High Resolution Ultrasonic In-Line Inspection Using InVista™ at the Ain Dar Area Project in Saudi Aramco

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Quest Integrity Group successfully completed an in-line inspection for Saudi Aramco at its Abqaia Plant (Ain Dar Area) with its InVista pipeline inspection tool. This technology comprehensively inspects non-scrapable pipelines, or those that cannot be inspected by conventional ILI tools. The inspection was requested by Saudi Aramco engineers as part of their maintenance plan to help maintain the integrity of their vast pipeline network.

InVista inspected six 8-inch and one 14-Inch flow lines in Abqaiq field (Ain Dar area). The data collected by InVista identified corrosion at several locations along both flow lines. Selective locations were later excavated, and field verification using conventional inspection techniques confirmed the accuracy of the inspection results. Major modifications to the pipelines were not required. The inspection data was then utilized as the input for a Fitness-for-Service assessment of the pipelines. This information enabled Saudi Aramco engineers to focus on areas of concern and take appropriate action.

Internal inspection of non-scrapable pipelines is a major challenge for Saudi Aramco. The company employs in-line inspection as an effective methodology to maintain pipeline integrity. The use of in-line inspection tools a standard procedure regarding the maintenance of high pressure pipelines. Inspection tools utilizing ultrasound technology have been successfully used for close to 20 years now and have proven reliability, measurement accuracy and robust data. Over the years, the capabilities of this class of tools have been extended, and today a large variety of special tool configurations are available to address a multitude of inspection requirements for the pipeline industry.

With a worldwide aging pipeline infrastructure and increasing economical and regulatory constraints for pipeline operators, pipeline integrity issues are an area of increasing relevance. In many countries, pipeline regulations not only demand inspections or monitoring of structural integrity at certain intervals, but require a continuous process of verification of pipeline integrity and fitness-for-service. In-line inspections complemented by other inspection techniques applied externally are the preferred method for these inspection requirements. Many regulations recommend or require the use of ILI technology because it provides an effective and efficient way to inspect long pipelines within reasonably short time spans. The purpose of an in-line inspection is the detection, sizing and location of flaws and defects within the pipe wall. In other words, the determination of geometric dimensions, which in turn are used as input for the codes applied for integrity assessment.

This paper will discuss the Saudi Aramco project and InVista's ability to inspect difficult pipelines.
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Mohammed Al-Hamad, Quest Integrity Group
InVista™ Full Navigational Capabilities

- High-fidelity ultrasonic inspection for direct measurement of pipeline integrity
- Tight bend radius at 1.0 Diameter (1.0 D) 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 (e.g. vaults, offshore and loading lines)
- Low flow or no flow conditions (delivery and tank farm pipelines)
- Above ground piping with multiple underground sections (road crossings)
- Pipelines with poor or missing construction and maintenance data
- On board data storage
- 100% data coverage with 0.25” resolution
API 579-1/ASME FFS-1 2007
Historical Background

- **Early 1990s** – Joint industry program was established to develop FFS guidelines
  - Sponsors consisted of most of the major oil companies
  - A draft FFS document was prepared by a small group of consultants

- **Late 1990s** – API FFS committee was formed

- **2000** – API 579 was published
  - Recommended practice
  - Targeted to refinery equipment but document was used more widely

- **Early 2000s** – Joint API/ASME committee was formed
- **2007** – API/ASME standard was published
- **2009** – B31G references API 579 as approved methodology
**API 579 explicitly included in B31.G-2009**

The “API 579 Level 2” assessment, when reduced to its simplest form, is equivalent to the Effective Area Method presented herein, and therefore qualifies as a Level 2 assessment for purposes of meeting the requirements of this document.

- Obtain thickness data from in-line inspection (ILI)
- Compute RSF at short segments
- Rank the corrosion damage over the various segments
Level 2 RSF Calculation

Compute RSF for each possible \( s_i \) and find the minimum value.

\[
RSF^i = \frac{1 - \left( \frac{A^i}{A_o^i} \right)}{1 - \frac{1}{M^i_t \left( \frac{A^i}{A_o^i} \right)}}
\]
If $RSF < RSF_a$, the component can be rerated as follows:

$$MAOP_r = MAOP \left( \frac{RSF}{RSF_a} \right) \text{ for } RSF < RSF_a$$

- $MAOP_r$ = Rerated maximum allowable working pressure
- $MAOP$ = Original MAOP
A Brief History

• InVista™ presented to Saudi Aramco New Technology department in Dhahran in 2008
  ▪ Discussed requirements for un-scrapable trunk lines and flow lines
• Several visits and presentations throughout 2009
  ▪ Price discussions regarding replacement costs and comparison to InVista
  ▪ Insufficient budgets – 50 % share with producing department allows trial project
• Discussed specific flow lines for trial in June 2009 and provided proposal
  ▪ Contracted through Aramco services in Houston, Texas due to contracting restrictions of overseas companies within Saudi Arabia
  ▪ Sub-contract Anabeeb for mechanical requirements and cleaning; initial pricing below:
    1. ABGOSP-3 / ABQQ-284 remote header (8” x Sch-40 / Approx. 1,850m (6,068’) in length
    2. ABGOSP-3 / ABQQ-51 N/S T/L (8” x Sch-40 / approx. 2,590m (6,560’) in length)
Trial results

- Scope was changed from AB – 51 due to isolation issues. AB – 242 given as substitute. This caused demands on the capacity of water due to increase in pipeline length.

- 12 days were eventually required to complete the trial project

- Preliminary results were provided followed by a webinar of the final report to Abqaiq NGPD management approximately 28 days after completion of the inspection
  - AB-242 had mainly external wall loss of up to 77%
  - AB-284 had mainly external wall loss of up to 49%

- A request was made by Saudi Aramco to identify dig sites in the field
• After the success during the trial project, Abqaiq NGPD inspection department provided 14 critical lines requiring inspection, this eventually increased to 31. An Anabeb/Quest Integrity Group proposal was issued with several requests for discounts and reductions.

• For budgetary reasons this was reduced to 7 lines within the Aindar area of the North Ghawhar field with a suggested combined length of 38577m. The trunk lines/flow lines have varying challenges such as:
  ▪ Diameters changes
  ▪ Sand / wax deposits
  ▪ Water limitations
## Project Overview

<table>
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<tr>
<th>Pipeline Name</th>
<th>Piping OD (in)</th>
<th>Length (m)</th>
<th>GOSP</th>
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<tbody>
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<td>T/L 172 / 235 / 425 / 440</td>
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<td>ADGOSP-1</td>
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<tr>
<td>FAZRAN</td>
<td>12</td>
<td>24,000</td>
<td>FAZRAN</td>
</tr>
</tbody>
</table>
Equipment Requirements

- The equipment spread allows controlled bi-directional flow rates from each end of the pipeline comprising of:
  - Two specialised DDT pumping units designed for mechanical decoking of fired heaters; the pumps provide 1200 USGPM and up to 1000psi discharge pressure
  - Several 65m³ tanks to provide quantitative of line volume + 30%
  - Auxiliary flooding pumps
  - Launcher receivers and connection spools
  - Containerised messing/office with electrical generators
  - Two 50m³ water tanker/vacuum trucks

- Initial planning involved 24-hour mechanical supply, to allow preparation of the next pipeline in sequence. Prior to commencement Anabeeb/Quest Integrity we informed that this would not be feasible and night shift would not be allowed.
  - We resolved this to a certain degree with a mechanical crew working in advance
• Initial flushing and blinding is the responsibility of Saudi Aramco.
  ▪ We found the lines to contain large volumes of crude of which Anabeeb needed to displace and dispose of by running foam pigs.

• In comparison to sand, we have experienced soft wax deposits that have effected the tool efficiency and data collection quality.
  ▪ We used Bi-Di pigs in order to apply a diesel oil batch in an attempt to remove the wax deposits more efficiently.
Typical Tie-In Launcher Location

- Flow line 135
- Flow line 416
- Trunk line 135 / 416
Launcher Equipment Spread

Note: similar equipment spread is required at receiver.
• Line Fails API 579 Level 2 due to MAOPr

• Line Integrity is Limited by GW-1050
  - GW-1050, MAOPr = 6.85 MPa (993.5 psig)

• 1 Joint to Repair or Replace
  - Repaired MAOPr is 7.56 MPa (1,096 psig)
All Inspections Delivered With LifeQuest™

Converts ILI data sets into synchronized 2 and 3 dimensional views

• Displays 100% of inspection data
• Allows for better defect characterization
• Allows for simultaneous visualization of multiple data values
• Defect growth models become more accurate
• Visualization allows for operators to improve mitigation
• Advanced analysis improves Fitness-for-Service evaluation
Customized Reporting With LifeQuest™

Program configuration and data display able to be customized by the end user

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• Data synchronized across multiple 2D and 3D display windows
• Data windows can be customized for individual user preference and displayed across multiple monitors
• Customizable client feature list spreadsheet
• Can generate client customizable dig sheets for any location
THANK YOU