Rubber Expansion Joints for Pump & Piping Systems

Avoid some of the more common installation issues.

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An expansion joint must perform several functions. The rubber joint is the most flexible part of a piping system, but this flexibility has a tradeoff. An expansion joint is usually the weakest component of a piping system and must be carefully selected for the application. Connected to a pump, it reduces vibration. If located in the connected piping, the expansion joint moves with the thermal pipe movement. It does this while providing a seal under system pressure and at temperature and resisting corrosive media. The keys to success are selecting the proper elastomer for the application, knowing the required movement, pressure and temperature and proper installation.

Contents of Rubber Joints

Simply, rubber. Or more technically, elastomers. Elastomers are made of high-molecular weight polymer chains that, when vulcanized (or cured), can be repeatedly stretched and returned to the original length. The different types of polymer chains, when combined with the curing method, give the rubber properties that make it suitable for various applications. But there is more than elastomers to an expansion joint. A typical expansion joint consists of three components: the tube, carcass and cover.

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	4 3 4 0	4 4 0 1	2 3 4 6	4 5 4 3	5 4 2 4	5 2 4 5	4 4 4 4	5 5 6 5
NR	AA	**GUM RUBBER** POLYISOPRENE, SYNTHETIC	5 3 X X	X 0 0 4	0 0 3 3	0 6 5 5	6 6 4 6	6 6 2 7	5 0 5 2	4 0 2 0
IR	AA	**NATURAL RUBBER** POLYISOPRENE, SYNTHETIC	5 3 X X	X 0 0 4	0 0 3 3	0 6 5 5	6 6 4 6	6 2 2 6	5 0 5 2	4 0 2 0
IIR	AA	**BUTYL** ISOBUTENE-ISOPRENE	5 6 5 4	4 0 3 4	0 0 4 6	0 4 5 5	5 4 3 0	5 2 6 4	4 0 4 5	6 5 5 6
CIIR	AA BA	**CHLOROBUTYL** CHLORO-ISOBUTENE-ISOPRENE	5 6 5 4	4 0 3 4	0 0 4 6	0 4 5 5	5 4 3 0	5 2 6 4	4 0 4 5	6 5 5 6
NBR	BE BK CH	**BUNA-N/NITRILE** NITRIL-BUTADIENE	4 3 5 0	4 5 2 0	4 6 4 4	5 5 4 1	0 5 5 4	4 5 4 4	3 0 3 4	4 0 2 2
SBR	AA	**SBR/GRS/BUNA-S** STYRENE-BUTADIENE	5 3 X 2	4 0 0 4	0 0 3 3	0 6 5 5	4 5 4 4	4 4 2 5	3 0 5 3	2 0 2 0
CSM	CE	**CSM** CHLORO-SULFONYL-POLYETHYLENE	5 6 4 4	4 4 3 1	2 3 4 6	4 5 4 3	5 2 2 2	4 2 4 4	3 4 4 4	6 7 6 7
FKM	HK	FLUOROCARBON ELASTOMER	5 6 6 0	4 6 1 0	6 6 6 5	6 5 5 3	5 5 6 2	4 5 5 5	2 6 2 7	7 7 7 7
EPR	BA CA DA	**EPDM** ETHYLENE-PROPYLENE-DIENE-TERPOLYMER	5 6 5 6	6 0 3 6	0 0 4 6	0 7 6 6	7 5 4 6	6 5 4 5	4 0 5 6	6 7 6 7
AFMU		**PTFE/TFE/FEP** FLUORO-ETHYLENE-POLYYMERS	7 7 7 7	7 7 7 7	7 7 7 7	7 3 7 X	X X X X	X X X 4	X X X 7	7 7 7 7
SI	GE	**SILICONE**	5 5 5 0	2 X 0 2	0 0 2 6	2 5 6 6	4 0 3 6	6 0 2 0	2 2 6 7	6 6 6 6

IMAGE 1: Table II from the Expansion Joints Piping Handbook, 8.0 Edition. (Images courtesy of the author)

Typical Expansion Joint Terms

Tube:

The tube is a protective, leak-proof lining made of synthetic or natural rubber as the service dictates. This is a seamless tube that covers the bore to the outside edges of the flanges. Its purpose is to stop the materials being handled from penetrating the carcass and weakening the fabric. These tubes can be designed to cover service conditions for chemical, petroleum, sewage, gaseous and abrasive materials.

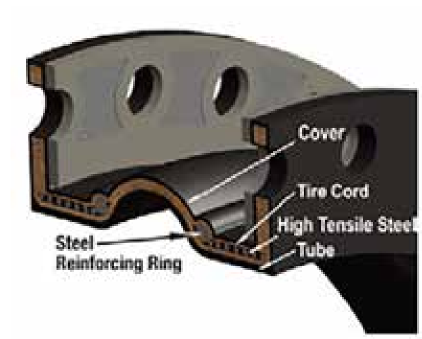

IMAGE 2: Typical expansion joint terms

Carcass:

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

- **Fabric reinforcement:** The carcass fabric reinforcement is the flexible and supporting member between the tube and cover. Standard constructions normally use high-quality synthetic fabric. Natural fabrics can also be used at reduced pressures and temperatures. All fabric plies are impregnated with rubber or synthetic compounds to permit flexibility between the fabric plies.
- **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.

Cover:

The exterior surface of the joint is formed from natural or synthetic rubber, depending on the 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.

A rubber expansion joint may be compared to a tire in several ways. Both are made of reinforced rubber, customized for various conditions as necessary and contain pressure.

Types of Joints

There are two main styles of rubber joints: spool and spherical. Spool-type joints have cylindrical bodies with steel reinforcing rings. This style of joint will typically also have arches to accommodate additional movement. Spool-type joints may be custom-manufactured for specific installation requirements. The sealing surface is a full-face flange.

Spherical expansion joints use the body shape to provide a strong and flexible connector. The spherical body shape results in a uniform pressure distribution throughout the body, precluding the requirements for reinforcing steel and only using fabric reinforcement. Spherical joints typically have floating flanges and a bead seal instead of a full-face flange.

Application Considerations

Although a rubber joint appears flexible and may be easily bent, twisted and stretched, there are plenty of considerations when these joints are incorporated into a piping layout.

Pressure thrust

Pressure thrust sometimes surprises the installers, and it could be a rude surprise. Since a rubber joint has a flexible wall, when put under pressure it will inflate like a balloon. The fabric and reinforcing steel will restrain stretching in the radial direction, but there is no real restraint in the axial direction. The only axial restraints will be external in the form of either control rods or pipe anchors.

As a result, the axial restraints will be subject to a pressure thrust force in addition

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

IMAGE 3: Typical temperature ratings for tube/cover elastomers combined with reinforcing fabrics

IMAGE 4: Examples of spool-type expansion joints

IMAGE 5: Examples of spherical joints (single and double spheres)

to the spring force of the rubber body. The total force on a pipe anchor will be the pressure thrust added to the spring force of the rubber body. For an expansion joint with control rods, the pressure thrust will be restrained by the control rods unless the joint is compressed.

In Equation 1, say the pipe and expansion joint are 6 inches in diameter, the operating pressure is 100 pounds per square

> 100 psi x 52 in^2 = 5,200 pound force (lbf) thrust
>
> If the axial spring rate is 345 pounds per inch (lb/in) (also specific to the manufacturer, but typical values can be found in Fluid Sealing Association's [FSA] "Technical Handbook for Expansion Joint Piping") the spring force will be:
>
> 345 lb/in x l in = 345 lbf
>
> The total anchor reaction would then be:
> 5,200 lbf thrust + 345 lbf spring force = 5545 lbf per anchor
>
> Equation 1

IMAGE 6: Typical expansion joint installed between two anchors

inch (psi) and the thermal movement of the pipe is calculated at 1 inch. The pressure thrust from the expansion joint will be the pressure multiplied by the joint effective area. This example will use an effective area of 52 square inches (this is different for each manufacturer and can be found in the product literature).

The spring force may be obvious but the pressure thrust may not be. If the expansion joint is installed without restraints, the pressure thrust can easily move the connected pipe.

Another common installation has the expansion joint as a pump connector. For this installation, it is also common to include control rods to restrain the joint.

For this installation, no anchors would be required because the pressure thrust is restrained by the control rods. If the same parameters are being used as the anchored pipe example, the control rods would be restraining the 5,200 lbf pressure thrust with no thermal movement.

Elastomeric Joint Standards

The FSA is the main standards organization for rubber pipe expansion joints. There are three standards and one handbook to reference for more detailed information:

- *"FSA Piping Expansion Joints Handbook, current edition:"* The handbook covers design and fabrication, application, installation, maintenance and troubleshooting of expansion joints.
- *"FSA-PSJ-701-19 – Hydro and Vacuum Testing:"* This covers hydrotesting and vacuum testing of nonmetallic flanged expansion joints.
- *"FSA-PSJ-702-19 – Installation, Maintenance, Storage:"* This covers the installation, maintenance and storage of rubber flanged nonmetallic expansion joints.
- *"FSA-PSJ-703-19 – Guidelines for Elastomers:"* This covers the typical properties of elastomers most frequently used for the tube and compounds in the manufacture of piping expansion joints for a wide range of applications.

IMAGE 7: Typical rubber joint pump installation

In addition to these standards, elastomeric expansion joints can be fabricated to additional standards as required. Examples are American Society of Testing Materials (ASTM) F1123, National Sanitation Foundation (NSF)-61 and various military specifications. Also, the FSA website contains information on the Knowledgebase at fsaknowledgebase.org

Maintenance & Installation

Like car tires, rubber expansion joints have a service life and will be a maintenance item for the system. Unlike car tires, the service life is not measured in miles. The service life of an expansion joint depends on several factors including operating temperature and pressure, ambient conditions, movement and proper installation.

The best expansion joint for an application can be rendered useless if it is not installed according to the manufacturer's instructions and following FSA recommendations.

The general rule for replacement of an expansion joint is five years for a joint in a critical service application. For joints not in a critical service, observe the joint at regular intervals and plan to replace after 10 years. Some joints can last as long as 30 years depending on the operating conditions.

Expansion joint failures are routinely traced back to installation problems. Here are some of the more common installation issues:

- *The expansion joint was used to make up for a pipe misalignment.* The nature of a flexible joint makes it tempting to use to compensate for a pipe misalignment. Do not do this. If a joint is used to make up for misaligned pipe, some of the rated movement will be taken up by the misalignment. At this point, the joint can be easily overextended.
- *No anchors or control rods installed.* This unfortunate situation will usually result in the joint overextending itself under pressure. As described above, a lack of restraints will allow the joint to extend beyond its movement limits.
- *The expansion joint was not installed at the proper face-to-face length.* This is similar to the joint making up for a pipe misalignment, except the pipes may be aligned, but the space between the flanges is either too short or too wide to install the joint in a neutral position. Many times, the joint is crammed between two flanges that are too close together. This can damage the bead of spherical joints, resulting in seal failure.
- *Loose bolts.* Nearly every installation visited has had loose bolts, loose enough to finger-tighten. Be sure to follow the manufacturer's recommendations for bolt torque and retightening schedules.

We've only scratched the surface of the subject of rubber joints. To learn more about the subject, read FSA's "Piping Expansion Joints Handbook." The same authors of the handbook have also written several in-depth articles on the subjects mentioned above, and they are also free downloads from the FSA. ■

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