Guidelines for selecting lead pipe rehabilitation and replacement technologies

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ABSTRACT: Lead levels in potable water are regulated by the USEPA’s Lead and Copper Rule and the European Union’s Drinking Water Directive. In 1997 the AWWA Research Foundation sponsored a team of international investigators to identify, test, and evaluate available and emerging techniques for the rehabilitation or replacement of small diameter pipes in the size range typically used for water service lines (<25mm). The project included a survey and case studies by utilities regarding their experience with specific techniques. The project focused on field trials that were conducted with manufacturers and participating utilities in North America and Europe. This paper discusses five technology categories that were identified by this study and factors affecting the use and performance of each. In addition, this paper summarizes guidelines and cost estimates that can be used by utilities for selecting lead pipe rehabilitation and replacement technologies for site-specific applications.

1 INTRODUCTION

The leaching of lead from pipes and piping materials is recognized as having adverse health effects for humans, most notably neurological and developmental problems in children. Lead levels in potable water are regulated in the United States by the U.S. Environmental Protection Agency’s Lead and Copper Rule and in Europe by the European Union’s Drinking Water Directive. From 1997 through 1999, the AWWA Research Foundation sponsored a project to test and evaluate existing technologies and promising emerging techniques for rehabilitating or replacing lead piping in the distribution system. The approach included a literature review, utility survey, case studies, and field trials conducted with participating manufacturers at participating utilities in North America and Europe. Results were used to develop guidelines for evaluating and selecting lead pipe rehabilitation and replacement technologies. Utilities that need to abide by the lead pipe replacement requirements of the USEPA Lead and Copper Rule can use these guidelines to plan site-specific programs.

A schematic cross section of a home and service connection in a typical water distribution system is shown in Figure 1. A variety of techniques currently are available for the rehabilitation or replacement of small diameter pipes in the size range typically used for water service lines (<25mm). These techniques can be classified under one of five general technology categories described below (Kirmeyer et al., 2000).

Figure 1  Schematic cross section of home and service connection in a typical water distribution system

(1) Open trench replacement – the traditional method for installing or replacing a water service line. The procedure typically requires cutting and breaking of surface pavement and excavation of soil from the point of connection to the main along the entire length of the service pipe.
(2) **Replacement on new route** – the discarded pipe is left in the ground and new pipe is installed along a different route using a trenchless method such as impact moling or guided boring. The procedure requires excavation of two access pits, typically located at the point of connection at the water main and the curb stop.

(3) **Replacement using existing route** – the existing lead pipe is removed or displaced while simultaneously replacing it with new pipe. Techniques include pipe pulling which removes the pipe and pipe splitting which leaves the pipe in the ground but enables the new pipe to be installed along the original route.

(4) **Slip lining** – the existing lead pipe is lined with a loose or tight fitting liner made of plastic material such as polyethylene or polyethylene terephthalate. The procedure requires excavation of at least two access pits at the water main and curb stop similar to other trenchless technologies.

(5) **Pipe coating** – the existing lead pipe interior is coated with epoxy, wax, polymer, or other material. The procedure requires excavation of access pits, but the technology can be applied in certain circumstances by excavating only one access pit per service line.

2 FACTORS AFFECTING SELECTION OF TECHNOLOGIES

Factors affecting the use and performance of each of these lead pipe rehabilitation and replacement technologies can be classified as non-controllable or controllable factors. **Non-controllable factors** include below-grade site conditions, above-grade site conditions, and the condition of the existing lead pipe as summarized below.

- **Below-grade site conditions**
  - Water main (location, depth, material, age, condition)
  - Geotechnical (soil characteristics, depth to groundwater, depth to road foundation)
  - Other buried service pipes (sewer, storm drain, power, cable, gas telephone, location and depth)

- **Above-grade site conditions**
  - Site access (proximity to buildings, parked vehicles, other immovable objects)

- **Pipe Conditions**
  - Breaks and leaks
  - Length of pipe
  - Configuration (e.g., loops, bends, kinks)
  - Pipe diameter and wall thickness
  - Location and buried depth of pipe
  - Common service from the main for more than one service

**Controllable factors** include installation issues (e.g., operator skills, need for special fittings) and customer concerns (e.g., disruption to traffic, suspended water service).

- **Installation issues**
  - Time for utility staff to acquire skills needed for using the technique
  - Time to prepare the site
  - Time to install material or replace the pipe
  - Time for curing (e.g., pipe coating material)
  - Time to reconnect the water service
  - Special fittings needed to reconnect service
  - Operational concerns or special requirements

- **Customer concerns**
  - Time the water supply is disconnected
  - Overall speed of operation
  - Disruption to automobile and pedestrian traffic
  - Environmental nuisances (e.g., noise, dirt)
  - Adverse effects on water quality
  - Potential interruption of other utility services

These lists of non-controllable and controllable factors can be used as preliminary checklists for assessing site-specific applications.

The cost of implementing a rehabilitation or replacement program can vary widely depending on site specific conditions and the availability of specific technologies. For example, the cost to dig an open trench typically would be lower for a service line buried 30 inches below a low-traffic road compared to a service line buried 8 feet below a high-traffic concrete road. Costs are further affected by local expertise, other simultaneous activities such as main replacement, local labor prices, soil conditions, the length of the service pipe, the type of main connection, and other factors.
For this research, cost estimates were developed that could be used by utilities to compare alternatives and plan site-specific lead pipe rehabilitation and replacement programs. Cost estimates are based on results from field trials and utility responses to the survey developed for the project. Cost estimates for the five technology categories are summarized in Table 1.

3 GUIDELINES

A systematic procedure has been developed as a guide for evaluating and selecting lead pipe rehabilitation and replacement technologies. The procedure is based on findings from the literature review, utilities survey, and field trials for this project. The procedure can be used to screen possible technologies, but the reader should be aware that no technology may be considered 100 percent successful and an alternative technology always should be available on-site. This procedure consists of the following five-step approach.

1. Eliminate Unsuitable Technologies
2. Evaluate Technologies
3. Summarize Evaluation Results
4. Rank Technologies
5. Identify Available Techniques

After eliminating unsuitable technologies for a site, the applicability of the remaining lead pipe rehabilitation and replacement technologies are evaluated further based on the following criteria:

- Below-grade site conditions
- Above-grade site conditions
- Lead pipe conditions

 Ease of installation
 Estimated costs
 Customer impacts

The first three criteria pertain to non-controllable factors. The last three criteria pertain to controllable factors. Procedural guidelines, modules for evaluating and selecting technologies, and an example application of the procedure are included the project report (Kirmeyer et al., 2000).

Figure 2 can be used as a guide for coordinating and implementing a lead pipe rehabilitation and replacement program for site-specific applications (Boyd et al.). Beginning with identification of lead service lines, the flow chart can be used as a checklist for coordinating project team members, collecting samples, implementing fieldwork, and documenting the success of the program.

4 ACKNOWLEDGMENT

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- N.V. Waterbedrijf Groningen, Holland
- Louisville Water Company, USA

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Table 1. Estimated Costs per Connection for Lead Pipe Technologies *

<table>
<thead>
<tr>
<th>technology category</th>
<th>Open trench replace</th>
<th>Replace existing route</th>
<th>Replace New route</th>
<th>Slip lining</th>
<th>Pipe coating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor1</td>
<td>$700 - $1,000</td>
<td>$600 - $800</td>
<td>$600 - $800</td>
<td>$600 - $800</td>
<td>$600 - $700</td>
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<td>Equipment 2</td>
<td>$270 - $550</td>
<td>$300 - $350</td>
<td>$200 - $400</td>
<td>$200 - $600</td>
<td>$300 - $400</td>
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<tr>
<td>Materials 3</td>
<td>$80 - $120</td>
<td>$100 - $150</td>
<td>$100 - $200</td>
<td>$50 - $90</td>
<td>$100 - $150</td>
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<tr>
<td>Restoration4</td>
<td>$800 - $1,000</td>
<td>$600 - $700</td>
<td>$600 - $1,200</td>
<td>$600 - $700</td>
<td>$400 - $600</td>
</tr>
<tr>
<td>Total5</td>
<td>$1,850 - $2,670</td>
<td>$1,600 - $2,000</td>
<td>$1,500 - $2,600</td>
<td>$1,450 - $2,190</td>
<td>$1,400 - $1,850</td>
</tr>
</tbody>
</table>

* Costs are based on estimates per service connection and conversion to 1998 USA dollars (Kirmeyer et al., 2000).

1 Includes utility field crew, supervision and labor hired for specialty services
2 Includes cost to rent or purchase field equipment
3 Includes cost of rehabilitation materials or replacement pipe
4 Includes cost to restore sod, driveway, sidewalk and road
5 Total of labor, equipment, materials, and restoration
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- Polyl ine Technologies Ltd., UK
- UTILX Corporation, USA

REFERENCES


Figure 2. Guidelines for Coordinating and Implementing a Lead Pipe Rehabilitation and Replacement Program