The Practical Application of Condition Assessment for Small Water Main Renewal

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Because NDE is seldom used for small mains.....

» **Relatively strong mains are discarded** because they are perceived to be weak

» **Unnecessary breaks occur** because some weak mains are left in service too long

» **Renewal methods are not always appropriate** for the condition of the host main
NDE is rarely used for small water mains, because...

- **Cost**: “Money is better spent on renewal”
- **Risk**: “Something could go wrong”
- **Misunderstanding**: “Old mains have no value”
- **Uncertainty**: “What do the data indicate?”
THIS IS IMPORTANT!!!

» Because small mains break the most

» Because cast iron mains break the most

SMALL MAINS are our CANARIES in the coal mine

Failure rates from survey of 188 North American Utilities

Source: Utah State University (Folkman), 2012
...and even small mains can have catastrophic consequences

Photo: Al Seib, LA Times
Finding Ways to Effectively Use NDE on Small Mains

WRF Project 4471: Leveraging NDE
» Use NDE to “sample”
» Employ where easy

WRF Project 4473: Assess and Fix
» Perform NDE with rehab
» Tailor rehab using NDE
Calgary Case Study: Using NDE to optimize

» 8% of system scanned in 15 years

» “Badness” rating for prioritization

» 50% fewer breaks

» Replace program reduced by 66%

» Costs savings pay for program
Calgary Case Study: Using NDE to optimize

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Replacements of Cast Iron, kilometres

0 2 4 6 8 10 12 14 16 18 20
Project 4471, Phase 1: Valleyheart Tests, LADWP

2000-ft, 6-inch main, discarded in 2010
  » 1933 (unlined spun cast)
  » 1946, 1950, 1952 (factory-lined spun cast); 1971 welded steel CML
Four Technology Firms Proposed Five Methods

1. Push-in video/audio probe (JD7 / Wachs)
2. Keyhole broadband electromagnetic scanning (Rock Solid)
3. In-pipe broadband electromagnetic scanning (Rock Solid)
4. Acoustic velocity pipe wall thickness analysis (Echologics)
5. In-pipe remote-field electromagnetic scanning (PICA)

Pure did not have an appropriately-sized tool
Push-in probe (Investigator)

- Easy entry through 2-inch tap
- Video / audio (Wachs Water Service / Genivar)
- Advantage: little disruption of operation
- Limitations:
  - Can only be pushed a hundred feet, more or less
  - Time consuming; degree of inspection is limited
  - Provided no condition information
Broadband electromagnetic (Rock Solid)

» External scanning using vacuum-excavated keyhole
» Internal scanning of drained pipe
» Limitations
  • Limited coverage
  • Time consuming
  • Dry, straight pipe needed for in-pipe inspection
Acoustics velocity testing (Echologics)

» **Non-Invasive.** Pipe access using existing appurtenances or vacuum-excavated keyholes.

» Provides **average thickness** between transducers

» Limitations:
  • **Does not detect isolated pitting**
  • Validation does not exist for iron pipes
    » **Information is lost in data noise**

\[
v = v_o \times \sqrt{\frac{1}{1 + \left(\frac{D_i}{t_r}\right) \times \left(\frac{K_l}{E}\right)}}
\]
Remote-field testing (PICA SeeSnake)

» Generates / detects electromagnetic field

» Pros
  • High resolution detection of defects
  • Long runs possible
  • Proven over two decades

» Cons
  • Requires outage for pipe access
Using the SeeSnake on Valleyheart

Inserting the tool into the launching port. Normally this tool is launched from a fire hydrant’s vertical drop leg.

This custom hydrant guides the rope past a seal. By using clamps to hold the hydrant in place, flange patterns don’t have to match.

Ready to launch. The fire hose provided water to push the tool to the far end of the main. A plastic sheet contains water that leaks from the assembly. The hydrant is braced to the trailer to counteract the winching force.

The location of the NDE tool is tracked by measuring the amount and speed of tether rope deployment. Underneath the table is the motor used to winch back the tool. All tools and equipment were powered from a small electrical generator.
Exhumation plan with a focus on 1933 pipe
Seven pipe segments were split longitudinally into 14 pieces, then sandblasted.

Uncorroded pipe measurements were generally 7/16-inch thickness (0.43 inch).
Phase 1: Side-by-side technology comparisons

- Water Research Foundation Project 4471
- 5 technologies applied to 2000 feet of CI pipe
Phase 1: Findings and Conclusions

- No perfect method; interpretation is art and science
- **In-pipe remote field technology provided depth and breath**
- 80 percent of Valleyheart main was “Good” to “Excellent”
- A cost-effective strategy for Valleyheart main might have been:
  - Line the unlined 1933 pipe
  - Install a few anodes near repair areas
Interpreting NDE: Lessons Learned from Calgary

Calgary (~100 mi since 1999)

Stored Data in GIS

Institutional Knowledge:
- SeeSnake is effective
- Pits drive breaks

WRF Step 1: Examples to Validate Institutional Knowledge
Validating Institutional Knowledge

Example 1 (~1,300')

Breaks
Calgary SeeSnake Results – Example 2
Interpreting NDE: Lessons Learned from Calgary

Calgary
(~100mi since 1999)

Overlay breaks after inspection (e.g. inspected 2002)

143 condition-related breaks after NDE inspections

Institutional Knowledge:
- SeeSnake is effective
- Pits drive breaks

WRF Step 2: Verify data could forecast breaks

WRF Step 1: Examples to Validate Institutional Knowledge
Analysis: Why did these breaks occur?

- Pit depth and density = Primary Predictor of Future Breaks
- Pipe wall average / minimum thickness = Secondary Predictor of Future Breaks
- Data supports theory: **multiple deep pits** more likely to result in **longitudinal fractures**

<table>
<thead>
<tr>
<th>Pit Count</th>
<th>No Pits</th>
<th>Thru Pit (0% RW)</th>
<th>Deep Pit 1-30% RW</th>
<th>Modest Pit 31-50% RW</th>
<th>Shallow Pit &gt;50% RW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolated Pit</td>
<td>130</td>
<td>68</td>
<td>23</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Multiple Pits</td>
<td>208</td>
<td>79</td>
<td>66</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>
How to Use NDE Effectively on Water Mains

» **Access**: Scan 6”/8” mains thru hydrants

» **Target**: Mains likely to be most corroded

» **Sample**: Various vintages in various areas

» **Leverage**: Extrapolate information to mains of similar vintage and area (siblings)

**PHASE 2**: EACH UTILITY CHOSE RFT TO TRY IN THEIR SYSTEM
LADWP – 3 badly corroded mains
LADWP – 3 badly corroded mains

LADWP - 6in 218 Street Watermain

Remaining Wall (%) vs Pipe Number

Launch Hydrant @ 218th St & Harvard Blvd
Approximately 35ft from Discharge Hydrant at 218th St & Western Ave
LADWP – 3 badly corroded mains
Seattle – Mild to moderate corrosion…except unlined portion
Denver – Sporadic, moderate to severe corrosion
DC Water Pilot – Windom Place NW 8” Water Main

Data verifies:
- Condition = Good
- Non-structural liner is cost-effective solution
Risk has four components!

Likelihood x Consequences
Technical Stuff is There Too!

- Decision models
- Analytical methods

<table>
<thead>
<tr>
<th>DEGREE OF DETERIORATION</th>
<th>MODERATE</th>
<th>SEVERE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MILD</td>
<td>Attach Anodes</td>
<td>Renew Soon Open Trench or Class II/III Lining</td>
</tr>
<tr>
<td></td>
<td>No Action Needed</td>
<td>Renew Soon Open Trench or Class IV Lining</td>
</tr>
<tr>
<td>ISOLATED</td>
<td>Re-Assess in Future, as Appropriate</td>
<td></td>
</tr>
</tbody>
</table>

**EXTENT OF DETERIORATION**

\[
\frac{p}{p_c} + \left(\frac{w}{w_c}\right)^2 > 1
\]
Conclusions – Using NDE for Main Replacement Decisions

1. 80% of LADWP Valleyheart Main was salvageable

2. Programmatic replacement of mains in LA’s Harbor District would prevent future breaks

3. Seattle’s 16-inch feeder was likely in very good condition, based on assessment of nearby 8-inch mains

4. Anode attachments and spot repairs in Denver could extend the life of its main

5. DC Water’s decision to mortar line its main was prudent

6. Fairfax: it’s always good to have reliable record drawings
Project 4473: Assess and Fix
» Perform NDE with rehab
» Tailor rehab using NDE
Because NDE is seldom used for small mains.....

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The POTENTIAL for Cost-Savings was Affirmed
Condition Assessment of Water Mains

AWWA Manual M77
First Edition

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Appendix A – Other Assessment Methods
Questions?

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Keyhole Installation of Anode

Traffic control by LADWP. The hole location was pre-marked and cleared for excavation. The location is the intersection of Valleyheart Drive and Ethel Avenue.

The coring rig positioned over excavation location.

Two persons lifted the core using a special tool that grips the center pilot hole. The core was then tipped on its side and rolled out of the way.

Vacuum excavation was performed using a high-volume unit equipped and water jet lances.
A long-handled, air-powered grinder with plastic abrasion disk was used to prepare the pipe surface for wire bonding.

Another long-handled tool was used for exothermically welding the anode to the pipe.
Keyhole Installation of Anode

The excavations can be plated without a backhoe or other equipment. The plate has an underside ring that extends into the hole, preventing it from sliding. Plates are available that lock in place.

After backfilling using conventional methods, a layer of pea gravel was placed for leveling. This was followed by a dry-fit test to verify that the excavated core would be level with the adjacent pavement.

A grout-like bonding agent was pored into the hole. The extracted core, shown on the right side of this photo, is ready for placement.

The core is placed into the hole, then wiggled back and forth, forcing the bonding agent up the sides and center of the donut-shaped core. The core is aligned with marks made before-hand.