

# Service Life Analysis of Water Main Epoxy Lining [Project #2941]

**ORDER NUMBER:** 91154

**DATE AVAILABLE:** Fall 2006

## **PRINCIPAL INVESTIGATORS:**

Arun K. Deb, Jerry K. Snyder, John O. Hammell, Jr., Elizabeth Tyler, Linda Gray, and Ian Warren

## **OBJECTIVES:**

The objectives of this research were to (1) gather information on historical epoxy lining installations and document the effectiveness of these previously installed liners in protecting cast iron or steel water mains; (2) develop protocols and procedures and conduct accelerated life-cycle tests on epoxy liners to assess their long-term performance; and (3) assess the longevity of early epoxy liner installations for renewal planning.

## **BACKGROUND:**

About 50 percent of the water mains in North America are cast iron, and many of these are unlined. Although many of these unlined mains are structurally sound, many show severe tuberculation resulting in reduced hydraulic capacity and water quality problems. Rehabilitation of such mains using cleaning and lining techniques can result in significant cost savings compared with replacement. In North America, most cleaning and lining has been done using cement mortar, but epoxy lining has been shown to be a viable alternative for water main rehabilitation.

## **HIGHLIGHTS:**

This research found that careful and controlled surface preparation and epoxy liner application is the most critical factor in ensuring an effective, long-lasting liner. Poor cleaning and lining techniques can result in various application defects, including pinholes (called "holidays") and variations in liner thickness that may significantly reduce liner longevity and effectiveness. However, such defects can be reduced or eliminated by implementing careful QA/QC procedures during liner application. Well-constructed epoxy linings are very durable and can be expected to last at least 40 to 60 years.

## **APPROACH:**

First, the researchers reviewed literature relating to the history, effectiveness, and current practices used in epoxy lining. Next, they surveyed epoxy lining manufacturers and a selected group of water utilities with experience implementing epoxy lining. The research team collected, inspected, and conducted a laboratory analysis of pipe coupon samples removed from epoxy-lined water mains at five different utilities representing epoxy lining ages of between 1 and 25 years. The researchers then completed accelerated aging tests in the laboratory to assist with forecasting the expected service life of epoxy linings. Lastly, the researchers assembled epoxy lining industry experts in a workshop setting to review the findings from the laboratory testing and validate the approach used to estimate the expected longevity of epoxy-lined water mains.

## **RESULTS/FINDINGS:**

The following were the important findings of this study:

- Few North American water utilities have experience using epoxy lining, whereas in the United Kingdom, many water utilities have successfully used epoxy lining. Incidentally, polyurethane is now the preferred lining material in the United Kingdom.
- Poor construction and lack of QA/QC procedures can result in epoxy liners with holidays (pinholes) and significant

variations in dry film thickness (DFT), both of which can have a negative impact on the longevity of an epoxy liner.

- Epoxy liners, when constructed properly, can have a long life, which is estimated to be approximately 40 to 60 years based on this research.
- Controlled surface preparation and liner application are the most critical factors in ensuring an effective and long-lasting liner.
- Electrical impedance, as measured by electrochemical impedance spectroscopy (EIS), is a good measure of the barrier properties of liner materials. High impedance values indicate good barrier properties.
- Differences in epoxy lining materials seem to have minimum impacts on the longevity of a liner.

Based on the above findings, the following recommendations were made:

- North American water utilities should consider epoxy lining as a viable alternative to cement mortar lining.
- When implementing epoxy lining, it is imperative that water utilities strictly follow proper QA/QC procedures in order to obtain good longevity of the lined water mains.
- Water utilities should conduct closed-circuit television (CCTV) surveys and measure Hazen-Williams “C” values of the water main before and after completion of the lining. Water utilities should keep proper records of the construction of the lining and should take a sample coupon of the pipe after lining.

#### **IMPACT:**

This study demonstrated that epoxy lining is a viable rehabilitation method for unlined cast iron and steel water mains. For structurally sound water mains with severe tuberculation causing reduced hydraulic capacity and water quality problems, epoxy lining can provide a greater increase in hydraulic capacity than conventional cement mortar linings. When installed properly with appropriate QA/QC procedures, epoxy lining is expected to have a service life of at least 40 to 60 years.

#### **PARTICIPANTS:**

Eight utilities from the United States, Canada, and the United Kingdom participated in this project.