PERMANENTLY INSTALLED TRANSDUCERS FOR GUIDED WAVE MONITORING OF PIPELINES

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Abstract

The Guided Wave inspection method (GW) is now used routinely in the petrochemical industry to screen long lengths of pipe for corrosion. The method is attractive because it gives 100% coverage of the volume of the pipe within the diagnostic range of the test, and tens of metres can be covered from a single transducer location. Therefore full coverage can be obtained at a fraction of the cost required for spot thickness gauging or automated UT inspection. The conventional application of the method is to use a removable transducer ring and to gain temporary access to the pipe at test locations spaced out along the pipeline. The spacing of test locations selected according to the test range which is achieved for a given application, but is typically of the order of tens of metres.

In many applications where the GW testing method is applied, a large percentage of the total cost of the inspection is spent on gaining access to the pipe at the test location, for example offshore risers, road-crossings and elevated pipe-work. In these cases a cost effective option is to use a permanently installed transducer ring, where one-time access is needed to attach the transduction system and subsequent repeat tests can be carried out from an easily accessible remote location. The gPIMS® pipe monitoring system manufactured by Guided Ultrasonics Ltd., used in conjunction with the proven WaveMaker®G3 instrumentation and WaveProG3 software, provides a complete solution for permanently installed GW repeat measurement of pipe condition.

This paper reports the performance, in terms of stability of results, reliability for long-term testing and sensitivity achieved using the gPIMS® system. There is also a discussion of the applications for which it is recommended.

Introduction

The screening of pipes using the GW method has been accepted by the oil and gas industry and several government bodies around the world as a good approach in a wide range of inspection situations (for example screening of insulated pipes, road crossings and offshore risers). In several of these applications a large percentage of the total time and cost of the inspection is spent on gaining access to the pipe at the test location. For example; the erection of scaffolding for elevated pipe-work; the removal (and replacement) of insulation or pipe coatings; the excavation (and backfilling) of buried and cased road crossings and the provision of roped access for offshore risers. In these cases a very cost effective option is to use a permanently installed guided wave sensor where one-time access to the test location is needed to install the sensor and repeat measurements can subsequently be made from a remote, easily accessible location. The gPIMS® system (manufactured by Guided Ultrasonics Ltd.) is a permanently installed guided wave sensor designed for precisely this purpose.

The Guided Wave testing method (GW)

Guided waves in pipes propagate along the axis of the pipe and enable the coverage of a large area from a single test position (see Figure 1). The generation of these waves is obtained using a transducer array which is wrapped around the circumference of the pipe (1).

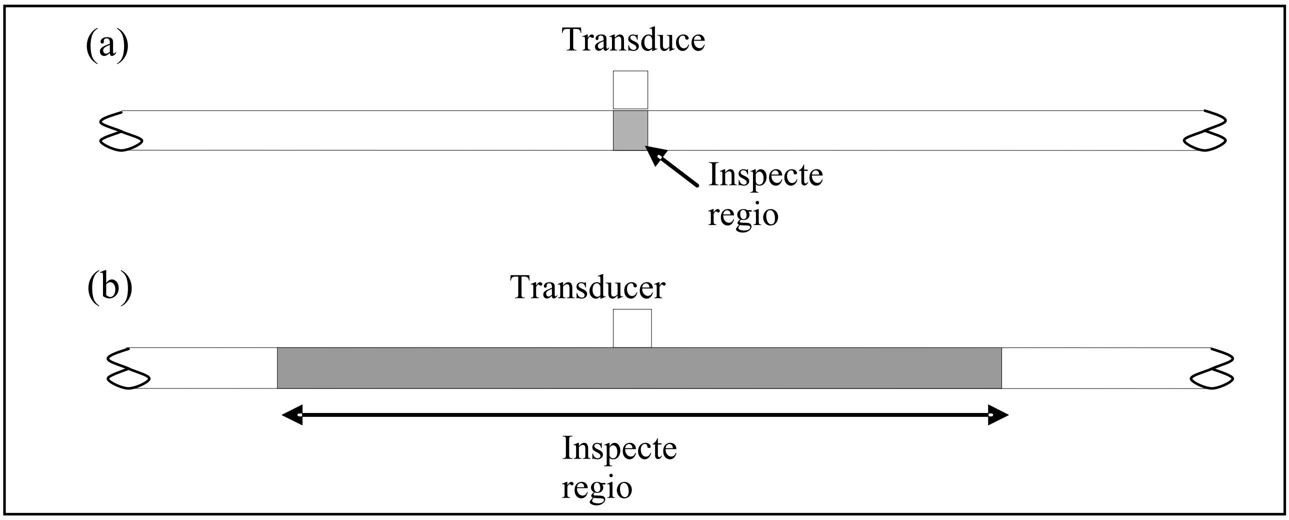

Figure 1 – Difference between traditional NDT methods (a) and GW method (b).

The WaveMaker®G3 system is already used world-wide for the screening of pipe-work using removable transducer rings. The contact between the pipe and the transducer ring is dry and a mechanically or pneumatically applied force is used to ensure good coupling. After the transducer ring is positioned around the pipe the operator starts a rapid test which automatically sweeps several frequencies collecting data from both sides of the ring with a single test. A range of several tens of meters in either direction from the transducer ring position can be obtained when the pipe is in generally good condition and there is a low density of features (such as change of directions, drains, vents, valves, welds etc..). The range decreases for pipes generally corroded. The system has been designed to detect defects that remove about 5% of the pipe cross sectional area although defect dimensions well below 5% (e.g. 1-2%) can be identified in pipes with isolated defects.
Due to the large area screened from a single inspection point GW screening can increase the probability of detection (POD) of defects in a pipeline compared to other NDT approach that rely on point measurements (2).

GUL gPIMS® transduction system

The gPIMS® permanently installed sensors manufactured by Guided Ultrasonics Ltd., used in conjunction with the proven WaveMaker®G3 instrumentation and WaveProG3 software, provide a complete solution for permanently installed GW repeat measurement of pipe condition. The gPIMS® has been developed to utilize all of the software features available for GW screening, including the frequency animation and C-scan tools (3).
gPIMS® Transducer: The transducer is produced as a low profile flexible array which is bonded and clamped in place on the pipe surface. The whole transducer is then sealed in a polyurethane jacket to provide complete environmental protection. The sealed unit height is only about 10mm giving a wide range of possible install locations. Figure 2a) shows a gPIMS® being installed via roped access on a vertical offshore riser.
Connection box: The connection box is a sealed weatherproof unit with connectors which allow the interfacing with the WaveMaker®G3 instrument. Figure 2b) shows a typical installation on a buried line. The connection box has internal electronics which stores the test parameters such as pipe size, collection parameters and the file reference number for the previous test result to allow direct comparison.

Figure 2a) – gPIMS® transducer

Figure 2b) – Connection box

Repeatability of results

The repeatability of results is a basic requirement for any NDT method. Figure 3 shows an example of an annual repeat measurement using gPIMS® transducer exposed to in-service conditions. For comparison purposed the test results are overlaid using the 'A-Scan' display format. The A-scan display has a horizontal axis which shows the distance of any reflectors from the transducer and a vertical axis which shows their amplitude, on a linear scale in this case. The horizontal axis shows both positive and negative direction corresponding to the two directions of propagation along the pipe from the transducer location. The vertical green band at zero distance indicates the dead zone at the transducer ring, within which no interpretation can be done. The grey zone covering a short distance to the left and right of this indicates the near field, in which measurements can be interpreted but not as accurately as elsewhere.

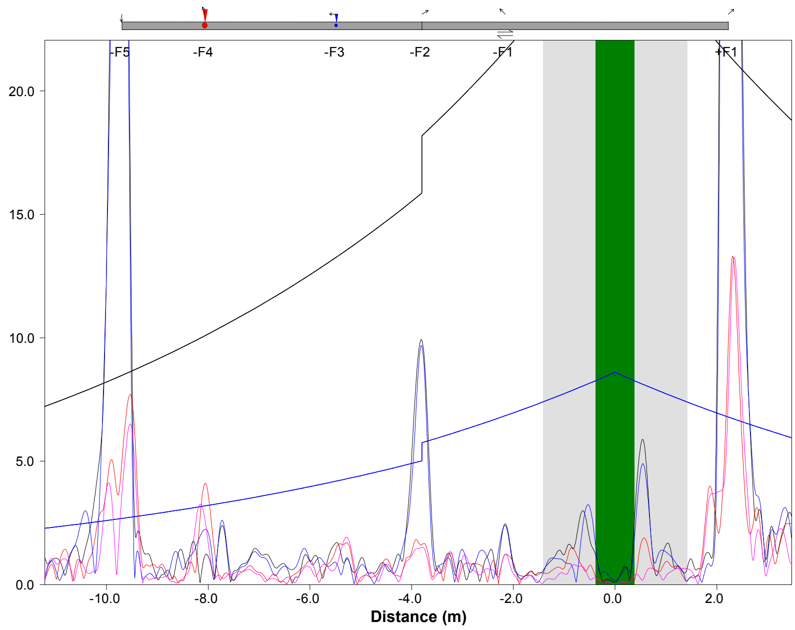

Figure 3 – Repeatability of gPIMS® results.

The black and red traces are the torsional and flexural wave respectively for the initial measurement and the blue and pink traces are the torsional and flexural wave results for the annual repeat measurement.

The data displayed confirm that the variation of the recorded trace with time are well below 0.5% of the cross section change.

Sensitivity

To demonstrate the sensitivity that can be obtained from the PIMS a trial was carried out on a 16" diameter test pipe. This had a PIMS transducer installed toward one end of the 6m sample and a reference data collection was performed. After this a defect was machined into the sample 3.5m from the transducer. The size of the initial defect was 0.5% change in pipe cross section. This defect was then increased in size to 0.7% and then 0.9%. The results from this trial can be seen in Figure 4. This shows that both the initial defect and the incremental changes are clearly identifiable. The result shown has traces taken from the initial data collection and three subsequent sets of data from different defect sizes. The section of trace between 1m and 3m shows how repeatable the results are when there are no changes to the cross-section of the pipe.

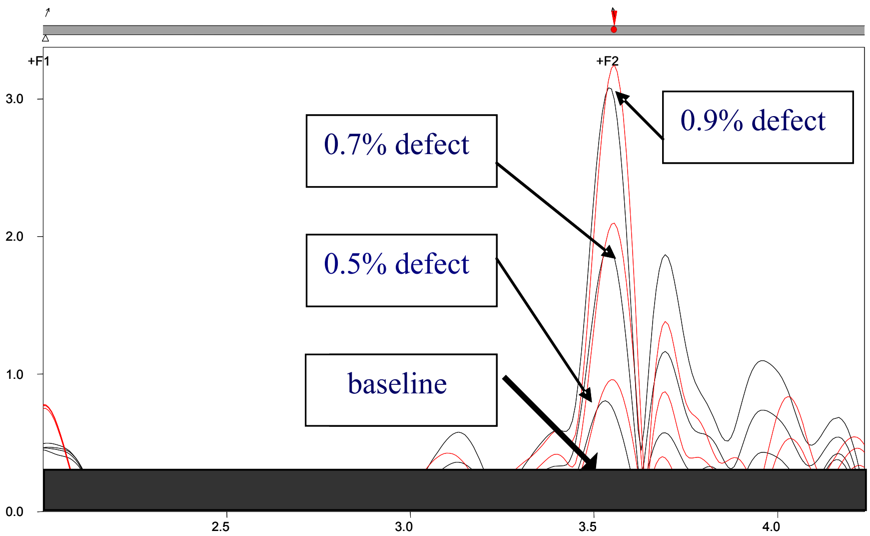

Figure 4 – Sensitivity of gPIMS® results.

Applications

Road crossings

Figure 5 shows an excavated site where 5 gPIMS® sensors were installed on adjacent, cased road crossing pipes. The gPIMS® is designed to be protected from environment and external mechanical damage so backfilling does not present a risk to the operation of the transducer. In the image shown, the connection boxes and cable are simply resting on the pipe. Prior to back-filling the cables are strapped along the main pipe and up the vertical casing vent pipe. The connection box is then connected to a permanent post on the surface.

Figure 5 – Several gPIMS® sensors installed on cased road crossing pipes.

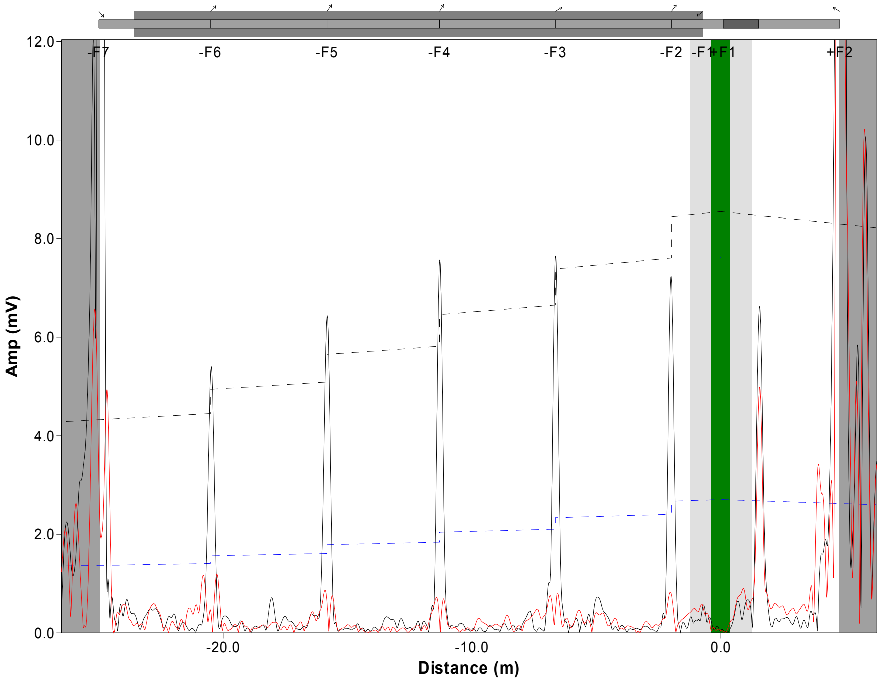

Figure 6 –Typical test result for cased road crossing pipe shown in Figure 5.

The result from one of the pipes is shown in Figure 6. In this case the range of test was sufficient to test the full length of the casing.

Offshore Risers

When monitoring riser pipes both installation from topside using rope access and subsea installation are possible. Figures 7 and 8 show examples of sensors installed on cased and un-cased offshore risers. The sensor in Figure 7 was installed via roped access whereas Figure 8 is being installed from scaffolding. In both cases the connection box was situated at deck level to allow easy access for repeat measurements.

	
Figure 7 – Installation at casing entrance on an offshore riser.	Figure 8 – Installation close to splash-zone on an un-cased offshore riser.

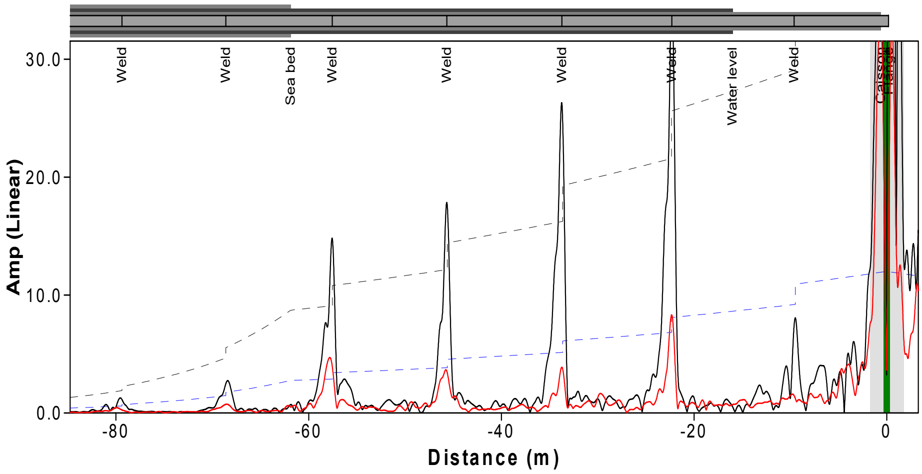

Figure 9 – The result obtained from the sensor shown in Figure 7.

Figure 9 shows the A-Scan test result from the cased riser shown in Figure 7. The result shows the casing entrance, sea level and sea bed locations on the schematic diagram above the A-Scan trace. The reflected signals from successive weld locations are clearly shown on the A-Scan trace which demonstrates that the riser pipe is in good condition all the way to the sea bed, a range of 60m in this case.

Conclusions

The stability and sensitivity of the gPIMS® reported in this article demonstrate the general reliability of the transduction system. The capabilities of the system to detect circumferential distribution of wall loss and the operation over a wide frequency range enable high probability of detection (POD) and low probability of false indication (PFI). The experience when working in relatively difficult operational environments (road crossings and offshore pipes) demonstrates the robustness and durability of the gPIMS® sensors. The gPIMS® have been shown to be reliable in applications where a remote sensor approach provides a good solution in terms of cost/benefit.

References

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