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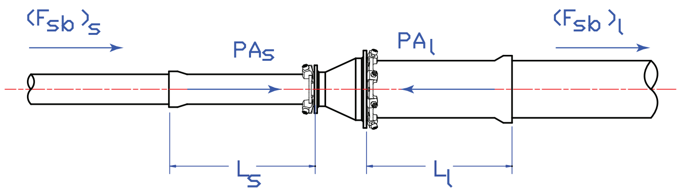
TECHNICAL DATA FOR THE WATER & WASTEWATER PROFESSIONAL

THRUST RESTRAINT DESIGN OF DEAD ENDS, VALVES, REDUCERS, AND ENCROACHING RESTRAINED LENGTHS

This bulletin describes the restrained length calculations for dead ends, valves, reducers, and sleeves with a discussion of several situations where economics and other factors may favor an alternate restraint method. Consideration overlapping or encroaching restrained lengths and of restrained piping having expansion joints and repair clamps is also discussed.

The restrained length calculation for these fitting differs slightly from bends, offsets, and tees where both passive resistance between the soil and the pipes projected surface and the pipe to soil friction are combined to prevent joint separation. In these cases, the passive resistance factor is generally considered negligible leaving only pipe to soil friction as the force to oppose the unbalanced hydrostatic force.

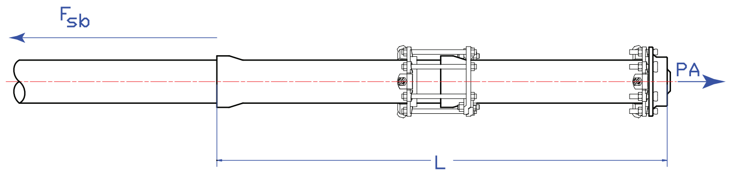


DEAD ENDS

Mechanical joint caps are used in piping systems where future expansion is anticipated as well as during the hydrostatic proof test of the line. These fittings generate a dead end thrust equal to the pressure multiplied by the area. As mentioned, this restrained length calculation does not involve the passive resistance, leaving only pipe to soil friction to oppose the thrust force. The restrained length for a dead end is given by:

$$L_s = S_f \bullet P \bullet A / F_{sb}$$

Where: A = Cross sectional area of pipe, sq in
L = restrained length, ft
F_{sb} = frictional resistance based on full circumstance of the pipe, lbs/ft



This is a very simple restrained length calculation. However, a quick example and review of an alternate restraint configuration is in order.

Take an example of a 24" ductile iron pipeline buried three feet deep in an ASTM classified SM soil consisting of a sand/clay mixture and subject to a 150 PSI test. Calculations show that (F_{sb}) = 1002 lbs/ft, and a customary 1.5 safety factor is to be used.

$$L = 1.5 \bullet (150) \bullet (523) / 1002 = 117 \text{ ft.}$$

This restrained length would require either 6 or 7 restrained full lengths of pipe respectively. In some instances, it may be favorable to pour a thrust collar around the first joint of the pipe.
This can be accomplished by utilizing a restraining device, such as a Series 1100 SDB MEGALUG® restraint that is properly oriented approximately midspan of the pipe. Wrapping the restraint with polyethylene will retain its wedging action capability after it is encased in a concrete collar formed and poured to bear directly against undisturbed soil. The surface area of such a collar must be determined using the passive resistance value of the soil. Obviously, this situation would still require the use of restraint at the cap.

VALVES

An open valve in a straight pipeline is taken care of in the same way the same manner as an un-restrained line joint (Connections Bulletin PD-02). A closed valve that is pressurized on one side only is treated as a dead end from a thrust restraint calculation standpoint. It is important, in this case, to remember that the unrestrained, dead end thrust can cause the joints on the non-pressurized side of the valve to "over-insert" or "over-bell" and can be problematic. Therefore, the pipe on the pressurized side of the valve should be restrained based on the use of the dead end formula. If desired it may be possible to incorporate the first length of pipe on the non-pressurized side of the valve as a part of the restrained length requirement. That is true if over-insertion of joints will not be an issue.

In a redundant network it is important to keep in mind that it is possible for either side of the valve to be pressurized so proper restrained length accommodation should be made on each side of the valve. It is also desirable to restrain a valve to resist the moment created during the opening and closing operation.

REDUCERS

The unbalanced force is generated by the pressure acting on the difference in cross sectional area between the large and small side of the reducer. This may be opposed by friction along the large side pipe of the fitting in a manner similar to the dead end. This restrained length is given by:

$$L_l = S_f \bullet P (A_l - A_s) / (F_{sb})_l$$

Where: Ll = length of restrained pipe on the large side of the reducer, ft

$(F_{sb})_l$ = frictional resistance based on the entire circumference of the large pipe, lbs/ft

ENCROACHING RESTRAINED LENGTHS

For encroaching restrained lengths (when calculated restrained lengths overlap) there is no industry consensus on how to reconcile those lengths. In these situations the designer should evaluate locations where encroaching restrained lengths exist and determine where any thrust force is coming from and how that force affects the pipeline as a whole. Remember that a properly restrained joint will not impart any thrust load on the pipeline and, as an extension of that, if all joints in a system are restrained there is no need to calculate restrained lengths.

MISCELLANEOUS FITTINGS

Other fittings requiring special attention in the design of restrained piping are expansion joints, couplings, and repair clamps.

Due to the nature of expansion joints, the performance desired would be negated if it were restrained from expansion. The design of a sliding type expansion joint makes this a hydraulic cylinder generating a force in both directions. As before, this force may not be a problem in a straight run of pipe but does require consideration if placed near a bend where the expansion force can create a lever arm putting undue stress on adjacent joints. The use of a thrust block or transferring the thrust to a structural member may be necessary.

Couplings and repair clamps are two other devices common to the waterworks industry. Though many of these are well manufactured devices, questions directed to our office indicate that they are often misapplied or overlooked in a restrained piping system. Many coupling type device utilize a modified mechanical type joint for ease of installation but due to the nonstandard bolt flange, bolt circle, and joint configuration, they require restraint systems that harness over the entire coupling. A more economical and often overlooked alternative is the common mechanical joint sleeve. These fittings are readily available with standardized mechanical joint ends and are an excellent solution when combined with MEGALUG joint restraint. Split versions of this restraint gland are also available to provide a permanent restrained repair.

SUMMARY

It can be seen that, with few exceptions, in a properly designed restrained piping system the need for external thrust blocking and rodding can be eliminated. This is accomplished by transferring the unbalanced force generated by changes in direction and changes in diameter to soil bearing and frictional resistance. In this manner, the pipeline itself acts as a thrust block. The design of a restrained piping system is both simple and proven. Determine the native soil type and choose an adequate trench backfilling procedure and depth of cover. This information combined with known pipe materials and soil parameters, test pressure, and a proper factor of safety are necessary for a good design. Cooperation, inspection, and good workmanship will assure a good installation.

REFERENCE:
Ductile Iron Pipe Thrust Restraint Design Handbook,
EBAA Iron Sales, Inc., 1993