Long Range Ultrasonic Testing - Case Studies

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ABSTRACT

Long Range Ultrasonic Testing (LRUT) is widely used for detecting corrosion and other metal loss in pipes and pipelines especially where access for inspection is difficult or expensive. Ultrasonic Guided wave testing (GWT) is established in the petrochemical and related industries, primarily for the detection of corrosion flaws.

Developments of testing specialized procedures, the interpretation methods and calibration methods have significantly enhanced the capabilities of GWT. This paper presents the data and results, obtained from bare, cement lined and coal tar coated-buried lines. Inspection was carried out using piezoelectric sensor technology.

Keyword: Guided wave, Piezoelectric, Bare, Coated and Buried line, internal cement lined, Attenuation etc.

1. INTRODUCTION

Long-Range Ultrasonic Testing (LRUT) is an advanced Non-destructive Testing technique. LRUT has been developed to detect metal loss in piping and pipelines. The technique was initially developed for detecting Corrosion under Insulation (CUI) for piping in petrochemical plant. Afterwards, it has found widespread use in other inspection situations.

If the wavelengths of elastic waves are comparable with or larger than typical dimensions of the structure (e.g., pipe or plate thickness), the waves are called guided waves (GW). Due to the boundary conditions imposed by the structure, those waves are guided within the volume of a pipe or plate. Due to their complex character, GWs have been used for NDE in very special applications, only. The first feature, which complicates potential GW applications, is the existence of several wave modes that can propagate simultaneouslywith different velocities. Three basic modes occurring in cylindrical structure are longitudinal, torsional and flexural modes. The first two are axi-symmetric while the latter is non-axi-symmetric one. Each of those modes, depending on frequency appears in a number of orders.

Long range ultrasonic testing (LRUT) using guided wave has been successfully used for some years as a screening technique for corrosion in piping capable of detecting corrosion in pipes in different conditions, e.g., under insulation, road crossings, buried pipes and offshore risers. GW inspection is a remote inspection technique: in typical industrial pipe with general surface corrosion (e.g. in refinery or chemical plant) it is possible to test approx. 30 m in each direction from a single transducer location. Transducer ring located at one location on the pipe excites guided waves along the pipe and receives returning echoes from pipe features.

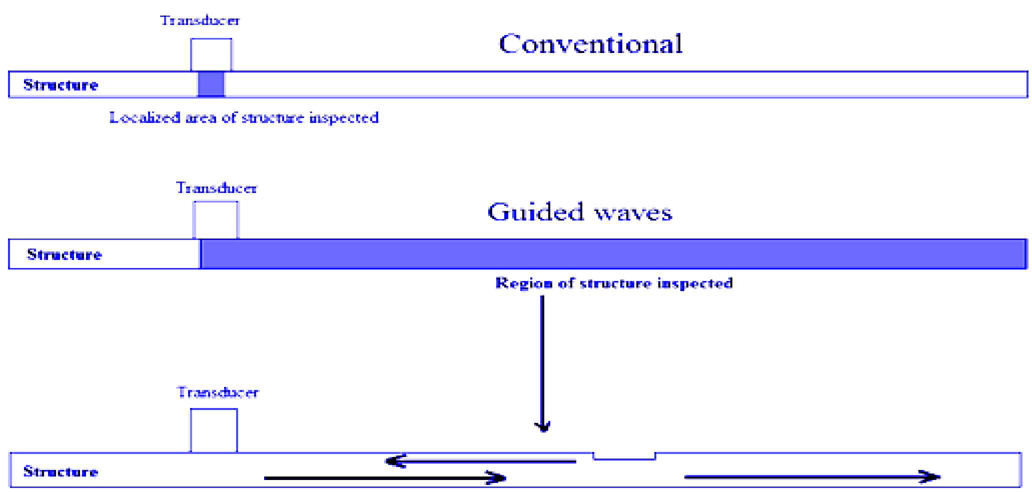

Fig. 1: Comparison of a pipe testing using conventional and Guided waves Ultrasonic Testing. Guided waves propagate along the pipe length and reflected back from welds or loss in wall thickness

Although guided wave methods are now widely accepted [1-4] there are limitations and restrictions to the use of the technology for many applications. The main benefits are reduction in cost of inspection, ability to inspect inaccessible areas, 100% examination of pipe wall. Low attenuation losses favor waves that transmit along the whole circumferential pipe propagating in the planar direction. These waves travel across the straight stretches of pipes from a single point. The concept of using guided waves for inspection and monitoring of piping and tubing system has been progressing over the last decade. In the arena of non-destructive testing (NDT), the method is usually called long range ultrasonic testing (LRUT). The first commercially available guided wave actuators were based on piezoelectric [5, 6] transducers (PZTs). PZTs have been used to generate ultrasonic guided waves for pipeline inspection [7, 8].

2. EQUIPMENT

The Guided Wave long range ultrasonic testing is a process of rapidly surveying pipelines from a single test location by generating low frequency ultrasonic guided waves through the material boundary. Test Equipment - The Plant Integrity Limited Teletest® MK4 FOCUS system. It is a pulse- Echo system; achieve to inspect long lengths of material from a single test location. Multi-Channel transmitters and receivers for controlling the wave propagation direction and the system have Frequency Range in kHz. Multi-frequency data analysis is used for finding different size of defects.

Focusing Technique will give support to defect confirmation and finding the location on the pipeline on the clock wise. Inspection was carried out using based on piezoelectric transducer technology. Tool (collar) installation is possible for the monitoring the pipelines. The features of the system are given in Table 1. Piezoelectric transducer uses the direct and inverse piezoelectric effect that occurs in materials. It is possible to induce ultrasonic wave propagation along the pipeline as the longitudinal and torsional wave modes. The presence of defects due to corrosion and pipe features along the pipeline generates a reflected wave which will be detected by the same piezoelectric transducer in the transmission using the inverse piezoelectric effect.

Table 1: Main features of Teletest Focus+ diagnostic system.

S. No.	Parameters	Description
1	Sensitivity	3 - 9 % of “cross - sectional area” change - depends on the background noise ratio
2	Operating Frequency	10 to 100 kHz

3	Wave – operating modes	Longitudinal, Torsional and Flexural
4	Pipe size Tested	2-inch to 48-inch diameter pipe
5	DiagnosticLength	10 to 125 m diagnostic length; the effective range depend on pipeline geometry (diameter, numberof weld joints, elbows, branches) and pipeline state (pipeline above ground or buried, pipeline coated or uncoated) on the pipeline.
6	Time required for inspection	A few minutes once the collar fixed

3. RESULTS AND DISCUSSION

The Guided wave ultrasonic technique employs the pulse-echo configuration in which guided waves are propagated in the axial direction of the pipe by using no. of transducers arrangement which is also used to receive the reflections echoes. The major advantage of this configuration is that it minimizes the requirements for equipment and testing time. All of the results presented in this article were acquired using the pulse-echo technique. Reflections are generated at locations where there is a change of stiffness or a change of the pipe cross sectional area (for example, at girth welds or corrosion patches) along the pipe length.

The results of this method of processing the data allows the interpretation to locate both the axial and circumferential (clock) locations of cross sectional area loss. This also allows for a more accurate prediction of the corrosion characteristics and provides a more intuitive method of displaying the GWT results.

3.1 CASE 1: Bare Pipe line, 8” diameter

Pipe Details

LRUT inspection was conducted on Carbon Steel Material
Job Details: 8” OD * 8.1 mm thickness

Test frequency used: 65 kHz andTest Wave mode: Longitudinal
Coating: Bare
Pipe condition: Above ground

The pipe had no coating and was above ground condition. Inspection range was 12m. The result obtained is as shown in Figure 2. All of the weld locations were classified as highly repeatable amplitude. The cat.1 amplitude of the echoes from sensor location in the negative direction was caused by one 5 mm dia. artificially made through hole.

Results at optimum longitudinal frequency are as shown below in fig. 2:

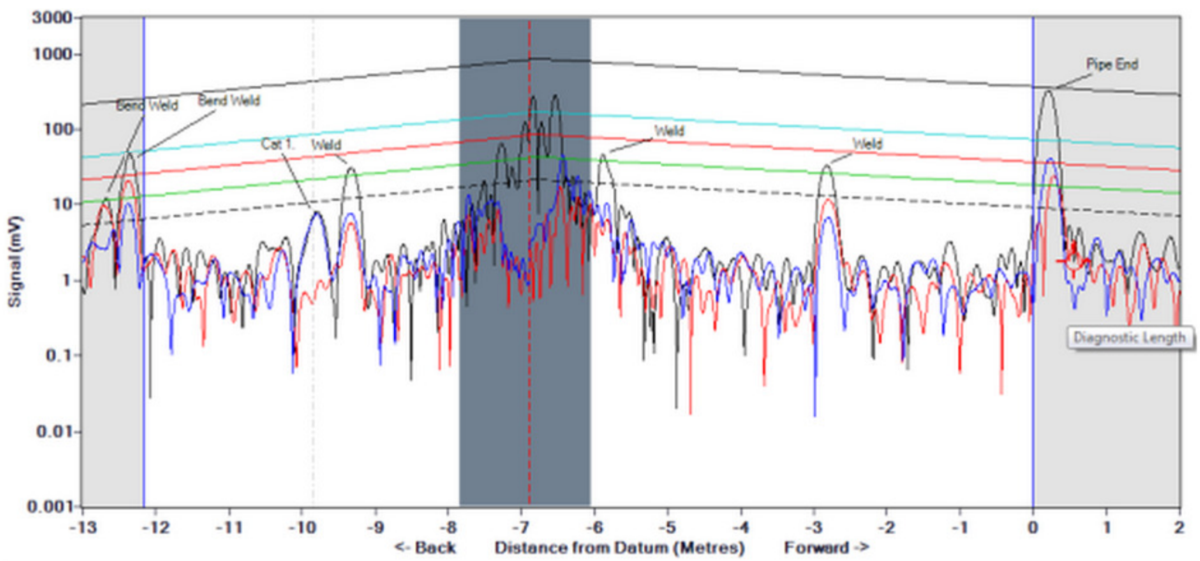

Fig 2: Amplitude graph illustrating result of GWT. Regular weld signals give highly repeatable amplitudes that can be used for calibration of the distance amplitude correction.

Good signal to noise ratio was obtained and the entire pipe length (12m) was inspected. Good quality data was obtained in both longitudinal and torsional mode.

3.2. CASE 2: 14” Outer dia. - Cement lined Pipeline

LRUT inspection was conducted on Carbon Steel Material

Job Details: 14” OD * 8.5 mm thickness

Test frequency used: 27 kHz and Test Wave mode: Torsional
Coating: Internal Cement Lined
Pipe condition: Above ground

It was an above ground pipe and internally lined with cement. The purpose of this test was to determine the reliable inspection range and corrosion monitoring of pipeline. The data obtained at optimum torsional mode frequency is as shown in fig. 3 below:

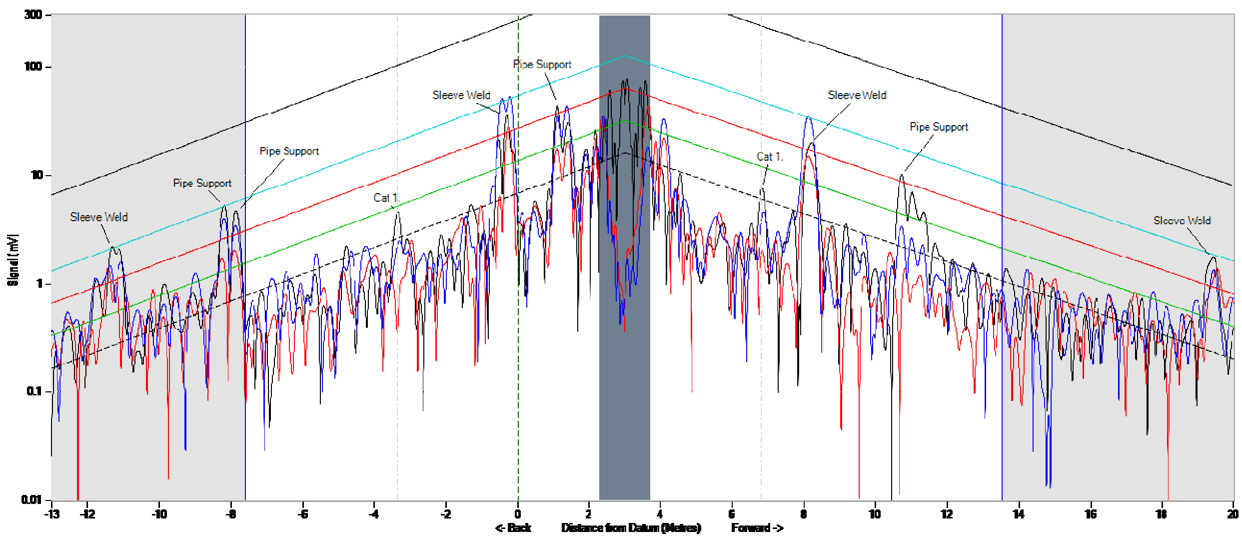

Fig 3: Amplitude graph illustrating result of GWT. Regular weld signals give repeatable amplitudes that can be used for calibration of the distance amplitude correction.

In the cement lined pipe, good quality data could be obtained up to 22 m. With longitudinal mode, a poor signal to noise ratio data was obtained. Also, the velocity of the torsional mode varied from 3640 m/s to 2720 m/s. This could be because of guided wave propagation in both carbon steel and cement lining. This velocity variation may be due to propagation of guided wave in both carbon steel pipe material as well as internal cement lining.

3.3 CASE 3: Coal Tar Coated and Buried line

Job Details: 10" OD * 7.0 mm thickness
Test frequency used &Test Wave mode: Longitudinal 51 KHz frequency
Coating: Coal Tar

Pipe Condition: Buried

Inspection was carried out on a buried with coal tar coated line condition. The pipeline was buried 2-3m below the ground level. The region of interest was buried and coal tar coated portion of the line. Data obtained at optimum longitudinal frequency shown in fig. 4 below:

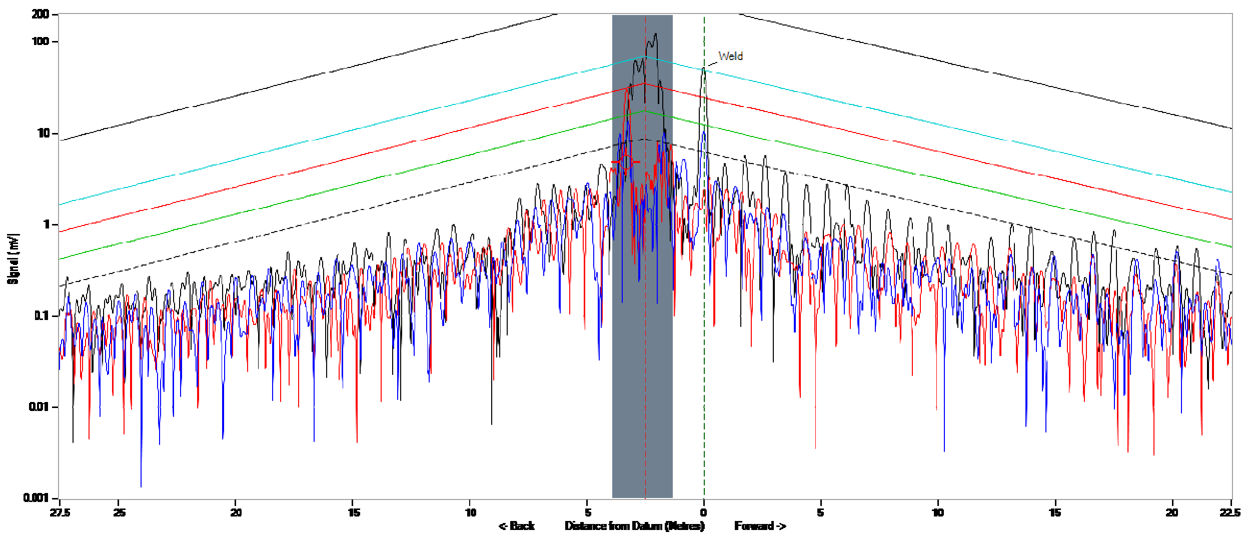

Fig 4: Amplitude graph illustrating result of GWT. Longitudinal mode was used with 51 KHz frequency.

In the buried and coal tar coated portion of the pipe, a featureless data was obtained because of high ultrasonic wave attenuation.

4. CONCLUSION:

Guided wave testing is a powerful method for the inspection and screening of operating pipelines.

Piezoelectric transducer used for long range pipelines inspection could be used to monitor the pipe network for any damages due to degradation mechanisms.

There are challenges when applying guided waves to detect and correctly classify indication under thick coatings, soil pressure, buried condition and cement lining varies guided wave velocity in addition to high attenuation which may greatly reduce the frequency-regime range of data used for the interpretation.

5. ACKNOWLEDGEMENT

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