Ductile Iron Pipe Research Association

Strength and Durability for Life®

APPLICATIONS

Ductile Iron Pipe Subaqueous Crossings

Last Revised:
May 2016

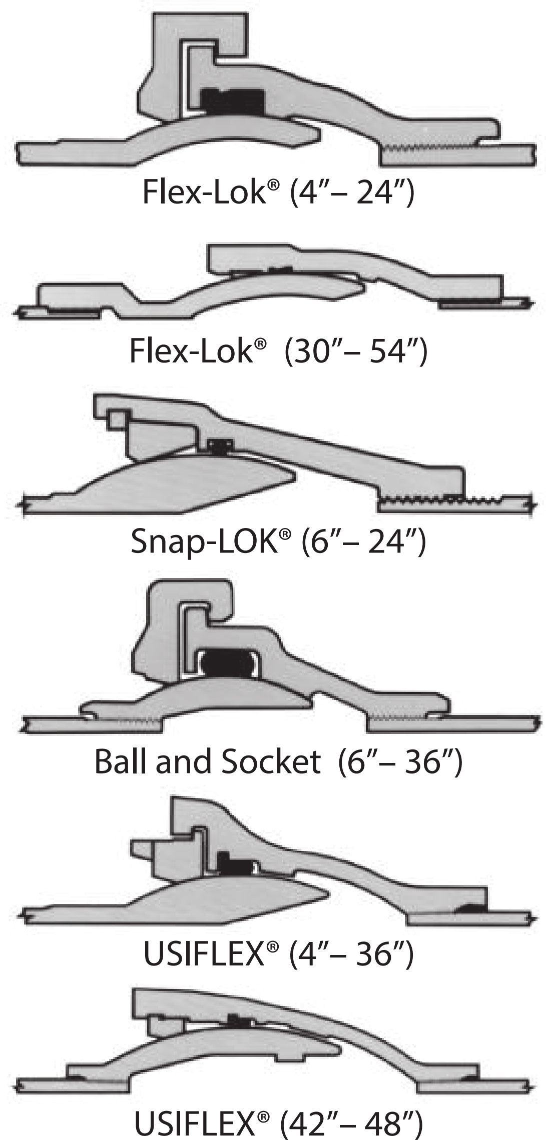
Ductile Iron Pipe with boltless ball and socket joints is an extremely versatile product for use in subaqueous construction. Important in this context are the flexibility and the restraint against joint separation provided by the ball and socket. In addition, the proven strength and durability of Ductile Iron Pipe assure a trouble-free installation and a maintenance-free pipeline. The high pressure rating and large safety factors used in the design of this pipe also provide assurance against unforeseen pressure increases.

Although Ductile Iron Pipe with ball and socket joints is not inexpensive compared with the various types of land piping, its adaptability with respect to rigorous construction techniques and its long, dependable service life make it a prudent choice for subaqueous crossings.

The installation of underwater pipelines is a challenging undertaking, and in order to achieve maximum economy, the constructor must be free to choose the best procedure for a particular job. Since the available construction methods are demanding not only on the skill of the contractor but also on the strength and versatility of the pipe material, that material most suitable to the widest range of installation methods should be specified. The characteristics of Ductile Iron subaqueous pipe have for many years made it a favorite of utilities, engineers, and contractors.

This brochure will present general methods of construction that are used in installing Ductile Iron ball and socket pipe and the factors that must be considered in choosing the proper procedure for a specific project. The first section discusses the basic characteristics of the ball and socket joint, followed by a discussion of the various underwater construction practices and the several factors that must be considered to successfully install subaqueous pipelines.

Typical Ball and Socket River Joint Crossings



The Joint

The ball and socket joints available for Ductile Iron Pipe are boltless. They consist of a precision-machined ball which fits into a machined socket, a rubber gasket to provide a pressure-tight seal, and a retainer ring which provides longitudinal restraint. The joint is designed so that the rubber gasket is properly compressed and the joint is leak-free throughout the full range of deflection.

Maximum deflection is 15° per joint in sizes up to and including 24-inch pipe; in sizes 30-inch and larger, maximum deflection varies from 12 1/2° to 15°. At maximum deflection, the joint remains pressure-tight and retains the full flow area available in the undeflected joint.

Workers use come-alongs while installing Ductile Iron Pipe with boltless ball and socket joints. These joints consist of a precision-machined ball that fits into a precision-machined socket, a rubber gasket that provides a pressure-tight seal, and a retainer ring that provides longitudinal restraint. The joint is leak-free throughout the full range of deflection.

In many subaqueous installations, the majority of the assembly can be done on dry land. Here, a crew lowers a piece of Ductile Iron Pipe into place on top of a launching ramp from which cables will pull it across the water.

An installation crew member is shown driving a steel wedge into a pipeline joint. The wedge provides a lock that prevents rotation of the locking gland after assembly.

Good design practice dictates that no joint be installed in a final position in a fully deflected alignment. This allows for slightly more deflection, if needed, during subsequent settlement of the line. For design purposes, the deflection should be limited to 80 percent of the maximum recommended by the manufacturer. Ductile Iron ball and socket pipe is normally furnished in 18- and 20-foot nominal laying lengths, depending on the particular pipe being used. Where greater deflection of the line is required than is available in one joint, pipe of short laying lengths can usually be furnished to provide additional deflection.

The Ductile Iron ball and socket joints are designed to provide end restraint against joint separation not only due to internal pressure in service, but also against the large longitudinal loads that may be encountered during construction. Allowable safe end loads for each type of joint can be supplied by the manufacturer. Assembly of the ball and socket joints is relatively simple. Each manufacturer provides detailed instructions for the proper and most efficient assembly of its particular joint. Special lubricant which clings tenaciously to joining surfaces is recommended for underwater or extremely wet installation conditions (this includes cases where water is flowing into and out of joints during installation). Such special lubricant can be obtained from pipe manufacturers.

Construction Methods

Ductile Iron Pipe with ball and socket joints is adaptable to the full range of subaqueous construction methods; therefore, the constructor is free to select the most economical procedure. The method used will necessarily be unique to the requirements and specifications of each particular job.

There are three general categories of construction techniques employed in laying subaqueous pipelines: the pipe can be assembled on one bank and pulled into place from the other bank; the pipe can be lowered from a barge; or the water can be diverted and the pipe laid in a dry trench according to normal good installation practice.

Bank Installation.

Except in small, shallow streams where the water can easily be diverted, assembly of the pipe on a bank and pulling the line into place from the opposite bank is usually the most economical means of construction. Joints should be assembled in line with the crossing and pulled as straight as possible to avoid over-deflection of the joints and excessive beam loads during installation.

In this method, sections of pipe consisting of one or more lengths are assembled on the bank. The assembled section of the line is then pulled into the water and the process repeated until the installation is complete. The pulling force is usually provided by a winch located on the opposite bank, attached to the leading end of the line by a steel cable.

For some pipe sizes, it is necessary to provide additional buoyancy to float the pipe into position. Here, steel drums are used for that purpose.

Portions of three parallel pipelines assembled on land are shown prior to their being pulled across the water. Ductile Iron Pipe's durability and deflection capabilities make it ideal for installations in this situation as well as other rugged water crossings.

In the vast majority of installations, the pipe is pulled along the bottom through a previously prepared trench. It is recommended that the first length of pipe be floated in order to prevent its leading end from digging into the trench bottom. While this method is preferable, the line may be floated into position and subsequently lowered to the bottom if dictated by rough bottom or other circumstances. If the line is floated into position, it should be lowered to the bottom in a controlled manner to avoid damage to the pipe. In such instances, particular care should be taken to avoid over-deflection of joints in the bank approach locations. In such installations, it may also be necessary to consider the effects of fluid drag on the pipeline due to current, etc.

It is highly recommended to cap or plug the lead end of the first pipe to prevent water from entering, thereby providing buoyancy and reducing the end pull required to move the pipe once it is in the water. Ductile Iron ball joint pipe in smaller sizes, generally 4-inch through 16-inch, is heavier than the water it displaces and will not float even when it contains no water.

Additional buoyancy can be provided for long pulls or for the flotation method of installation by attaching steel drums or other flotation devices to the pipe as it is assembled.

Ductile Iron ball joint pipe, particularly in the 18-inch and larger sizes, may be lighter than the water it displaces and therefore float when empty of water. Heavier classes of pipe may be available for installations where flotation is not desired or weights may be attached to the pipe to overcome buoyancy. Buoyancy data for each type of ball pipe can be supplied by the manufacturer.

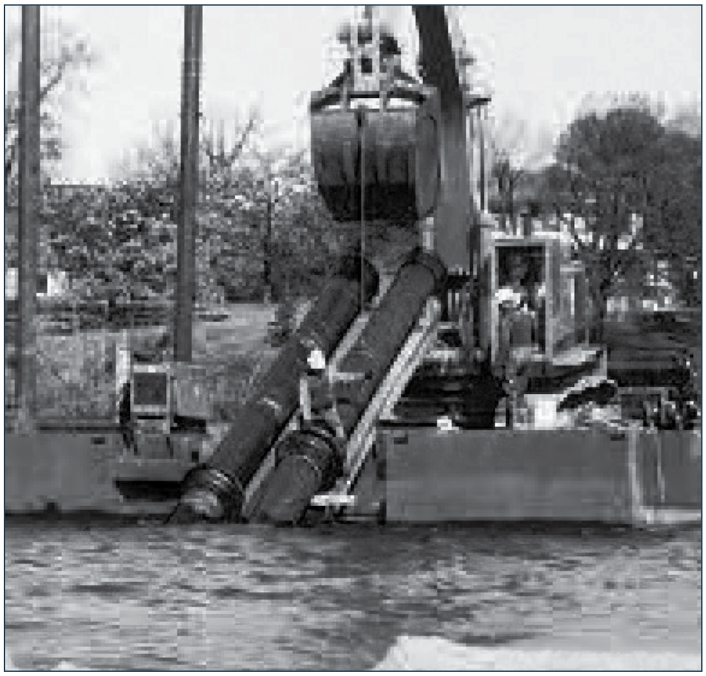
When employing the pulling method, a cable or harness is attached behind the first joint and the pulling cable is secured to the lead end to keep it up during pulling. Special pulling flanges are also available from some manufacturers. Under certain conditions it may be advisable to provide the lead end with a sled to reduce resistance from the trench bottom.

To determine whether the pulling method of construction is appropriate for a given job, several factors must be considered. First, there must be access to the banks. On the assembly bank, there must be room to store the pipe, to accommodate the pipe-handling equipment, and to effect the assembly. The condition of the bank is also critical. It must be sufficiently stable to support the pipe and the required equipment. The bank must be graded to provide an angle of entry for the pipe into the water that does not exceed the design deflection. On the opposite bank, there must be adequate access and space to accommodate the pulling equipment.

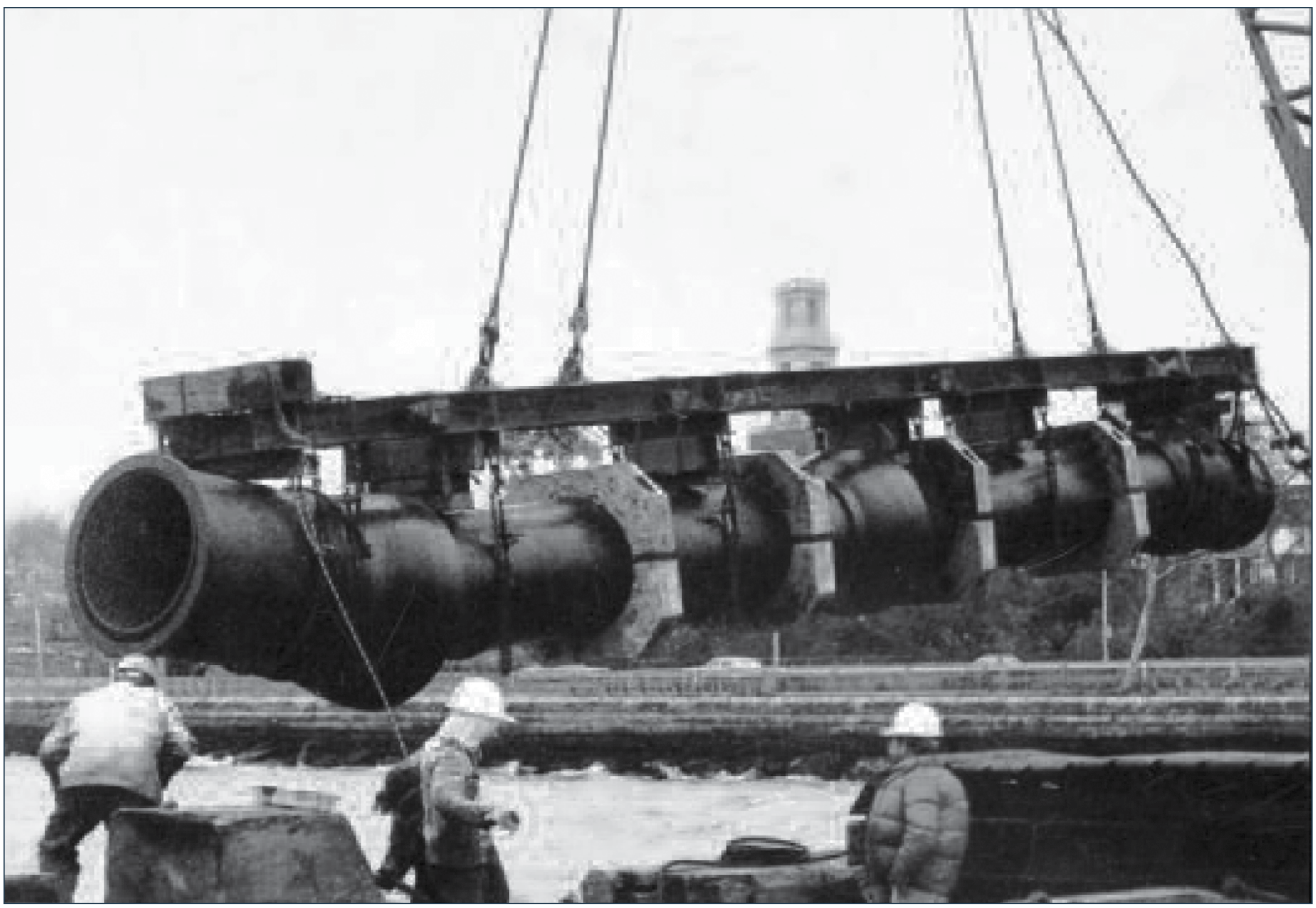
The length of the crossing is another important factor. For extremely long crossings, the pulling force required to move the entire line may be excessive. Also, strong currents may preclude floating the pipeline into position or require special alignment control.

When the pulling method is employed, a ramp is often constructed extending into the water from the assembly bank. The completed ramp, which is often built of previously used materials such as rails and cross-ties, structural members, and timbers, provides certain advantages such as an assembly location off the ground, facilitating clean joints during assembly, and reduction in force required to pull the pipeline.

Finishing assembly touches are made to a Ductile Iron Pipe joint. This particular pipeline is cradled in an inclined launching ramp that prevents the pipe from touching the ground. This facilitates clean joints and will make it easier and faster to pull the pipeline across the water.



Ductile Iron Pipelines can be assembled on a barge and lowered by means of a chute extended to the bottom of the waterway. Here, that procedure is used for a set of parallel lines. Pipelines can also be assembled by lowering sections from the barge into the water where assembly is performed by underwater divers.



Several lengths of Ductile Iron Pipelines can be assembled above the water and lowered on a strongback to underwater divers who will connect the assembly to the pipeline. Concrete collars have been attached to ensure that the pipe sinks properly into position.

In some situations, barge installations are a necessity. That includes situations in which the route of the line is not straight, where the banks are unsuitable or unavailable for assembly, when the bottom is unstable and a trench will not remain open long enough for a bank installation, or where the line being installed is extremely long.

Installation From a Barge

Laying pipe from a barge can be accomplished by either of two general methods. In the first method, the pipe is simply lowered from the barge and assembled underwater by a diver. Variations of this method involve assembling two or more joints aboard the barge; then, using slings or a strongback, the assembled section is lowered to the diver for connection to the line. The second method of installation from a barge employs a launching chute extending from the barge to the bottom of the waterway. The pipeline is assembled on the ramp and as the assembly progresses, the barge is moved forward, allowing the pipe to slide down the chute into position on the bottom. The chute should be designed to support the pipe all the way to the bottom to protect the joints from excessive beam loads during installation. The hanging of several lengths of pipes in full deflection without support can result in undesirable bending moments being exerted on joints.

Although installing ball joint pipe from a barge is generally less economical than from a bank, in many cases it is the only suitable method. Such cases may include installations where the route of the line is not straight, where the banks are unsuitable or unavailable for bank installation, where the bottom is unstable and a trench will not remain open long enough for a bank installation, or where the line being installed is extremely long.

Dry Installation

The third general type of subaqueous construction is “dry” installation. When crossing small or shallow streams where there is room to divert the water from the construction area, normal dry land pipe laying practices are used.

Designing and Planning the Subaqueous Crossing

The most economical installation of a subaqueous pipeline crossing is the result of careful design and planning prior to construction. Factors must be considered in the design and planning stages of the project to assure the most efficient and successful completion.

Permits

When a pipeline is to be installed across a navigable waterway, a permit from the U.S. Army Corps of Engineers is required. "Permits for Work in Navigable Waters," a Corps of Engineers publication, explains the procedure for obtaining such a permit. In general, the designer should keep in mind that the Corps must approve any design and that emphasis will be placed on the effects of the project on navigation, both during and after construction. A check should also be made with local and state governmental units; permits and approval from such agencies are often required in addition to permits from the Corps of Engineers.

Corrosion Protection

The many installations of Gray and Ductile Iron subaqueous piping in fresh and seawater applications have demonstrated the corrosion resistance of both materials, Ductile Iron having equal or better corrosion resistance than Gray Iron. While the great majority of subaqueous installations require no special consideration with respect to corrosion, there are instances where bottom soil conditions will necessitate corrosion protection. Saltwater installations generally present no problem in this regard if the bottom is free of pollutants.

Polyethylene encasement, and now V-Bio Enhanced Polyethylene encasement, in accordance with ANSI/AWWA C105/A21.5 are the standard methods of protecting Ductile Iron Pipe from most corrosive environments. V-Bio Enhanced Polyethylene encasement builds upon the more than 60 years of research and successful field applications of polyethylene encasement to provide the most advanced protection for Ductile Iron Pipe. The polyethylene must remain intact and free from physical damage during installation.

Polyethylene encasement can be used in some subaqueous crossings as corrosion protection for Ductile Iron Pipe.

The rigors of some of the subaqueous construction methods (e.g., pulling the pipeline along the bottom) make this difficult to accomplish. However, polyethylene encasement has been successfully employed in underwater installations using the technique of lowering pipe sections from a barge with the polyethylene in place, sometimes utilizing a strongback so that several lengths of pipe may be wrapped prior to installation. Divers then make the connection to the previously laid pipe and complete the overlap of the polyethylene at the joint.

For installations where conditions are known to be corrosive and it is not practical to employ polyethylene encasement, other means of corrosion protection such as cathodic protection should be considered.

Project Completion

Connections to the Land Piping

Connections to the on-shore line are usually made by use of plain end connecting pieces and a solid mechanical joint sleeve. It is usually good practice to backfill the underwater line and allow it to settle for a reasonable period before making the end connections. Where this is not possible, or where the river bottom is particularly unstable, connecting pieces with restrained joints are available and are recommended.

Inspection and Testing

The line may be hydrostatically tested in accordance with ANSI/AWWA C600 "Installation of Ductile Iron Water Mains and Their Appurtenances," usually at 1.5 times the operating pressure, prior to connection to the land piping. Caps, plugs, and special closure pieces are available to seal off the ends of the line for this test. These are tapped for line filling and venting. After pressure testing, the line may be backfilled.

Trenching and Backfilling

In most cases, subaqueous crossings should be laid in trenches in the river bottom. The trench provides protection from damage by navigation or large anchors (and conversely protects navigation from interference by the pipeline structure). It also prevents erosion and obstruction of river flow, provides freedom from installation obstructions, and furnishes good bedding for the pipeline.

Trenching is accomplished by dredging, jetting, or digging with a backhoe or dragline. The handling of spoil material may be a condition of the Corps of Engineers permit; it may be stored on shore, in barges, or alongside the trench. Backfill may be dumped or chuted into position or allowed to erode into the trench when spoil material is piled upstream.

Crushed stone may be used as base material in the trench to form good bedding and also as ballast material for backfill. Careful planning is required in streams with appreciable current where the pipe laying operation may have to be accomplished within a short time after trenching to prevent erosion of the prepared trench.

Summary

The combination of joint flexibility, toughness, and corrosion-resistance of Ductile Iron ball and socket pipe make it the ideal material for use in difficult underwater installations. The versatility of the pipe allows the installer to devise installation methods as variations of the general methods presented here to accommodate the particular conditions of his job and equipment. As in other types of construction, proper planning and site preparation prior to the actual installation provide the fastest and most economical job. Consultation with the pipe manufacturer concerning proposed construction methods, safe end pull, buoyancy, and joint capabilities is suggested to the engineer and installer to assure a successful installation.

For more information contact DIPRA or any of its member companies.

Ductile Iron Pipe Research Association

An association of quality producers dedicated to the highest pipe standards through a program of continuing research and service to water and wastewater professionals.

P.O. Box 190306
Birmingham, AL 35219
205.402.8700 Tel
www.dipra.org

Social Media

Get in the flow with Ductile Iron Pipe by connecting with us on Facebook, Twitter, and LinkedIn.

Visit our website, **www.dipra.org/videos,** and click on the YouTube icon for informational videos on Ductile Iron Pipe's ease of use, economic benefits, strength and durability, advantages over PVC, and more.

Member Companies

AMERICAN Ductile Iron Pipe
P.O. Box 2727
Birmingham, Alabama 35202-2727

Canada Pipe Company, Ltd.
55 Frid St. Unit #1
Hamilton, Ontario L8P 4M3 Canada

McWane Ductile
P.O. Box 6001
Coshocton, Ohio 43812-6001

United States Pipe and Foundry Company
Two Chase Corporate Drive
Suite 200
Birmingham, Alabama 35244

Ductile Iron Pipe is SMART certified

Strength and **Durability** for **Life**®

dipra
Ductile Iron Pipe Research Association