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White Paper

Reduce Your Hydraulic Structure Footprint

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ABSTRACT

This paper explores the method of using grooved and shouldered couplings in place of conventional, unrestrained couplings equipped with external harnesses to stabilize piping during the construction of hydraulic structures in water treatment and wastewater management conveyance systems. This alternative construction method can reduce the hydraulic structure footprint within the structure interior and at the structure walls. The findings presented in this paper establish that using couplings with groove technology is an effective method of providing the necessary thrust restraint for pressure piping that passes through the structure walls and furthermore when this method is utilized, the hydraulic structure footprints and square footage are reduced resulting in decreased construction costs.

INTRODUCTION

Hydraulic structures are a key component and represent a significant cost of conveyance systems. They are typically located below grade and house mechanical equipment including valves, flanges, couplings, dismantling joints and other piping appurtenances that are not suitable for direct burial and require periodic inspection and maintenance (Figure 1. Hydraulic Structure (Pigging Station) Showing 96" Dismantling Joint and Blind Flange). Because structures are confined spaces, they require adequate lighting, ventilation and drainage to provide safe ingress-egress for maintenance personnel and operators. The constructed cost of hydraulic structures can amount to $1000/square foot or more, which creates an economic incentive to reduce the footprint.

Providing efficient thrust restraint of pressure piping that passes through the structure achieves the goal of reducing the hydraulic structure footprint. Unrestrained piping is unstable and may require external thrust blocks to prevent movement. Often the structure walls are used as a substitute for thrust blocks, however large thrust forces may require thickened walls to resist punching shear from piping thrust loads. Thrust restraint of pressure piping joints can be provided by welding, flanging or grooving as indicated in AWWA Manual M11 (Reference 1).

When compared to conventional methods of welding and flanging and the use of unrestrained couplings with external harnesses to resist thrusts, grooved and shouldered couplings provide restraint and flexibility and can reduce the structure footprint. Footprint reductions are possible in two places: 1) within the structure interior and 2) the structure walls (Figure 2. 96" Dismantling Joint and Figure 3. 96" Flexible Grooved Coupling).

GROOVED AND SHOULDERED COUPLINGS

A typical grooved pipe joining method is simple and reliable. The four basic components are the grooved pipe, the housing, the bolts/nuts, and the gasket (Figure 3. 96" Flexible Grooved Coupling).

- Grooved Pipe: Grooved pipe can be prepared with either a roll groove for a standard wall and lighter pipe, or a cut groove for a standard wall and heavier pipe. Both roll and cut grooved pipe have/use the same pressure rating as standard wall pipe.

- Housing: The coupling housing performs several functions as an integral part of the pipe joint. It fully encloses the elastomer gasket and secures it in position for a proper seal. It also engages the groove around the full pipe circumference to create a self-restrained joint, along with the advantages of mechanical joining.

- Bolts/Nuts: The bolts and nuts hold the housings together around the pipe.

- Gasket: The synthetic elastomer gasket creates a triple seal effect on the pipe ends. A tension seal is created as the gasket is stretched around the pipe, and a compression seal is created as the coupling housings press the gasket onto the pipe. Finally, the sealing lips of the gasket are forced down onto the pipe end when the system is energized.

All features result in a leak-tight, self-restrained joint. Grooved and shouldered couplings can be either flexible or rigid coupling joints, as specified by the engineer, and are fully restrained and able to handle full end thrust load when installed and used in accordance with AWWA standards and the manufacturer's instructions. For more details see AWWA C606, Grooved and Shouldered Joints (Reference 3).

DISMANTLING JOINTS

Dismantling joints, also called "flanged coupling adaptors" (FCAs), provide a means of adding flexibility and movement to a piping system to permit removal of flanged valves and fittings (Figure 5. Hydraulic Structure Walls (Thrust taken by walls) and Figure 6. An Example of a Conventional Flanged Valve Assembly (left), an AGS Grooved Coupling (center), and a Grooved Butterfly Valve and AGS Couplings (right). According to AWWA Manual M11 (Reference 1) "To prevent a valve from being strained, there should be at least one flexible joint located close enough to allow for any anticipated movement." M11 (Reference 1) suggests usage of the familiar Bolted Sleeve-Type Couplings (BSTCs) including dismantling joints per AWWA C219, Bolted Sleeve-Type Couplings for Plain-End Pipe (Reference 2). Additionally, since BSTCs do not provide restraint from thrust due to internal pressure forces, external harnesses are often required. M11 (Reference 1) provides guidance for the design of harnessed joints where the focus is to determine the proportions of tie rods and harness assembly necessary to resist internal pressure forces.

WITHIN THE HYDRAULIC STRUCTURE INTERIOR

Dismantling Joints require space for the harness assembly (Figure 5. Hydraulic Structure Walls (Thrust taken by walls). The tie rods that restrain the component must span across the joint to a pair of rings designed to transmit the loads from the rods into the pipe wall. Disassembly of the dismantling joint requires removal of the harness rods that must be un-threaded and withdrawn through holes in the rings in a direction parallel to the pipe wall. Adequate space within the structure must be available for disassembly of the tie rods; for example, if the tie rods are 4 feet long, an additional 4 feet of space must be allocated to disassemble the tie rods. This has the adverse effect of increasing the footprint within the hydraulic structure interior.

HYDRAULIC STRUCTURE WALLS

Hydraulic structure walls are often used in place of anchor blocks to stabilize unbalanced thrust forces. The piping that passes through the hydraulic structure walls transmits forces via thrust rings designed according to M11 (Reference 1) for the pressure loads. The structure walls may need to be thickened to resist punching shear forces from the piping loads. This has the adverse effect of increasing the footprint of the hydraulic structure walls (Figure 3. 96" Flexible Grooved Coupling).

FOOTPRINT REDUCTION WITHIN THE HYDRAULIC STRUCTURE INTERIOR

Footprint reduction within the hydraulic structure interior is possible by eliminating dismantling joints in favor of grooved flexible couplings. Since grooved couplings are fully self-restrained, tie rods can be eliminated as shown in Figures 5 & 6. Assuming the hydraulic structure plan dimension is 40 feet wide and 40 feet long and, by using grooved couplings, the width can be reduced from 40 feet to 36 feet, a reduction of 160 square feet (40x40-40x36=160) is possible. The footprint reduction within the hydraulic structure interior amounts to 10 percent. If the unit cost of the constructed hydraulic structure is $1000/square foot, a potential savings from eliminating the dismantling joint in favor of the grooved and shouldered coupling equals $160,000.

FOOTPRINT REDUCTION OF THE HYDRAULIC STRUCTURE WALLS

Footprint reduction of hydraulic structure walls is possible when unrestrained couplings that require piping be anchored via structure walls are eliminated in favor of grooved and shouldered couplings that restrain the piping internally so that external anchor blocks (or walls) are not required for stability.

The example shown in Figure 2. 96" Dismantling Joint and Figure 3. 96" Flexible Grooved Coupling illustrate that the 6 feet thick walls in Figure 5. Hydraulic Structure Walls (Thrust taken by walls) can be reduced to 2 feet thick, as shown in Figure 4. Hydraulic Structure Walls (Thrust taken by grooved flexible couplings), assuming the grooved couplings fully restrain the piping. This represents a reduction in structure wall thickness of 4 feet (6-2=4). Assuming the hydraulic structure plan dimension is 60 feet wide and 80 feet long and grooved and shouldered couplings are installed, the wall thickness can be reduced from 6 feet to 2 feet resulting in new plan dimensions of 52 feet wide and 72 feet long. This solution provides a reduction of 1056 square feet (60x80-52x72=1056). If the unit cost of the constructed hydraulic structure is $1000/square foot, the potential savings of using a grooved and shouldered coupling solution is $1,056,000.

Grooved technology reduces the footprint for hydraulic structure piping appurtenances. Figure 6. An Example of a Conventional Flanged Valve Assembly (left), an AGS Grooved Coupling (center), and a Grooved Butterfly Valve and AGS Couplings (right) indicates a conventional flanged valve assembly (left), a Victaulic AGS Grooved Coupling which eliminates the dismantling joint and simplifies the layout (center), and a Victaulic Grooved Butterfly Valve & AGS Couplings, a solution which further simplifies the layout (right). While each solution does the same thing, the simplest solution, depicted in the figure on the right, clearly creates the largest value for the system because of the notable potential cost savings.

PROGRESSIVE STAGES OF FOOTPRINT REDUCTION

Figures 7, 8, and 9 illustrate the progressive stages of footprint reduction comparing conventional methods of the use of unrestrained couplings with external harnesses to resist thrusts, vs. grooved and shouldered couplings that provide restraint and flexibility resulting in a reduced hydraulic structure footprint. Footprint reductions are possible in two places: 1) within the structure interior and 2) the structure wall. Figure 7 illustrates the conventional bolted sleeve-type coupling for settlement and valve dismantling. The thrust taken by the walls results in a large footprint. Figure 8 illustrates the grooved flexible couplings for settlement and valve dismantling. The thrust taken by the piping reduces the structure wall footprint. Figure 9 illustrates the grooved flexible couplings for settlement and grooved valve (dismantling joint not required). The thrust taken by piping reduces the structure interior and structure wall footprint.

CONCLUSIONS

This paper has demonstrated that reducing the hydraulic structure footprint is achieved by providing efficient thrust restraint of pressure piping that passes through the hydraulic structure. Reduction in hydraulic structure footprint is possible with the use of grooved and shouldered couplings which provide restraint yet flexibility when compared to conventional methods of welding and flanging or the use of unrestrained couplings with external harnesses. Footprint reductions are possible within the structure interior and the structure walls. Hydraulic structures are a key component and represent a significant cost component of conveyance systems. The use of groove technology can minimize the hydraulic structure footprint, thereby reducing constructed costs of conveyance systems.

REFERENCES

1. American Water Works Association (AWWA). (2017). Steel Water Pipe: A Guide for Design and Installation (M11), Fifth Edition.

2. American Water Works Association (AWWA). (2017). AWWA C219, Bolted Sleeve-Type Couplings for Plain-End Pipe

3. American Water Works Association (AWWA). (2015). AWWA C606, Grooved and Shouldered Joints.

FIGURES

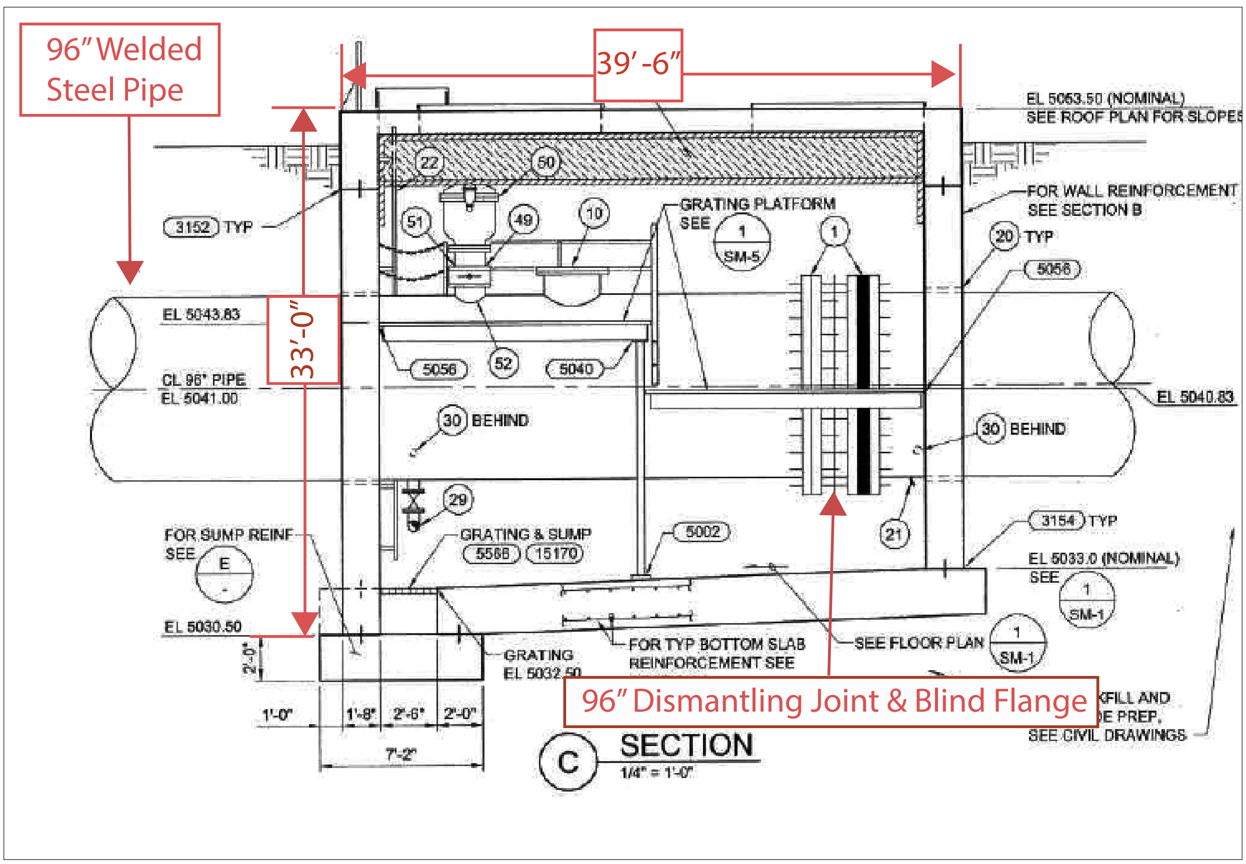

Figure 1. Hydraulic Structure (Pigging Station) Showing 96" Dismantling Joint and Blind Flange

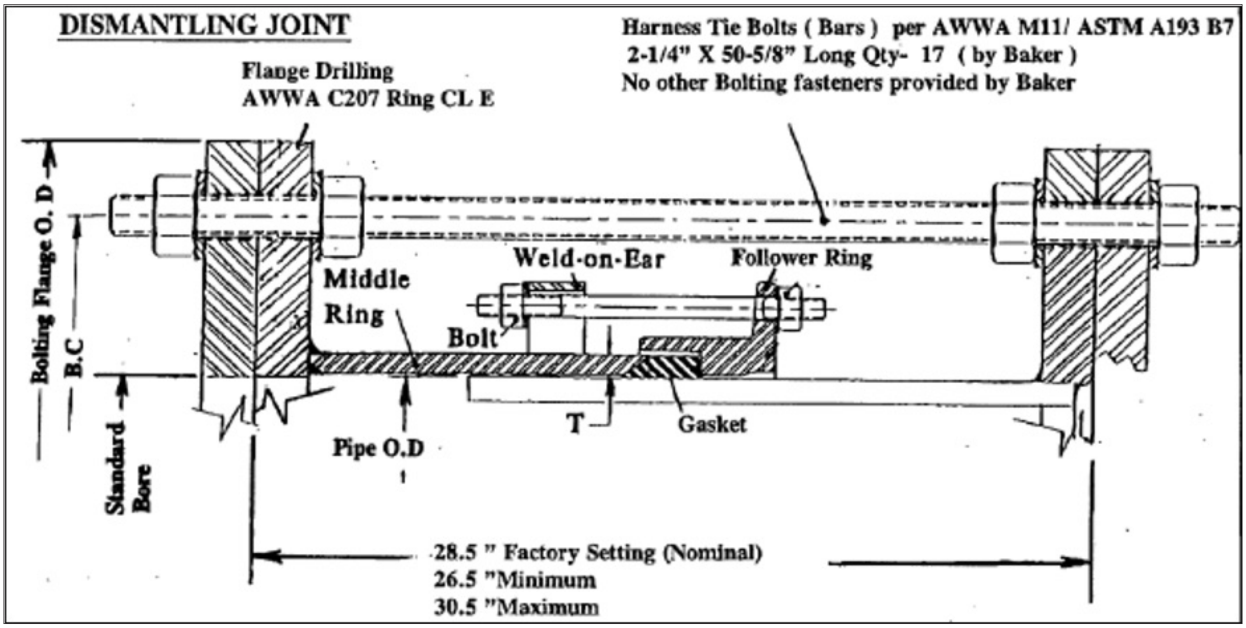

Figure 2. 96" Dismantling Joint

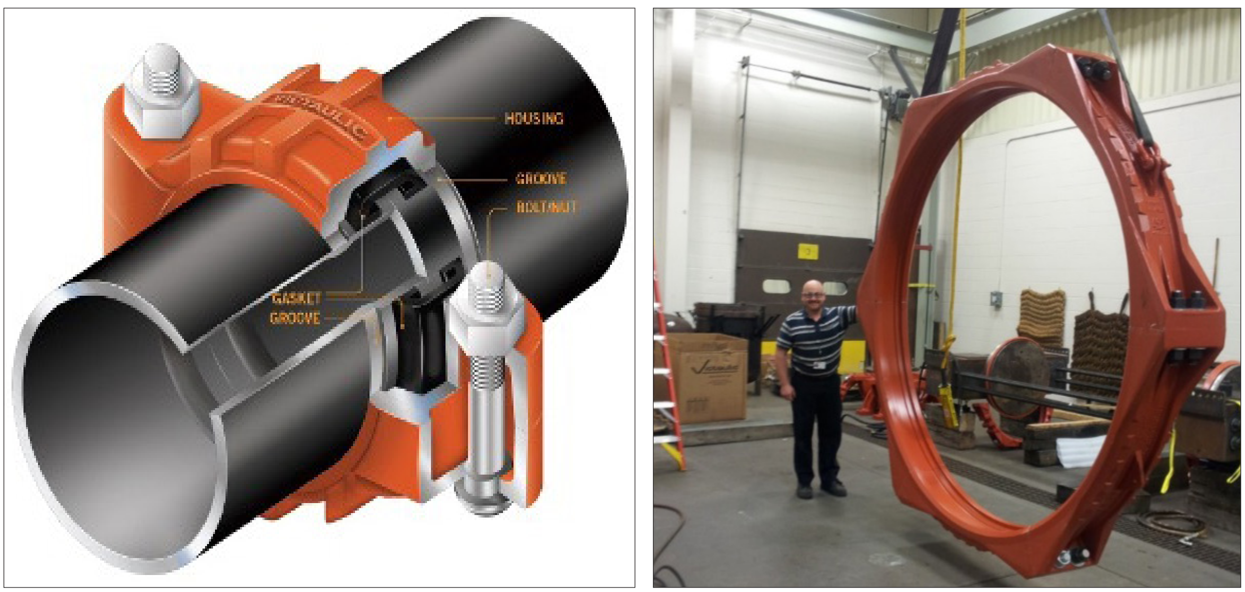

Figure 3. 96" Flexible Grooved Coupling

Figure 4. Hydraulic Structure Walls (Thrust taken by grooved flexible couplings)

Figure 5. Hydraulic Structure Walls (Thrust taken by walls)

Figure 6. An Example of a Conventional Flanged Valve Assembly (left), an AGS Grooved Coupling (center), and a Grooved Butterfly Valve and AGS Couplings (right)

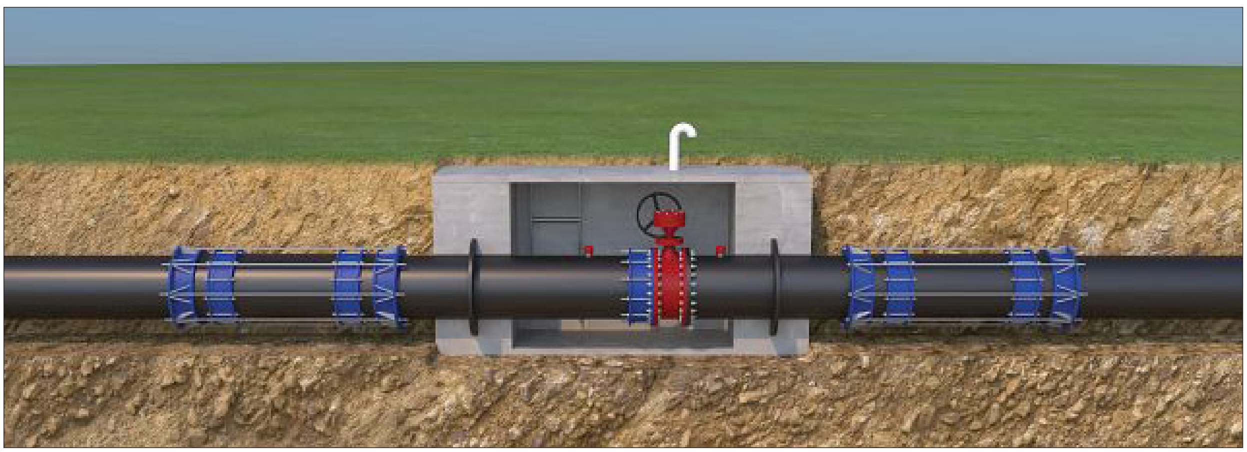

Figure 7. Conventional Bolted Sleeve-Type Coupling for Settlement and Valve Dismantling (Thrust taken by walls results in a large footprint)

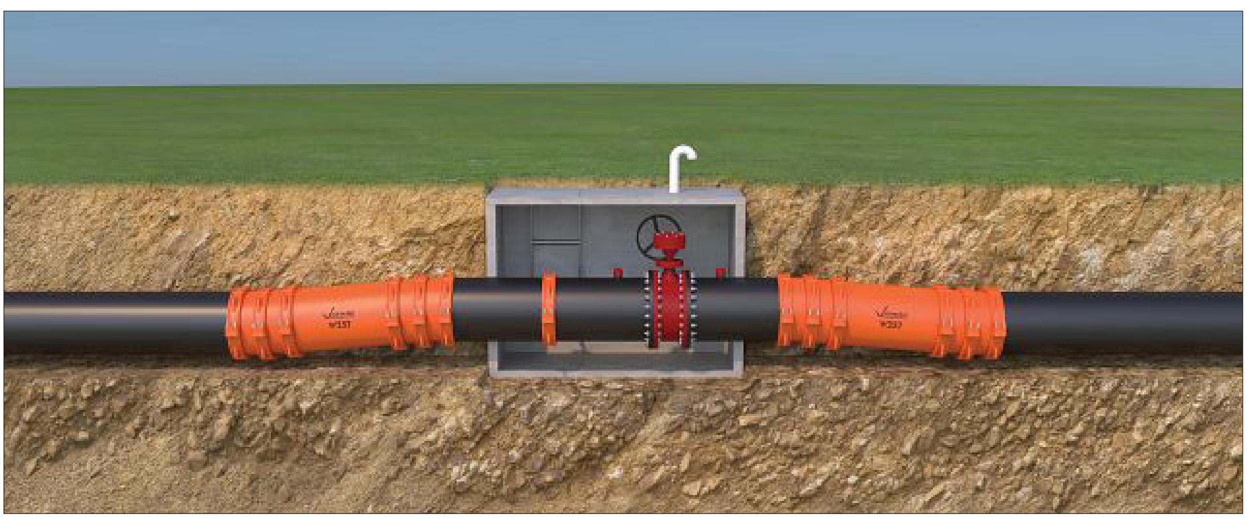

Figure 8. Grooved Flexible Couplings for Settlement and Valve Dismantling (Thrust taken by piping reduces the structure wall footprint)

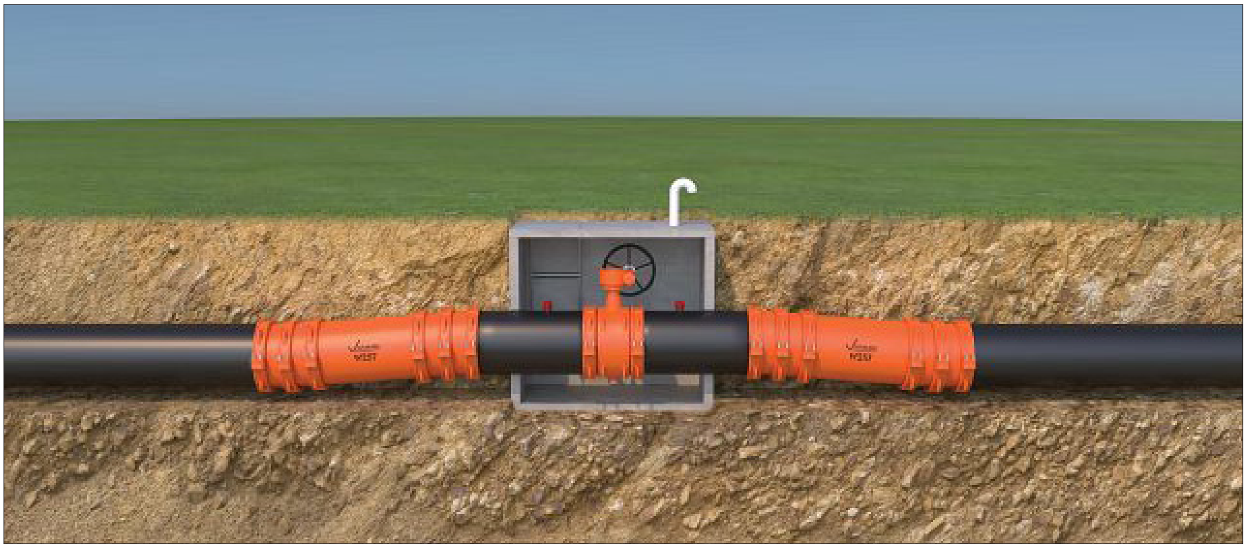

Figure 9. Grooved Flexible Couplings for Settlement and Grooved Valve - Dismantling Joint Not Required
(Thrust taken by piping reduces the structure interior and structure wall footprint)