	3	6	60	1500	35	53	71	106	141
1-3/4	44	2	51	4	8	62	1550	33	50	66	100	133
1-7/8	48	2	51	4	8	66	1650	30	44	59	89	119
1-7/8	48	2	51	4	8	72	1800	25	38	50	75	101
2	51	2-1/4	57	4	8	78	1950	28	42	56	84	112
2-1/4	57	2-1/4	57	4	8	84	2100	24	37	49	73	98
2-1/2	63	2-1/2	63	4	8	90	2250	26	40	53	79	106
2-1/2	63	2-3/4	70	4	8	96	2400	29	43	58	86	115
2-1/2	63	2-3/4	70	4	8	102	2550	25	33	51	76	102
2-1/2	63	2-3/4	70	4	8	108	2700	23	34	46	75	92
2-1/2	63	2-3/4	70	4	8	120	3000	18	28	37	56	75
2-1/2	63	2-3/4	70	4	8	132	3300	15	23	31	46	62
2-1/2	63	2-3/4	70	6	12	144	3600	13	19	26	39	52

NOTICE:
1. NMEJ Division recommended plate thickness and rod diameter based in a yield strength of 36,000 PSI (248,211 kPa) with a maximum allowable stress of 23,400 PSI (161,337 kPa)(65% of yield.) Rod and plate load based on thrust, calculated using diameter "D." See Figure 4 and Chapter VIII, Section A.2. Dimensions can vary with a manufacturer's grade of steel and material.
2. A "Standard Control Unit Assembly" is generally furnished when ordered. If specifications and/or order does not call out a specific number of control rods or a design/test pressure of system.
3. For Control Unit length see Appendix D.
4. Pressures listed above do not relate to the actual design pressure of the expansion joint products (see Table IV), but are the maximum pressure for a specific control rod number/dimension.
5. All values based upon arch height of 2-1/2 inches (63.5 mm).
6. Reducer Type (Taper) Expansion Joints may require specially designed control rod assemblies; i.e.

Appendix D: Mating Flange Thickness

NOMINAL PIPE SIZE		ANSI B16.1 CLASS 25	ANSI B16.1 CLASS 125	ANSI B16.24 150LB CLASS 25	ANSI B16.5 CLASS 150	AWWA C207 TABLE 1, CLASS B	AWWA C207 TABLE 1, CLASS D	AWWA C207 TBL 2, CLASS A&B	AWWA C207 TABLE 3, CLASS E	MSS SP-44 CLASS 150
in.	mm									
1/4	5	•	•	9/32	•	•	•	•	•	•
3/8	10	•	•	9/32	•	•	•	•	•	•
1/2	15	•	•	5/16	7/16	•	•	•	7/16	•
3/4	20	•	•	11/32	1/2	•	•	•	1/2	•
1	25	•	7/16	3/8	9/16	•	•	•	9/16	•
1-1/4	32	•	1/2	13/32	5/8	•	•	•	5/8	•
1-1/2	40	•	9/16	7/16	11/16	•	•	•	11/16	•
2	50	•	5/8	1/2	3/4	•	•	•	3/4	•
2-1/2	65	•	11/16	9/16	7/8	•	•	•	7/8	•
3	75	•	3/4	5/8	15/16	•	•	•	15/16	•
3-1/2	88	•	13/16	11/16	15/16	•	•	•	15/16	•
4	100	3/4	15/16	11/16	15/16	•	•	•	15/16	•
5	125	3/4	15/16	3/4	15/16	5/8	5/8	1/2	15/16	•
6	150	3/4	1	13/16	1	11/16	11/16	9/16	1	•
8	200	3/4	1-1/8	15/16	1-1/8	11/16	11/16	9/16	1-1/8	•
10	250	7/8	1-3/16	1	1-3/16	11/16	11/16	11/16	1-3/16	•
12	300	1	1-1/4	1-1/16	1-1/4	11/16	13/16	11-16	1-1/4	1-1/4
14	350	1-1/8	1-3/8	•	1-3/8	11/16	15/16	3/4	1-3/8	1-3/8
16	400	1-1/8	1-7/16	•	1-7/16	11/16	1	3/4	1-7/16	1-7/16
18	450	1-1/4	1-9/16	•	1-9/16	11/16	1-1/16	3/4	1-9/16	1-9/16
20	500	1-1/4	1-11/16	•	1-11/16	11/16	1-1/8	3/4	1-11/16	1-11/16
22	550	•	•	•	•	3/4	1-3/16	1	•	1-13/16
24	600	1-3/8	1-7/8	•	1-7/8	3/4	1-1/4	1	1-7/8	1-7/8
26	650	•	•	•	•	13/16	1-5/16	1	2	2-11/16
28	700	•	•	•	•	7/8	1-5/16	1	2-1/16	2-13/16
30	750	1-1/2	2-1/8	•	•	7/8	1-3/8	1	2-1/8	2-15/16
32	800	•	•	•	•	15/16	1-1/2	1-1/8	2-1/4	3-3/16
34	850	•	•	•	•	15/16	1-1/2	1-1/8	2-5/16	3-1/4
36	900	1-5/8	2-3/8	•	•	1	1-5/8	1-1/8	2-3/8	3-9-16
38	950	•	•	•	•	1	1-5/8	1-1/8	2-3/8	3-7/16
40	1000	•	•	•	•	1	1-5/8	1-1/8	2-1/2	3-9/16
42	1050	1-3/4	2-5/8	•	•	1-1/8	1-3/4	1-1/4	2-5/8	3-13/16
44	1100	•	•	•	•	1-1/8	1-3/4	1-1/4	2-5/8	4
46	1150	•	•	•	•	1-1/8	1-3/4	1-1/4	2-11/16	4-1/16
48	1200	2	2-3/4	•	•	1-1/4	1-3/4	1-3/8	2-3/4	4-1/4
50	1250	•	•	•	•	1-1/4	2	1-3/8	2-3/4	4-3/8
52	1300	•	•	•	•	1-1/4	2	1-3/8	2-7/8	4-9/16
54	1350	2-1/4	3	•	•	1-3/8	2-1/8	1-3/8	3	4-3/4
56	1400	•	•	•	•	•	•	•	•	4-7/8
58	1450	•	•	•	•	•	•	•	•	5-1/16
60	1500	2-1/4	3-1/8	•	•	1-1/2	2-1/4	1-1/2	3-1/8	5-3/16
66	1650	•	•	•	•	1-5/8	2-1/2	1-1/2	3-3/8	•
72	1800	2-1/2	3-1/2	•	•	1-3/4	2-5/8	1-1/2	3-1/2	•
78	1950	•	•	•	•	2	2-3/4	1-3/4	3-7/8	•
84	2100	2-3/4	3-7/8	•	•	2	2-3/4	1-3/4	3-7/8	•
96	2400	3	4-1/4	•	•	2-1/4	3	2	4-1/4	•
102	2550	•	•	•	•	2-1/2	3-1/4	2-1/4	4-5/8	•
108	2700	•	•	•	•	2-1/2	3-1/4	2-1/4	4-5/8	•
120	3000	•	•	•	•	2-3/4	3-1/2	2-1/2	5	•
132	3300	•	•	•	•	3	3-3/4	2-3/4	5-3/8	•
144	3600	•	•	•	•	3-1/4	4	3	5-3/4	•

NOTICE:
1. When ordering/specifying control units, always note the mating flange thickness or specification. In the absence of this data, control units will be sized to flanges meeting ANSI B16.5 or AWWA C207 Table 3, Class E.
2. 3 or more rods are better for 20" or higher as minimum.

A. DEFINITION:

Molded spherical expansion joints incorporate the movement and vibration dampening capability of a spool joint into a compact and robust device. Spherical joints are available in several sizes and variations. The distinguishing features of the spherical joints are the shape of the body, floating flanges and the beaded seal.

The more common configurations include the single sphere, double sphere and double sphere union. The double sphere is for applications requiring greater movement than a single sphere, while double sphere unions are installed in smaller-sized threaded pipe applications.

B. FUNCTIONS:

Applications requiring vibration or sound dampening are good candidates for spherical joints. These joints are commonly installed as pump and equipment connectors to acoustically isolate rotating equipment from system piping.

Spherical joints are designed for installation in metallic piping systems only; however, the medium carried by the pipe can vary widely. Several types of rubber are available to accommodate different pressures, temperatures and pipe media. Common rubber compounds include EPDM, Neoprene, Butyl and Nitrile.

C. ADVANTAGES:

Spherical joints have a distinct advantage over metallic expansion joints for corrosive applications and installations requiring a high cycle life. The contour prevents sediment accumulation and creates less turbulence and pressure drop than spool joints.

The seal bead eliminates any requirement for gaskets between mating flanges. Spheres may be installed on raised-face or flat-face flanges.

D. CONSTRUCTION DETAILS:

Spheres are a very strong yet flexible expansion joint. The shape is inherently stronger than a spool joint, and results in uniform pressure distribution throughout the wall. The inner tube incorporates several plies of nylon cord reinforcing mesh for added strength. The inner tube and outer cover may be constructed of different rubber compounds if required.

When incorporated with the specially-designed floating flanges, the bead design provides a robust and resilient sealing system for the life of the joint. The seal bead is partially recessed into the flange when installed, and will typically include a reinforcing cable to hold the bead in place. Flanges are specially designed to clamp the bead without damaging the rubber, while also securing the bead from pulling out of the mating flanges. Standard flanges have class 150 drillings, but manufacturers offer several options for projects that require different drillings.

Double spheres have similar construction and performance, but to provide greater movement this style incorporates a second arch and an external reinforcing root ring. This ring may not be necessary for the smaller double sphere union design.

E. TYPES:

E.1. *Single Sphere.*

Table VII.A: Molded Spherical Type Expansion Joints with Solid Floating Flanges

Sizes • Movements • Pressure • Flange Standards • Weights

Nominal		Standard Flange Bolting Dimensions				Capability: From Neutral Position				Pressure		Wt./Lbs.
Pipe Size I.D. Inches	Neutral Length Inches	Fig. O.D. Inches	Bolt Circle Inches	No. of Holes Inches	Bolt Hole Dia. Inches	Axial Compression Inches	Axial Extension Inches	± Lateral Deflection Inches	± Angular Deflection Degrees	Positive PSIG	Vacuum In. Hg	Weight Joint & Flanges
1.25	6	4.63	3.50	4	0.625	0.500	0.375	0.500	31	225	26	5.0
1.5	6	5.0	3.88	4	0.625	0.500	0.375	0.500	27	225	26	6.0
2	6	6.0	4.75	4	0.750	0.500	0.375	0.500	20	225	26	9.0
2.5	6	7.0	5.50	4	0.750	0.500	0.375	0.500	17	225	26	12.0
3	6	7.5	6.00	4	0.750	0.500	0.375	0.500	14	225	26	14.0
4	6	9.0	7.50	8	0.750	0.625	0.375	0.500	14	225	26	18.0
5	6	10.0	8.50	8	0.875	0.625	0.375	0.500	11	225	26	22.0
6	6	11.0	9.50	8	0.875	0.625	0.375	0.500	9	225	26	27.0
8	6	13.5	11.75	8	0.875	0.625	0.375	0.500	8	225	26	40.0
10	6	16.0	14.25	12	1.000	0.750	0.500	0.750	7	225	26	56.0
12	8	19.0	17.00	12	1.000	0.750	0.500	0.750	6	225	26	83.0
14	8	21.0	18.75	12	1.125	1.000	0.625	0.750	5	150	20	115.0
16	8	23.5	21.25	16	1.125	1.000	0.625	0.750	4	125	20	165.0
18	8	25.0	22.75	16	1.250	1.000	0.625	0.750	4	125	15	168.0
20	8	27.5	25.00	20	1.250	1.000	0.625	0.750	3	125	15	170.0
24	10	32.5	31.75	20	1.375	1.000	0.625	0.750	3	110	15	255.0

Notes:

1. *Pressure ratings are based on 170°F operating temperature. The pressure ratings are reduced slightly at higher temperatures.*
2. *Pressures shown are recommended "operating pressures" and are based on a minimum safety factor of 3.1.*
3. *Vacuum ratings are based on neutral installed length, without external load.*
4. *All expansion joints are furnished complete with flanges. Control units are recommended on applications where movements could exceed rated capabilities. (See Chapter IV of the Non-Metallic Expansion Joints and Flexible Pipe Connectors Technical Handbook, Sixth Edition).*
5. *All dimensions are in inches. All weights are in pounds.*
6. *Movements stated are non-concurrent.*

E.2. *Double Sphere.*

Table VII. B: Molded Double Spherical Type Expansion Joints with Solid Floating Flanges

Sizes • Movements • Pressure • Flange Standards • Weights

Nominal		Standard Flange Bolting Dimensions				Capability: From Neutral Position				Pressure		Wt./Lbs.
Pipe Size I.D. Inches	Neutral Length Inches	Fig. O.D. Inches	Bolt Circle Inches	No. of Holes Inches	Bolt Hole Dia. Inches	Axial Compression Inches	Axial Extension Inches	± Lateral Deflection Inches	± Angular Deflection Degrees	Positive PSIG	Vacuum In. Hg	Weight Joint & Flanges
2	7	6.0	4.75	4	0.750	2.000	1.000	0.500	45	225	26	9.0
2.5	7	7.0	5.50	4	0.750	2.000	1.000	0.500	43	225	26	13.0
3	7	7.5	6.00	4	0.750	2.000	1.000	0.500	38	225	26	15.0
4	9	9.0	7.50	8	0.750	2.000	1.375	0.500	34	225	26	20.0
5	9	10.0	8.50	8	0.875	2.000	1.375	0.500	29	225	26	25.0
6	9	11.0	9.50	8	0.875	2.000	1.375	0.500	25	225	26	30.0
8	13	13.5	11.75	8	0.875	2.375	1.375	0.500	19	225	26	44.0
10	13	16.0	14.25	12	1.000	2.375	1.500	0.750	15	225	15	66.0
12	13	19.0	17.00	12	1.000	2.375	1.500	0.750	13	225	15	95.0
14	13.75	21.0	18.75	12	1.125	2.375	1.500	0.750	12	150	15	124.0

Notes:

1. *Pressure ratings are based on 170°F operating temperature. The pressure ratings are reduced slightly at higher temperatures.*
2. *Pressures shown are recommended "operating pressures" and are based on a minimum safety factor of 3.1.*
3. *Vacuum ratings are based on neutral installed length, without external load.*
4. *All expansion joints are furnished complete with flanges and stabilizing ring. Control units are recommended on applications where movements could exceed rated capabilities. (See Chapter IV of the Non-Metallic Expansion Joints and Flexible Pipe Connectors Technical Handbook, Sixth Edition).*
5. *All dimensions are in inches. All weights are in pounds.*
6. *Movements stated are non-concurrent.*

E.3. *Double Sphere.*

Table VII.C: Double Sphere with Union Ends

Nominal		Movements					Pressure		Wt./Lbs.
DIA	F/F	Compression Inches	Extension Inches	Lateral Inches	Angular Inches	Torque Inches	Positive PSIG	Vacuum In. Hg	Weights w/ Unions
0.75	8	0.875	0.25	0.875	36	4.8	150	26	2.2
1	8	0.875	0.25	0.875	30	3.7	150	26	2.8
1.25	8	0.875	0.25	0.875	27	3	150	26	3.7
1.5	8	0.875	0.25	0.875	25	2.5	150	26	4.7
2	8	0.875	0.25	0.875	21	2	150	26	6.8
2.5	8	0.875	0.25	0.875	13	1.9	150	26	9.7
3	8	0.875	0.25	0.875	12	1.8	150	26	12.3

Notes:

A. Movement Capability
   1. The degree of Angular Movement is based on the maximum extension shown.
   2. Movements shown are non-concurrent.

B. Pressures
   1. Pressure ratings are based on an operating temperature of 180°F.

FOREWORD:

Another non-metallic type of expansion joint is available, manufactured of Fluoroplastic. This type of expansion joint has been used with highly corrosive medias, with glass or plastic piping or in heating, ventilating and air conditioning applications, where space is a premium.

A. DEFINITION:

A flexible Fluoroplastic pipe connector is a 2 or more convolution expansion joint consisting of a member of FEP, PTFE or PFA, reinforced with metal rings and attached with ductile iron flanges, designed to absorb movement and vibration in a piping system.

B. PERFORMANCE CHARACTERISTICS:

B.1. *Chemical Resistance.* Molded or machined Fluoroplastic connectors are used in corrosive applications due to the inherent resistance of Fluoroplastic to a vast range of chemicals.

B.2. *Vibration Absorption.* Fluoroplastic connectors are sometimes used in HVAC applications to absorb vibration and attenuate noise.

B.3. *Temperature Limits.* Fluoroplastic connectors can withstand temperatures as high as 450°F and as low as - 100°F. Note: Temperatures of the system significantly affect the pressure rating of the connectors.

B.4. *Pressure Limits.* Pressures vary widely depending upon system temperature. Consult each manufacturer for its specific pressure/temperature relationship. See Tables VIII, IX and X.

C. CONSTRUCTION DETAIL:

C.1. *Body.* The body of the Fluoroplastic connectors are manufactured of 100% FEP, PTFE or PFA Fluoroplastic, which may be colored or opaque/clear depending upon the manufacturer.

C.2. *Reinforcing Rings.* Metal reinforcing rings of stainless steel, Monel or other metals may be used to add strength between the convolutions.

C.3. *Flanges.* The flanges are normally manufactured of ductile iron, coated or plated with a rust inhibiting paint. Flanges of other materials are available upon request. The flanges are normally drilled with ANSI B16.5 150# tapped holes. Some manufacturers also provide drilling for glass pipe flange bolting (Corning Style #2). See Figure 9.

C.4. *Control Rods.* All connectors are supplied with factory set control rods. The control rods are set to prevent over- extension during operation.

C.5. *Stabilizing Rings.* Some manufacturers offer styles of expansion joints with stabilizing rings to prevent squirm.

C.6. *Liners.* Internal sleeves are sometimes available for abrasive or high velocity flow rate applications. Consult each manufacturer for information.

D. DIMENSIONS:

Connectors are available in nominal pipe sizes from 1" to 24" diameter. The installed neutral lengths vary from manufacturer to manufacturer. See Tables VIII, IX and X.

E. TYPES OF CONNECTORS:

E.1. *Coupling.* A two convolution connector designed for minimum movements. See Figure 8A and Table VIII.

E.2. *Expansion Joint.* A three convolution connector designed for easy movement and ease of system installation. See Figure 8B and Table IX.

E.3. *Bellows.* A five convolution connector designed for maximum movements and vibration elimination. See Figure 8C and Table X.

Figure 8A: Coupling

Figure 8B: Expansion Joint

Figure 8C: Bellows

CHAPTER IV

Table VIII: Coupling, 2 Convolutions

NOMINAL PIPE SIZE [1]	TYPICAL MOVEMENTS [2]			TYPICAL PRESSURES AT VARIOUS TEMPERATURES [3]		
	Maxi Axial	Maxi Lateral Move	Maxi Angular Move			
(inches)	(inches)	(inches)	(Degrees)	150°F (PSI)	250°F (PSI)	350°F (PSI)
1	1/4	1/8	31	150	115	85
1-1/4	1/4	1/8	24	150	115	85
1-1/2	1/4	1/8	20	150	115	85
2	1/4	1/8	15	150	115	85
2-1/2	3/8	1/8	15	150	115	85
3	3/8	3/16	15	150	115	85
4	1/2	1/4	15	150	115	85
5	1/2	1/4	12	150	115	85
6	1/2	1/4	10	150	115	85
8	1/2	1/4	7	130	100	75
10	1/2	1/4	6	130	100	75
12	1/2	1/4	5	45	35	30

Table IX: Expansion Joint, 3 Convolutions

NOMINAL PIPE SIZE [1]	TYPICAL MOVEMENTS [2]			TYPICAL PRESSURES AT VARIOUS TEMPERATURES [3]		
	Maxi Axial	Maxi Lateral Move	Maxi Angular Move			
(inches)	(inches)	(inches)	(Degrees)	150°F (PSI)	250°F (PSI)	350°F (PSI)
1	1/2	1/4	45	105	75	55
1-1/4	1/2	1/4	38	105	75	55
1-1/2	1/2	1/4	33	105	75	55
2	3/4	3/8	36	105	75	55
2-1/2	3/4	3/8	31	105	75	55
3	1	1/2	33	105	75	55
4	1	1/2	26	105	75	55
5	1-1/8	1/2	24	105	75	55
6	1-1/8	9/16	20	105	75	55
8	1-1/8	9/16	15	90	65	45
10	1-1/8	3/8	12	90	65	45
12	1-3/16	5/16	11	55	35	20

Notes:

1. Neutral Lengths: Installed Neutral Lengths vary from manufacturer to manufacturer. Consult each manufacturer for its standard neutral length.

2. Movements: Axial, Lateral and Angular movements vary slightly by manufacturer. The above figures are typical movements; however, consult each manufacturer's literature for specific movements.

3. Temperature/Pressure: The working pressure of various temperatures vary slightly by manufacturer. The above figures are typical, however, consult each manufacturer's literature for specific pressure.

F. ANCHORING:

Fluoroplastic connectors should always be installed in piping systems which are properly anchored and guided. The connectors should be protected from movements which are greater than that for which they are designed.

G. INSTALLATION AND MAINTENANCE:

A great deal of the information in Chapter IV. Section D applies to Fluoroplastic connectors. Since the connectors have a Fluoroplastic flange, no other sealing device, such as a gasket, is required. Remove flange covers only when ready to install. Thread the installation bolts from the mating flange side and be sure bolts do not extend beyond the bellows flange. No nuts are required.

Note: See Chapter II, A.4. for information on Teflon Lined Rubber Expansion Joints.

Protective shields are recommended to protect personnel from splash. See Chapter VI, C.

Table X: Bellows, 5 Convolutions

NOMINAL PIPE SIZE [1]	TYPICAL MOVEMENTS [2]			TYPICAL PRESSURES AT VARIOUS TEMPERATURES [3,4]		
	Maxi Axial	Maxi Lateral Move	Maxi Angular Move			
(inches)	(inches)	(inches)	(Degrees)	150°F (PSI)	250°F (PSI)	350°F (PSI)
1	1/2	1/2	45	48	35	28
1-1/4	3/4	1/2	45	48	35	28
1-1/2	3/4	1/2	45	48	35	28
2	1	1/2	45	48	35	28
2-1/2	1	1/2	38	48	35	28
3	1	1/2	33	48	35	28
4	1-1/4	5/8	32	48	35	28
5	1-1/4	5/8	26	48	35	28
6	1-1/4	5/8	22	48	35	28
8	1-3/4	5/8	23	30	17	10
10	1-3/4	5/8	19	30	17	10
12	2	5/8	18	30	17	10

Notes:

1. Neutral Lengths: Installed Neutral Lengths vary from manufacturer to manufacturer. Consult each manufacturer for its standard neutral length.

2. Movements: Axial, Lateral and Angular movements vary slightly by manufacturer. The above figures are typical movements; however, consult each manufacturer's literature for specific movements.

3. Temperature/Pressure: The working pressure of various temperatures vary slightly by manufacturer. The above figures are typical, however, consult each manufacturer's literature for specific pressure.

4. Vacuum: Not usually recommended for vacuum service.

Figure 9: *All Ductile Iron or Metal Joint Flange*

FOREWORD:

The four previous chapters have dealt primarily with rubber expansion joints manufactured in single or multiple arch type designs. This design provides substantial flexibility to allow the expansion joint to absorb pipe movements, whether induced by thermal changes or other mechanical means. In certain applications, the features provided by arch-type construction may not be of paramount importance, and it is possible to manufacture no-arch-type expansion joints. It is more common, however, to specify flanged pipe connectors having a substantially longer length than an expansion joint of the same pipe size, and this chapter will consider the construction, usage and dimensions of these pipe connectors.

A. DEFINITION:

A flexible rubber pipe connector is a reinforced straight rubber pipe, fabricated of natural or synthetic elastomers and fabrics, primarily designed to absorb noise and vibration in a piping system.

B. PERFORMANCE CHARACTERISTICS:

B.1. *Sound Limiting Characteristics.*

Rubber pipe connectors are used in air-conditioning and heating installations because of their ability to limit or interrupt the transmission of sound from operating equipment to the piping system. See Appendixes F and G.

B.2. *Pressure/Temperature Limits.*

Flexible rubber pipe can be furnished in either 150 PSIG or 250 PSIG working pressure designs at different temperature ratings. See Tables I and II for standard material types and temperature limits.

B.3. *Resistance to Fluids.*

Rubber pipe corrosion resistance is the same as for elastomeric expansion joints. See Chapter VII, Section E and Table II.

C. CONSTRUCTION DETAIL:

C.1. *Tube, Cover and Carcass.*

Details concerning the tube, cover and carcass fabric reinforcement are the same as for expansion joints. See Chapter I, Section D and Figure 7A.

C.2. *Metal Reinforcement.*

Helical-wound, steel reinforcement wire is imbedded in the carcass to provide strength for high pressure operations and to prevent collapse under vacuum. See Figure 7A.

Figure 7A: *Flanged Type Rubber Pipe*

D. TYPES OF PIPE CONNECTORS:

D.1. *Flanged Type.*

The most common type of rubber pipe incorporates a full face flange integral with the body of the pipe. The flange is drilled to conform to the bolt pattern of the companion metal flanges of the pipeline. (See Appendix B.) This type of a rubber-faced flange, backed with a retaining ring, is of sufficient thickness to form a tight seal against the companion flange without the use of a gasket.

D.2. *Floating Flange Type.*

Similar to the flanged type. Instead of having a full-face rubber flange, this design has a solid floating metallic flange or a split interlocking flange. The Van Stone flange principle is used with the beads of the rubber part specifically designed to fit the mating pipe flange. See Figure 7B.

Figure 7B: *Coupled Type Rubber Pipe Connector*

E. ANCHORING AND CONTROL UNITS:

Flexible rubber connectors should always be installed in piping systems that are properly anchored so that the connectors are not required to absorb compression or elongation piping movements. If axial forces can act in the system to compress or elongate the connector, control units will be required to prevent axial movement. In general, control units are always recommended as an additional safety factor, preventing damage to the connector and associated equipment. See Chapter IV, Section B, and Appendixes C and D.

F. INSTALLATION AND MAINTENANCE:

The information in chapter IV, Section D applies to flexible pipe connectors as well as expansion joints. See Chapter VIII, Section D.

Table XI: Rubber pipe connectors. Available Sizes and Suggested Length-to-Face Lengths.

Nominal Pipe Size Connector Inside Diameter		Recommended Face-to-Face "F" Dimensions	
in	mm	in	mm
1/2	15	12	305
3/4	20	12	305
1	25	12	305
1-1/4	30	12	305
1-1/2	40	12	305
2	50	12	305
2-1/2	65	12	305
3	75	18	457
3-1/2	90	18	457
4	100	18	457
5	125	24	610
6	150	24	610
8	200	24	610
10	250	24	610
12	300	24	610
14	350	24	610
16	400	24	610
18	450	24	610
20	500	24	610
22	550	24	610
24	600	24	610

Notes:

1. For drilling See Appendix B.

2. Above lengths are recommendations only.

Appendix A: Dimension Inspection Procedure

TOLERANCES FOR RUBBER PIPE & EXPANSION JOINTS								
Nominal Pipe Size Exp. Jt. ID	Exp. Joint I.D.[1]	Non-Critical Flange O.D.[1]	Bolt Line[3]	Face-to-Face Length "F"2 (Inches) All Dimensions to be an Averaged Reading. Applies to Open or Filled Arch				Number Of Measurements to be Averaged
				0 to 6	7 to 12	14 to 18	20 & Up	
1" 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	8

Notes:

1. All diameters to be measure with a "Pi" tape.

2. All linear dimensions to be measure with a steel rule and averaged.

3. Bolt Line = Actual I.D. +2 (Average "X" Dimension) + Bolt Hole Diameter.

TYPICAL FLANGE THICKNESS				
Nominal Flange Thickness		# Measurements	Tolerance	
in	mm		in	mm
9/16	14	4	± 1/16	± 2
5/8 - 7/8	16 - 22	4	± 3/16	± 5
1	25	4	± 1/4	± 6
1-1/8 - 1-1/4	29 - 32	4	± 5/16	± 8
1 - 1-3/8	25 - 35	4	± 3/8	± 10

Notes:

Measurements taken at the bolt hole.

A. RETAINING RING:

Split Metal Retaining Rings. Retaining rings must be used to distribute the bolting load and assure a pressure tight seal. They are coated for corrosion resistance and drilled as specified. (See Appendix B-Common Flange Drilling). The rings are installed directly against the back of the flanges of the expansion joint and bolted through to the mating flange of the pipe. Steel washers are recommended under the bolt heads against the retaining rings; at a minimum at the splits. Rings are normally 3/8" (9 mm) thick, but can vary due to conditions. The ring I.D. edge installed next to the rubber flange should be broken or beveled to prevent cutting of the rubber. Special retaining rings may be required for many of the expansion joint types depicted in the Chapter. ***See Figure 2T.***

Figure 2T: Retaining Rings for Standard "Arch" Type Expansion Joints

B. LIMIT/CONTROL UNIT ASSEMBLIES:

Many manufacturers presently brand their expansion joint products with the following label identification: ***WARNING "Control units Must Be Used to Protect This Part from Excessive Movement if Piping is Not Properly Anchored." See Appendixes C, D and Figure 6.*** for information regarding the definition, purpose and recommendations concerning the use of control rod assemblies.

When an elastomeric expansion joint with a control unit assembly is to be installed directly to a pump flange, special care must be taken. Make sure that there is sufficient clearance behind the pump flange, not only for the plates, but also for the nuts, bolts and washers. In cases where there is not sufficient clearance, the retaining ring can be designed as an integral gusset.

C. EXPANSION JOINT SPRAY SHIELDS AND PROTECTIVE COVERS:

Unusual applications of rubber expansion joints may require the specification of: A. Protective Shield; B. Protective Cover; C. Fire Cover. These three types of covers, when manufactured of metal, have one end which is bolted to or clamped to the mating pipe flange. The other end is free, designed to handle the movements of the expansion joint. A Protective Cover of metal is required when an expansion joint is installed underground. Protective Shields should be used on expansion joints in lines that carry high temperature or corrosive media. This shield will protect personnel or adjacent equipment in the event of leakage or splash. Wrap around Protective Shields of Fluoroplastic impregnated fiberglass are the most common. Protective covers of expanded metal are used to prevent exterior damage to the expansion joint. Fire covers, designed oversize, are insulated on the I.D. to protect the expansion joint from rupture during a flash fire. They are normally installed on fire water lines. Contact the manufacturer for specific design details.

See Figure 2Z.

CAUTION: Protection / Spray shields have some insulating properties. It is not recommended to insulate over elastomeric expansion joints. This makes required external inspections difficult. If external protection is required, do not use insulating materials.

Figure 2Z: Protective Cover/Shields

Protective metal spray shield

A. EXPANSION JOINT MOTIONS:

A flexible rubber pipe connector is a reinforced straight rubber pipe, fabricated of natural or synthetic elastomers and fabrics, primarily designed to absorb noise and vibration in a piping system.

A.1. *Axial Compression.* The dimensional reduction or shortening in the face- to-face parallel length of the joint measured along the longitudinal axis. See Figure 3A to the right and Table V, VI, VIII, IX, X.

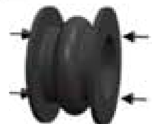


Figure 3A

A.2. *Axial Elongation.* The dimensional increase or lengthening of face-to-face parallel length of the joint measured along the longitudinal axis. See Figure 3B to the right and Table V, VI, VIII, IX, X.

Figure 3B

A.3. *Lateral or Transverse Movement.* The movement or relating displacement of the two ends of the joint perpendicular to its longitudinal axis. See Figure 3C to the right and Table V, VI, VIII, IX, X.

Figure 3C

A.4. *Vibration.* The ability of a flexible connector to absorb mechanical oscillations in the system, usually high frequency. See Figure 3D to the right and Appendixes F and G.

Figure 3D

A.5. *Angular Movement.* The angular displacement of the longitudinal axis of the expansion joint from its initial straight line position, measured in degrees. This is a combination of axial elongation and axial compression. See Figure 3E to the right and Table V, VI, VIII, IX, X.

Figure 3E

A.6. *Torsional Movement.* The twisting of one end of an expansion joint with respect to the other end about its longitudinal axis. Such movement is measured in degrees.
See Figure 3F to the right and Table V & VI.

Figure 3F

A.7. *Concurrent Movement.* The combination of two or more of the above expansion joint movements. This value is expressed as the Resultant Movement. To calculate concurrent movement use the following formula:

The concurrent movement formula is the sum of the individual movements except for Angular (because angular movement is covered by compression and elongation when looking at concurrent movements). Therefore the sum of the following: Compression, Elongation, Lateral, and Torsional still needs to be less than one or the joint is operating outside the design intent and needs to be evaluated.

Formula: $1 \geq \frac{\Delta C}{RC} + \frac{\Delta E}{RE} + \frac{\Delta L}{RL} + \frac{\Delta T}{RT}$

Sample Calculation: $1 \geq \frac{2''}{4''} + \frac{0''}{2''} + \frac{.75''}{1''} + \frac{0^\circ}{5^\circ}$

$1 \geq .5 + .75 + 0$

$1 \geq 1.25$ Joint is operating outside its design movements and needs to be evaluated.

ΔC = Change in compression — RC = Rated Compression
ΔE = Change in Elongation — RE = Rated Elongation
ΔL = Change in Lateral — RL = Rated Lateral
ΔT = Change in Torsional — RT = Rated Torsional

B. Sound Limiting Characteristics:

The ability of a rubber expansion joint to limit or interrupt the transmission of a sound from operating equipment to the piping system. See Appendixes F and G and Table III.

Table III: Comparison of Acoustical Impedances

Material	Sound Velocity In/sec.	Density lbs./In.^{3}	Acoustical Impedance lbs./In.^{2} sec	Relative Impedance
Steel	206,500	0.283	58,400	500.0
Copper	140,400	0.320	45,000	425.0
Cast Iron	148,800	0.260	38,700	365.0
Lead	49,800	0.411	20,400	190.0
Glass	216,000	0.094	20,300	190.0
Concrete	198,000	0.072	14,200	134.0
Water	56,400	0.036	2,030	19.0
Pine	132,000	0.0145	1,910	18.0
Cork	19,200	0.0086	165	1.6
Rubber	2,400	0.0442	106	1.0

Acoustical impedance is defined as the product of material density times velocity of sound in the material. In acoustical systems, low impedance corresponds to low sound transmission. Relative impedance is based on Rubber = 1.0

C. PRESSURE CHARACTERISTICS:

The pressure ratings decrease with size and/or temperature increases from 200 PSIG (1379 kPa) to 30 PSIG (207 kPa) operating pressure, dependent upon construction design. If requirements exceed these ratings, special constructions can be designed to meet the required conditions. The number of control rods are specified on the basis of the design pressure of the system, not the rated operating pressure of the expansion joint. See Table IV and Appendixes C, D, and H.

Table IV: Typical Pressure Characteristics of Spool Type Rubber Expansion Joints.

NOMINAL PIPE SIZE I.D. OF EXP. JOINT		DESIGN OF EXPANSION JOINT CONSTRUCTION							
		Series A & B Pressure/Vacuum Design				Series C High Pressure Design			
		Positive		Negative		Positive		Negative	
in.	mm	PSIG	kPa	in. of Hg.	mm of Hg.	PSIG	kPa	in. of Hg.	mm of Hg.
1/4 to 4	6 to 102	165	1138	26	660	200	1379	26	660
5 to 12	127 to 305	140	965	26	660	190	1310	26	660
14	356	85	586	26	660	130	896	26	660
16 to 20	406 to 508	65	448	26	660	110	758	26	660
22 to 24	559 to 610	65	448	26	660	100	689	26	660
26 to 40	660 to 1,016	55	379	26	660	90	621	26	660
42 to 66	1067 to 1676	55	379	26	660	80	552	26	660
68 to 96	1727 to 2438	45	310	26	660	70	483	26	660
98 to 108	2489 to 2743	40	276	26	660	60	414	26	660
110 to 155	2794 to 3937	30	207	26	660	50	374	26	660

NOTES:

1. *Pressure limitations listed are generally accepted by most manufacturers for temperatures up to 180°F yielding a 3:1 safety factor. For higher temperatures, consult the manufacturer for alternate designs and/or materials.*
2. *For higher pressure than indicated, contact manufacturer for guidance.*
3. *Always advise manufacturer if product will be subjected to "full vacuum"*
4. *For terminology on pressure, See Appendix H.*
5. *Parts listed at 26" (660 mm) Hg vacuum have a design rating of 30" (762 mm) Hg (full vacuum).*

D. RESISTANCE TO FLUIDS:

The superior corrosion resistance characteristic of natural rubber and synthetic elastomers permits the safe handling of a wide variety of materials within the pressure limits and temperature characteristics noted above. Contact the manufacturer for a special elastomer recommendation. See Table II.

E. FORCE POUNDS AND SPRING RATES:

E.1. *Force Pounds.* The force to deflect an expansion joint is defined as, the total load required to deflect the expansion joint a distance equal to the maximum rated movement of the product. This force figure is expressed in pounds for compression, elongation and lateral movements. The force figure is expressed in foot-pounds for angular deflection.

E.2. *Spring Rate.* The spring rate is defined as the force in pounds required to deflect an expansion joint one inch in compression and elongation or in a lateral direction. For angular movement the spring rate is the force needed in foot-pounds to deflect the expansion joint one degree. See Table V & VI.

E.2.A. *Filled Arch.* The spring rate for a Filled Arch Type expansion joint is approximately 4 times that of a Standard Single Arch Type. This rate will vary with manufacturers and is dependent upon the material used in the filled arch section of the expansion joint.

E.2.B. *Multi-Arch.* The spring rate for a Multi-Arch Type expansion joint is equal to the spring rate for a Single Arch Type product divided by the number of arches.

F. HYDROSTATIC TESTING:

If required, joints can be hydrostatically tested up to 1.5 times the Maximum Allowable Working Pressure of the product, for a minimum of 10 minutes without leaks.

G. SEISMIC TESTING:

It is the position of the EJ - Piping Expansion Joint Division that, although seismic testing may apply to rigid components of a piping system, it does not apply to an individual non- metallic expansion joint due to its inherent flexibility. The problem is further complicated by the absence of any definitive specification. The industry is unable to quote on seismic testing unless specific information on test procedures and results required becomes available.

H. CYCLE LIFE:

One full movement cycle is defined as the sum of the total movements incurred when an expansion joint fully compresses from the neutral position then moves to the position of maximum allowed elongation and finally returns to neutral. Cycle life depends not only on the amount of movement, but also on the frequency of cycles or cycle rate. Cycle life can also be affected by installation practices, temperature and type of media being handled.

Testing can involve full movement cycling of an expansion joint at the rate of 10 cycles per minute at rated maximum temperatures and pressures to various duration, without failure. Much longer cycle life occurs with reduced movement.

Reducer Type (Taper):

Minimum Recommended Face-to-Face Lengths.

NMEJ DIVISION STANDARDS RECOMMENDATIONS				
NOMINAL PIPE SIZES ID X ID			Minimum Concentric	Minimum Eccentric
Inches			Length	Length
1.5	X	1.	6	6
2.	X	1.	6	6
2.	X	1.25	6	6
2.	X	1.5	6	9
2.5	X	1.	6	8
2.5	X	1.25	6	6
2.5	X	1.5	6	6
2.5	X	2.	6	6
3.	X	1.	8	9
3.	X	1.25	8	8
3.	X	2.	6	6
3.	X	2.5	6	6
3.5	X	1.5	8	9
3.5	X	2.	6	8
3.5	X	2.5	6	6
3.5	X	3.	6	6
4.	X	1.5	8	12
4.	X	2.	6	9
4.	X	2.5	6	8
4.	X	3.	6	6
4.	X	3.5	6	6
5.	X	2.5	8	11
5.	X	3.	6	9
5.	X	3.5	6	8
5.	X	4.	6	6
5.	X	4.5	6	6
6.	X	3.	8	12
6.	X	3.5	8	11
6.	X	4.	6	9
6.	X	5.	6	6
8.	X	4.	10	15
8.	X	5.	8	12
8.	X	6.	6	9
10.	X	6.	10	15
10.	X	8.	6	9
12.	X	8.	10	15
12.	X	10.	8	9
14.	X	10.	10	15
14.	X	12.	8	9
16.	X	10.	10	21
16.	X	12.	8	15
16.	X	14.	8	9
18.	X	12.	12	22
18.	X	14.	10	16
18.	X	16.	8	10
20.	X	14.	12	22
20.	X	16.	10	16
20.	X	18.	8	10
24.	X	16.	16	28
24.	X	18.	14	22
24.	X	20.	10	16
30.	X	20.	18	34
30.	X	24.	14	22
36.	X	24.	24	40
36.	X	30.	14	22
42.	X	30.	24	40
42.	X	36.	13	22
48.	X	42.	14	22
54.	X	42.	22	40
54.	X	48.	13	22
60.	X	48.	22	40
60.	X	54.	13	22

NOTES:

1. The N.M.E.J. Division standard recommendations are calculated using the following formulas:
a. Concentric Expansion Joints: Maximum angle of 20° plus 3".
b. Eccentric Expansion Joints: Maximum angle of 20° plus 4".

2. For sizes other than shown, consult the manufacturer.

INTRODUCTION:

It can be stated generally that the proper location of rubber expansion joints is close to a main anchoring point. Following the joint in the line, a pipe guide or guides should be installed to keep the pipe in line and prevent undue displacement of this line. This is the simplest application of a joint, namely, to absorb the expansion and contraction of a pipeline between fixed anchor points.

Figure 5A:
Typical Piping Layout Utilizing Expansion Joints When Equipment and Piping are Properly Anchored

A. ANCHORING AND GUIDING THE PIPING SYSTEM:

A.1. *Anchors Are Required.* Figure 5A illustrates a simple piping system. You will notice that in all cases, solid anchoring is provided wherever the pipeline changes direction and that the expansion joints in that line are located as close as possible to those anchor points. In addition, following the expansion joints, and again as close as is practical, pipe guides are employed to prevent displacement of the pipeline. It should be pointed out that the elbows adjacent to the pump are securely supported by the pump base so that no piping forces are transmitted to the flanges of the pump itself. Anchors shown at the 90° and the 45° bend in the pipeline must be solid anchors designed to withstand the thrust developed in the line together with any other forces imposed on the system at this point.

A.2. *Calculation of Thrust.* When expansion joints are installed in the pipeline, the static portion of the thrust is calculated as a product of the area of the I.D. of the arch of the expansion joint times the maximum pressure that will occur with the line. The result is a force expressed in pounds. Refer to Figure 4.

Figure 4

$$T = \frac{\pi}{4}(D)^2(P)$$

T = Thrust
P = Pressure
D = Arch I.D.

A.3. *Branch Connection Anchors.* Figure 5B is another illustration of the proper anchoring that should be provided in a line with a branch connection. The anchor shown at the tee and elbow connections must be designed to withstand both the thrust and any other forces imposed on the system at these points. Again emphasis is placed on the relative location of the joints, their anchoring points and the pipe guides.

B. CONTROL UNITS:

B.1. *Definition and Purpose.* A control unit assembly is a system of two or more control rods (tie rods) placed across an expansion joint from flange to flange to minimize possible damage to the expansion joint caused by excessive motion of the pipeline. This excessive motion could be caused by the failure of an anchor or some other piece of equipment in the pipeline. Figure 6 shows the proper assembly of an expansion joint with control unit details. The control rod assemblies are set at the maximum allowable expansion and/or contraction of the joint and will absorb the static pressure thrust developed at the expansion joint. When used in this manner, they are an additional safety factor, minimizing possible failure of the expansion joint and possible damage to the equipment. Control units will adequately protect the joints, but the user should be sure that pipe flange strength is sufficient to withstand total force that will be encountered. The term "Control Unit" Is synonymous with the term "Tie Rod" as defined by the standards of the Expansion Joint Manufacturer's Association (EJMA).

Figure 5B:
Typical Layout Utilizing Expansion Joints and the Proper Use of Anchors in Branch Locations

B.2. *Use in Restraining the Piping System.* Control units may be required to limit both extension and compression movements.

B.2.A. *Extension.* Control units must be used when it is not feasible in a given structure to provide adequate anchors in the proper location. In such cases, the static pressure thrust of the system will cause the expansion joint to extend to the limit set by the control rods which will then preclude the possibility of further motion that would over-elongate the joint. Despite the limiting action that control rods have on the joint, they must be used when proper anchoring cannot be provided. It cannot be emphasized too strongly that rubber expansion joints, by virtue of their function, are not designed to take end thrusts and, in all cases where such are likely to occur, proper anchoring is essential. If this fact is ignored, premature failure of the expansion joint is a foregone conclusion.

B.2.B. *Compression.* Pipe sleeves or inside nuts can be installed on the control rods. The purpose of the sleeve is to prevent excessive compression in the expansion joint. The length of this pipe sleeve should be such that the expansion joint cannot be compressed beyond the maximum allowable compression figure stated by the manufacturer. See Tables V & VI and Figure 6.

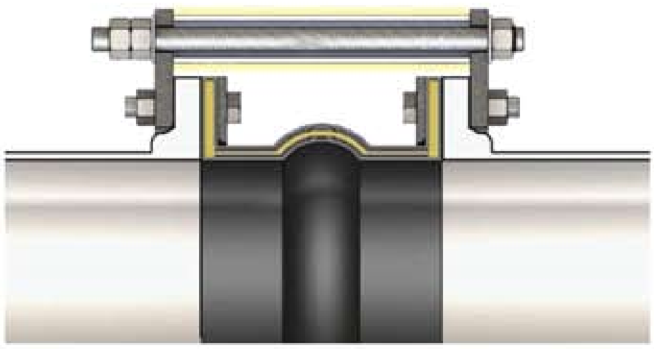
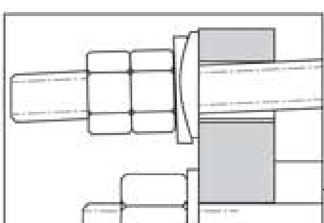
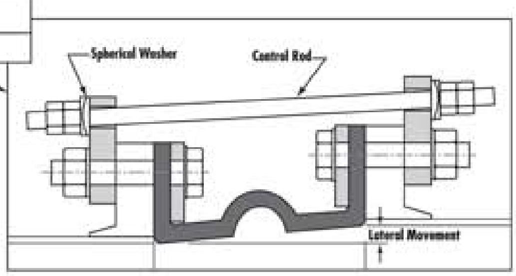


Figure 6:
Expansion Joint with Assembly/Installation of Control Unit Components

B.3. *Specifications.* For control unit dimensional specifications see Appendix C. These specifications are recommended for standard construction type expansion joints. The exact number of control rods should be selected on the basis of the actual design/test pressure of the system. Always specify the mating flange thickness when ordering control unit assemblies. See Appendix D.



For significant lateral movement spherical washers are recommended.



Spherical washer equal axial and lateral load distribution

B.4. *Illustration of the Use of Control Rods.* Figure 5C demonstrates the type of piping connections that must be used in the event it is impossible to employ anchoring. The anchor point at the upper 90° elbow in the discharge line has been eliminated. (It is shown in Figure 5A.) In this situation, it is necessary to employ properly designed control units with the joints located in this non-anchored line. Without the use of these control units, the pipeline between the pump and the anchor, at the 45° bend, would be severely displaced due to elongation in the flexible rubber expansion joint. This elongation would proceed until the joints rupture. The use of control units in this case permits expansion of the pipeline in both the vertical and horizontal direction between the pump and the anchor, at the 45° bend. However, it does preclude the possibility of contraction in these respective lines as the further extension of the expansion joint is impossible because of the control units.

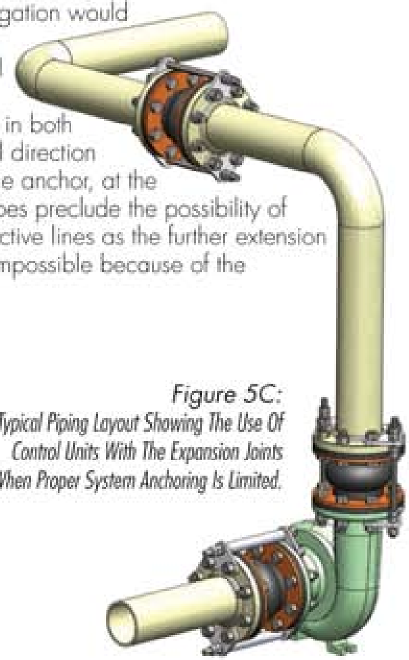


Figure 5C:
Typical Piping Layout Showing The Use Of Control Units With The Expansion Joints When Proper System Anchoring Is Limited.

C. OTHER INSTALLATIONS:

C.1. *Vibration Mounts Under Foundation.* Figure 5D shows a very common pump installation. Instead of being mounted on a solid foundation, the pump is supported off the floor on vibration mounts. There is nothing wrong with this type of installation. The supplier of the vibration mounts should be made aware of the fact that these mounts must be designed, not only to support the weight of the pump, its motor and base, but must also absorb the vertical thrust that will occur in both the suction and discharge lines. To calculate thrust see Chapter VIII, Section A.2. It should also be noted that the thrust in the respective pipelines will exert a force on the inlet and outlet flanges of the pump, and the pump manufacturer should be contacted to determine whether or not the pump casing is strong enough to withstand this force. If this is not done, it is very possible that this force can be large enough to crack the connecting flanges.

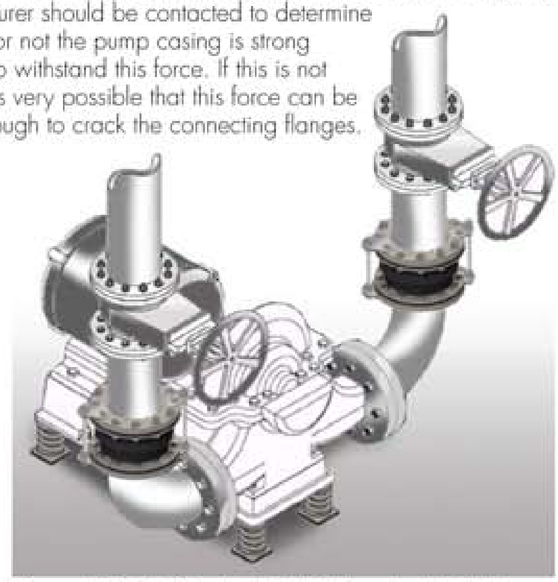
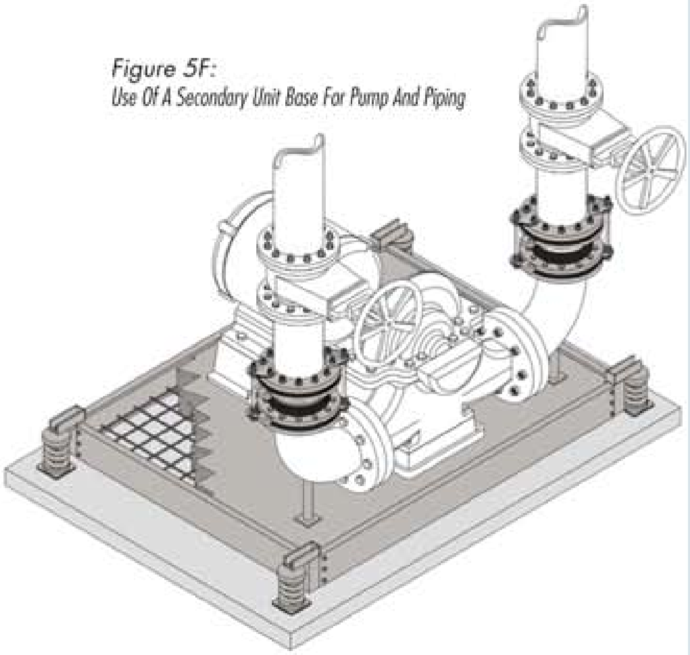


Figure 5D: Typical Pump Installation With Expansion Joints Utilizing Vibration Mounts

Figure 5E:
Superior Installation With Pump Base Independently Supported

Figure 5F:
Use Of A Secondary Unit Base For Pump And Piping



C.2. *Vibration Mounts or Springs Under Base and Anchor.* A variation of the design as shown in Figure 5D is illustrated in Figure 5E. An improved installation is shown here. The vibration mounts under the pump base need only support the pump, its motor and base. The vibration mounts under the elbow supports can then be designed to withstand the thrust developed in the suction and discharge lines, respectively.

C.3. *Secondary Base.* See Figure 5F. In this installation, a complete secondary base is provided for the pump base and the two elbow supports. This secondary base is equipped with vibration mounts to isolate it from the floor. Once again, these mounts must be designed to take into account all of the loads and forces acting upon the secondary base. These obviously are the weight of the equipment plus the thrusts developed in the suction and discharge lines.

D. INSTALLATION INSTRUCTIONS FOR NON-METALLIC EXPANSION JOINTS:

D.1. *Service Conditions.* Make sure the expansion joint rating for temperature, pressure, vacuum and movements match the system requirements. Contact the manufacturer for advice if the system requirements exceed those of the expansion joint selected. Check to make sure the elastomer selected is chemically compatible with the process fluid or gas.

D.2. *Alignment.* Expansion joints are normally not designed to compensate for piping misalignment errors. Piping should be lined up within 1/8". Misalignment reduces the rated movements of the expansion joint and can induce severe stress and reduce service life. Pipe guides should be installed to keep the pipe aligned and to prevent undue displacement. See Chapter VIII, Section A and Table IV.

D.3. *Anchoring.* Solid anchoring is required wherever the pipeline changes direction, and expansion joints should be located as close as possible to anchor points. If anchors are not used, the pressure thrust may cause excessive movements and damage the expansion joints. See Chapter VIII, Section A & B for Anchoring, Guiding and Control Rods.

D.4. *Pipe Support.* Piping must be supported so expansion joints do not carry any pipe weight.

D.5. *Mating Flanges.* Install the expansion joint against the mating pipe flanges and install bolts so that the bolt head and washer are against the retaining rings. If washers are not used, flange leakage can result - particularly at the split in the retaining rings. Flange-to-flange dimensions of the expansion joint must match the breech type opening. Make sure the mating flanges are clean and are flat-face- type or no more than 1/16" raised-face-type. Never install expansion joints that utilize split retaining rings next to wafer type check or butterfly valves. Serious damage can result to a rubber joint of this type unless installed against full face flanges.

D.6. *Tightening Bolts.* Tighten bolts in stages by alternating around the flange. If the joint has integral fabric and rubber flanges, the bolts should be tight enough to make the rubber flange O.D. bulge between the retaining rings and the mating flange. Torque bolts sufficiently to assure leak-free operation at hydrostatic test pressure. Bolt torquing values are available from most manufacturers. If the joint has metal flanges, tighten bolts only enough to achieve a seal and never tighten to the point that there is metal- to-metal contact between the joint flange and the mating flange.

D.7. *Storage.* Ideal storage is a warehouse with a relatively dry, cool location. Store flange face down on a pallet or wooden platform. Do not store other heavy items on top of an expansion joint. Ten year shelf-life can be expected with ideal conditions. If storage must be outdoors joints should be placed on wooden platforms and should not be in contact with the ground. Cover with a tarpaulin.

D.8. *Large Joint Handling.* Do not lift with ropes or bars through the bolt holes. If lifting through the bore, use padding or a saddle to distribute the weight. Make sure cables or forklift tines do not contact the rubber. Do not let expansion joints sit vertically on the edges of the flanges for any period of time.

WARNING: Expansion joints may operate in pipelines or equipment carrying fluids and/or gases at elevated temperatures and pressures and may transport hazardous materials. Precautions should be taken to protect personnel in the event of leakage or splash. See Chapter VI, C. Rubber joints should not be installed in inaccessible areas where inspection is impossible. Make sure proper drainage is available in the event of leakage when operating personnel are not available.

D.9. *Additional Tips.*

D.9.A. Do not insulate over a non-metallic expansion joint. See Chapter VI, C.

D.9.B. It is acceptable (but not necessary) to lubricate the expansion joint flanges with a thin film of graphite dispersed in glycerin or water to ease disassembly at a later time.

D.9.C. Do not weld in the vicinity of a non-metallic joint.

D.9.D. If expansion joints are to be installed underground, or will be submerged in water, contact manufacturer for specific recommendations.

D.9.E. If the expansion joint will be installed outdoors, make sure the cover material will withstand ozone, sunlight, etc. Materials such as EPDM and Hypalon® are recommended. Materials painted with weather resistant paint will give additional ozone and sunlight protection.

D.9.F. Check the tightness of leak-free flanges two or three weeks after installation and re-tighten if necessary.

D.10. *Control Rod Installation.* Also see Chapter VI, B. Control Unit Assemblies.

D.10.A. Assemble expansion joint between pipe flanges to the manufactured face-to-face length of the expansion joint. Include the retaining rings furnished with the expansion joint.

D.10.B. Assemble control rod plates behind pipe flanges as shown in Figure 6. Flange bolts through the control rod plate must be longer to accommodate the plate. Control rod plates should be equally spaced around the flange. Depending upon the size and pressure rating of the system, 2, 3 or more control rods may be required. Contact manufacturer for optional installations.

D.10.C. Insert control rods through top plate holes. Steel washers are to be positioned at the outer plate surface. An optional rubber washer is positioned between the steel washer and the outer plate surface. (See Figure 6.)

D.10.D. If a single nut per unit is furnished, position this nut so that there is a gap between the nut and the steel washer. This gap is equal to the joint's maximum extension (commencing with the nominal face-to-face length). Do not consider the thickness of the rubber washer. To lock this nut in position, either "stake" the thread in two places or tack weld the nut to the rod. If two jam nuts are furnished for each unit, tighten the two nuts together, so as to achieve a "jamming" effect to prevent loosening. Note: Consult the manufacturer if there is any question as to the rated compression and elongation. These two dimensions are critical in setting the nuts and sizing the compression pipe sleeves.

D.10.E. If there is a requirement for compression pipe sleeves, ordinary pipe may be used and sized in length to allow the joint to be compressed to its normal limit. (See Figure 6.)

D.10.F. For reducer installations, it is recommended that all control rod installations be parallel to the piping.

D.11. *Location.* The expansion joint should always be installed in an accessible location to allow for future inspection or replacement.

E. INSPECTION PROCEDURE FOR EXPANSION JOINTS IN SERVICE:

The following guide is intended to assist in determining if an expansion joint should be replaced or repaired after extended service.

E.1. *Replacement Criteria.* If an expansion joint is in a critical service condition and is five or more years old, consideration should be given to maintaining a spare or replacing the unit at a scheduled outage. If the service is not of a critical nature, observe the expansion joint on a regular basis and plan to replace after 10 years service. Applications vary and life can be as long as 30 years in some cases.

E.2. *Procedures.*

E.2.A. *Cracking.* (Sun Checking) Cracking, or crazing may not be serious if only the outer cover is involved and the fabric is not exposed. If necessary, repair on site with rubber cement where cracks are minor. Cracking where the fabric is exposed and torn, indicates the expansion joint should be replaced. Such cracking is usually the result of excess extension, angular or lateral movements. Such cracking is identified by:

(1) a flattening of the arch, (2) cracks at the base of the arch, and/or (3) cracks at the base of the flange. To avoid future problems, replacement expansion joints should be ordered with control rod units.

E.2.B. *Blisters-Deformation-Ply Separation.* Some blisters or deformations, when on the external portions of an expansion joint, may not affect the proper performance of the expansion joint. These blisters or deformations are cosmetic in nature and do not require repair. If major blisters, deformations and/or ply separations exist in the tube, the expansion joint should be replaced as soon as possible. Ply separation at the flange O.D. can sometimes be observed and is not a cause for replacement of the expansion joint.

E.2.C. *Metal Reinforcement.* If the metal reinforcement of an expansion joint is visible through the cover, the expansion joint should be replaced as soon as possible. Additionally, if any external metal reinforcement is exhibiting signs of fatigue or wear, the expansion joint should be replaced as soon as possible.

E.2.D. *Dimensions.* Any inspections should verify that the installation is correct; that there is no excessive misalignment between the flanges; and, that the installed face-to- face dimension is correct. Check for over-elongation, over-compression, lateral or angular misalignment. If incorrect installation has caused the expansion joint to fail, consider ordering a new expansion joint sized to fit the existing piping dimensions. If neither options are available, adjust the piping and order a new expansion joint to fit the existing installation.

E.2.E. *Rubber Deterioration.* If the joint feels soft or gummy, plan to replace the expansion joint as soon as possible. For expansion joints that may have become too "stiff" (although a durometer reading can give you an idea of the current hardness of the tube or cover of the expansion joint) their cannot be a guaranteed accuracy of the overall health of the expansion joint. Given the nature of the applications where expansion joints are used, the variety of manufactures, and numerous combinations of materials, it is unlikely that a durometer reading is capable of providing a health indication for a specific expansion joint.

E.2.F. *Leakage.* If leakage or weeping is occurring from any surface of the expansion joint, except where flanges meet, replace the joint immediately. If leakage occurs between the mating flange and expansion joint flange, tighten all bolts. If this is not successful, turn off the system pressure, loosen all flange bolts and then re-tighten bolts in stages by alternating around the flange. Make sure there are washers under the bolt heads, particularly at the split in the retaining rings. Remove the expansion joint and inspect both rubber flanges and pipe mating flange faces for damage and surface condition. Repair or replace as required. Also, make sure the expansion joint is not over elongated as this can tend to pull the joint flange away from the mating flange resulting in leakage. If leakage persists, consult the manufacturer for additional recommendations.

Rubber Expansion Joint & PTFE Lined Expansion Joints

Request For Installation Details

(A separate sheet must be completed for each item)

To: ______________________

Fax #: ______________________

From: ______________________

1. Purchase Order #: ______________________
2. Date Of Order/Shipment: ______________________
3. Item Size: ____________ I.D. X ____________ F/F Flange Rating: Type (RF, FF) ________ / ________
4. Item Style No./Tag No.: ______________________
5. Item Drawing No: ______________________
6. Medium Gas/Liquid/Steam: ______________________
7. Operating Pressure: ______________________
8. Surge Pressure/Duration: ____________ / ____________
9. Operating Temperature: ______________________
10. Surge Temperature/Duration: ____________ / ____________
11. Installed Face-To-Face Length:
    (to be measured in four positions)

    3 O'clock Flange Position: ______________________

    6 O'clock Flange Position: ______________________

    9 O'clock Flange Position: ______________________

    12 O'clock Flange Position: ______________________
12. Installation Orientation (Horz/Vert): ______________________
13. Distance To Nearest Anchor Point (Each End): ______________________

14. Confirm Mating Flanges Are Parallel: ____________________
15. Confirm The Centerline Alignment: ____________________
16. Advise Torsional (Rotation) Offset (Deg): ____________________
17. Advise Angular Offset (Deg): ____________________
18. Advise Axial Compression: ____________________
19. Advise Axial Extension: ____________________
20. Advise Lateral Offset(s): ____________________ / ____________________
21. Are Control Rods Installed/Number Of Rods: Yes No / ____________________
22. Confirm Proper Orientation Of Flow Liner And Flow: ____________________
23. In-Service Date: ____________________
24. Frequency Of System Operation (Daily, Weekly, Continuous): ____________________
25. Are Digital Images Available: ____________________
26. Are Site Reports/Logs Available: ____________________
27. Were Any Personnel Injured: ____________________
28. Please Attach a Detailed Description Of Failure Including Diagram(s) To Illustrate Location Of Failure:

A. FSA-PSJ-701-19, Hydro and Vacuum Testing:

A.1. *SCOPE*

A.1.1 *Application:*

This specification covers the hydrotesting and/or vacuum testing of non-metallic flanged expansion joints. The purpose of the testing is to prove the expansion joint meets a standard pressure/vacuum or a pressure/vacuum as requested by a customer purchase order or specification. For definition of terms used in this specification, refer to the Technical Handbook, Expansion Joints – Piping Technical Handbook, 8.0 Edition.

A.1.2 *Safety - Hazardous Materials:*

While the materials, methods, applications and processes described or referenced in this standard may involve the use of hazardous materials, this standard does not address the hazards which may be involved in such use. It is the sole responsibility of the user/tester to ensure familiarity with the safe and proper use of any hazardous materials and test procedure, and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

A.2. *APPLICABLE DOCUMENTS*

A.2.1 *Fluid Sealing Association:*

Technical Handbook, Expansion Joints – Piping Technical Handbook, 8.0 Edition, Fluid Sealing Association, Expansion Joint Division. Application for copies should be addressed to:

Fluid Sealing Association
Expansion Joint Division
994 Old Eagle School Road, Suite 1019
Wayne, PA 19087-1866

A.2.2 *American Society of Testing Materials (ASTM):*

ASTM D-380
Standard Test Methods for Rubber Hose

ASTM D-412
Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension

ASTM D-413
Standard Test Methods for Rubber Property - Adhesion to Flexible Substrate

ASTM D-471
Standard Test Methods for Rubber Property - Effect of Liquids

ASTM D-1415
Standard Test Methods for Rubber Property - International Hardness

ASTM D-2240
Standard Test Methods for Rubber Property - Durometer Hardness

ASTM F-1123
Standard Specification for Non-Metallic Expansion Joints

Application for copies should be addressed to:

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959

A.3. *GENERAL REQUIREMENTS*

A.3.1 *Preparation:*

A.3.1.1 *Tests to be Performed*

Determine the types of tests required by the order or specification. If the expansion joint is to receive both hydro test and vacuum test, perform the vacuum test first.

A.3.1.2 *Test Fixtures/Apparatus/Gauges/Materials*

A.3.1.2.1 The test fixture shall consist of end plates, which will be bolted or affixed to the end of the expansion joint, so as to allow the testing of the expansion joint without leakage. This is normally done by bolting plates to the expansion joint flanges. Hydraulic presses may also be used eliminating the need for end plates.

A.3.1.2.2 The test fixture shall be restrained by control rods with or without compression sleeves (compression sleeves are required for vacuum testing only) or a hydraulic press with compression stops so as to restrain the expansion joint from either compressing or elongating during testing.

A.3.1.2.3 The gauges used in the testing shall be indicating pressure or vacuum gauges. The gauges shall be calibrated at intervals not to exceed twelve (12) months. The gauges shall be positioned in such a location as to be readable by both the personnel controlling the pressurization and the test administrator.

A.3.1.2.4 The hydrotest and vacuum pump should be of size capable of maintaining the pressure and vacuum required by the order or specification.

A.3.1.2.5 The hydrotest medium shall be water. The use of gases, such as air, nitrogen or carbon dioxide, should be avoided or special precautions taken for safety reasons.

A.3.1.2.6 TThe typical hydrotest and vacuum testing setup is shown in figures 1 and 2 attached.

A.3.1.3 *Test Temperature*

The tests should be conducted at ambient temperatures. For hydrotest the medium should not be greater than 1200 F (490 C).

Tests may be conducted at other temperatures; however, special precautions should be taken not to subject the expansion joint to over pressurization at elevated temperatures.

A.3.1.4 *Test Pressure/Vacuum*

The tests shall be performed at pressures and vacuums as specified by the order or specification. The standard hydrotest is to be performed at a pressure 1.5 times the maximum operating pressure of the expansion joint.

The vacuum test pressure is not to exceed below 26 inches Hg (880 mbar).

CHAPTER IX

A.4. *TEST PROCEDURES*

A.4.1 *Vacuum Testing*

The vacuum test should be done prior to the hydrotest, when both tests are to be performed, to protect the vacuum pump from water contamination.

A.4.1.1 *Connection*

Connect the vacuum line to the test fixture. Close or plug the relief holes in the fixture, vent if needed. Open the valve between the expansion joint and vacuum pump.

A.4.1.2 *Test*

Slowly increase the vacuum while inspecting for leaks. A portable ultrasonic detector may be used in this detection process. Should leakage be detected, re-tighten the flange bolts and begin the test again. Once the test vacuum has been reached (the order or specification vacuum but not more than 1.0 times the design vacuum of the expansion joint), the test should be run for 10 minutes with the expansion joint isolated from the vacuum pump.4.1.3 Acceptance The expansion joint has passed the test when the test has been performed in accordance with 4.1.2 without discernable vacuum decay or loss of structural integrity.

A.4.1.3 *Acceptance*

The expansion joint has passed the test when the test has been run in accordance with 4.1.2 without leaking or loss of structural integrity.

A.4.1.4 *Documentation*

TThe results of the test should be recorded on an expansion joint testing form. A typical form is shown in Figure 3.

A.4.1.5 *Post Test Procedure*

After the expansion joint has been removed from the test fixture, the expansion joint should be inspected for damage resulting from the test. Special attention to tube delamination should be made.

A.4.2 *Hydro testing*

A.4.2.1 *Connection*

Connect the water line to the test fixture. Open the vent ports in the fixture. Open the valve between the water supply/ accumulator and the expansion joint. Allow the water to flow until the expansion joint is completely full of water and all air is expelled. When the expansion joint is full of water, close or plug the vent valve.

A.4.2.2 *Test*

Slowly increase the pressure while inspecting for leaks. Should leakage be detected, re-tighten the flange bolts and begin the test again. Once the test pressure has been reached (the order or specification pressure but not more than 1.5 times the pressure of the expansion joint), the test should begin and run for 10 minutes with the expansion joint isolated from the water source.

A.4.2.3 *Acceptance*

The expansion joint has passed the test when the test has been performed in accordance with 4.2.2 without visible leakage, discernable pressure decay or loss of structural integrity.

A.4.2.4 *Documentation*

The results of the test should be recorded on an expansion joint testing form. A typical form is shown in Figure 3.

A.4.2.5 *Post Test Procedure*

After the joint ha s b een removed from the test fixture and dried, the expansion joint should be inspected for damage resulting from the test.

A.5. *QUALITY ASSURANCE*

A.5.1 *Responsibility*

The Quality Assurance Department is responsible for running or monitoring the hydrotest and/or vacuum test.

A.5.2 *Record Maintenance*

Records of the testing should be retained by the Quality Assurance Department inaddition to those records submitted with the order.

Figure 1

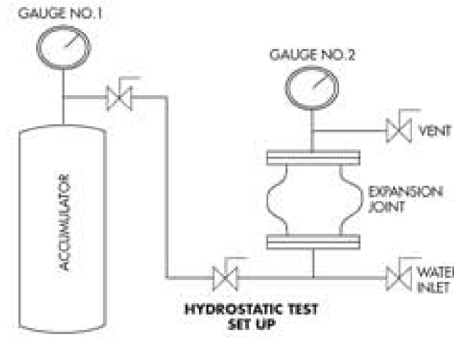


Figure 2

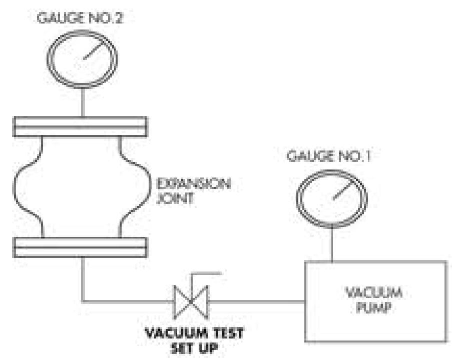


Figure 3

(COMPANY NAME) | HYDROSTATIC TEST REPORT | Date: | Page:

Customer: | Sales Order No:

Customer P.O.: | Spec. Req'ts:

Traveler Operation No./Remarks:

The above listed items were tested in accordance with FSA Standard FSA-PSJ- ______ and are acceptable to referenced specification requirements.

QUALITY ASSURANCE MANAGER

http://www.fluidsealing.com/standards/FSA-PSJ-701-19.pdf

B. FSA-PSJ-702-19, Installation, Maintenance, Storage:

B.1. *SCOPE:*

B.1.1 *Application:*

This specification covers the installation, maintenance and storage of rubber flanged non-metallic expansion joints. The purpose of the standard is to ensure the proper handling of expansion joints. For definition of terms used in this specification, refer to the Technical Handbook, Non-Metallic Expansion Joints and Flexible Pipe Connectors.

B.1.2 *Safety - Hazardous Materials:*

While the materials, methods, applications and processes described or referenced in this standard may involve the use of hazardous materials, this standard does not address the hazards which may be involved in such use. It is the sole responsibility of the user/installer to ensure familiarity with the safe and proper use of any hazardous materials and to take the necessary precautionary measures to ensure the health and safety of all personnel involved.

B.2. *APPLICABLE DOCUMENTS:*

B.2.1 *Fluid Sealing Association:*

Technical Handbook, Non-Metallic Expansion Joints and Flexible Pipe Connectors, Edition 7.3

Application for copies should be addressed to:

Fluid Sealing Association
Expansion Joint - Piping Division
994 Old Eagle School Road, Suite 1019
Wayne, PA 19087-1866
www.fluidsealing.com

B.2.2 *ASTM International*

ASTM F-1123 Standard Specification for Non-Metallic Expansion Joints

Application for copies should be addressed to:

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959
www.astm.org

B.3. *GENERAL REQUIREMENTS:*

B.3.1 *INSTALLATION:*

B.3.1.1 *Inspection of Expansion Joint:*

Remove expansion joint from protective/shipping packaging. Check the interior, exterior and flange faces of the expansion joint for cuts or gouges. Inspect the mating flanges or rough/damaged areas:

B.3.1.2 *Application, Anchoring, Alignment:*

B.3.1.2.1 Review the application to which the expansion joint is going to be applied. Special attention should be paid to the pressure/vacuum, temperature, and movements to ensure that the expansion joint meets the system requirements.

B.3.1.2.2 Review the system to ensure that the anchors, supports and alignment guides are properly designed. If the system is not properly anchored and/or guided, control rods with compression sleeves should be used to protect the expansion joint against excessive axial movements. In addition, the anchors and/or guides should be designed to withstand the thrust forces generated by the expansion joint.

Note: 1. *Control rods do not protect the expansion joint and piping system against lateral offsets and are not a replacement for proper system anchors, guides and supports.*

Note: 2. *Control rods should not be used with non-metallic flanges such as PVC, FRP and other flanges which do not have sufficient strength.*

B.3.1.2.3 Inspect the piping to ensure that the pipes are properly aligned axially and laterally within the tolerances as outlined in the Technical Handbook, Non-Metallic Expansion Joints and Flexible Pipe Connectors (see Paragraph 2.1). If the piping is not properly aligned, the pipes should be adjusted. When the piping cannot be properly aligned, an offset joint should be used.

B.3.1.3 Installation:

Refer to the manufacturers' installation manuals/instructions for any special installation requirements.

B.3.1.3.1 Flange Lubricant:

Apply a thin layer of non-petroleum based lubricant, such as soapy water to the rubber flange for ease of installation or removal at a later date.

B.3.1.3.2 Expansion Joint:

Install the expansion joint between the mating flanges. Special care, such as the use of slings, should be taken to ensure the expansion joint is not damaged during this process. Do not lift by bolt holes. Continued support of the expansion joint is required until the expansion joint is bolted in place. Spacer gaskets may be required with raised face pipe flanges, consult manufacturer.

B.3.1.3.3 Flange Bolts:

Install the flange bolts through the retaining rings, expansion joint and mating flange from the arch side of the expansion joint in a cross pattern. Metal washers are required at all splits of the retaining rings and are recommended for all other bolts. Attach and tighten nuts alternately around the flange until hand tight. Torque each bolt to full torque with the cross-bolt pattern until the values given in the table below are reached. Alternatively, a traditional method of tightening full faced flanges until the outside edge of the expansion joint flange bulges slightly can be used.

NOMINAL BOLT TORQUE
Beaded-Ends (Spherical) or PTFE Bellows

Pipe Size		Torque	
in	mm	ft-lbs	Nm
1 - 1.25	25 - 32	30 - 45	40 - 60
1.5 - 2	40 - 50	30 -45	40 - 60
2.5	65	35 - 50	47 - 68
3 - 5	80 - 125	45 - 60	60 - 80
6 - 8	150 - 200	50 -65	68 - 88
10 - 12	250 - 300	55 - 75	75 - 100
14 - 16	350 - 400	60 - 80	80 - 110
18	450	70 - 90	95 - 120
20	500	75 - 95	95 - 120
24	600	80 - 100	110 - 135
30	750	95 -130	120 - 175

NOMINAL BOLT TORQUE
Full-Faced Elastomer Flanges

Pipe Size		Torque	
in	mm	ft-lbs	Nm
1 - 2	25 - 50	30 - 50	40 - 68
2.5 - 5	60 - 125	50 - 70	68 - 95
6 - 8	150 - 200	90 - 120	120 - 160
10 - 12	250 - 300	110 - 140	150 - 190
14 - 16	350 - 400	130 - 160	175 - 215
18 - 24	450 - 600	150 - 200	200 - 270
26 - 40	650 - 1000	200 - 300	270 - 410
42 - 54	1050 - 1400	300 - 400	410 - 540
60 - 72	1500 - 1800	400 - 500	540 - 680

NOTE 1: *Recommended Torque values are for reference only and may require more or less torque due to flange facing, and other variables. Caution: Mating flange material or equipment may dictate lower torque values. Consult the Manufacturer for specific recommendations.*

NOTE 2: *The Flange Bolts should be retightened after about one week of operation and checked periodically, thereafter.*

B.3.1.3.4 *Control Rods:*

When Control Rods are required, install the gusset plates to the outboard side of the mating flange at the same time as the Flange Bolt installation. The number and distribution of the control rods must meet manufacturers approved or design specified minimums. FSA Technical Handbook (see paragraph 2.1) minimums shall apply if not specified otherwise. Install the control rod through the remaining hole in the gusset plate. If required, install a compression sleeve at the time of the control rod insertion in the control rod plate. Place the rubber and metal washers on the control rods and tighten the nuts until snug. Stake the threads of the control rods to prevent nut movement during operation.

B.3.2 *MAINTENANCE:*

B.3.2.1 *Periodic Inspection:*

The expansion joint should be inspected periodically to ensure proper operation and installation. Periodically re-torque bolts. Apply plant-approved maintenance procedures as required. In full sun or desert-like conditions periodic recoating of the UV protective paint is recommended.

B.3.2.2 *Welding:*

If welding is to occur in the vicinity of the expansion joint, a welding blanket or protective cover should be used to protect the expansion joint.

B.3.3 *STORAGE:*

B.3.3.1 *Standard Storage:*

Ideal storage is a warehouse with a relatively dry, dark, cool location. The warehouse temperature should not be over 80°F (27°C). Storage near ozone producing equipment should be avoided. Store flange face down (in an axis vertical position) on a pallet or wooden platform. Do not store other heavy items on top of an expansion joint. A minimum five year shelf-life may be expected with ideal conditions. If storage must be outdoors, the expansion joints should be placed on wooden platforms and should not be in contact with the ground. Cover with a tarpaulin.

http://www.fluidsealing.com/standards/FSA-PSJ-702-19.pdf

C. FSA-PSJ-703-19, Guidelines for Elastomers:

C.1. *SCOPE:*

C.1.1 *Application*

This guideline provides the typical properties of elastomers most frequently used for tube and cover compounds in the manufacture of piping expansion joints for a wide range of applications. Properties listed have shown to provide acceptable performance in various services. The Standard is not intended to limit or restrict the use of materials to those listed in this Standard. Other materials may also be suitable and future developments may provide other materials that also are suitable.

C.1.2 *Safety*

While the materials and methods described or referenced in this standard may involve the use of hazardous substances, this standard does not address the hazards that may be involved in such use. It is the sole responsibility of the user/tester to ensure familiarity with the safe and proper use of any hazardous materials and test procedures and to take the necessary precautionary measures to ensure the health and safety of all personnel involved.

C.2. *APPLICABLE DOCUMENTS:*

C.2.1 *ASTM International:*

ASTM D-2000 Standard Classification System for Rubber Products in Automotive Applications

ASTM D-395 Test Method for Rubber Property – Compression Set

ASTM D-412 Rubber Properties in Tension

ASTM D-471 Rubber Property - Effect of Liquids

ASTM D-573 Rubber - Deterioration in an Air Oven

ASTM D-2240 Rubber Property - Durometer Hardness

ASTM D-297 Rubber Products - Chemical Analysis

C.3. *SIGNIFICANCE AND USE*

The Standard is based on ASTM International Standard D-2000-08 which classifies important properties of elastomers through designation of types and classes. This edition of the D-2000 remains the default subsequent to any revisions. Should these guidelines conflict with any specification for any of these elastomers the specification should take precedence.

C.4. *LIST OF APPLICABLE ELASTOMERS AND THEIR PROPERTIES*

FLUOROELASTOMER (FKM)

USED IN NON-METALLIC PIPING EXPANSION JOINTS

D-2000-08 CLASSIFICATION:

LINE CALL OUT: **M1HK707Z1Z2Z3Z4**

Note - these values are based on Non-Post cured material

Details of Recommended Requirements:

GRADE = 1

DUROMETER – TYPE A = 70 ±5

Z1 TENSILE STRENGTH - MINIMUM (MPa) = 6
(Minimum Tensile Strength - psi = 870)

Z2 ULTIMATE ELONGATION – MINIMUM = 225%

HEAT RESISTANCE TEST METHOD D573: 70 Hr @ 250°C
Maximum Change in Hardness = ± 15 Points
Maximum Change in Tensile Strength = -30%
Maximum Change in Ultimate Elongation = -50%

IRM 903 Oil TEST METHOD D471: 70 Hr @ 150°C
Maximum Volume Change = + 10%

Z3 COMPRESSION SET TEST METHOD D395:
22 Hr @ 150°C (METHOD "B" SOLID DISCS)
Maximum Compression Set = 50%

Z4 (SPECIAL REQUIREMENTS):
Specific Gravity 1.75 – 1.90

CHLOROPRENE (CR)

USED IN NON-METALLIC PIPING EXPANSION JOINTS

D-2000-08 CLASSIFICATION:

LINE CALL OUT: M3BC610 A14 Z1

Details of Recommended Requirements:

GRADE = 3

DUROMETER – TYPE A = 60 ±5

TENSILE STRENGTH - MINIMUM (MPa) = 10
(Minimum Tensile Strength - psi = 1450)

ULTIMATE ELONGATION– MINIMUM = 350%

HEAT RESISTANCE TEST METHOD D573: 70 Hr @ 100°C
Maximum Change in Hardness = ± 15 Points
Maximum Change in Tensile Strength = -15%
Maximum Change in Ultimate Elongation = -40%

IRM 903 Oil TEST METHOD D471: 70 Hr @ 100°C
Maximum Volume Change = + 120%

COMPRESSION SET TEST METHOD D395: 22 Hr @ 100°C (METHOD "B" SOLID DISCS)
Maximum Compression Set = 80%

Z1 (SPECIAL REQUIREMENTS):
Specific Gravity 1.30 – 1.50

CHLOROSULFUNATED POLYETHYLENE (CSM)

USED IN NON-METALLIC PIPING EXPANSION JOINTS

D-2000-08 CLASSIFICATION:

LINE CALL OUT: **M2CE610 A16 Z1**

Details of Recommended Requirements:

GRADE = 2

DUROMETER – TYPE A = 60 ±10

TENSILE STRENGTH - MINIMUM (MPa) = 10
(Minimum Tensile Strength - psi = 1450)

ULTIMATE ELONGATION– MINIMUM = 350%

HEAT RESISTANCE TEST METHOD D573: 70 Hr @ 150°C
Maximum Change in Hardness = ± 20 Points
Maximum Change in Tensile Strength = ±30%
Maximum Change in Ultimate Elongation = -60%

IRM 903 Oil TEST CONDITIONS: 70 Hr @ 125°C
Maximum Volume Change = + 80%

COMPRESSION SET TEST METHOD D395:
22 Hr @ 70°C (METHOD "B" SOLID DISCS)
Maximum Compression Set = 80%

Z1 (SPECIAL REQUIREMENTS):
Specific Gravity 1.25 – 1.40

EPDM (EP, EPDM)

USED IN NON-METALLIC PIPING EXPANSION JOINTS

D-2000-08 CLASSIFICATION:

LINE CALL OUT: M4CA610 A25 EA14 Z1

Details of Recommended Requirements:

GRADE = 4

DUROMETER – TYPE A = 60 ±10

TENSILE STRENGTH - MINIMUM (MPa) = 10
(Minimum Tensile Strength - psi = 1450)

ULTIMATE ELONGATION – MINIMUM = 250%

HEAT RESISTANCE TEST METHOD D573: 70 Hr @ 125°C
Maximum Change in Hardness = ± 10 Points
Maximum Change in Tensile Strength = ± 20%
Maximum Change in Ultimate Elongation = - 40%

IRM 903 Oil TEST METHOD D471: No Requirements
Maximum Volume Change = No Requirements

COMPRESSION SET TEST METHOD D395:
22 Hr @ 100°C (METHOD "B" SOLID DISCS)
Maximum Compression Set = 60%

WATER RESISTANCE TEST METHOD D471: 70 Hr @ 100 °C
Volume Change % = ± 5

Z1 (SPECIAL REQUIREMENTS):
Specific Gravity 1.00 – 1.20

BUTYL (HR)

USED IN NON-METALLIC PIPING EXPANSION JOINTS

D-2000-08 CLASSIFICATION:

LINE CALL OUT: M2AA608 A13 Z1

Details of Recommended Requirements:

GRADE = 2

DUROMETER – TYPE A = 60 ±5

TENSILE STRENGTH - MINIMUM (MPa) = 8
(Minimum Tensile Strength - psi = 1160)

ULTIMATE ELONGATION – MINIMUM = 300%

HEAT RESISTANCE TEST METHOD D573: 70 Hr @ 70°C
Maximum Change in Hardness = ± 15 Points
Maximum Change in Tensile Strength = ±30%
Maximum Change in Ultimate Elongation = - 50%

IRM 903 Oil TEST METHOD D471: No Requirement
Maximum Volume Change = No Requirements

COMPRESSION SET TEST METHOD D395:
22 Hr @ 70°C (METHOD "B" SOLID DISCS)
Maximum Compression Set = 50%

Z1 (SPECIAL REQUIREMENTS):
Specific Gravity 1.10 – 1.20

CHLOROBUTYL (CHR)

USED IN NON-METALLIC PIPING EXPANSION JOINTS

D-2000-08 CLASSIFICATION:

LINE CALL OUT: M2BA607 Z1 Z2

Details of Recommended Requirements:

GRADE = 2

DUROMETER – TYPE A = 60 ±5

TENSILE STRENGTH - MINIMUM (MPa) = 7
(Minimum Tensile Strength - psi = (1015)

ULTIMATE ELONGATION – MINIMUM = 300%

HEAT RESISTANCE TEST CONDITIONS: 70 Hr @ 100°C
Maximum Change in Hardness = ± 15 Points
Maximum Change in Tensile Strength = ±30%
Maximum Change in Ultimate Elongation = - 50%

IRM 903 Oil TEST CONDITIONS: No Requirement
Maximum Volume Change = No Requirements

COMPRESSION SET TEST METHOD D395: 22 Hr @ 70°C
(METHOD "B" SOLID DISCS)
Maximum Compression Set = 50%

Z1 (SPECIAL REQUIREMENTS):
Specific Gravity 1.10 – 1.40

Z2 (SPECIAL REQUIREMENTS):
WATER RESISTANCE TEST METHOD D471: 70 Hr @ 100 °C
Volume Change = ± 5%

STYRENE-BUTADIENE (SBR)

USED IN NON-METALLIC PIPING EXPANSION JOINTS

D-2000-08 CLASSIFICATION:

LINE CALL OUT: M2AA608 A13 Z1

Details of Recommended Requirements:

GRADE = 2

DUROMETER – TYPE A = 60 ±5

TENSILE STRENGTH - MINIMUM (MPa) = 8
(Minimum Tensile Strength - psi = (1160)

ULTIMATE ELONGATION – MINIMUM = 300%

HEAT RESISTANCE TEST METHOD D573: 70 Hr @ 70°C
Maximum Change in Hardness = ± 15 Points
Maximum Change in Tensile Strength = ±30%
Maximum Change in Ultimate Elongation = - 50%

IRM 903 Oil TEST METHOD D471: No Requirement
Maximum Volume Change = No Requirement

COMPRESSION SET TEST METHOD D395:
22 Hr @ 70°C (METHOD "B" SOLID DISCS)
Maximum Compression Set = 50%

Z1 (SPECIAL REQUIREMENTS):
Specific Gravity 1.10 – 1.30

NITRILE (NBR)

USED IN NON-METALLIC PIPING EXPANSION JOINTS

D-2000-08 CLASSIFICATION:

LINE CALL OUT: M5BG610 A14 B14 EO34 Z1

Details of Recommended Requirements:

GRADE = 5

DUROMETER – TYPE A = 60 ±5

TENSILE STRENGTH - MINIMUM (MPa) = 10
(Minimum Tensile Strength - psi = (1450)

ULTIMATE ELONGATION – MINIMUM = 300%

HEAT RESISTANCE TEST METHOD D573: 70 Hr @ 100°C
Maximum Change in Hardness = ± 15 Points
Maximum Change in Tensile Strength = -20%
Maximum Change in Ultimate Elongation = - 40%

IRM 903 Oil TEST METHOD D471: 70 Hr @ 100°C
Change in Hardness = 0 to -15 Points
Maximum Change in Tensile Strength = -45%
Maximum Change in Ultimate Elongation = -45%
Volume Change = 0 to +35%

COMPRESSION SET TEST METHOD D395:
22 Hr @ 100°C (METHOD "B" SOLID DISCS)
Maximum Compression Set = 25%

Z1 (SPECIAL REQUIREMENTS):
Specific Gravity 1.20 – 1.30

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Appendix E: Definitions

Abrasion Resistance: The ability to withstand the wearing effect of a rubbing surface. In elastomers, abrasion is a complicated process, often affected more by compounding and curing than by the elastomer. Soft, resilient compounds, such as pure gum rubber, are frequently specified.

Abrasive Wear: Damage caused by being rubbed by a foreign object; a wearing away by friction of solids.

Absorption: The process of taking in fluid. Joint materials are often compared with regard to relative rates and total amounts of absorption as they pertain to specific fluids.

Accelerated Life Test - Accelerated Aging Test: a method designed to approximate in a short time the deteriorating aging effects obtained under normal service conditions.

Acid Resistant: The ability to withstand the action of acids within certain limits of concentration and temperature.

Active Length: The portion of the flexible part of the joint that is free to move. Also called flex length.

Adhesion: The strength of bond between cured rubber surfaces or cured rubber surface and a non-rubber surface.

Adhesion Failure: The separation of two bonded surfaces at an interface

Air Flow: the volume of air that can flow through an expansion joint in a given time period (see CFM)

Ambient Temperature: The external environment temperature adjacent to the external face of the expansion joint.

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

Amplitude of Vibration and/or Movement: the distance of reciprocating motion of an expansion joint assembly. Half this deflection occurs on each side of the normal expansion joint centerline.

Anchor: Terminal point or fixed point in a piping system from which directional movement occurs.

Angular Deflection/ Movement: The movement which occurs when one flange of the expansion joint is moved to an out of parallel position with the other flange. Such movement is measured in degrees.

ANSI: American National Standards Institute

API: American Petroleum Institute

Aramid Fibers: a class of heat-resistant and strong synthetic fibers

Arch: That portion of an expansion joint which accommodates the movement of the joint.

Assembly: a general term referring to any expansion joint coupled with end fittings of any style attached to one or both ends.

ASTM: American Society for Testing and Materials

Autoclave: an apparatus using superheated high pressure steam for sterilization, vulcanization and other processes.

Atmospheric Cracking: Cracks produced on surface of rubber articles by exposure to atmospheric conditions, especially sunlight, ozone and pollution.

Average Burst: Used by the manufacturer to determine Maximum Allowable Working Pressure.

Axial Compression: The dimensional reduction or shortening in the face- to-face parallel length of the joint measured along the longitudinal axis.

Axial Elongation/extension: The dimensional increase or lengthening of face-to-face parallel length of the joint measured along the longitudinal axis.

Axial Movement: compression or elongation along the longitudinal axis.

Back-up Rings: Refer to Retaining rings

Baffle (Flow Liner): A product that consists of a sleeve extending through the bore of an expansion joint with a full face flange on one end. Constructed of hard rubber, metal or fluoroplastic; it reduces the frictional wear of the expansion joint and provides smooth flow, reducing turbulence.

Bearing Point: See Fixed Point.
The point at which the piping system is anchored.

Bellows: The portion of an expansion joint which accommodates the movement of the joint. It may be convoluted or flat (see also Active length)

Bench Test: A modified service test in which the service conditions are approximated, but the equipment is conventional laboratory equipment and not necessarily identical with that in which the product will be employed.

Bending Modulus: A force required to induce bending around a given radius; hence a measure of stiffness.

Bias Angle: the angle at which the reinforcement, either fabric or cord, is applied to the expansion joint relative to the horizontal axis.

Blister: A raised spot on the surface or a separation between layers, usually forming a void or air-filled space in the rubber article.

Bloom: A natural discoloration or change in appearance of the surface of a rubber product caused by the migration of a liquid or solid to the surface. Examples: sulfur bloom, wax bloom.

Body: See Carcass

Body Rings: Solid steel rings embedded in the carcass used as strengthening members of the joint.

Body Wire: normally a round or flat wire helix embedded in the expansion joint wall to increase strength or to resist collapse.

Bolt Hole Circle: See Bolt Hole Pattern or Drill Pattern

Bolt Hole Pattern or Drill Pattern: The location of bolt holes in the expansion joint flanges, where joint is to be bolted to mating flanges.

Bolt Torque: The torque with which bolts must be fastened. This varies according to bolt dimensions, bolt lubrication, flange pressure etc.

Boot or Belt: The flexible element of an expansion joint.

Bore: A fluid passageway, normally the inside diameter of the expansion joint.

Brand: a mark or symbol identifying or describing a product and/or manufacturer, that is embossed, inlaid or printed.

Burst: A rupture caused by internal pressure

Burst pressure: the pressure at which rupture occurs.

Burst Test: A test to measure the pressure at which an expansion joint bursts.

C of C or COC: Certificate of Compliance or conformance: a document typically signed and dated pertaining to a particular lot or purchase order of items(s), which describes any standards, specifications, tests, materials and/or performance attributes which the referenced item(s) have met or will meet.

Calender: A three-roll or four-roll piece of equipment used to produce elastomer plies for an expansion joint at the thickness and width required; also used to skim elastomer onto reinforcing cord or fabric.

Capped End: A seal on the end of a sleeve joint or flange to protect internal reinforcement.

Carcass: The carcass or body of the expansion joint consists of fabric and, when necessary, metal reinforcement.

Cemented Bolt Hole: A method of sealing exposed fabric in a bolt hole.

Cemented Edge: An application of cement around the edges of an expansion joint with or without internal reinforcement for protection or adhesion. (A form of Capped End.)

CFM: cubic feet per minute

Chalking: Formation of a powdery surface condition due to disintegration of surface binder or elastomer, due in turn to weathering or other destructive environments.

Checking Cracks: produced on surface of rubber articles by exposure to atmospheric conditions, especially sunlight, ozone and pollution.

Chemical Resistance: The ability of a particular polymer, rubber compound, or metal to exhibit minimal physical and/or chemical property changes when in contact with one or more chemicals for a specified length of time, at specified concentrations, pressure, and temperature.

Cloth Impression: impression formed on the rubber surface during vulcanization by contact with fabric jacket or wrapper.

Cold Flow: Permanent deformation under stress.

Cold Pe-Set: Dimension that flexible elements are deflected to in order to ensure that desired movements will take place.

Compensator: A non-metallic expansion joint is a flexible connector fabricated of natural or synthetic elastomers, fluoroplastics and fabrics and, if necessary, metallic reinforcements to provide stress relief in piping systems due to thermal and mechanical vibration and/or movements.

Compound: the mixture of rubber or plastic and other materials, which are combined to give the desired properties when used in the manufacture of a product.

Compression Set: The deformation which remains in rubber after it has been subjected to and released from a specific compressive stress for a definite period of time, at a prescribed temperature.

Compression Sleeves: Pipe sleeves or inside nuts can be installed on the control rods. The purpose of the sleeve is to prevent excessive compression in the expansion joint.

Compression Stops: *See "Compression sleeves"*

Concurrent Movements: Combination of two or more types (axial, angular or lateral) of movements.

Conductive: An expansion joint material having qualities of conducting or transmitting heat or electricity. Most generally, applied to rubber products capable of conducting static electricity.

Connector: Another term for expansion joint

Continuous Temperature Rating: Temperature at which an expansion joint may be operated continuously with safety

Control Rods or Units: Devices usually in the form of tie rods, attached to the expansion joint assembly whose primary function is to restrict the bellows axial movement range during normal operation. In the event of a main anchor failure, they are designed to prevent bellows over-extension or over-compression while absorbing the static pressure thrust at the expansion joint, generated by the anchor failure.

Convolution: That portion of an expansion joint which accommodates the movement of the joint.

Copolymer: a blend of two polymers

Corrosion resistance: ability of the materials to resist chemical attack.

Coupling: Another term for expansion joint

Cover: The exterior surface of the expansion joint formed from natural or synthetic rubber, depending on service requirements. The prime function of the cover is to protect the carcass from outside damage or abuse.

CR: Chloroprene Rubber; ASTM designation for Neoprene; a rubber elastomer.

Cracking: Cracks produced on surface of rubber articles by exposure to atmospheric conditions, especially sunlight, ozone and pollution.

CSM: ASTM designation for chloro-sulfonyl-polyethylene; a rubber elastomer

Cuff End: An expansion joint without flanges. Used to slip over the pipe O.D. and secured with clamps.

Curing: the act of vulcanization.

Cycle Life: The cumulative number of times the flexible element moves from neutral to extended or compressed position and then back again until failure.

Date Code: any combination of numbers, letters, symbols or other methods used by a manufacturer to identify the time of manufacture of a product.

Design Pressure/Vacuum: The maximum pressure or vacuum that the expansion joint is designed to handle during normal operating conditions.

Design Temperature: The maximum high or low temperature that the expansion joint is designed to handle during normal operating conditions. Not to be confused with excursion temperature.

Diameter (Inside): The actual inside diameter of an expansion joint which may be different from the nominal pipe size

DIN: Deutsches Institut für Normung; DIN, the German Institute for Standardization, is the acknowledged national standards body that represents German interests in European and international standards organizations.

Directional Anchor: A directional or sliding anchor is one which is designed to absorb loading in one direction while permitting motion in another.

Displacement: the amount of motion applied to an expansion joint for axial motion and parallel offset and angular misalignment.

Double Expansion Joint: Also known as a Universal Expansion Joint designed to permit extension, compression, lateral and angular movements. The arrangement consists of two rubber expansion joints connected by a center spool with restraint hardware.

Drain: A fitting to drain the expansion joint of liquids that collect at the lowest point.

Drill Pattern: The location of bolt holes on the joint and mating flanges to which the expansion joint and mating flanges will be attached. Usually meets a specification.

Duck: A durable, closely woven fabric.

Durometer: A measurement of the hardness of rubber and plastic compounds.

Ears: Lugs or gusset plates that a control rod goes through to be attached to the mating pipe flanges.

Eccentricity: A condition in which two diameters deviate from a common center.

Effective Length: The portion of the flexible part of the joint that is free to move.

Effective thrust area: Cross-sectional area described by the mean diameter of the arch/convolution if present.

EJMA: Expansion Joint Manufacturers Association (Metal Expansion Joints)

Elasticity: The ability to return to the original shape after removal of load without regard to the rate of return.

Elastomer: A natural rubber or synthetic polymer having elastic properties that can recover its original shape after deformation.

Electrical Resistivity: The resistance between opposite parallel faces of material having a unit length and unit cross section. Typically measured in Ohms/cm.

Elongation: Increase in length expressed numerically as a fraction or a percentage of initial length.

Enlarged End: An end with inside diameter greater than that of the main body of an expansion joint.

EPDM: ASTM designation for Ethylene-Propylene-Diene-Terpolymer; a rubber elastomer.

Excursion Temperature: The temperature the system could reach during an equipment failure. Excursion temperature should be defined by maximum temperature and time duration of excursion.

Expansion Joint: A flexible connector fabricated of natural or synthetic elastomers, fluoroplastics and fabrics and, if necessary, metallic reinforcements to provide stress relief in piping systems due to thermal and mechanical vibration and/or movements.

Expansion Joint Assembly: The complete expansion joint, including, where applicable, the flexible element, the exterior hardware and any flow liners or ancillary components.

External Influences: Forces or environment acting on the expansion joint from outside of the process.

External Insulation: Insulation materials applied to the outside of the pipe, not the expansion joint.

Fabric impression: Impressions formed on the outer surface during vulcanization by contact with a fabric wrap.

Face-to-Face (F/F): Dimension between the mating flange faces to which the expansion joint will be bolted. This is also the length of the expansion joint when the system is in the cold position.

Fastening Element: Bolts, nuts, studs, washers and other items for securing a connection.

Fatigue: The weakening or deterioration of a material caused by a repetition of strain.

FDA: U.S. Food and Drug Administration.

FEP: ASTM designation for Fluoro-Ethylene-Propylene.

Field Assembly: A joint that is assembled at the jobsite.

Filled Arch: Arch-type expansion joints supplied with a bonded-in-place soft rubber filler to provide a smooth interior bore. Filled arch joints have a seamless tube so the arch filler cannot be dislodged during service.

Finite Element Analysis (FEA): A computerized method to study a structure and its components to ensure that the design meets the required performance criteria.

Fixed Point: The point at which the piping system is anchored.

Flame retardant: Materials added to compounds to inhibit, suppress or delay the production of flames to prevent the spread of fire.

Flange: The component which is used to fasten the expansion joint into the piping system.

Flanged End: The ends or flanges of an expansion joint so it can be bolted to adjacent flanges.

Flanged Expansion Joint: An expansion joint with flanged ends.

Flange Gasket: A gasket which is inserted between two adjacent flanges to form a sealed connection.

Flex Cracking: A surface cracking induced by repeated bending or flexing.

Flexible Connector: An expansion joint or flexible pipe fabricated of natural or synthetic elastomers, fluoroplastics and fabrics and, if necessary, metallic reinforcements to provide stress relief in piping systems due to thermal and mechanical vibration and/or movements.

Flexible Element: *See Flexible Connector*

Flexible Length: The portion of the flexible part of the joint that is free to move. *See Active Length*

Flex Life: The cumulative number of times the flexible element moves from the cold to hot position and then back to cold again until failure.

Floating Flange: Metal flange which is grooved to contain the bead on each end of an expansion joint. It is used on spherical expansion joints.

Flow Direction: The direction in which the media is flowing.

Flow Liner: This product consists of a sleeve extending through the bore of the expansion joint attached on one end. Constructed of hard rubber, metal or fluoroplastic; it reduces frictional wear of the expansion joint and provides smooth flow, reducing turbulence.

Flow rate: A volume of media being conveyed in a given time period.

Flow Velocity: The rate of flow through the expansion joint system.

Fluorocarbon: A general class of compounds containing fluorine and carbon.

Fluoroelastomers: FKM, FPM, fluorine containing compounds which have excellent resistance to a broad spectrum of oils, gases, fluids and chemicals at elevated temperatures.

Fluoropolymer: A fluorocarbon based polymer with strong carbon-fluorine bonds. PTFE, PFA, FEP

Fluoroplastics: Fluoroplastics are thermoplastic resins of general paraffin structures that have all or some of the hydrogen replaced with fluorine. PTFE, PFA, FEP

Flutter: The action that occurs on the flexible element caused by the turbulence of the system media or vibration in system.

Free Length: The portion of the flexible part of the joint that is free to move. See Active Length.

Frequency: The rate at which some event occurs.

Frictioned Fabric: A fabric with a surface treatment which will bond two surfaces together usually by means of a calender with rolls running at different surface speeds. May also be used to adhere to only one surface.

Gas Flow Velocity (see Flow Velocity): The rate of flow through the expansion joint system.

Gimbal Expansion Joint: Gimbal type rubber expansion joints are designed to permit angular rotation in multiple planes. The arrangement consists of two pairs of hinge plates connected with pins to a common gimbal ring and attached to the expansion joints' external or internal hardware.

GPM: gallons per minute

Guide: A pipe guide is framework fastened to some rigid part of the installation which permits the pipeline to move freely in only one direction along the axis of the pipe. Pipe guides are designed primarily for use in applications to prevent lateral deflection and angular rotation.

Gusset Plates: The ears, or lugs that a control rod goes through to be attached to the mating pipe flanges.

Hardness: Measured by the amount of an indenter point of any one of a number of standard hardness testing instruments to penetrate the product. *Also see Durometer.*

Heat Resistance: The ability to resist the deteriorating effects of elevated temperatures.

Helix: Shape formed by spiraling a wire or other reinforcement around the cylindrical body of a rubber pipe.

Hg: The symbol for mercury, used in measuring vacuum, as in, inches of mercury.

Hinged Expansion Joint: Hinged type rubber expansion joints are designed to permit angular rotation in one plane. The arrangement consists of a pair of hinge plates connected with pins and attached to the expansion joints external or internal hardware.

HVAC: heating, ventilation, air conditioning

Hydrostatic Test: Test used to demonstrate system or expansion joint capability. The standard test is 1-1/2 times the Maximum Allowable Pressure, held for 10 minutes, without leaks.

I.D.: the abbreviation for inside diameter

Inches of mercury: The height of a column of mercury used to measure air pressure or vacuum

Inches of water: The height of a column of water used to measure air pressure or vacuum

In-Line Pressure Balanced Expansion Joint: Pressure Balanced type rubber expansion joints are designed to absorb compression, lateral and angular movements while resisting the pressure thrust force. The arrangement consists of two or three rubber expansion joints and interconnecting hardware and attached to the external or internal interconnecting hardware. This configuration is designed to function in a straight pipeline.

Inner Ply: The media side ply of the flexible element.

Installed Face-to-Face Distance: Dimension between the mating flange faces to which the expansion joint will be bolted.

Installed Length: *See Installed Face Distance*

Integrally Flanged Type Expansion Joint: An expansion joint in which the joint flanges are made of the same rubber and fabric as the body of the joint.

Intermediate Anchor: An anchor which must withstand the expansion joint thrust due to flow, spring forces, and all other piping loads, but not the thrust due to pressure.

Internal Sleeve: A sleeve extending through the bore of the expansion joint attached on one end. Constructed of hard rubber, metal or fluoroplastic; it reduces frictional wear of the expansion joint and provides smooth flow, reducing turbulence.

ISO: International Organization for Standardization

Joint Cuff: The ends of a sleeve type expansion joint. Used to slip over the pipe O.D. and secured with clamps.

Lateral Movement/Deflection: The relative displacement of the two ends of the expansion joint perpendicular to its longitudinal axis.

Lateral Offset: The distance between two adjacent flanges or faces perpendicular to its longitudinal axis.

Life Cycles: The cumulative number of times the flexible element moves through its motion range until failure.

Lifting Lugs: A lifting device that is attached to the metal portion of the expansion joint for field handling and installation.

Limiting Stress: The load which, when applied, does not exceed the elastic limits of the material and provide a safe operating level.

Limit Rods: Devices usually in the form of tie rods, attached to the expansion joint assembly whose primary function is to restrict the expansion joint axial movement range during normal operation. In the event of a main anchor failure, they are designed to prevent bellows over-extension or over-compression while absorbing the static pressure thrust at the expansion joint, generated by the anchor failure.

Lined Bolt Holes: A method of sealing exposed fabric in a bolt hole.

Liner: A sleeve extending through the bore of the expansion joint attached on one end. Constructed of hard rubber, metal or Fluoroplastic; it reduces frictional wear of the expansion joint and provides smooth flow, reducing turbulence.

Live Length: Active Length (Flex Length): The portion of the flexible part of the joint that is free to move.

Main Anchor: A main anchor is one which must withstand all of the thrust due to pressure, flow and spring forces of the system.

Mandrel: A form used for sizing and to support the expansion joint during fabrication and/or vulcanization. It may be rigid or flexible.

Mandrel Built: An expansion joint fabricated and/or vulcanized on a mandrel.

Manufactured length: The manufactured width of the flexible element measured from joint end to end.

Manufacturer's identification: A code or symbol used on or in an expansion joints to indicate the manufacturer.

Maximum Burst: Is the theoretical (predetermined) burst pressure of an expansion joint.

Maximum Design Temperature: The maximum temperature that the system may reach during normal operating conditions. This is not to be confused with excursion temperature.

MAWP: Maximum Allowable Working Pressure

Mean Diameter: The midpoint between the inside diameter and the outside diameter of an expansion joint.

Media, Medium: The substance conveyed through a system.

Membrane: A ply of material.

Metal Reinforcement: Wire or solid steel rings embedded in the carcass are frequently used as strengthening members of the joint. The use of metal sometimes raises the rated working pressure and can supply rigidity to the joint for vacuum service.

Minimum temperature: The lowest temperature to which the system will be exposed.

Misalignment: The out of line condition that exists between the adjacent faces of the flanges.

Molded Type Expansion Joint: An expansion joint that is cured in a mold, not wrapped finished.

Motion Indicators: Devices attached to an expansion joint to record the amount of motion of the joint during operation.

Movements: The dimensional changes which the expansion joint is designed to absorb, such as those resulting from thermal expansion or contraction.

Nitrile Rubber: Buna-N, NBR, used heavily for oil, fuel and chemical resistance.

Noise Attenuation: The reduction of noise transmitted through the piping systems by the expansion joint.

Nominal: A size indicator for reference.

Nominal Thickness: The design value.

Non-conductive: Having the ability to stop the flow of electricity.

Non-Metallic Expansion Joint: A flexible connector principally fabricated of natural or synthetic elastomers, fluoroplastics and fabrics. If necessary, it may include metallic reinforcements.

NSF: National Sanitation Foundation

Nylon: A material of the polyamide family, which may be woven or cord type, used in the construction of an expansion joint.

O-A-L: Alternative term for the "face to face" dimension or the overall length of an expansion joint.

O.D.: The abbreviation for outside diameter.

OE/OEM: Original Equipment Manufacturer

Offset-lateral, parallel: The offset distance between two adjacent flanges or faces.

Oil Resistant: The ability to withstand the deteriorating effects of oil on the physical properties.

Oil Swell: The increase in volume of rubber due to absorption of oil.

Open Arch: An arch or convolution of an expansion joint that is not filled.

Operating Pressure/Vacuum: The pressure at which the system works under normal conditions. This pressure may be positive pressure or vacuum.

Operating Temperature: The temperature at which the system will generally operate during normal conditions.

Outer Cover: The exterior surface of the expansion joint formed from natural or synthetic rubber, depending on service requirements. The prime function of the cover is to protect the carcass from outside damage or abuse.

Overall length (OAL): Dimension between the mating flange faces to which the expansion joint will be bolted.

Oxidation: The combination of a substance or material with oxygen causing a change in its appearance and condition.

Ozone cracking: Cracks produced on surface of rubber articles by exposure to atmospheric conditions.

Ozone resistance: The ability of a material to resist the deteriorating effects of ozone exposure.

Pantograph Control Mechanism: A special metal construction using a "scissors" principle to distribute large movements uniformly between two or more flexible elements in line.

Permanent Set: The deformation remaining after a specimen has been stressed in tension or compression and then released for specified periods of time.

Permeation: The penetration of a liquid or gas through the expansion joint material.

Permeability: The ability of a liquid or gas to pass through the expansion joint material.

Pipe Alignment Guide: A pipe alignment guide is framework fastened to some rigid part of the installation which permits the pipeline to move freely in only one direction along the axis of the pipe. Pipe alignment guides are designed primarily for use in applications to prevent lateral deflection and angular rotation.

Pipe Section: The section of a pipeline that is between two anchor points.

Pipe Sleeve: Pipe sleeves or inside nuts can be installed on the control rods. The purpose of the sleeve is to prevent excessive compression in the expansion joint. The length of this pipe sleeve should be such that the expansion joint cannot be compressed beyond the maximum allowable compression figure stated by the manufacturer.

Plain Ends: An end with inside diameter the same as that of the main body, as in straight ends.

Ply: One concentric layer or ring of material, such as fabric plies in an expansion joint.

Polymer: A chemical compound where molecules are bonded together in long repeating chains.

Pre-Assembled Joint: The combination of the metal framework and a flexible element, factory assembled into a single assembly.

Pre-Compression: Compressing the expansion joint (shortening the F/F) so that in the cold position the joint has a given amount of compression set into the joint. The purpose of pre-compression is to allow for unexpected or additional axial extension. This is performed at the jobsite.

Pre-Set: The dimension which joints are expanded, compressed or laterally offset in the installed position, in order to ensure that system design movements will take place.

Pressure Balanced Expansion Joint: An expansion joint designed to absorb compression, lateral and angular movements while resisting the pressure thrust force. The arrangement consists of two or three rubber expansion joints with interconnecting hardware. It can be designed to function as an in-line or elbow configuration.

Proof Pressure Test: Hydrostatic test up to 1.5 times the Maximum Allowable Working Pressure of the product, for a minimum of 10 minutes without leaks.

Protective Shipping Cover: Material used to protect the expansion joint during shipment and installation.

Pulsation: The action that occurs on the expansion joint caused by the turbulence of the system fluids, gases or vibration set up in the system.

Pump Connector: An expansion joint used to connect a pump to a pipeline.

Psi: Pounds per Square Inch

PTFE: Polytetrafluoroethylene, a strong non-flamable synthetic resin produced by the polymerization of Tetrafluoroethylene. It has excellent chemical resistance.

Quality conformance inspection or test: The examination of samples from a production run to determine adherence to given specifications.

Reducers: Reducing expansion joints are used to comment piping unequal diameters. They may be manufactured as a concentric reducer or as an eccentric reducer. Reducers in excess of 20 degrees are not desirable.

Reinforcement: The carcass or body of the expansion joint consisting of fabric and, when necessary, metal reinforcement.

Resultant Movement: The net effect of concurrent movement.

Reinforcing Rings: Solid steel rings embedded in the carcass used as strengthening members of the joint.

Retaining Rings: Rings used to distribute the bolting load and assure a pressure tight seal. They are coated for corrosion resistance and drilled as specified. The rings are installed directly against the back of the flanges of the joint and bolted through to the mating flanges of the pipe.

RMA: The Rubber Manufacturers Association Inc.

SAE: The Society of Automotive Engineers. This organization has developed methods of testing and classifying elastomers.

Safety factor: A ratio used to establish the minimum burst strength of an expansion joint based on the design pressure.

SBR: ASTM designation for Styrene-Butadiene: a rubber elastomer.

Service Life: Estimated time the expansion joint will operate without the need of replacement.

Shelf/storage life: The period of time prior to use during which an expansion joint retains its intended performance capability.

Simultaneous Movements: Combination of two or more types of movements.

Site Assembly: An expansion joint which is assembled at the jobsite.

Sleeve Type Expansion Joint: An expansion joint which has sleeved or cuffed ends for securing to the pipe as opposed to flanged ends.

Soft Cuffs/Soft Ends: An end in which the rigid reinforcement of the body, usually wire, is omitted.

Specific Gravity: The ratio of the weight of a given substance to the weight of an equal volume of water at a specified temperature.

Spool Type: An expansion joint with flanged ends.

Spring Rate: The force required to move the expansion joint a certain distance in compression, extension or laterally. It is most often expressed in lb/in.

Stabilizer: An external attachment to the expansion joint assembly, whose primary function is to increase the stability of a universal expansion joint assembly.

Static Wire: A wire incorporated in an expansion joint for conducting or transmitting static electricity.

Straight End: An end with inside diameter the same as that of the main body.

Sun Checking: Cracks produced on surface of rubber articles by exposure to atmospheric conditions, especially sunlight, ozone and pollution.

Surge (spike): A rapid rise in pressure.

Tapers: Reducing expansion joints are used to connect piping with unequal diameters. They may be manufactured as a concentric reducer or as an eccentric reducer. Reducers in excess of 20 degrees are not desirable.

Tensile Strength: Ability of a material to resist or accommodate loads until the breakage point.

Thermal Movement: Movements created within the piping system by thermal expansion. Can be axial compression, axial extension, lateral, angular or torsional.

Top Hat Liner: A product that consists of a sleeve extending through the bore of an expansion joint with a full face flange on one end.

Torsional Movement: The twisting of one end of an expansion joint with respect to the other end about its longitudinal axis. Such movement is measured in degrees.

Torsional Rotation: *See Torsional Movement*

Transverse Movement: The movement or relative displacement of the two ends of the expansion joint perpendicular to its longitudinal axis.

Tube: The innermost continuous rubber or synthetic element of an expansion joint.

Under Gauge: Thinner than the thickness specified.

Universal Expansion Joint: Universal type rubber expansion joints are designed to permit extension, compression, lateral and angular movements. The arrangement consists of two rubber expansion joints connected by a center spool with restraint hardware.

UV Resistance: The ability of a material to resist the deteriorating effects of exposure to ultraviolet rays.

Vacuum: Pressures below atmospheric pressure.

Vacuum Resistance: Expansion joint's ability to resist negative gauge pressure.

Van Stone Flange: A loose, rotating type flange, sometimes called a lap-joint flange.

Velocity Resonance: Vibration due to the elastic response of a high velocity gas or liquid flow.

Volume change: A change in dimensions of a specimen due to exposure to a liquid or vapor.

Volume swell: An increase in volume or linear dimension of a specimen immersed in liquid or exposed to a vapor.

Volumetric expansion: The volume increase of an expansion joint when subjected to internal pressure.

Wear Resistance: The ability of a material to withstand abrasive particles without degradation or wear .

WG: Water gauge or column of water used to measure pressure.

Welding Blanket: A fire resistant blanket that is placed over the expansion joint to protect it from weld splatter during field welding operations.

Wide Arch: A term used for an arch that is wider than the original narrow arch.

Wire gauge: The measurement of how large a wire is in diameter.

Wire Reinforced: Wire embedded in the carcass of an expansion joint frequently used as a strengthening member of the joint. The use of metal can raise the rated working pressure and can supply rigidity to the joint for vacuum service.

Working pressure/ WP: The maximum pressure or vacuum that the expansion joint will be subjected to during normal operating conditions.

Working temperature: The maximum or minimum temperature that the expansion joint will be subjected to during normal operating conditions.

Wrapped Cure (Wrap Marks): Impressions left on the cover surface by the material used to wrap the expansion joint during vulcanization. Usually shows characteristics of a woven pattern and wrapper width edge marks.

Zinc-plated [retaining rings or flanges]: A term for a type of Galvanizing

Appendix F: Noise and Vibration Transmitted Through the Hydraulic Media Reduced with the Installation of Expansion Joint
A Summary Test Report of Cerami and Associates, Inc.

1. **Purpose.** To measure the effects of rubber expansion joints in piping systems which produce objectionable hydraulic resonance noise.

2. **Test System and Location.** The main condenser water riser piping and the secondary chilled water piping systems running to the Board Room of a major retailer, located on the 46th floor of a building in New York City from a sub-basement. *See Drawing 1.*

3. **Problem.** These piping systems were found to transmit a highly objectionable surging noise in the Board Room. Noise frequency was identified as the pump impeller passage frequency (number of vanes in the impeller, times the rotating frequency).

3.A. **Amplified Fluid Pulsations.** It is interesting to note that while the pumps are located remotely from the Board Room, the acoustical energy was conveyed by the piping for more than 500 feet, in the case of the sub-basement located condenser water pumps; and transmitted structurally into the Board Room via pure riser anchors and supports located near the 46th floor. This condition represented a phenomenon which was created by a resonance condition in the piping system, re-acting in harmony with the impeller vane passage frequency and thereby amplifying the fluid pulsations to much higher levels than those at the source.

3.B. **Pure-Tone Noise Fluctuations.** Metal expansion joints were in the piping system prior to the installation of rubber expansion joints. Operating with the metal expansion joints in place, the system noise level had a surging quality, meaning that whenever more than one pump was operating, the puretone noise increased and decreased with a wide range of fluctuation. The peak of the surging noise was measured to be NC-49. Correcting for the highly objectionable pure-tone quality of the noise, the equivalent NC would be as high as NC-54, a totally unacceptable environment for the Board Room. *See Chart - Typical Recommended Noise Criteria Levels.*

4. **Corrective Action and Results.** Rubber expansion joints were installed, replacing the metal expansion joints near the top of the main condenser discharge and return risers. Rubber expansion joints were also installed on the intake and discharge sides of the secondary water pump on the 46th floor. *See Drawing 1.*

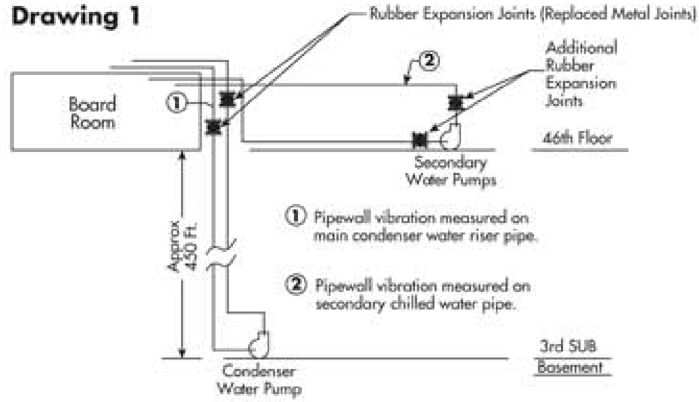
4.A. **Noise Level Reduced, Pure-Tone Eliminated.** With the rubber expansion joints installed into the system, the noise level in the Board Room with two condenser water pumps and two secondary chilled water pumps operating simultaneously, was measured to be only NC-31. Furthermore, the new NC-31 environment contained no pure-tone quality. In fact, by shutting and starting the pumps, there was no detectable change in the ambient sound level. *Table 1* shows the "before and after" noise levels recorded in the Board Room.

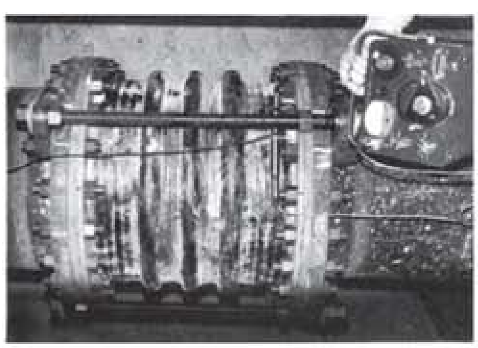
4.B. Pipe Wall Vibration Reduced. The pipe wall vibration patterns were in fact significantly altered as evidenced by "before and after' readings on the pipe walls. Tables 2 and 3 show the spectrum shapes of pipe wall vibration "before and after' the installation of the rubber expansion joints. Tables show substantial reductions of pipe wall vibration, further indications of a quieter piping system.

Drawing 1 shows, schematically, the location of pumps relative to the Board Room, as well as the locations where pipe wall vibration measurements were taken.

5. **Conclusions.** The installation of the rubber expansion joints into the piping system effectively lowered the noise level from NC-54 to NC-31, eliminating the pure-tone quality of the noise. We attribute the highly successful attenuation provided by the rubber expansion joints to a disruption in the acoustical standing wave pattern in the piping configuration. This disruption was being created by the sudden change in pipe wall rigidity at the expansion joint. The soft wall of the expansion joint would actually "breathe" with the fluid pulsations, thereby disrupting the steel pipe wall vibration pattern as well.

Drawing 1





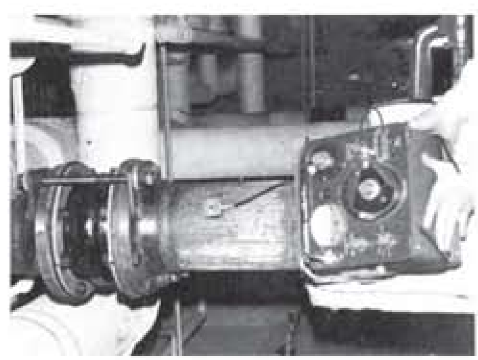
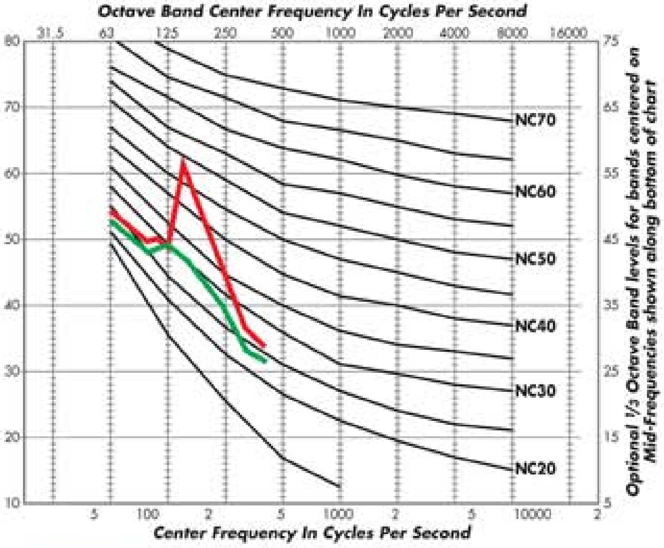


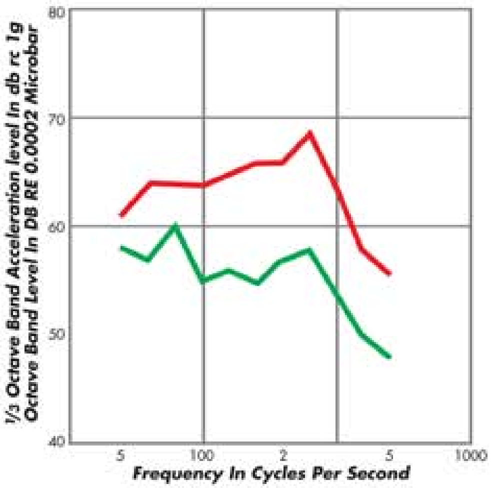
Table 1: Noise Level Plotted on NC Chart



NC - 49 Noise level in board room with condenser water and secondary chilled water pumps operating

Same as above except rubber expansion joints were installed NC - 31

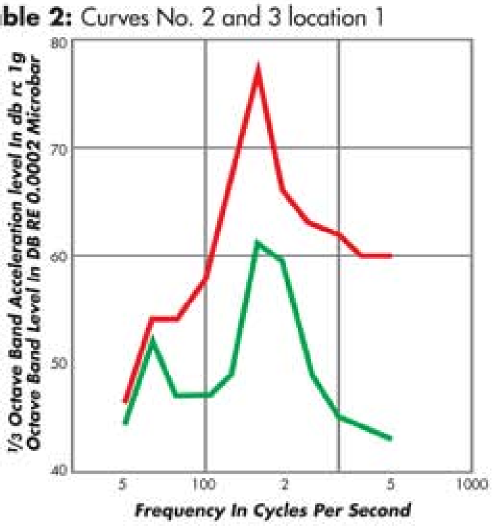
Table 2: Curves No. 2 and 3 location 2



Secondary chilled water pipewall vibration before the installation of rubber expansion joints

Same as above except with rubber expansion joints installed

Table 2: Curves No. 2 and 3 location 1



Condenser water pipewall vibration before the installation of rubber expansion joints.

Same as above except with rubber expansion

Typical Recommended Noise Criteria Levels

Type of Room	NC* Range
Small Private Office	30 to 40
Conference Room for 20	30 to 40
Conference Room for 50	25 to 35
Theaters for Movies	30 to 40
Theaters for Drama	25 to 30
Concert Hall	25 to 35
Secretarial Offices	35 to 45
Home, Sleeping Areas	20 to 30
Assembly Hall	25 to 35
School Room	30 to 40

**Noise Criteria*

Appendix G: Mechanical Vibration in a Steel Piping System Reduced with the Installation of Pipe Connectors or Expansion Joints.

The Non-Metallic Expansion Joint Division has done extensive work on relating the vibration absorbing qualities of rubber to rigid steel pipe. These tests were conducted by a nationally recognized independent Testing Laboratory.* The chart below is an effort to show a practical application of these test results for both an expansion joint and a flexible rubber pipe.

Pipe System Vibration Frequency	Installation Pipe with A/AN					
	Expansion Joint 8" ID X 5' F/F			Rubber Pipe 8" ID X 24" F/F		
	Vibration Reduction At			Vibration Reduction At		
HZ	10 PSIG	50 PSIG	80 PSIG	10 PSIG	50 PSIG	80 PSIG
40	37%	55%	72%	87%	91%	93%
68	80%	68%	78%	95%	96%	99%
125	44%	50%	60%	98%	99%	99%
250	44%	50%	50%	96%	97%	99%
500	65%	89%	90%	91%	93%	94%
1000	90%	96%	98%	82%	91%	96%
2000	94%	95%	96%	99%	99%	99%
4000	90%	93%	97%	97%	99%	99%
8000	89%	89%	94%	94%	97%	98%

Example: If an 8" steel piping system had a major vibration frequency of 1000 Hz at 50 PSIG, the installation of an expansion joint into the system would reduce vibration 96%

*Name of the testing laboratory and other test details, available on request

Appendix H: Pressure Terminology

In 1971, the Non-Metallic Expansion Joint Division of the Fluid Sealing Association sent out a terminology survey to some of the leading engineering firms in the country asking their help in defining certain terms that are continually used in our industry. The purpose of the survey was to arrive at a standard definition of these terms. Our Division Membership has made a very careful study of the answers received and, after consolidating and refining the answers, has been able to reduce the terms in question to the following:

1. **Operating Pressure.** The actual pressure at which the system works under normal conditions. This pressure may be positive or negative (vacuum.)
2. **System Design Pressure.** The highest or most severe pressure expected during operation. Sometimes used as the calculated operating pressure plus an allowance for safety margin.
3. **Expansion Joint Design Pressure.** The highest most severe pressure the expansion joint will handle.
4. **Surge Pressure.** Operating pressure plus the increment above operating pressure that the expansion joint will be subjected to. For a very short time duration due to pump starts, valve closings, etc.
5. **Maximum Allowable Pressure.** This term is used by the expansion joint manufacturer to define the maximum operating pressure recommended for a specific expansion joint. See Table II.
6. **Hydrostatic Test Pressure.** The hydrostatic test pressure is used to demonstrate system or expansion joint capability. The standard test is 1-1/2 times the Maximum Allowable Pressure, held for 10 minutes, without leaks.

Appendix I: List of Specifications

A. **ASTM Designation:** F1123-87, "Standard Specification for Non- Metallic Expansion Joints." Approved December 31, 1987. American Society for Testing and Material, 1916 Race Street, Philadelphia, PA 19103 USA.

B. **MIL-E-15330D(SH):** "Military Specification Expansion Joint, Pipe, Non-Metallic, Fire-Retardant", revised October 14, 1977. U.S. Government Printing Office Form 1977-7103-122-6336. The section on class A, Type 1, Arched, Spool-Type Expansion Joint is replaced by ASTM F 1123-87, effective August 10, 1993.

C. **COAST GUARD:** Code of Federal Regulations (C.F.R.46) Parts 56.35-10 and 56.60-1 (B). Revised 10/1/91. Office of the Federal Register, National Archives and Records Service, General Services Administration. ASTM F 1123-87 is the governing specification.

D. **Fan Connector Spec:** MIL-R-6855-D: Military Specification, "General specification for rubber synthetic; sheets, strips, molded or extruded shapes." Class 2 is specified for Navy fan connectors.

Appendix J: Bibliography of Rubber Expansion Joint Articles

A. **ASHRAE Handbook & Product Directory,** 1984 Systems Chapter 32, "Flexible Pipe Connectors."

B. **Building Construction,** June, 1967: "A Guide to Expansion Joints in Modern Piping Systems", by D. Bruce Keep.

C. **Chemical Engineering,** December 29, 1980" "Elastomeric Expansion Joints", by Joseph H. Bedson.

D. **Elastomerics, January,** 1980: "Elastomers in Flexible Pipe Joints", by R. R. O'Toole.

E. **Elastomers Notebook,** August, 1976: "Hot Gas Exposure", by Gene Johnson.

F. **Elastomers Notebook,** June, 1978: "Flangless Flexibility", by General Rubber Corporation.

G. **Engineering Appliances,** Ltd., January, 1979: "Noise Absorption by Bellows", by Stenflex GMBH.

H. **Heating/Piping/Air Conditioning,** December, 1961: 'When and How Flexible Rubber Connectors Can Help Reduce System Noise, Vibration", by Robert L. Swenson.

I. **Heating/Piping/Air Conditioning,** November, 1979: "Refrigeration for 1980 Winter Olympics", by D. Bruce Keep.

J. **Heating/Piping/Air Conditioning,** January, 1985: "Noise Control in Plumbing Systems", by Lyle F. Yerges.

K. **Mechanical Contractor,** February, 1966: "Rubber Expansion and Vibration Joints, Selection/Installation/ Maintenance", by Ray Michael.

L. **Pipeline & Gas Journal,** March, 1988: "Rubber Expansion Joints", by Ray Magner.

M. **Plant Engineering,** May 17, 1978: "Fabric-Reinforced Rubber Expansion Joints", by Ed Holland.

N. **Plant Engineering,** July 26, 1979: "Methods of Handling Thermally Induced Pipe Movement', by Ernest R. Cunningham.

O. **Plant Services,** April, 1990: "Pump Alignment: When to do it", By Igor J. Karassik.

P. **Power, August,** 1986: "Expansion Joints for Ductwork and Piping", by William O'Keefe.

Q. **Pump and Systems Magazine.** December, 1993: "Ask the Experts - Expansion Joints and Air Chambers", by Bob Stover.

R. **Water/Engineering & Management.** November, 1986: "Cushioning Stress and Strain in Pipe Systems", by Ray Magner.

In the February 2006 issue, we discussed how an expansion joint can relieve stress in piping systems and prevent flange gaskets from being crushed. The case study used in that article was based on the application involving a metal expansion joint.

Figure 1. Typical Rubber Expansion Joint

We did mention that if the same situation occurred under lower temperature service, an elastomeric (rubber) expansion joint designed to compensate for the thermal expansion also would have solved the problem. Let us first describe the two types of expansion joints:

Rubber— a flexible connector fabricated of natural and/or synthetic elastomers and fabric and, if necessary, internal metallic reinforcements designed to provide stress relief in piping systems due to thermal movements and mechanical vibration.

Metal— a flexible element (bellows) constructed of relatively thin gage material (generally stainless steel) designed to absorb mechanical and thermal movements expected in service.

Figure 2. Typical Metallic Expansion Joint

Advantage: Metal

Temperature. Rubber joints with standard construction and materials have an upper range to 230-deg F. Most manufacturers, however, can offer special constructions up to 400- deg F. Metal expansion joints do offer a far greater range, from minus 420-deg F to +1800-deg F. However, working pressures are reduced at elevated temperatures.

Pressure. Rubber joints typically, depending on diameter, can have pressure capabilities up to 250-psi with a full vacuum rating. Metal joints can be designed for pressures up to 1000-psi. The strength of metal is definitely an advantage in high pressure applications; however, the relative stiffness or spring rates coupled with thrust forces should be carefully examined. Piping systems/anchors must be designed to handle the combined load.

Advantage: Rubber

Movements. Rubber and metal expansion joints have similar movement capabilities in the axial plane (compression and extension). However, rubber joints are certainly able to absorb far greater lateral movements when compared to metal joints that have similar face to face dimensions. Constructions (dual or universal) are available for metal joints where large movements in the lateral plane are required but these are considered special design and can be costly.

Spring Rates. Defined as the total force required to move an expansion joint 1-in in any direction. Rubber and metal joints do have similar characteristics in the axial plane for the standard face to face dimensions. Metal joints are much stiffer when subjected to lateral motion and, therefore, typically have a much lower lateral movement capability. Note that all spring rate values are at 0- psig. Both rubber and metal joints produce thrust forces when pressurized that must be considered for proper system design. These forces are defined by the formula shown in *Figure 3*.

$$T = \frac{\pi}{4} (D)^2 (P)$$

T = Thrust
P = Pressure
D = Arch I.D.

Figure 3. Thrust forces on expansion joint.

Acoustical Impedance. Although well designed (multi-ply) metal joints can lower the transmission of visible vibration, they will continue to transmit distracting and/or damaging noise. Rubber joints significantly reduce the undesirable transmission in piping systems. The elastomeric composition of the joint acts as a dampener that absorbs the greatest percentage of perceptible noise and vibration.

Abrasion/Erosion Resistance. Metal joints typically have a wall thickness anywhere between .012-in to .080-in. Rubber joints on the other hand are much thicker, 0.5-in to over one inch. The thin gauge construction of metal joints makes them susceptible to erosive chemicals and abrasive liquids and slurries. Rubber joints are highly resistant to abrasion and erosion of all types and do outperform metal joints in the applications where these conditions prevail. Drop-in or fixed liners can be provided to enhance the life of metal joints in many of these applications but at best can only prolong the time to eventual failure.

Fatigue/Cycle Life. The fatigue life of a metal joint is affected by many factors such as temperature, pressure, movement, vibration and, of course, how the joint was initially designed. Typically, metal joints have a defined cycle or fatigue life that can be calculated through various formulas. Metal joints frequently succumb to fatigue failure from excessive cycling/movement. Rubber joints on the other hand are constructed of resilient elastomers and the joint itself acts as a vibration dampener, not susceptible to fatigue/cycle failure.

Installation/Maintenance. As a rule of thumb, rubber joints are 25 percent to 50 percent lighter than metal joints. Rubber joints do not require additional gasketing and, in many cases, are installed easily by one or two men without the use of special handling equipment. Metal joints must be serviced occasionally to insure that the flange gasket is still intact and not deteriorated. For both rubber and metal expansion joints, control units are recommended to minimize possible damage to the expansion joint caused by excessive motion of the pipeline and in some applications, to absorb thrust forces. When control units are set to eliminate axial extension and compression, the only movement the joint can take is in the lateral plane.

Summary

Metal expansion joints are applied more frequently than rubber primarily because application conditions, e.g. temperatures and pressures, favor their use. Some experts in this industry estimate the metal expansion joint market to be 4X larger than the rubber expansion joint market. The writer of this article has been in the manufacturing business of both rubber and metal joints for over 35 years and would venture to say that is a good estimate.

It may appear that the above comparison is slanted toward the rubber expansion joints. The fact is, rubber can't replace metal in all applications, but it is a better choice for many applications involving high vibration and sound dampening within the guidelines mentioned above. Consultation with a reputable manufacturer for your specific application is always recommended.

Appendix L:

FLUID SEALING® ASSOCIATION FSA

Expansion Joint Specification Sheet

Prepared By:
Non-Metallic Expansion Joint Division
Fluid Sealing Association

YOUR CUSTOMER		
DATE:	THIS IS SHEET NO.	
PROPOSAL NUMBER:		
CUSTOMER NAME:		
PROJECT NAME:		
INQUIRY/JOB NUMBER		
ITEM NO. TAG NO.		
QUANTITY REQUIRED:		

YOUR COMPANY	
COMPANY NAME:	
MAILING ADDRESS:	
CITY, STATE/PROVINCE, ZIP/POSTAL CODE, COUNTRY	
NAME OF PERSON SUBMITTING DATA:	PHONE NO.

Section	Item		
SIZE	PIPE SIZE OF APPLICATION Nominal pipe size or the inside diameter of the connecting flange.	INCHES	
SIZE	INSTALLED LENGTH: Is the space between connecting pipe flanges. Indicate limitations, if any.	INCHES	
FLOWING MEDIUM	FLOWING MEDIUM: Indicate chemical. If flowing medium is corrosive, abrasive, or viscous, explain in detail.		
FLOWING MEDIUM	TYPE OF MEDIUM: Indicate if liquid, gas, slurry, solids, etc.		
FLOWING MEDIUM	TEMPERATURE OF FLOWING MEDIUM: Indicate both operating and maximum temperatures at the expansion joint.	OPERATE F	MAXIMUM F
FLOWING MEDIUM	TEMPERATURE OF SURROUNDING ATMOSPHERE: Indicate both minimum and maximum temperatures of atmosphere at the expansion joint.	MINIMUM F	MAXIMUM F
PRESSURES	OPERATING PRESSURE AT THE JOINT: Actual pressure in which system works in normal conditions.	POSITIVE PSIG	NEGATIVE "Hg
PRESSURES	DESIGN OR TEST PRESSURE OF THE SYSTEM: Highest/most severe pressure expected during operation.	POSITIVE PSIG	NEGATIVE "Hg
PRESSURES	SURGE PRESSURE OF THE SYSTEM: Increased pressure due to pump starts, valve closing, etc.	POSITIVE PSIG	NEGATIVE "Hg
MOVEMENTS	AXIAL COMPRESSION AT JOINT: In inches as a result of pipe extension - expansion.	INCHES	
MOVEMENTS	ACTUAL ELONGATION AT JOINT: In inches as a result of pipe contraction.	INCHES	
MOVEMENTS	LATERAL DEFLECTION AT JOINT: In inches.	INCHES	
MOVEMENTS	ANGULAR MOVEMENT AT JOINT: In degrees.	DEGREES	
MOVEMENTS	TORSIONAL MOVEMENT AT JOINT: In degrees.	DEGREES	
MISCELLANEOUS	PIPE FLANGE DRILLING: Indicates specific standard such as 150# ANSI B16.5. If special, provide: Flange O.D., Bolt, Circle, Number and Size of Holes.	SPECIFICATION	
MISCELLANEOUS	MATING PIPE FLANGE THICKNESS: In inches.	INCHES	
MISCELLANEOUS	LOCATION OF JOINT INSTALLATION: Indoors or Outdoors.		
MISCELLANEOUS	RETAINING RINGS: Are required on all installations. Reusable, they need not be ordered with replacement or spare expansion joints.	YES OR NO	
MISCELLANEOUS	CONTROL UNIT ASSEMBLIES: Are recommended for use in all expansion joint applications. Control units must be used when piping support or anchoring is insufficient.	YES OR NO	
MISCELLANEOUS	HYDROSTATIC TEST OF JOINT REQUIRED BY MANUFACTURER OF PRODUCT:	YES OR NO	

EXPANSION JOINTS-PIPING DIVISION

For current Members and Associate Members, please go to the Expansion Joints-Piping Division section of the Fluid Sealing Association website:

www.fluidsealing.com

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Acknowledgments

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