COMPREHENSIVE INSPECTION AND CONDITION ASSESSMENT OF DUCTILE IRON FORCE MAIN PIPES

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT
Team

- MMSD / Owner - set goals for risk vulnerability assessment and capital planning
- Corrosion Engineer – Corrosion Control Technologies
- Pipeline Inspection and Condition Analysis Corp. (PICA) – Pipe Condition Inspection and Assessment with RFT
- Flo-more – Pipeline PIG Cleaning
- National Power Rodding – Pipe STI
- Local Mechanical Contractor – Access to the Pipe
- Owner’s O&M staff – work around pipe outages
- Donohue & Associates – Engineer, coordination of team members and activities
MMSD System

- MMSD provides wastewater services for 28 municipalities in the Milwaukee area.
- MMSD recognized for innovation in resource recovery, energy, green infrastructure, and overflow reduction.
- The MMSD conveyance system includes 54 miles of pressure sewers including force mains and siphons.
- MMSD is conducting a pressure sewer condition assessment master plan.
Interplant Biosolids Pipeline

Interplant Solids Pipeline

- Primary Sludge
- WAS & Digested Sludge

Phase I Dewatering
IPS Junction Structure
IPS Pump Station

South Shore WRF
Send WAS (20-40 dt/d)
Send DSD (20-50 dt/d)

Jones Island WRF
Send PSD (10-50 dt/d)
Interplant Biosolids Transfer Pipeline

- 12 mile pipeline
- Commissioned 1990
- Two 12-inch pipes
- Two 14-inch pipes
- Heavy class 54 DIP
- Cathodic protection for most of the pipe
- Three failures on plant site in the past 5 years
Greenfield Park Force Main

- 1/2 mile force main provides for wet weather flow transfer to a higher capacity interceptor system.
- One 24-inch DIP with poly wrap coating
- Pipe joints bonded but no cathodic protection
- Operates 20-50 days per year
Pipe Assessment Goals

- Reduce the likelihood and consequence of force main pipe failures, avoid unplanned emergencies
- Establish programs and procedures to monitor force main pipes condition
- Provide information for infrastructure capital planning and budgeting
- Quantify the pipe condition
- Target repairs to specific pipe locations or conditions
- Identify cost effective repairs to extend the pipe service life and reduce life cycle costs
Pipe Failure Modes

- Blockage / Restriction
- External Corrosion Leak
- Internal Corrosion Leak
- Structural Failure / Collapse
- Service Life Expired
Pipe Corrosion Considerations

- External Corrosion – Soil and Water Conditions
  - DIPRA 10-point soil corrosivity index used
Pipe Corrosion Considerations

- Internal Corrosion – H2S and Bacteria Conditions
  - Can be an issue for force main not flowing full due to uneven grade, unvented high points, corrosion occurs at pipe crown/soffit

- Corrosivity of the soils

- Cathodic Protection or Not

- Pipe Coating System
  - Bonded (paint)
  - Un-bonded (polyethylene encasement, baggy)
Pipe Corrosion Considerations

- Cathodic Protection System
- Impressed current system to provide high current required to protect under polyethylene encased pipe.
- Redundancy for system components
Pipe Inspection Alternatives

- Failure history – (date, location, type/cause)

- Inspection via pipe excavation
  - Select locations (corrosive soils, high points, failures)
  - Visual with sandblast to remove graphitization
  - Ultrasonic thickness testing at observed corrosion sites

- CCTV
  - Internal condition visual (blockages, cracks, leaks), not wall thickness or corrosion degradation

- Acoustic sensing
  - Identifies existing leaks and air pockets, may identify H2S
Pipe Inspection Alternatives

- Laser profile
  - Internal blockages or deformities
- Electromagnetic
  - Measure pipe wall thickness
  - Identify and locate deep corrosion pits

Figure B1: RFT stripchart display.
Pipe Inspection Constraints

- Force main has no redundancy
- Force main must be operated routinely
- Access to the force main is limited (pump station pipe access, PIG station?, force main route is below street)
- Force main distance makes bypass pumping impractical
- Can flow diversions temporarily reduce need for force main?
- Can the inspection device be sent via pumped wastewater?
The inspection program included:

- Two excavations with external visual inspections covering cathodic protected and unprotected sections
- Electro-magnetic inspection of ½ mile section covering cathodic protection and non-cathodic protection sections
- Two excavations with external visual inspection in severe duty area (variable ground water, salt storage, damaged cathodic protection system)
Biosolids Transfer Pipeline

- Excavation to access pipe
- Poly Wrap Pipe Coating System
Biosolids Pipeline Visual Inspections

- Visual Inspection Poly Wrap Pipe, No Cathodic Protection
- Visual Inspection Poly Wrap Pipe with Cathodic Protection
Biosolids Pipeline Visual Inspections

- Visual Inspection – Poly Wrap, No Cathodic Protection, Pre Sand Blast
- Visual Inspection – Poly Wrap, No Cathodic Protection, Post Sand Blast
Biosolids Pipeline Visual Inspections

- Visual Inspection – Bonded (Paint) Coating, Cathodic Protection, Pre Sand Blast
- Visual Inspection – Bonded (Paint) Coating, Cathodic Protection, Post Sand Blast
The Electro-Magnetic inspection program included:

- PICA requires assurance of clear pipeline
- PIG cleaning to confirm no obstructions
- Install temporary PIG launch and catch stations, (long enough to also accept the PICA See-Snake)
- Use the pipeline pump system with flush water to PIG clean and to slowly pump the See-Snake
- Restore the pipe at the temporary PIG stations
Biosolids Pipeline PICA Inspection

- Pipeline Inspection and Condition Analysis Corp. provides electromagnetic inspection of pipe wall thickness

- Pipe must be verified to have no restrictions – PIG Cleaning Station

- PICA See-Snake Inspection Tool pumped through the pipeline.
Biosolids Pipeline PICA Inspection

- PICA inspected 2,928 feet of 12-inch force main, (total length >50,000 ft).
- Plant site pipe does not have cathodic protection
- Off plant site pipe does have cathodic protection
- PICA inspection tool pumped with flush water from on-site excavation to off-site excavation
The PICA inspection showed a significant difference in the number and depth of corrosion pits between the CP protected section and the non-protected section.
Biosolids Pipeline PICA Inspection

- Although the average pipe wall thickness is nearly 90%, there are numerous corrosion pits including 3 pits of 0% - 10% remaining wall thickness.

Table 1 summarizes the RFT inspection results for the 12-in wastewater pipeline.

<table>
<thead>
<tr>
<th>Feature Indication Summary</th>
<th>Launch Contract</th>
<th>Retrieve Contract</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Inspected length (ft)</td>
<td>1424.9</td>
<td>1404.5</td>
<td>2927.8</td>
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<tr>
<td>Number of pipe sections</td>
<td>82</td>
<td>88</td>
<td>170</td>
</tr>
<tr>
<td>Number of analysed pipe sections</td>
<td>71</td>
<td>83</td>
<td>154</td>
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<tr>
<td>Number of push-on joints</td>
<td>71</td>
<td>63</td>
<td>135</td>
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<tr>
<td>Number of flanged connections</td>
<td>1</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Number of restrained joints</td>
<td>0</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Number of Vertical Bends/Elbows</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Number of Horizontal Bends/Elbows</td>
<td>6</td>
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<td>6</td>
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<tr>
<td>Number of Tees</td>
<td>2</td>
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<td>2</td>
</tr>
<tr>
<td>Number of Unidentified Features</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Average Wall Thickness (%NWT)</td>
<td>89.3%</td>
<td>92.3%</td>
<td>90.9%</td>
</tr>
<tr>
<td>Number of pipes without localized wall loss indications</td>
<td>37</td>
<td>57</td>
<td>94</td>
</tr>
<tr>
<td>Number of pipes with localized wall loss indications</td>
<td>36</td>
<td>25</td>
<td>61</td>
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<tr>
<td>Number of pipes with Through Hole (TH) indications</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
Biosolids Pipeline
Conclusions & Recommendations

- Cathodic protected section of pipeline in good to very good condition, with 50 years or more of remaining service life.

- Implement repairs to the cathodic protection system, monitor its operation and performance

- The non-cathodic protected section of the pipeline on the SSWRF plant site will be repaired:
  - Use PICA “Dig Sheet” to locate and repair the 3 deep corrosion pits
  - Install cathodic protection system on the pipeline to mitigate further corrosion
The inspection program included:

- No excavations, entire pipeline length was inspected by PICA’s See-Snake
- Assure clear pipeline with visual inspection by sewer televising
- Use cable and winch system to send See-Snake through the pipe
- Schedule activities with a minimum 3 day clear weather forecast
Sewer televising selected for pre-inspection

- The 2,800 foot length was just within STI capability of National Power Rodding (up to 3,300 feet). This length cannot be met by most STI contractors.
- STI camera tractor installs 5/8” rope (mule tape) as it is pulled back following the inspection
- Rope used to pull through PICA winch cable
- STI crew was just able to traverse the full length, camera tractor was struggling near the end
Wet Weather Force Main PICA Inspection

- Pump Sta. discharge pipe disassembled for inspection access
- PICA See-Snake Inspection Tool staged for winch pull through the pipe.
Wet Weather Force Main PICA Inspection

- Force main discharge manhole, PICA winch pulling See-Snake

- See-Snake Inspection Tool pulled out of the force main manhole.
The PICA inspection showed several corrosion pits of 20% or less remaining wall thickness.
This force main operates intermittently and residual solids lay in the bottom of the pipe. There is a high concentration of corrosion pits at the pipe invert.
The higher concentration of deep corrosion pits closer to the pump station suggest galvanic corrosion (pipe was not constructed with electrical isolation from the pump station.

Corrosion pits at the pipe invert could be from microbiologically influenced corrosion (MIC) or from tears in the polywrap at the pipe invert due to careless installation.

Root cause of corrosion cannot be determined without visual inspection.
Several deep corrosion pits significantly raise the risk for pipeline leak

Repair options include:

- Use PICA “Dig Sheet” to locate and repair the deep corrosion pits or replace pipe segments
- Electrically isolate the pipe from the pump station
- Install cathodic protection system on the pipeline to mitigate further corrosion
- Install CIPP liner system or slip lining
Wet Weather Force Main Condition
Conclusions & Recommendations

- If MIC corrosion, solution is pipe lining or pipe replacement ($1.4M - $1.9M).
- If external / galvanic corrosion, solution is spot repairs + electrical isolation + cathodic protection system ($0.4M).
- Conduct excavation(s) with visual inspections to confirm the corrosion root cause.
- Design the pipe remediation based on the root cause.
- Assess aged force main pipes for vulnerability and risk mitigation
- Force main assessments are challenging
  - Avoiding will lead to unplanned emergencies
  - Fit the inspection methods to the force main constraints
- Ductile iron force mains will have a long service life if well installed and well maintained
- Make a plan and follow it through