A Discussion of Steel Pipe versus Ductile Iron Pipe

The comparison of spiral-welded steel pipe to ductile iron pipe below highlights how steel is not only equal to ductile iron as a material for use in municipal piping applications, but in many ways how it is superior to the latter, providing the design engineer to fully engineer a project to very specific needs.

FULLY ENGINEERED SYSTEM VERSUS COMMODITY PRODUCT

The versatility and strength of steel pipes enables customized performance-based designs to meet the criteria specified. Unlike other pipe materials such as ductile iron pipe, the type of steel can be selected to meet the specific strength and other physical/mechanical properties that are needed for a given application. Ductile iron pipe is manufactured and marketed as an off-the-shelf type of product, with only one type of **tensile:yield:elongation** ratio. This makes it a commodity and limits the ability of a design engineer to engineer a ductile iron system to specific needs.

The ability to fully engineer a steel pipe system, from the necessary wall thickness in increments of 1/1000-inch, to the type of integral jointing system needed, to the specific type of lining and coating based on the nature of the soils in which it is buried and the fluid it transports, to the inside-diameter required, make it one of the most versatile products available for use in Municipal applications. The most critical water projects for the last hundred years in the Western United States where potable water is in high demand and must be transported from remote locations, have either used steel pipe or have had steel pipe as a construction option. Availability of steel pipes in sizes 20" to 144-inch diameters makes them ideal for critical water transmission projects. Of course the ability to fully engineer a system results in significant cost savings.

TENSILE, YIELD AND ELONGATION

Ductile iron pipes available in the market place as a commodity product where a **tensile:yield:elongation** ratio of **60:42:10** is representative of all ductile iron pipes used in water and wastewater applications. The items discussed herein are based on steel pipe that meets or exceeds the physical/mechanical properties of ductile iron pipe. The tensile:yield:elongation ratio for steel can be adjusted as needed. For example, tensile strength can be varied from 50 ksi to 70 ksi, yield strength can be varied from 33 ksi to 55 ksi, and elongation can be varied from 18% to 30% and greater.

Steel pipe with a minimum yield strength of 42,000 psi and tensile strength of 60,000 psi has a corresponding elongation of 22% and greater. Ductile iron pipe, on the other hand, has a single elongation factor of 10%. The **tensile:yield:elongation** ratio of the typical steel pipe used in Municipal applications is therefore **60:42:22**. Again, this can be easily varied as needed. The higher elongation of steel pipe allows it to withstand stresses and strains without fracturing under shocks from surge, water hammer, earthquakes, cave-ins, washouts, extreme temperature changes, traffic vibrations, unstable foundations, and blasting. In short, steel pipe outperforms ductile iron pipe by offering a built-in safety factor in its chemistry.

JOINTS

Bell-and-spigot gasket joints are the most common type of jointing system for ductile iron pipe. A dual-durometer rubber gasket is placed within a groove in the bell, and then a spigot is inserted into the bell, a positive seal is achieved. Joint restraint in ductile iron pipe is typically achieved by using external, non-integral, lug-type devices. Assembly is time consuming and allowable longitudinal deflection is non-existent with these systems. While integral joint restraint products are available for ductile iron pipe, used in trenchless applications such as directional drilling, these joints are proprietary and therefore, available from a single source. Joint designs vary significantly. Figure 1 shows various types of proprietary integral joint restraint systems for ductile iron pipe.

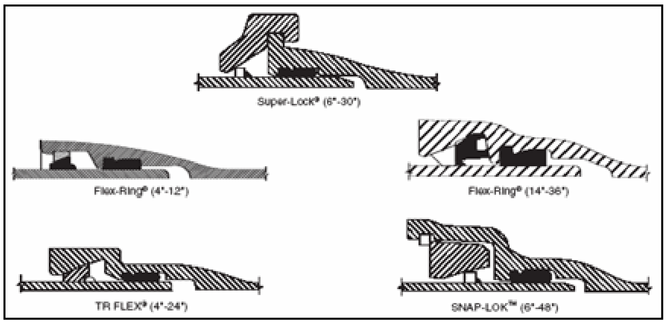
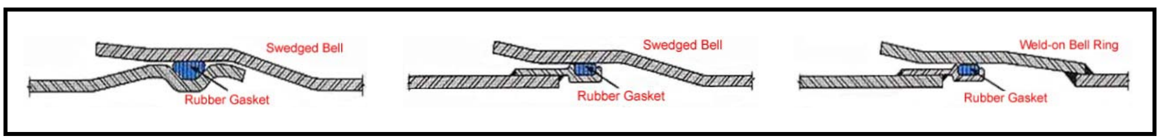


Figure 1: Proprietary Restrained Joints for DIP

Steel pipes are also available with bell-and-spigot gasket-type joints, in the form of the Rolled Groove or the Carnegie-type, Figure 2 a, b, and c.



Figures 2a, b, c: Rolled Groove Joint, Carnegie w/ Swedged Bell Joint, Carnegie w/ Weld-on Bell Joint

These systems are widely used throughout the United States and have a proven track record of over fifty years. When joint restraint is needed, steel pipe joints are typically welded either internally or externally, Figure 3a. In more demanding environments such as in seismic zones, double welded slip joints may be specified, Figure 3b.

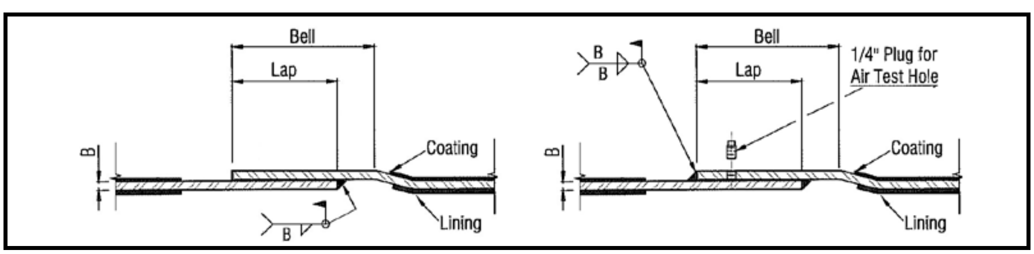


Figure 3a, b: WSP w/ Single, and w/Double Lap Welded Slip Joints

The superior beam strength of steel pipes is a key reason for its frequent selection over ductile iron pipe in seismic zones, as well as for stream and river crossings. When steel pipe joints are welded, it results in a monolithic structure of uniform strength that is not only fully restrained but also provides a completely leak-free system.

BEAM, SHEAR, AND COMPRESSIVE STRENGTHS

The high beam, shear and compressive strengths of steel pipes make their selection and use on bridges and bridge crossings very common. Again, both welded and gasketed joint steel pipes are used for this application. Aerial crossings with steel pipes for water and wastewater as well as oil and gas applications are much more common than with other pipe materials. These same properties also make steel pipes ideal for buried applications. The resistance of steel to scour is the reason steel pipes are regularly installed into or under river beds.

HYDRAULIC PROPERTIES

Both ductile iron pipe and steel pipe typically have cement mortar lining; even though the lining in steel pipe is usually 3 to 5 times thicker than the lining in DIP. The CML gives the lined pipe a typically accepted Hazen-William C value of 140. In steel pipes lined with either polyurethane or epoxy, the Hazen William C is as high as 150. Steel pipe is typically supplied to the nominal ID specified. A number of the hydraulic calculations presented in the DIPRA document neglect that fact that steel pipe can be manufactured to whatever internal diameter is specified by the design engineer to meet the hydraulic requirements of the project; steel pipe does not have the same ID or OD controls as DIP.

CORROSION CONTROL

The reason for the wide use of steel pipe is directly related to the steel pipe industry's efforts to control the effects of corrosion when metal pipes are buried, resulting in a service life of 50 to 100 years minimum. A variety of linings and coatings are offered with steel pipes, whereas the only recommended corrosion protection technology offer by the ductile iron pipe industry is a polyethylene encasement or baggy that is not bonded to the pipe.

Linings and Coatings: The steel pipe industry offers very effective lining and coating systems that give steel pipes a minimum design life of 50 to 100 years and beyond. Linings such as cement mortar significantly improve the long-term hydraulic capabilities of steel pipe by preventing internal corrosion or tuberculation. Cement-mortar lined steel pipes per AWWA C205 offer 3 to 5 times the lining thickness of comparable C104 cement mortar in ductile iron pipe.

Other protective linings for steel pipe such as polyurethanes are gaining in popularity for both water and wastewater applications due to its flexibility, strength, ease of application as well as its ability to withstand abrasion. On the coatings side, both cement mortar and polyurethane are products of choice. Other dielectric coatings such a bonded three-layer tape systems are also specified throughout North America for both water and wastewater applications. These coating have proven significantly more effective in preventing corrosion in the long term than the polyethylene baggies recommended by the ductile iron pipe industry.

Rate of Corrosion of Ductile Iron and Cast Iron Pipe: As a rule of thumb, it is widely accepted that "Cast Iron and Ductile Iron pipes (as well as steel pipes), corrode at 18 lb (8.2 kg) of metal loss/1 A of corrosion current/year."[1, 2, 3, 4] The fact that DIP water mains corrode at the same rate as its forerunner product, grey cast iron water mains, was established as far back as 1964. Numerous other studies have made the same conclusion. These same studies have also concluded that the factory-applied asphaltic coating that is typically provided for DIP provides no appreciable level of corrosion protection to underground piping and that the internal lining in DIP can delay external leakage from corrosion failures. Therefore, while a ductile iron may be corroded, leakage is delayed due to the cement mortar lining, which too, eventually will fail due to internal pressure and without the external support of the pipe material itself.

Bonded Coatings for Ductile Iron Pipe: While the DIP industry in the US has completely disregarded the importance of bonded coatings, with the rationale that due to the manufacture process of DIP, it is not possible to cost effectively apply any type of bonded coatings, the practice of applying bonded coating to DIP is the norm and not the anomaly in Europe and elsewhere around the world. The largest manufacturer of DIP in the world, Pont-a-Mousson, whose parent company is Saint-Gobain, based in France, manufactures DIP pipes with a zinc coating overlaid by a bonded polymer, or epoxy finishing layer. The European standard for corrosion protection of DIP, EN 545/598**,** mandates a minimum zinc content of 135 g/m^2 (with local minima of 110 g/m^2 at 99.99% purity) and a minimum average finishing layer thickness of 70 mils (with local minima of 50 mils). Countries such as Sweden and the UK have had very good results with bonded coatings on DIP. Other countries around the world such as Saudi Arabia, Japan, Turkey and others are also known to use bonded coatings on DIP with good results. Here in North America, several Municipalities have begun installing DIP with ONLY BONDED COATINGS. The City of Seattle, WA is an example of one such municipal entity.

Attached is an article from the **Materials Performance** magazine that gives a clear understanding of the differences in corrosion control methods of the steel pipe industry versus the ductile iron pipe industry. The article makes a good case for adopting the same approach for the corrosion protection of all buried metallic pipelines.

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[1] M. Romanoff, *Exterior Corrosion of Cast-Iron Pipe*, Journal AWWA (Sept. 1964)
[2] M. Romanoff, *Performance of Ductile Iron Pipe in Soils—An 8-Year Progress Report*, (Atlantic City, NJ: AWWA, Dec. 1976)
[3] *A Summary of the Findings of Recent Watermain Corrosion Studies in Ontario*, by Robert G. Wakelin, Canadian Region Western Conference, Saskatoon, Saskatchewan, Canada, 1991, NACE International, Houston, TX
[4] *Corrosion Behavior of Ductile Cast-Iron Pipe in Soil Environments*, by W.F. Gerold, J. AWWA (Dec. 1976)

MYTHS CREATED BY THE DIP INDUSTRY

In the Ductile Iron Pipe Research Association, DIPRA's, publication *All Pipe Materials are not Created Equal: Ductile Iron versus Steel Pipe*, many technically incorrect statements are made. Some of the items are briefly address below.

Myth #1: It is easier and less expensive to control corrosion on ductile iron pipe than it is on steel pipe. This statement could not be further from the facts discussed earlier. If proper corrosion control methods are followed per the recommendations of organizations such as NACE, International, DIP would be protected against corrosion just like steel pipe. The consequence of the DIP industry's insistence that their pipes do not corrode have led to the regular failure of DIP throughout municipalities in the US and Canada, while critical steel transmission and distribution mains continue to provide reliable service year after year.

Myth #2: Ductile iron pipe is easier to install than steel pipe. When gasket joint steel pipes are specified, the simplicity of joint assembly with steel is the same as gasket-joint DIP. When restrained joints are specified, it is arguably faster and easier to weld together steel pipe joints than it is to install a lug-type external joint restraint on DIP. The number of nuts and bolts on the lug-type device increases with the diameter of the pipe; furthermore, they are subject to the use of correct torque strengths, and must also be assembled in a generally star-pattern fashion, something that is rarely done in the field. The result is unevenness in the assembled restraint mechanism, which can result in joint leakage, and in the worst scenario, result in join separation. The nuts and bolts at the bottom on the pipe is always the most difficult to tighten to specified torques. Failure to follow proper assembly, again, results in leakage or failure down the road.

The nature in which steel pipe systems are custom built, there is rarely a need for field cutting of pipe when using gasket-joint system. In the worst-case scenario if field cutting of a joint is needed, the use of butt straps very quickly resolve the problem.

While the DIP industry points their finger at the proper joint completion methods of steel pipe using diapers for cement mortar coated pipe, or heat shrink sleeves for flexible coatings, the fact remains these procedures are followed for steel pipe to provide proper corrosion protection. The same procedures would be need for DIP if they attempted to properly protect their pipes from corrosion!

Myth #3: Ductile iron pipe inside diameters are normally larger than steel. Steel pipe is typically supplied to the nominal inside diameter specified after cement mortar lining. If one specifies a 36" pipe the inside diameter is 36". Cast iron pipe and ductile iron pipe are both OD controlled due to the molding process. Cast iron was originally ID controlled also – if you ordered 36" you got 36" ID pipe. Over the years the thickness of "iron pipe" has dramatically decreased by upwards to 75%. Since the OD remained the same the ID grew as less wall thickness was available. Hence the standard ID is larger but for all the wrong reasons.

Myth #4: Pumping costs are lower for ductile iron pipe. This may be true as the dramatic decrease in wall thickness resulted in corresponding amount increase in ID. It is doubtful that the larger ID is really needed but is in reality a marketing topic to address a weakness – that being reduction in wall thickness.

Myth #5: Ductile Iron Pipelines Are More Energy Efficient than Standard Steel Pipelines: The DIPRA document makes the point that due to the procedures followed for the proper protection of steel pipe, DIP systems are more energy efficient. The fallacy of this statement once again goes back to the denial of the DIP industry to follow proper protection methods against corrosion as addressed by NACE.

We hope the above discussion clearly highlights the similarities as well as some of the superior physical/mechanical characteristics of steel pipe compared to ductile iron pipe. Some of the false statements made in the DIPRA document that have turned into industry myths have also been briefly addressed. For further discussion on any of the other items, please contact Northwest Pipe Company.

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Present Levels of Corrosion Protection on Ferrous Water Piping in Municipal Infrastructure: A Manufacturer's Perspective

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In 2000, the Water Infrastructure Network estimated that costs of corrosion for drinking water systems were $19.95 billion per year in the U.S. Although most agencies address corrosion on the inside of pipes with linings, corrosion on the outside of pipes often is addressed with a less-than-scientific approach. This article discusses the approach taken by the steel and ductile iron pipe industry to address the corrosion issue by assigning a risk value to the level of protection taken.

According to the American Water Works Association (AWWA) (Denver, Colorado) industry database, there are ~876,000 miles (1,483,000 km) of municipal water piping in the U.S. In a study conducted by CC Technologies Laboratories, Inc. (Dublin, Ohio) with support from the U.S. Department of Transportation's Federal Highway Administration (Washington, D.C.) and NACE International,[1] the total estimated cost of corrosion in the U.S. is $276 billion per year. Of that total cost, $19.25 billion is attributed to drinking water systems and $13.25 billion is assigned to sewer systems. Contributing to the total estimate were the cost of replacing aging infrastructure; the cost of unaccounted-for water through leaks; the cost of corrosion inhibitors; and the cost of linings, coatings, and cathodic protection (CP). It may seem surprising that drinking water and sewage infrastructure corrosion costs are higher than those of any other sector that was studied. What has caused the sector to lag, and what can be done to improve the situation?

Findings of the Cost of Corrosion Study

The study states the following about corrosion:

- External corrosion can be effectively mitigated by the application of coatings and CP.
- Although the systems have problems of their own, the initial cost for installing coatings and CP on new systems is almost always warranted because large maintenance cost savings can be achieved over the life of the piping system.
- External corrosion can be prevented...with the use of external coatings and the application of CP.

The Cost of Corrosion Study also examined some of the major reasons why the problem is so extensive. Some of the conclusions include:

- A major barrier to progress in corrosion management is the absence of complete and up-to-date information on all water systems. Limited communication among water utilities restricts the spread of information about—and thus the awareness and implementation of—available corrosion control technologies, such as new coatings and CP.
- A second barrier to progress in corrosion management is the lack of understanding and awareness of corrosion problems at the local level. Also, the limited amount of time dedicated to solving corrosion problems contributes to this obstacle.
- Educating maintenance personnel and water system designers about corrosion would allow corrosion engineering to play a more effective role in this sector.

Addressing Risk

Much of the confusion about corrosion in municipal infrastructure may stem from how risk is addressed. Corrosion protection is simply a method of mitigating the risk of a pipe failure caused by corrosion. It is weighed against the cost of corrosion protection as it establishes a cost-benefit ratio for the protection. How one addresses the acceptable level of risk is the focus of this article. The authors will review six levels of corrosion protection that presently are in use for piping with metallic components (Table 1).

TABLE 1

CORROSION PROTECTION LEVELS FOR FERROUS PIPE MATERIALS

Level 1	No protection, pipe installed bare without monitoring system.
Level 2	Install pipe bare with loose PE encasement, without monitoring system.
Level 3	Add monitoring system (bonded joints and test leads) to Level 2.
Level 4	Bonded dielectric coatings or cement mortar coatings without monitoring system.
Level 5	Add monitoring system (bonded joints and test leads) to Level 4.
Level 6	Add CP to Level 5 or Level 3.[A]

[A]There currently is debate about the level of effectiveness of CP on loose film coatings.

Coatings & Linings

The majority of the steel pipe manufacturing industry has endorsed and written standards using corrosion Level 5 as the guideline for determining the best life-cycle cost-benefit acceptance criteria. There currently are 23 approved standards under the auspices of AWWA's Steel Pipe Committee. Of these standards, 14 deal with coatings and linings that are available for the protection of metallic pipe (Table 2). They vary from the earliest standard for coal tar enamel coatings and linings to the most recent fused polyethylene (PE) coating. The list includes cold-applied tape, fusion-bonded epoxy (FBE) coatings, paint systems for interior and exterior of pipe, extruded polyolefin coatings, petrolatum coatings, shrink sleeves for joints, cement mortar coating and lining, and polyurethane (PU) coatings and linings. Most of the dielectric coatings originally were used in the oil and gas industry. Many of the criteria for these coatings were established to meet the stringent requirements of those hazardous material pipelines.

TABLE 2

AWWA STANDARDS FOR COATING STEEL PIPE

AWWA C-203, "Coal-Tar Protective Linings and Coatings for Steel Water Pipelines—Enamel and Tape—Hot Applied"
AWWA C-205, "Cement-Mortar Protective Lining and Coating for Steel Water Pipe—Shop Applied"
AWWA C-209, "Cold Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines"
AWWA C-210, "Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Pipelines"
AWWA C-213, "Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines"
AWWA C-214, "Tape Coating Systems for the Exterior of Steel Water Pipelines"
AWWA C-215, "Extruded Polyolefin Coatings for the Exterior of Steel Water Pipelines"
AWWA C-216, "Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines"
AWWA C-217, "Cold-Applied Petrolatum Tape and Petroleum Wax Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Buried or Submerged Steel Water Pipelines"
AWWA C-218, "Coating the Exterior of Aboveground Steel Water Pipelines and Fittings"
AWWA C-222, "Polyurethane Coatings for the Interior and Exterior of Steel Water Pipelines"
AWWA C-224, "Two-Layer Nylon-11-Based Polyamide Coating System for the Interior and Exterior of Steel Water Pipe, Connections, Fittings, and Special Sections"
AWWA C-225, "Fused Polyolefin Coatings for the Exterior of Steel Water Pipelines"
AWWA C-602, "Standard for Cement-Mortar Lining of Water Pipelines in Place"

In the development of the dielectric coating standards, consideration is given to dielectric strength, adhesion, cathodic disbondment, handling, holidays, field procedures, and materials and repair of damage to the coatings. These considerations are given so that the risk of corrosion failure is diminished, if not eliminated. Similar consideration is given to the integrity of cement mortar coatings and linings. Levels of strength, water-soluble chloride ions, cement mixture, and water content all are part of the AWWA C-205[2] requirements. The thickness of the cement mortar lining for 24-in. (61-cm)-diameter pipe is 3/8 in. (0.95 cm) with pipe >36-in. (91-cm) going to

TABLE 3

SELECTED REQUIREMENTS OF COATING AND LINING QUALITY ASSURANCES

AWWA Standard	Thickness	Adhesion	Adsorption	Holiday Test	Date
C-203	3/32 in. (2.38 mm)	Pull test	N/A	Required	1940
C-210	16 mils (0.41 mm)	400 lb/in.^{2}	Vapor transfer	NACE Standard RP0188[4]	1978
C-213	12 mils (0.3 mm)	Knife test	N/A	NACE Standard RP0490[5]	1979
C-214	50-80 mils (1.3-2 mm)	200 ozf/in. wide	0.2%	6,000 V min.	1983
C-215	49-69 mils (1.2-1.8 mm)	N/A	0.2%	NACE Standard RP0274[6]	1988
C-216	40-60 mils (1-1.5 mm)	8 lb/linear in.	Vapor transfer	Required	1989
C-217	40 mils	N/A	Vapor transfer	N/A	1990
C-218	3.5-14 mils (0.09-0.36 mm)	V cut	N/A	N/A	1991
C-222	20-25 mils (0.51-0.63 mm)	750-2,000 psi (5-14 MPa)	3.0%	NACE Standard RP0188	1999
C-224	24-40 mils (0.6-1 mm)	2,000 psi	2.7%	NACE Standard RP0188	2001
C-225	50-75 mils (1.3-1.9 mm)	32 lb ft/in. wide	0.2%	NACE Standard RP0188	2003

1/2-in. (1.3-cm) thickness. Bonded joints normally are recommended.

The dielectric coating standards were requested and written as new materials were developed. All have special uses that affect the risk factors that might be considered in corrosion protection. Some coatings have better dielectric strength while others are more abrasion-resistant. Some coatings are made specifically for fittings while others are for aboveground service. Costs will differ for many of these products as they hinge on diameter, end use, and protection needs—specifically transmission lines vs distribution lines.

The standards became complex as the materials diversified. Materials include coal tar enamels and epoxy, polyolyfin (extruded, cross-linked, and fused), PU, petrolatum wax and tape, and nylon polyamides. Each requires different methods of application and inspection. All of the dielectric coatings listed above have some things in common as each requires at least a NACE No. 3/SSPC SP-6[3] blast cleaning. The confusion lies in the numerous alternative testing requirements, some of which Table 3 highlights.

What is the sufficient level of thickness? What is the correct adhesion? Which test method and value are appropriate answers to each of these questions depend on what level of risk is acceptable. The values in Table 3 were written so that the products would be roughly equivalent. They differ because the inherent natures of the products differ. The guideline used to write the standards assumed that the owner would specify either Level 5 or Level 6 corrosion protection—a reminder that most dielectric standards originated in the oil and gas industry.

Differences Between Metallic Pipe Manufacturers

Are the metallic water pipe manufacturers helping to eliminate the uncertainty surrounding water/sewage corrosion control, or are they helping to exacerbate it? The two major metallic pipe manufacturer segments for water pipelines—steel and ductile iron (DI)—have different views. Although it has been documented that steel and DI corrode at the same rate in the same soil,[7-8] the industries have written standards that follow different paths. Much of the confusion may be in the different methods that the two industries employ when considering corrosion protection and its cost benefit.

The DI pipe industry has promoted Level 2 corrosion protection as the corrosion level with the best cost-benefit ratio. The only approved AWWA coating standards for DI are AWWA C-104[9] for cement mortar lining, AWWA C-105[10] for PE encasement, and AWWA C-116[11] for FBE fittings. AWWA design manual M-41[12] states: "Joint bonding of ductile iron pipelines is generally discouraged except in cases where electrical continuity is needed for corrosion monitors and cathodic protection." It also states: "Although cathodic protection can be applied to ductile iron pipe, it is seldom cost effective." In a more recent development, the Ductile Iron Pipe Research Association (DIPRA) (Birminghan, Alabama) announced that its members—the eight leading DI manufacturers in North America—no longer will honor a warranty for DI pipe with any exterior dielectric coating other than PE encasement.[13]

AWWA C-105 contains requirements for thicknesses of 4 or 8 mils (0.10 or 0.20 mm), dielectric strength, and tensile strength. The standard also states: "The polyethylene encasement shall prevent contact between the pipe and the surrounding backfill and bedding material but is not intended to be a completely airtight or watertight enclosure." AWWA C-104 for cement mortar lining of DI pipe requires a thickness of 3/32 in. (0.24 cm) for 24-in.-diameter pipe and 1/8 in. (3 cm) for all larger sizes. Double lining can be requested. This is the same material as the steel pipe lining, which is a required 3/8-in. for 24-in.-diameter pipe and 1/2-in. thickness for all pipe over 36-in. diameter.

The reason for the divergence of thought processes about two similarly corroding materials may be found by considering the historical use for each. Steel pipe historically has been used in larger sizes (24 in. and larger) while DI pipe has had most of its market share in smaller sizes (36 in. and smaller). Studies have shown that CP costs have a life-cycle current rate of return of as much as 42 times the investment.[14] Also, it has been shown that diameter is one of the factors affecting rate of return. Such rates of return would affect the decision matrix regarding whether to protect the pipe or to leave it unprotected and replace it as it deteriorates and fails.

In a recent paper, Spickelmire[15] advances a decision matrix that includes risk factors for diameter and the critical nature of the pipeline. He proposes an expanded version of DIPRA's 10-point system, which includes numerous items with a 25-point threshold. The matrix is suitable for establishing a risk threshold. The decision to cathodically protect a 6-in. (15.2-cm) looped pipeline that serves 45 people vs a 60-in. (152.4-cm) pipeline that is a single-source pipeline to 12,000 people should consider the difference in risk levels.

AWWA M-27,[16] the organization's corrosion manual, is a compromise document that reflects the myriad philosophies within the pipe manufacturing industry. There are many instances in which an engineer, concerned about corrosion, will fill the interior voids at joints and apply a bonded joint material on steel pipe. However, that same engineer will allow the use of DI pipe with no interior filling and PE wrap as a substitute. Such a compromise promotes the continued separation of the steel and DI manufacturing communities. Corrosion may occur under any voids and introducing oxygen greatly increases the likelihood that a voided area will corrode.

The differing viewpoints leave the corrosion control community with a conundrum: how do they educate the utilities and engineering communities that, although the two philosophies are different, they fit together in a risk-based evaluation? Because steel and DI corrode in a similar manner in similar soils, it is the authors' opinion that both materials should be evaluated equally and be given the same level of corrosion protection.

The Cost of Corrosion Study states that education and lack of communication are the major obstacles to better implementation of corrosion technologies. Understanding the differences in the education many people are receiving may make the task easier. This article is an attempt to clarify some of the differences. The authors believe that it is the responsibility of all individuals in the corrosion industry to convince utilities and municipalities of the need to evaluate all metallic pipes equally. This educational process should include some procedure that takes into account the risk the owner deems acceptable on the specific pipeline being designed. In addition, it would include some evaluation of the expected life of the pipeline based on the level of protection given to the exterior surface of the chosen pipe product.

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