Inspection and Assessment of Large Diameter Concrete Pipelines
About Pure Technologies

30+ Years of Pipeline Management Experience
22,000+ Kilometers of Transmission Pipeline Data
500+ Individual Pipe Repairs Managed

Inspecting and monitoring PCCP since 1997

Partner with Xylem in the Middle East
Value of Collecting Actual Condition Data
Changes Risk Profile of the Pipeline

Before condition assessment

After condition assessment
Finding the “Weak Links”
Not All Old Pipe is Bad Pipe

1. Find the weak links
2. Repair
3. Manage pipeline
“Assess and Address” Approach

Understand: Formulate an assessment method based on the pipeline’s characteristics, failure mode, background, history, and context.

Assess: Collect relevant and actual condition data over the length of the pipeline.

Address: Take immediate action on repairing or replacing pipes based on assessment.

Manage: Consider long term capital planning, re-inspections, and preventative methods to further reduce risk.
Technology Selection through Risk Assessment

- **LOW**
  - Hydraulic Study
  - Correlators
  - Corrosion Survey

- **MEDIUM**
  - Inline Acoustic Survey
  - Inline Pipe Wall Screening

- **HIGH**
  - Hi Resolution Inline Scan
  - Inline Mapping

**Priority**

**RESOLUTION**

**COST**

**Reliability**

**Structural Model**

**Statistical Life Cycle Analysis**
A prestressed wire is wrapped helically around the pipe and gives it the strength to withstand the pressure of the fluid inside.

- PCCP can range in size from 24” (600mm) to 20’ (6m) diameter
- Generally a good material
Concrete Pressure Pipe

- AWWA C300 Reinforced Concrete Cylinder Pipe (RCCP)
- AWWA C301 Prestressed Concrete Cylinder Pipe (PCCP)
- AWWA C302 Reinforced Concrete Pipe (RCP)
- AWWA C303 Bar-Wrapped Pipe (BWP)
Bar-Wrapped Pipe
Reinforced Concrete (Cylinder) Pipe

C300 RCCP

C302 RCP
Concrete Pressure Pipe

- DYWIDAG-Sentab-pipe (DS)
- Brespa-pipe
- Zueblin-pipe
- Arkel-pipe (AR)
- Bonna-pipe (BO)

A steel cylinder made of rolled steel plates welded lengthwise or helically with welded end-rings.

A steel reinforcement made by helical winding of a steel wire at a constant pitch.

A double concrete coating with a very smooth concrete inner surface giving an excellent and permanent hydraulic flow coefficient and an outer reinforced concrete wall.

BONNA Pipe is complying with AWWA C300 and EN 639 - 641
Why do we Monitor PCCP?

- The prestressed wires can fail over time.
- Corrosion, stress, and embrittlement can cause the wires to break.
- Failures usually occur without warning.
PCCP Deterioration

- Cracking of Outer Mortar
- Corrosion or Embrittlement of Wires
- Wires Break
- Mortar Coating Delaminates
- Concrete Core Delaminates
- Core Cracks
- Failure
Deterioration of Wires

- Dissolution corrosion (rusting)
- Hydrogen embrittlement
Focus of Assessment Programs

Wire break damage
PCCP Management
Toolbox Approach Required

1. Desktop Study
2. Leak Detection
3. Internal Inspection
4. Engineering Evaluation
5. Repair/Rehabilitation
6. Long Term Monitoring

Find and correct existing problems

Manage pipeline to avoid future problems
We *believe* that using a *risk* based approach to deploy *complimentary* technologies to collect *robust* condition data facilitates *cost effective* pipeline management strategies.
Leak Detection
Benefits for Concrete Pipelines

- Reduce water loss
- Can identify pipes in advanced state of deterioration
- Find leaks at joints
Large Diameter Leaks are “High Value” Leaks
Volume loss 20x greater than small diameter mains

- Small and medium leaks are hard to find with external tools
- Inline technologies **bring the sensor to the leak**

**SmartBall®**  
**Sahara™**
SmartBall Leak Detection
Accurate Leak Detection for a Variety of Industries

Over 20,000 Kilometers of Pipeline Inspected
SmartBall Inspection Process

• Ideal for long transmission mains
• Up to **40km** can be inspected in **one day**
• Pinhole leaks detected, even at low pressures down to 1 bar
Sahara Leak Detection
Proven and Reliable Tethered Platform with CCTV

Over 1,000 Kilometers of Pipeline Inspected since 1999

WATER
SEWER
Sahara™ Leak Detection
Proven and Reliable Tethered Platform – Hundreds of Kilometres since 1999

- Tethered cable provides high degree of operator control
- Platform technology offers leak & gas pocket detection as well as video inspection
Visual and Sounding
Find pipes in a state of incipient failure
Electromagnetic Inspection
Detect, locate and quantify broken wires
Electromagnetic Inspection Data Analysis

- Functions like a radio transmitter and receiver
- Transmitter produces electromagnetic field which is amplified by prestressing wires
- Receiver captures the signal and:
  - Detects and quantifies wire break damage
  - Provides estimate of wire breaks in each pipe section
  - Provides location of wire breaks
Electromagnetic Inspection Data Analysis

Wire Breaks

EM Data

Pipe Number

370 Joint
371 Joint
372 Joint
373 Joint
374 Joint
375 Joint
Electromagnetic Inspection Platforms

**PipeWalker**
- Diameter: 900mm +
- Line Preparation: Dewatered
- Manned system

**PipeScanner**
- Diameter: 450mm +
- Line Preparation: 3 pipe segments excavated to crown
- Manned system

**PureRobotics™**
- Diameter: 450mm +
- Line Preparation: Depressurized
- Robotic with EM, CCTV, SONAR, laser, mapping, etc.

**PipeDiver™**
- Diameter: 400mm +
- Line Preparation: In Service
- Free swimming
PipeWalker
PipeDiver
Inspect Pipelines Without Shutdown or Dewatering

Free-Swimming Inspection for Concrete and Metallic Mains

Over 1000 Kilometers of Pipeline Inspected
PipeDiver Inspection Family

Mini PipeDiver
400-750mm

Small Diameter PipeDiver
600mm – 1200mm

Large Diameter PipeDiver
1200mm – 3000mm
PipeDiver Insertion and Extraction

- Launch
- Reservoir
- Chamber
- 12" Hot Tap
- Open Channel

- Retrieval
- Chamber
- Surface Tracking
- 12" Hot Tap
- Reservoir
- Open Channel

300 mm Hot Tap
PureRobotics
Inspect Pipelines Without Shutdown or Dewatering

Long-Range, Modular, Powerful Robotic System

Safely Inspects 16”–120” Pipelines
Robotic System Components

Operator Control Station

Umbilical Winch / Power Supply

Robotic Crawler
Data Quality (Spalling with EM anomaly)
Large Diameter Configuration

- PCCP 60” up to 120”
- 24” min access (some configurations can fit 18”)
- Various configurations of large diameter to suite application
- Currently requires manned entry to set up
Structural Analysis & Engineering Evaluation
How Many Wire Breaks is Too Many?
Recommendations

• Repair/Replace Individual Pipe Sections

• Long-Term Management Solutions
Repairs

- **External**
  - Encasement
  - Pipe replacement with closure piece
  - Post-tensioning
- **Internal**
  - Steel lining
  - Steel pipe liner
  - CFRP hand lay-up repair
  - HDPE slip-lining repair
1. Desktop Study
2. Leak Detection
3. Internal Inspection
4. Engineering Evaluation
5. Repair/Rehabilitation
6. Long Term Monitoring

Find and correct existing problems

Manage pipeline to avoid future problems
SoundPrint® AFO
Fibre Optic Monitoring of Critical Water Infrastructure

1000KM of Pipeline Currently Being Monitored Across the Globe.
Manage the Pipeline
Acoustic Fibre Optic Monitoring

Data Acquisition System

Fiber Optic Cable

Data Analysis

E-mail Notification
How Does AFO Work?
3 Main Components

1. The Data Acquisition Unit (DAQ)
   • IDENTIFIES events and saves the information

2. The AFO Cable
   • One fiber LISTENS to the pipeline (acoustic fiber)
   • One fiber LOCATES the wire break along the length of the pipeline (locating/OTDR fiber)

3. Exit Details
   • Mechanical components permanently mounted to pipe to protect the AFO cable
Case Study – Non-Linear Deterioration

- EM inspection in March 2006 shows 5 WBs on “Pipe 83”
- August 2008: First acoustic wire break (29 months after EM inspection)
- April 2011: Second acoustic wire break (another 32 months later)
- June 1 & 2, 2012: 4 acoustic wire breaks raises some concerns
- June 11: one more wire break

Detailed on next slide
Case Study – Non-Linear Deterioration

- **Rapid acceleration of damage**
  - 13 wire breaks in 26 days (Pipes 81 & 82)

  - **August 3 to 6**: 3 WBs in 4 days.
  - **August 9**: Client decides to repair pipe as part of scheduled January 2013 pipeline shutdown
  - **August 11**: 1 WB,
  - **August 12**: 2 WBs,
  - **August 13**: 6 WBs.
  - **August 14**: Client reduces pressure to 80 psi.
  - **August 17**: Full pipe excavation.

  Single acoustic wire break July 18 (first in 5 weeks)
Case Study – Non-Linear Deterioration

- Reported Wire Break Location Distribution (before adjustments after impacts performed right on pipe joint)

Wire breaks concentrated in a 9’ region
Case Study – Non-Linear Deterioration

- Excavation
- Damage immediately evident
- Inspecting the damage
- Wire Breaks
- Damage concentrated in 9’ section
- Close up of the damage
WSSC Inspection and Engineering Services Program

- 8th largest utility in the US
- 8,900 km water pipelines
- 8,500 km wastewater pipelines
- Over 225 km 1000mm and larger PCCP water transmission mains
WSSC Inspection and Engineering Services Program

- Internal inspection of 1200mm and larger PCCP transmission mains
- Robotic inspection of 1000mm to 1100mm PCCP transmission mains
- Acoustic fiber optic monitoring in all PCCP inspected

- And so much more......
WSSC Inspection and Engineering Services Program
200+ km of 1200mm and larger PCCP inspected to date

More than 30 pipes identified in a state of incipient failure

Over 250 individual pipe repairs

Only 1.5 km of 1400mm PCCP recommended to capital program

AFO monitoring in all transmission mains inspected

20+ interventions based on AFO abating failures
Case Study:
Palo Verde Nuclear Generation Station, Arizona

Since 1998, the largest nuclear plant in U.S. deploys Manned Entry and PureRobotics® for PCCP condition assessment of its Water Reclamation Pipeline

- PureRobotics® electromagnetic condition assessment
- Manned Entry for visual and sounding inspection
- Risk prioritization

Program Highlights

- Pure surveys 37 miles of PCCP main over 18 years
- 5 mobilizations & total of 18 separate electromagnetic inspections
- PVNGS conducts over 500 repairs to date
- Inspections typically performed using PureRobotics and Manned Entry

<table>
<thead>
<tr>
<th>PIPE MATERIAL</th>
<th>LENGTH</th>
<th>DIAMETER</th>
<th>TRANSMISSION TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCCP</td>
<td>37 miles (59.5 km)</td>
<td>96 to 144-inch (2440 to 3660-mm)</td>
<td>Treated Wastewater</td>
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</tbody>
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Case Study: NORTH AMERICAN STEEL MILL

This North American steel mill deploys PureRobotics for PCCP condition assessment and visual inspection on recirculating water lines.

- PureRobotics electromagnetic condition assessment
- PureRobotics HD-CCTV inspection
- Risk assessment and prioritization
- Single day mobilization and inspection

Program Highlights

- **0.68 MILES** total distance inspected
- **117** pipes inspected
- **31** pipes with broken wire wraps
- **25** repaired and replaced pipes

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<th>INSPECTION LENGTH</th>
<th>DIAMETER</th>
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</thead>
<tbody>
<tr>
<td>Lined Cylinder and Embedded Cylinder Pipe (Thrace of BCCP)</td>
<td>0.68 miles</td>
<td>48-inch &amp; 54-inch</td>
<td>Recirculating Water</td>
</tr>
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</table>
Finding the “Weak Links”
Not All Old Pipe is Bad Pipe

1. Find the weak links
2. Repair
3. Manage pipeline
Condition Assessment Viewer
Pipeline risk is color coded
Each pipe segment is plotted with, xyz coordinates, pipe segment risk is displayed based on color.
Another view
Street View to Evaluate Consequence of Failure
Click on Pipe Segment 26-8 for More Info...
Pipe Segment 26-8
26-8 Real Time Risk Calculation

FEA Curve

Pressure (psi)

Wire Breaks

Repair / Replacement
No repairs / replacements.

Laying Schedule Information
Contract: 64-2534
Design Note: Straight - Open 1st JT 1/2" on Top LT
Inspection Date: 16:03
Pipe No.: 26-8
Length: 16:03
Start Station: 440:24:50
Condition Summary of Pipeline
Questions?
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