INSPECTION OF NON-PIGGABLE PIPELINES

OFFSHORE WATER INJECTION LINE & OFFSHORE OIL PRODUCTION LINES

By L.J. Gruitroij, A Hak Industrial Services BV, Geldermalsen, The Netherlands

In this paper the following topics are covered.

- Introduction of on-line inspection techniques for non-piggable pipelines
- Development of the PigLet technology
- The on-line information; software and analysis
- Example of 2 specific Offshore applications

1. INTRODUCTION

Pipelines have been laid worldwide for some 100-year's, and more often than not, once operational, are left without any planned maintenance and the internal condition of these pipelines remains unknown. The normal management approach has been to prioritise on a failure consequence basis, selecting maintenance and inspection options on a failure mode and effect analysis.

Intelligent pig inspection systems are important tools to manage the integrity of the pipelines. An intelligent pig survey enables the operator responsible for the integrity of the pipeline, to assess the failure risk due to metal loss corrosion using the findings of the inspection survey. However, not all pipelines can be inspected using intelligent pig technology, due to the pipelines origin. In addition the inspection results are not directly available during the inspection process and therefore important decisions can not be made until the inspection report has been issued in a later stage.
This paper discusses specific applications for offshore pipelines.

2. NON-PIGGABLE PIPELINES

At the time the pipelines were laid, pigging and inspection services were not thought of. Pipes were laid to transport the product and how the pipeline was constructed was of minor importance. This meant that the majority of these pipelines were built without launching/receiving facilities, consisting of varying diameters, mitred bends etc made normal pigging techniques impossible. Modern day pipelines are constructed using special design codes (DEP's) which include these launching/receiving facilities allowing Ultrasonic Inspection techniques to be utilised.

These codes are not commonly used for the relative short "connection" lines i.e. transport pipeline to the storage tanks, which meant that these lines, being of standard design were not-piggable. We observed that most of the problems occur in these relative short pipelines, due to lack of protection. In addition the ownership of these pipelines is not clearly defined and a lack of responsibility is observed. This implies that the integrity program for these pipelines is of less importance than the larger/longer transfer pipelines.

These connection lines are in most cases non-piggable because:

- Pipeline dimensions (length, diameter and wall thickness, dual diameter)
- Pipe material (SS, ductile, exotic materials, GRE, coatings, linings)
- Bend restrictions (forged bends <1.5 D, one cut mitre bends, mitre bends, field bends, back to back bends)
- Off takes (un-barred tees, barred tees, sphere, Laterals)
- Offset junctions (Convergence angle, Bores), Diverters

- Valves (In-line block valves, check valves)
- Relative position of features (pig-signalling)
- Operation conditions (product, pressure, temperature, fluid velocity)
- No entrance point or single entry (availability of launchers and receivers)

Examples of such pipelines are:
- Loading lines
- Offshore pipelines
- Off-plot pipelines
- On-plot piping/pipelines
- Tankfarm connection lines
- Connection Piping in refineries
- Furnace piping (180 degrees 1D bends)

3. ON-LINE INSPECTION TOOLS

Intelligent pig inspection systems are important tools to manage the integrity of the pipelines. An intelligent pig survey enables the operator responsible for the integrity of the pipeline, to assess the failure risk due to metal loss corrosion using the findings of the inspection survey. However, not all pipelines can be inspected using standard intelligent pig technology, due to the pipelines origin specifically offshore.

4. PIGLET TOOL & THE FULL SERVICE PACKAGE

The PigLet consists of various modules, such as: ultrasonic measuring head, electronics, odometer, battery pack's and glass-fibre modules. Either these modules are build into a Bi-directional pig (larger diameters) or are used as single modules with discs for the inspection of smaller diameters.
The various modules are connected by flexible connectors to each other and the various modules are in more detail described below. The PigLet is pumped through the pipeline with product like an ordinary pig.
The service of A. Hak Inspection group is focussing on being a one-stop service provider meaning delivering the full package for determining Pipeline Integrity with respect to non-piggable pipelines.

5. ULTRASONIC MEASURING HEAD

The ultrasonic measuring head consists of an ultrasonic transducer and a rotating "mirror". The ultrasonic signal is transmitted to the pipe surface via the rotating mirror, and is received via this mirror as well.A sound pulse is send from the transducer in the middle of the pipe in the direction of the pipe wall. From the inner wall the sound pulse will be partially reflected back to the centre of the pipe were it is detected by the same ultrasonic transducer. A part of the sound pulse at the pipe wall will not be reflected but will travel through the pipe steel and will be reflected back from the outer pipe wall. The time difference between both reflections (inner and outer pipe wall) determines the wall thickness at that point.
The UT sensor device uses a rotating mirror to enable to measure the complete circumference of the pipe wall. This enables the UT sensor device to scan the full 100% of the pipe wall. The step motor which rotates the mirror can be adjusted in various steps to the proper number measurements per revolutions.

To increase the detectabillity or measuring quality, different ultrasound sensors with different frequencies and crystal size can be used. The type of transducer depends on the size of the pipeline, size of defects which have to be detected, product and the cleanliness in the

pipeline. Various measuring configurations can be made to optimising the system to comply with the clients wishes.
Prior to the job the measuring head will be prepared and calibrated, and will be re-calibrated prior to the inspection.

6. DATA ACQUISITION SYSTEM

The data acquisition system is epecially developed for the PigLet system, used to capture the data and control the Piglet. The core features are High data storage capabilities per second, Floating window, state of the art computers, high resolution TFT screens.
The data acquisition system consists of two parts namely the hardware consoles and the software.

6.1 PigLet console

The PigLet console consists of the electronics and a high capacity computer with special developed AD-board to digitise and analyse the raw data. The computer is also used for analysing the raw data, controlling the PigLet speed, rotation and data communication between the PigLet and the Computer console. One monitor shows the ultrasonic C-scan images and A-Scan images and the second monitor will be used to change the parameters during inspection without interference to the inspection. In addition the system can be used for “on-line” post processing, and produce a valuable on-site report. The upper menu bar shows the travelled distance, ultrasonic coverage, average coverage per pipe sections, clock position and others The information is available on-line and is monitored by the inspection engineer. In the left upper window the wall thickness is displayed in colour ranges. In the left window below the internal radius is displayed while in the right windows the amplitudes are given used to discriminate between internal and external defects. In the lowest figure the complete ultrasonic A-scan is displayed, including the multiple backwall echo’s used to determine accurately the remaining wall thickness.

6.2 Software

The software used on the PigLet console has been developed in-house. The software is designed to show and give the field engineer direct information about the condition of the pipe using the online ultrasonic C-scan information. In addition the travel speed, travelled distance and the rotation of the PigLet is given on-line.
For optimising the quality of the data and the inspection coverage the measurement parameters can be changed on-line. Therefore the second monitor will be used.
The software installed is designed to show on-line the measurements of the PigLet in four view pictures. The size and the place of the C-scan could be changed on-line this to obtain a better overview of i.e. the wall thickness measurements.

6.3 Defect assessment

After the inspection report is finished a defect assessment can be carried. The most commonly used method is ANSI B31.4/8. The result of these defect assessment methods is to calculate the maximum allowable operating pressure (MAOP) and determine the factor with the design pressure (DP).

The MAOP is said to de de-rated when the de-rating factor MAOP/DP is below 1. At lower MAOP/DP, deeper defect can be tolerated by a shift of the defect acceptance/rejectance curve to larger length and depth. MAOP/DP is one of the most important factors that determine defect detection and sizing requirements for inspection tools.

The critical defect depth is defined as the defect depth of localised corrosion with a maximum length according to its definition which lies exactly on the acceptance/rejectance curve, see figure below.

The defect assessment curve and hence the critical defect depth is dependent on the method (ANSI B31.4/8, RSTRENG, SHELL92, DNV), the de-rating factor (MaOP/DP), the pipe diameter (D) and the pipe wall thickness (WT). The defect acceptance curve is also dependent on pipe steel grade and different equations on critical defect depth have to be derived.

7. LIMITATIONS OF THE TOOL

The Piglet can be used for the inspection of relative short pipelines commonly know as being Non-piggable.

However some limitations of the tool must be mentioned. Due to the ultrasonic technology a liquid is required to transport the ultrasound through the pipe. Normally water is used, but also inspections using products such as crude, petrol, kerosene, NAFTA, etc has been successfully carried out. If the inspection has to be carried out in other type of product tests have to be carried out to determine the suitability of the product.
Due to the mechanical design of the measuring module (one sensor and rotating mirror) the capturing of data in bends is limited due to misalignment. All ultrasonic tools have a problem with the scattering of the ultrasound by debris and gasses in the pipeline. Therefore a good cleaning and a fully filed line is required fro the optimum inspection results.

8. TWO SPECIFIC EXAMPLES OF SUCCESSFUL INSPECTIONS OFFSHORE:

Offshore Water Injection Pipeline & Oil Production Pipeline:

These projects show a typical combination of all the techniques and experience A. Hak applies for offshore projects. These applications consisted of lines that never had been pigged before and weren't equipped with launchers receivers. Furthermore they had one cut mitred bends, one-to-one non barred T-joints, wall thicknesses over 20mm and many WT variations.

The specific approach from A. Hak involved the full scope of activities, from de-commissioning to preparing the line mechanically. Specific launching and receiving had to be prepared in order to get the line suitable for "pigging: .The next stage consisted of the cleaning to gauging activities in order to obtain optimum results during inspection. Specific cleaning procedures were written and specifically developed cleaning pigs were used to get all debris out. A brief example is given in the PowerPoint presentation and some photo material for reference.
The inspections were then carried out with the results available on-line showing the kind of defects detected. Also here some screenshots are part of the PowerPoint presentation to show the severe bottom corrosion for the Water Injection Line and the quite deep corrosion of the Oil Production Line in its first sections and some at the riser section.

These examples show the complexity of inspection offshore pipelines and the capabilities of A. Hak coping with this.