Efficient Asset Management with Acoustics

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Echologics
Agenda

• Background
• Innovative Solutions for Buried Pipeline Asset Management
  ▶ Acoustic Leak Detection
  ▶ Acoustic Pipe Wall Integrity Testing
• Case Studies
  ▶ Newark, NJ
  ▶ Las Vegas
• Q&A
Optimizing Pipeline Asset Management: How to Prioritize Based on Condition?

<table>
<thead>
<tr>
<th>Pipeline 1</th>
<th>Pipeline 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed 1860</td>
<td>Installed 1860</td>
</tr>
<tr>
<td>Brown clay soil</td>
<td>Brown clay soil</td>
</tr>
<tr>
<td>Corrosive soil</td>
<td>Moderately corrosive soil</td>
</tr>
<tr>
<td>6” Cast Iron Pipe</td>
<td>18” Cast Iron Pipe</td>
</tr>
</tbody>
</table>

47.3% Measured Loss  
18.5% Measured Loss
Condition Assessment: Pyramid Model

1. Desktop study
2. Survey level inspection: ePULSE
3. Invasive / Disruptive inspection
4. Destructive testing

- CE: $200/ft
- Rehab: $50/ft
- Repair
- Defer: $0/ft
Condition Assessment: Prioritization Model

Inputs
Age, Pipe Material, Bedding, Leak History, Traffic Loading, etc.

Believable Guess

Formula

Predicted Condition

Proven Using CA

Poor Prediction

Reliable Prediction
Optimizing Pipeline Asset Management: 
\textit{Economic Value of Non-Invasive Assessment}

- Prioritize utility investments based on actual pipe condition
  - Enables a Master Planning approach to pipeline Asset management
    - Condition-driven schedule for pipe replacement and rehabilitation
  - Offers objective data for "proof of need" in rate cases

- Offers an immediate Return on Investment
  - Interest on deferred capital: Finding good pipe
  - Reduced water loss: Isolating leaks years in advance
Innovative Solutions for Buried Pipeline Asset Management
The Myth of Aging Pipes

• Contrary facts about aging water mains
  ▶ *Rate of rise* (water loss) accelerates as water distribution systems age
  ▶ **However,** 70%+ of pipes being replaced have remaining life

• Asset Management critical to pipe life cycle management
  ▶ Active leakage control to minimize water loss
  ▶ **Direct Inspection** used to prioritize rehabilitation / replacement

• Innovative, non-invasive solutions are available to:
  ▶ Prevent catastrophic failures
  ▶ Significantly reduce Non-Revenue Water (NRW)
  ▶ Prioritize capital spending for pipe infrastructure
Economics of Water Main Leaks

• **Main Break Repair:** $5,000 - $20,000 per incident

• **Typical 5-10 GPM Leak**
  ▶ **ENERGY:** 8,800 kWh annual energy loss for pumps and systems
    • $1,057 annually at $.12/kWh
  ▶ **CARBON**: Lost energy creates 5,300 lbs of CO₂, work of ~ 100 trees

• **Catastrophic Failures:** $50K to $ Millions per break
  ▶ Collateral damage, contamination, EPA/state penalties

• **Cost of Water**

<table>
<thead>
<tr>
<th>Hole Size (inch)</th>
<th>Leakage (g/min)</th>
<th>Leakage (g/day)</th>
<th>Marg Cost/Yr @ $600 / MG</th>
<th>Value/Yr @ $2,000 / MG</th>
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</thead>
<tbody>
<tr>
<td>Small</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>0.125</td>
<td>2</td>
<td>2,880</td>
<td>$631</td>
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<td>0.250</td>
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<td>21,600</td>
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<td>Medium</td>
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<td>0.500</td>
<td>25</td>
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<td>Large</td>
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<tr>
<td>0.875</td>
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<td>4.000</td>
<td>1436</td>
<td>2,067,840</td>
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</tbody>
</table>

* 1 kWh saves 1.3 lbs of CO₂
Leakage Control

Leak Detection Technologies

- Acoustic
- Acoustic with Correlation
- Infrared Thermography
- Chemical
- Mechanical
- Ground Penetrating Radar
- RFEC - Intrusive technologies for transmission mains
  - Sahara and Smartball

Leak Locations

- Water and force mains
- Fire hydrants
- Valves
- Blow-offs
- Meters
- Service connections

Sources of Leaks

- Environmental factors:
  - Ground heave and slip
  - Earth and Traffic loading
  - Ground support: pipe spans
  - Thermal changes
- Corrosion
- Public works:
  - Road salts
  - 3rd party digging
- Age and neglect
Acoustic Leak Detection Technology

Limited Technology Advancement

- Interference from surroundings and ambient noise
- Unable to detect low frequency noise
  - Plastic and AC pipe
  - Larger diameter mains
  - Muffled leaks, e.g., underwater
- Questionable accuracy

Solving the Problem

- Human Voice: 125 – 5000 Hz
- Music - Middle C Note: 256 Hz
- Music - A440: 440 Hz
- Typical 6” Cast Iron Pipe: 200 – 800 Hz
- Typical ¾” copper pipe: 400 – 2000 Hz
- **Typical 6” PVC Pipe: 5 – 30 Hz**
Assessing Pipe Condition

Bursts per km per yr

Maximum economical failure rate

Installed defect failure period

Random failure period

Degradation related failure period

Age
**Indirect Condition Assessment: Current Methods**

- **Internal Environment**
  - Water Quality Testing, including Corrosivity
  - Flow rate, temperature, pressure, etc.

- **Soil Environment**
  - Soil / Geological mapping
  - Soil corrosivity (pH, sulphate content)
  - Soil testing

- **Desktop - Statistical/Criticality Models**
  - Review break rate, soil type
  - Includes consequence of failure
Direct Condition Assessment: Ferrous Pipe

• Historical Methods
  ▶ Electromagnetic
    • Broadband (BEM), Magnetic flux leakage (MFL), RFEC
    • Requires direct access to the pipe through a pit, and 360 degree access to the pipe, or a pig inserted into the pipe
  ▶ Pipe Sampling (coupons)
    • Tuberculation level
    • Graphitic Corrosion
    • Metallurgical, e.g. Young’s modulus, metal loss, thickness

• Acoustic Assessment Methodology - Pipe Integrity Testing
  ▶ Provides an Minimum Average Structural Thickness measurement
  ▶ Leak detection is performed at the same time
  ▶ Cost: 1.0 - 1.5% of the cost of pipe replacement
Pipe Condition Assessment: How it Works

• Acoustic signals induced in pipe by flowing water from hydrants or using acoustic exciters
  ▶ Causes pipe to “breath”
• Velocity of acoustic wave is measured, wall thickness is calculated from propagation delay
• Derive *Minimum Average Wall Thickness* for typically 300 – 400 feet sections
Case Study: City of Newark

- Condition assessment performed on section of 1890s era 6” cast iron pipe
- Service leak discovered
- 3 coupon samples extracted along street to confirm
- Pipes in area were part of Concrete Mortar relining program
Pilot Study in Newark
Pilot Study in Newark

This is the remaining structural thickness!
Case Study: Las Vegas Valley Water District

- LVVWD planned to replace 6.5 miles of 16” to 36” bar-wrapped steel cylinder transmission main on Las Vegas Blvd
  - Expected to spend $10,300,000
- Identified mains that did NOT need rehab or replacement
  - Only 15-20% of pipe sections had lost >15% of pipe wall thickness
  - Degraded mains were prioritized for renewal
- LVVWD reallocated over $2M budget to other projects
Pilot Study - LVVWD

• Two Sections of 6” AC pipe tested
• Excavated 6” Pipe to confirm our results
• Also tested a 24” AC pipe
  ▶ Showed it was in good condition
LVVWD Contract

- LVVWD standardized on acoustics testing for AC Pipe based on confidence and repeatability
- To date have assessed approximately 30 miles of AC in Las Vegas, NV
- Most AC in excellent condition
- Several areas of degraded AC pipe found
- Case Study: 14” pipe assessed to be approximately 30% degraded
Serviceable Lifetime Prediction: What is it?

- Models developed to predict remaining serviceable life based on condition assessment measurements
- Based on the measurement results and current loading conditions of the pipe (pressure and depth), an estimate will be provided on how many more years the pipe can be used
- Provides an accurate idea of when in the future the pipe will need to be rehabilitated or replaced

*Translation*: When to spend capital on this pipe section?
Serviceable Lifetime Prediction: How does it work?

- The Failure thickness is predicted by calculating the minimum required thickness to carry the given loads.
- The loads include: internal pressure from the water column and external pressure from the soil and traffic loads.
Summary - Creating New Options
Master Planning Pipe Improvements

- Capital Improvement Programs lack Direct condition data
  - Joint leaks often false indicator of pipe condition
  - Relining programs ineffective on pipes lacking structural integrity
  - Estimate 70% of replaced pipes have remaining life

- Leakage
  - Pipe Replacement Programs do not typically address service leaks, estimated to be 2/3 of the leaks in distribution networks
  - Conventional leak detection fails on Plastic / Asbestos Cement

<table>
<thead>
<tr>
<th>No Condition Assessment (Historic Practice)</th>
<th>REPLACE: $150-400/ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition Assessment</td>
<td>REHAB: $50-200/ft</td>
</tr>
<tr>
<td></td>
<td>GOOD PIPE: $0</td>
</tr>
</tbody>
</table>
Summary

• Utilities need to understand the condition of their assets
• Much of the pipe is in excellent condition and has significant remaining life
• There are several assessment options available to utilities, both indirect and direct assessment options have a place in the assessment process
• Acoustic assessment has distinct advantages over other methods of direct assessment, but is complementary with other techniques
• Utilities should undertake some kind of assessment for their pipe assets
Questions?