INSPECTION OF BURIED OR INACCESSABLE PIPING IN PROCESS PLANTS UTILIZING ULTRASONIC BASED INTELLIGENT PIGGING TECHNOLOGY

By: Richard D. Roberts

Buried or inaccessible piping systems within process plants present a challenge in terms of overall inspection. Limited access and complex piping configurations restrict the type of indirect or direct NDE methodologies which can be applied by inspectors. Due to the complexity of buried and above-grade piping systems routed in and around these facilities, many plants have been forced to look outside of the industry to determine if other industries such as nuclear, pipeline, etc. have existing NDE technologies which can be applied within these complex facilities.

For several decades, various industries (i.e. terminals, transmission pipeline) have applied intelligent pigging technology to inspect pipelines ranging from 4" to 52" diameter. Due to an aging infrastructure and numerous highly publicized failures with loss of containment, fires, etc. within various refining and chemical complexes, these facilities are being forced to push the envelope in terms of advancing their overall piping systems or circuit approaches. Similar to the challenges the refining and chemical industries face today, the terminals and transmission pipeline industries have thousands of miles of buried or inaccessible piping that branch off of main transmission lines, which have gone uninspected since the original construction.
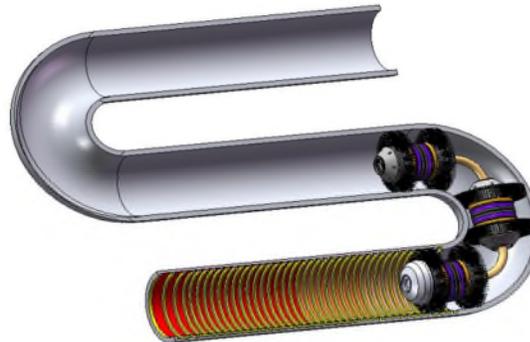

Figure-1 Example of Intelligent Pig in Short Radius 1D, 180° Return Bend

Based on the global demand, significant investments were made resulting in tremendous advancements in ultrasonic based intelligent pigging technologies. Several years were spent designing, testing and proving specific intelligent pig designs, validating the overall process. The new designs required minimal or no launching and receiving facilities, and are capable of navigating complex piping both below ground and overhead within crowded pipe racks. In addition to navigating complex back-to-back, short radius (1D) return bends as tight as 180° (See Figure-1), changing diameters, varying thicknesses, and unbarred tee fittings, smaller tools were developed allowing inspection of piping as small

www.QuestIntegrity.com

as 3" in diameter. Ultrasonic systems which provide 100% inspection coverage were preferred, as these tools produced quantitative results allowing rapid and accurate fitness-for-service (FFS) calculations to be performed in compliance with API-579 / ASME-FFS1 and other industry accepted guidelines while utilizing 100% of the inspection data. Transmission pipeline operators have been applying this technology for several decades with tremendous success. Many refineries and chemical plants globally are in the early stages of adopting the technology and building it into their overall API-570 piping inspection programs.

In order to build confidence with applying intelligent pigging technology, several of the major oil and chemical companies have fabricated mock-up piping test systems. The mock-ups contained many fittings such as 90 & 180-degree bends, etc. Additionally, flaws were placed on both interior and exterior surfaces of various sizes and shapes. Vendors supplying inspection services utilizing intelligent pigging technologies (and other technologies) have been invited to run their systems through the test coil so the clients could assess the upper and lower detection, sizing and repeatability limits.

THE TECHNOLOGY

The InVista™ intelligent pigging technology utilized to inspect difficult to access piping systems was recently introduced into the various industries. These advanced intelligent pigging systems were specifically designed to overcome access and negotiation restrictions associated with challenging piping system configurations. Additionally, the exterior of these tools is designed with foreign material exclusion (FME) in mind (See Figure-2). The most advanced of these intelligent pig designs are fully self-contained, untethered and provide 100% inspection coverage. The unique designs on the market today enable plants to inspect traditionally "unpiggable" piping systems such as those with 3" to 24" diameters and challenging features such as short radius 1D bends. Although new to many industries, many earlier versions of this technology, such as the FTIS™, are time-proven superior inspection methodologies.
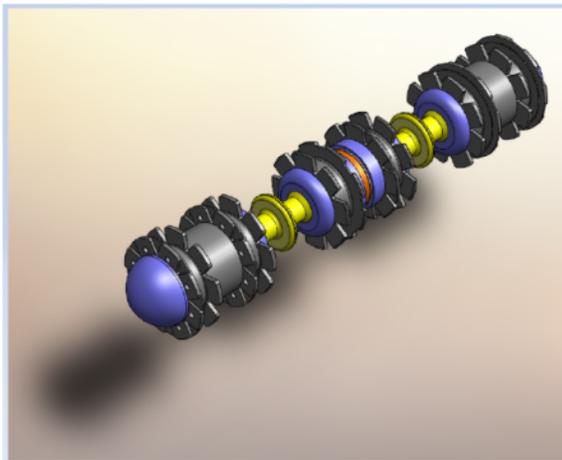

Figure-2 Intelligent Pig with FME Design Considerations

The intelligent pigs are equipped with dozens (48 - 366) of small diameter fixed ultrasonic sensors, which are distributed around the circumference of the inspection tool. The presence of corrosion, erosion or other anomalies such as deformation (denting, ovality, bulging, etc.) in the pipe are detected by the ultrasonic sensors and automatically recorded onboard the tool while in transit. Both pipe shape and remaining wall thickness data are acquired simultaneously to enable overlaying of both sets of critical information once the intelligent pig completes the inspection and has been removed from the pipe.

The data collected by the inspection tools are viewable in high resolution two dimensional (2D) and three-dimensional (3D) formats which encompass the full length of a piping system immediately when the intelligent pig completes the inspection. (See Figure-3) The ability to view near photo-like graphical images of damage mechanisms is powerful when evaluating damage patterns, especially when the patterns are an indicator of the damages' root cause.
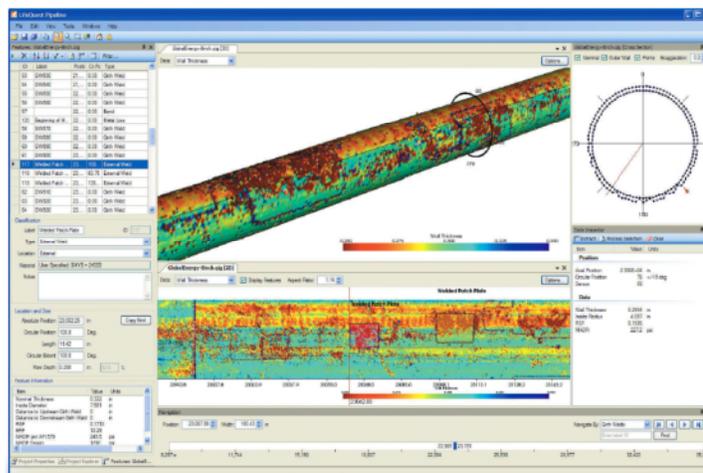

Figure-3 2D & 3D Data Output Graphics

The ultrasonic sensors provide direct measurement of anomalies, which in turn provides superior piping integrity assessment in comparison to utilizing indirect measurement techniques.

Important attributes of intelligent pigging technologies are:
- 100% overlapping axial and circumferential coverage
- Absolute measurements to 0.005" accuracy
- Between 2,500 and 12,000 (depending on pipe diameter) ultrasonic measurements per linear foot
- Capable of inspecting pipe diameters of 3" – 24"
- Differentiates between defects on interior and exterior pipe surfaces
- Pinpoints circumferential and longitudinal location of defects
- Bi-directionality (ability to enter and exit the piping system at one location)
- Above-ground GPS-based markers
- Measures wall thickness

The most advanced of these intelligent pigs detect and measure wall thickness as well as changes in internal and external pipe diameter caused by anomalies. They are designed with multiple modules which are propelled with a liquid medium (i.e. water, diesel, etc.) down the length of the piping. The fluids in the piping system also provide acoustic coupling for the ultrasonic sensors. Because of the unique sensor configuration, the system operates within tighter tolerances, providing a more accurate and more confident measurement of defect dimensions and profiles.

The unique navigational capabilities enable these inspection tools to be used with limited or no launcher/receiver systems. Piping with a single entry and exit point and low-flow conditions are now able to apply such systems. As a result, plants can easily inspect drain, diesel fuel oil, service water, condensate, fire protection, lube oil, gas and other piping systems.

A broad selection of materials such as carbon steel, stainless, copper, aluminum, galvanized, etc. used to construct piping can be inspected utilizing ultrasonic based intelligent pigging technology. Even piping which contains internal or external coatings (i.e. epoxy, etc.) is capable of being inspected with this technology; however density and thickness may affect test results. Because there is such a broad range of potential materials and coatings within plant piping systems, a lab mock-up test is highly suggested to validate the technology to detect and quantify flaws prior to field applications.

Ultrasonic based intelligent pigs are specifically designed to detect and quantify a broad range of damage mechanisms. The tools are capable of detecting pipe wall loss due to corrosion, pitting, erosion, etc., regardless if the damage is on the interior or exterior of the pipe, and sometimes both at the same location. Corrosion under insulation (CUI) is also a real strength of this technology, especially since 100% of the surfaces are inspected without removal of the insulation. Detection of corrosion caused by the soil environment when coatings fail is another benefit. In addition to measuring wall loss, the ability to simultaneously detect and quantify pipe deformation such as dents, bulging, swelling and ovality is an added benefit, especially since the combined effect of wall loss and structural degradation may result in the piping system no longer being fit for service.

SUMMARY

By applying more advanced inspection and assessment technologies, plants will achieve a greater level of piping integrity, with the additional benefit of maintaining public and regulatory confidence. Pinpointing areas of degradation will ensure precise excavation locations when pipe repairs are necessary. By determining the condition of various piping systems, plants will also satisfy the direct assessment requirements required by process plants. Most importantly, the probability of damage and injury to personnel, the environment and assets is significantly reduced.

Use of the most advanced intelligent pigging designs play a significant role in reducing costs associated with difficult to inspect piping systems, reducing maintenance costs by more accurately pinpointing anomalies and assessing fitness-for-service conditions, and gaining insight into conditions for piping systems previously not capable of being inspected. The ultrasonic based direct inspection technology is highly accurate and goes beyond assessing risk of potential problems to pinpoint the problems themselves. These findings often reduce or eliminate the need for remediation or field work, thereby decreasing overall operational and safety costs year over year.

REFERENCES

1) API-570, "Piping Inspection Code: In-service Inspection, Rating, Repair, and Alternation of Piping Systems", Washington DC USA

2) ASME FFS / API-579-1, "Fitness-for-Service Standard", Washington DC USA

3) API RP-574, "Inspection Practices for Piping System Components", Washington DC USA

4) ASME Section V, "Boiler and Pressure Vessel Code", New York NY USA

5) Roberts R, "Inspection of Buried or Inaccessible Piping in Nuclear Power Plants Utilizing Ultrasonic Based Intelligent Pigging Technology" 9th Annual International NDE Nuclear Plant Conference" Bellevue Washington USA, May 2012

6) Roberts R, "Inspection of Piping Systems in Nitrogen or Syngas Plants Utilizing Ultrasonic Based Intelligent Pigging Technology", Nitrogen & Syngas Conference, Athens Greece, 2010.

7) Roberts R, "Recent Technological Advances in Ultrasonic Based Intelligent Pigging Technology", Global Plant Piping Conference, Salvador Brazil, 2007.