CPM PIPELINES

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ACQUARIUS

In-line Inspection Technology

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With on-board ultrasonic testing (UT) circumferential scanning sensors and internal mapping unit (IMU), the Acquarius is a diverse in-line inspection tool designed to use in different types of pipes and materials. Acquarius' sensors record the condition of many miles of transmission, pressure or sewer pipelines in a single run with minimal shut down. Once the inspection is complete, the data from the onboard data logger is verified and uploaded to the cloud where Acquaint's analytics team begins analysis for reporting. The tool is designed to provide high-quality, accurate data in a wide range of applications, service conditions and pipeline environments. Collected data provides insight into the condition, risks and lifetime of the inspected pipeline. This ultra flexible, configuration friendly, and reliable tool provides wall thickness measurements, ID changes, precise pipe geometry, joint defects, leak and air pocket detection, pipe ovality, delamination, AC leaching (degradation of asbestos cement), and plots XYZ locations. Acquarius's comprehensive report helps set maintenance and management priorities based on data driven results. Asset managers can predict and repair pipeline damage before it occurs. This proactive approach provides data driven insights to set actionable decisions with known budgets for rehabilitation, eliminating disruptive pipe breaks, and associated environmental and economic impacts.

INSPECTION SEQUENCE

The sequencing of the inspection is broken into pre-inspection, inspection, and post-inspection phases. The tasks involved in each of these phases is summarized below.

Pre-Inspection Phase

- Scope definition
- Project planning
- Role and responsibilities
- Pig configuration

Inspection Phase

- Mobilization
- Last minute risk assessment
- Pipeline cleaning
- Plotting marker points
- Perform "dry" ILI run (if needed)
- Perform true run
- Data verification

Post Inspection Phase

- Remove markers/equipment
- Demobilization

> "The results were impressive. In less than four hours, the tool had charted over a mile of pipeline."

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The Acquarius deliverable provides great insight into the current condition of the pipeline and serves as foundation for remaining useful life calculations, finite element analysis and risk curves. Structural calculations, finite element analysis, and risk curves provide the foundation for determining remaining useful life. Capital improvement decisions can be reached based on the data including pipeline rehabilitation or replacement and which area(s) of the pipe to prioritize. The data gathered during the inspection is compiled in a straightforward report and deliverables include a geographic shape file (Shape/GIS/RD) with the results of the inspection. A summary of information obtained as part of the inspection is included in the table below.

A complete condition assessment in one run, with minimal downtime.

INSPECTION DATA

Information Collected and Accuracy	Data Format
Deviating location	GIS / XLS or HTML
XYZ Mapping (0.5 m)	GIS / XLS or HTML
Leaks (>13.0 dB)	GIS / XLS or HTML
Wall thickness (0.49 mm)	GIS / XLS or HTML / C-scan
Joint Angular Displacement, vertical and horizontal (0.25º)	GIS / XLS or HTML per joint
Joint Gap Width (4.0 mm)	GIS / XLS or HTML per joint
Ovality (0.5%-point)	GIS / XLS or HTML
Axial Deformation (0.2 m)	GIS / XLS or HTML
Air Pockets	GIS / XLS or HTML
Debris	GIS / XLS or HTML
Wire Breaks (non-cylinder pipe)	GIS / XLS or HTML

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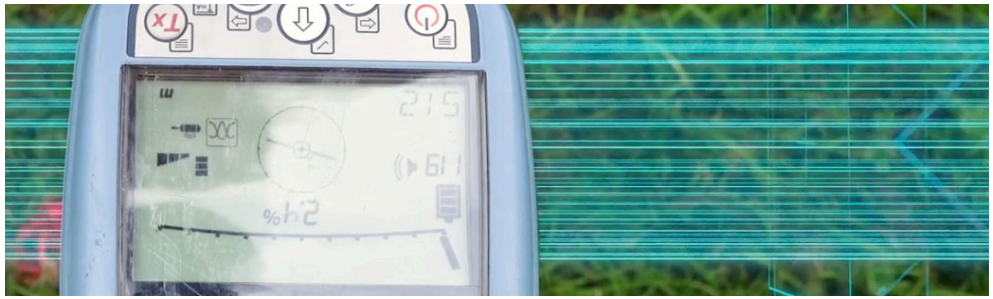
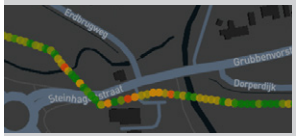


DETAILED DATA POINTS

Location Data

Location data is obtained through magnetic, accelerometer, and gyroscopic technology. The data is calibrated and corrected by using physical markers placed along the alignment that connect with the sensor in the Acquarius tool. The markers are placed roughly 500-feet apart prior to the deployment of the tool and are not required to be placed directly above the line (within 60-feet).

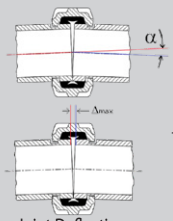


If a deviation is observed, it will be indicated in the final analysis data. Changes in the pipeline material are also detected by the tool including the location of transitions. XYZ coordinates are provided in the National Triangle Coordinate system with the 'Z' coordinate being the deviation from the connection, causing the value to vary around the zero position. Location data is included in GIS format for the final deliverable. This information serves as a valuable addition to refine existing GIS databases with accurate geographical pipe alignment data.

Joints and Connections

The state of pipe segment connections is reported in three values: angular rotation (horizontal and vertical) and joint width. Angular rotation corresponds to the angular displacement reported per joint over 20-centimeters from the center of the joint in both directions.

Angular joint displacement output carries a resolution of approximately 0.125 degrees with an inspection speed of about 0.2 meters per second. The angular displacement is reported in two values: horizontal (rotated left or right) and vertical (rotated up or down). Joint width is based on the distance and time traveled and the detected internal diameter change at the joint (via ultrasonic measurements). There are cases where joint width is not detected, for example, when joints are obscured by sediment or other debris. In such cases, it can be possible to determine joint width based on the amplitude of the ultrasonic signal. The detectability of joints can also be beneficial in circumstances where joints were (or were intended to be) grouted during installation and have deteriorated or failed to be grouted initially.



Joint Deflection Analysis

When joints are detectable, they are reported in the feature list of the deliverable. The accuracy of the measurement depends on the inspection speed and measurement speed.

What does Acquarius measure?

Depending on the pipe material, the Acquarius provides a complete condition inspection and assessment, measuring:

Degradation of healthy wall thickness:

- **Corrosion in metals (remaining wall thickness)**
- **Leaching in AC (remaining structural density)**
- **H2S deterioration**

Condition of a joint:

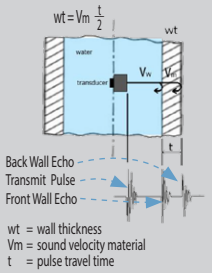
- **Angular displacement (vertical and horizontal)**
- **Joint gap width**

Also measures:

- **Ovality**
- **Axial deformation**
- **Leaks**
- **Wire breaks in reinforced non-cylinder concrete pipelines**
- **Plots XYZ locations**
- **Contamination or debris at the bottom of the pipe**
- **Gas pockets**

Wall Thickness Measurement

Ultrasonic sensors within the Acquarius tool provide data surrounding the pipeline wall thickness. The sensor measures the detection of sound reflections based on variations of the host material. The time difference between sending and receiving the signal is measured and interpreted to produce pipe wall thickness (t in the figure) data. The speed of sound through the materials and liquids encountered is known and therefore wall thickness can be calculated. Our team of engineers and experienced operators allow for the necessary QA/QC processing of the data.



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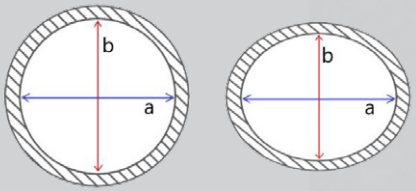
DETAILED DATA POINTS

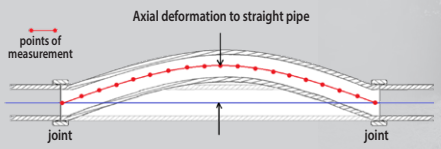
Pipeline Deformation

The internal diameter of the pipeline is determined based on the ultrasonic measurements. The first reflection of the sensor corresponds to the inner radius of the pipeline and therefore ovality/ roundness can be detected.



Ovality/Roundness Detection

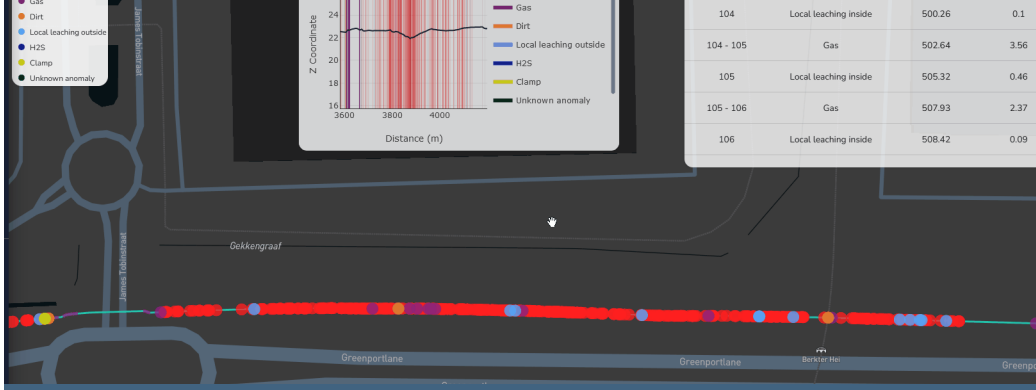
Axial deformation is also detected during the inspection based on deviations from a straight pipe. The deformation is determined per pipe section (joint to joint) as shown below.



Axial Deformation Detection

Leak Detection

A hydrophone on board the Acquarius tool continuously records sound during the inspection. When local deviations of the sound spectrum are detected, its location is recorded as an area of a potential leak. When a potential leak is detected, further investigation can be utilized to determine the true nature of the anomaly.

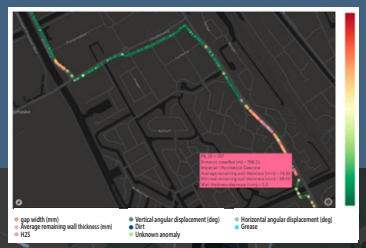


104	Local leaching inside	500.26	0.1
104 - 105	Gas	502.64	3.56
105	Local leaching inside	505.32	0.46
105 - 106	Gas	507.93	2.37
106	Local leaching inside	508.42	0.09

Deliverable

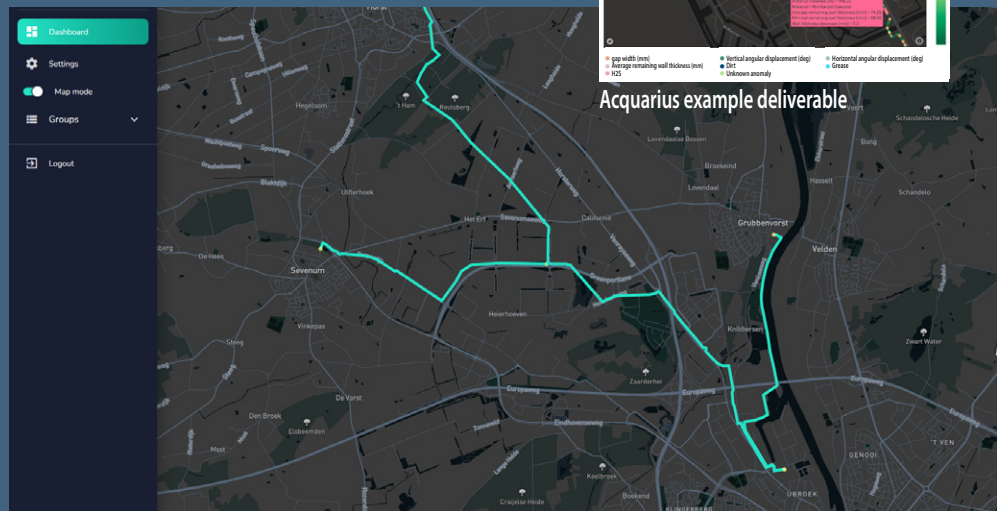
The deliverable includes a summary report including executive summary and spreadsheet of anomalies detected. As stated, it shall also include a summary of findings in GIS format. A sample output of an inspection is shown below, illustrating the various data points gathered and the geographical representation of the locations of points of interest. The data can also be reviewed through an optional 3D HTML dashboard containing a comprehensive overview of the pipeline anomalies.

Acquarius's sensors assess the condition of transport, pressure and sewer pipes in a single run: https://www.youtube.com/watch?v=pG45U2mGvbg



Acquarius example deliverable

Acquarius dashboard screenshot



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