Preventative Maintenance Program for Cast & Ductile Iron Water Lines Reduces Leakage & Operating Cost

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Introduction

Corrpro's Break Reduction / Life Extension (BRLE) program for cast and ductile iron water pipe derives primarily from life extension programs that have been and are presently being successfully implemented throughout Canada by various water utilities. The Canadian experience dramatically illustrates the significant capital and repair monies that can be saved by implementing such a program.

The key elements of the BRLE program include: (1) an upfront corrosion assessment of the water distribution system and; (2) installation of galvanic anodes in selected areas of the water distribution system based on the corrosion assessment.

The corrosion assessment ordinarily includes a review of the water system's general characteristics (e.g. age, material, pipe wall thickness, construction practices, etc.), a review of its break/leak history, a field survey (e.g. soil conditions, electrical tests), and, when appropriate, inspection of the pipe at selected bell-hole excavations. The data are then analyzed to develop a priority indexing for the water system. The priority indexing identifies and prioritizes opportunities for economically reducing replacement/repair costs by installing galvanic anodes in selected areas of the water system.

Typical Installation Procedures

Figures 1 through 4 show the typical installation of the galvanic anodes, on nominal 15.25 meter (50-foot) spacing. For the situation depicted, 14.5 kilogram (32-lb.) magnesium anodes, enclosed in cardboard containers and containing specially prepared backfill, are installed in augered holes immediately above the water main. Before inserting the anode in the augured hole, the electrical lead wire from the anode is silver-soldered to a 7.62 centimeter (3-inch) steel rod that is then welded to the water main using stud-welding apparatus. This procedure achieves the necessary good electrical connection between the anode and water main.

Results

Figures 5 through 7 show typical results in graphical fashion of the reduction in the number of breaks after the installation of cathodic protection systems, versus the projected number of breaks without cathodic protection. The results are for three separate areas of the water distribution system for the City of Durham, Ontario, Canada. Figure 5 shows the results for the area of the water distribution system where anodes were installed in 1984 1,844 meters (6,051 ft). The trend line projects the number of leaks that would have been experienced if cathodic protection had not been installed. The trend line was obtained by performing a linear regression analysis on the last three data points prior to the installation of cathodic protection. Figures 6 and 7 show similar results for installations in the years 1988 and 1992. The results demonstrate that cathodic protection can reduce breaks in rather dramatic fashion. Results for all years between 1983 and 1995 are available in the previously referenced report titled "Status of Cathodic Protection Program to Minimize the Effects of Corrosion of Existing Ductile iron Watermains within the Region of Durham". Similar results have been observed elsewhere in Canada.

Economic Analysis Of Rehabilitation Options

The most cost-effective rehabilitation alternative can be determined by comparing the Equivalent Annual Cost of each option. The three options to consider would be:
(1) do nothing, continue to repair breaks
(2) replace the water main and
(3) implement the BRLE program.

The Equivalent Annual Cost for the do nothing repair option is USD $2000/mile/year based on an assumed break rate of 50 breaks/100 miles/year and an assumed average direct repair cost of USD $4,000/break:

EAC = 50 breaks/100 miles/year x $4,000/break = $2,000/mile/year

The Equivalent Annual Cost (EAC) for the replacement option is calculated as follows:

$$EAC = (PW)\,(i)\,(1+i)^n / \{(1+i)^n - 1\} + 0.005\,(2000)$$

where,

PW = Present Worth (Current Replacement cost) = assumed to be $560,000/mile
i = annual interest rate, assumed to be 10%
n = economic life in years, assumed to be 50 years

Using the above-assumed parameters, the Equivalent Annual Cost for replacing the pipe is USD $56,480/mile/year.

The Equivalent Annual Cost for the BRLE option is $2,092 based on the following:

Anode Installation: $16,960/mile (nominal 50-ft spacing)
Estimated Anode Life: 20 years
Residual Break Rate: 5% of 50 breaks/100 miles/year

$$EAC = (\$16{,}960)\,(0.1)\,(1+0.1)^{20} / \{(1+0.1)^{20} - 1\} + 0.05(\$2000)$$

$$EAC = \$2{,}092 \text{ (3.7\% of Equivalent Annual Cost of replacement)}$$

The data suggest that if one considers only the direct repair cost of a leak, the break rate at which it becomes economically attractive to implement the BRLE program is approximately 50 breaks/100 miles/year. However, the indirect costs of a water main break (e.g. residential/commercial water damage, emergency personnel costs, legal costs associated with claims settlement, other utility damage, etc.) are usually equal to or in excess of the direct repair costs.

When the indirect costs are added to the direct costs, the average cost of a break is probably on the order of $8,000/break rather than the $4,000/break cost used in the above calculation. If $8000 is used as the average cost of a break, the Equivalent Annual Cost for the "do nothing, repair" option becomes $4,000/mile/year (assuming a break rate of 50 breaks/100 miles/year). Based on this, the break rate at which it makes economic sense to implement the BRLE program is probably around 20 breaks/100 miles/year.

References

1. "The Status of the Cathodic Protection Program to Minimize the Effects of Corrosion of Existing Ductile Iron Watermains Within the Region of Durham", *a report prepared by the Technical Support Works Dept., Region of Durham*, January, (1998).

Related Material

2. "Underground Corrosion of Water Pipes in Canadian Cities, Case: The City of Calgary", *Canada Centre for Mineral and Energy Technology Report No. OSQ81-00096,* (1985).
3. B. J. Doherty, "Controlling Ductile-Iron Water Main Corrosion", *Materials Performance,* January (1990)
4. J. Peter Nicholson, "The Efficiency of the Cathodic Protection System Installed on the Water Mains in Peterborough", *a report to the Peterborough Utilities Commission*, December (1991).

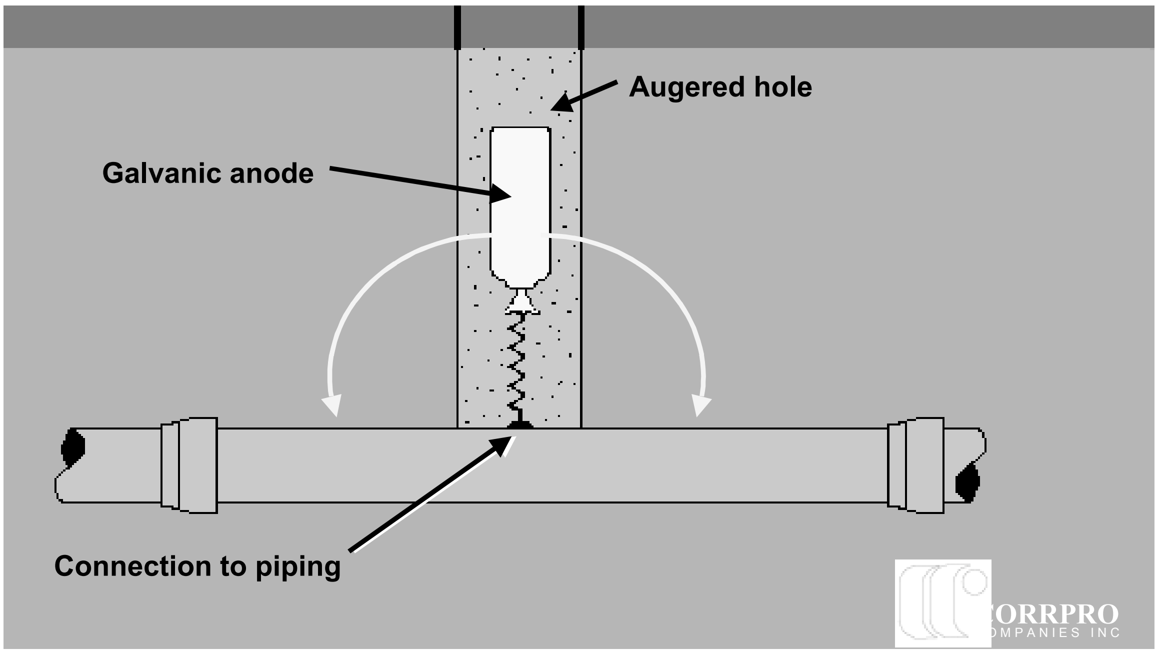

Figure 1. Anode Installation

Figure 2. Galvanic Anode Packaged in a Cardboard Container with Prepared Backfill.

Figure 3. Lay-out of Pre-packaged Anodes Prior to Installation

Figure 4. Stud-weld Connection of Anode Lead Wire to Water Main

Sanitary Sewer and Underdrain Separation

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The Newton Sanitary Sewer and Underdrain Separation project is the largest cured-in-place-lining project undertaken in New England. The project utilizes a multi-faceted approach to remove infiltration and inflow (I/I) from the sanitary sewer while simultaneously reducing the potential for sanitary contamination of local receiving waters.

The project area consists of approximately 27,432 meters (90,000 feet) of 30.48 centimeters (12") to 60.96 cm x 91.44 cm (24"x36") sanitary sewer lines with 15.24 cm to 45.72 cm (6" to 18") underdrains. Constructed in the late 1800s, the underdrains were originally used for de-watering during construction. Underdrains are pipes with open joints that were installed beneath the sewer line to convey groundwater to a local drain or water body. These underdrains are connected to the sanitary sewer through "access points" located inside sanitary manholes (see Figure 1). The access points were built to provide locations to perform maintenance on the underdrain piping system. Over time, these access points deteriorated, resulting in a direct connection between the sanitary sewer and underdrain. The direct connection allowed sanitary flow to enter the underdrain system and groundwater from the underdrain system to enter the sanitary system. This mixing of flows between the two (2) systems results in sewer overflows during extreme wet weather events, increased sewer user costs, and contamination of local receiving waters.

Figure 1. *Left* - Access point located on the manhole bench; *Right* - Access point located in the sewer invert; *Below* - Cavern type access point

The goals of this project were to minimize the amount of groundwater entering the sanitary sewer system through access points and to eliminate future underdrain related contamination of local receiving waters.

Background

The Charles River surrounds the City of Newton on three sides. Prior to the city becoming established, numerous brooks and streams permitted swampy areas to drain to the Charles during periods of high precipitation. When the sanitary waste collection system construction began in the late 1800s, the high groundwater in these areas became a problem.

The technology of this time period involved creating an extensive underdrain system, which was laid to drain the groundwater and permit construction of a sewer system immediately above in a stable, dry soil. These underdrains were made of vitrified clay pipe (VCP) and were open at the joints to allow groundwater to enter. The pipes were carefully laid in screened gravel and wrapped in bagging to prevent fine materials from washing into the pipe. At this time, it was believed that by the time the bagging decayed, the overlying material would be sufficiently compacted to prevent significant infiltration. The underdrains, which were laid beneath an estimated 400,000 linear feet of sewer (see Figure 2), conveyed groundwater to surface water conduits flowing by gravity to the Charles River. In addition to dewatering the construction trench, the series of underdrains permanently lowered the groundwater table, allowing for development in previously undevelopable areas.

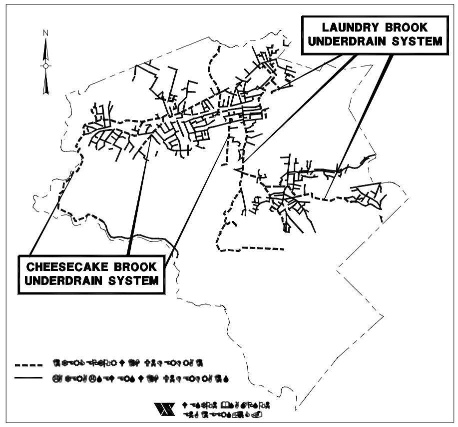

Figure 2. City of Newton map showing the project area and the extent of the underdrain system. The project areas are shown as bold lines and are labeled Cheesecake and Laundry Underdrain Systems. Other underdrain locations are shown tributary to these lines and as the Hyde Brook Underdrain System.

A lack of maintenance over the last 100 plus years resulted in an underdrain system that no longer performs as it was intended. Access points located in sanitary sewer manholes, originally designed to provide access to the underdrain, deteriorated and provided a direct connection between the sanitary and underdain systems. These points allowed the two systems to mix, creating contamination of the underdrain and infiltration of groundwater to the sewer system. In other instances, portions of the underdrain system were deliberately rerouted and combined with the sanitary system. For example, when the Massachusetts Turnpike was extended into Boston through Newton in the 1960s, instead of relocating two separate pipelines, the flows were combined and conveyed across the Turnpike in a single crossing. In addition to direct connections, numerous indirect connections exist as wastewater exfiltrates through aging brick pipes to the underdrain.

For years the contaminated underdrains discharged to surface water conduits and the Charles River. In the 1970s, as part of the U.S. Environmental Protection Agency's (EPA's) effort to clean up the Charles River, the majority of underdrain discharge points were sealed. This action, while preventing the direct discharge of contaminated underdrain flow, created new problems in the upstream collection systems. Sealing the discharge points forced underdrain flow through open access points to the sewer, and in some cases, to the drain system.