CANADIAN NATURAL RESOURCES LTD

PHASED ARRAY ULTRASONIC REPORT-04-08-031-18W4

Client	Canadian Natural Resources Ltd.	**Work Location**	Drumheller, Alberta
Client Representative	Darren Welch	**Date of Inspection**	October 4th to 6th 2016
AFE / PO #		**Report Number** **Client Number**	SG-001 PAUT-04-08-031-18w4-2016 AB-101-10062016-01
Reference Specifications	ASME SECTION V ART 4 UT	**Acceptance Criteria**	Client Spec
Item Inspected	Circ seam, Long seam and Nozzle	**Material Type/Thickness** **Material Grade**	Carbon Steel / 19.73mm SA516-70
Equipment Line #	Drum-04-08-031-18w4	**Location #**	Drumheller
Welding Contractor **Weld Type**	N/A N/A	**Welder / ID** **Weld Procedure**	N/A N/A
Inspection Method	Phased Array/TOFD Ultrasonic Testing	**Procedure** **Technique**	FOCUS UT-04C/B-09 Rev.3 Scanplan-TS#01
Technician 1	Selva Ganesan S	**Qualifications**	SNT/ASNT -UT3 /PCN-PA2/CGSB-UT2

Examination Settings

Method:	☒ Contact ☐ Immersion ☐ Other:	**Surface Temp (C):**	☐ < 5° ☒ > 45°/ < 45° ☐ > 60°
Type:	☒ PE ☐ T/T ☐ Dual ☒ Automated ☒ PAUT/TOFD	**Scanning Surface:**	☒ OD ☐ ID ☐ Other:
Application:	☐ Laminar ☒ Shear Wave ☒ Volumetric ☐ Thickness	**Surface Condition:**	Acceptable

Instrumentation:	Manufacturer:	OlympusNDT	Type:	Omni-Scan	Instrument Ser. #:	OMNI2-101772	
Calibration:	Date:	10/04/2016	Reference Flaw Size:	2.38mm SDH	Module Ser. #:	OMNI-600688	
Calibration Block(s):	Type:	IIW Block Type 1	FOCUS #:	20107	Type:	N/A	FOCUS #: N/A
	Type:	Scanner Block-0.75"	FOCUS #:	UT-001	Type:	Software Version:	4.1R7
Couplant:	Brand: H2O	Type:	Water	Cable:	Type:	Umbilical	Length: 20 meter

Probe						Settings – Db			Range - ☐ inches ☒ mm		
Manufacturer	**Type**	**Serial #**	**Angle**	**Freq.**	**Size**	**Wedges**	**Ref. Level**	**Scan Level**	**Screen Size**	**Skip Value**	**Beam Travel**
OlympusNDT	5L64	M2881	40°-65°	5.0MHz	64 elms.	SA2-N55S	80%	+6	Variable	Variable	Variable
OlympusNDT	5L64	M2881	55°-72°	5.0MHz	64 elms.	SA2-N55S	80%	+6	Variable	Variable	Variable
OlympusNDT	5L64	M2883	40°-65°	5.0MHz	64 elms.	SA2-N55S	80%	+6	Variable	Variable	Variable
OlympusNDT	5L64	M2883	55°-72°	5.0MHz	64 elms.	SA2-N55S	80%	+6	Variable	Variable	Variable
Panametrics	C563	697859	70°	10.0MHz	3.00	ST1-70L-IHC	80%	+0	Variable	Variable	Variable
Panametrics	C563	677040	70°	10.0MHz	3.00	ST1-70L-IHC	80%	+0	Variable	Variable	Variable

SCOPE:

Carry out Phased Array Ultrasonic (PAUT) examination on the Bullet 04-08-031-18w4, circumferential seam, longitudinal seam welds and drain nozzle, in areas designated by the client (refer Figure 1). The examination shall consist of Phased Array sectorial and Time of Flight Diffraction scan, a 0° UT thickness verification and Manual shear wave (Transverse) scan. The examination shall cover the weld and it associated heat affected zones. Report all relevant indications and analyze in accordance with ASME V Section VIII Div. 1.

Figure 1: Item inspected by PAUT and direction of scan

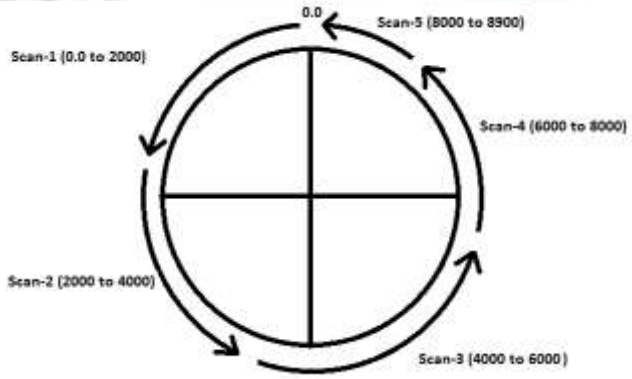

Figure 2: Scan Directions and layout

SUMMARY OF INSPECTION AND RESULTS

- Circumferential seam weld (100% examined on the area specified by client)
- Longitudinal seam weld (100% examined on the area specified by client)
- Nozzle (100% examined on the area specified by client)

1. Summary of 0° UT Thickness Inspection:

   A UT thickness measurement reading was performed prior to this examination on all shell side of the vessel. The majority of readings were found to be in the range of 20.13 to 20.93mm.

2. Summary of Shear wave inspection:

   Manual Shear wave was carried out on all accessible drain Nozzle weld utilizing a 45° and 60° probe to detect and locate any possible cracks or cracking within the welds, no cracks were noted during examination. See Figure 3 below.

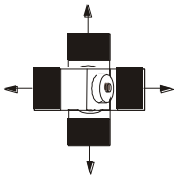

Figure 3: Manual Shear Wave (45°) scan pattern

3. Summary of Manual Phased Array Examination:

   Automated Phased Array Ultrasonic Technique (PAUT) was carried out to locate and size the nature of the defect utilizing the sweep angles of 40˚ to 72 ˚ degrees to locate, size and image the nature of the defect. All scan areas & datum marks are clearly marked out on the vessel for further examinations if so required. This examination was carried out from OD side of the Vessel.

Final Analysis:

After the final analysis it appears that there was no evidence of cracks or cracking in any of the welds and nozzles at the time of inspection. However there were random linear indications such as lack of fusion (L.O.F) within the weld volume noted during examination, may need continuous monitoring; please refer to ASME Indication Table #3. Summary of Indication images can be found on pages 5 of this report.

Submitted by:

Selva Ganesan S

Report Accepted by: _____Client Representative: Darren Welch

Report Reviewed by: _____Focus NDT SNT Level III: Emmanuel Aggrey

CIRCSEAM #	SCAN LENGTH	SCAN #	EVALUATION	ACCEPT	REJECT	COMMENTS
CS1	0.0 - 8800.0	S1	Linear indication @ 801.0 and 1290.0	√		No Cracks Found Continuous monitoring required.
		S5	Linear indication @ 8078.0	√		No Cracks Found Continuous monitoring required.
CS2	0.0 - 8800.0	S1	Linear indication @ 1421.0	√		No Cracks Found Continuous monitoring required.
		S2	Linear indication @ 2835.0	√		No Cracks Found Continuous monitoring required.
		S4	Linear indication @ 6266.0	√		No Cracks Found Continuous monitoring required.
CS3	0.0 - 8800.0	S1	Minor Porosity/Slag inclusion	√		No Cracks Found
CS4	0.0 - 8800.0	S2	Linear indication @ 2358.0	√		No Cracks Found Continuous monitoring required.
		S4	Linear indication @ 8635.0			No Cracks Found Continuous monitoring required.
CS5	0.0 - 8800.0		Minor Slag inclusion	√		No Cracks Found
CS6	0.0 - 8800.0		Minor Porosity/Slag inclusion	√		No Cracks Found
LS1	0.0 - 3100.0		Minor Porosity/Slag inclusion	√		No Cracks Found
LS2	0.0 - 3100.0		Minor Slag inclusion	√		No Cracks Found
LS3	0.0 - 3100.0	S2	Linear indication @ 2955.0	√		No Cracks Found Continuous monitoring required.
LS4	0.0 - 3100.0		Minor Slag inclusion	√		No Cracks Found
LS5	0.0 - 3100.0		Minor Slag inclusion	√		No Cracks Found

Table 1: Result (All measurement are in mm)

Report #:	SG-01-PAUT-04-08-031-18w4	Job#:	AB-101-10082016-01	Date:	06th October 2016
Client:	CNRL	PO #:		Contact:	Darcey Greig
Welder Id.:	N/A	Joint Id	CIRC AND LONG SEAM	Thickness:	19.73mm
Welding Process:	SMAW	Code:	ASME	Section #:	SEC VIII
Remarks:	All measurement are in mm				

Indication N°	Weld N°	Beam Angle and Beam Direction	Reference Level	Probe		Indication						Remarks
				Sound Path	Stand Off	Maximum TCG %	X axis	Y axis	Length	Depth from 'A' Surface	Height	
1	CS1-SC1	72°	45.2	63.85	20.0	>100%	801.0	+2.0	10.0	16.5	1.3	LOF
2	CS1-SC1	48°	41.8	29.49	20.0	>100%	1290.0	-15.0	10.0	1.5	1.1	LOF
1	CS1-SC5	48°	41.8	29.49	20.0	>100%	8078.0	-17.0	19.0	14.4	4.1	LOF
1	CS2-SC1	43°	41.3	26.98	20.0	>100%	1412.0	0.0	6.0	5.7	2.1	LOF
1	CS2-SC2	52°	41.3	32.05	20.0	>100%	2835.0	0.0	10.0	6.5	3.5	LOF
1	CS2-SC4	62°	41.8	42.03	20.0	>100%	6266.0	-9.0	570.0	17.7	3.0	Intermittent LOF
1	CS4-SC2	51°	41.3	31.35	20.0	>100%	2358.0	+5.0	7.0	7.0	2.7	LOF
1	CS4-SC5	53°	41.3	32.78	20.0	>100%	8635.0	+6.0	6.0	10.3	2.6	LOF
1	LS3-SC2	51°	41.8	31.35	20.0	>100%	2955.0	-20.0	10.0	18.2	4.1	LOF

Table 2: ASME Indication Table

Notes:

1) Distance from X is used in describing the location of a weld discontinuity in a direction perpendicular to the weld reference line. Unless this figure is zero, a plus or minus sign must accompany it.
2) Distance from Y s used in describing the Position of weld discontinuity in a direction parallel to the weld reference line. This figure is attained by measuring the distance from the Y end of the weld to the beginning of said discontinuity.
3) Beam Direction is towards 0, 90, 180 or 270 (see Figure 1 below.
4) Make separate report following repairs. (Suffix report no. with R1, R2, etc)

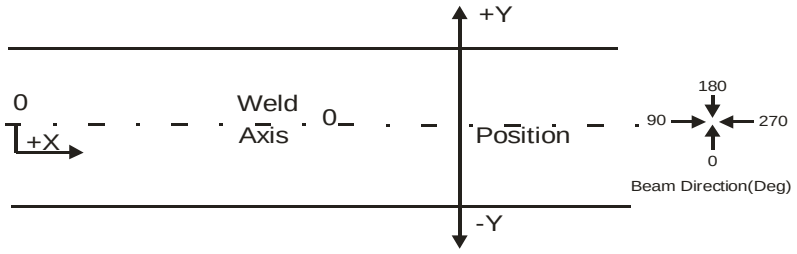

Figure 4: Beam Directions

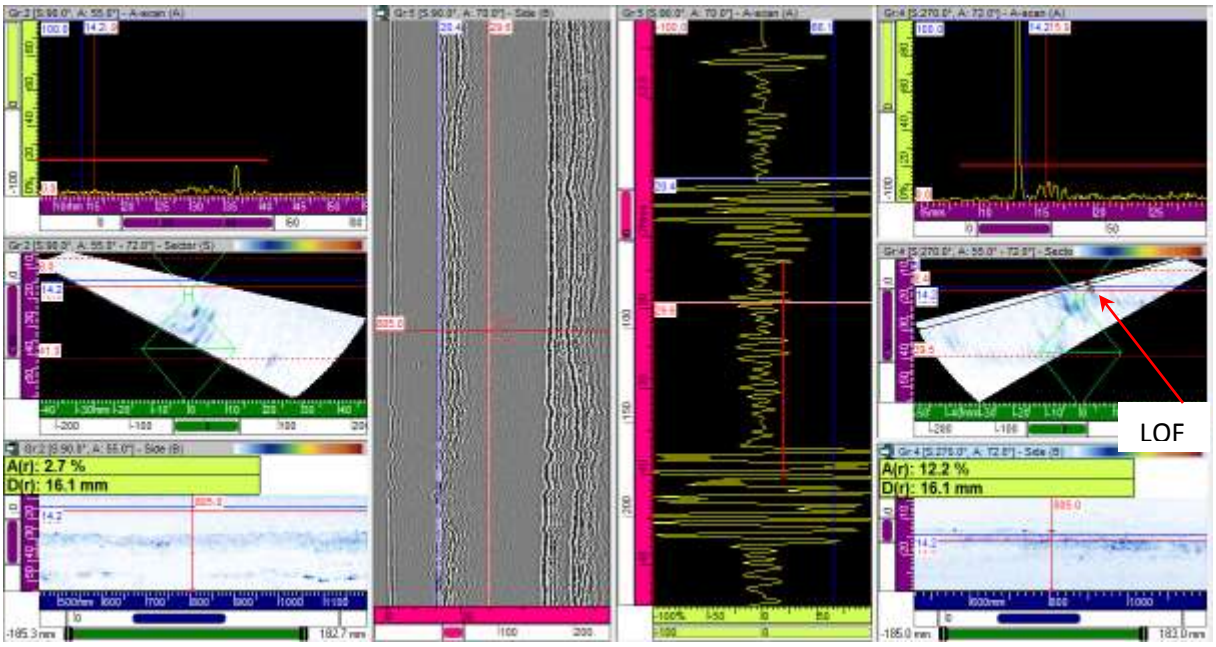

Figure 5: CS1-SC1 INDICATION-LOF

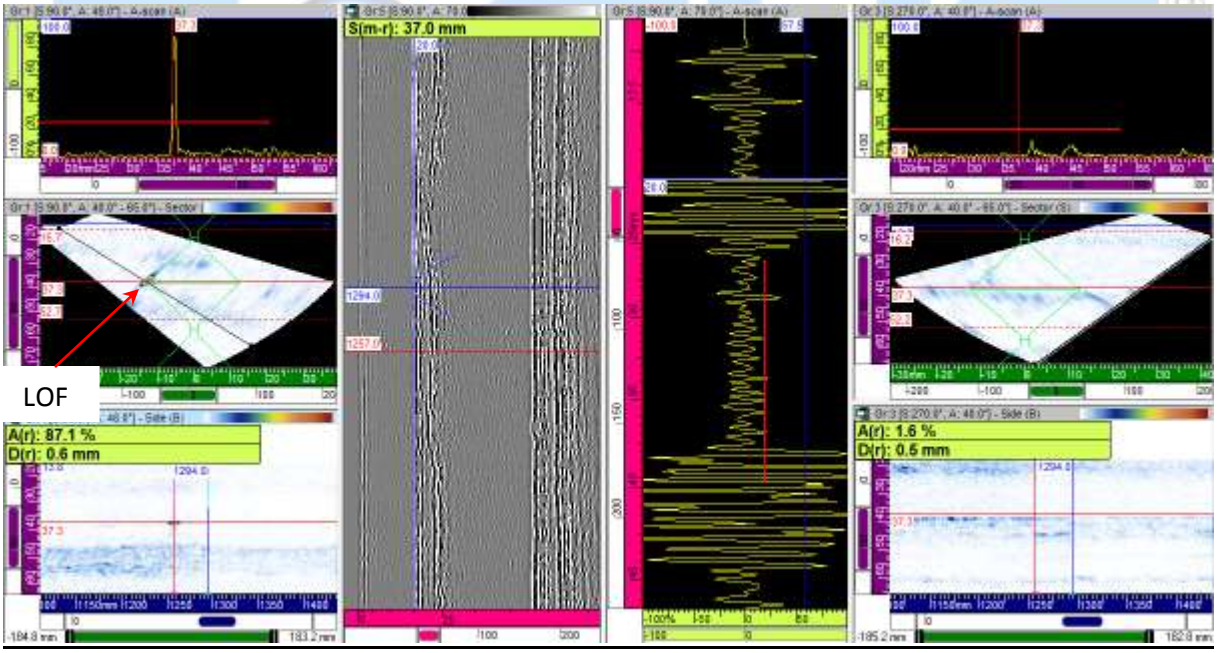

Figure 6: CS1-SC1 INDICATION-LOF

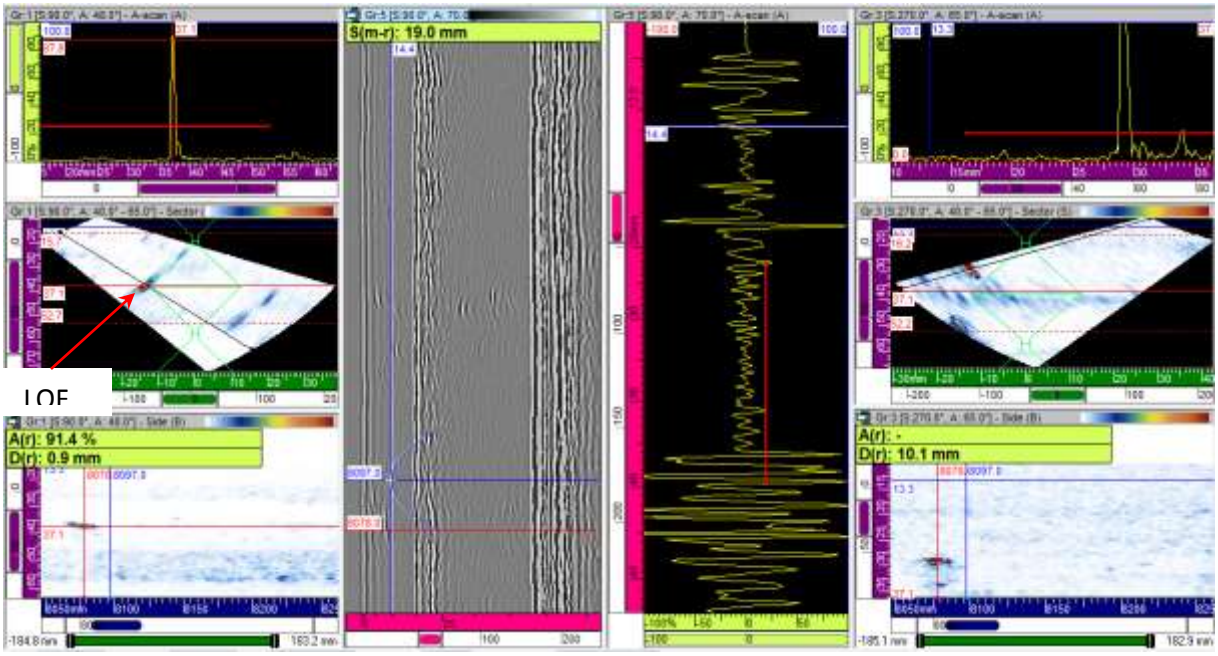

Figure 7: CS1-SC5 INDICATION-LOF

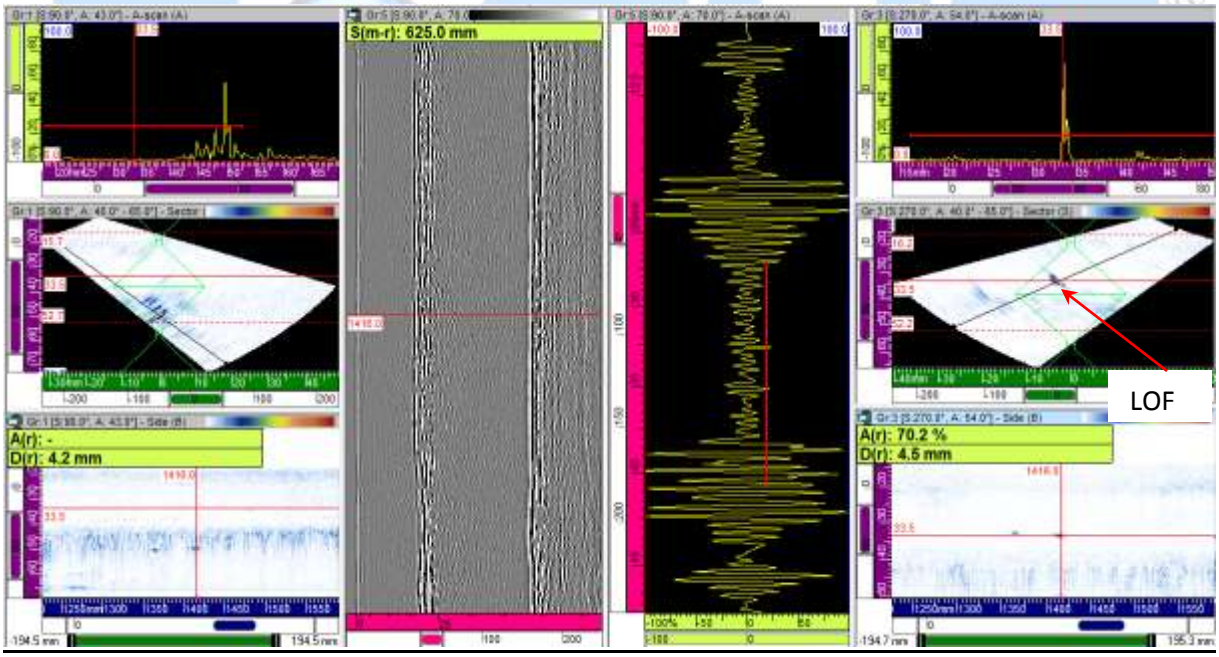

Figure 8: CS2-SC1 INDICATION-LOF

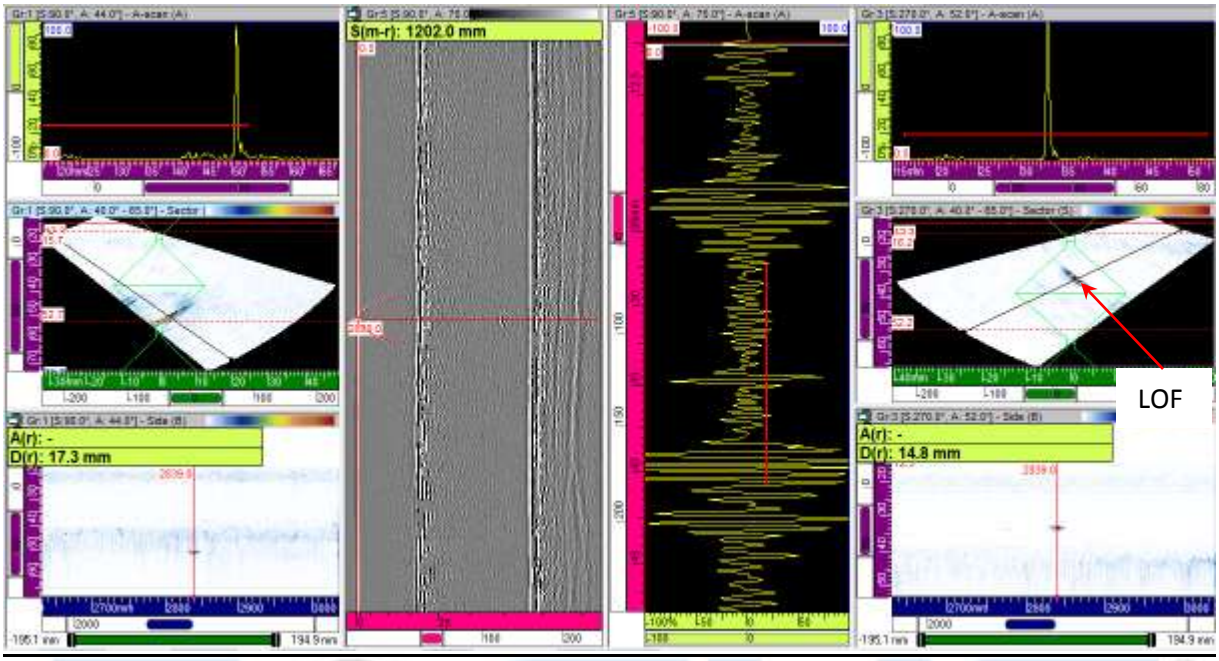

Figure 9: CS2-SC2 INDICATION-LOF

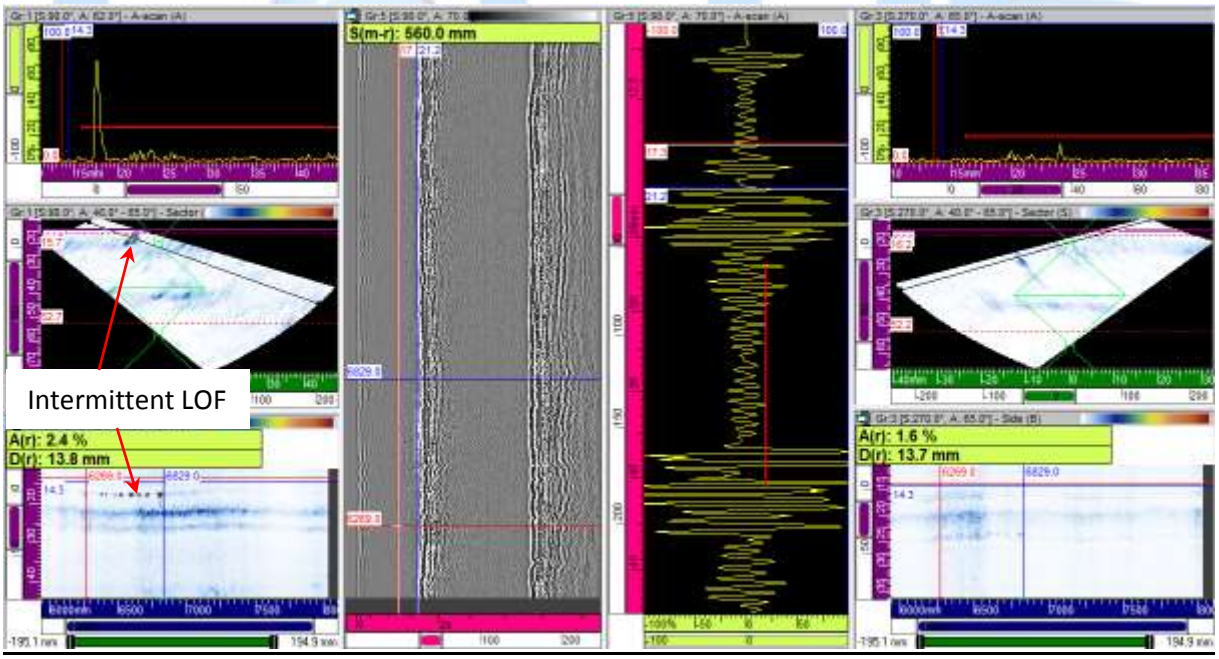

Figure 10: CS2-SC4 INTERMITTENT INDICATION-LOF

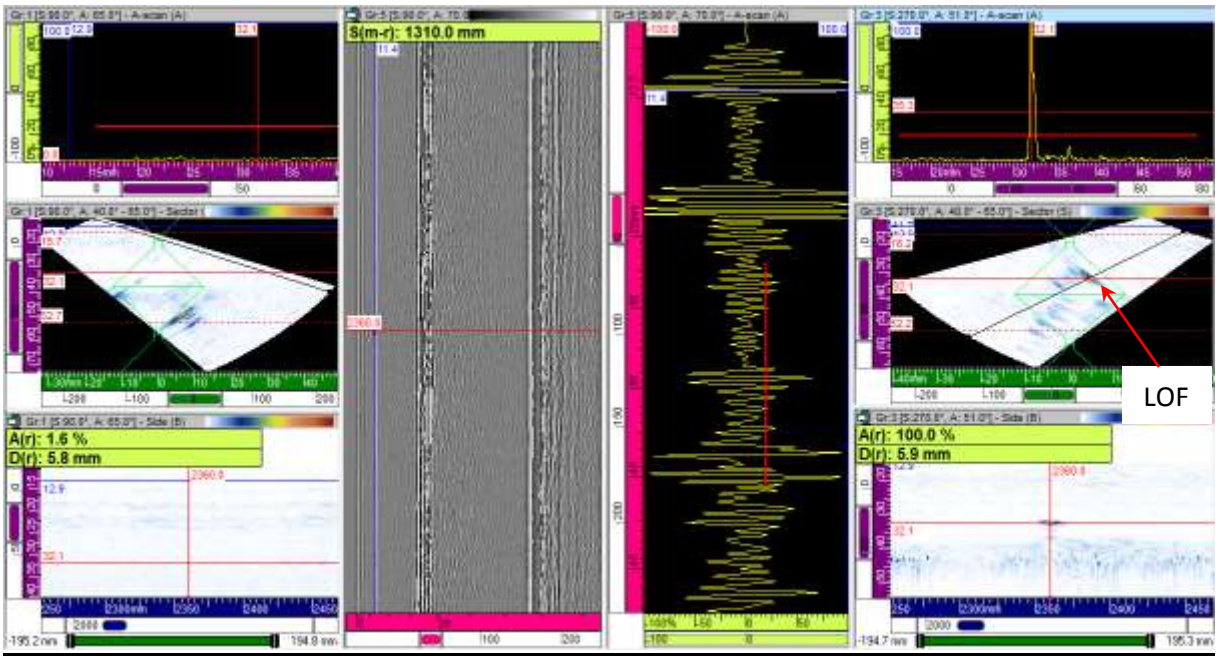

Figure 11: CS4-SC2 INDICATION-LOF

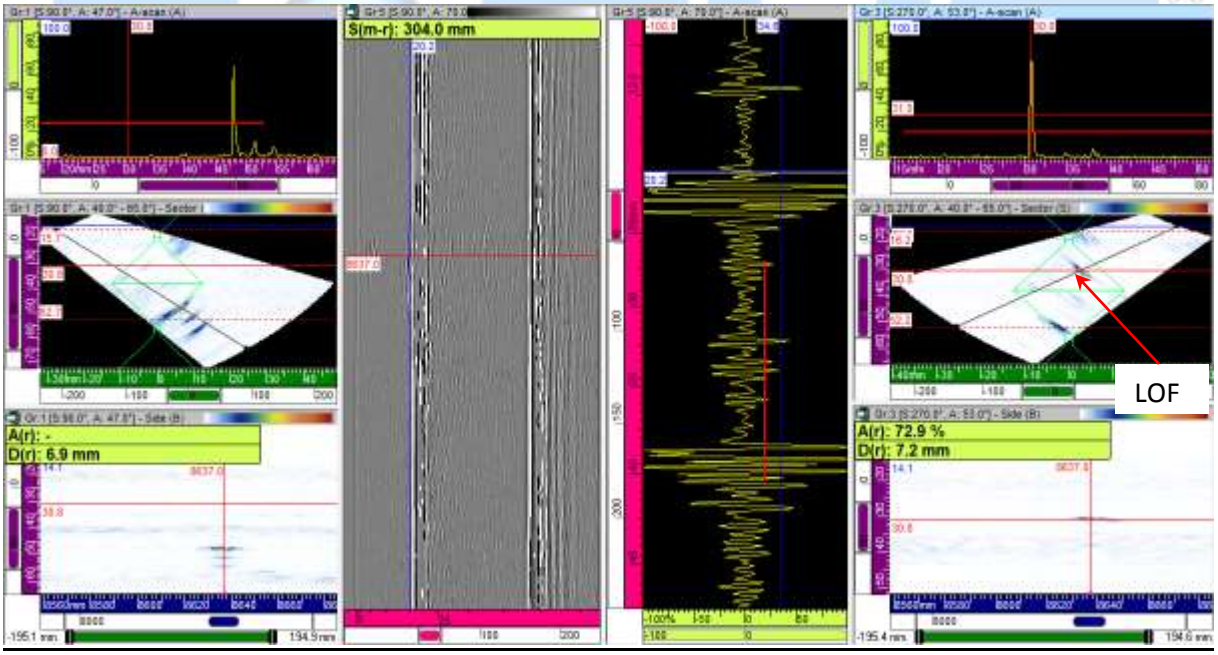

Figure 12: CS4-SC5 INDICATION-LOF

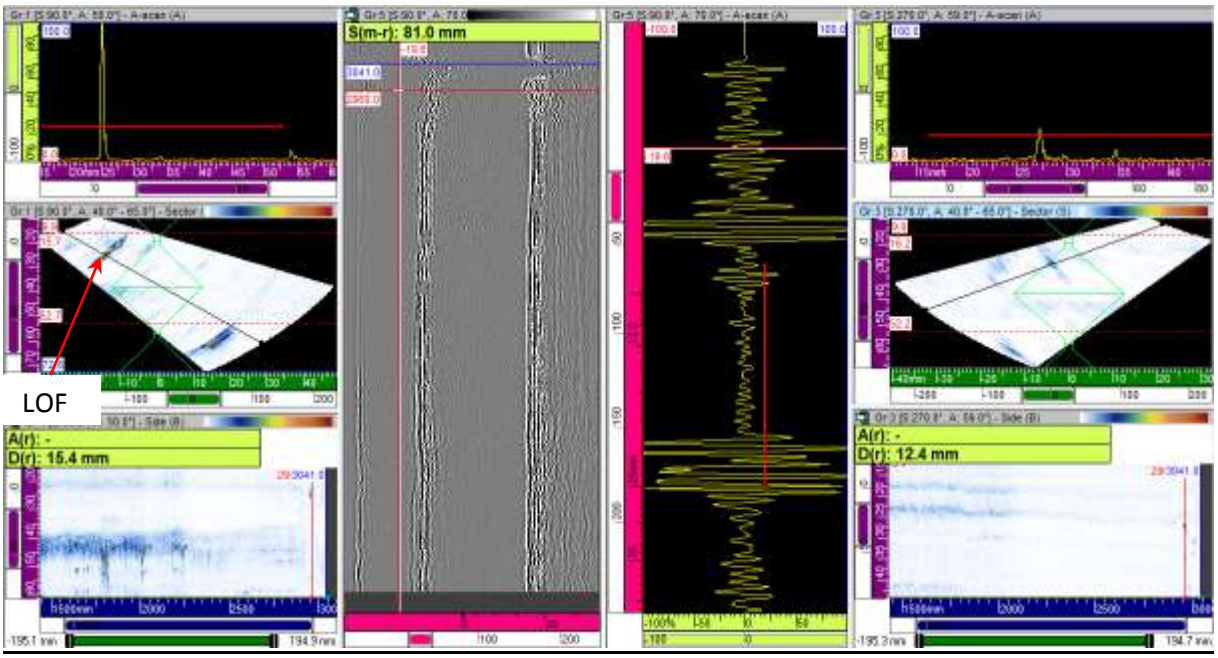

Figure 13: LS3-SC2 INDICATION-LOF