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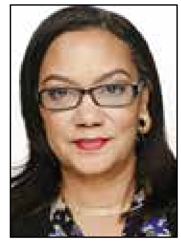

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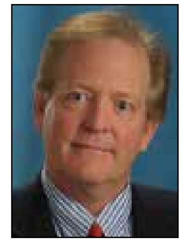

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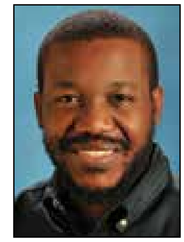

Obodoako

Merging Sustainability, Engineering, and Procurement to Foster Innovation

The Washington Suburban Sanitary Commission (WSSC) in Laurel, Md., recently changed its standard pipe material from ductile iron pipe (DIP) to zinc-coated DIP. This change was recommended by the agency's engineering staff to continue to improve the sustainability of the utility into the next 100 years. WSSC now uses a unique approach combining its sustainability goals with field assessments and engineering expertise to inform procurement decisions.

WSSC

Established in 1918, WSSC is one of the largest water and wastewater utilities in the United States. WSSC manages a network of nearly 5,800 mi of freshwater pipeline and more than 5,600 mi of sewer pipeline to serve approximately 1.8 million residents. WSSC's water network spans a service area of 1,000 mi^2.

The materials that make up WSSC's pipe network include metal, concrete, plastic, and cement. Each pipe material can be further subcategorized according to fabrication method and composition. Materials used in the WSSC service area include cast-iron pipe (CIP), DIP, steel pipe, polyvinyl chloride pipe, prestressed concrete cylinder pipe, and asbestos cement pipe. Although the water network is composed of various pipe materials, over 90% of the network is either CIP or DIP, so many of the water network challenges that WSSC encounters primarily involve iron pipe.

FACTORS THAT AFFECT PIPE SERVICE LIFE

Soil. Soil attributes play a significant role in how buried pipes degrade over time (Peabody 2001). The most common types of soil in WSSC's service area are blue–gray clay, clay, silt, and sand. Of these, WSSC engineers have determined that clay soil contributes most to pipe degradation because, generally speaking, it is moderately corrosive (Dillion 1994).

Soil sampling and analysis have been performed across WSSC's service area since 1986. Presently, soil samples are obtained during opportune activities such as pipe break repairs, pipe rehabilitation, or new pipe installation. Soil samples are analyzed and compared with an associated pipe corrosion rate, and this information ultimately supports WSSC's asset management program.

During soil testing and analysis, WSSC engineers use soil resistivity to determine soil corrosion rates. Between 2013 and 2016, the resistivity of WSSC soils, which is a measure of how much a soil resists the flow of electricity, ranged from 500 to 20,000 ohm-cm. In general, a lower resistivity means a higher potential for corrosion. To address the corrosion concerns created by the wide range of resistivity values in WSSC's service area, various pipe materials and corrosion control methods are approved by WSSC specifications.

As part of the ongoing testing, WSSC has developed a soils geotechnical database for its service area that compiles and provides information on soil corrosivity. By developing the database, WSSC has specific data to

Layout imagery by Shutterstock artists: Zally, Fine Art, 21kompot determine pipe material or corrosion control techniques to use during pipe replacement activities.

Manufacturing methods. WSSC has almost 100 years of operating experience with various pipe materials. Each pipe material has a unique manufacturing method that results in a range in condition assessment techniques. In addition, variation in the pipe material sometimes requires different corrosion control methods. For CIP and DIP, manufacturing methods are important parameters that are considered when managing pipeline replacement or rehabilitation programs.

CIP, sometimes called gray cast-iron pipe, was historically manufactured using two techniques (i.e., pit casting or spun casting). Pit-cast CIP was first installed in the WSSC service area in 1918 and was last installed in 1956. Pit-cast pipe is slightly thicker than spun-cast pipe because of the manufacturing process. Spun or centrifugal gray cast-iron pipe was first installed in 1925 and was last installed in 1977. The spun-cast process eventually replaced the pit-cast process as the major form of pipe fabrication method because of its high rates of production, among other advantages (Woodcock 2006).

DIP is manufactured using the centrifugal technique. This type of pipe was first installed in WSSC's service area in approximately 1975 and continues to be the primary iron pipe material being installed to date.

Corrosion. Since CIP and DIP are metallic materials, their life expectancy can be affected by corrosion. By performing pipe evaluations and testing, WSSC staff determined that certain corrosion mechanisms were concerning with regard to pipe degradation. Specifically, it was found that galvanic, pitting, microbiologically induced, and stray-current corrosion mechanisms were critical to long-term pipe material performance.

General galvanic corrosion is characterized as a uniform loss of material due to corrosion. Pitting corrosion is a localized form of corrosion that leads to pits or through-wall holes. Whereas pitting corrosion is an issue that affects a single pipe material, galvanic corrosion is a phenomenon whereby one metal corrodes preferentially to another when the two metals are in electrical contact. Stray-current corrosion is caused by the flow of stray currents through a pipeline. In stray-current corrosion, the pipe corrodes where the current exits the pipe. Microbiologically induced corrosion is caused by microorganisms such as sulfate-reducing bacteria.

Other factors. Pipe failures can be caused by additional factors, including material deterioration, poor installation practices, manufacturing defects, and operating conditions. In the case of material deterioration, pipe failure can take the form of pipe distortion and erosion, which cause the pipe to lose material or deform. Unlike pipe deterioration, improper pipe installation and poor quality assurance during installation can lead to unintended leaks at joints, subsequently increasing corrosion rates. Manufacturing defects such as cracks and other discontinuities may serve as suitable locations for corrosion initiation once a pipe is installed. Service conditions such as loose bedding or excessive external or internal loads are examples of operating conditions that may also lead to pipe failure.

MAIN BREAKS

When water mains break, the failure often occurs in one of two ways: either a circular break or a split break. Circular breaks are breaks that occur along the circumference of the pipe. These breaks occur because of either excessive longitudinal tensile stress or beam action stress. Conversely, split breaks are characterized by a break along the axis of the pipe. These breaks usually occur because of excessive hoop or ring stress. For WSSC pipes, the general break failure pattern for pipes less than or equal to 10 in. in diameter is circular break failure. Split breaks primarily occur for pipes with diameters larger than 16 in. Pipes with diameters between 10 and 16 in. usually fail by both failure modes.

CORROSION CONTROL PROGRAM

One way to understand the effect of corrosion degradation on pipes is to evaluate pipe failures. WSSC examined its record of pipe failures in the 1980s and determined that the highest rate of general corrosion for DIP in its inventory was 3.06 thousandths of an inch per year (mils/year). At this corrosion rate, an uncoated pipe with a wall thickness of 0.39 in. would reach its service life in 127 years. WSSC engineers also calculated rates of 0.86 and 7.7 mils/year for moderate and severe rates of general corrosion, respectively. The fact that the average age of mains that experience breaks in WSSC's service area is approximately 50 years indicates that other factors in addition to or in concert with corrosion are likely contributing to main breaks.

To mitigate the effects of corrosion on pipes, WSSC developed a corrosion control program. One method that has been adopted as part of this program is using a protective external coating in conjunction with polyethylene pipe wrap. One particular external coating that has been recently added to WSSC's pipe standards is zinc-coated DIP, where the zinc coating applied to the pipe exterior serves as a sacrificial material that protects the DIP.

One of WSSC's senior materials engineers, Mike Woodcock, was instrumental in evaluating the effectiveness of zinc pipe installations in Europe. He recommended that WSSC change from regular DIP to zinc-coated DIP. In 2015, the Technical Services Group began an in-depth review of the literature available from pipe manufacturers and utilities and determined that the zinc-oxide coating developed over time would become a permanent barrier to corrosion, thus extending the life of the pipe. The case studies indicated that using zinc-coated DIP could potentially double the life expectancy of the pipe from 50–75 years to 100–150 years.

The Ductile Iron Pipe Research Association also recommended that an enhanced polyethylene encasement pipe wrap[1] be installed to further mitigate microbiologically induced corrosion. WSSC has been installing pipe in polyethylene pipe wrap since 2005, and the organization developed a business case based on the assumption that a 1.42% increase in the cost of replacing 1 mi of 8 in.-diameter DIP would reduce replacement capital needs by half over the pipe's service life. WSSC estimated a savings of $2.8 million over the 100-year service life if the life cycle could be increased from 50 to 100 years, since there would be no need to replace the pipe twice in that time frame.

PROCUREMENT STRATEGY

In 2013, WSSC initiated an aggressive transformation of its procurement strategy, which was designed to drive down the cost of doing business. This included launching strategic sourcing teams to incorporate strategic sourcing best practices and negotiations management into the procurement process. These teams focus on improving WSSC's procurement efficiencies, identifying supply chain risks, improving contract administration, and monitoring cost reduction and cost avoidance in the procurement of goods and services within the supply chain. The teams include pipe subject matter experts on the technical and operational sides as well as participants from the budget and procurement offices.

The ductile iron strategic sourcing team fully explored the use of zinc-coated pipes, and these efforts ultimately enabled WSSC to negotiate a deal with a supplier that was not based on low bid but rather was based on the overall long-term value. The team also determined that WSSC could use its buying power to obtain a significant reduction in cost by purchasing pipe directly from the manufacturers and having it delivered "just in time" to the construction sites. This was expected to save a minimum of about 10% of the cost of the pipe since it wouldn't be marked up by the installation contractors. The minimal incremental costs of the zinc coating were offset by this strategy and resulted in WSSC paying less for its pipe as compared with before the changes. The estimated savings added to the benefits of greater sustainability made this an economically preferable option. WSSC plans to use another strategic sourcing team as it prepares to convert to automated metering infrastructure.

FORENSIC ANALYSIS

As part of its pipe program, WSSC has been conducting forensic analysis on pipelines to help determine the causes of water main breaks. There are plans to expand the forensics program to include monitoring of zinc-coated DIP through indirect and direct methods. Indirect methods include ultrasonic and acoustic emissions testing to detect internal flaws and wall thinning. In addition, WSSC will be using direct measuring techniques such as corrosion probes and mass-loss coupons to further evaluate pipe corrosion and its effect on useful life.

SUMMARY

WSSC made a significant change to the way it manages the largest single material in its water network—pipe. As part of this process change, WSSC selected an innovative pipe coating method and improved its procurement practices. The thoughtful planning and dedicated efforts of this process improvement have created a series of positive outcomes, including procuring the most suitable pipe material, determining ways to protect that pipe once it was in the ground, and spending less money throughout the process.

ENDNOTE

[1]V-Bio® Enhanced Polyethylene Encasement, Ductile Iron Pipe Research Association, Golden, Colo.

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