A PRIMER ON PRESSURE THRUST

One of the most misunderstood factors in the application of expansion joints is the determination of the thrust at the anchors, particularly the end anchors. Everyone knows that expansion joints are placed in a pipe line to allow for movement as the temperature of the pipe changes and the various sections of pipe increase or decrease in length. Also, everyone will agree that if one end of pipe is anchored and the pipe grows longer, the other end must move, and that this movement will be resisted by the frictional drag of the pipe supports and guides plus any resistance within the expansion joint itself (for example, packing friction in a slip joint). It is universally agreed that these resistances to motion result in a slight axial compressive load in the pipe and a reaction, or thrust, at the anchor.

Up to this point the problem is no different from that presented by the thermal expansion of a railroad rail or a bridge truss. However, most pipelines contain a fluid under pressure and this pressure causes an additional thrust on the anchor which is often greater than all the other minor thrusts combined. It is this pressure thrust which is sometimes misunderstood.

At the risk of boring the reader with over-simplification, the following discussion has been broken down into elementary steps to show exactly how and why a pressure thrust exists, where it is exerted, and how much force is developed.

Figure 1 shows a straight length of pipe closed at both ends. If there is an internal pressure, it will be exerted equally on the two ends. and will be "balanced out" so that there is no net force tending to move the pipe in either direction and it will remain in place without anchors.

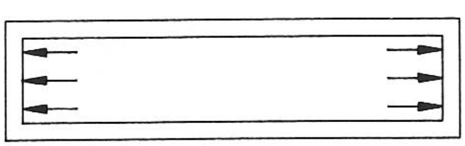

Figure 1

However, in opposing each other, these end forces create an axial tension in the walls of the pipe, and as long as the material is strong enough to resist this tension, there will be no relative motion of the two end sections - ***they will not come apart***. This will be true in Figure 2 and in any rigid assembly of sufficient strength, no matter how complex its shape.

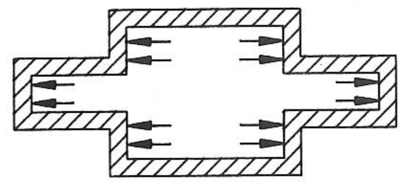

Figure 2

The fundamental purpose of an expansion joint is to permit relative motion between its two ends. Hence in Figure 3, the rigid side of the wall has been replaced by a telescopic section, or slip joint, to permit movement. However, because of this joint, the side walls can no longer carry the axial tension as they did before, and the ***two ends will be blown apart unless resisted by some external force, F.*** This is the pressure thrust, which must be resisted by the end anchors. Careful study of Figure 3 will show that it is equal to the internal pressure times the cross sectional area at the diameter, d. This will be the diameter at which the relative motion takes place in the sealing device - **in this case the O.D. of the slip or the I.D. of the packing rings.**

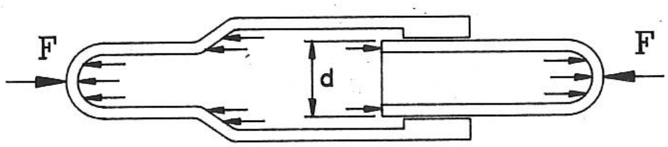

Figure 3

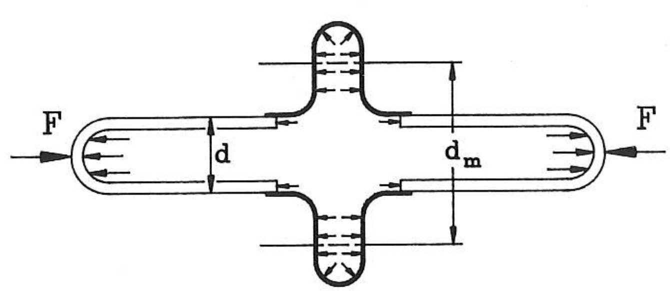

Figure 4

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A Primer on Pressure Thrust, cont'd.

In a corrugated (Bellows) expansion joint the effective diameter for determining the pressue thrust is equal to the mean (pitch) diameter of the Bellows **(which is greater than the pipe O.D. as used for slip type expansion joints)**. Consider the diaphragm of a pressure regulating valve or a pneumatically operated remote control of the diaphragm type. As is well known, the force on the valve stem is a function of the pressure acting on the working area of the diaphragm; and if a large force is required from a low control pressure, a large diaphragm is used.

In Figure 4, one half corrugation may be considered a a diaphragm, and even though it is less flexible than the rubber diaphragm , the same fundamental principles will still apply. **Therefore, the pressure thrust reaction at an end anchor in a line having Bellows joints will be equal to the internal pressure times the effective thrust area of the Bellows, not the pipe diameter.**

Figure 5 illustrates a pipe segment containing Expansion Joints, Guides and Anchors. Anchor A_1 will always have the pressure thrust exerted upon it. The intermediate Anchors A_2 and A_3 will not be subject to any pressure thrust force since they are equal and opposite and will cancel each other. With the Valve open Anchor A_4 will be subjected to frictional forces only; however **Anchor A_4 must be designed to resist the pressure thrust force in event the valve is closed.**

In special cases, where an intermediate anchor lies between two joints of different size there will be a net differential pressure thrust which may be easily calculated from the two cross-sectional areas.

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It should be understood that all of the above discussion has been limited to pressure thrust for simplicity. The force due to guide/support friction and joint friction resistance will be present and may be calculated as shown in ATS's TP2 Expansion Joint Bulletin and added to the pressure thrust. ***The ATS Engineering Bulletin EJ-1091 provides sample calculations for main (end) and intermediate anchors.***

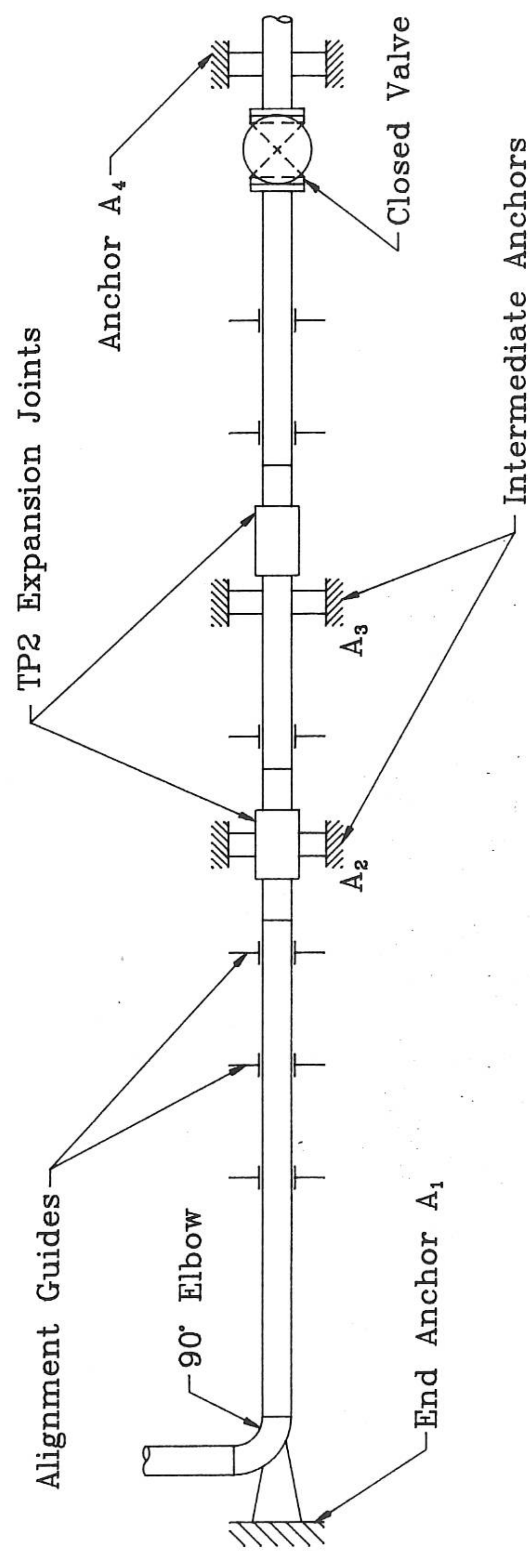

Figure 5

"A Primer on Pressure Thrust" was originally prepared by A. L. Preston, former Research Engineeer.