2200

PTFE Expansion Joint Engineering Guide

ETHYLENE

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This manual is offered as an aid to the piping designer or maintenance engineer in the proper utilization of expansion joints in piping systems. **It is not intended to be used as a design manual.** The information contained herein does not constitute a warranty of any kind, expressed or implied, of Ethylene Corporation Flexijoints® or their fitness for any specific use.

I. Foreword

Piping systems of any sort, whether used for the conveyance of either innocuous or corrosive liquids, are generally subjected to problems relating to temperature changes, vibration, or misalignment. These conditions, if not compensated for by some flexibility in the pipe structure, will impose either high stresses in the piping or excessive loads on connected equipment.

Piping code compliance requires that careful attention be paid to piping systems and reactions (specifically paragraphs, 3191.1 of ANSI B31.3 1980, the Piping Code for Petroleum Refineries and Chemical Plants)

While there are a number of ways in which the engineer can design "flexibility" (such as "pipe loops" or "changes-in-direction") into the piping system, we will be restricting ourselves to a discussion of one of such methods, namely PTFE bellows and specifically Flexijoints®.

Bellows expansion joints are installed in pipelines to:

1. compensate for thermal expansion/contraction
2. reduce vibration and sound transmission
3. compensate for settling of auxiliary equipment such as tanks, columns, etc.
4. reduce stress imposed on fragile mating flanges and nozzles

But: Expansion joints should never be used to compensate for misalignment unless such misalignment is a calculated basis of design.

While a bellows expansion joint will often prove to be the most economical solution to pipe movement problems, it should be recognized that **Design Parameters And Not Cost** must determine the ultimate choice.

In consideration or application of a bellows type expansion joint, it should be recognized that:

> **These joints are not commodity items; they are precision mechanical equipment and must not be casually specified or arbitrarily dropped into a piping system.**
>
> **Their application requires careful engineering analysis to insure that they function up to their design parameters.**

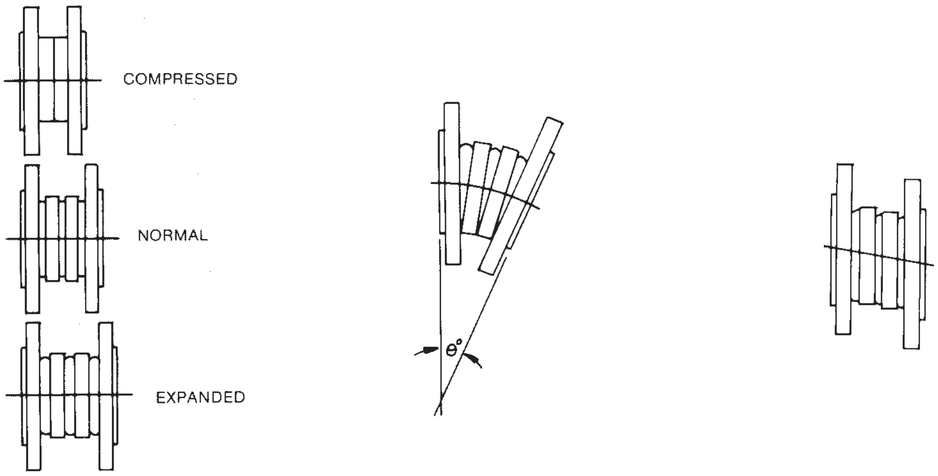
When an expansion joint fails, it is usually for one of two reasons: improper application or faulty installation. Improper application includes wrong material selection, poor piping design and specification procedures. Faulty installation includes improper installation of the piping and it's attendant restraints, as well as mishandling of the bellows.

A single expansion joint can absorb piping movements in any combination of three degrees of freedom; axial, lateral or angular misalignment. These movements can occur either individually or simultaneously. **(See Figure 1)** While an Ethylene Flexijoint can also be subjected to small amounts of torsion, it is not considered good design practice to impose torsional moments on a bellows.

It is important to note that while a bellows will lower the forces caused by thermal displacement strains, it will not eliminate them entirely. This is especially true of metallic and elastomeric bellows; their spring rates remain fairly constant throughout the life of the application. However, a PTFE bellows, such as the Ethylene Flexijoint® will experience an approximate 50% reduction in the forces required to deflect the bellows during the first twenty-four hours of operation, due to the unique creep behavior of PTFE. This reduction of deflection force is particularly useful when dealing with glass-lined or fiberglass reinforced plastic piping and equipment.

Throughout this manual, reference will continually be made to the standards of the Expansion Joint Manufacturers Association, Inc. (EJMA). While Ethylene Corporation is not a member of this association, (it being made up entirely of metallic bellows manufacturers) Ethylene does feel that these standards are an excellent guide to accepted good engineering practice regarding the utilization of bellows type expansion joints. All piping designers responsible for the implementation of bellows into piping systems should have a copy of these standards available for ready reference.

Figure 1



ABSORPTION OF AXIAL MOVEMENT

ABSORPTION OF ANGULAR ROTATION

ABSORPTION OF LATERAL DEFLECTION

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(1) Flexijoint® is the registered trademark of PTFE bellows manufactured by Ethylene Corp.

II. PTFE as Expansion Joint Material

Bellows type expansion joints are manufactured in PTFE, metallic, elastomeric, and fabric materials. In this Guideline, it is assumed that the piping designer has specified a PTFE bellows for one of the following reasons:

1. **Long Flex-Fatigue Life:** PTFE bellows exhibit a flex-fatigue life far superior to metal or rubber when subjected to flexural stressing, either intermittently or continually.
2. **Chemical Resistance:** PTFE has near universal corrosion resistance and is not subject to chloride stress corrosion, caustic embrittlement, ozone degradation, etc.
3. **Spring Rate:** PTFE expansion joints have low spring rates for axial, lateral and angular movement. This becomes critical when mating to stress sensitive equipment at elevated temperatures.
4. **Face to Face Dimension:** PTFE expansion joints offer short face to face dimensions thus saving space and permit a more compact design layout.
5. **Low Accoustical Impedance:** PTFE bellows are unexcelled in their ability to dampen vibration and noise.

III. Anchor, Guide, and Support Requirements

The proper operation of expansion joints requires proper piping alignment and anchoring. This is accomplished by use of pipe restraints, commonly called pipe supports. Anchors, guides and supports have a similar primary function; to restrain the thermal growth of a piping system, thus directionally influencing its displacement. Therefore, through proper use of pipe restraints, it can be assured that the only movements occurring in a piping system are those intended by the piping designer.

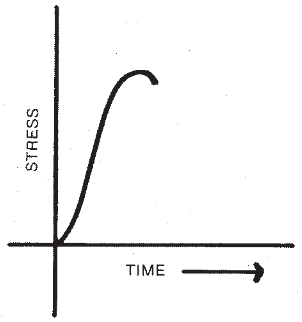
Pipe restraints may be divided into three categories:

1. **Anchors:** both main anchors, and intermediate anchors.
2. **Guides:** including alignment guides and lateral restraints.
3. **Supports:** which includes slides and hangers.

While it is true that anchors and guides also support the pipe, their main function is to directionally influence the growth of the piping system. Thus, Ethylene prefers the term "pipe restraint", rather than referring to all three types generically as "supports".

Thermal growth cannot be contained. To illustrate this, imagine a straight piece of pipe of any given length. Anchor it at both ends. These anchors are immovable objects. Next, apply an increase in temperature to the pipe; this increase in temperature will cause a change in the length of the pipe if the pipe is unrestrained. If the pipe is restrained, then a force will result from the pipe's inability to move freely. Now we have an irresistable force (due to the change in temperature) and an immovable object (the pipe anchors). In real life this paradox cannot exist. Having had the foresight to equip our length of pipe with strain guages, the following phenomenon would be observed: **(Figure 2)**

Figure 2



Notice, that as expected, stress will increase with time, up to a point. Then the induced stress will level off and actually begin to decrease. What happened? Since immovable objects and irresistable forces cannot simultaneously coexist, something must have moved, relieving the force caused by the change in temperature. This movement could have been allowed by the failure of an anchor, or by the failure (buckling) of the pipe wall, as the pipe would behave like a compressively loaded column. These are gross manifestations of failure. A more subtle mode of failure, (particularly if this pipe were guided perfectly) would be a yielding of the pipe wall material, a sliding of the molecules of the wall material over one another, thus relieving the stress. This is a more insidious form of failure, as nothing will have appeared to have happened to the unaided eye, but it is a failure all the same. It is important to note that the thermal forces can theoretically become very high unless something relieves them.

Since it is now obvious that we cannot restrain thermal growth, we must use restraints to control and direct the movement that will occur in a thermally cycling piping system. Anchors will conveniently divide a piping system into smaller, individually moving segments. It is the function of expansion joints to absorb the growth that occurs between these anchors.

Connected equipment such as chemical reactor vessels, pumps, turbines, compressors, heat exchangers, etc., often function as anchors at terminal ends of piping systems. This means that any forces (and their resulting moments) will be transmitted to this equipment, just as they would be transmitted to any pipe anchor. It is a relatively simple matter to design enough "meat" into an anchor, but we must be extremely careful when we consider connected equipment.

Paragraph 319.1 of ANSI B31.3 1980 states that: "Piping systems shall have sufficient flexibility to prevent thermal expansion or contraction or movements of piping supports and terminals from causing:

a. Failure of piping or supports from overstress or fatigue;

b. Leakage at joints; or,

c. Detrimental stresses or distortion in piping or in connected equipment (pumps, turbines or valves, for example) resulting from excessive thrusts and moments in the piping."

Even if your particular piping system does not fall under the jurisdiction of the B31 piping codes, their guidelines are the industry standard for accepted good practice.

The amount of loading that can be applied to a piece of equipment is generally specified by the manufacturer. There are some guidelines published by independent organizations such as the American Petroleum Institute (API) standards for pumps, or the National Electrical Manufacturers Association (NEMA) standards for turbines. In all cases, the manufacturer of the individual piece of equipment should be notified of any loadings imposed on his equipment by the piping system.

Other than piping terminations at connected equipment, main anchors generally occur at:

a. Any change in direction of flow,

b. Between two expansion joints of different size installed in the same straight run,

c. At the entrance of a side branch into a main run,

d. Where a shut off or pressure reducing valve is installed in a pipe run between two expansion joints, and

e. At blind pipe ends.

The following paragraphs will outline the procedures for calculating the magnitude of the major axial forces acting on both main and intermediate anchors. It is important to remember that while the difference in cost between an adequately and inadequately designed anchor is nominal, the failure of an anchor will cause damage far costlier than that of the more conservative design. Thus, the engineer should recognize any and all lateral forces imposed on the anchor in addition to the axial forces.

Main pipe anchors must be designed to withstand all forces (and their resultant moments) imposed by all of the pipe segments to which they are connected. Should a pipe segment contain an expansion joint, these forces consist of those required to deflect the bellows (over it's full rated movement), the friction forces from the pipe guides, supports or directional anchors, and any thrusts resulting from internal pressure or fluid flow. Some applications may require that the engineer consider the piping system's deadweight (including insulation and flowing medium) as well as wind load or the result of a section of the system being bent, etc. Net loading on an anchor is calculated by vector addition of the forces acting on the anchor point and summation of the resulting moments about it.

The following are formulas useful in calculating loading on anchors. They are from EJMA standards:

Equation 1. $F_s = ap$ where F_s=static thrust (lbs.) due to internal pressure in the bellows.
a=pressure thrust area (in^2)
p=design pressure (PSI)

Equation 1 is useful for applications involving straight runs of pipe that contain caps or shut-off valves. As this only gives us the force due to static pressure thrust, one must also add the force due to compression or extension of the bellows, **Fm,** commonly called the spring force, and the frictional forces resulting from pipe restraints such as slides and guides, **Fg.** Thus, the main anchor force (Fma) is calculated by **Equation 2.**

Equation 2. $$F_{ma} = F_s + F_m + F_g$$

or

Equation 3. $$F_{ma} = ap + F_m + F_g$$

Remember, that in order to determine the net load on the anchor, one must vector sum the forces imposed on it by each of the pipe segments to which it is attached.

It must be noted here that Ethylene Flexijoints®, due to the creep behavior of PTFE, exhibit spring rates differently than do metal bellows. In reference to Ethylene Bulletin 2002, pages 2 and 3, "Strain Factors", you will note that the force resulting from deflection of an Ethylene Flexijoint diminishes with time. This is because the material yields, (creeps or cold-flows) as a result of the strains imposed on it by the deflection, thus relieving these internal strains. However, to be conservative, one should consider the instantaneous strain factor as the spring rate in factor Fm of **Equation 3.**

If an elbow is contained in a segment that also contains an expansion joint, the effects of the centrifugal thrust at the elbow due to the fluid flow must also be considered.

Equation 4. Centrifugal thrust, $$F_p = \frac{2APV^2}{g} \text{ SIN } \frac{\theta}{2}$$

Where: A=Internal area of pipe (FT.^{2})
P=Fluid density (lbs. per FT.^{3})
V=Velocity of fluid (FT per sec.)
g=Gravitic constant (32.2 FT per sec. per sec.)
θ=Angle of pipe bend (degrees)

The forces imposed on intermediate anchors are calculated in the same way as those for main anchors. The difference being that any sustained loads, such as pressure thrusts (Fs from **Equation 1**), will cancel out. Thus, intermediate anchor loadings will always be lower in magnitude than main anchor loadings.

Of prime importance to the proper functioning of an Ethylene Flexijoint® is the **proper alignment of the adjoining pipe.** Expansion joints will perform as designed only when the movements they absorb are those that they were designed to absorb. Pipe guides are necessary to assure that only intended movements are imposed on a bellows. This will minimize distortions in the bellows. Buckling, a form of distortion, is a function of two things; the discontinuity in the pipe wall caused by the flexibility of the bellows and the internal pressure loadings, which cause the pipe to act like a compressively loaded column.

Pipe guides or sleeves are frameworks attached to rigid structures which permit pipe movement in only one axis, usually the longitudinal axis. A planar guide, or lateral restraint, is a guide that is modified to allow movement in one plane in addition to movement axially. The planar guide, or lateral restraint, is only used in applications involving "L" or "Z" shaped pipe configurations.

Proper design of pipe guides must permit sufficient clearance between their fixed and moving parts to insure proper guiding without inducing excessive friction. It is important to note that while most commercially available guides are acceptable, they must be installed carefully to insure proper functioning; if not installed properly, you may end up with an anchor and not a guide. Serious considertion should also be given to guiding mechanisms lined with PTFE to attain minimum friction loses.

Roller supports, U-bolts, or pipe hangers, since they only support the deadload of the piping system, are not to be considered proper guides. However, roller supports may be used as guides providing that a minimum of three, or preferable four, rollers are used and are equally spaced circumferentially on the pipe.

As was noted with anchors, the materials of construction for the pipe guides must be sufficiently strong to provide proper rigidity under design operating conditions. Guides, like anchors, must be able to sustain lateral forces as high as 15% of the total axial force; their design must be conservative. Care must be taken to insure that there will be no relative shifting of the guides due to movement of the structures to which they are attached.

It is important that the first guides be located within four pipe diameter of the expansion joint. The following formula, from EJMA, will be useful for calculating the intermediate guide spacing:

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

Equation 5.

$$L = .131\sqrt{\frac{EI}{pa \pm fe_x}}$$

Where: L=maximum intermediate guide space, (feet)

E=modulus of elasticity of pipe material, (psi)

I=moment of inertia of pipe (in^4)

p=design pressure, (psig)

a=bellows effective area, (in^2)

f=bellows initial spring rate per convolution, (lb/in/conv.)

e_x=axial stroke of bellows per convolution, (in/conv.)

Note: When bellows is compressed in operation, use (+) |fex|; when extended, use (-) |fex|.

Guide spacing for standard wall carbon steel pipe may be determined from the chart shown in the appendix. (Pg. 15) Even if a particular application should involve axial movement only, the use of a single guide should be avoided as it may act as a fulcrum and impose a lateral or an angular deflection on the bellows that was not intended to be imposed on the bellows. However, there are instances where a single guide will be adequate. This will be illustrated in the next section.

IV. Sample Installations

In this section a number of examples will be given illustrating good engineering practice regarding the installation of a single or multiple bellows in a piping system. (For an explanation of the symbols used in the diagrams, please refer to **Table 1** in the appendix.

Figure 3 illustrates standard practice regarding the use of a single Flexijoint to absorb axial pipe movements. Please notice that there is one expansion joint located between the main anchors and the close proximity of the first pipe guide (G1). Also, notice the relative spacing of the intermediate guides.

Figure 3

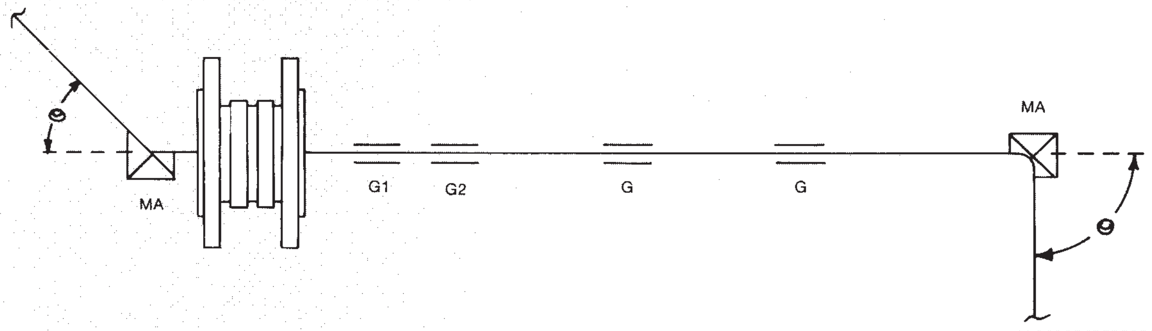


Figure 4 illustrates typical practice when using two expansion joints in a relatively long run of pipe. Note that an intermediate anchor was employed to divide the straight run into two smaller individually expanding segments. Again, note the guide spacing and the location of the main anchors. There is an alternative to this example. If the total expansion can be accommodated by one expansion joint, an Ethylene Anchorbase Flexijoint can be employed. This will eliminate one of the bellows in **Figure 4** and it will also provide it's own intermediate anchor. Be certain to consult Ethylene before using an Anchorbase Flexijoint in this situation for the total amount of axial movement is critical in the design of the bellows. Ethylene will also need to know all loads expected to be imposed on the intermediate anchor.

Figure 4

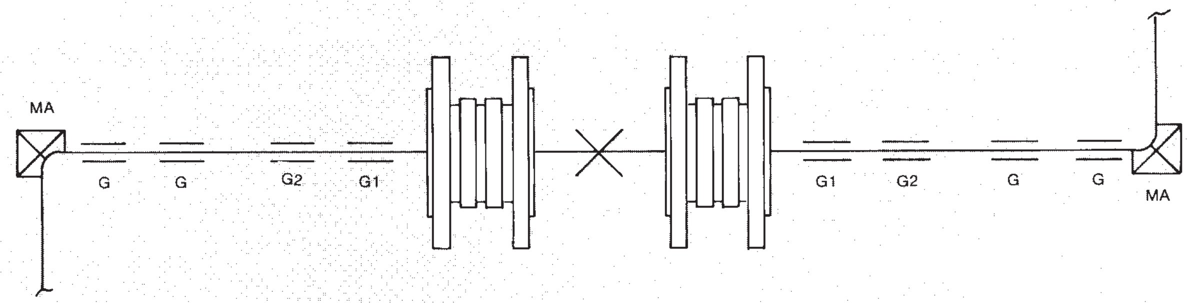


Figure 5 illustrates good engineering practice when using Flexijoints to absorb axial pipe movements in a straight run with a branch connection. The main anchor at the branch connection must be designed to absorb the axial thrusts of the expansion joint in the branch, in addition to the resultant of the loadings from the expansion joints in the main run. Again, please note the guide spacings.

Figure 5

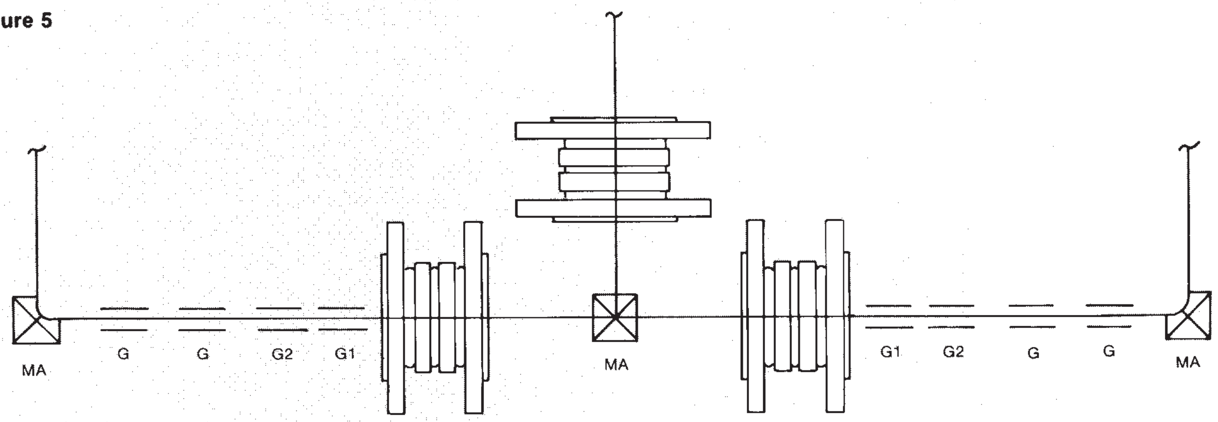


Figure 6 illustrates good engineering practice when absorbing axial expansion in a straight run containing a reducer. A main anchor must be placed at the point of reduction and it must be designed to absorb the force differential between the expansion joints on either side of the reducer. Again, note the guide spacing. Also note the close proximity of the bellows to the main anchor.

Figure 6

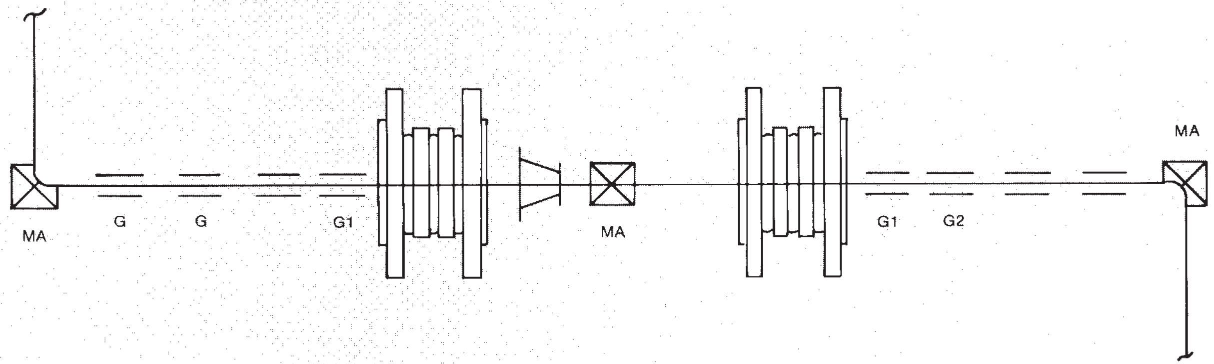


Figure 7 illustrates the use of a Flexijoint in a line containing an offset. Ethylene cannot recommend this configuration as it will perform satisfactorily only within certain limits. Note that, as in **Figure 3** there are main anchors at both ends of the run to absorb the terminal reactions, and that the guides are spaced accordingly. All loads must be transmitted through the offset leg, and, as a result, there will be a bending moment in the piping. Should the line size be small, the offset appreciable, or should the movement and pressure thrust forces from the bellows be relatively high, the piping may be overstressed.

Again, note the placement of the bellows next to a main anchor, and notice the placement of the alignment guides. Notice that guides are placed close to the ends of the offset; this will tend to minimize the bending moments. Be careful; though the moments are minimized, the guide loadings may become appreciable.

Figure 7

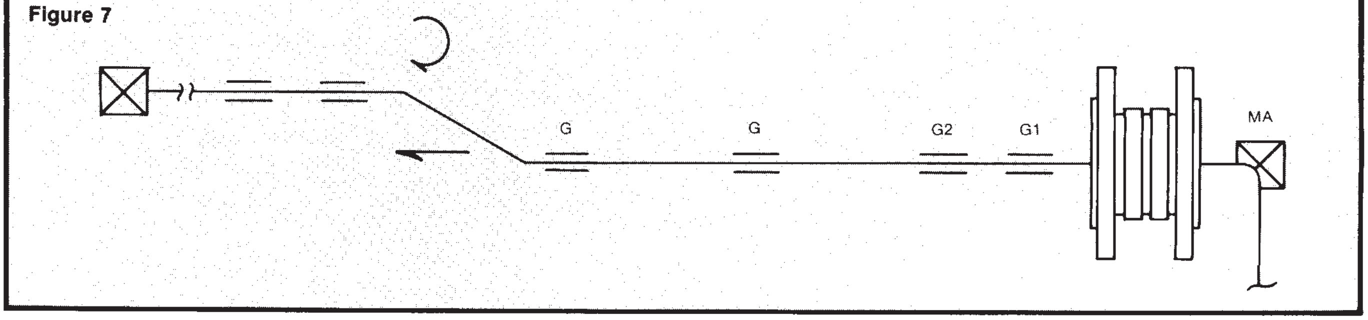
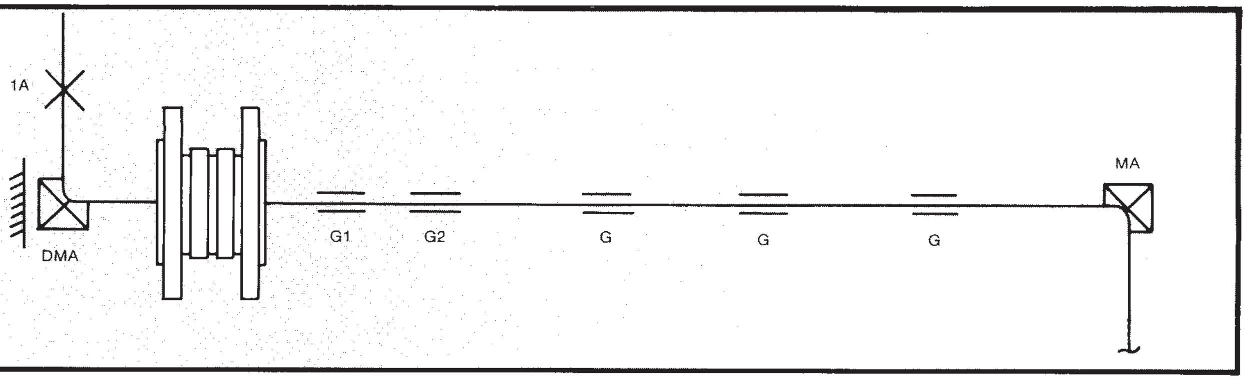


Figure 8 illustrates good engineering practice regarding the use of a Flexijoint to absorb both axial and lateral displacements. The use of a Flexijoint to absorb movements in more than one axis involves the careful examination of many variables such as the piping configuration, loading limitations on connected equipment, desired cycle life, operating conditions, and the available support structure, if any.

Figure 8



Note that **Figure 8** closely resembles **Figure 1,** which was for axial movement only. The Flexijoint is located at one end of the pipe run, with main anchors at both ends and the guide spacing is per EJMA standard practice. This provides proper control of movement and protects the pipe from buckling. Note, that in this example, the anchor on the left side is a directional main anchor, often called a bump-stop. This directional main anchor is designed to absorb all thrusts in the direction of the expansion joint's axis while still allowing movement laterally. This lateral movement results from the thermal growth of the short leg on the left, which is absorbed by the lateral deflection of the expansion joint.

Figure 9

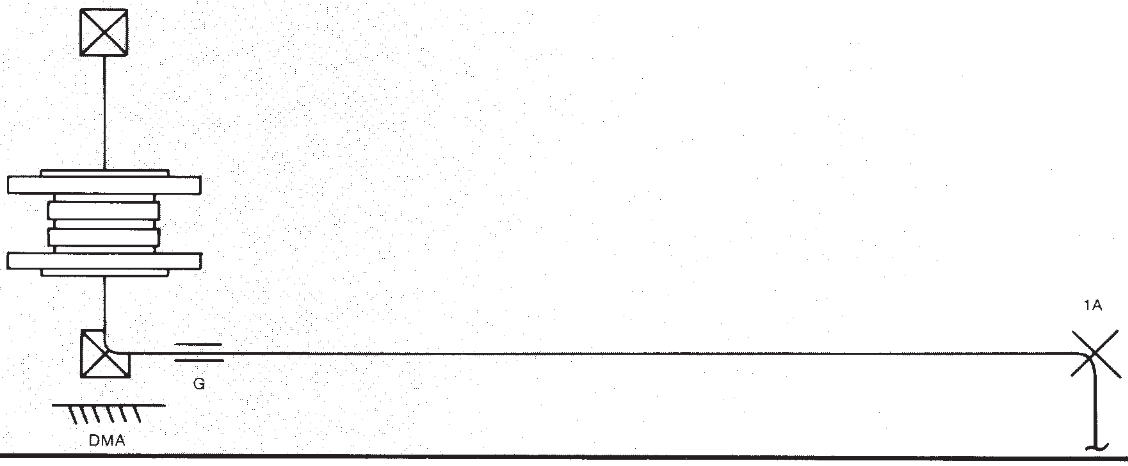


Figure 9 is an alternative to **Figure 8.** This arrangement allows the expansion, resulting from the growth of the longer leg, to be absorbed laterally by the bellows. Thus, with no compressive loading, the long leg only requires an intermediate anchor and directional guiding. The bellows must still, of course, absorb the axial deflection resulting from the growth between the two main anchors. The alignment guide and the directional main anchor may be combined into one device.

Figure 10

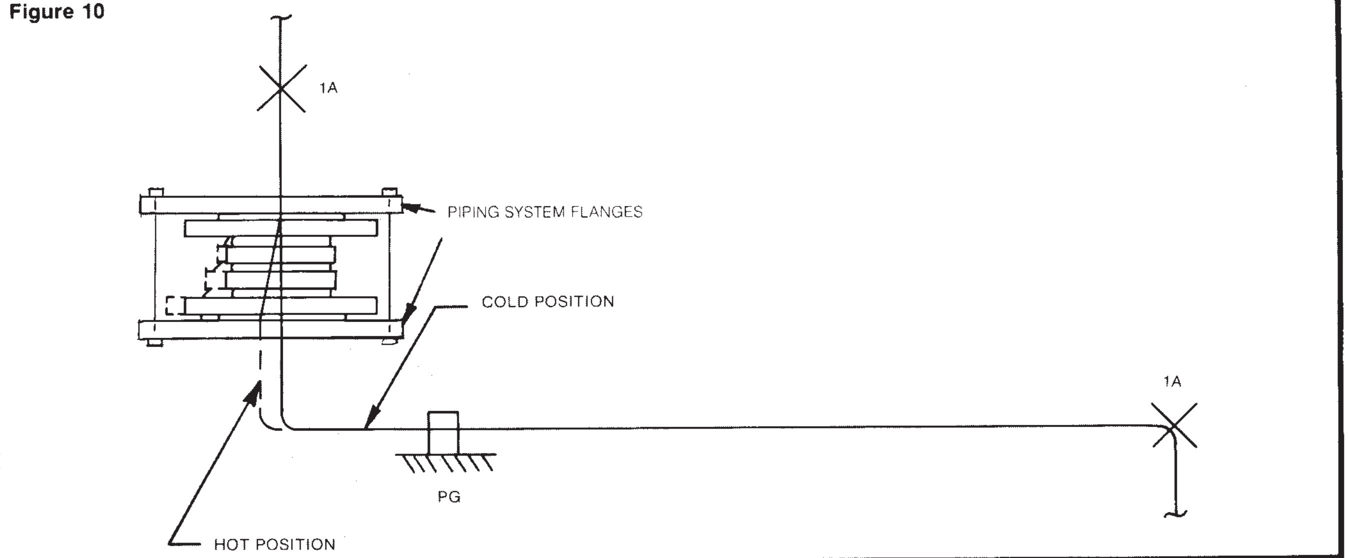


Figure 10 is a modification of **Figure 9.** This arrangement eliminates the directional main anchor by the use of limit bolts on the Flexijoint. When a bellows is equipped with limit bolts, it can only absorb it's internal axial growth; the limit bolts will contain the internal pressure thrusts. As a result, any axial growth of the short leg in **Figure 10** must be imposed as a deflection of the longer leg. Note the use of the lateral restraint, the planar guide (PG). The situation may arise when the flexibility of the leg is insufficient and if the length of the short leg is suitable, tie-rods spanning the entire length of the short leg can be installed so no deflection is imposed on the long leg.

This example is a preferred arrangement. Where possible, try to equip bellows with tie-rods and take movements laterally. **UNDER NO CIRCUMSTANCES ARE THE LIMITLINKS™ OR LIMIT BOLTS ON AN ETHYLENE FLEXIJOINT TO BE CONSIDERED AS SUBSTITUTES FOR PIPE ANCHORS. THEY ARE SAFETY DEVICES ONLY!** Limitlinks are designed to prevent catastrophic failure of a Flexijoint should a main pipe anchor fail.

Figure 11

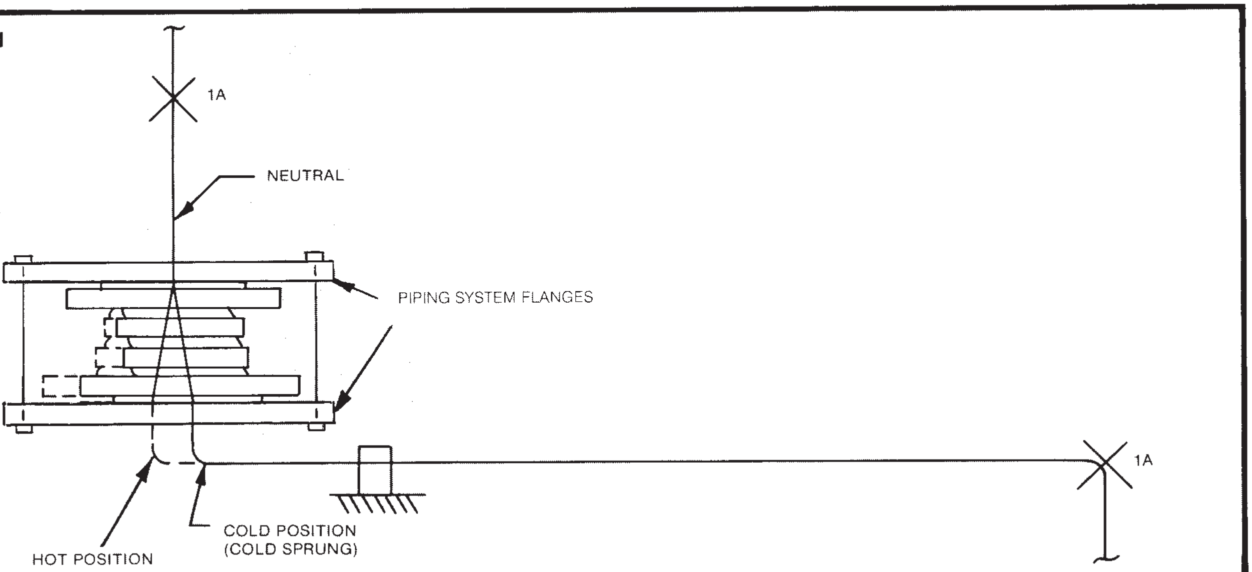


Figure 11 illustrates the cold-springing of a Flexijoint. Where the lateral deflection imposed on this joint is very great, a shortening of the bellows, resulting from the deflection of the tie-rods, occurs. Extreme care should be taken to insure that sufficient piping flexibility exists to accommodate this deflection. Cold-springing, as in **Figure 10,** can minimize the lateral deflection. Please consult Ethylene whenever a cold-springing condition occurs.

V. System Design Checklist

This section reviews some basic considerations to be evaluated **prior** to making any detailed calculations. Some of these items fall outside the information supplied to the bellows manufacturer and must be considered by the design engineer.

1. Operating Pressure ________ psig.
2. Operating Temperature ________ °F
3. Maximum Upset Pressure ________ psig.
   a. Limited by relief valve Yes ____ No ____
   b. Limited by pump discharge pressure Yes ____ No ____
   c. Limited by rupture disc Yes ____ No ____
   d. Limited by other safety appliance Yes ____ No ____
4. Maximum Upset Temperature ________ °F
   a. Limited by what means? ____
   b. Is runaway reaction or other form of Exotherm possible? Yes ____ No ____
   c. Is maximum upset temperature coincident with higher upset pressure or in inverse relationship? Yes ____ No ____
5. Maximum obtainable vacuum? ______ in. H_20 ______ mmHg.

   Vacuum can and does often occur during start-up or shut-down even though not part of design criteria. Investigate carefully and determine if a vacuum beaker is required. Flexijoints® can be designed to handle full vacuum at temperatures to 400°F.
6. Other factors
   a. Is the equipment to which a bellow is connected on load cells? Yes ____ No ____
   b. If so, how many bellows in total are connected to same equipment? ______
   c. What is the maximum total force permitted to act upon this equipment without effecting instrument readings?________ lbs.
   d. Can the instruments be calibrated to compensate for the forces exerted by the bellows? Yes ____ No ____
7. Surges
   a. Can water hammer or other forms of surge take place in the piping system? Yes ____ No ____
   b. Are there quick closing check valves in system? Yes ____ No ____
   c. Can these be modified to non-slam types by addition of springs, counterbalances or other means? Yes ____ No ____
   d. Are there quick closing or opening, automatic or remotely operated shut-off valves in the system? Yes ____ No ____
   e. Can they be made "time delay to close" (or open?) Yes ____ No ____
   f. Are there surge eliminators in the system if slow closing check or automatic valves are not feasible? Yes ____ No ____
   g. Can the shut-down of a pump cause water hammer? If so, what steps have been taken to control the surge? ________________________________ Yes ____ No ____

   ____

   ____

   NOTE: Water hammer can cause catastrophic failure of any expansion joint.
8. Are there positive displacement pumps in the system? If so, how is excessive pressure relieved? ________________________________ Yes ____ No ____

   ____

9. Shut-off Valves

   a. Is the bellows between two shut-off valves in a line carrying fluid with a high coefficient of expansion? (such as liquid chlorine) Yes ____ No ____

   b. If so, what provision exists for pressure relief if the line experiences a temperature (and therefore pressure) increase with both valves in closed position? ____________

   ____

10. Abrasive

    a. Is the fluid conveyed abrasive? Yes ____ No ____

    b. If so, determine its' effect on the convolutions. Consider the use of an internal liner.

    ____

    ____

11. a. Is the fluid conveyed highly toxic, carcinogenic, flammable or otherwise dangerous? Yes ____ No ____

    b. If so, does it fall into category "M" as defined in ANSI B31.3 Chapter VIII (1976 or later) or other similar code or governmental regulation? Consider the necessity of using a Flexarmor™ Flexijoint PTFE Lined Stainless Steel Expansion Joint. (In case of an external fire the Flexijoint because it is a thermoplastic, will be destroyed quickly.) Yes ____ No ____

12. If the joint is bolted to a storage tank located on unsettled ground where there is the possibility of settlement or tilting of tank, has there been sufficient allowance made (on the conservative side) in selection of joint to allow maximum conceivable movement? Yes ____ No ____

13. Sometimes it is necessary to bolt a bellows directly to a quarter turn valve (plug, ball, butterfly) which in turn is bolted to a fragile tank outlet. Consequently it becomes necessary to support the valve independently thus preventing valve turning torques from being transmitted to the tank nozzle or the expansion joint. In case of damage to the tank nozzle the entire contents of the tank may be lost. Consider use of gear operators on valves, or multiple turn valves such as diaphragm or gate valves.

14. Turbulence, high fluid velocity, steam, abrasive materials or materials which may settle in convolutions may necessitate use of Linersleeves™. Investigate process stream for possible need of linersleeves.

15. Are PTFE spacer-washers specified if hooking up to brittle mating flanges? Yes ____ No ____
    When mating to a flat-faced brittle flange, PTFE spacer washers must be used around the bolt holes to produce a flat-face effect.

16. COMPONENT AND MATERIAL CONSIDERATIONS
    PTFE joints can be used with almost any type and kind of piping materials; the considerations which should be analyzed are pressure, vacuum, temperature, and service. PTFE bellows work well with the piping materials listed below provided of course, the basic design conditions are met.

    a. All metallic piping.

    b. All solid plastic piping.

    c. Fiberglass reinforced plastic: both commercially available standard off-the-shelf products and piping custom made by the hand lay-up method.

    d. Asbestos or graphite reinforced phenolic pipe.

    e. Imprevious Graphite pipe.

    f. Glass pipe.

    g. Glass-lined steel pipe.

    h. Plastic-lined steel pipe.

VI. Bolting Considerations

PTFE expansion joints may be bolted to any mating pipe; in some cases without difficulty while in other cases damage may occur to either the expansion joint or the mating flange if extreme caution is not taken. If the Flexijoint recommended bolt torques are exceeded, "cold flow" of the PTFE flare may result making sealing difficult. Therefore, it is extremely important that bolting be done with torque wrenches to the specified limits.

PTFE envelope gaskets may be used at anytime with Flexijoints. Often gaskets are not required because the PTFE flare face forms its own gasket, but certain piping materials dictate the use of PTFE envelope gaskets. Glass-lined steel is typical of such a case because of the uneven flange surface resulting from the glassing operation. Mating metallic or press-molded FRP flanges may contain deep serrations, thus requiring envelope gaskets.

Extreme care must be used when bolting to brittle materials such as impervious graphite, fiberglass reinforced plastic, glass-lined steel, etc. It is far less costly to damage a Flexijoint flare than to destroy a graphite heat exchange nozzle or a Furan storage tank nozzle. Therefore, when bolting to stress sensitive equipment, bolt loads specified by the equipment manufacturer should not be overlooked.

Flexijoints flare faces are raised face sealing surfaces. When mating to a flat faced brittle flange, PTFE space washers must be used around the bolt holes to produce a flat face effect.

VII. Liners and Shields

Serious consideration must be given to the use of liners if the bellows is subjected to abrasive materials. While PTFE is a superior bellows material it does exhibit a basic weakness, (poor abrasion resistance) and this can most often be compensated for by the use of a PTFE or metallic liner.

A second important consideration concerning the requirement of a liner is the fluid velocity. Ethylene Flexijoints® require Linersleeves when smooth flow is desired and friction losses are to be minimized. If flow velocities are high a resonant vibration of the bellows may occur; as this condition must be avoided, an Ethylene Linersleeve is required. A rule of thumb, postulated by EJMA, is to use a liner when:

a) For Liquids:
   In pipes up to 6" diameter, velocity exceeds 2 feet per second per inch of diameter. In pipes over 6", velocity exceeds 10 feet per second.

b) For Gases:
   In pipes up to 6" diameter, velocity exceeds 4 feet per second per inch of diameter. In pipes over 6" diameter, velocity exceeds 25 feet per second per inch of diameter.

If turbulence is generated directly upstream of a Flexijoint, a liner should be specified. Please observe Figure 6, on page six, of Ethylene Bulletin 2002; when a liner is used, the thickness of the liner must be added to the overall length of the bellows.

All Ethylene Flexijoints should be ordered with Flexishield™ covers. The added expense is relatively small and the cover will help protect the bellows from external mechanical damage after installation, as well as help to prevent fluid spray in the event of a pressure or temperature surge (beyond the design limit of the bellows) that could lead to failure of the bellows.

VIII. Specifications

The final control on proper application, once the piping has been properly designed, is the expansion joint specification. Ethylene requires very specific information to properly design an expansion joint.

First, the fluid properties must be stated. Both the constituents of the flowing media and it's velocity must be noted. While a Flexijoint, made of PTFE fluorocarbon resin, is practically inert to most any chemical compound, the information is vital to Ethylene.

Be certain to specify flange diameter and drilling. Ethylene Flexijoint flanges confirm to ANSI BI6.5 standards, but Ethylene can accommodate any optional configurations.

Specify a Flexishield cover. As stated previously, this will add little extra cost but may save the Flexijoint from mechanical damage after installation.

Describe the bellows. Start with the size; list the nominal diameter of the joint. List the installation position. Is it horizontal? Vertical? If the installation is vertical, is the flow up or down? List the number of convolutions and the installed length, found in Ethylene Bulletin 2002. If, based on the data you supply, Ethylene agrees with your selection, this is what will be supplied. If Ethylene disagrees with your selection, they will notify you immediately.

Provide a listing of system design parameters, starting with testing conditions, list test pressure and temperature. Paragraph 337.3 of ANSI B31.3 states: "Expansion joints shall be provided with temporary restraint if required for additional pressure load under test, or shall be isolated from the test". Failure to do this will result in premature failure of the bellows. Next, list your field installation tolerance. This may vary from one company to another, but typically ± .125" axial, .125" lateral and 1.0 degree angular should be sufficient. List the normal operation conditions including temperature, pressures, vacuum, axial, lateral, and angular displacements, and the operting design cycle life. Consider cold weather shut-down and list the temperature and displacements resulting from such a condition. Allow a minimum of 1,000 cycles for cold weather shut-down. Finally, list the design conditions for the bellows. Design conditions should be the largest variations in pressure and temperature, the sum of the normal operation, cold weather shut-down and installation tolerance deflections and a cylce life of at least 7,000 cycles. Ethylene Flexijoints can display cycle-lives exceeding hundreds of thousands of cycles, but 7,000 cycles will give ANSI B31.3 minimums for piping system design.

For field information, request a stamped tag be affixed to the bellows listing "conditions not to be exceeded". Include the test pressure, design pressure, and temperature, and design condition axial, lateral, and angular movements.

The Ethylene Flexijoint is fully described in Engineering Bulletin No. 2002. They are available in diameters through 42 inch with from two to twelve convolutions. The number of convolutions selected for the application is a function of pipe movement, pressure/temperature rating and spring rate. It should be emphasized that the technical staff of the manufacturer should be consulted as frequently as possible, and in many instances the bellows design can be modified to fit an unusual set of serious conditions.

Note: See Appendix for **Sample Expansion Joint Data Sheet** for use when specifying any expansion joint.

IX. Installation Notes

Providing that the bellows has been engineered properly, and that the piping and it's restraints have been designed properly, then careful attention to proper installation procedures will result in a Flexijoint installation that will have a service life that is as good as the pipe to which it is connected.

The most common installation error is when the bellows is forced to fit an excessive, beyond construction tolerance, gap in piping. The piping design engineer must strive to insure that the construction personnel make the piping fit the expansion joint and not vice versa. **When a Flexijoint is stretched, compressed, or offset to fit poorly fabricated pipe, it is probable that the joint will not perform well in service.** This is why the installation tolerance must be added to the expected bellows deflections, to accommodate reasonable expected misalignments. Obviously, any misalignments of greater magnitude than the stated installation tolerance are unacceptable as the bellows was not designed to accommodate such excessive deflection. The installation personnel must be made aware of the fact that the expansion joint is not there for their convenience. It must be located just as carefully as a pump or other piece of equipment.

When a Flexijoint arrives in the field, it should be examined for possible damage during transit. Look for broken hardware, nicks, scratches, etc. Check the container for nut, bolts, removable liners or other loose parts. Ethylene Flexijoints should be stored in clean, dry, protected areas in their shipping containers. Do not allow them to be exposed to work traffic or dirt.

If a Flexijoint is to be lifted by a crane, use only the designated lifting lugs. Never use a chain or wire rope directly on a Flexijoint bellows, or on an unrestrained Flexijoint that may deflect when lifted. Failure to follow this procedure will result in a bellows that will be damaged and may then fail in service.

Because of the notch sensitivity of the PTFE material, Flexijoints must remain free from abrasion and nicks before, during, and after installation. Weld splatter spells death to PTFE corrugations; protect Flexijoints from weld splatter at all costs. Likewise, do not use wire brushes, steel wool or other abrasives near Ethylene Flexijoints. Scratches and abrasions will reduce cycle life and cause premature bellows failure.

When shipping bars are attached to a Flexijoint (as in a factory cold-sprung installation), do not remove them until the entire piping system is installed, including all pipe restraints. **Be sure to remove the shipping bars prior to testing and start-up.** Proper test procedures should be adhered to; the Flexijoint must not be subjected to test pressures higher than those designated on the bellows specification. Under no circumstances is the system to be pressure tested until the entire system, with its pipe restraints, is installed and functional.

In the appendix is a copy of Ethylene Bulletin 4001. This bulletin contains installation instructions and is packed with every Flexijoint. These instructions are to be followed, not discarded.

Summary

It should be obvious by now that Ethylene Flexijoints are to be carefully engineered into piping systems and not purchased as commodity items. If the piping is designed and restrained properly, the Flexijoint should last as long as the piping system; providing, of course, that the bellows is installed properly.

Start-Up Check List

The final control any designer has is to **visit the field, prior to start-up, to ensure that the piping system, including all it's restraints, was installed properly.** It is important to insure that:

1. All restraints are positioned and will function exactly as the designer intended.
2. The piping was aligned properly and that the Flexijoint was not made to fit a poorly fabricated pipe arrangement.
3. The pipe guides are in place and correctly positioned.
4. All Flexijoints are covered with a shield wherever possible.
5. The Flexijoints are not misaligned beyond recommended limits. If limit bolts are used, the bolts should not be hung-up or cocked in the holes of the flanges thru which the limit bolts pass.
6. The Flexijoints are installed within their neutral or normal length. If the joint is fully expanded or compressed prior to start-up (or even after start-up) the piping assembly is faulty.
7. No weld splatter or metal chips or other types of foreign material are present.
8. Provisions have been made to prevent pressure or temperature surges.

This manual is intended to be used as a guide for Good Engineering Practice regarding the use of Ethylene Flexijoints. This does not imply that Ethylene Corporation takes any responsibility for any Flexijoint installation. Ethylene will furnish a quality product; it is the piping designer's responsibility to insure that this product is applied and installed correctly.

If a designer ever has any questions regarding an expansion joint application, he should not hesitate to contact Ethylene Corporation.

Bibliography

Standards of the Expansion Joint Manufacturers Association, Inc. Fifth Edition, 1980. Published by EJMA, Inc., 707 Westchester Ave., White Plains, New York 10604.

Survey Report on Structural Design of Piping Systems and Components, TID-25553, E.C. Rodabaugh, et.al., National Technical Information Service, U.S. Department of Commerce.

"Preventing Failure of Bellows Expansion Joints", D.R. McCulloch, Chemical Engineering Vol. 88, No. 23, Page 259.

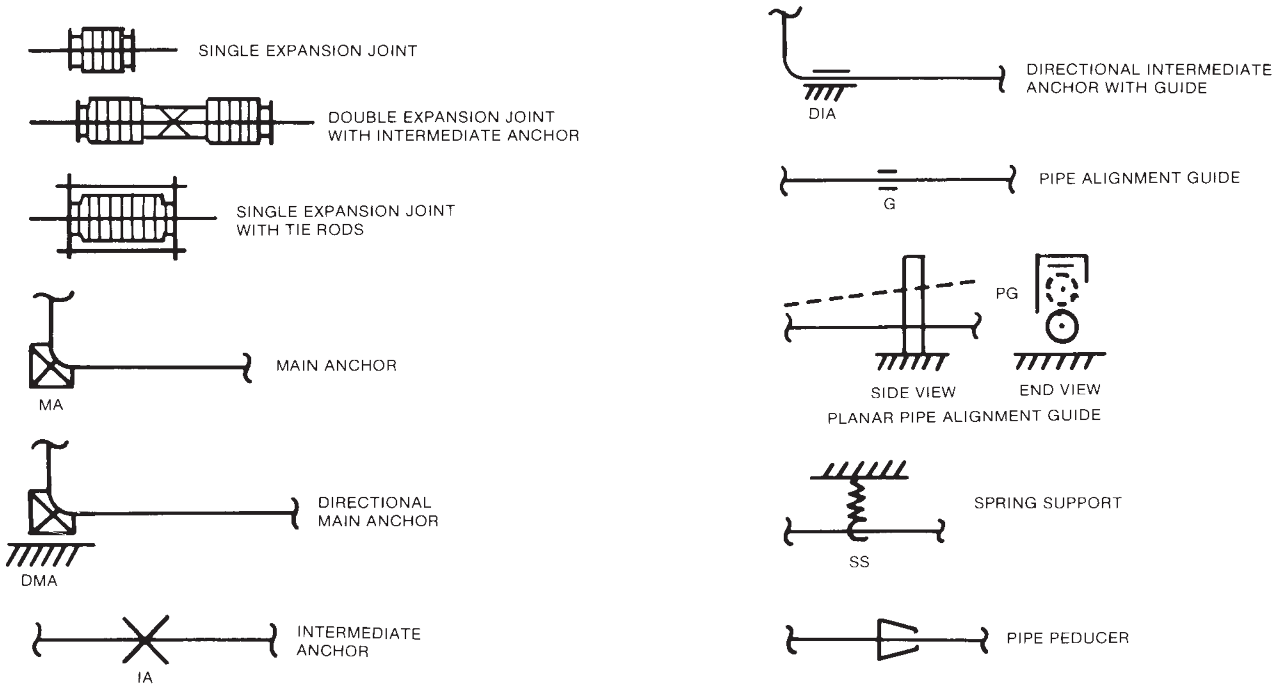
"Expansion and Flexibility", Chapter 4, **Piping Handbook,** 5th Edition, John E. Brock.

ANSI/ASME B31.3, Code for Pressure Piping, **Chemical Plant and Petroleum Refinery Piping,** 1980 ed.

Bulletin No. 2002, PTFE-Fluorocarbon Flexijoint, Ethylene Corporation, 755 Central Avenue, Murray Hill, New Jersey 07974.

Appendix

Table 1 Symbol Nomenclature



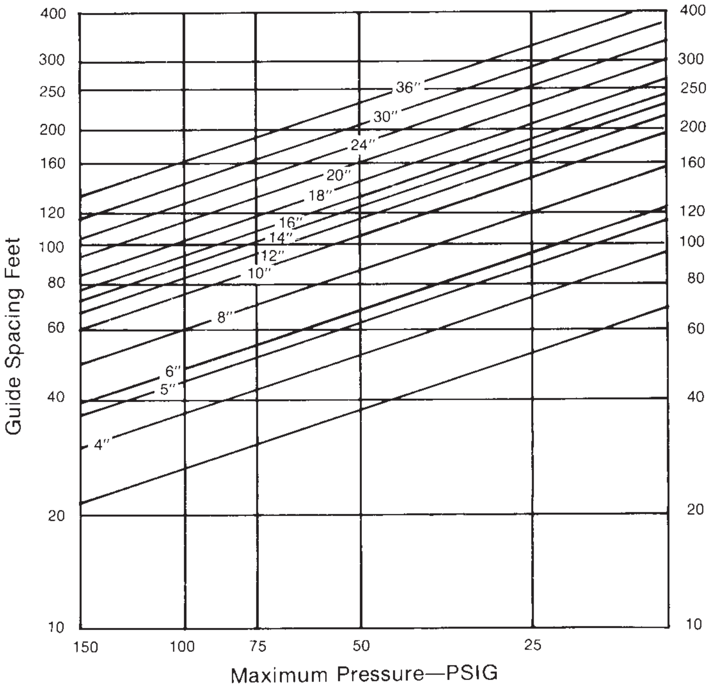
Maximum Recommended Spacing for Pipe Guides

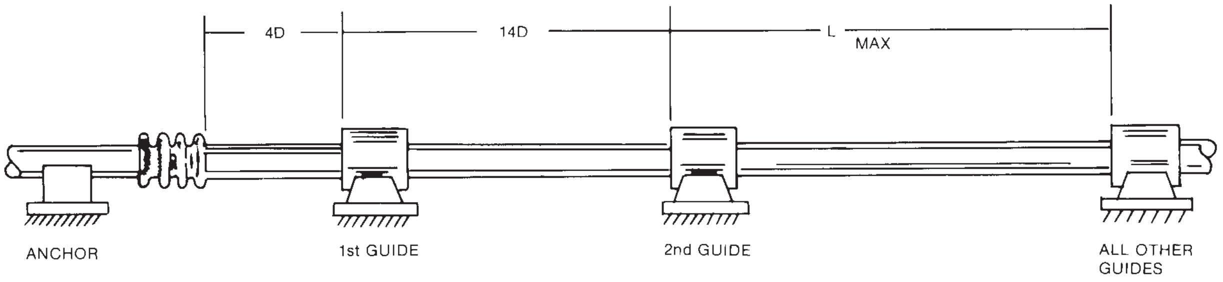
(Axial Deflection Only—Std. Weight Carbon Steel Pipe)

Expansion joints should not be located immediately downstream from turbulent producing devices such as valves, sudden pipe size changes, etc. If it is impossible to locate the expansion joint an adequate distance away from the turbulence producers, the joint should be equipped with a heavy liner.

Wherever possible, an expansion joint should be located immediately adjacent to a pipe anchor; if not possible, pipe guides should be used on both sides of the expansion joint. The first pipe guide must be located within 4 pipe diameters of the expansion joint—the second guide must be within 14 pipe diameters of the first guide—recommended spacing for additional guides along the balance of the pipe section can be determined from the chart below.

Proper alignment is extremely important in the installation of all expansion joints. No expansion joint will operate properly unless the pipe line in which it is installed is securely anchored and guided, and adequately supported.





Coefficients of Expansion Piping Materials

Material	Mean Linear Expansion in/in/°F x 10^{-6}	Total Expansion in/100 Ft/Δt of 100°F	Source
Carbon Steel	6.8	0.82	ANSI B 31.3
Carbon-Moly			
Low Chrome			
(thru 3 Cr Mo)			
5 Cr Mo thru 9 Cr Mo	6.3	0.76	ANSI B 31.3
3½% Nickel	6.8	0.82	ANSI B 31.3
Aluminum	13.6	1.63	ANSI B 31.3
Gray Cast Iron	6.1	0.73	ANSI B 31.3
Bronze	10.2	1.22	ANSI B 31.3
Brass	10.2	1.22	ANSI B 31.3
79 Cu 30 Ni	8.9	1.07	ANSI B 31.3
Titanium	5.1	0.61	Tico Titanium
Saran Lined Carbon Steel	6.8	0.82	Used Carbon Steel Data
Polypropylene Lined Carbon Steel	6.8	0.82	Used Carbon Steel Data
Kynar Lined Carbon Steel	6.8	0.82	Used Carbon Steel Data
Teflon Lined Carbon Steel	6.8	0.82	Used Carbon Steel Data
Rubber Lined Carbon Steel	6.8	0.82	Used Carbon Steel Data
Glass Lined Carbon Steel	6.8	0.82	Used Carbon Steel Data
Hastelloy G	7.7	0.92	Cabot Corp., Stellite Div.
Hastelloy B	5.8	0.70	Cabot Corp., Stellite Div.
Hastelloy C	6.8	0.82	Cabot Corp., Stellite Div.
Hastelloy X	7.8	0.94	Cabot Corp., Stellite Div.
Haynes Alloy 718	7.5	0.90	Cabot Corp., Stellite Div.
Haynes Alloy R-41	6.8	0.82	Cabot Corp., Stellite Div.
Haynes Alloy 25	7.2	0.86	Cabot Corp., Stellite Div.
Haynes Multimet	8.6	1.03	Cabot Corp., Stellite Div.
Haynes Multimet 188	7.0	0.84	Cabot Corp., Stellite Div.
304, 304L S.S.	10.4	1.25	Carpenter Steel
316, 316L S.S.	10.3	1.24	Carpenter Steel
317 S.S.	10.3	1.24	Carpenter Steel
310, 310S S.S.	9.7	1.16	Carpenter Steel
309 S.S.	10.0	1.20	Carpenter Steel
347, 348 S.S.	10.4	1.25	Carpenter Steel
321 S.S.	10.4	1.25	Carpenter Steel
305 S.S.	10.5	1.26	Carpenter Steel
302 S.S.	10.4	1.25	Carpenter Steel
20 Cb3	8.3	1.00	Carpenter Steel
430 S.S.	6.6	0.79	Carpenter Steel
405 S.S.	6.7	0.80	Carpenter Steel
410 S.S.	6.5	0.78	Carpenter Steel
420 S.S.	6.8	0.82	Carpenter Steel
450 S.S.	5.7	0.68	Carpenter Steel
Fibercast Centrifugally Cast	13.0	1.56	Fibercast
F-Chem	10.5	1.26	Fibercast
PVC 1120	30.0	3.60	ANSI B 31.3
PVC 1220	35.0	4.20	ANSI B 31.3
PVC 2110	50.0	6.00	ANSI B 31.3
PVC 2112	45.0	5.40	ANSI B 31.3
PVC 2116	40.0	4.80	ANSI B 31.3
PVC 2120	30.0	3.60	ANSI B 31.3
Vinylidine Fluoride (Kynar)	85.0	10.2	ANSI B 31.3
Vinylidine/Vinyl Chloride	100.0	12.0	ANSI B 31.3

The data shown represents information derived from sources as indicated.

In most instances the coefficient of expansion shown is applicable at 400°F (205°C) which is approximately the maximum termperature limit for the PTFE joints.

These data are for information only and it is **not** implied that materials are suitable for the temperature shown.

Individual compounds may vary from the values shown. Consult manufacturer for specific values for his products.

Coefficients of Expansion Piping Materials

Material	Mean Linear Expansion in/in/°F x 10^{-6}	Total Expansion in/100 Ft/Δ*t* of 100°F	Source
Incoloy 800	8.8	1.07	Int'l Nickel (Huntington Alloys)
Nickel 200	7.7	0.92	Int'l Nickel (Huntington Alloys)
Monel 400	8.6	1.03	Int'l Nickel (Huntington Alloys)
Inconel 600	7.7	0.92	Int'l Nickel (Huntington Alloys)
Polypropylene PP 1110	48.0	5.76	ANSI B 31.3
Polypropylene PP 1208	43.0	5.16	ANSI B 31.3
Polypropylene PP 2105	40.0	4.8	ANSI B 31.3
Borosilicate Glass	1.8	0.22	ANSI B 31.3
Impregnated Graphite	2.4	0.29	ANSI B 31.3
Hard Rubber (Buna N)	40.0	4.80	ANSI B 31.3
Polysulfone	31.0	3.72	Union Carbide
Haveg 41	13.0	1.56	Haveg Indust.
Haveg 61	13.0	1.56	Haveg Indust.
Bondstrand 2000	8.5	1.02	Amercoat
Bondstrand 4000	8.8	1.07	Amercoat
Bondstrand 5000	8.8	1.07	Amercoat
A.O. Smith			
Red Thread 2", 3", 4"	13.5	1.62	A.O. Smith/Inland
6"-12"	8.8	1.07	A.O. Smith/Inland
Silver Thread 2", 3", 4"	12.2	1.46	A.O. Smith/Inland
6"-12"	8.8	1.07	A.O. Smith/Inland
Green Thread 1", 1½", 6"-12"	11.4	1.37	A.O. Smith/Inland
2", 3", 4"	12.7	1.52	A.O. Smith/Inland
Poly Thread (All Sizes)	10.5	1.26	A.O. Smith/Inland
Chemline	10.8	1.30	A.O. Smith/Inland
Acetal AP 2012	2	0.24	ANSI B 31.3
Acrylonitrile-Butadiene-Styrene			
ABS 1208	60	7.20	ANSI B 31.3
ABS 1210	55	6.60	ANSI B 31.3
ABS 1316	40	4.80	ANSI B 31.3
ABS 2112	40	4.80	ANSI B 31.3
Cellulose Acetate Butyrate (CAB)			
MH 08	80	9.60	ANSI B 31.3
S 004	95	11.40	ANSI B 31.3
Chlorinated Polyvinyl Chloride (CPVC)			
4120	35	4.20	ANSI B 31.3
Polybutylene PB 2110	72	8.64	ANSI B 31.3
Polyether, Chlorinated	45	5.40	ANSI B 31.3
Polyethylene PE 1404	100	12.00	ANSI B 31.3
Polyethylene PE 2305	90	10.80	ANSI B 31.3
Polyethylene PE 2306	80	9.60	ANSI B 31.3
Polyethylene PE 3306	70	8.40	ANSI B 31.3
Polyethylene PE 3406	60	7.20	ANSI B 31.3
Polyphenylene POP 2125	30	3.60	ANSI B 31.3

The data shown represents information derived from sources as indicated.

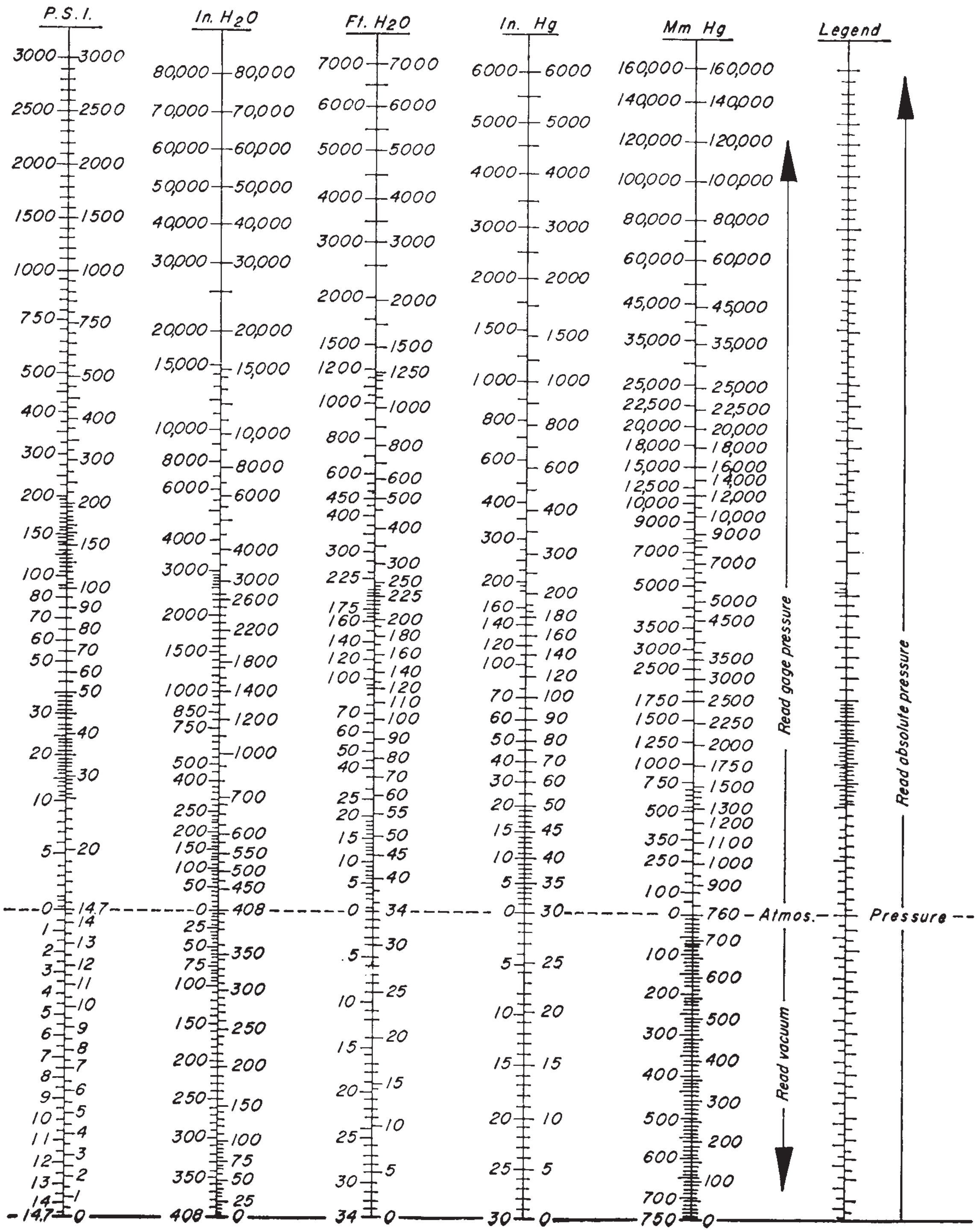
In most instances the coefficient of expansion shown is applicable at 400°F (205°C) which is approximately the maximum temperature limit for the PTFE joints.

These data are for information only and it is **not** implied that materials are suitable for the temperature shown.

Individual compounds may vary from the values shown. Consult manufacturer for specific values for his products.

Pressure Conversion Chart

Absolute pressure values are on the right side of all vertical scales. Vacuum values are on the left side and are read from atmospheric pressure down. Gage pressure values are also on the left, but read from atmospheric pressures up. A straight edge placed on the chart through any known value will cross all other vertical scales at the correct conversion.



Feet Head of Water to PSI

Feet Head	Pounds Per Square Inch	Feet Head	Pounds Per Square Inch
1	.43	100	43.29
2	.87	110	47.62
3	1.30	120	51.95
4	1.73	130	56.28
5	2.16	140	60.61
6	2.60	150	64.94
7	3.03	160	69.26
8	3.46	170	73.59
9	3.90	180	77.92
10	4.33	200	86.58
15	6.49	250	108.23
20	8.66	300	129.87
25	10.82	350	151.58
30	12.99	400	173.16
40	17.32	500	216.45
50	21.65	600	259.74
60	25.97	700	303.03
70	30.30	800	346.32
80	34.63	900	389.61
90	38.96	1000	432.90

NOTE: One foot of water at 62° Fahrenheit equals .43 pound pressure per square inch. To find the pressure per square inch for any feet head not given in the table above, multiply the feet head by .43.

Steam Table

Temp. (°F)	Absolute Pressure (psia)	Temp. (°F)	Absolute Pressure (psia)
32	0.08854	210	14.123
35	0.09995	212	14.696
40	0.12170	220	17.186
45	0.14752	230	20.780
50	0.17811	240	24.969
60	0.2563	250	29.825
70	0.3631	260	35.429
80	0.5069	270	41.858
90	0.6982	280	49.203
100	0.9492	290	57.556
110	1.2748	300	67.013
120	1.6924	320	89.66
130	2.2225	340	118.01
140	2.8886	360	153.04
150	3.718	380	195.77
160	4.741	400	247.31
170	5.992	420	308.83
180	7.510	440	381.59
190	9.339	460	466.9
200	11.526	480	566.1
		500	680.8

NOTE: psia=psig+14.7

Design Data
Water Hammer

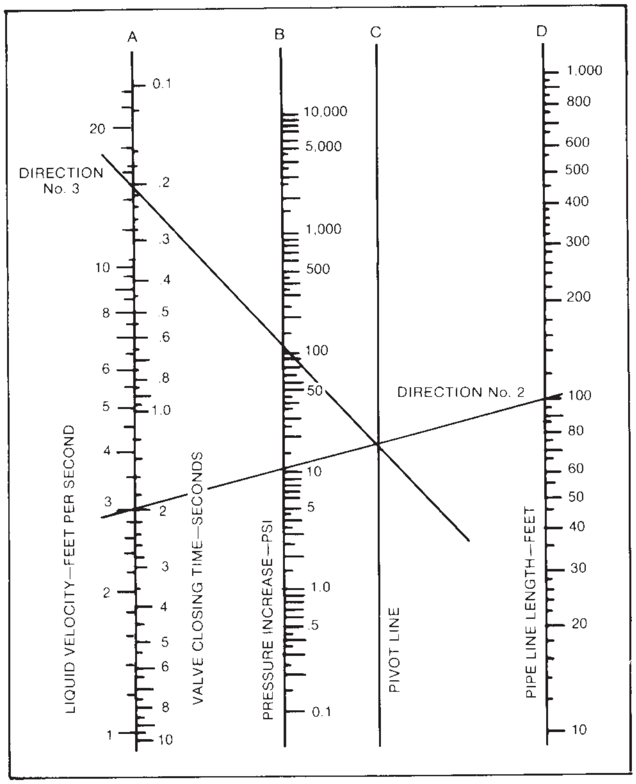
A moving column of liquid has momentum, or inertia proportional to its weight and velocity. When flow is stopped suddenly, as by a quick closing valve or check, this inertia is converted into a shock load or high pressure surge. The longer the line and the faster the liquid velocity; the greater the shock load will be. These shock loads can be of sufficient force to burst pipe and break fittings and valves. This is usually called water hammer.

Maximum pressure caused by water hammer, or momentum pressure surges, can be calculated from the chart below. The chart is based on data for water and is applicable to other similar industrial liquids. In general, good design will eliminate quick opening valves on anything but very short lines. (The reverse is true in using check valves when pumping against gravity or pressure. In this case valves should close as quickly as possible to keep the velocity of the liquid flowing back through the check valve to a minimum.)

Directions:

1. Liquid Velocity (ft/sec), pipeline length (ft) and valve closing time (sec) must be known.
2. Place a straight edge on the liquid velocity in pipe (line A) and the pipeline length (line D).
3. Mark intersection of straight edge with pivot line (line C).
4. Placed straight edge on mark just placed on pivot line (line C) and on valve closing time for valve being used (line A).
5. The intersection of the straight edge with the pressure increase line (line B) is the **liquid momentum surge pressure** (water hammer).

The **liquid momentum surge** (water hammer) should be added to the previous line pressure to determine the maximum line pressure to be used to determine selection of pipe schedule or wall thickness.



The chart is based on the formula

$$P = \frac{0.070\ VL}{T}$$

Where P is increased in pressure due to momentum surge in psi, L is pipeline length in feet. V is liquid velocity in ft. per sec. T is valve closing time in seconds.

Expansion Joint Data Sheet

1.0 FLUID PROPERTIES:

1.1 Medium ____________________

1.2 Velocity ____________________ ft./sec.

2.0 MATERIALS OF CONSTRUCTION:

2.1 Bellows ____________________

____

2.2 Flanges ____________________

____

2.3 Piping ____________________

____

2.4 Liner ____________________

____

2.5 Cover ____________________

____

3.0 SPECIFICATIONS:

3.1 Flanges ____________________

____

3.2 Piping ____________________

____

4.0 SPRING RATES:

4.1 Axial ________ lbs./in.

4.2 Lateral ________ lbs./in.

4.3 Angular ________ in.-lbs./deg.

5.0 JOINT FEATURES:

5.1 Size _____ in. nominal dia.

5.2 Type ____________________

____

5.3 Internal Sleeve Yes ☐ No ☐
5.4 External Cover Yes ☐ No ☐
5.5 Installation Position
Horizontal ☐ Flow Up ☐
Vertical ☐ Down ☐
5.6 Installed Length ________ in.

5.7 Pressure Thrust Area ________ sq. in.

6.0 STAMPING:

"CONDITIONS NOT TO BE EXCEEDED"

6.1 Pressure Test _____ psig.

6.2 Pressure _____ psig @ _____ °F

6.3 Axial Movement _____ in.

6.4 Lateral Movement _____ in.

6.5 Angular Movement ________ deg.

7.0 Design Parameters:

Condition	Vacuum In., Hg.	Pressure Psig	Temp. Deg. F	Movements (1)			Cycles
				Axial-In.	Lateral-In.	Angular-Deg.	
Testing				—	—	—	—
Installation Tolerance	—	—					—
Normal Operation							
Cold Weather Shutdown	—	—					1000
Design							

(1) Axial movement causing joint to compress is designated as Positive (+), Axial Extension as Negative (-).

BULLETIN NO. 4001
INSTALLATION INSTRUCTIONS
PTFE-FLUOROCARBON*
Flexijoint*

INSPECTION

After inspection return the Flexijoint to its carton until time for installation so that the white PTFE flares at each end (which act as gaskets) will remain flat.

FLARES

During installation protect the PTFE flares from abrasion, cutting, paint, welding splatter, etc.

BOLT TIGHTENING

When installing flanged Flexijoints prevent overtightening by limiting bolt torque to:

IPS	Torque Ft.-Lbs.	IPS	Torque Ft.-Lbs.	IPS	Torque Ft.-Lbs.	IPS	Torque Ft.-Lbs.
1/2	**5**	2	**25**	5	**40**	14	**70**
3/4	**5**	2-1/2	**30**	6	**45**	16	**65**
1	**10**	3	**40**	8	**60**	18	**90**
1-1/4	**10**	3-1/2	**25**	10	**50**	20	**80**
1-1/2	**15**	4	**30**	12	**60**	24	**90**

ANCHORING

Most fluid conducting systems are subject to a variety of forces such as thermal, mechanical, and hydraulic, which produce unwanted pipe movement. Safe installation of Flexijoints and similar devices of rubber, metal and plastic requires that the components to which they are connected be anchored, guided, or otherwise restrained so that these forces do not flex or distort the Flexijoint or similar device beyond the limits for which it was designed. The limits for Flexijoints are shown on the other side of this sheet. It is important to remember, also, that when a Flexijoint or similar device is pressurized internally it tends to expand, and this expanding force can be great enough to create unsafe stresses. If pipe movement caused by forces in the piping system or by the Flexijoint itself is not provided for please consult your design engineer or us before installation.

IMPORTANT!

Improper installation of this part might be dangerous. Please comply with the following instructions.

IMPORTANTE!

La instalación impropia de ésta pieza puede ser peligrosa. Por favor lea las instrucciones. Si usted no puede leer Inglés, pida ayuda antes de continuar.

WICHTIG!

Falscher Einbau dieses Teiles könnte gefährlick sein. Bitte Anweisungen auf das genaueste befolgen. Falls nicht Englisch gelesen wird, den Text übersetzen lassen bevor Beginn des Einbaus.

IMPORTANT!

Installer incorrectement cette pièce peut être dangereux. Prière d'observer strictement les instructions suivantes. Si vous ne lisez pas l'anglais, faites les traduire avant de procéder à l'installation.

IMPORTANTE!

Inadatta installazione di questa parte può essere pericolosa. Per favore seguite le istruzioni seguenti. Se non leggete l'Inglese, fatele tradurre prima di proseguire.

VERTICAL PIPE SUPPORT

Provide support for vertical piping at any point where the weight of the piping might cause the Flexijoint to be flexed beyond the limits shown on the other side of this sheet.

ALIGNMENT

For greatest Flexijoint life keep misalignment minimum. Maximum limits are shown on the other side of this sheet.

FLANGE SPACING

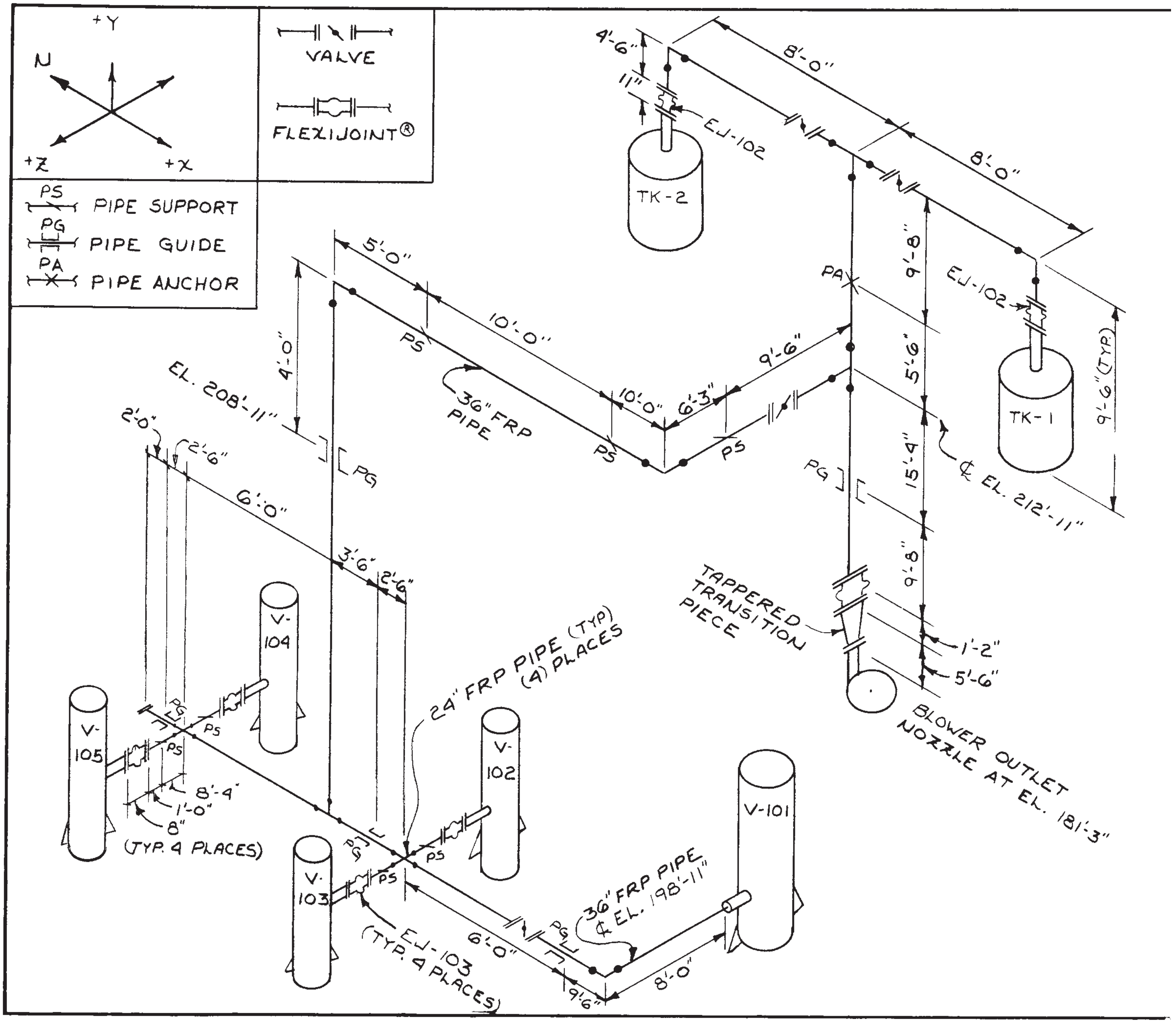
Piping systems should be designed so that when Flexijoints are bolted in place, and before the system is put on stream, their lengths from contact face to contact face are as close as practical to the normal lengths shown on the other side of this sheet.

MAINTENANCE

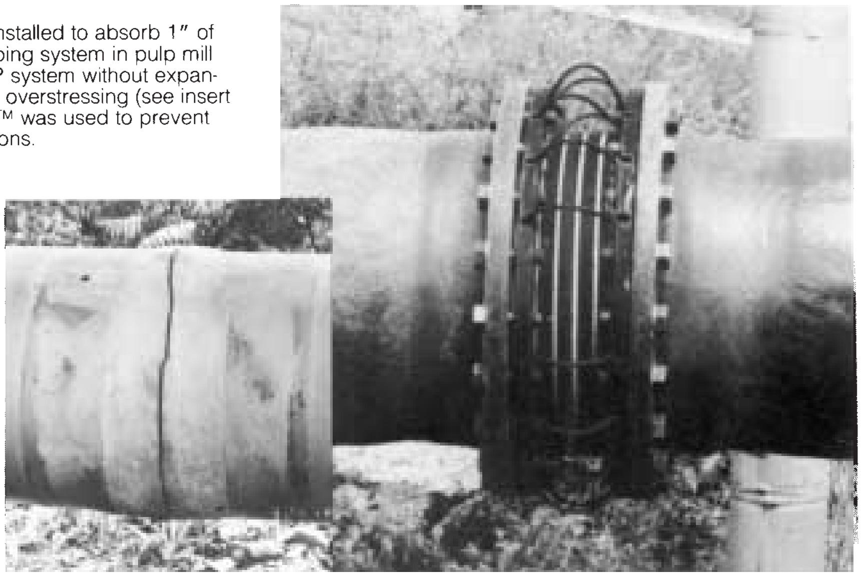
No maintenance is necessary. It is recommended, however, that Flexijoints be inspected at appropriate intervals to determine whether they have reached the limits of flexure shown on the other side of this sheet. If one or more of the Limitlinks®, Collarbars®, or Cablecords®, whichever is being used, is in tension, or if the T-Bands® are touching each other, the limit of flexure has been reached, and stresses being generated elsewhere in the system are threatening failure. Steps should be taken immediately to relieve them.

*Flexijoints is Ethylene Corporation's registered tradename for its bellows, expansion joints, and flexible couplings.

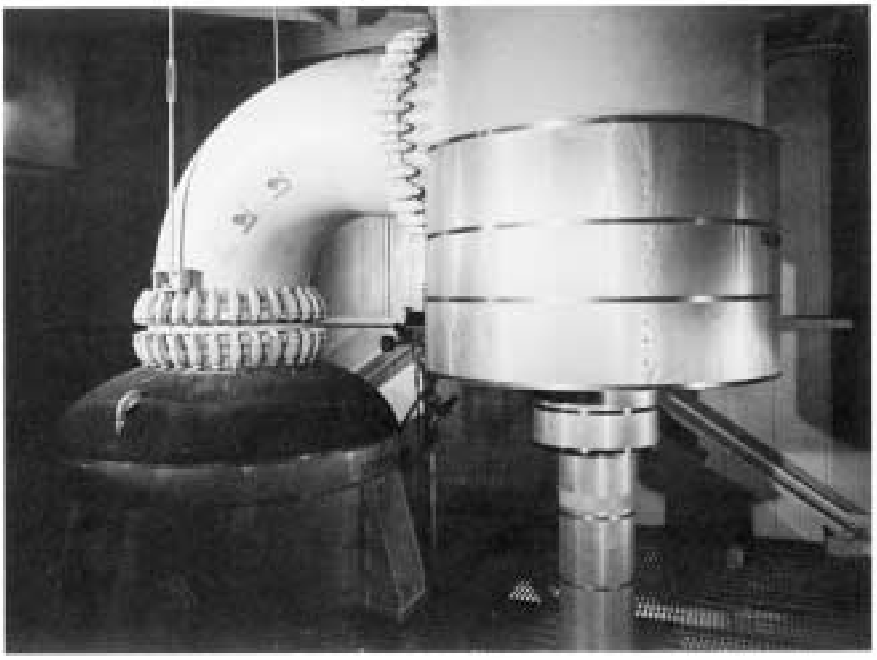
Typical PTFE Expansion Joint Installations



20″ diameter Flexijoint® installed to absorb 1″ of thermal growth of FRP piping system in pulp mill effluent line. Previous FRP system without expansion joints cracked due to overstressing (see insert photo). PTFE Linersleeve™ was used to prevent solid build-up in convolutions.



16″ diameter Flexijoint® with Titanium Linersleeve™ and Titanium Vacubands™ designed to dampen system vibration in highly corrosive chlorine dioxide service. (One of 14 such installations world-wide)



30″ diameter Flexijoint® with J-Bolt™ flanges installed to prevent overstressing of glass-lined steel column and mating elbow. Vacuband™ of Tantalum provide for full vacuum service at 350°F in sulfuric acid concentration facility.

THE WORLD LEADER IN FLUOROPOLYMER TECHNOLOGY FOR OVER 50 YEARS

Flexijoint® PTFE Expansion Joints

Flexijoint® is designed for severe service applications that demand consistent reliability, lower permeation rates and maximum travel. Available in sizes of 1/2" to 42" diameters with 2 to 12 convolutions to compensate for pipe movement, misalignment and/or vibration. Features include - Full vacuum resistance to 400°F, Uniformed PTFE wall thickness,T-Bands™ for convolution support and Limitlink™ axial restraints that eliminate cumbersome limit bolts. Flexijoints® low spring rate is ideal for stress-sensitive FRP piping, graphite pumps and glass lined process vessels and equipment.

FlexArmor® PTFE Lined (double contained) Bellows

FlexArmor® combines a 321 stainless steel armored bellows with a Flexijoint® heavy wall PTFE liner to provide higher pressure capability (200psi), outstanding chemical resistance and the added security of double containment. The bellows have a size range to 24" diameter and can operate at temperatures from -40°F to +400°F. FlexArmor® bellows are designed and engineered to any specific customer requirements.

FACTORY MUTUAL APPROVED

FLO-VU® Sight Indicators With Safety Shield

Ethylene's sight flow indicators incorporate energized PFA seals with a full 360° view Borosilicate glass that provides a continues bubble-tight seal at 150psi even after repeated thermal cycling - GUARANTEED!
Available in 1" to 8" diameter and lengths from 5" to 30" and can operate at temperatures of -20°F to +350°F.
Also available with tri-clamp end connections and dual containment configuration.

MonoDerm™
Large Diameter Lined Pipe and Special Shapes

MonoDerm™ is Ethylenes trademark for its heavy duty, seamless lined piping components. Available in PTFE, PFA or ETFE with a size range from 1/2" to 42" diameter. Ethylene's isostatic molding and high capacity rotational molding cells can line virtually any configuration imaginable such as piping headers, pump casings and valves.

EthylArmor® & pHampler®
Dip Tubes, Spargers & Sampling

EthylArmor® is a PTFE lined and covered armored dip pipe or sparger designed exclusively for the rigorous demands of agitating vessels or the high stress of injection. Also available is Ethylene's Solid PTFE dip pipes and spargers for non-agitated services.
pHampler® is a patented reactor sampling, monitoring and control system that eliminates fugitive emissions and employee exposure to hazardous media while providing guaranteed analyzed results.

T-Line Strainers™

Fully lined ETFE or PFA ductile iron strainers in sizes 2" to 8", temperatures to 450°F delivers maximum Cv's and chemical resistance while protecting your valuable downstream equipment such as lined pumps, heat exchangers and glass lined vessels.

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