SLOFEC™ LS150 & ULTRASONIC VESSEL INSPECTION

Client: Client

Facility: Client's Facility

Items Inspected: BT Vessel

Inspection Method: SLOFEC™ & Ultrasonic's

Date Commenced: 13th January 2014

Date of Completed: 18th January 2014

Type of Report: Final Report

Report Number: K0xx-13/Jxx22

FPAL empowered by Achilles
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W W W . I N N O S P E C T I O N . C O M

SLOFEC™ LS150 & MANUAL ULTRASONIC VESSEL INSPECTION REPORT

Executive Summary

As requested by Client; Innospection has carried out a SLOFEC^{TM} (Saturation Low Frequency Eddy Current) inspection, on the Vessel identified as BT.

The inspection was conducted at the Client's Facility, from the 13th of January 2014 and completed on the 18th of January 2014.

This inspection report documents in detail the specific inspection that has been conducted; the individual technique and equipment utilised, and the results, observations and conclusions obtained.

This SLOFEC^{TM} inspection indicated internal indications primarily at the 5-7 o'clock locations; with wall losses indicated up to and greater than 50%, of the original nominal manufactured wall thickness.

The corrosion appeared to be that of internal pitting, that was noted wide spread and most severe across the middle lower sections of this vessel. Random spot checking with Ultrasonic around the dome ends, nozzles, branches, take offs and SLOFEC™ scanner dead zones, also showed areas of wall loss present.

The lowest ultrasonic wall thickness measured, was found in zone 2 (please see the included appendix mapping), where a result of 3.6mm remaining wall was indicated.

Content

Appendix

1. Test Object Data

Object Identification :	BT Vessel
Location of Object :	Client's Facility
Orientation of Scan :	Longitudinal
Wall Thickness :	Nominal 9.5 mm
Material :	Carbon Steel with a painted coating.
Surface Condition :	Generally clean and free from loose debris.

2. Inspection Task

As requested by Client, a SLOFEC™ (Saturation Low Frequency Eddy Current) inspection was performed on the BT Vessel located at the Client's Facility from 13/01/14 to 18/01/14.

The inspection was performed with a SLOFEC™ technology scanner, type LS150.

SLOFEC™ is regarded as a fast corrosion screening technique, detecting corrosion on either side of the wall inspected. This method of testing makes it practical to inspect storage vessels from the external surfaces, whilst they are still in service and at operating temperatures.

The SLOFEC™ inspection team consisted of qualified engineers from Innospection Ltd.

All areas described in Section 4 – Inspection Volume were inspected with the SLOFEC™ Scanner.

The inspection was to survey for evidence of internal and external corrosion.

3. Inspection Personnel

Lead Inspection Technician	: Technician a, ET PCN level 2, UT PCN level 2 / 000000
Inspection Technician	: Technician b, ET PCN level 2, UT PCN level 2 / 000001
Assistant	: Technician c, ET PCN level 2 / 00002

4. Inspection Volume

The SLOFEC™ Scans were intended to be taken over 360º coverage of the general vessel body. Weather and time constraints lead to 6 specific zones being inspected (as per the appendix). The seam welds including the heat affected zones were not scanned.

All accessible areas of the vessel were targeted for inspection with the exception of specific dead zones, which could not be inspected due to the design of the scanner (i.e. the wheels of the scanner butted against weld beads).

The Dead Zone refers to the following areas:

a. 15 mm on either side of any weld
b. 15 mm on either side of any nozzles/off takes

5. Inspection Equipment

5.1 SLOFEC™ Equipment

The inspection system consisted of the following SLOFEC™ equipment and accessories:

Scanner :	SLOFEC™ Scanner LS150 (width 150mm)
Description of Scanner :	The SLOFEC™ Scanner LS150 is a handheld system equipped with permanent magnets and multiplexed electronics. 8 sensors each with a width of 18.75mm are located between the pole shoes. A trigger encoder is connected via a belt drive to one wheel. 2 wheels at the front and 2 wheels at the rear are adjustable in height for lift off.
Scanning Speed :	100% (approx.: 24m/min)
Eddy Current Instrument :	IBM-AT-compatible computer with 2-frequency Eddy current plug-in cards. Type : eddyMax - EMC07/08.03
Eddy Current Sensors :	8 x EC-B-18.75mm
Software Version :	EddyMax Eddy Current Multiplex Software With trigger use – SN 20000997 TMT Version 5.07.07.20
Cable :	30 metres of specific cable connection between the computer eddy current instrument and SLOFEC™ Pipe Scanner LS150
Reference Plate :	9.5mm from Innospection – S/N 265
Reference Defect :	20%, 40%, 60%, 80% FBH

5.2 Ultrasonic Equipment

The Ultrasonic Equipment consisted of the following accessories:

GE – USM GO Ultrasonic Flaw Detector capable of both “A” scan display and digital thickness readout - **USMG009110981**
5 MHz 10mm Ø twin crystal transducer
2mm – 12mm carbon steel calibration step wedge

6. SLOFEC™ Equipment Setting

In general, the SLOFEC™ system is calibrated using sample test samples with artificial reference defects. The reference samples should be of the same material and thickness as the surface to be inspected.

In the case of a coating being present on the surface to be inspected, the average thickness of the coating (if applicable) should also be simulated on the reference sample for the calibration.

Typical reference defects that are used are flat bottom holes or conical bottom holes are with a diameter of 5mm, 10mm and 20mm.

The depths of the artificial reference defects are typically 20%, 40%, 60%, 80% and 100%.

For calibration, the SLOFEC™ system is driven over the reference defects and the channels are set (one sensor per channel) to give a sufficient sensitivity level for the detection of topside and underside corrosion defects.

The calibration is performed at beginning, after breaks, at the end of every shift or in the case of changes to the equipment.

The calibration results and reference defect data from the calibration sample, is always stored in the system.

The Eddy Current signal analysis is done online. The computerised equipment and the software allow the analysis of the signal amplitude [in div.] and signal phase [in °].

In discussion with the individual client, indications comparable with the reference defect indications can be marked on the floor and are usually recommended to be re-inspected by Ultrasonic examination.

7. SLOFEC^{TM} Equipment Calibration

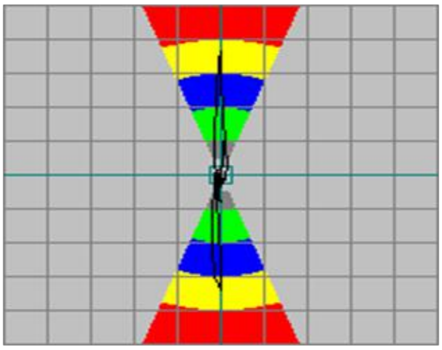
7.1 Equipment Calibration

For internal corrosion detection, the differential mode was used. The frequency setting used for Channel 1-4 (differential mode) was 80 - 100 KHz.

The amplitude of the signals was set so that the artificial reference defect (Ø 8mm 80% depth) was set to 8 screen divisions. This is only classed as the initial pre-calibration setup and may then be further adjusted when the first true indication is detected and evaluated for depth, this by utilising the Ultrasonic pulse echo technique.

Optimum signal/noise ratio and signal phase separation between the internal defect indications and other indications were considered when selecting a suitable test frequency.

The differential channels of all the sensors were set so that internal defects were indicated in the vertical signal phase direction as shown in the diagram below. By moving the scanner in the positive forward direction, the internal defect signal would show the first peak down, followed by the second peak up with an upward movement.



Sample signal display of internal defect

7.2 Calibration Control

The general setting and calibration was performed at the beginning of the inspection, with all calibration data being stored digitally. Calibration controls were performed at the beginning and end of each working shift and after any other significant interruption (i.e. breaks or lunch). Re-calibration is also deemed necessary when significant changes are made to the settings of the equipment.

Calibration samples are used for the initial set-up and for the random check of operator's settings. Accuracy of sensitivity settings can only be evaluated and achieved, when the first true indication found on the item undergoing the test is verified by a U/T operator, with the corresponding depth of indication and SLOFEC™ sensitivity being adjusted accordingly. With this setting, external corrosion defects would be detected and distinguished by phase separation from the internal defects.

7.3 Calibration Samples

The calibration samples are manufactured by Innospection Ltd in accordance to the setting standard requirements.

7.4 Change of Settings

In the event of any scanner adjustment, re-calibration is performed.

8. Inspection Procedures

The inspection was performed according to the following valid procedure:

SLOFEC Vessel Procedure No. InnoVSloVes-001-08 – Current Issue

9. Inspection Performance

9.1 Scanner Movement

The scanner assistant, who was in permanent communication with the SLOFEC™ operator, was responsible for positioning and moving the scanner on the pipe surface. The SLOFEC™ Scanner LS150 is marked clearly on the top with the FORWARD and BACKWARD directions so that all scan directions are made clear to the operator and assistant at all times. In addition, some visual contact between the operator and assistant was established during the inspection.

The scanner was moved manually with the scanned tracks being overlapped at all times.

All scans for the inspection were recorded in the forward position.

9.2 Scan Track Positioning

The six vessel zones inspected were marked circumferentially into equal tracks.

9.3 Parameter Storage

The Eddy Current testing parameter was set during the calibration and digitally stored according to the scan direction and lift off.

10. Defect Analysis

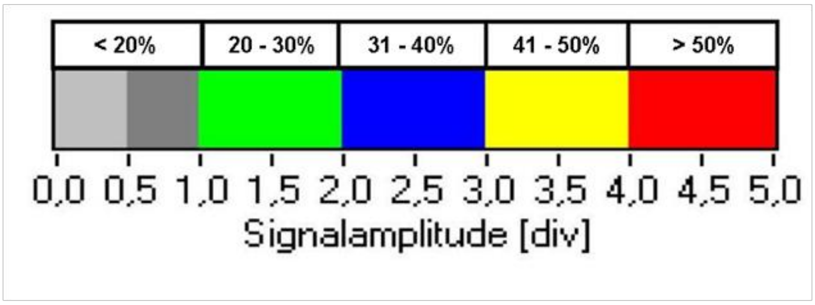
All indications which showed a clear signal phase direction similar to that of the reference defects and had signal amplitude equivalent to that of the test piece were subjected to analysis. Signals that are clearly out of the corrosion phase direction were not reported.

11. Comments to Inspection

It is recommended for future inspections that a canopy be erected over the vessel, before the inspection start date. The weather caused significant delays during this particular inspection. Also preferably the vessel bund area should also be emptied of water before inspection. The cleaning status of the vessel surfaces was found suitable for inspection. The general external surface was painted and in very good condition.

12. Sensitivity Setting

The general overview of the inspected areas with the results is presented in the attached colour scan reports with wall loss being represented in colour classes as shown in the Wall Loss Legend below:



Below 20% wall loss	**-**	**Grey**
20-30% wall loss	**-**	**Green**
31-40% wall loss	**-**	**Blue**
41-50% wall loss	**-**	**Yellow**
Above 50% wall loss	**-**	**Red**

Note

Eddy Current inspection is an evaluation method of NDT; hence all results obtained are based upon the test piece used. Material and wall thickness of the test piece should be as near as reasonably practicable to the item under inspection. Artificial defects should be as near in size and shape as to the type sought.

Because SLOFEC™ signal amplitudes are an indication of defect depth and volume, the defect depth analysis by signal amplitude can only be done in comparison with artificial reference defects having varying depths.

13. Inspection Summary

Significant internal corrosion was discovered during this vessel inspection.

The maximum wall loss found present was 50%>, with the minimum ultrasonic wall thickness result recorded in zone 2 being 3.6mm remaining wall.

The most severe wall loss was seen in the bottom half (5-7 o'clock) of the vessel and concentrated in the middle inspected section. The characteristic of the corrosion was determined to be corrosion pitting.

14. Documentation

The inspection result, parameters and data are stored in the Innospection Limited archive database system.

15. Signature

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Lead Inspection Technician a
Inspection Technician
Innospection Limited

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Senior Engineer Level 3
Inspection Technician
Innospection Limited

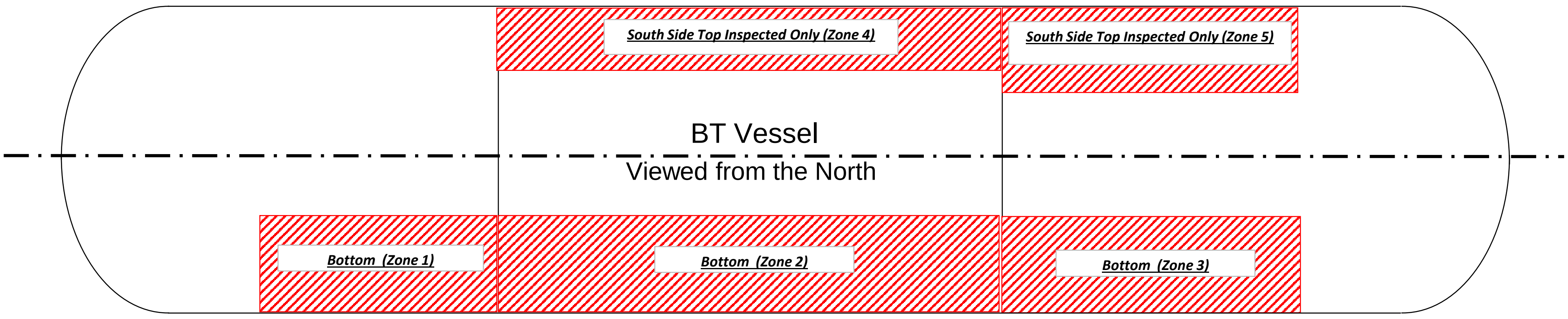
APPENDIX 01

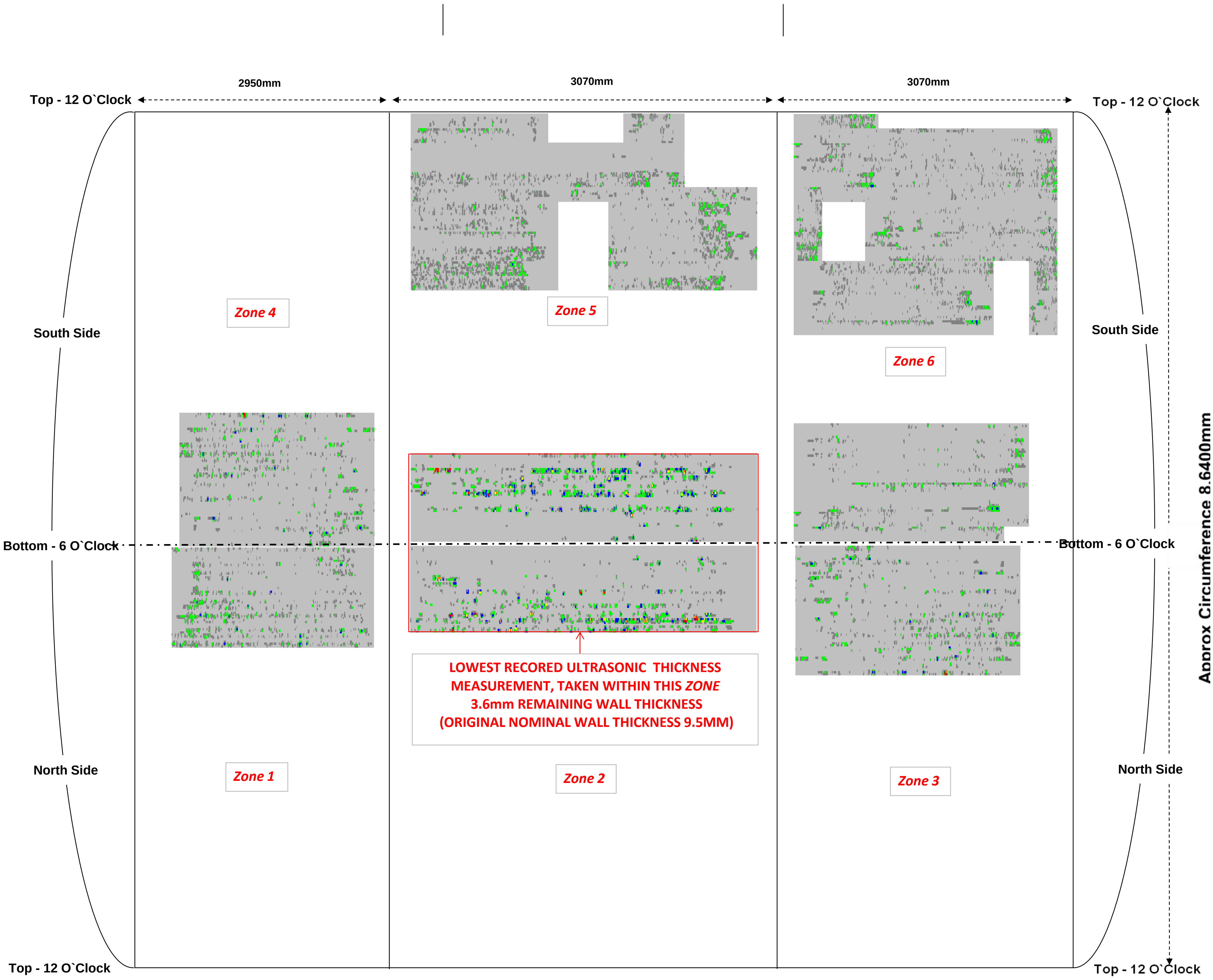
SLOFEC Scan Report

SLOFEC™ Vessel Scan Report

Client	**Client**	Date	**13/01/14 - 18/01/14**
Plant	**Facility**	K-No.	**K0xx-13**
Subject	**BT Vessel**	Operator	**Technician a - Technician b**
Identification			**Innospection limited**

Inspected Areas





(Plan) Full Circumfrential Internal Opened Out View (BT Vessel)
Not to Scale

Signal Y-component / angle analysis
window set for indication of internal

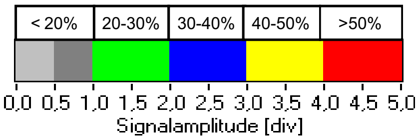
< 20%	20-30%	30-40%	40-50%	>50%

0,0 0,5 1,0 1,5 2,0 2,5 3,0 3,5 4,0 4,5 5,0
Signalamplitude [div]

Client	Client
Location	Facility
Vessel	BT
Identif.	
Section	**Zone 1**
Date	13 to18 January 2014
K-No.	0xx-13

SLOFEC™ Zone Scan Report

Signal Y-component / angle analysis window set for indication of internal defects with approx. depth information



Client	Client
Location	Facility
Vessel	BT
Identif.	
Section	**Zone 2**
Date	13 to18 January 2014
K-No.	0xx-13

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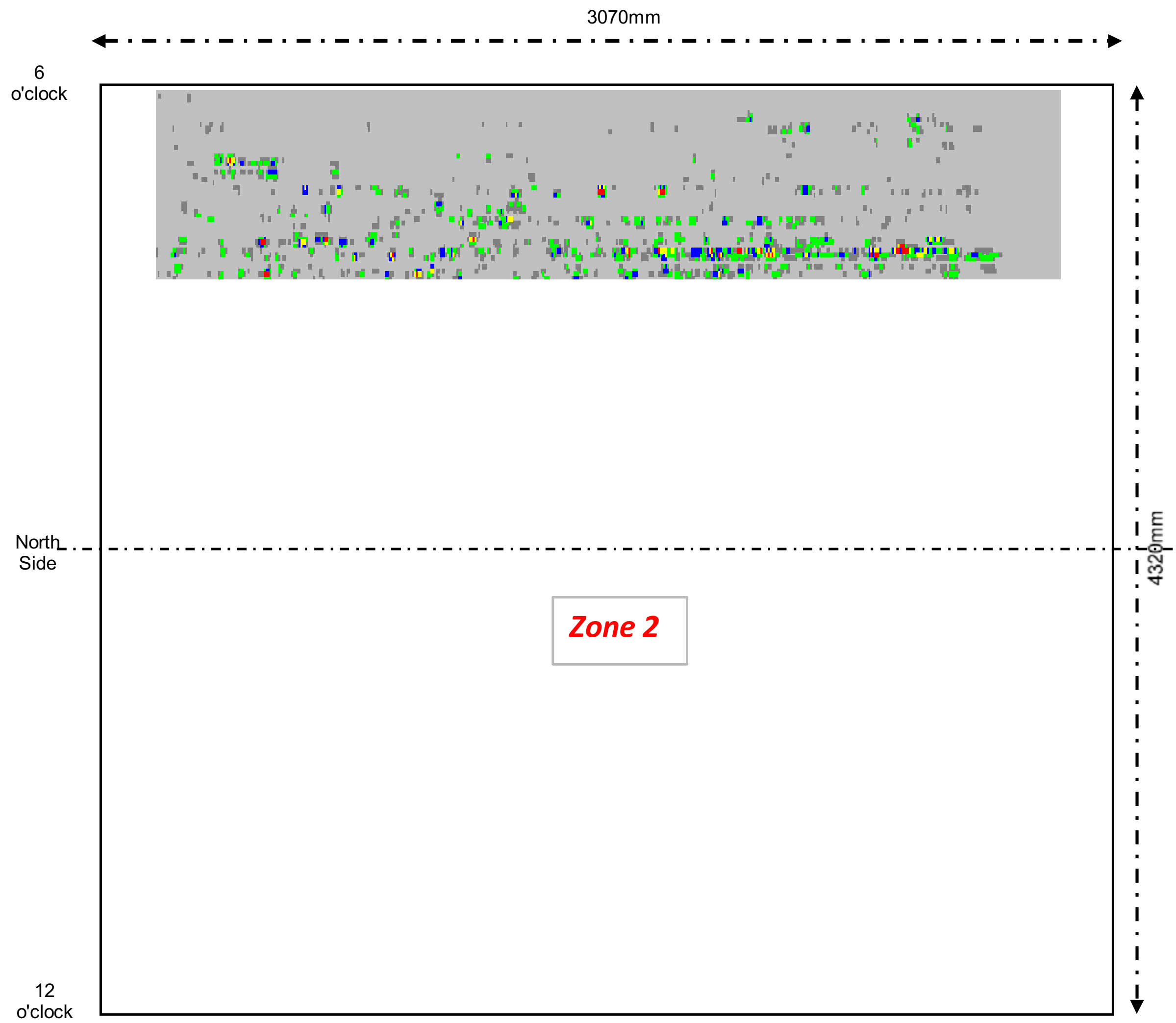
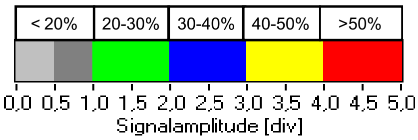
SLOFEC™ Zone Scan Report



Signal Y-component / angle analysis window set for indication of internal defects with approx. depth information



Client	Client
Location	Facility
Vessel	BT
Identif.	
Section	**Zone 3**
Date	13 to18 January 2014
K-No.	0xx-13

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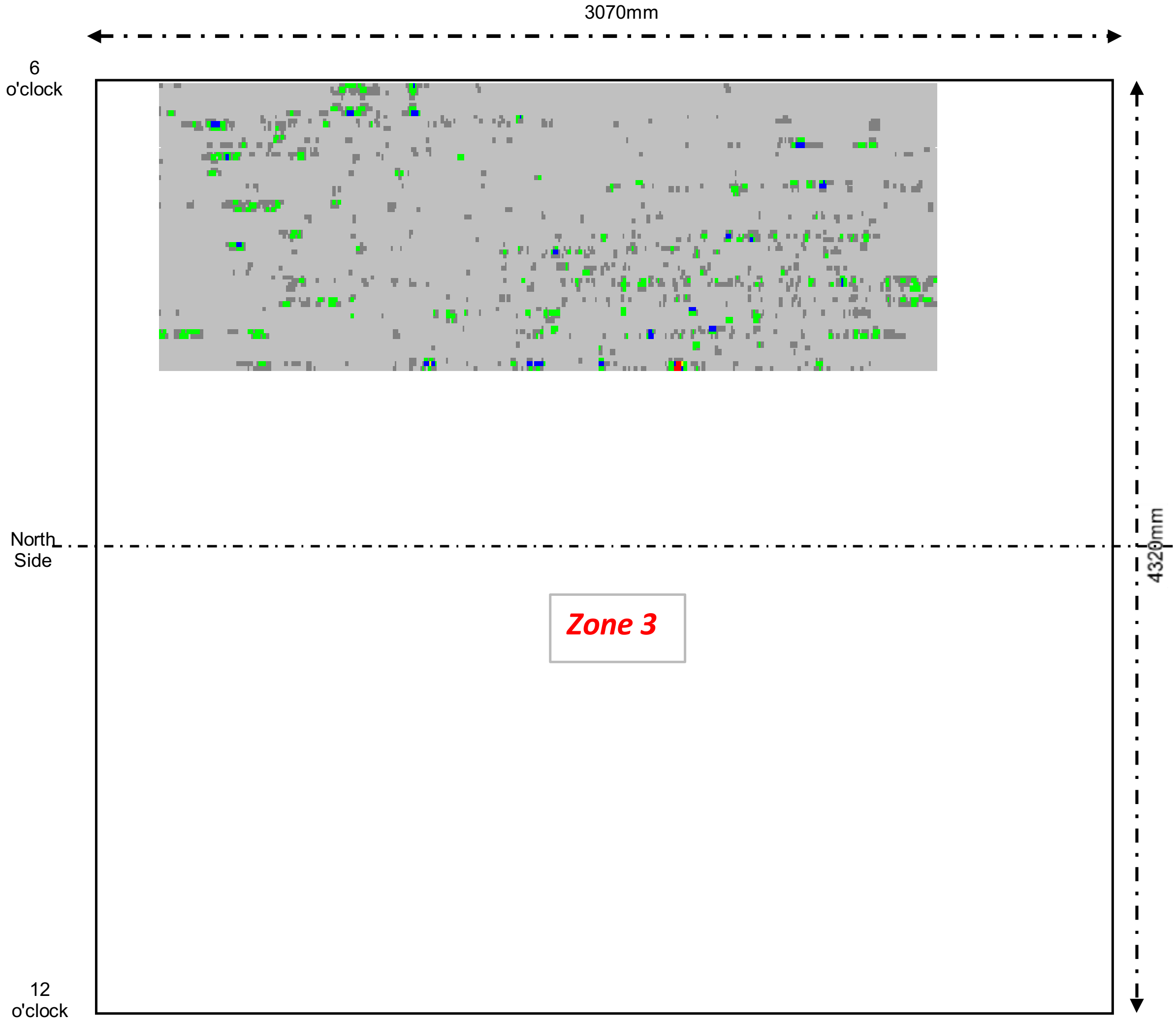
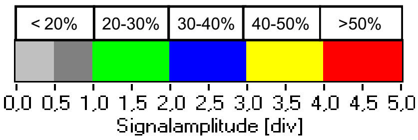
SLOFEC™ Zone Scan Report



Signal Y-component / angle analysis window set for indication of internal defects with approx. depth information



Client	Client
Location	Facility
Vessel	BT
Identif.	
Section	**Zone 4**
Date	13 to18 January 2014
K-No.	0xx-13

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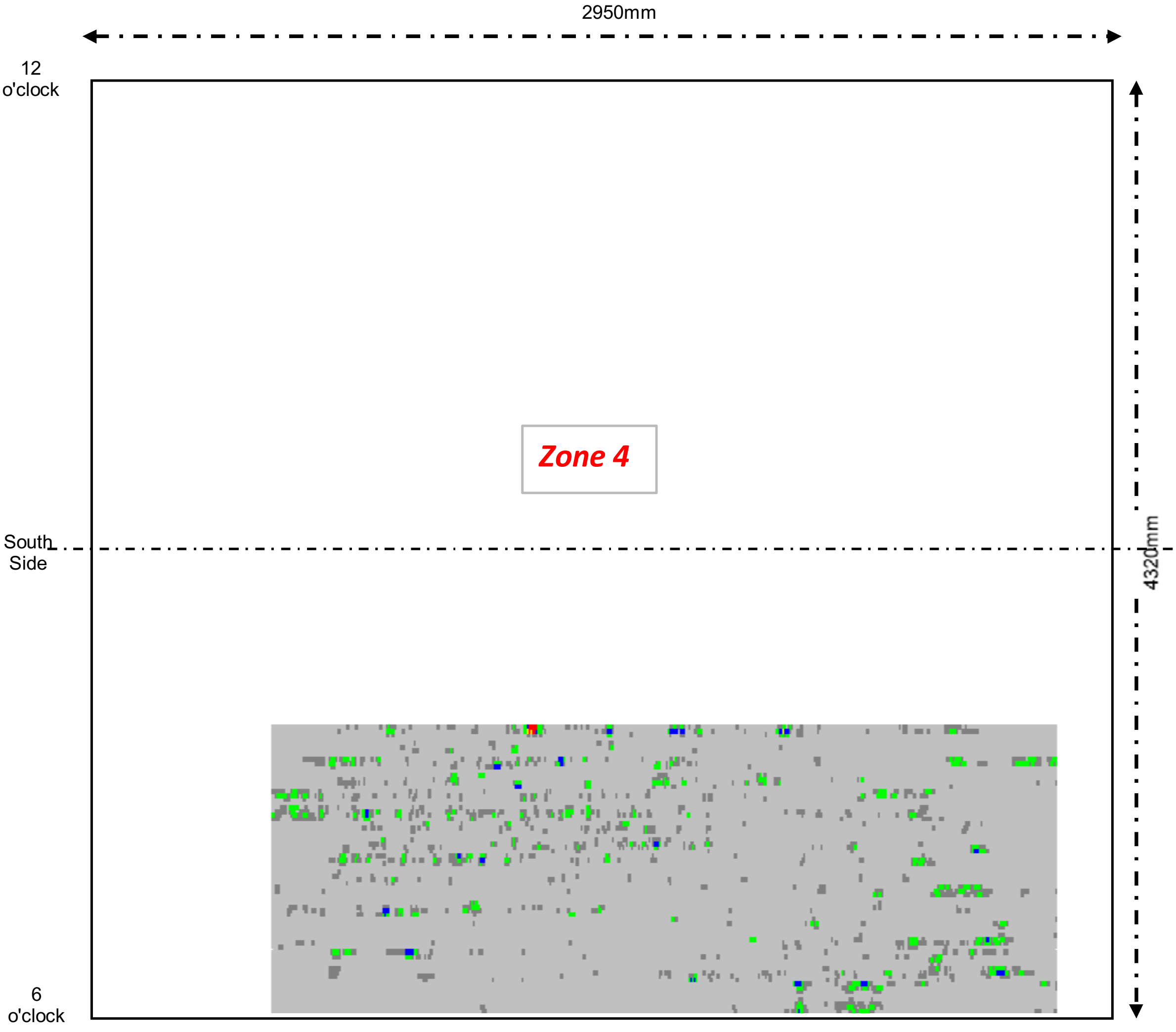
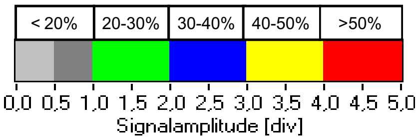
SLOFEC™ Zone Scan Report



Signal Y-component / angle analysis window set for indication of internal defects with approx. depth information



Client	Client
Location	Facility
Vessel	BT
Identif.	
Section	**Zone 5**
Date	13 to18 January 2014
K-No.	0xx-13

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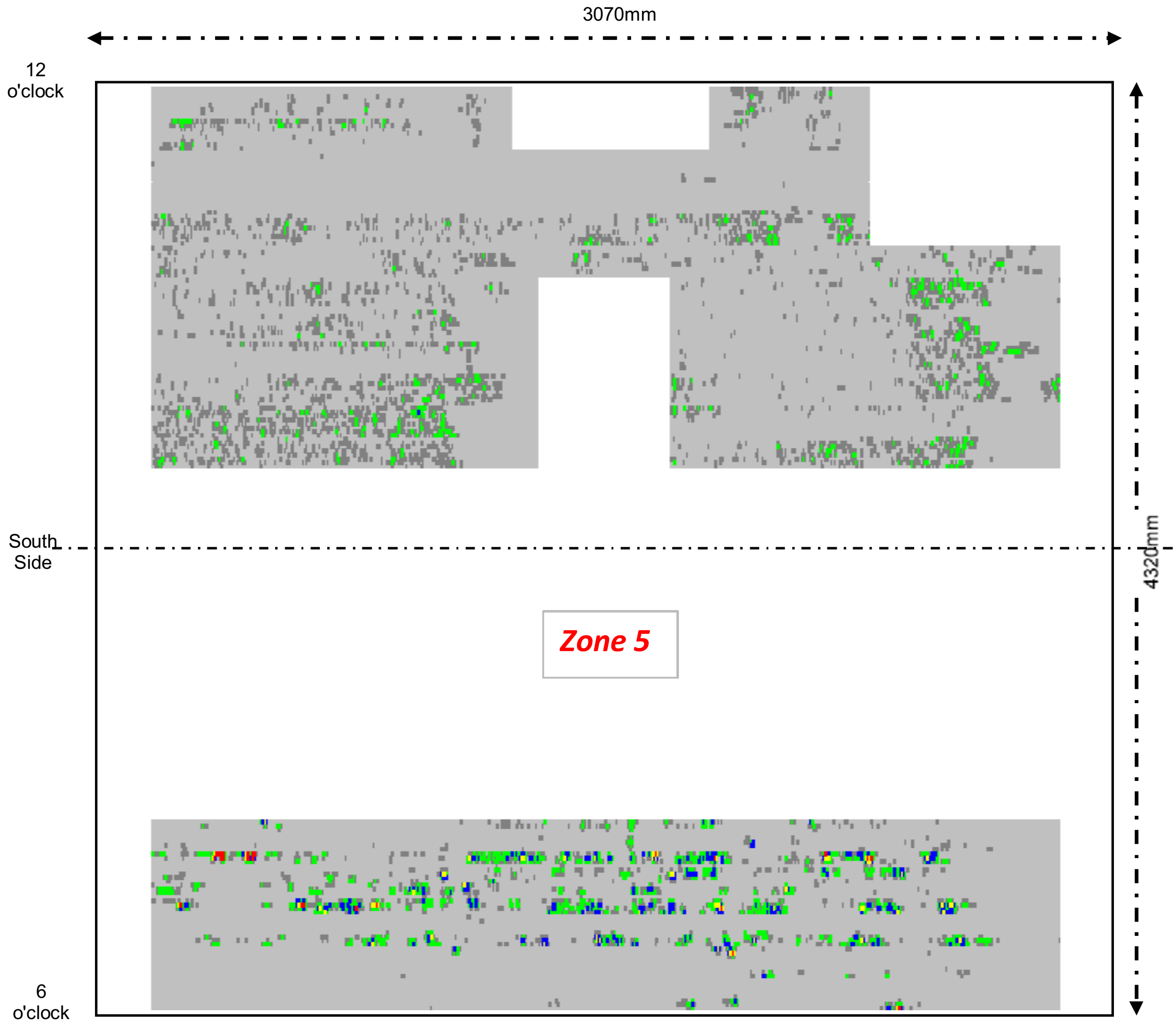
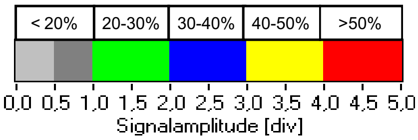
SLOFEC™ Zone Scan Report



Signal Y-component / angle analysis window set for indication of internal defects with approx. depth information



Client	Client
Location	Facility
Vessel	BT
Identif.	
Section	**Zone 6**
Date	13 to18 January 2014
K-No.	0xx-13

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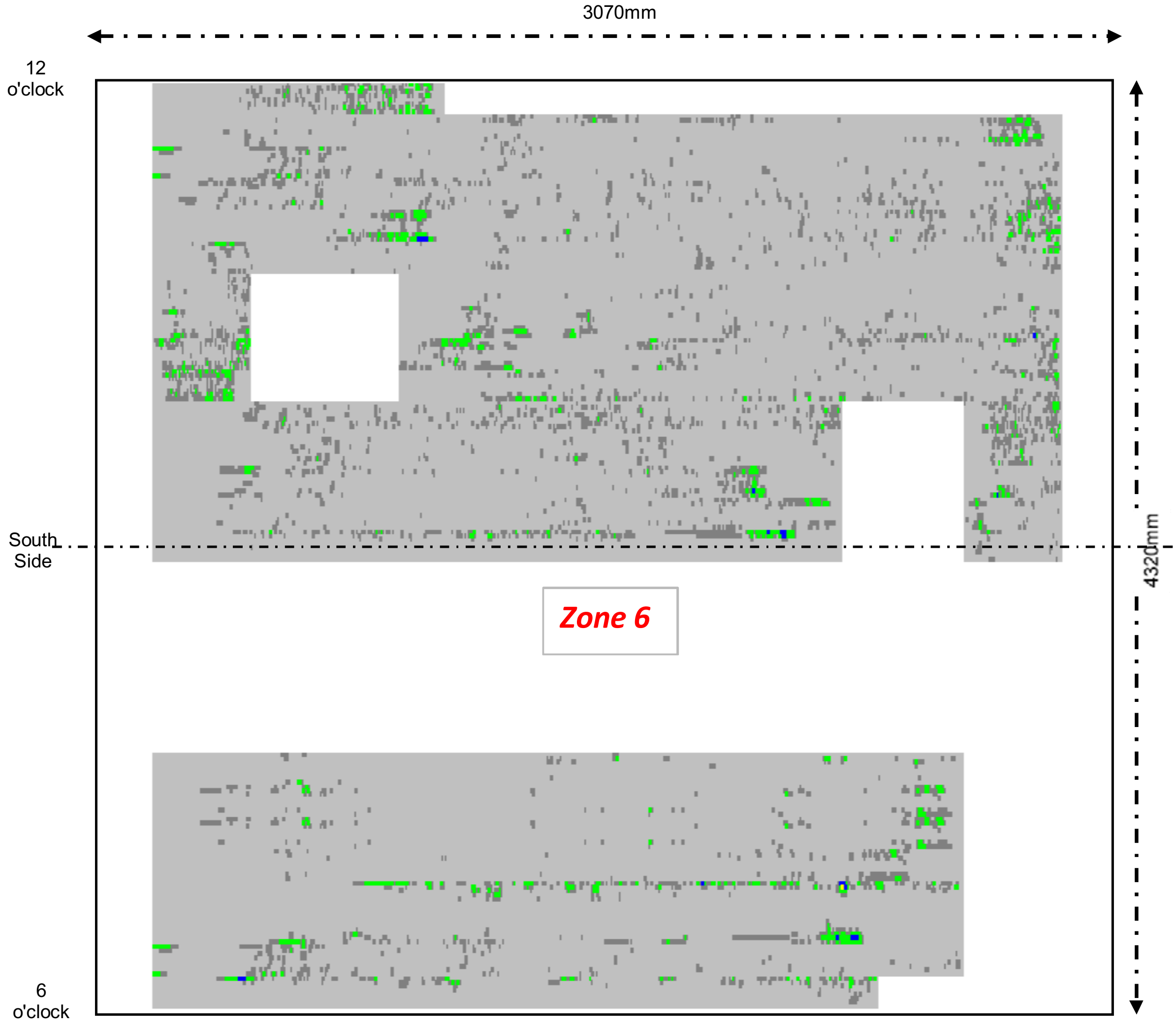
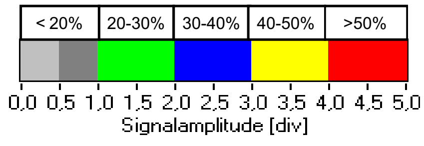
SLOFEC™ Zone Scan Report



Signal Y-component / angle analysis window set for indication of internal defects with approx. depth information



APPENDIX 02

Ultrasonic Thickness Results

Report No K-No 0xx-13	Customer Client				
Location Plant, UK					
Project B T Vessel			Line No N/A		
Description Ultrasonic Thickness Inspection On Areas of SLOFEC Dead Zones					Test Date 13-18 Jan 2014
Procedure No InnoUTSD-001-12			Material Carbon Steel		Standard BS EN 1714

Equipment

Couplant Water Based Gel	Equip. Manufacturer GE USM		Model GO		Serial No. USMG009110981
☑ Visual	☑ Time Base Linearity	☑ Amplifier Linearity	Calibration Block No 3536738		Timebase Range 0-25
Serial No 26751	Type Twin Crystal	Angle ° 0	Crystal Size(mm) 10	Freq (MHz) 5	Basic Sens (db) 58

Test Restriction/Limitations:
Uneven covering of paint made some areas of UT inspection not possible.
Scaffold prevented some areas of deadzones to be inspected with UT.

Ultrasonic Inspection Results

Dome Ends

A UT reading was taken on the barrel, the knuckle of the dome end and 3 readings for each clock position as depicted

East Dome End	Barrel	Knuckle	1	2	3
Position	(mm)	(mm)	(mm)	(mm)	(mm)
1 o'clock	12.7	12.0	12.5	11.8	11.2
2 o'clock	12.8	12.7	12.7	11.7	11.2
3 o'clock	12.0	12.0	11.8	11.7	11.4
4 o'clock	9.9	11.0	9.5	11.1	11.2
5 o'clock	11.7	9.6	12.4	11.4	11.3
6 o'clock	12.2	12.1	11.5	11.2	11.2
7 o'clock	12..4	11.8	12.2	11.4	11.2
8 o'clock	12.5	11.4	11.3	11.4	11.2
9 o'clock	11.8	11.0	11.4	11.6	11.2
10 o'clock	12.1	11.2	11.6	12.1	11.5
11 o'clock	12.1	11.6	12.2	11.6	10.9
12 o'clock	12.3	13.1	12.5	6.0	11.3

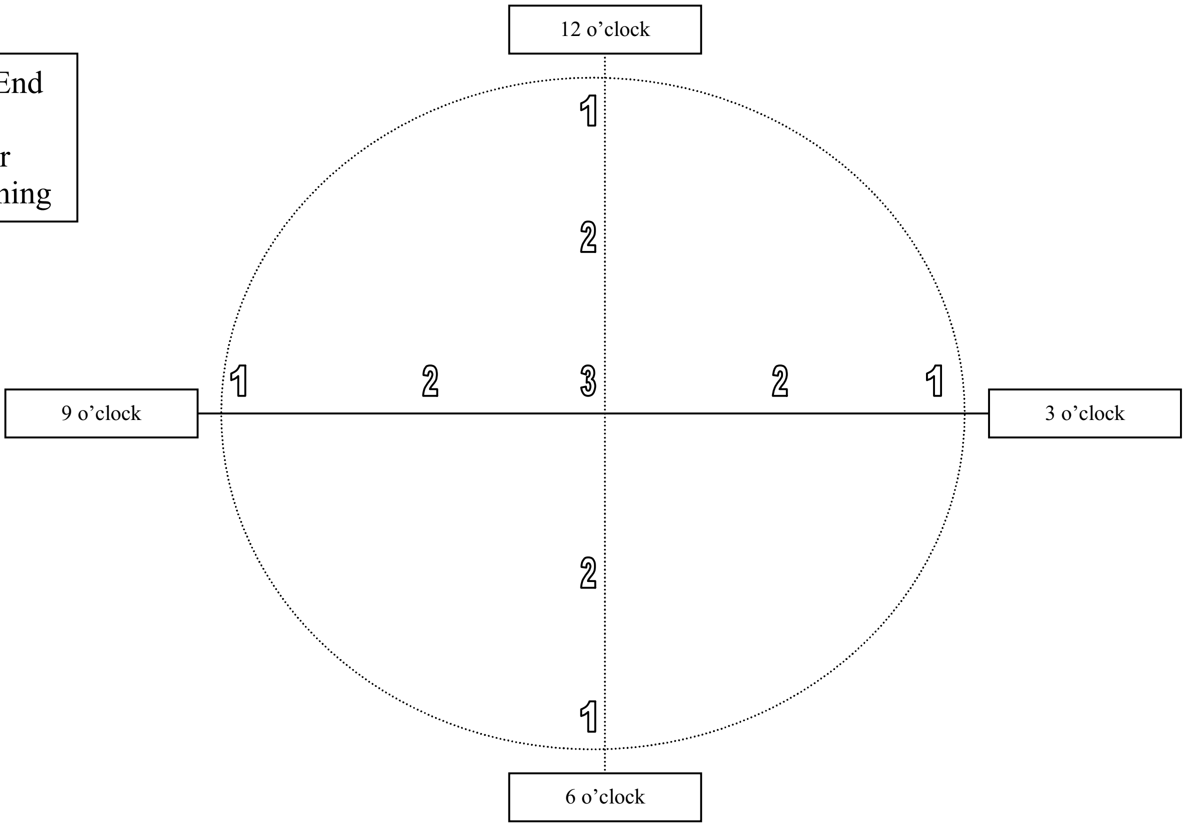
Ultrasonic Inspection Results

Dome Ends

A UT reading was taken on the barrel, the knuckle of the dome end and 3 readings for each clock position as depicted

West Dome End	Barrel	Knuckle	1	2	3
Position	(mm)	(mm)	(mm)	(mm)	(mm)
1 o'clock	12.1	11.7	12.4	11.7	11.3
2 o'clock	11.8	12.0	11.4	11.5	11.3
3 o'clock	11.4	11.3	12.4	11.1	11.4
4 o'clock	10.8	11.0	11.6	11.2	11.5
5 o'clock	12.0	11.7	12.0	11.2	11.3
6 o'clock	11.8	11.2	11.8	11.4	11.4
7 o'clock	11.7	11.2	11.7	9.5	11.5
8 o'clock	11.5	11.0	10.3	10.8	11.4
9 o'clock	11.5	11.1	11.4	11.5	11.5
10 o'clock	12.0	11.6	12.0	12.0	11.4
11 o'clock	12.2	11.7	11.9	11.7	11.4
12 o'clock	12.1	11.8	12.0	11.5	11.7

Dome End Scan Number Positioning



Ultrasonic Inspection Results	
Slofec Deadzones around Nozzle/Manway	
A UT reading was scanned 180mm around all nozzles and manways as depicted below.	
Nozzle/Manway	**UT Reading (mm)**
Area 1	**8.8**
Area 2	**8.3**
Area 3	**8.0**
Area 4	**7.7**
Area 5	**8.4**
Area 6	**8.2**

Ultrasonic Inspection Results

Slofec Deadzones around Circumferential Weld and Saddle

A UT reading was scanned 180mm around all circumferential welds and welds of the vessel saddle as depicted below. No body of welds were scanned using shear wave. Due to time constraints only from 3 o'clock to 9 o'clock were scanned (underside of vessel).

Weld No.	UT Reading (mm)
1	8.3
2	5.2
3	6.7
4	7.7
Eastern Saddle	5.2
Western Saddle	5.0