UnPiggable Pipeline Case Studies; Actual Pipeline Inspections with InVista™ Ultrasonic ILI tools

5th Pipeline Technology Conference 2010
April 19-20, 2010

InVista™ High-Fidelity Ultrasonics Technology

- Highest Resolution Direct Measurements
- 100% Overlapping Axial & Circumferential Coverage
- Eliminated Surface Contact Noise by Applying Ultrasonic Immersion Technique
- Absolute Measurements to 0.005” Accuracy
- Between 2,500 & 7,500 UT Measurements per Linear Foot
InVista™ Measurements Capabilities

- Pipe Diameters from 3” – 12” both Traditional & Unpiggable
- “Absolute” Measurements of both Wall Loss & Full Geometry
- Circumferential and Longitudinal Location of Defects
- Defect Discrimination between Pipe Interior and Exterior
- Inspection Distance up to 25 Miles to 100 miles extended survey distances.

InVista™ Full Navigational Capabilities

- Tight Bend Radius at 1.0 Diameter (1D) and Greater Than 90 Degrees
- Pipe Diameter and Wall Thickness Changes
- No Launcher or Receiver Facilities (refinery and station piping)
- Single Entry and Exit point (vaults, offshore and loading lines)
- Reduced Port Valves
- Low Flow or No Flow Conditions (delivery and tank farm pipelines)
- Above Ground Piping with Multiple Underground Section (road crossings)
- Pipelines with poor or missing construction and maintenance data
Case Study InVista™ 4” Pipeline

• 4” crude pipeline 1.7 miles in length with 1.5 D bends.
• Out of service due to pin hole failure.
• Survey performed in water
• Pipeline extremely dirty with high paraffin content
• Pipeline inspected with InVista with no modifications to the existing structure
• Data allowed operator to comply with PHMSA corrective action order
Case Study - 4" Crude Pipeline (InVista™ 2D Data Display)

- 7 major flaws detected with InVista™
- Corrosion and pitting damage mechanisms
- Customer verified each flaw with an alternate manual NDT method (i.e. pit gauge and/or manual ultrasonic scope)
- Repairs were made to all areas based upon InVista™ inspection results

InVista™ Inspection Data vs. Excavations
External Corrosion - InVista™ Output

Deformation Dent - InVista™ Output
Above Ground Marker and Tie-in

Photograph of the approximate location of Flaw 9. It is located in this 4" Riser just below the 4" T and just beneath the dock.

Case Study 6" Pipeline External Wall Thinning

- (2) 6" produced water pipelines tied together for approximately 7 miles
- Pipeline pressure 1500 PSI and 150 degrees
- No modifications made to existing pipeline
- 6" pipeline with 1.5D bends and existing launcher and receiver facilities
- Fitness-For-Service delivered in less than 24 hours
External Wall Thinning

- 81.1% Wall Loss
- RSF = 0.278
- MAOPr = 986 psi
- Pipe section replaced following inspection.

3D View of Corrosion
Thinning Data

- 63.2% Wall Loss
- RSF = 0.445
- MAOPr = 1583 psi
- MAOPr based on MAOP on record of the line of 3,200.

External Wall Thinning

- Near 40% wall loss

External Corrosion Area
Case Study 8”, 6” dual diameter products pipeline

• Same location for both 14” existing launch and receive.
• Multi-diameter pipeline was inspected with both a 6 inch and an 8 inch tool.
• Inspected over a mile of pipe beneath city streets with limited access.
• No prior inspections due to tight bends in line.
• Both water and diesel used to propel tool

Large Scale Wall Loss

Representative area of widespread corrosion

Tmm < 0.084 inches
Over 80% wall loss
Smaller Corrosion Flaws

External Flaw at 688 feet
Length = 1.0 in
Width = 0.25 in
Depth = 0.122 in
39% Wall Loss

RSF = 0.699
MAOPr = 1001 psi
B31G = 1415.3

Verified with prove up dig.
Location within an inch.
Wall loss within a percent.

Case Study triple diameter pipeline

• Pipeline was inspected in water with a 4 inch, 6 inch and an 8 inch tool.
• 4", 6", 8" pipeline with 1.5D bends
• Single launch and receive location.
• Nearly 3 miles of total pipeline inspected.
• Legacy line – no original drawings.
Ultrasonic FFS Assessment

- Long flaw found at RR Crossing.
- UT measurement has no problem with encased pipe.
- Fitness-For-Service Assessment allowed operator to restart line.

Case Study
Sulfuric Acid Line

- Refiner operated a 6" Diameter Sulfuric Acid Pipeline which had failed.
- Plant wanted to see if the pipeline was salvageable
- The pipeline contained multiple repairs which had occurred over its lifetime
- FTIS inspection detected and quantified severe areas of erosion damage on the downstream side of several circumferential welds.
- Inspection results provided justification for refiner to build a new replacement pipeline.
- Customer then inspected the new acid pipeline, both as a baseline to accurately monitor future damage and to ensure proper Q/C on root weld penetration
Erosion Damage after Excessive Weld Penetration

Localized Erosion Following The Weld

Root Weld Penetration Analysis on New Pipeline

GW #1 0.16 in. weld protrusion
GW #6 0.15 in. weld protrusion
GW #282 0.09 in. weld protrusion
GW #49 0.09 in. weld protrusion
LifeQuest® FFS & Remaining Life Assessment

Welded Patch with clear corrosion indication

External Corrosion

Inspection of a 8 inch wharf acid line.

Remaining wall thickness less than 0.100 in.

Pipe was rubbing on a support.

Client removed section and verified the damage.
LifeQuest™ FFS & Remaining Life Assessment

New Pipe to Severe Corrosion transition

Fitness-For-Service in road crossing

Inspection of a 8 inch wharf acid line.

$T_{mm} = 0.163$ in.
(33% wall loss)

Corrosion is located under a road crossing.

Satisfies API 579 Fitness-For-Service criteria for continued operation at current operating pressure.
2% Topside Dent

Inspection of a 12 inch petroleum line under the streets in a major metropolitan area.

Over 100 dents detected in 3 mile section.

Radius plots of the worst dent shown here (~ 2%).

Dent is located in the top half of the pipe and thus is a mandatory repair.

LifeQuest™ FFS & Remaining Life Assessment

A 5.5° Dent, 0.117” depth
**InVista™ & LifeQuest™ Data Deliverable**

Key point of market skepticism: We deliver more actionable and timely information – on an automated basis – that is just as reliable (and regulatory credible) as today’s cumbersome, conventional analytical approach?

**FEADent™ Advanced Dent Assessment**

- 3D finite element analysis simulates the formation of a dent and the subsequent pressure cycles.
- A proprietary damage model is used to compute remaining life.
Conclusion; Solutions for Unpiggable Pipelines

High Fidelity InVista™ ultrasonic pipeline inspection applications are available: “improves pipeline integrity management”

LifeQuest™ Fitness-For-Service methodology is applicable to those data sets: “identifies greatest failure risks, targets maintenance and inspection programs”

LifeQuest™ Fitness-For-Service for existing data sets are applicable: “improves performance based pipeline inspection programs”

FEAcrack™ & FEADent™ High level structural assessment, life assessment and certification of the pipeline asset is viable: “maximize the reliable service lifetime of critical pipelines”