BURIED GAS RISER PIPE INSPECTION USING MEDIUM AND LONG-RANGE GUIDED WAVES

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1. The Problem

An Australian LNG Company has many gas field riser pipes in remote locations. The risers are wrapped in various mediums depending on the chosen wrap technology at the time that they were constructed. Currently, the LNG Company policy is to excavate the risers and strip the wrap to visually inspect the pipes for external corrosion.

External corrosion primarily occurs at the soil-to-air interface and within buried sections where moisture and oxygen are most prevalent. Environmental exposure leads to localized oxidation beneath protective wraps and in inaccessible buried areas, resulting in wall thinning that can lead to catastrophic failure. Consequently, a reliable, non-invasive inspection method is required to manage these risks.

Excavation of the risers is costly, time-consuming, and high-risk, given the potential for rupture, high-pressure gas release, and explosions. Therefore, an accurate, cost-efficient inspection method that did not require excavation was needed. The LNG company requested a trial of Medium Range UT (MRUT) and/or Long Range UT (LRUT) guided wave technology to inspect buried risers for corrosion. The objective was to replace the current requirement for excavation and visual inspection.

For this test, live pipes containing high-pressure LNG were used. No minimum reportable defect criteria were provided, and no known defects were recorded in the sample pipes tested.

1.1. Location and Specimen Details

The test was conducted on 10" and 24" NPS (Schedule 60) carbon steel gas risers located in remote Central Queensland. These ground-penetrating pipes typically reach a depth of 3 m, where they meet a T-joint at a manifold or a 40-inch main gas line. While these risers often experience external corrosion between the ground line and the underground manifold, they are not subject to internal corrosion.

Risers wrapped in STOPAQ (green chewing gum type wrap) were tested some time ago, and it was found that STOPAQ was too attenuative to obtain any useful data from, behaving much like concrete, limiting the effective scan range to almost zero.

Many other risers are wrapped in a bituminous or Denso Tape wrap, with a UV protective white tape over the top. These pipes shall be targeted for this study, as they have less attenuation of ultrasonic sound energy than the STOPAQ wrapped pipes.

The risers posed distinct challenges for standard NDT methods:

- There is often very little straight pipe available between the flange or insulated joint and the 90-degree elbow. Other Guided Wave methods require longer straight sections before the inspection area to mount collars.
- The larger pipes can reach 24 inches in diameter with wall thicknesses up to 25 mm. Traditional piezo-based guided wave methods often struggle to inspect such thick-walled pipe sections.
- The protective wrap and surrounding soil heavily attenuate sound energy, which limits the effective inspection range.
- The pipes are typically in service, containing high-pressure gas.
- The pipes often have limited access for inspection tools.

Figure 1. Soil-to-Air Gas Riser Interface

2. Inspection Solution

The recommended solution for inaccessible areas and buried pipe sections is Innerspec's EMAT Guided Waves (LRUT and MRUT) techniques. While LRUT allows for rapid screening of pipes up to 100 m, MRUT provides higher sensitivity for defect qualification and quantification up to 3 m from the sensor.

All EMAT LRUT, and MRUT Guided Waves techniques are available with Innerspec's VOLTA 2 inspection platform.

2.1. LRUT

Long Range Ultrasonic Testing (LRUT) is a suite of advanced non-destructive testing techniques that utilize guided waves for fast screening of long sections of pipes up to 100m on each side from the point of inspection (+/-100m). LRUT is the recommended technique for buried sections when the required inspection range exceeds the limits of MRUT.

The proprietary Magnetostrictive Strip (MS) increases the Signal to Noise Ratio (SNR) by >20 dB compared to piezoelectric collars, while offering a smaller dead zone and superior mode selectivity. It is unaffected by vibrations and can be used during production. The axisymmetric ribbon used by Innerspec's technique can be adapted to various pipe diameters, eliminating the need for a separate piezoelectric collar for each size, which typically increases the cost, weight, and bulk of the system.

LRUT FOCUS patented technique permits obtaining the maximum circumferential resolution possible for each pipe diameter based on the flexural modes available in the pipe by pulsing with the axisymmetric ribbon and receiving with the proprietary scanner in small steps.

2.2. MRUT

Medium Range Ultrasonic Testing (MRUT) is a suite of advanced non-destructive testing techniques that utilize guided waves to inspect inaccessible areas up to 3 meters (10 feet) from the sensor location with high resolution and accuracy. MRUT complements LRUT with higher sensitivity and defect qualification, and quantification near the sensor.

The MRUT scanners and sensors are designed to generate high-frequency guided waves with different mode configurations (Shear Horizontal, Lamb) depending on the type of application and technical requirements. For inaccessible, buried sections, MRUT SH (Shear Horizontal) is the recommended technique.

Shear Horizontal waves have side-to-side motion parallel to the plane of entry (in-plane) with minimum particle motion and leakage on materials inside or outside the structure. The proprietary Magnetostrictive Strip (MS) adhered to the component enhances SNR >60db from other techniques, making it the most efficient reflection technique when there is only one-side access to the area of interest.

3. Results

3.1. Results 24NB Gas Riser No.1

An LRUT Focus Scan was performed on the 24-inch NB gas riser at a frequency of 64 kHz. The datum was established at the edge of the insulated joint closest to the elbow, with the test location situated 525 mm from the datum.

The 12 o'clock position was oriented upward, with the clockwise direction defined looking down the pipe. Gain was increased until the reducer (main manifold), located approximately 3000 mm below ground, was clearly visible in the scan. While the range was initially extended to 10 meters, no distinct reflections were observed beyond the reducer.

One area of moderate corrosion was identified below ground, yielding a 61% amplitude return. The indications immediately following the upper elbow weld are likely not significant defects; rather, they are attributed to the high gain required to overcome attenuation from the 25.8 mm wall thickness and the bituminous wrap. The actual defect indication was located below the ground line, 2800–3000 mm from the datum, and 1400–1800 mm circumferentially.

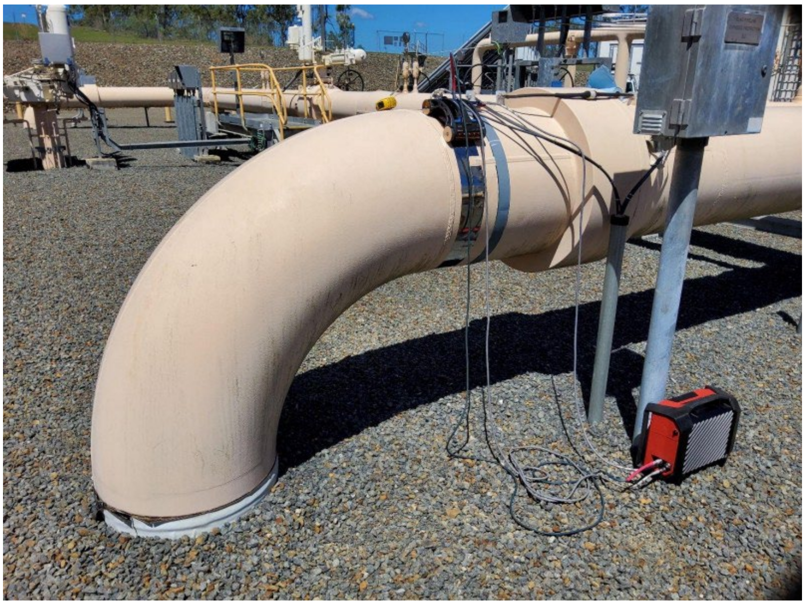
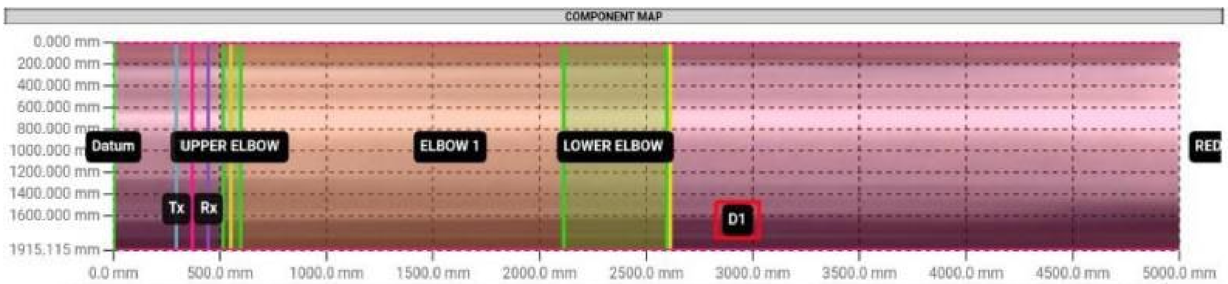


Figure 2. 24NB Gas Riser No.1



Id	Name	Type	Axial Start (mm)	Axial End (mm)	Circ. Start (mm)	Circ. End (mm)	Category	CSA%	FUP
1	Datum	Flange	0.00	0.00	0.00	1915.11	-	-	-
2	LOWER ELBOW	Weld	2111.86	2596.50	0.00	1915.11	-	-	-
3	UPPER ELBOW	Weld	514.14	598.91	0.00	1915.11	-	-	-
4	ELBOW 1	Elbow	550.38	2611.70	0.00	1915.11	-	-	-
5	D1	Indication	2826.83	3029.69	1470.00	1800.00	-	-	-
6	REDUCER	Weld	5148.30	5297.37	0.00	1915.11	-	-	-

Figure 3. Gas Riser No.1 Component Map and Results

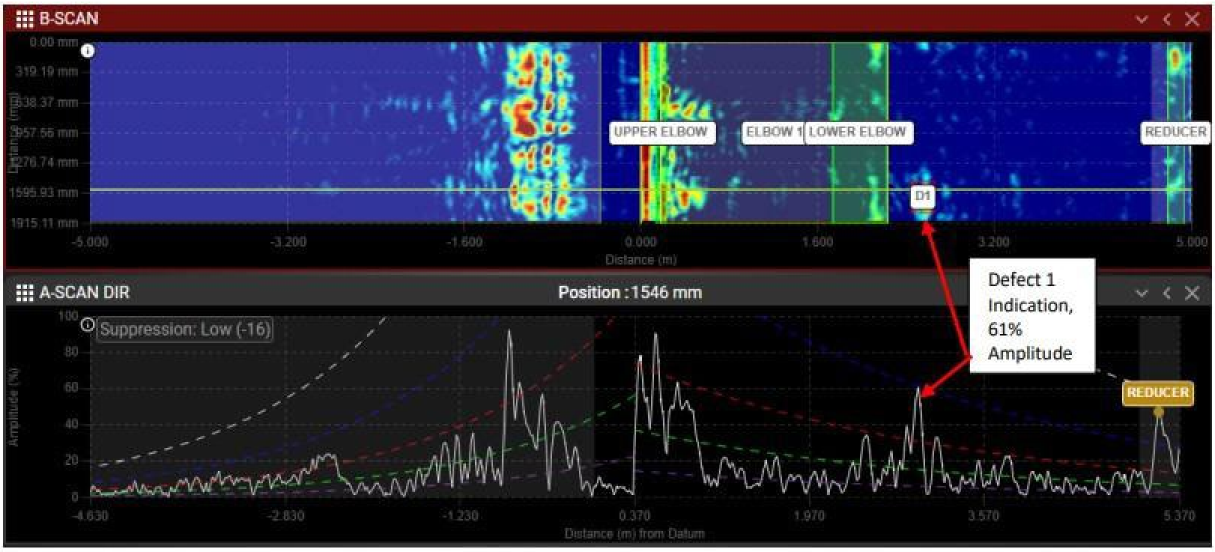


Figure 4. 24NB Gas Riser No.1 A and B Scan LRUT Focus

Note that the sound energy decays rapidly as it propagates along the pipe, particularly upon entering the wrapped section. The amplitude of any reflections must be compensated for based on distance. Typically, known reflectors are used to generate a Distance Amplitude Correction (DAC) curve to illustrate the rate of attenuation. This DAC curve is represented by the blue line in the A-scans.

The vertical position of this curve along the X-axis is calibrated based on the amplitude of the weld reflections. The white line represents 100% screen height, while the red and green lines denote 6-decibel (dB) intervals used to classify indications as minor, moderate, or severe relative to the weld returns.

Typically, two or more spool welds are used as reference reflectors to calculate the DAC curve. In this instance, the first weld is located in close proximity to the initial pulse. The second weld is clearly visible, though it appears as a broadened signal (spanning from 2.2 m to 2.5 m) due to the differing path lengths around the 90-degree elbow.

The third visible weld reflection at 5.2 m could not be utilized for the DAC calculation; its signal strength was significantly higher than the lower elbow weld, suggesting that the T-intersection at the reducer acts as a major reflector—far exceeding the profile of a standard spool weld. Consequently, a precise DAC could not be calculated, and an estimated DAC was employed instead.

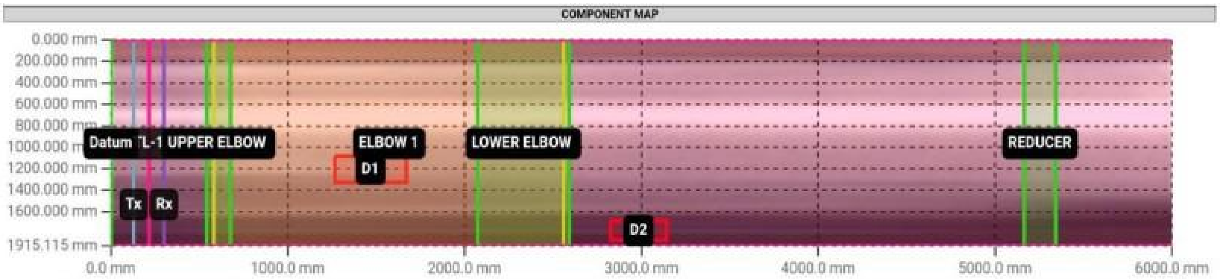
Based on this estimation, 'Defect 1' below the elbow is classified as having a moderate level of damage, representing at least a 10% loss of cross-sectional area (CSA), and warrants further investigation. The reducer at the main manifold was clearly visible at 5.2 m, confirming a successful inspection of the entire pipe segment from the datum to the reducer.

3.2. Results 24NB Gas Riser No.2

An LRUT Focus Scan was performed on the 24-inch NB Gas Riser No. 2 at a frequency of 64 kHz. The datum was established at the edge of the insulated joint closest to the elbow, with the test location situated 215 mm from the datum.

The 12 o'clock position was oriented upward, with the clockwise direction defined looking down the pipe. The gain was increased until the reducer (main manifold), located approximately 3000 mm below ground, was clearly visible in the scan.

Figure 5. 24NB Gas Riser No.2



Id	Name	Type	Axial Start (mm)	Axial End (mm)	Circ. Start (mm)	Circ. End (mm)	Category	CSA%	FUP
1	Datum	Flange	0.00	0.00	0.00	1915.11	-	-	-
2	LOWER ELBOW	Weld	2073.03	2592.86	0.00	1915.11	-	-	-
3	UPPER ELBOW	Weld	542.30	675.59	0.00	1915.11	-	-	-
4	ELBOW 1	Elbow	581.59	2561.29	0.00	1915.11	-	-	-
5	D1	Indication	1267.68	1671.06	1080.00	1330.00	-	-	-
6	D2	Indication	2827.17	3144.26	1680.00	1860.00	-	-	-
7	REDUCER	Weld	5165.35	5343.54	0.00	1915.11	-	-	-

Figure 6. 24NB Gas Riser No. 2 Component Map and Results

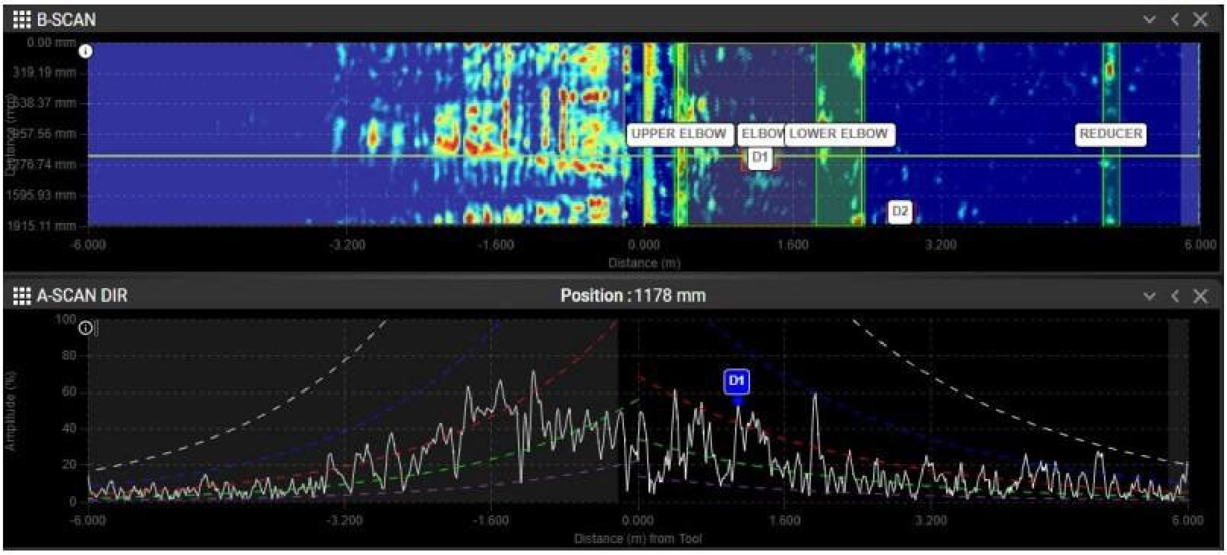


Figure 7. 24NB Gas Riser No. 2 A and B Scans showing Defect 1

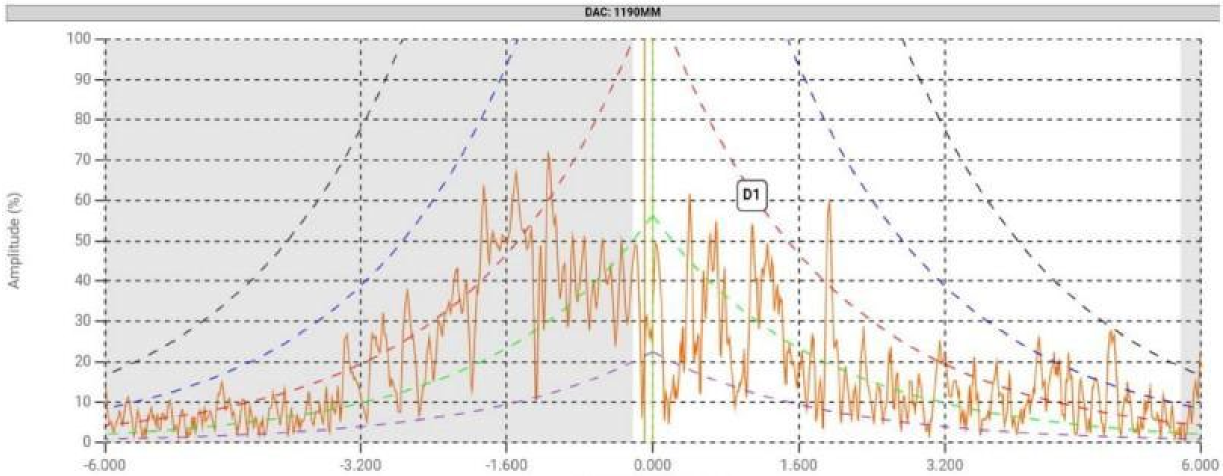


Figure 8. 24NB Gas Riser No. 2 A Scan showing Defect 1

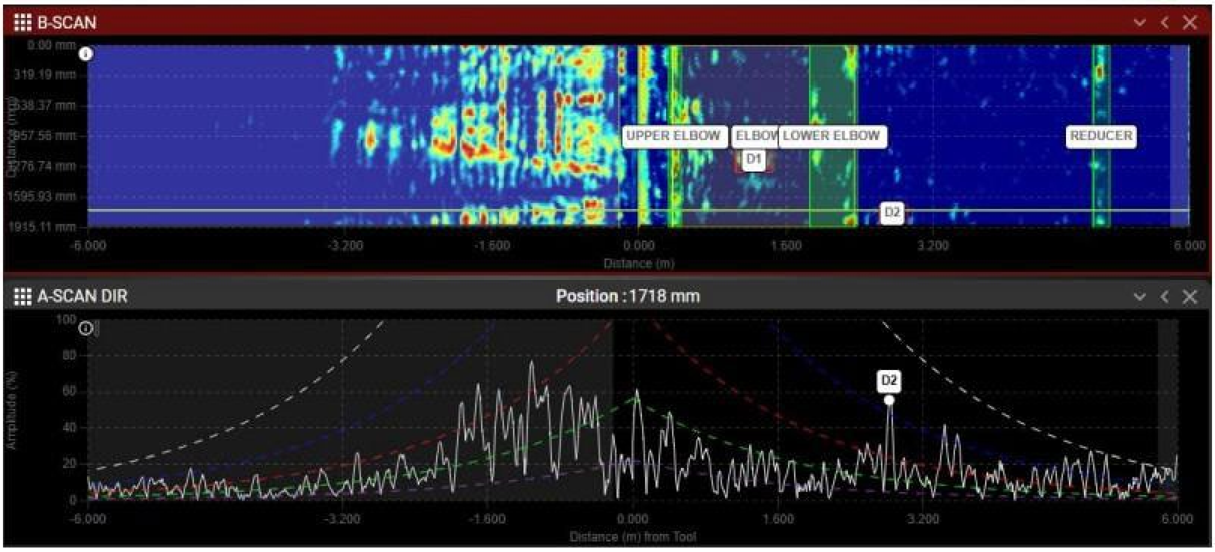


Figure 9. 24NB Gas Riser No. 2 A and B Scans showing Defect 2

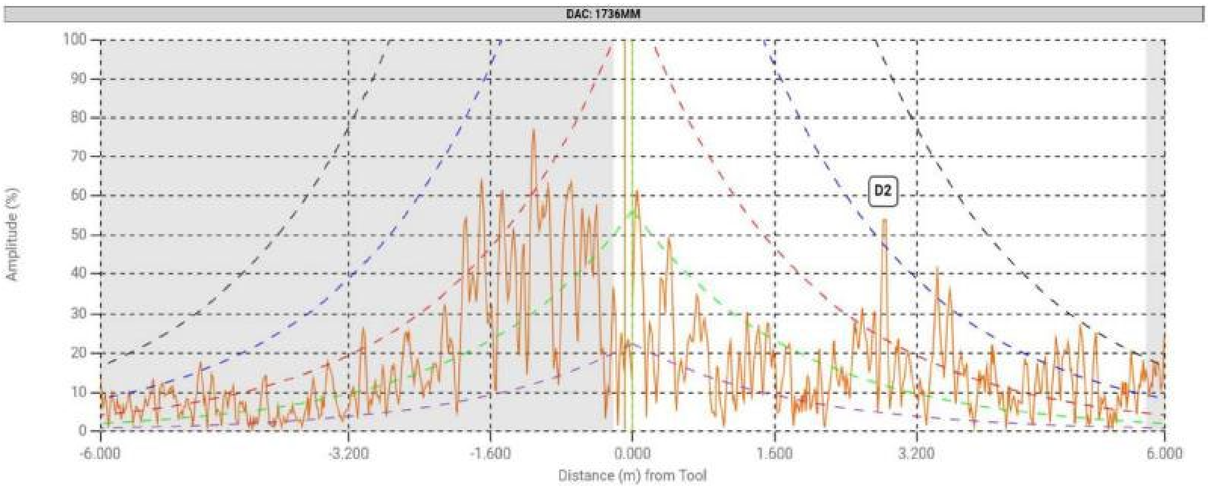


Figure 10. 24NB Gas Riser No. 2 A and B Scans showing Defect 2

Two minor-to-moderate defects were detected using LRUT FOCUS. Defect 1, located within the elbow, produced an A-scan reflection amplitude of 55% screen height. Defect 2, situated below the ground line, yielded an amplitude of 53%. It should be noted that sound energy attenuates rapidly as it propagates along the pipe, particularly upon entering the wrapped section.

Based on the estimated DAC, Defect 1 (located within the elbow) is considered minor. However, Defect 2—situated just below the ground line at 3,000 mm from the datum and approximately at the 10 o'clock position—exhibits a moderate level of damage and warrants further investigation. The reducer on the main pipe was clearly visible at 5,200 mm from the datum, confirming a successful inspection of the entire segment from the datum to the reducer.

3.3. Results 10NB Gas Riser

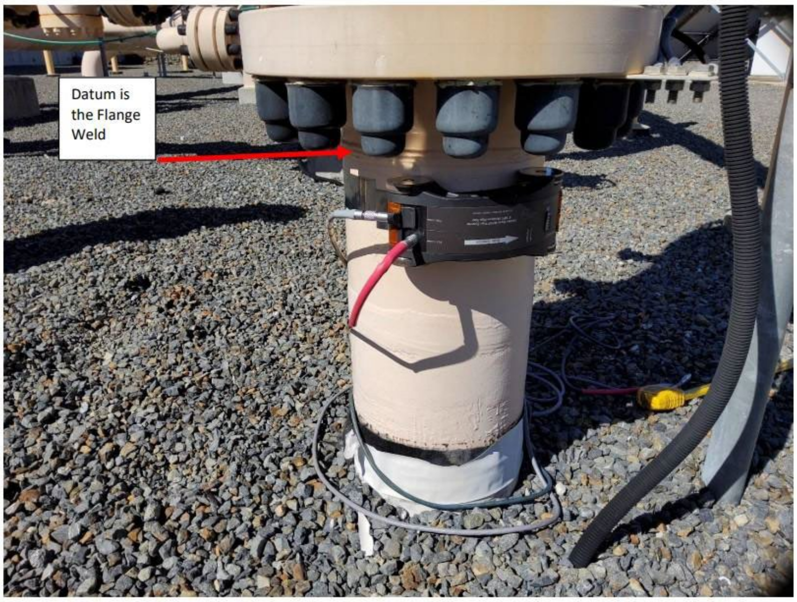
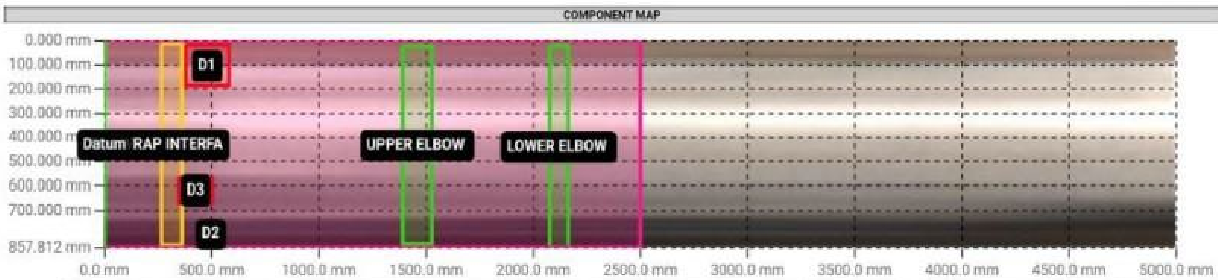


Figure 11. 10NB Gas Riser

The 10-inch NB vertical gas riser consisted of 12.7 mm wall thickness carbon steel Schedule 60 pipe. This riser was initially inspected using LRUT Lite, which revealed that the vertical 10-inch spool was welded to a 90-degree elbow approximately 1,400 mm below the datum. Given the relatively short length of the area of interest, a medium-range scan was performed at a frequency of 64 kHz.

The datum was the weld below the flange shown in Figure 11. The 12 o'clock position was defined as the circumferential point facing the entry gate fence (the camera location in Figure 11), with the clockwise direction oriented looking up. The test location was 50 mm from the datum.

The EMAT MRUT method demonstrated sufficient range to detect the first and second 90-degree elbow welds, located approximately 1,400 mm and 2,000 mm below the datum, respectively. Due to its superior resolution and sensitivity, MRUT was selected for the 10-inch NB pipe scans. While a 128 kHz scan was trialled for maximum sensitivity, the depth of penetration was insufficient, and the elbow welds were no longer detectable.



Id	Name	Type	Axial Start (mm)	Axial End (mm)	Circ. Start (mm)	Circ. End (mm)	Category	Description
1	Datum	Weld	0.00	0.00	0.00	857.81	-	-
2	UPPER ELBOW	Weld	1391.26	1527.04	22.01	842.26	-	-
3	LOWER ELBOW	Weld	2076.13	2164.11	19.81	857.81	-	-
4	WRAP INTERFA	Interface	265.90	361.63	12.00	846.27	-	-
5	D1	Indication	378.88	579.98	18.14	185.50	-	-
6	D2	Indication	466.86	524.59	771.55	826.45	-	-
7	D3	Indication	347.16	503.25	567.65	667.47	-	-

Figure 12. 10NB Riser Component Map and Results

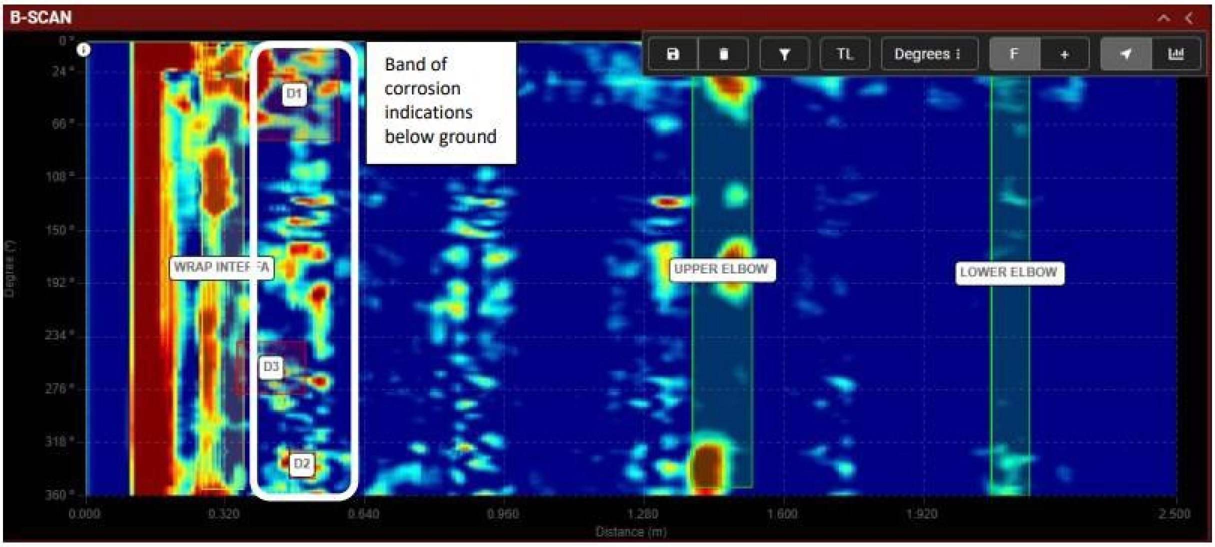


Figure 13. 10NB Riser B Scan

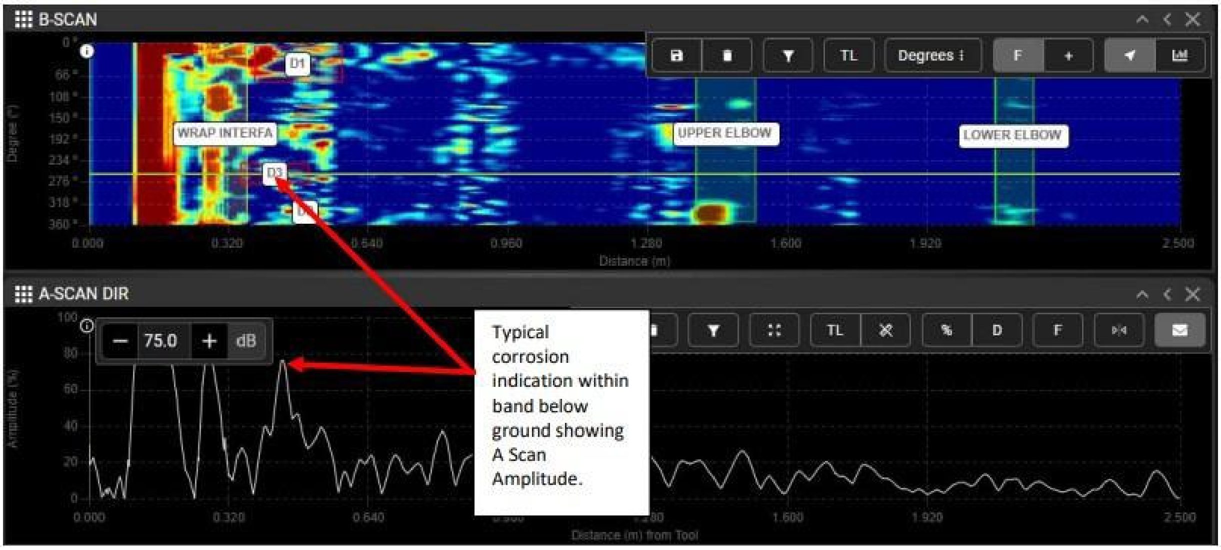


Figure 14. 10NB Riser A and B Scan

The interface between the painted bare pipe and the wrapped section is visible in the scan; however, it is difficult to distinguish between potential defects and interface signals. A distinct band of moderate corrosion is evident below ground, approximately 375 to 580 mm from the datum. The strongest indications in this region yielded an 85% A-scan amplitude, suggesting that the corrosion is moderate to severe. Additionally, several areas of minor corrosion indications were observed throughout the buried portion of the pipe.

4. Conclusions

The EMAT Guided Wave Ultrasonic Testing method was successfully validated for the inspection of buried gas riser pipes. Both medium and long-range methods provide sufficient reliability and accuracy in detecting sub-surface corrosion to serve as a viable alternative to excavation and visual inspection in most instances. Implementation of this technology significantly reduces inspection time and expenditure, minimizes the risk of mechanical damage during excavation, and enhances overall site safety.

While the sensitivity of these scans can only be verified through excavation and inspection, the ability of Shear Horizontal Guided Waves to detect known reflectors—such as elbow welds and reducers up to 3 meters underground—is very promising. This demonstrates that the waves successfully overcame the high attenuation caused by the pipe wrap and soil. Furthermore, they penetrated to a depth sufficient to detect typical corrosion, which generally occurs near the surface where oxygen and moisture are most prevalent.

It is also of note that the EMAT method of producing and receiving ultrasonic sound waves, specifically using the Magnetostrictive Strip and the VOLTA 2 platform, overcomes several common limitations found in short, medium, and long-range ultrasonic testing, such as:

- Capability to perform testing on short, straight pipe sections immediately preceding elbows.
- Capability of testing pipe wall thicknesses ranging from 1 mm to 25 mm.
- Inspection of pipes with restricted access (e.g., pipe racks, soil-to-air interfaces, or close-proximity flanges).
- Suitable for in-service pipes with both liquid and gaseous contents.
- Surface condition has minimal impact on results; coatings and paint can remain intact.
- High-temperature testing capability up to 250°C.
- Adaptability to perform various inspection types—including MRUT, LRUT, and other EMAT applications—using a single, lightweight, and cost-effective inspection platform.