A Measurement Method of Corrosion Rate in Condensate Pipeline Using Long Range Ultrasonic Test

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ABSTRACT

The pipeline is one of the important means necessary as the transport medium of oil and gas, so that when the pipeline leak would greatly disrupt the production process. Pipelines generally use carbon steel, a major problem in the use of carbon steel is corrosion. Therefore, there must be serious action to prevent and simultaneously tackling the corrosion. In this study, the method used to measure the rate of corrosion is LRUT, this method is the latest technology in Indonesia in the field of inspection of corrosion rate. By using ultrasonic waves, this method will detect a reduction in the thickness of the pipe (wall loss), which is then used as the primary data to calculate the corrosion rate. The following conclusions were obtained: (1) Measurement of corrosion rate by using LRUT method can detect corrosion of the inner and outer walls of the pipe, the testing process faster, efficient and more extensive inspection area when compared with conventional methods. (2) The rate of corrosion on the circuit pipelines are not the same, it is in line with the magnitude of wall loss that occurs in a series of pipelines that are influenced by internal and external factors such pipes. (3) In general, a series of pipelines that have been tested using the method LRUT have decreased performance with a reduction in the thickness of the pipe wall. The greatest reduction in thickness occurs in TP # 02, anomaly number 13 with the corrosion rate of 0237 so that the estimated remaining life at that point was 19.49 years.

KEY WORDS: *Pipeline; Corrosion; Ultrasonic Test*

1.0 INTRODUCTION

Corrosion is the destructive attack of a material by reaction with its environment [1] and a natural potential hazard associated with oil and gas production and transportation facilities [2]. The pipeline is an essential equipment in the oil and gas industry, therefore, in supporting the smooth production program needed inspection and surveillance equipment maintenance are quite strict, regular and planned aimed at ensuring the integrity and feasibility of the pipeline can be operated with well that would be able to reduce the risk will occur, one inspection and surveillance program maintenance of such equipment is the problem of corrosion in pipelines [3]. The integrity and reliability of the pipeline must be maintained and ensured so that the pipeline can operate properly without significant obstacles [4]. To anticipate the occurrence of damage to the pipeline network that would be fatal in the distribution process, the production must be known corrosion rate. Measurement of the corrosion rate can be done using several methods, namely specimens corroding, electrical and electrochemical techniques and long range ultrasonic test (LRUT). In this study, the method used to measure the rate of corrosion is LRUT, this method is the latest technology in Indonesia in the field of inspection of corrosion rate. By using ultrasonic waves, this method will detect a reduction in the thickness of the pipe (wall loss), which is then used as the primary data to calculate the corrosion rate.

2.0 LITERATURE REVIEW

Ultrasound travels in waves. A pulse of acoustic sound (frequency <10 KHz) emitted from a point source radiates outwards like ripples on the surface of water caused when a stone drops into a pond. The sound is reflected from objects as waves that travel at a constant velocity. When the reflected waves reach the source, their time of flight between transmission and reception can be used to find the distance of the reflector from the source.

If the frequency of the sound is increased into the MHz range, the point source becomes a matrix of minute point sources, each propagating a wave that interferes with adjacent waves in what is termed a Fresnel zone. The constructive and destructive interference of these waves eventually produces a conical beam as shown in Figure 1 [5].

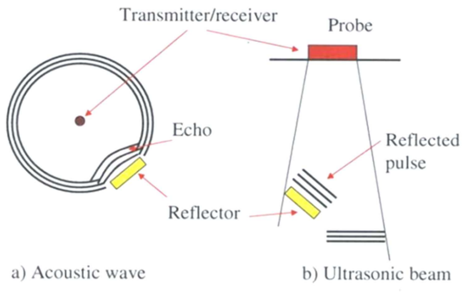

Figure 1: Propagation of sound

Manual ultrasonic testing with a hand held probe and flaw detector requires a high level of dexterity. Detecting defects with ultrasound has been likened to finding a mirror in a dark room with torch light. The mirror will only be seen if firstly, it falls within the beam and secondly, its surface is perpendicular to the axis of the beam. Full volumetric inspection of a test piece with ultrasound therefore requires scanning from the surface with a variety of sound beam angles at close scan interval.

The ultrasound propagates along the beam in bulk waves. Bulk waves can be in the form of compression movement of particles in the medium of propagation or shear movement as shown in Figure 2.

Shear waves travel at little more than half the velocity of compression waves and cannot be propagated through liquids. Their shorter wave length (1-2mm) makes them more sensitive for detecting discontinuities in the medium that reflect the sound. If the compression waves, more properly known as longitudinal (L) waves, strike an interface between two solid media at any angle of incidence other than 0^{o}, they spilt into shear (transverse (T-wave)) and L-wave components. This is how T-waves are generated for conventional ultrasonic NDT using L-wave piezo-electric transducers [5].

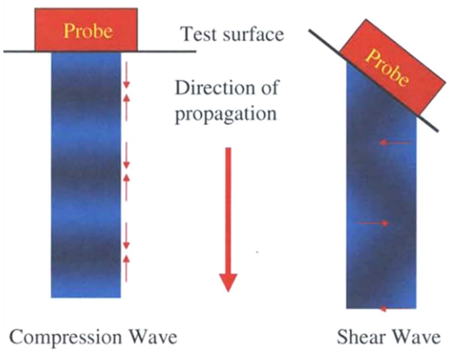

Figure 2: Bulk waves

The transducers are set on angled wedges of Perspex. Usually, the wedges are cut to refract T-waves at angles of 450,600 or 70^{o}. Ultrasound wave modes other than L-wave and T-wave can be generated, but are less widely used in ultrasonic NDT as shown in Figure 3 [5].

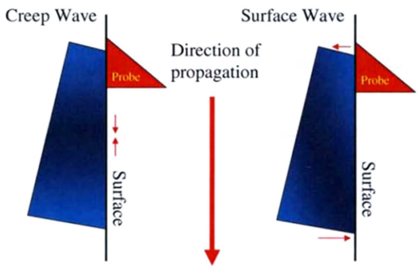

Figure 3: Other ultrasonic wave modes

The plate wave equivalent in a pipe is a guided wave. By regarding the pipe as a cylinder made from a plate, additional wave mode scan be visualized as shown in Figure 4 [5].

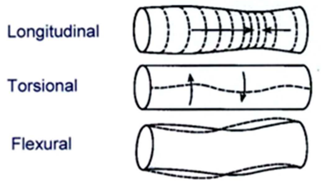

Figure 4: Guided waves in pipes

By looking along the pipe from the pipe end, the longitudinal (L) wave can be seen as a bulge travelling along it, the flexural (F) wave can be seen as a flexing of the pipe in any number of planes and the torsion (T) wave as a twisting of the pipe.

The attenuation of guided waves is lower than of bulk waves. The pipe acts as a wave-guide. This effect can be demonstrated with audible sound by shouting down a long length of pipe. The sound travels much further than when shouting into empty space. The attenuation is frequency dependent. High frequencies are attenuated more strongly than low frequencies.

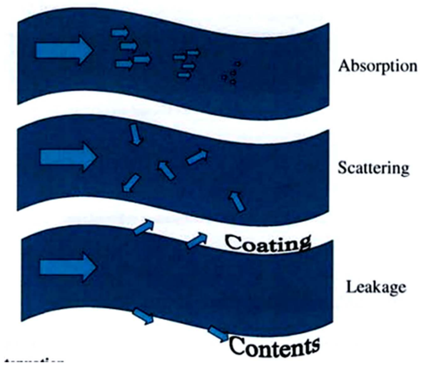

Figure 5: Attenuation

Guided waves, like conventional bulk waves are attenuated by absorption and scattering as shown in Figure 5 [5]. However they are also attenuated by leakage of sound energy across the pipe internal and external surfaces. The energy of the guided wave is depleted very rapidly if the pipe coating or contents are sticky in nature.

The amount of sound reflected at a boundary between two media depends upon their difference in acoustic impedance. If the difference in acoustic impedance is very great, there will be almost total reflection, no matter which direction the sound is travelling. As the miss-match in acoustic impedance decreases, so the amount of sound that is able to cross the boundary increases. For this reason, a liquid couplant is used in conventional ultrasonic to propagate sound from the probe into the test piece. Without couplant there would be almost total reflection and a sound beam would not be created in the test piece. Acoustic impedance is the product of velocity and density. Therefore reflection and refraction can be expected wherever there is a change in velocity across the boundary. Because their velocity is frequency, and therefore wavelength dependent, the velocity of guided waves will change where there is a change in thickness of the pipe wall. This could be a decrease in wall thickness, for example corrosion, or an increase in wall thickness, such as due to a pipe girth weld as shown in Figure 6 [5].

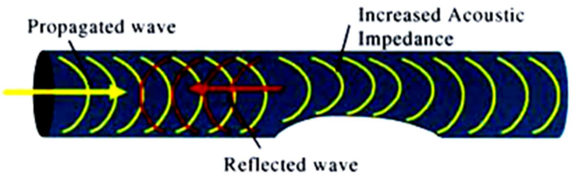

Figure 6: Reflection and guided waves at thinned area.

This fact is evident from the high amplitude of reflections from pipe girth welds. Normal girth welds, with cap and root bead, give a reflected signal that is consistently 20% of total reflection from the pipe end as shown Figure 7 [5].

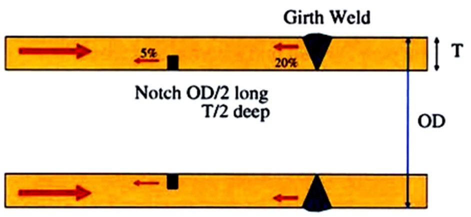

Figure 7: Reflection of guided waves from girth welds

When detecting corrosion, the amplitude of the reflected pulse will depend upon the cross-sectional area of wall loss. The aspect ratio (l/d) of the corrosion is as shown in Figure 8 [5].

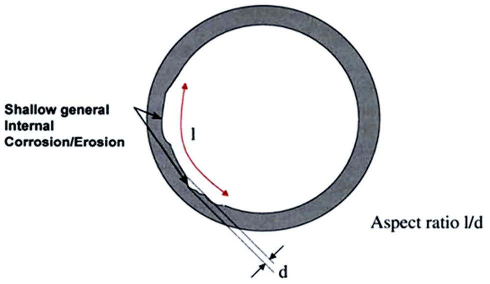

Figure 8: Aspect ratio of corrosion

A wide shallow area of corrosion might therefore reflect the same amount of guided wave energy as a narrow deep area of corrosion..

2.0 METHODOLOGY

The steps of the research procedures that have been made for the inspection of pipes, data is collected for the settlement of the problem in this study. Equipment to be used is checked, so that nothing is left behind. Ensuring the equipment in good condition and fit for use. For equipment that uses batteries to be fully charged condition. Location and pipes to be inspected / checked and fitted with supporting documents such as P & ID drawing, isometric drawing, pipe historical data. Estimates pipe length is measured in accordance with the work order given. The starting point of the inspection and the best distance range specified for the test point. Pipeline product flow direction is determined in accordance with a from- to- exist in the P & ID drawing to avoid wrong - select the pipe to be inspected. UT Scanning the Test Point is measured using UT Flaw Detector. Scanning (circum) carried out thorough on the pipe. to give a good reading of the results , it can be used couplant: water, oil, wallpaper paste, cellulose. Inflatable Ring transducer mounted in a position right connections in 3 hours, ring locked by turning the bolt. The ring is pumped up to a pressure of 20 psi (1.5 bar). Based on the analysis GWUT, further indication of the distance measurement with reference weld nearby as shown in Figure 9 and 10.

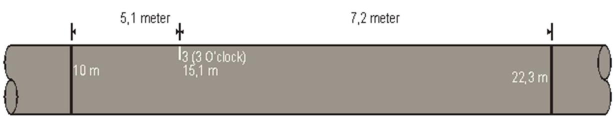

Figure 9: Distance measurement with reference weld nearby

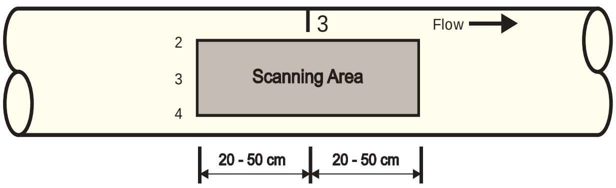

Figure 10: Area scanning indication

The location indicated by the lines marked along the orientation. The area indicated exceeded the mark indicative of a minimum of 20 cm for pipe diameters below 10 inches and a maximum of 50 cm for pipes up to 10 inches. The results of scanning are recorded and written with marker on the pipe as shown in Figure 11.

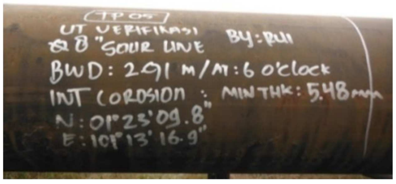

Figure 11. Marker on the pipe

The scheme of equipment installation is shown in Figure 12. Collar mounted in a way put on around the pipe and serves as a place to put the module (transducer). Module mounted on the collar for electrical energy is converted into sound energy and the sound is converted into electricity.

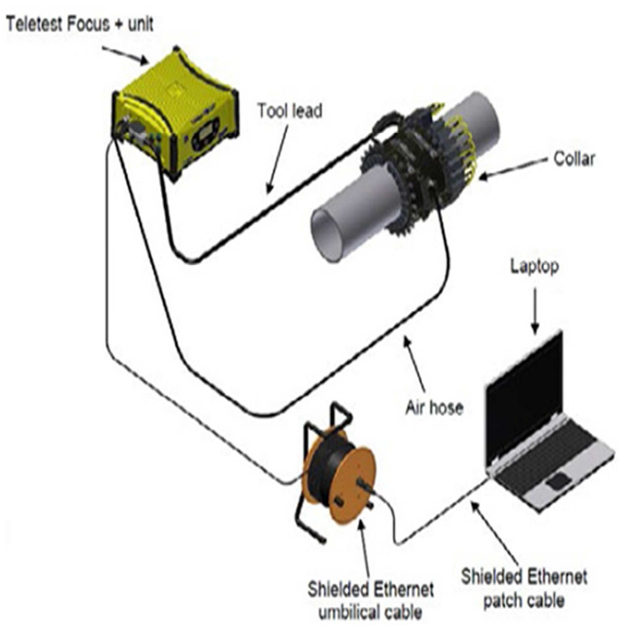

Figure 12: Scheme of equipment installation

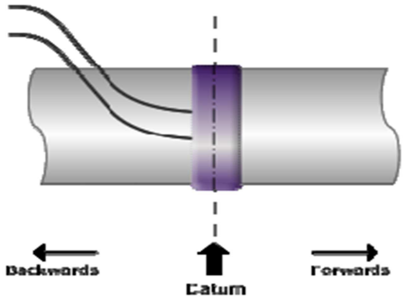

Figure 13: Datum position of pipe 24 inches

Table 1: Thickness measurement value of pipe 24 inches

No. pipe direction	Thickness, TP#01 (mm)	Thickness, TP#02 (mm)
3	9.68-10.00	9.33-9.94
6	9.63-10.12	9.45-10.07
9	9.84-9.99	9.75-9.80
12	9.35-9.89	9.38-10.00

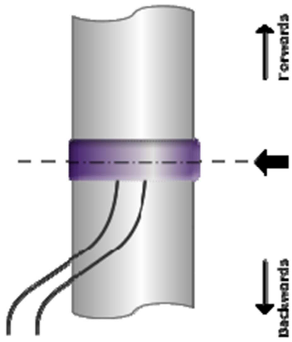

Figure 14: Datum position of pipe 30 inches

Table 2: Thickness measurement value of pipe 30 inches

No. pipe direction	Thickness (mm)
3	9.68-10.00
6	9.63-10.12
9	9.84-9.99
12	9.35-9.89

4.0 RESULT and DISCUSSION

Pipeline testing using the LRUT will give readings of data in the form of a reduction in the thickness of the pipe wall (wall loss) in millimeters (mm). However teletest will also present data that support as a result of data to complete the analysis of the test results.

LRUT A- scan graphs produced a graphic display of the reading process by the ultrasonic wave teletest system. From the graphic display can be inspected and reading so that the pipe or corrosion damage will be known. Figure 15 , 16 and 17 are LRUT readings in graphical form from each test point (test point) from a series of pipeline given ultrasonic waves .

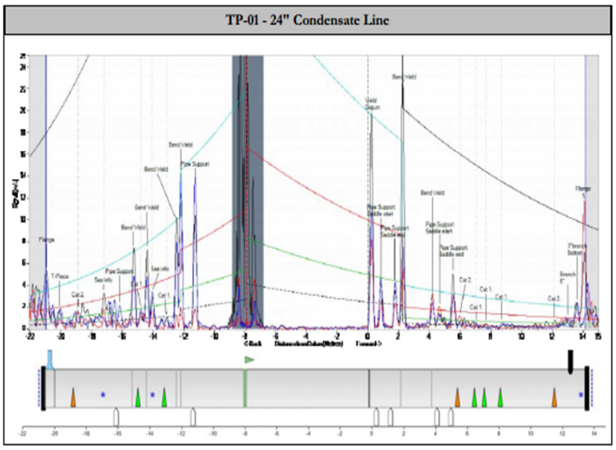

Figure 15. LRUT A-scan graphs 24" TP≠01 condensate line

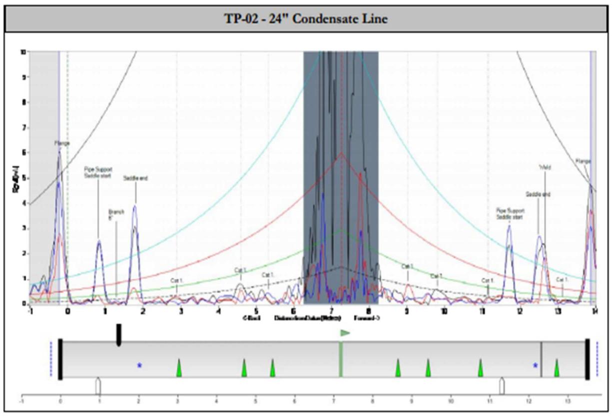

Figure 16. LRUT A-scan graphs 24" TP≠02 condensate line

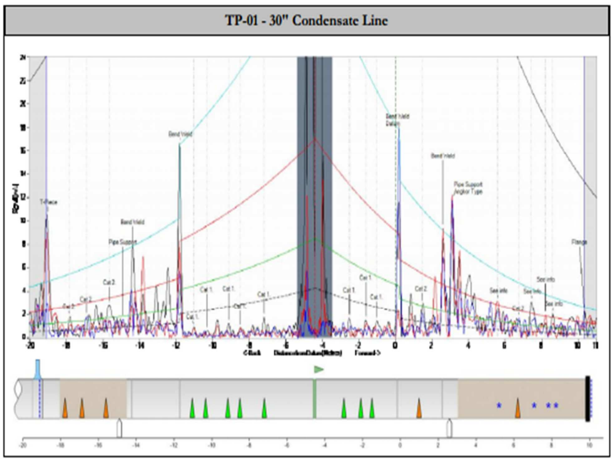

Figure 17: LRUT A-scan graphs 30" TP≠01 condensate line

There are three types of color that can show the presence of anomalies (irregularities) which indicates damage or reduction in performance of the pipeline which is below the green line is the category 1 which means minor damage, between the green line and the red is a category 2 showing moderate impairment and above the red line is a category 3 that is damage or severe corrosion.

Direction of anomalies indicated by the sign plus and minus means each of the direction and the opposite direction to the flow of fluid flowing in the pipe. Report data reported by teletest unit then carried interpretation by the Inspector and is made in the form of anomaly table which will provide data on the reduction of the thickness of the pipe (wall loss) as initial data to calculate the corrosion rate (corrosion rate). After all the data is done reading, engineers will describe the location of the damage (corrosion) in a series of pipeline.

From the calculating of corrosion rate, it is known that the thickness of actual large will produce remaining life is small, while the thickness of actual small will produce remaining life large, meaning that the thickness of the pipe wall is greater, the age of the pipe will be longer and on the contrary.

5.0 CONCLUSIONS

The measurement method of corrosion rate in condensate pipeline using long range ultrasonic test were studied experimentally. The following conclusions were drawn.

1. Measurement of corrosion rate by using LRUT method can detect corrosion of the inner and outer walls of the pipe, the testing process faster, efficient and more extensive inspection area when compared with conventional methods.
2. The rate of corrosion on the circuit pipelines are not the same, it is in line with the magnitude of wall loss that occurs in a series of pipelines that are influenced by internal and external factors such pipes.
3. In general, a series of pipelines that have been tested using the method LRUT have decreased performance with a reduction in the thickness of the pipe wall. The greatest reduction in thickness occurs in TP # 02, anomaly number 13 with the corrosion rate of 0237 so that the estimated Remaining Life at that point was 19.49 years.

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