CASE STUDY – Flare Header Pipeline Integrity Assessment

42" Flare Header Pipeline

Job Overview

Primary job scope of BHS was to carry out full integrity assessment of the 25 years old corroded flare header pipeline.

Total length of LP flare header pipeline is approximately 1050m including inside and outside the Central Degassing Station CDS up to the KO Drum inlet nozzle (N2). While the length of LP flares line from KO Drum outlet nozzle (N3) up to the flare stack battery limit is approximately 350m. The details of the pipeline section are as below

Section 1: Trains area to CDS Fence ~350 m

Section 2: CDS Fence to Flare KOD ~ 400 m

Section 3: Flare KOD to Flare Stack ~ 650 m

The Inspection of the 42" flare pipeline was done During April 2019.

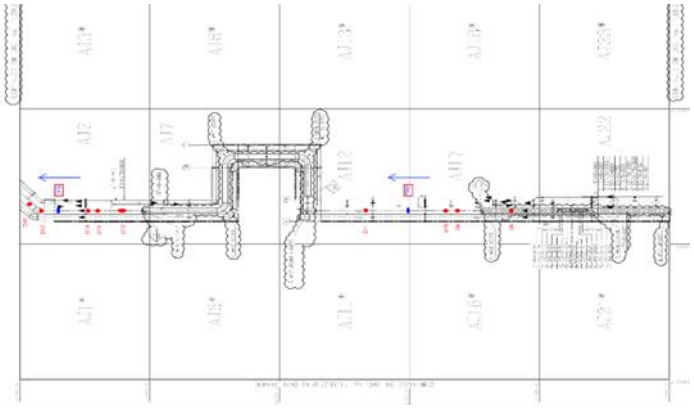

Fig 1: Pipeline Diagram

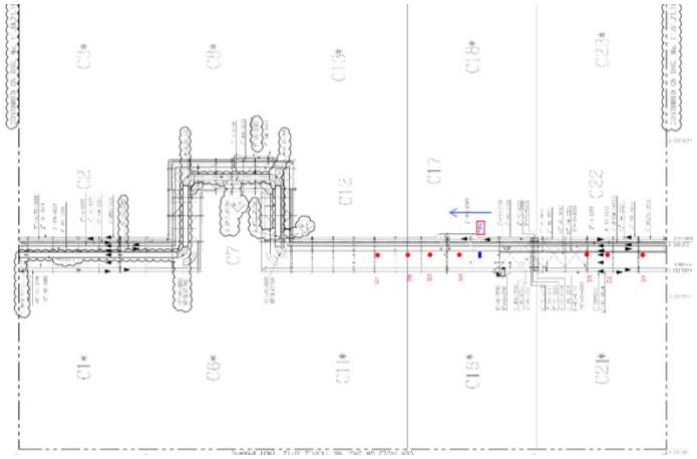

Fig 2: Pipeline Diagram

Inspection Equipment Details:

Equipment Tag:	42" Flare Pipeline	**Design Code:**	ASME B31.3
Design Pressure:	51 psi (3.5 barg)	**Inspection Code:**	API 570
Design Temperature:	150 °C	**Operating pressure:**	0.1 barg
Construction Material:	Carbon Steel	**Operating Temperature:**	36 – 127 °C
Nominal Thickness:	9.53 mm	**Material Specification:**	A672-C65 Cl22
In-service Date:	1993	**Insulation:**	None

Previous inspection history

- *Several leaks were experienced in the past.*
- *TML UT inspections in 2015/2016 reported up to 60% wall loss due to internal corrosion.*
- *UT scanning was conducted full length of section 1 and partial section 2 that revealed up to 80% wall loss.*
- *Liquid seepage (leak) found at one location in section 1 during UT scanning in 2016 inspection. The location clamped and later composite repair done*
- *Composite repair was done at total of 27 locations (20 in section 1 & 7 in section 2) in 2016 covering all defects have wall loss more than 60%*
- *During December 2018 inspection, 68% wall loss defects found in section 1 (adjacent to composite repaired locations).*

Expected damage mechanisms

The table below summarizes the expected damage mechanisms as per available data and previous experience in similar plants. Each damage mechanism categorized according to its' probability and potential:

*DM# as per API 571 Table5-4

SN	Damage Mechanism	DM#*	Probability	Active / Potential
1	**Wet H2S Damage (Blistering/HIC/SOHIC/SSC)**	2	High	Potential
2	**Sour Water Corrosion (Acidic)**	13	Medium	Potential
3	**Erosion / Erosion Corrosion**	20	Low	Potential
4	**CO2 Corrosion**	42	Medium	Active
5	**Atmospheric Corrosion**	47	Low	Active
6	**Vibration-Induced Fatigue**	56	Very Low	Active

Extent of inspection and Examination techniques

The intent of this scope is to ensure that the concerned section at the flare header is in sound condition and fit for purpose as part of this project by conducting a full integrity assessment. This includes the following:

- Full Visual inspection of the pipeline including evaluation by API 570 authorized inspector.

  API inspector is required to perform an external visual inspection of the flare header to highlight corroded areas and coating defects.
- GWT scanning with AUT/PAUT verification of findings.

  Guided Wave Testing (GWT)- Guided Waves Ultrasonic Testing (GWUT) will be utilized for primary screening of the pipeline to allocate the areas of concern within the pipeline.
  After the areas of concern / expected thinning locations being identified, more quantitative technique such as AUT and/or PAUT corrosion scanning to be utilized to determine the exact remaining wall thickness.
- Full PAUT scanning of circumferential welds.

  All the circumferential welds scanned using PAUT to ensure the soundness of the welds.
- PAUT/UTG Scanning of Fittings: Due to limitations of GWUT with regards to the elbows and fittings the other techniques such as UTG grid mapping and/or PAUT will be used for the inspection of elbows and fittings associated with the pipelines.

Guided Waves Ultrasonic Testing:

Guided Waves Ultrasonic Testing was performed for the purpose of primary quick screening of the flare header to allocate the areas of concern where further quantitative inspection to be performed.

Fig 1: Wavemaker G3 system

Fig 2: Ring with modules

GWUT Inspection Procedure:

- Rings were mounted on the pipeline and inflated for proper coupling. This allowed appropriate sensitivity and reliability of installation.
- Data was collected/monitored from both sides of the transducer ring.
- All measurements were given from the centre of the transducer ring location which was marked on the bottom of the pipe.
- GWUT data recorded during the examination was analysed as per the procedure.

GWUT Examination:

The Pipeline was examined according to

- Analysis GUL Procedure 105 2010
- Collection procedure GUL 1.1

GWUT Inspection Results:

Sample GWUT Findings in Pipeline:

Result: 1

Feature	Location	ECL	Length	Extent	Class	Clock	Notes
-F9	-10.11	2.7	1.38	0	Severe		D12. AUT scanning is recommended along
-F6	-6.82	2.2	0.25	0	Severe	4	D13.AUT scanning is recommended along
-F3	-5.31	13	0	0	Medium	3	D14. Non-symmetry in the weld. Weld
+F3	4.54	46	0	40	Medium	2	D15. Non-symmetry in the weld. Weld
+F5	7.22	9	0	30	Medium	7	D16. AUT scanning is recommended along

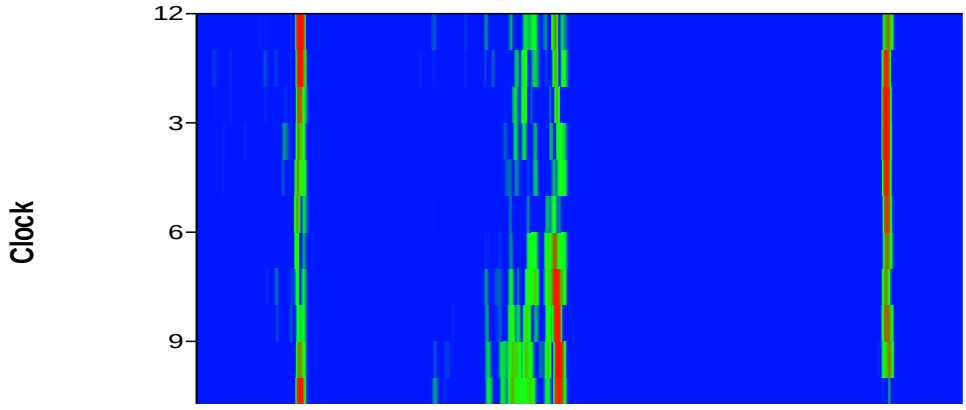

Fig 5: GWUT analysis finding & signals

Result: 2

Feature	Location	ECL	Length	Extent	Class	Clock	Notes
-F25	-20.06	3.5	0	14	Severe	9	D28. AUT scanning is recommended along 500mm of this point
-F21	-16.42	1	0	0	Severe	8	D29. AUT scanning is recommended along 500mm of this point
-F13	-10.79	3.3	0	19	Severe	8	D30. AUT scanning is recommended along 500mm of this point
-F9	-7.23	2.3	0	16	Severe	4	D31. AUT scanning is recommended along 500mm of this point
-F4	-2.68	2	0	5	Severe	4	D32. AUT scanning is recommended along 500mm of this point
+F11	10.34	1.7	0	0	Severe	4	D33. AUT scanning is recommended along 500mm of this point
+F14	15.49	1.9	0	12	Severe	7	D34. AUT scanning is recommended along 500mm of this point
+F21	21.21	3.2	0	0	Severe	11	D35. AUT scanning is recommended along 500mm of this point

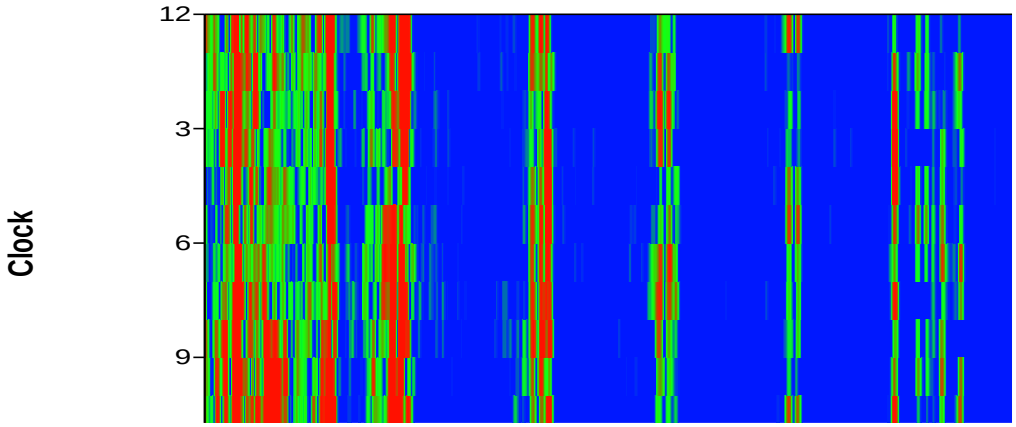

Fig 6: GWUT analysis finding & signals

Automated Ultrasonic Corrosion Mapping AUT:

Automated Corrosion Mapping was utilized for the verification of GWUT results and to accurately measure the remaining wall thickness at the areas of concerns allocated along the flare header.

Fig 7: Silverwing RMS system

AUT Inspection Procedure:

- AUT equipment was mounted on the pipeline by using the magnetic wheel.
- Sensor is adjusted to allow appropriate sensitivity and reliability of installation.
- AUT data recorded during the examination was analysed as per the procedure.

AUT Inspection Results:

Sample AUT Findings in Pipeline:

Result: 1

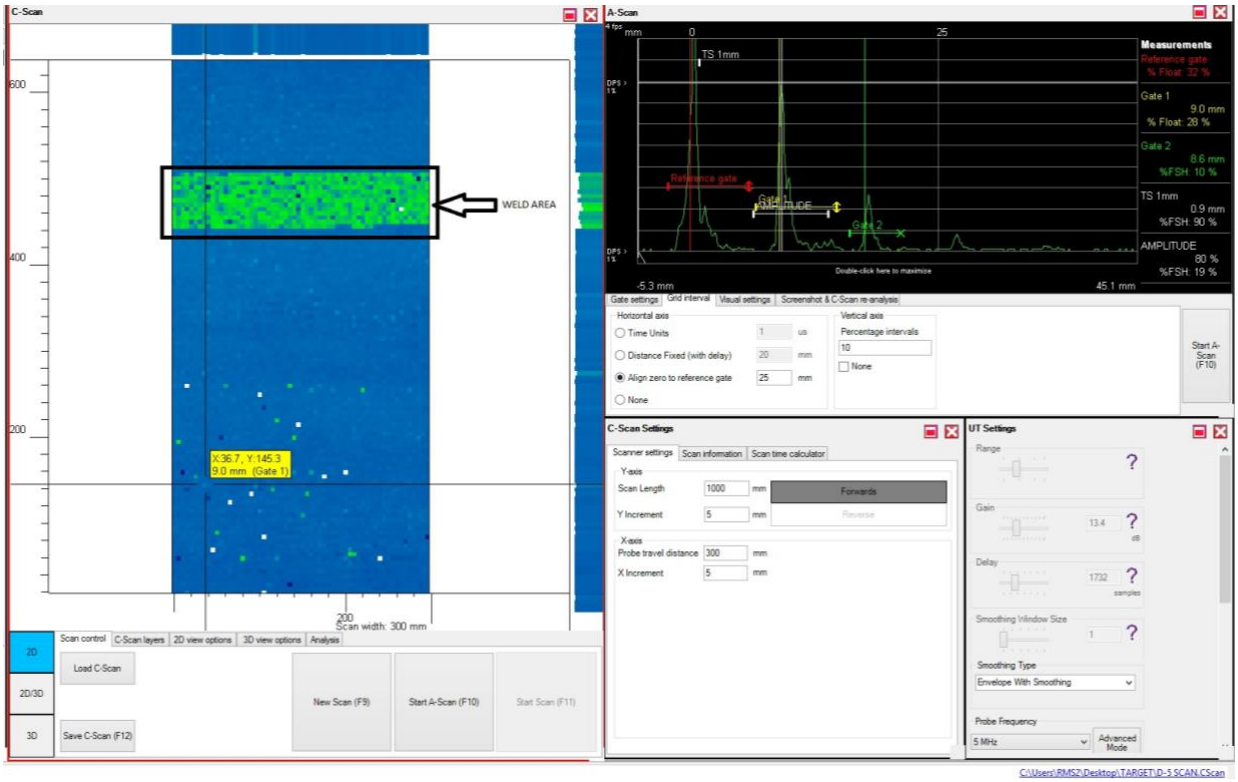

Fig 8: AUT analysis finding & signals

Result: 2

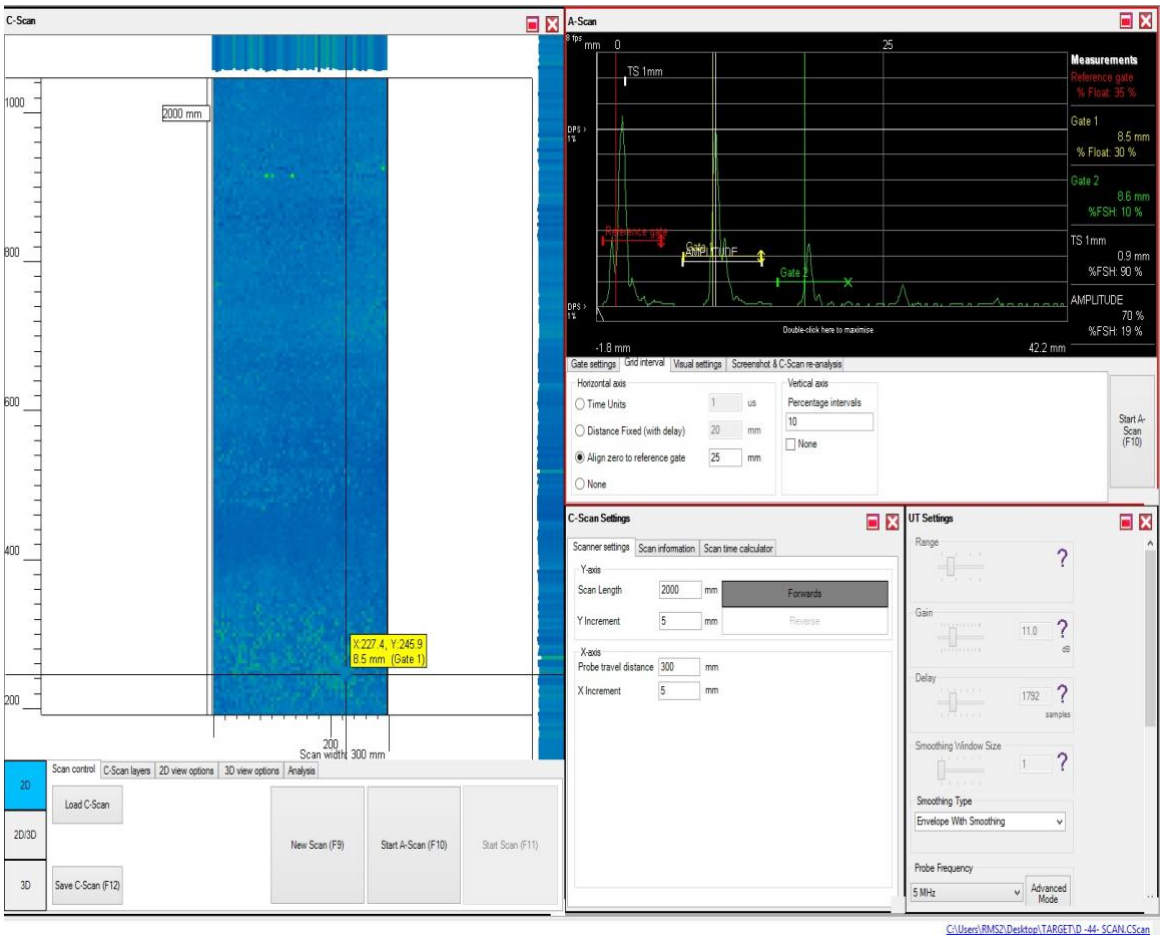

Fig 9: AUT analysis finding & signals

- Average and sever wall loss was found due to internal/ external general corrosion & pitting.

Phased Array Ultrasonic Testing:

PAUT was utilized for the assessment of the circumferential welds as well as the corrosion mapping of fittings which cannot be inspected by AUT technique due to the difficult geometry.

Fig 10: Eddyfi M2M system

Fig 11: Probes & Wedges

PAUT Inspection Procedure:

- PAUT equipment was setup and calibrated as per the requirement.
- All welds on the pipeline were inspected by using PAUT inspection.
- PAUT data recorded during the examination was analysed as per the procedure.

PAUT Inspection Results:

PAUT sample Findings:

Result: 1

Sr. No	Defect Type	Length	Minimum Thickness	Defect Location
1	COROSSION	30 mm	5.6 mm	11 O' clock
2	ISOLATED PITTINGS	SPOTS	5.2 mm	All around

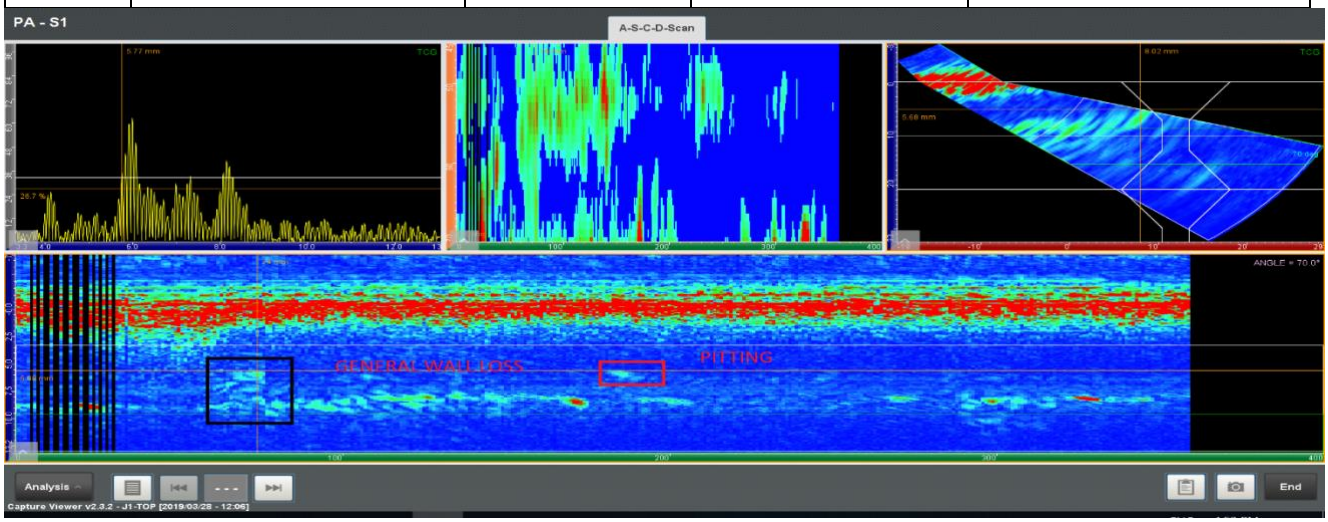

Fig 12: PAUT analysis finding & signals

Result: 2

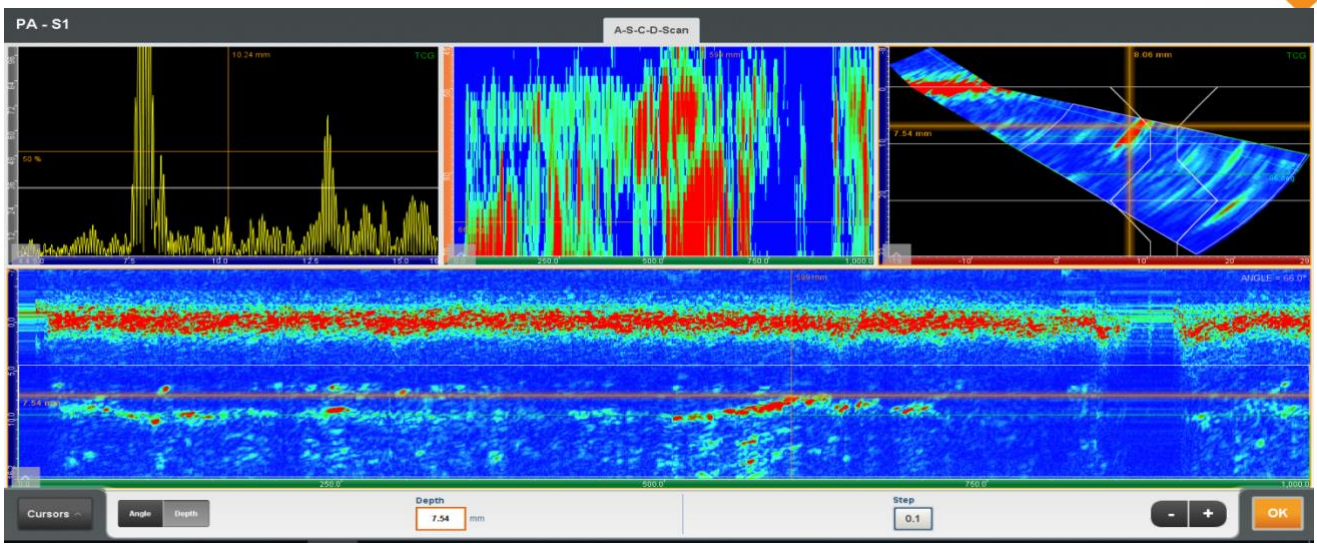

Fig 13: PAUT analysis finding & signals

- Minimum measured wall thickness was 4.6 mm.

1. Conclusion

There were no obvious critical visual findings in the pipeline. Most of the findings are general and localized corrosion indicated by advanced NDE (GWUT, AUT and PAUT).

The corrosion is concentrated in lower section (between 3 to 8 O'clock positions of the pipe) and in some sections in upper section (between 10 to 2 O'clock positions of the pipe).

The line has bad history of leaks and sever wall loss (pitting corrosion led to leak) in 2015 and 2016.

2. Repair Methodology

As per rehab project repair objective to re-instate the integrity of the pipeline for the next 30 years and according to the current condition of the pipeline (Corrosion and leak history) we can conclude that in-service maintenance repair is not the best option, hence, full replacement of section II & III is recommended to ensure the integrity of the pipeline for the next 30 years.

3. Recommendations

As per rehab project repair objective to re-instate the integrity of the pipeline for the next 30 years and according to the current condition of the pipeline (Corrosion and leak history), the line (sections 2 &3) shall be replaced with a new one according to applicable construction Code ASME B31.3 then painted according to coating project specification.

The client Engineering department has accepted our recommendations and requested the EPC contractor to proceed with replacement based on our report.

Next inspection intervals shall be 5 years started from service starting date after construction (reference to API 570, Class 1 piping system)