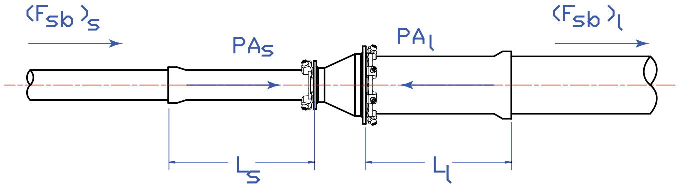
EBAA IRON Connections™
TECHNICAL DATA FOR THE WATER & WASTEWATER PROFESSIONAL

THRUST RESTRAINT DESIGN OF REDUCERS, DEAD ENDS, AND VALVES

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

REDUCERS

In any water distribution or wastewater force main system, regardless of the pipe material, the mechanical joint reducer will be common. The restrained length calculation for this fitting differs slightly from bends, off-sets, 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 the case of reducers, the passive resistance factor is generally considered negligible leaving only pipe to soil friction as the force to oppose the unbalanced hydrostatic force.



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 small side pipe, the large side pipe or a combination of both. If a sufficient length of pipe on the small side, L_s, is free of bends, valves, sleeves, or other fittings, and if the joints of this length are fully bottomed in their sockets, thereby eliminating linear compression, the reducer may not need restraint. The unobstructed length L_s is given by:

$$L_s = S_f \cdot P \cdot (A_l - A_s) / (F_{sb})_s$$

Where:
- L_s = length of unobstructed pipe on the small side of the reducer, (ft)
- S_f = factor of safety
- A_l = cross sectional area of large pipe. sq in
- A_s = cross sectional area of small pipe, sq in
- P = test pressure, psi
- $(F_{sb})_s$ = frictional resistance based on the entire circumference of the small pipe, lbs/ft

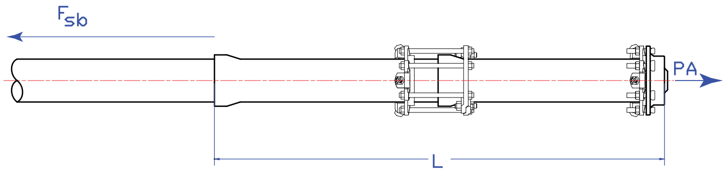
If the above situation is not true or future modifications dictate, the unbalanced force must be opposed using the friction of the large side pipe. This restrained length is given by:

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

Where:
- L_l = 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

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. Like a reducer, the 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:



$$L = S_f \cdot P \cdot A / F_{sb}$$

Where: A = cross sectional area of pipe, sq in

L = restrained length, ft

F_{sb} = frictional resistance based on full circumference of the pipe, lbs/ft

Though this case appears as the simplest of the restrained length calculations, 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 in an ASTM classified SM soil consisting of a sand/clay mixture and subject to a 150 psi test. Tabulated values show F_{sb} = 1002 lbs/ft, and a customary 1.5 safety factor is to be used.

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

This restrained length would require either 6 or 7 restrained full lengths of 20 ft or 18 ft pipe respectively. In some instances it may be favorable to pour a thrust collar around the first joint of pipe. This can be accomplished by utilizing a restraining device, such as a Series 1100 SDB MEGALUG® restraint that is properly oriented approximately mid-span 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

Although valves do not facilitate a change in direction or a change in diameter, they still require consideration in proper restrained piping design. In a situation where a valve is placed in a relatively long, straight, and unobstructed pipeline, restraint at this fitting may not be necessary to oppose the thrust created on closing. As in the case of reducers, the pipe to soil friction acting on the low pressure side of the valve may generate adequate force providing there are no bends, sleeves, or other fittings on this side and providing all of the joints are fully bottomed in their sockets.

If the above situation is not applicable, the hydrostatic force of differential pressure multiplied by the area must be accomplished by the frictional force acting on the unobstructed length of the low pressure side plus a suitable length on the high pressure side, or solely by the high pressure side. During such calculations and design one must keep in mind the fact that in a fully redundant network, the differential pressure may be reversed.

It is also desirable to restrain a valve to resist the moment created during the opening and closing operation.

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 devices 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.

ISSUE: 0210-3-A

P.O. BOX 857 • EASTLAND, TEXAS 76448 USA • PHONE 254.629.1731 • TELEFAX 254.629.8931 • TOLL-FREE 800.433.1716 • WWW.EBAA.COM • CONTACT@EBAA.COM