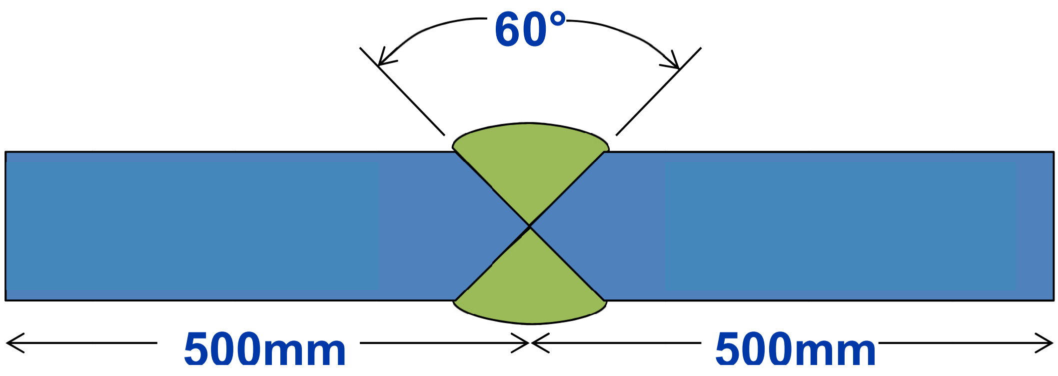

Figure 1 Double-V butt weld

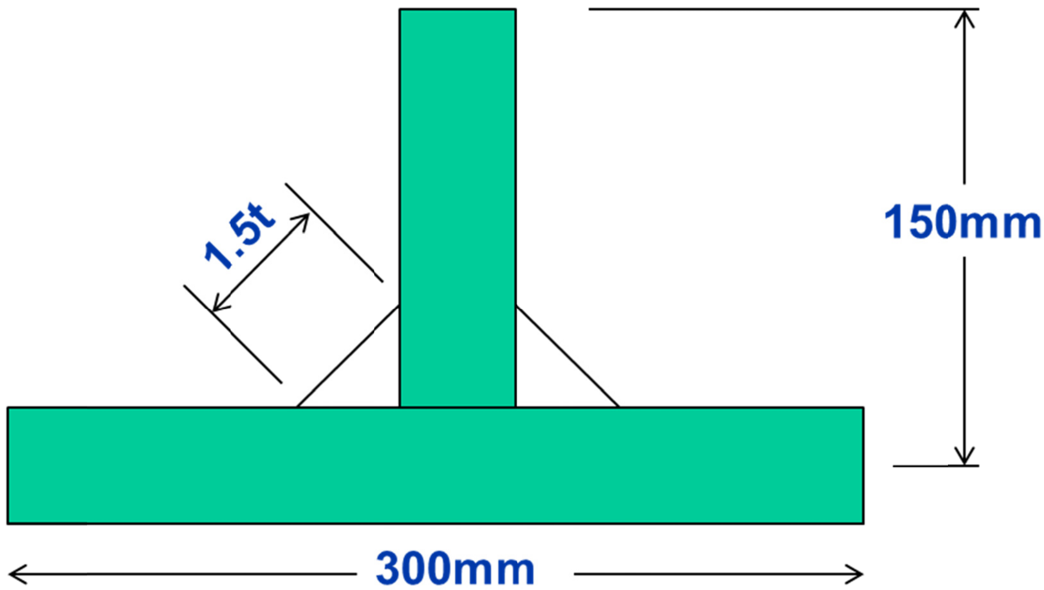

Figure 2 T-joint fillet weld

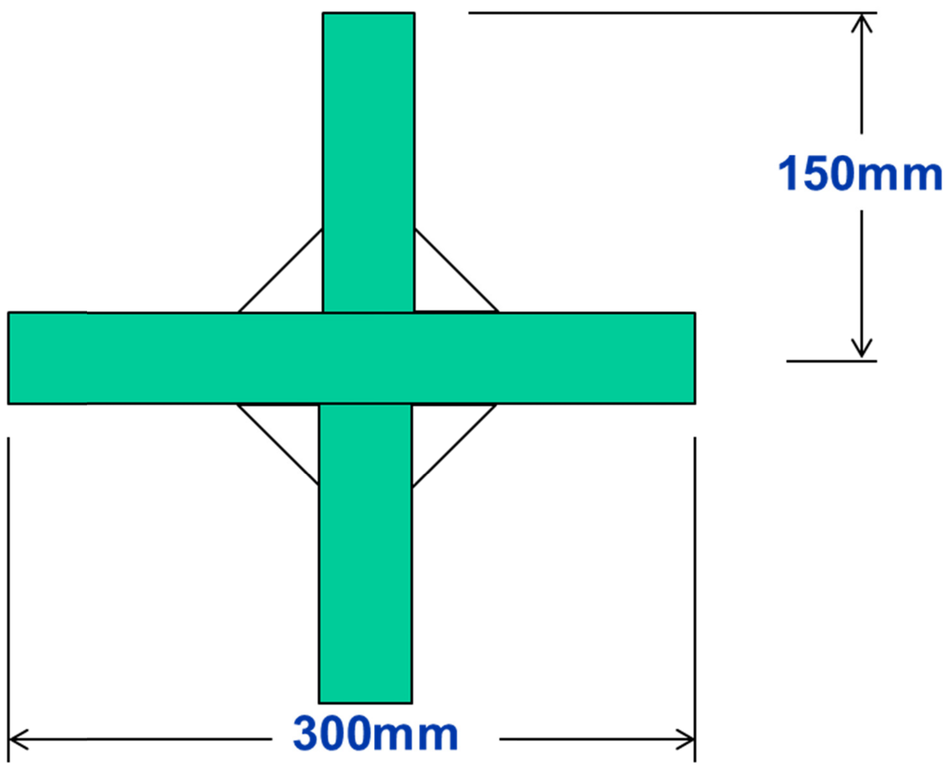

Figure 3 Cruciform fillet weld.

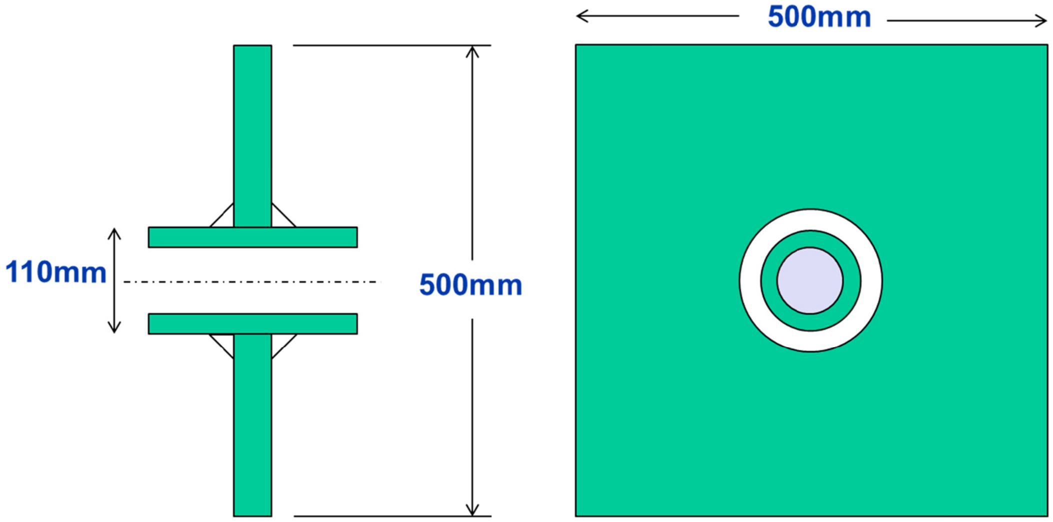

Figure 4 Pipe-in-sheet weld

Table 1 Details of the welded joints

Joint Type	15mm Thickness Material			
	Flaw Type			
	No Flaw	Embedded Al discs	Cold welds	Partially embedded Al discs
Double-V Butt	3	3	3	
T-Joint	1	1	1	1
Cruciform	1	4	1	5
Pipe-in-sheet	3	5	2	6
Total	8	13	7	12

Joint Type	25mm Thickness Material			
	Flaw Type			
	No Flaw	Embedded Al discs	Cold welds	Partially embedded Al discs
Double-V Butt	3	3	3	-
T-Joint	1	1	1	1
Cruciform	1	4	1	5
Pipe-in-sheet	3	5	2	6
Total	8	13	7	12

Joint Type	40mm Thickness Material			
	Flaw Type			
	No Flaw	Embedded Al discs	Cold welds	Partially embedded Al discs
Double-V Butt	3	3	3	-
T-Joint	1	1	1	1
Cruciform	1	4	1	5
Pipe-in-sheet	3	5	2	6
Total	8	13	7	12

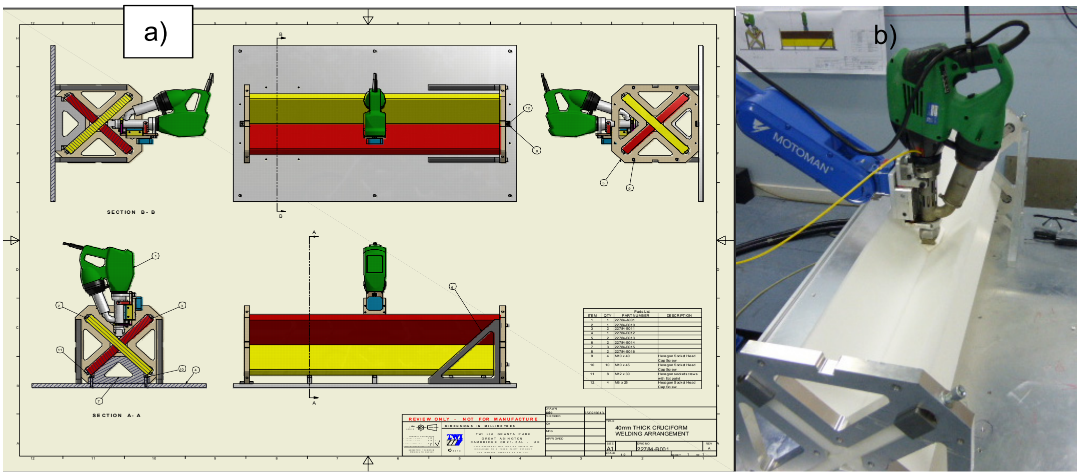

Figure 5 Aluminium tooling for the T-joints and cruciform joints: a) design drawing, b) photograph of the final assembly.

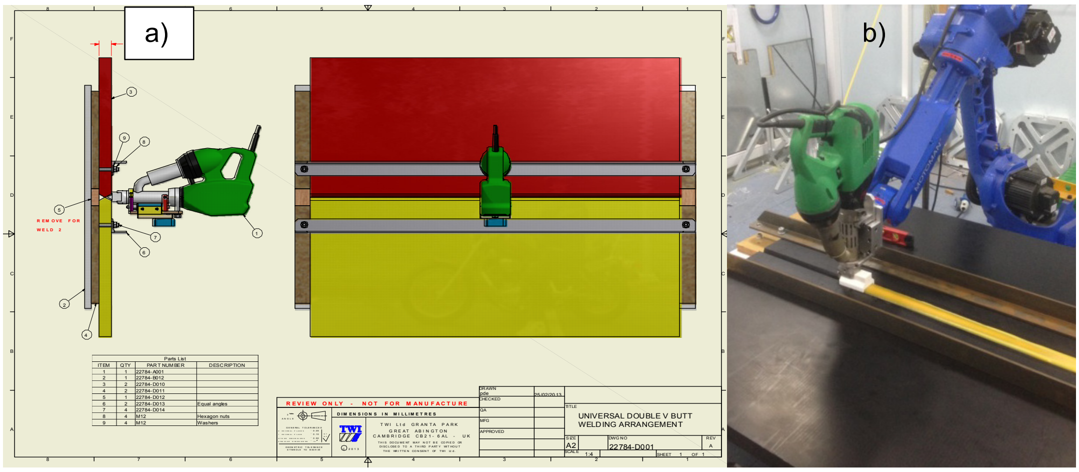

Figure 6 Base plate and clamping bars for manufacturing double-V butt joints: a) design drawing, b) photograph of the final assembly.

Figure 7 Pipe-in-sheet support fixture.

Table 2 Welds made

Weld ID	Sheet Thickness, mm	Joint Type	Flaw Type
1	15	Double-V butt	None
2	15	Double-V butt	None
3	15	Double-V butt	None
4	15	Double-V butt	Embedded Al discs (1x2mm, 1x3mm, 1x4mm, 1x8mm)
5	15	Double-V butt	Embedded Al discs (2x2mm, 2x3mm, 2x4mm, 2x8mm)
6	15	Double-V butt	Embedded Al discs (5x2mm, 5x3mm, 5x4mm, 5x8mm)
7	15	Double-V butt	Cold weld
8	15	Double-V butt	Cold weld
9	15	Double-V butt	Cold weld

Weld ID	Sheet Thickness, mm	Joint Type	Flaw Type
10	15	T-joint	None (and for machining vertical notches)
11	15	T-joint	Embedded Al discs (5x2x2mm, 5x2x3mm, 5x2x4mm, 5x2x8mm)
12	15	T-joint	Partially embedded 25mm Al discs (4x2x5 different depths)
13	15	T-joint	2 x cold welds
14	15	Cruciform	None
15	15	Cruciform	Embedded 2mm Al disc
16	15	Cruciform	Embedded 3mm Al disc
17	15	Cruciform	Embedded 4mm Al disc
18	15	Cruciform	Embedded 8mm Al disc
19	15	Cruciform	Partially embedded 25mm Al disc (Depth A)
20	15	Cruciform	Partially embedded 25mm Al disc (Depth B)
21	15	Cruciform	Partially embedded 25mm Al disc (Depth C)
22	15	Cruciform	Partially embedded 25mm Al disc (Depth D)
23	15	Cruciform	Partially embedded 25mm Al disc (Depth E)
24	15	Cruciform	1 x cold weld
25	15	Pipe-in-sheet	None (and for machining vertical notches)
26	15	Pipe-in-sheet	None
27	15	Pipe-in-sheet	None
28	15	Pipe-in-sheet	Embedded Al discs (4x2mm, 4x3mm, 4x4mm, 4x8mm)
29	15	Pipe-in-sheet	Embedded 2mm Al disc
30	15	Pipe-in-sheet	Embedded 3mm Al disc
31	15	Pipe-in-sheet	Embedded 4mm Al disc
32	15	Pipe-in-sheet	Embedded 8mm Al disc
33	15	Pipe-in-sheet	Partially embedded 25mm Al discs (2x5 different depths)
34	15	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth A)
35	15	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth B)
36	15	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth C)
37	15	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth D)
38	15	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth E)
39	15	Pipe-in-sheet	Cold weld
40	15	Pipe-in-sheet	Cold weld
41	25	Double-V butt	None
42	25	Double-V butt	None
43	25	Double-V butt	None
44	25	Double-V butt	Embedded Al discs (1x2mm, 1x4mm, 1x8mm, 1x15mm)
45	25	Double-V butt	Embedded Al discs (2x2mm, 2x4mm, 2x8mm, 2x15mm)
46	25	Double-V butt	Embedded Al discs (5x2mm, 5x3mm, 5x4mm, 5x8mm, 5x15mm)
47	25	Double-V butt	Cold weld
48	25	Double-V butt	Cold weld
49	25	Double-V butt	Cold weld
50	25	T-joint	None (and for machining vertical notches)

Weld ID	Sheet Thickness, mm	Joint Type	Flaw Type
51	25	T-joint	Embedded Al discs (5x2x2mm, 5x2x3mm, 5x2x4mm, 5x2x8mm, 5x2x15mm)
52	25	T-joint	Partially embedded 25mm Al discs (4x2x5 different depths)
53	25	T-joint	2 x cold welds
54	25	Cruciform	None
55	25	Cruciform	Embedded 2mm Al disc
56	25	Cruciform	Embedded 4mm Al disc
57	25	Cruciform	Embedded 8mm Al disc
58	25	Cruciform	Embedded 15mm Al disc
59	25	Cruciform	Partially embedded 25mm Al disc (Depth A)
60	25	Cruciform	Partially embedded 25mm Al disc (Depth B)
61	25	Cruciform	Partially embedded 25mm Al disc (Depth C)
62	25	Cruciform	Partially embedded 25mm Al disc (Depth D)
63	25	Cruciform	Partially embedded 25mm Al disc (Depth E)
64	25	Cruciform	1 x cold weld
65	25	Pipe-in-sheet	None
66	25	Pipe-in-sheet	None
67	25	Pipe-in-sheet	None
68	25	Pipe-in-sheet	Embedded Al discs (4x2mm, 4x3mm, 4x4mm, 4x8mm)
69	25	Pipe-in-sheet	Embedded 2mm Al disc
70	25	Pipe-in-sheet	Embedded 3mm Al disc
71	25	Pipe-in-sheet	Embedded 4mm Al disc
72	25	Pipe-in-sheet	Embedded 8mm Al disc
73	25	Pipe-in-sheet	Partially embedded 25mm Al discs (2x5 different depths)
74	25	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth A)
75	25	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth B)
76	25	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth C)
77	25	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth D)
78	25	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth E)
79	25	Pipe-in-sheet	Cold weld
80	25	Pipe-in-sheet	Cold weld
81	40	Double-V butt	None
82	40	Double-V butt	None
83	40	Double-V butt	None
84	40	Double-V butt	Embedded Al discs (1x2mm, 1x4mm, 1x8mm, 1x25mm)
85	40	Double-V butt	Embedded Al discs (1x2mm, 1x4mm, 1x8mm, 1x25mm)
86	40	Double-V butt	Embedded Al discs (3x2mm, 3x3mm, 3x4mm, 3x8mm, 3x15mm, 3x25mm)
87	40	Double-V butt	Cold weld
88	40	Double-V butt	Cold weld
89	40	Double-V butt	Cold weld
90	40	T-joint	None (and for machining vertical notches)
91	40	T-joint	Embedded Al discs (4x2x2mm, 4x2x3mm, 4x2x4mm, 4x2x8mm, 4x2x15mm, 4x2x25mm)

Weld ID	Sheet Thickness, mm	Joint Type	Flaw Type
92	40	T-joint	Partially embedded 25mm Al discs (4x2x5 different depths)
93	40	T-joint	2 x cold welds
94	40	Cruciform	None
95	40	Cruciform	Embedded 2mm Al disc
96	40	Cruciform	Embedded 4mm Al disc
97	40	Cruciform	Embedded 8mm Al disc
98	40	Cruciform	Embedded 15mm Al disc
99	40	Cruciform	Partially embedded 25mm Al disc (Depth A)
100	40	Cruciform	Partially embedded 25mm Al disc (Depth B)
101	40	Cruciform	Partially embedded 25mm Al disc (Depth C)
102	40	Cruciform	Partially embedded 25mm Al disc (Depth D)
103	40	Cruciform	Partially embedded 25mm Al disc (Depth E)
104	40	Cruciform	1 x cold weld
105	40	Pipe-in-sheet	None (and for machining vertical notches)
106	40	Pipe-in-sheet	None
107	40	Pipe-in-sheet	None
108	40	Pipe-in-sheet	Embedded Al discs (4x2mm, 4x3mm, 4x4mm, 4x8mm)
109	40	Pipe-in-sheet	Embedded 2mm Al disc
110	40	Pipe-in-sheet	Embedded 4mm Al disc
111	40	Pipe-in-sheet	Embedded 8mm Al disc
112	40	Pipe-in-sheet	Embedded 15mm Al disc
113	40	Pipe-in-sheet	Partially embedded 25mm Al discs (2x5 different depths)
114	40	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth A)
115	40	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth B)
116	40	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth C)
117	40	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth D)
118	40	Pipe-in-sheet	Partially embedded 25mm Al disc (Depth E)
119	40	Pipe-in-sheet	Cold weld
120	40	Pipe-in-sheet	Cold weld

Figure 8 Manufacturing pipe-in-sheet joints.

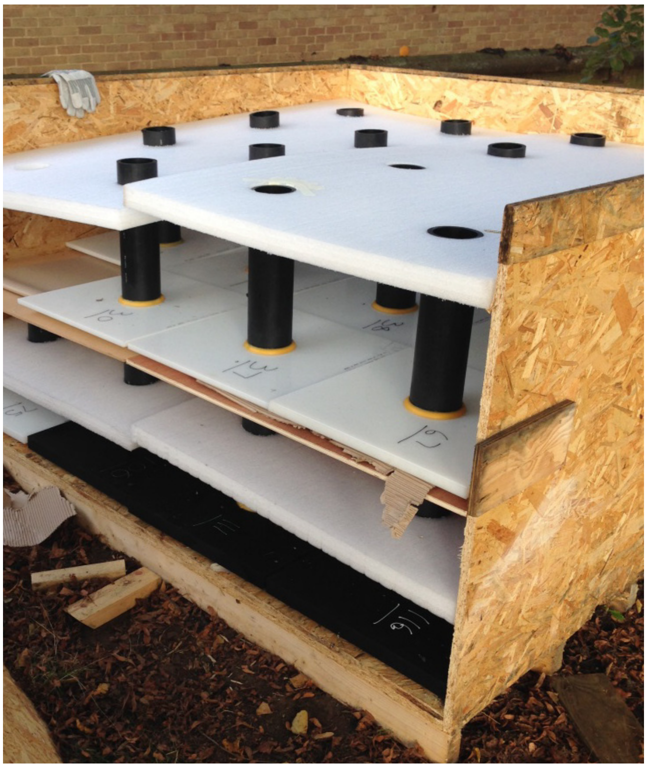

Figure 9 Completed pipe-in-sheet joints.

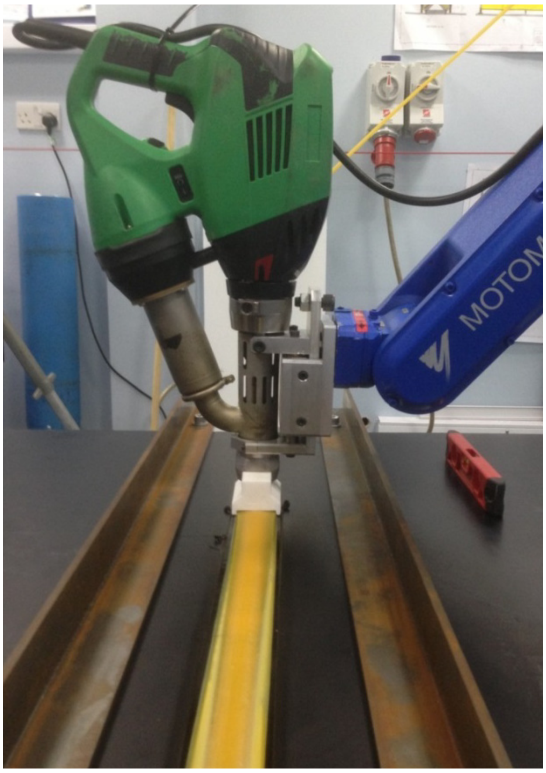

Figure 10 A 40mm thick double-V butt joint being manufactured.

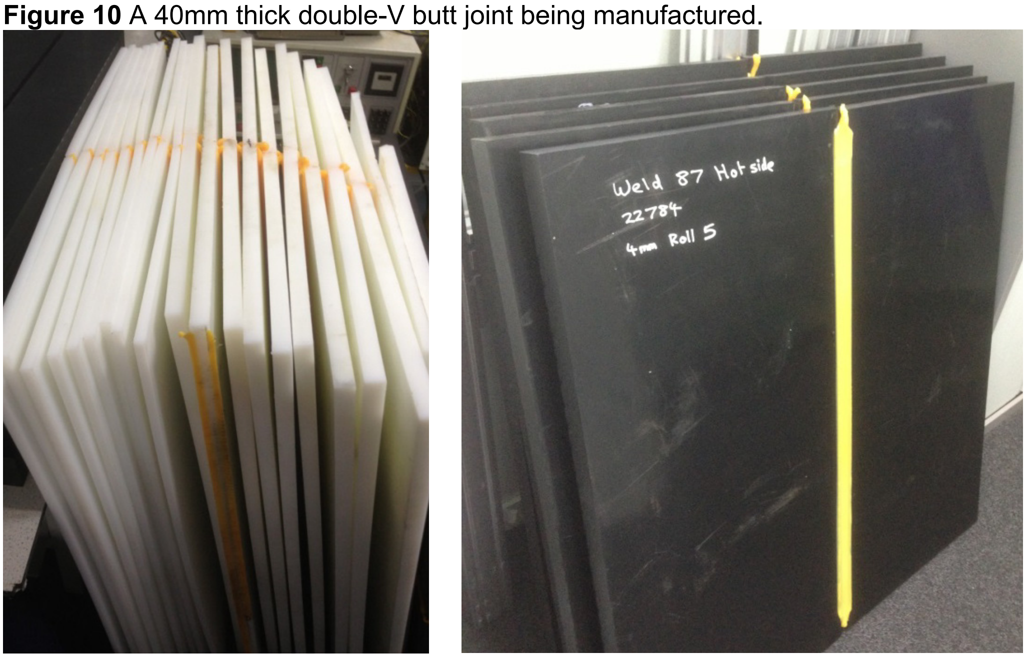

Figure 11 Completed double-V butt joints.

Figure 12 A 40mm thick T-joint being made.

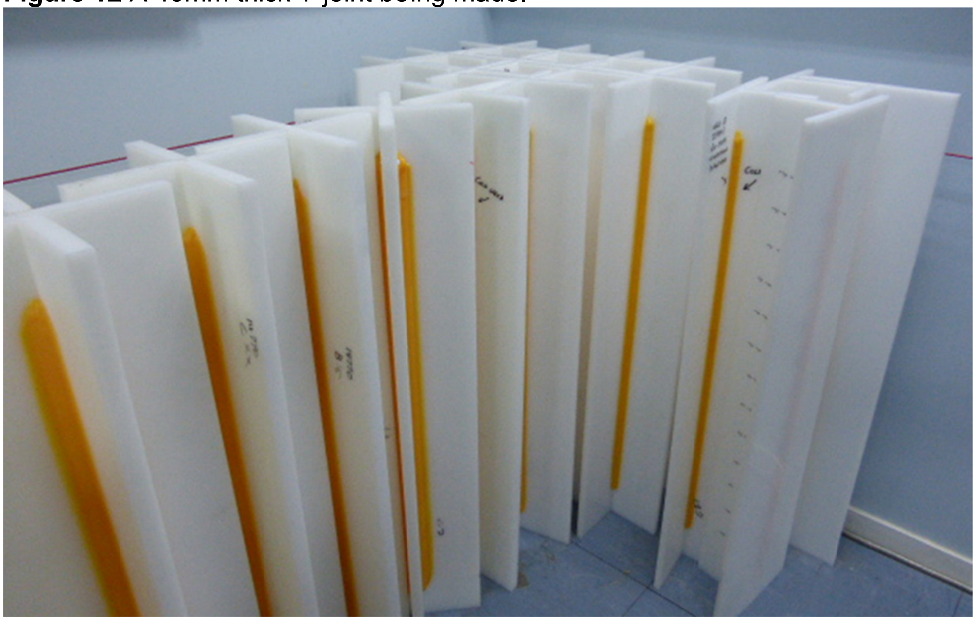

Figure 13 Completed 25mm cruciform joints.

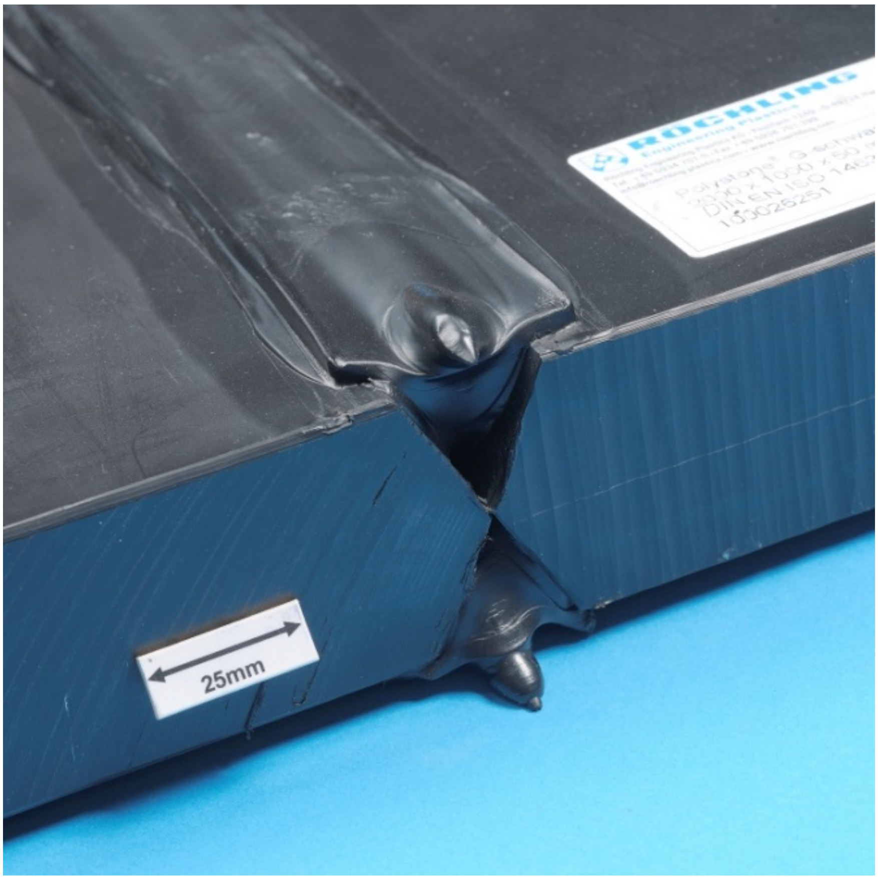

Figure 14 Double-V butt weld in HDPE sheet.

Figure 15 An extrusion welded cruciform joint containing partially embedded flaws.

Figure 16 Pipe-in-sheet weld.

Figure 17 15mm and 25mm punch and die.

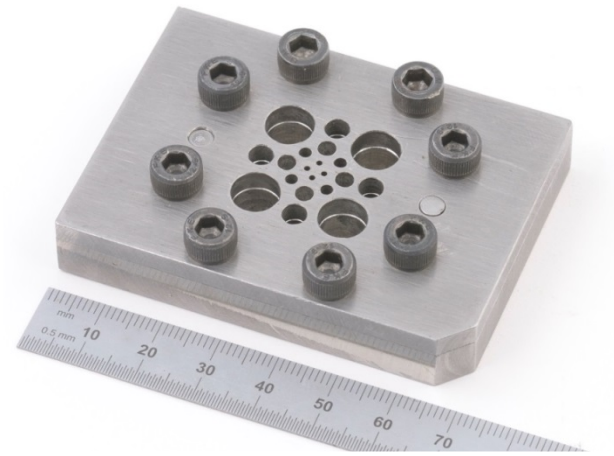

Figure 18 2-8mm punch die.

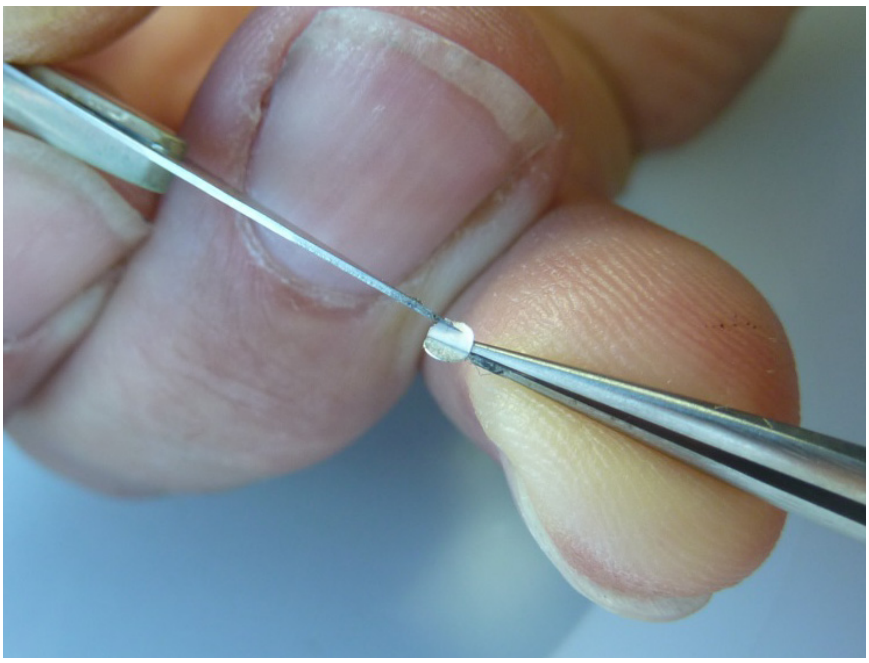

Figure 19 Removing the backing paper from an aluminium disc

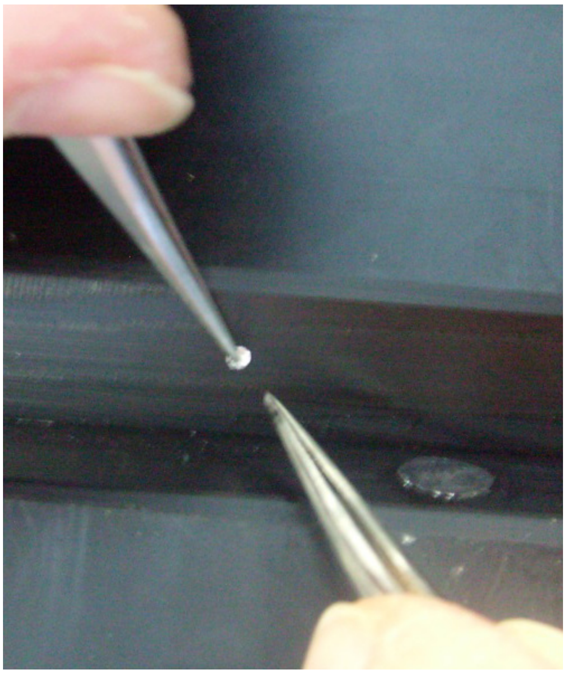

Figure 20 Insertion of 2mm aluminium disc on one side of V preparation.

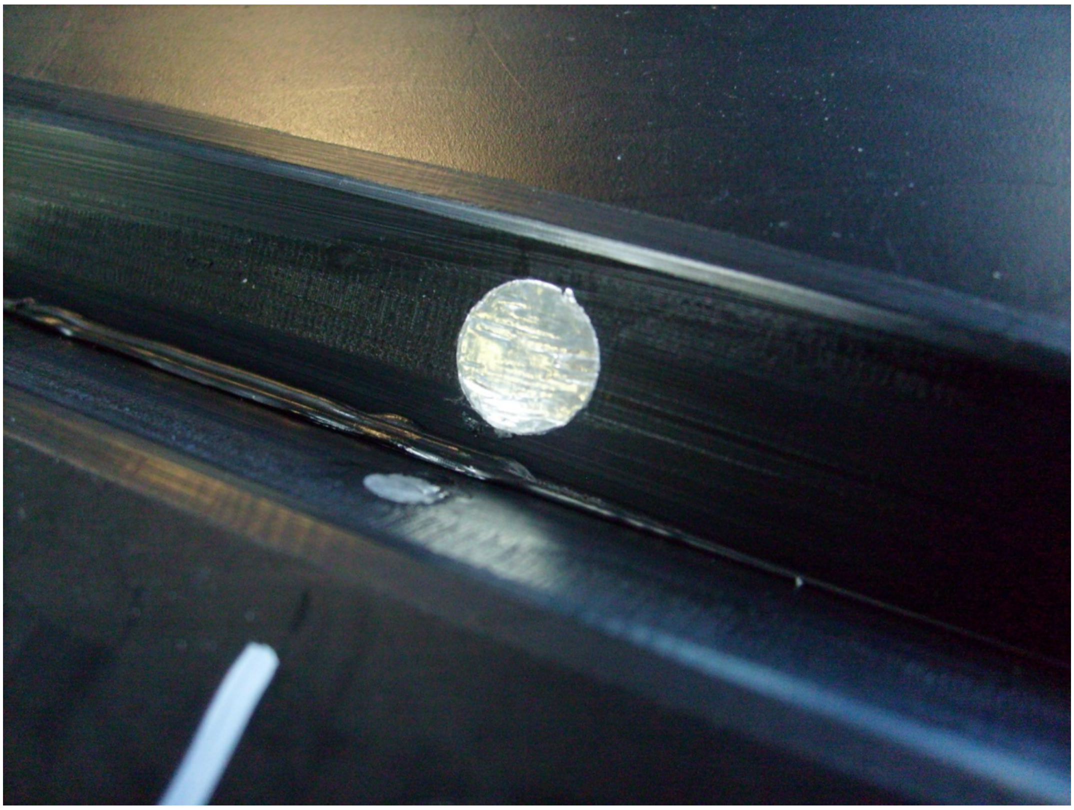

Figure 21 Aluminium disc adhered to side of V preparation.

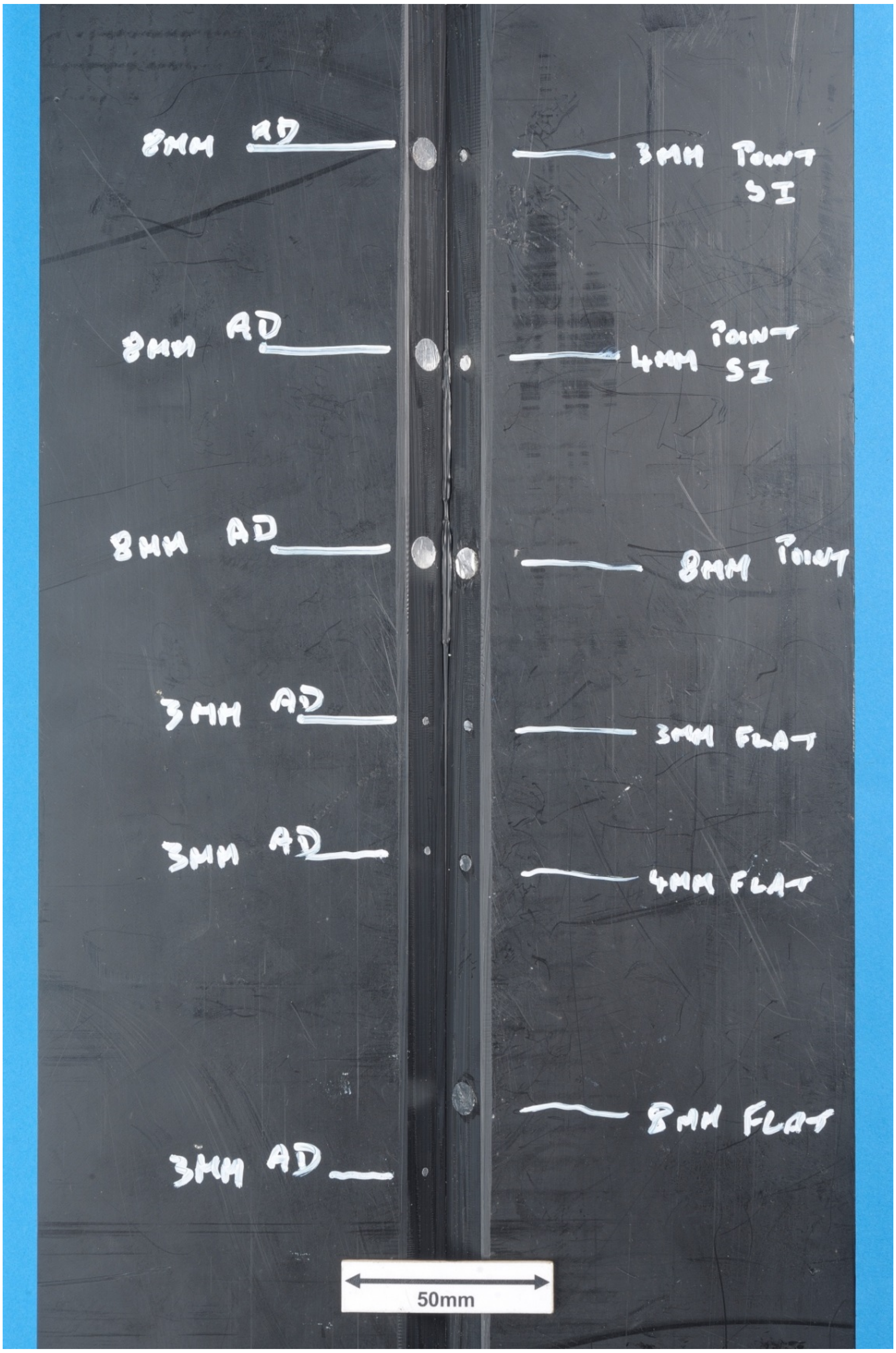

Figure 22 Example of double-V sample with aluminium discs in place and marked up ready for extrusion welding.

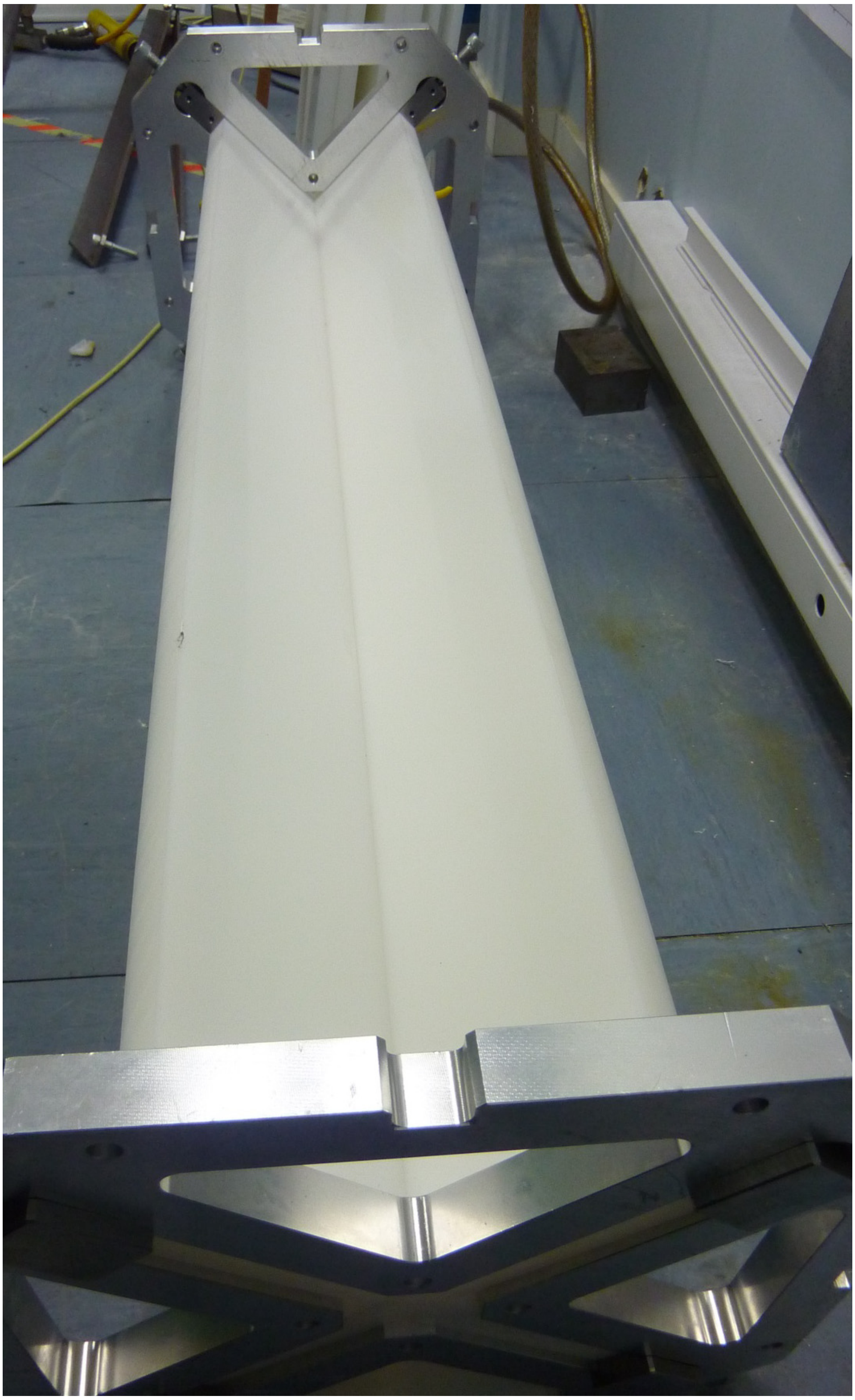

Figure 23 25mm thick HDPE sheet assembled in cruciform/T-joint welding fixture.

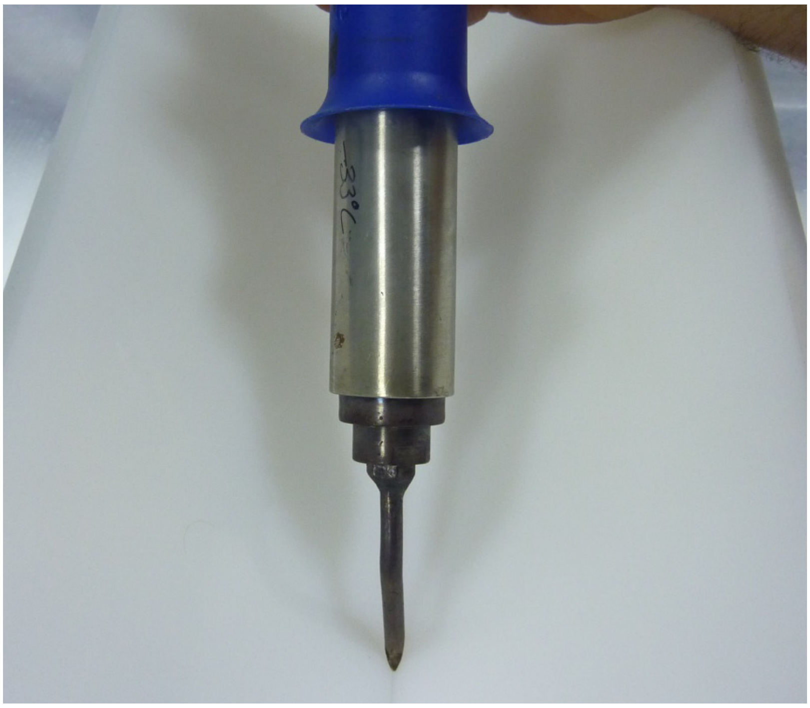

Figure 24 Tacking HDPE sheets together.

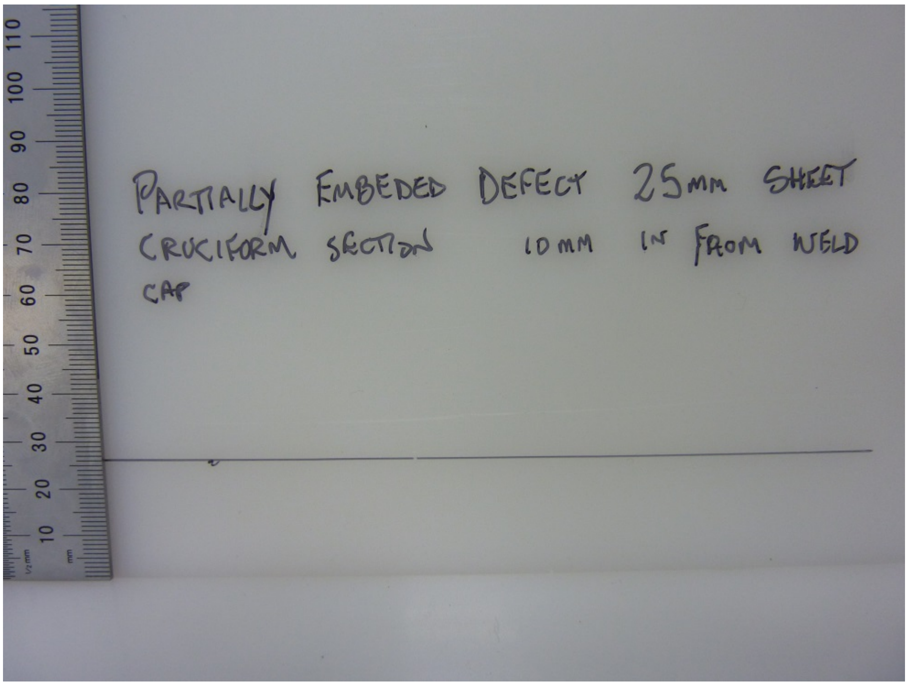

Figure 25 Marking the extrusion weld width on the HDPE plate.

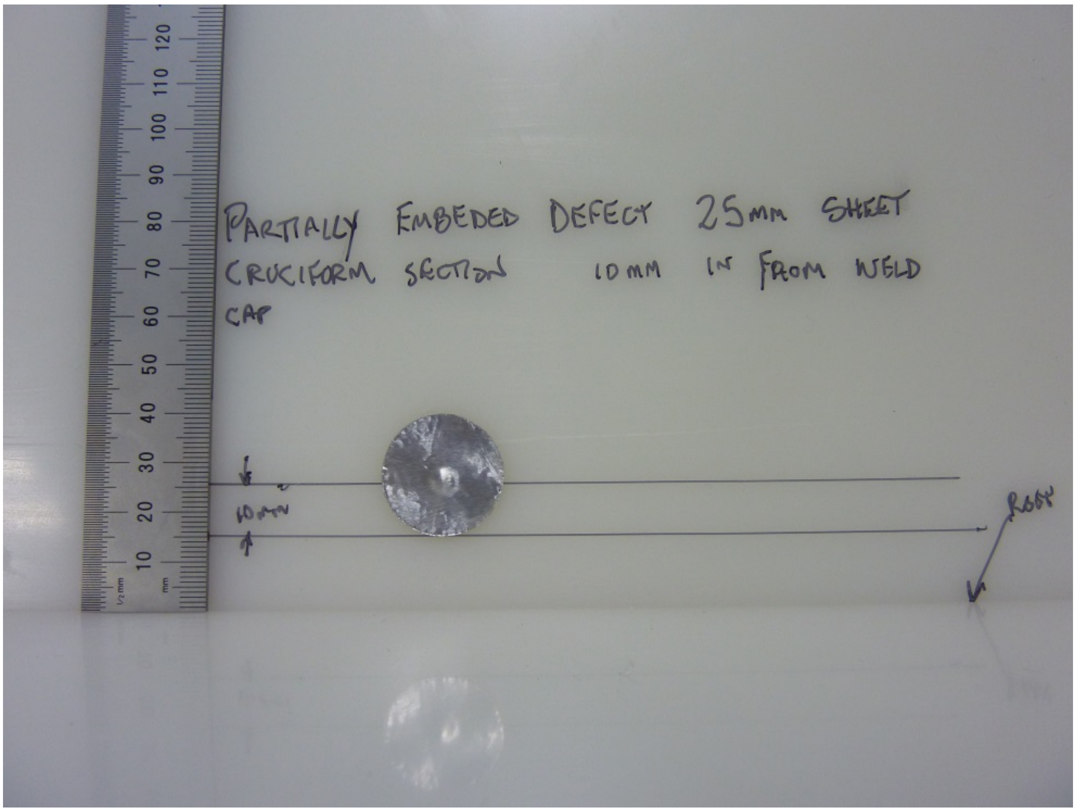

Figure 26 Aluminium disc placed on sheet so that it is embedded 10mm into extrusion weld.

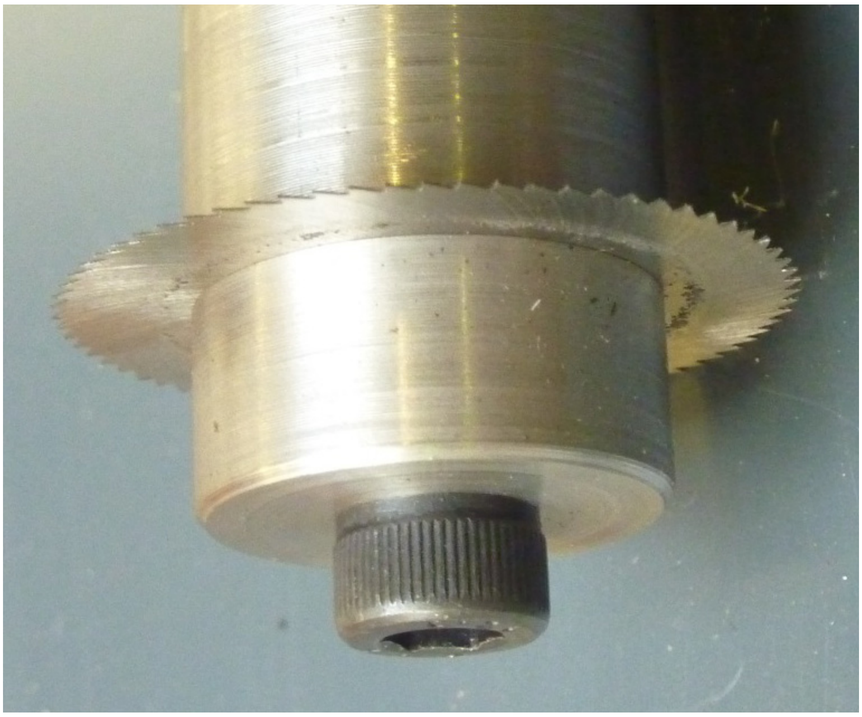

Figure 27 A 0.15mm slitting wheel.

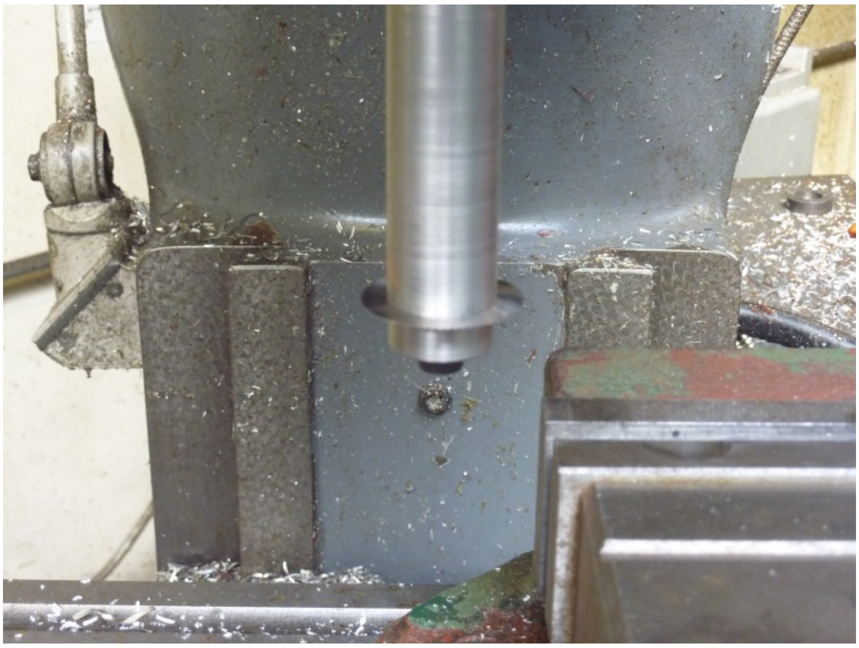

Figure 28 A slitting wheel fitted to a CNC milling machine.

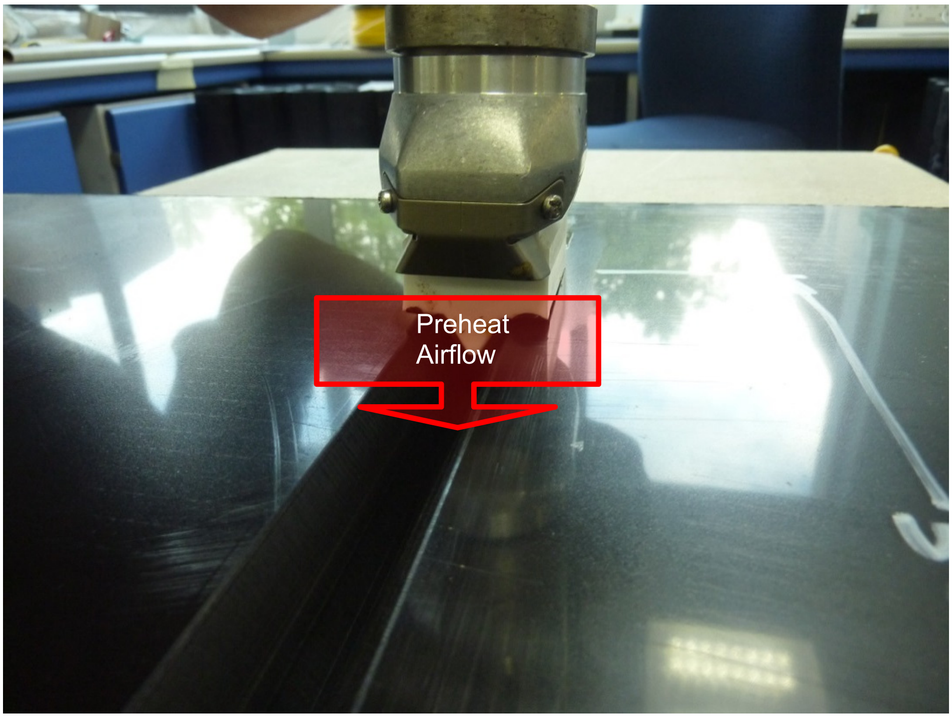

Figure 29 Extrusion welding gun with correct preheat position.

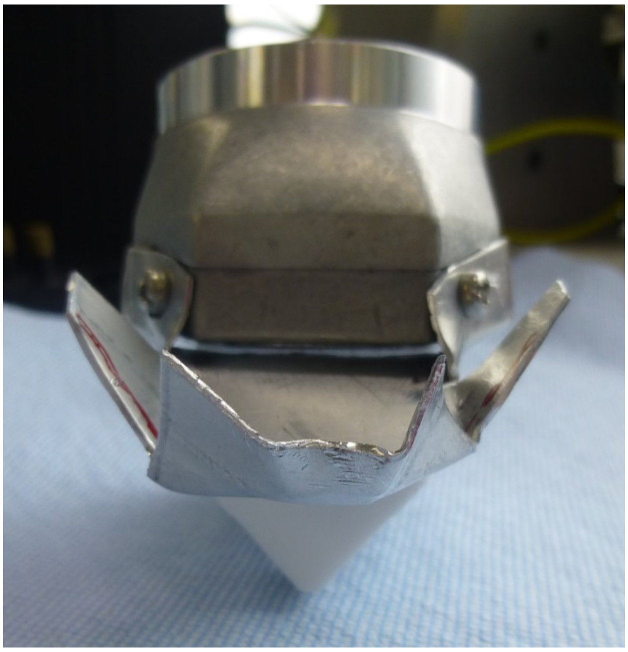

Figure 30 Extrusion welding gun nozzle with preheat deflector plate attached.

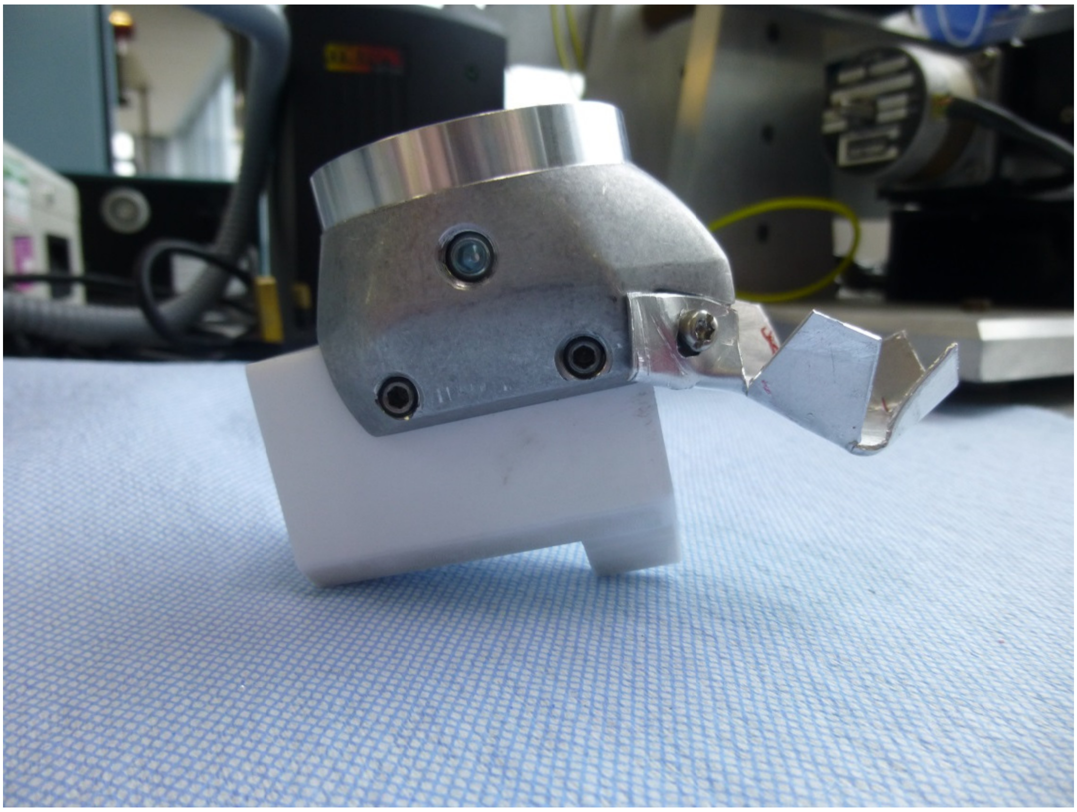

Figure 31 Extrusion welding gun nozzle with preheat deflector plate attached.

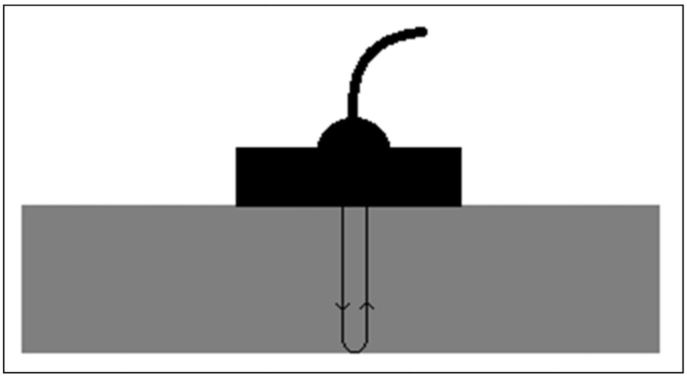

Figure 32 A schematic drawing of the experimental setup. Pulse-echo configuration was used; the same probe was used both for transmitting and receiving the signals.

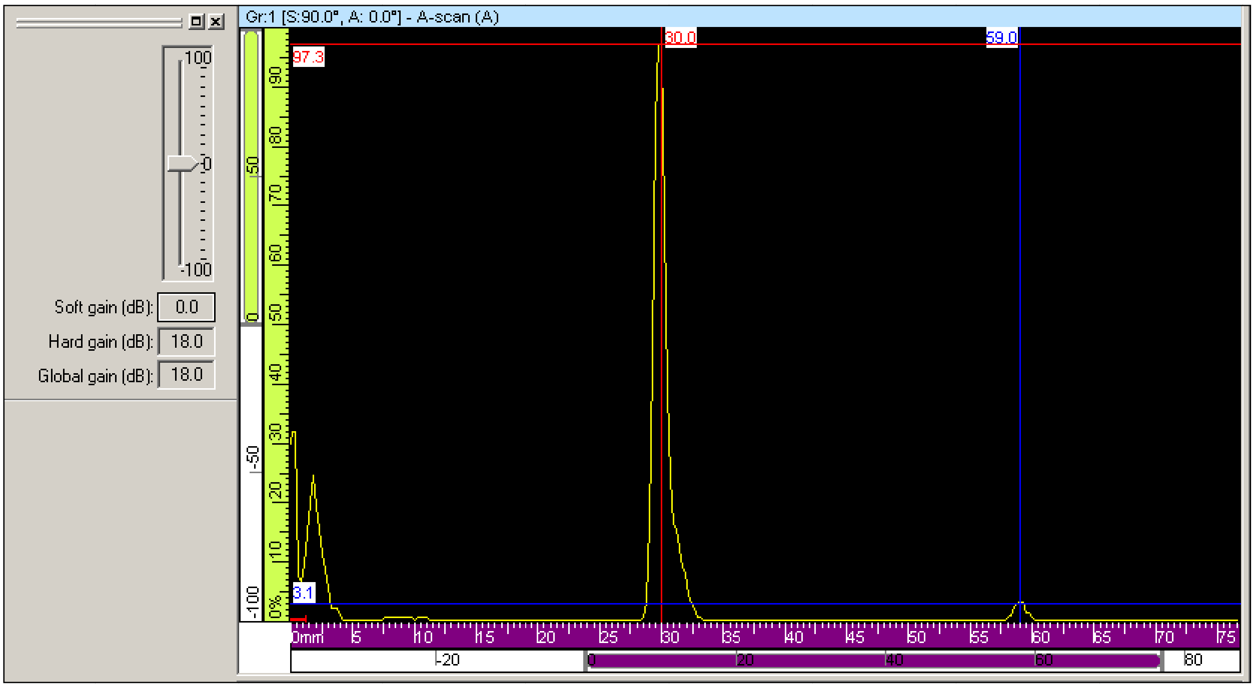

Figure 33 The ultrasonic A-scan from the plastic sheet using a 2MHz probe.

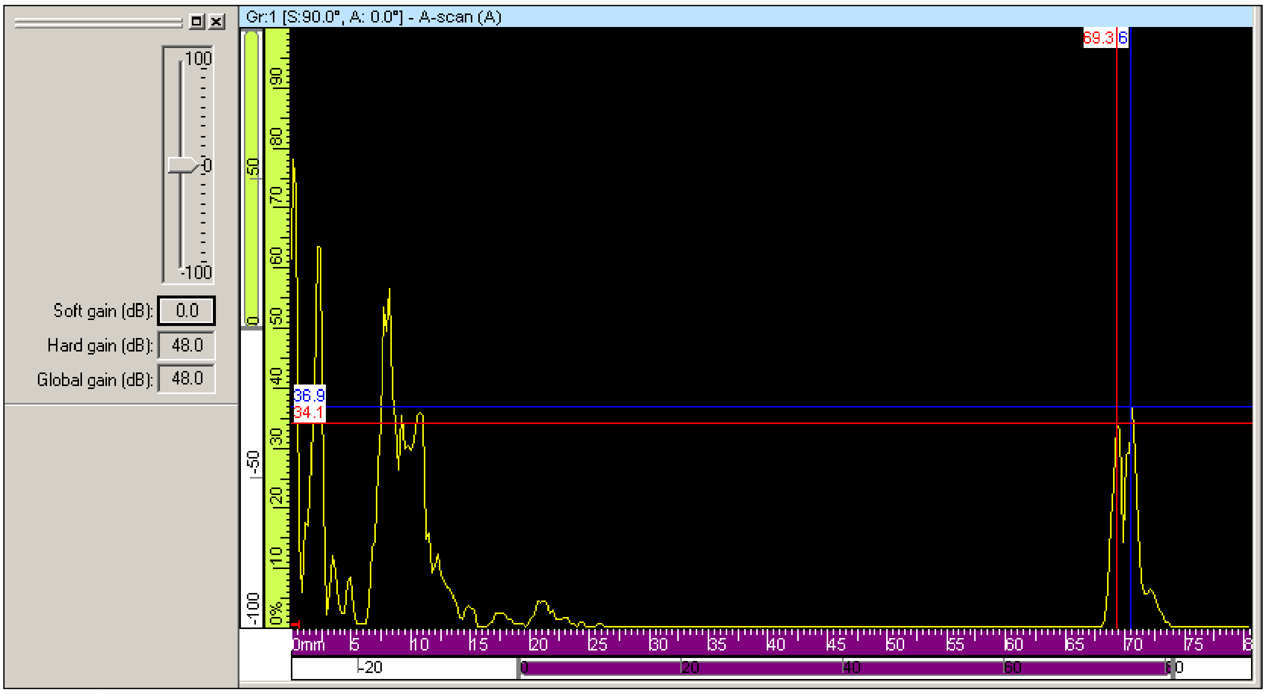

Figure 34 The ultrasonic A-scan from the plastic sheet in both the parent material and the weld using a 2MHz probe.

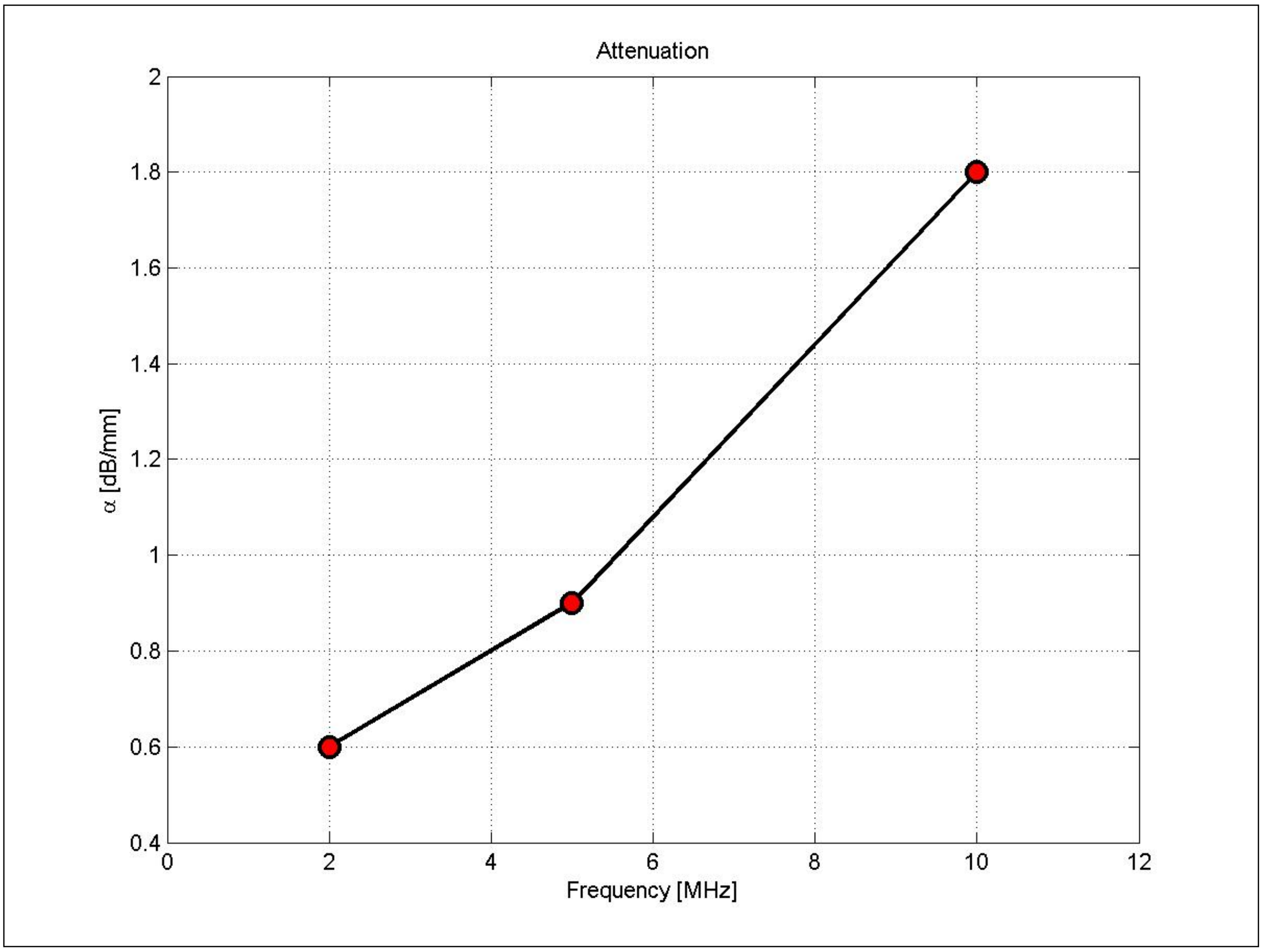

Figure 35 The measured attenuation in relation to probe frequency.

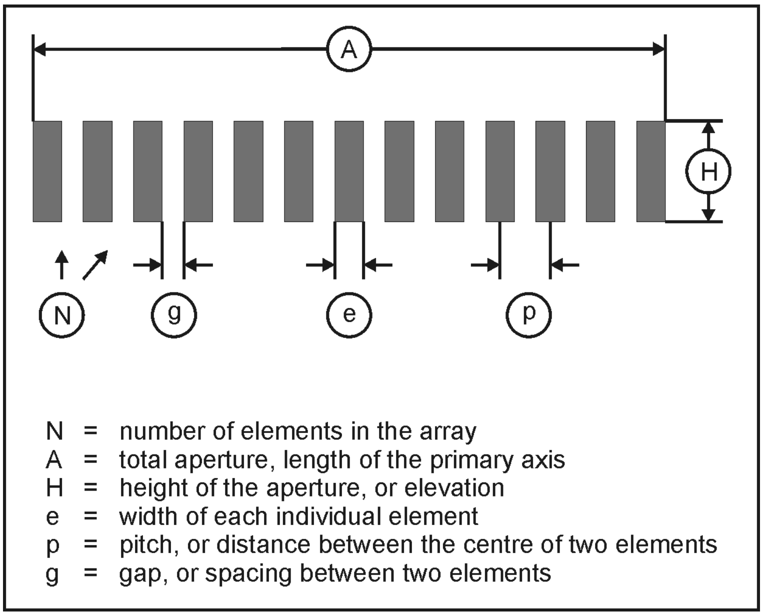

Figure 36 Dimensional parameters of a 1-D linear phased array.

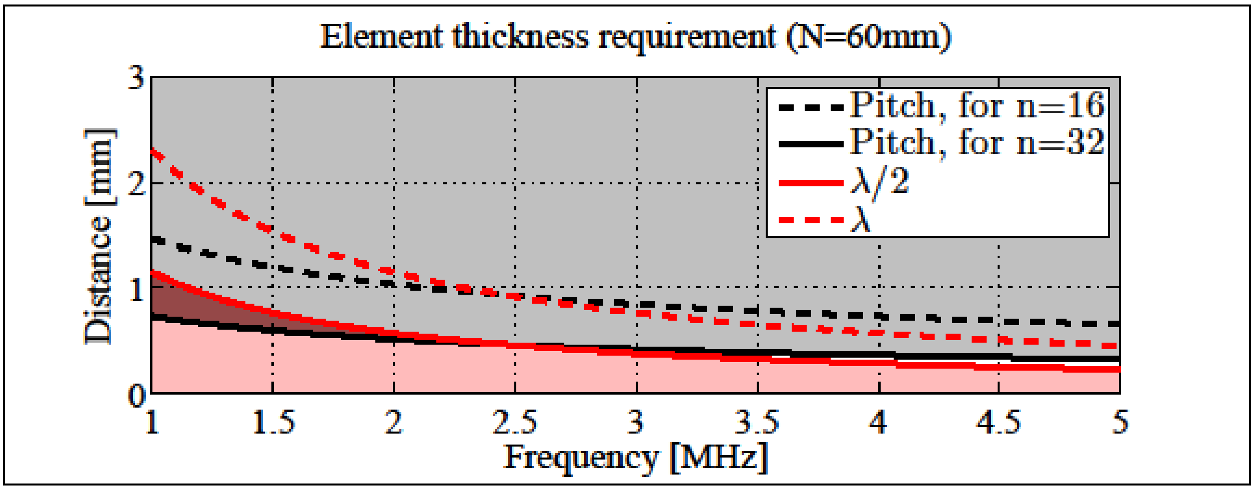

Figure 37 The pitch and the wavelength versus frequency for a fixed near field range (N=60mm).

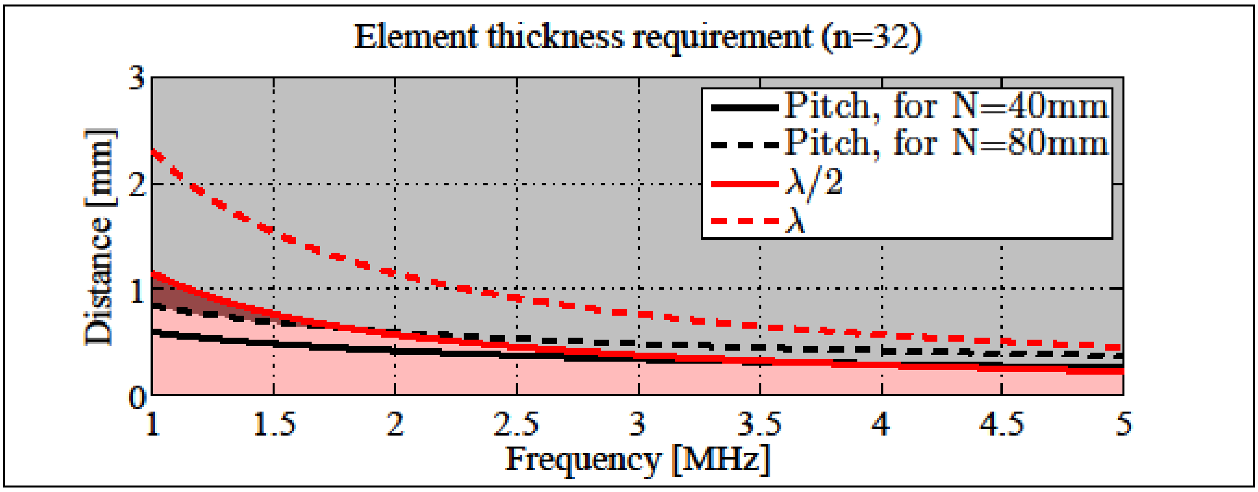

Figure 38 The pitch and the wavelength versus frequency for a fixed number of elements (n=32mm).

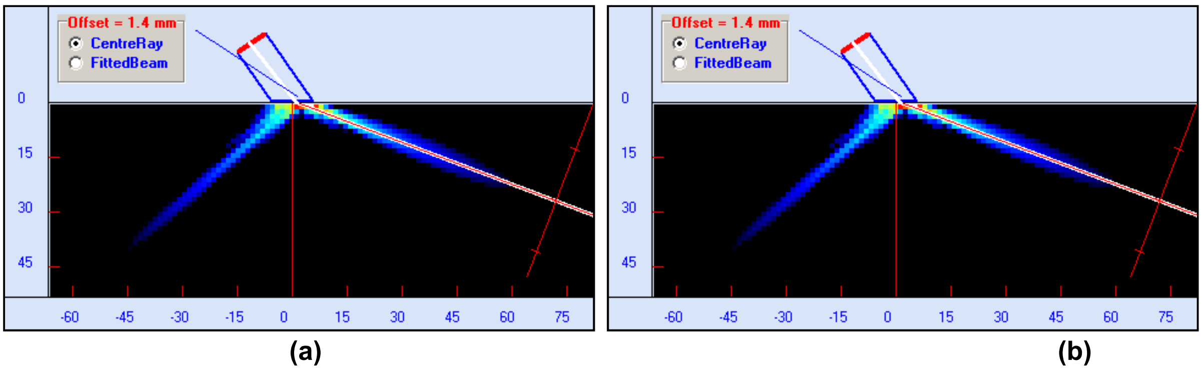

Figure 39 Beam plot; (a) 4MHz transducer with a beam angle of 69 degrees; (b) 2.25MHz transducer with a beam angle of 70 degrees.

Table 3 The probe parameters for the project.

	Fillet weld joints		Butt weld joints
	TJ1	**TJ2**	**BW1**
Number of elements	16	32	32
Frequency [MHz]	2.25	4	2.25
Pitch [mm]	1.0	1.0	0.6

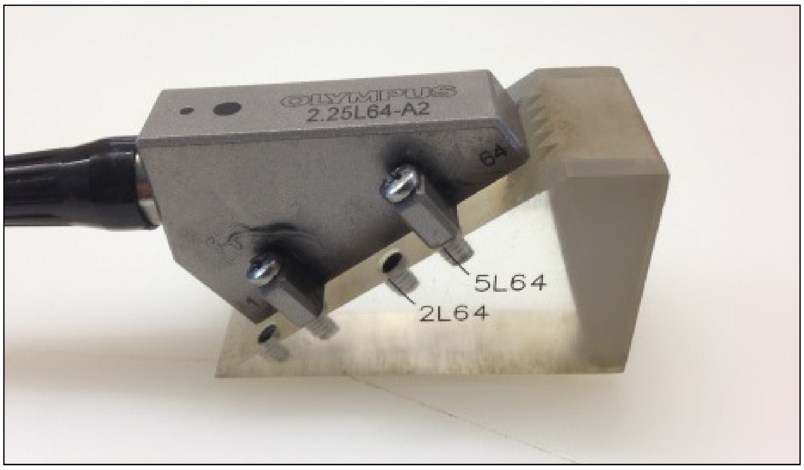

Figure 40 Transducer BW1 mounted on a rexolite wedge.

Figure 41 Transducer TJ1

Figure 42 The 4MHz transducer TJ2.

Figure 43 Basic Water wedge

Figure 44 Water wedge with sealing skirt and transducer

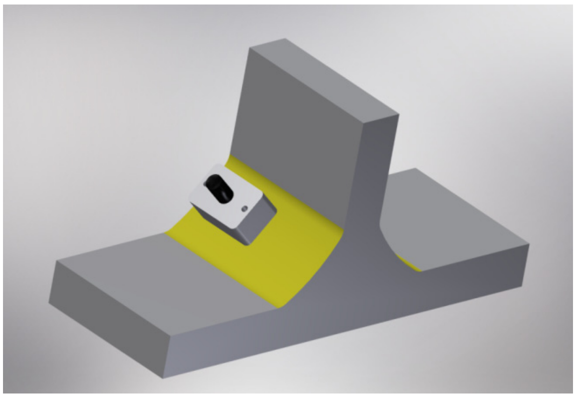

Figure 45 Probe model on sheet fillet weld

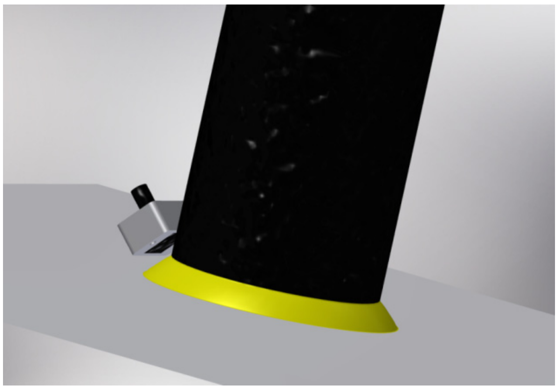

Figure 46 Probe model on pipe in sheet fillet weld

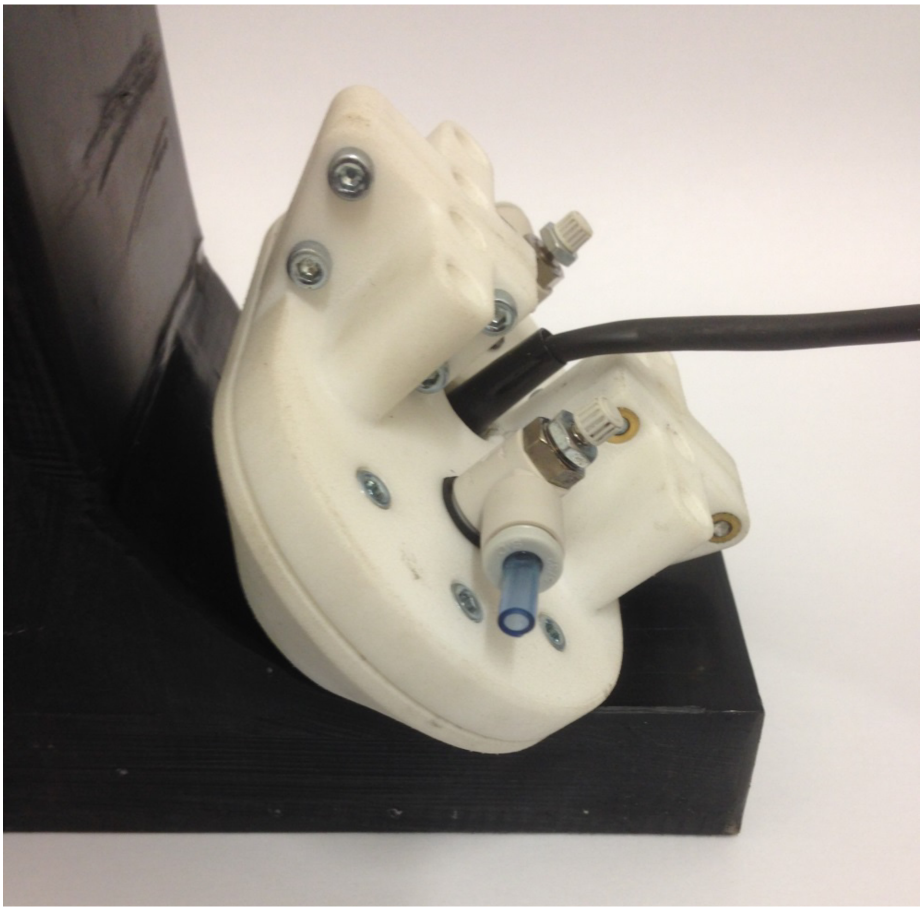

Figure 47 Fillet weld water wedge assembly positioned on tank base fillet weld

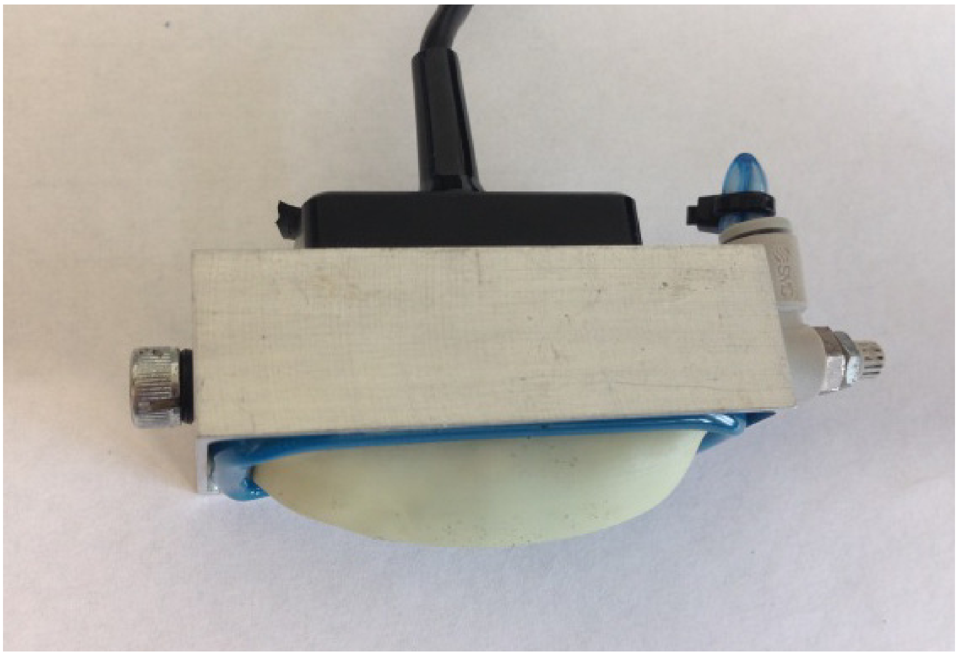

Figure 48 Compact fillet weld water wedge assembly

Figure 49 Angled membrane water wedge

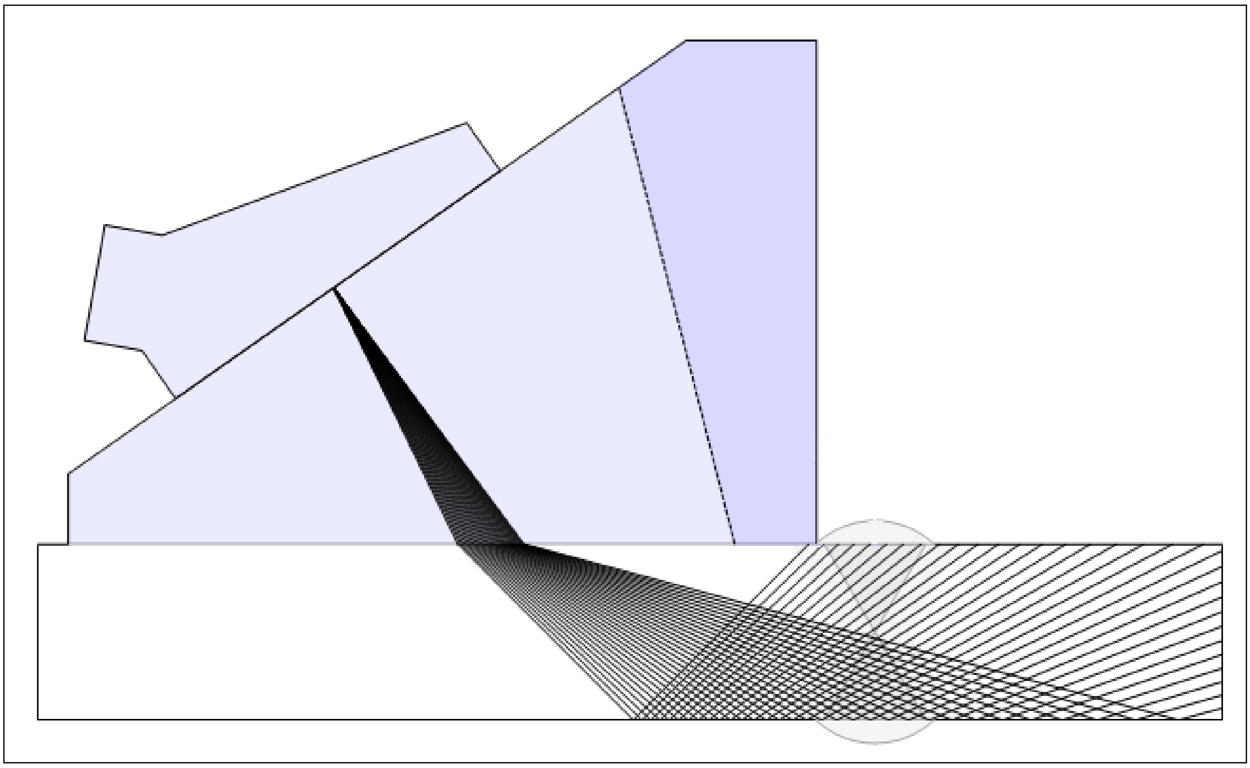

Figure 50 Inspection technique for the double V butt welds.

Table 4 Parameter settings for butt welds

	15mm	**25mm**	**40mm**
Start angle (°)	45	40	35
Stop angle (°)	75	75	75
Angle increment (°)	1	1	1
Focus depth (mm)	15	25	40
Standoff (mm)	5	17	33

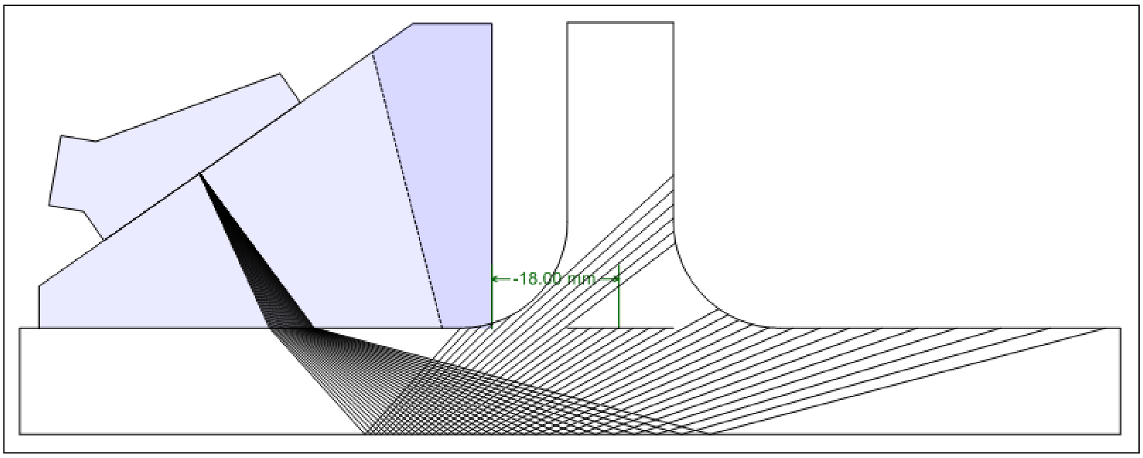

Figure 51 A possible inspection technique for the T-joints.

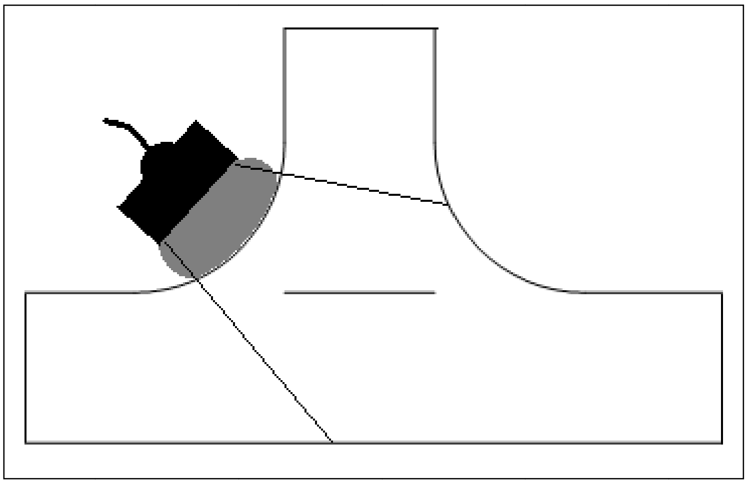

Figure 52 A possible inspection technique for the T-joints.

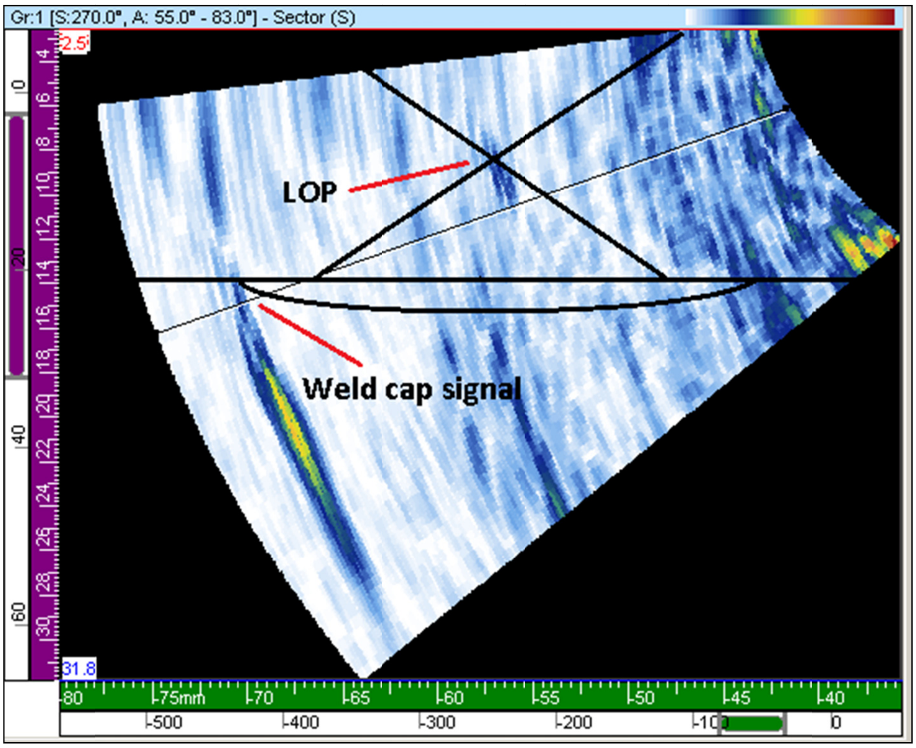

Figure 53 Sector scan acquired on one position on the plate. The weld cap signal is a geometrical feature and the lock of penetration (LOP) is a flaw generated by the welding. Any lack of fusion (LOF) defects should be present on the faces of the weld.

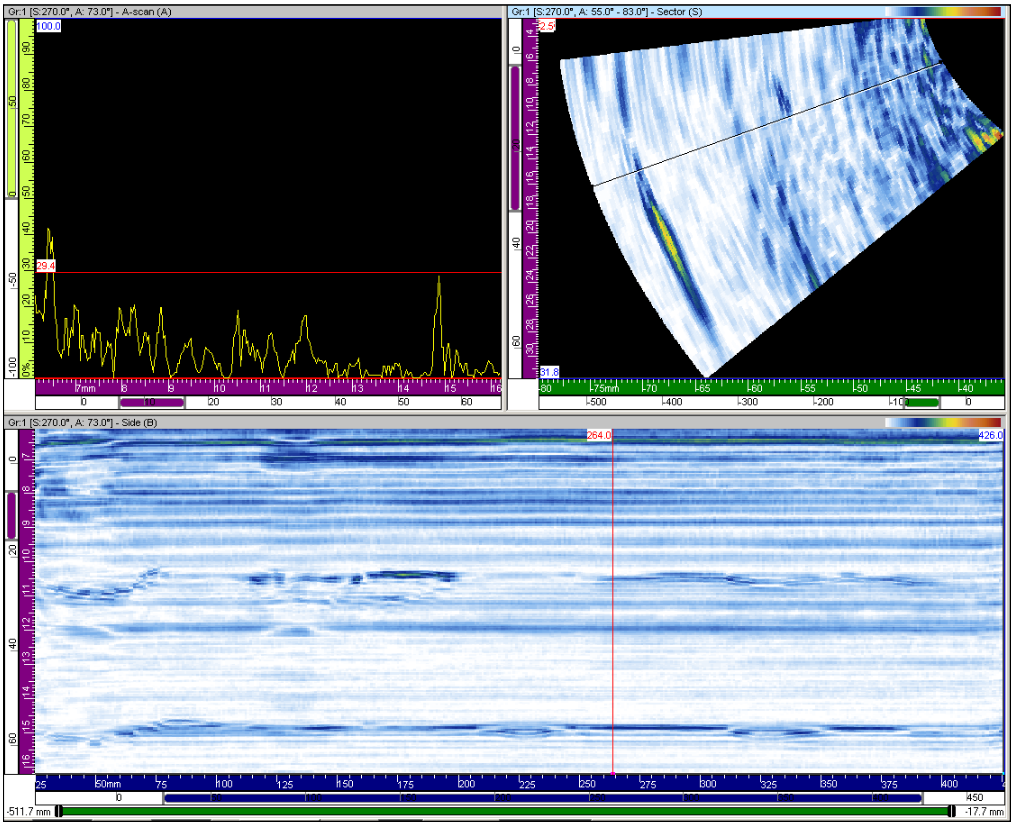

Figure 54 Signal from the weld cap on the internal surface of the plate. This is a geometrical feature that is present almost throughout the length of the weld.

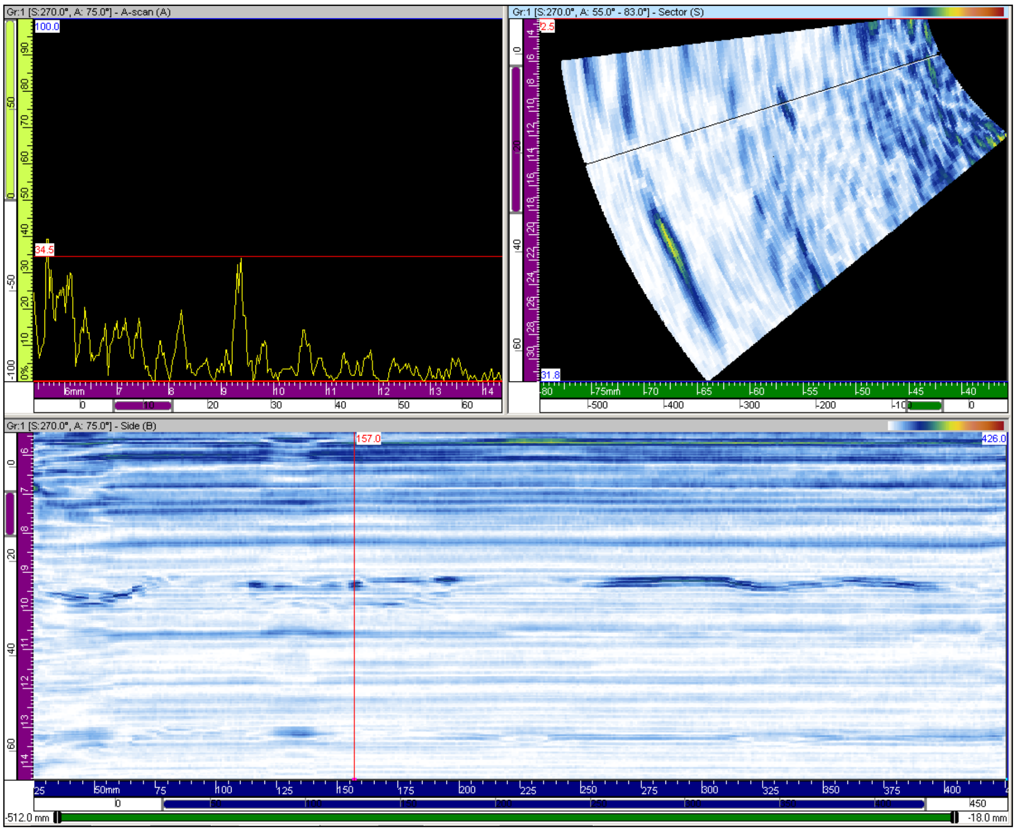

Figure 55 Signal from a lack-of-penetration (LOP) in the middle of the weld.

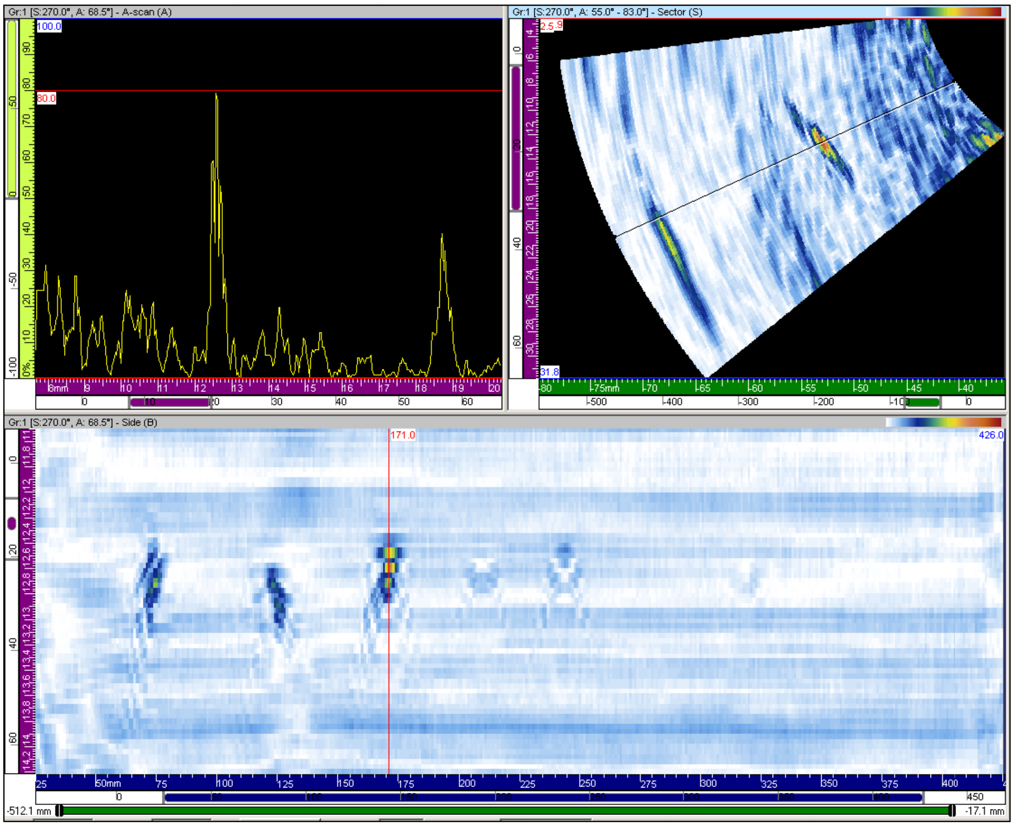

Figure 56 Signals from the aluminium discs located on one fusion face of the weld.

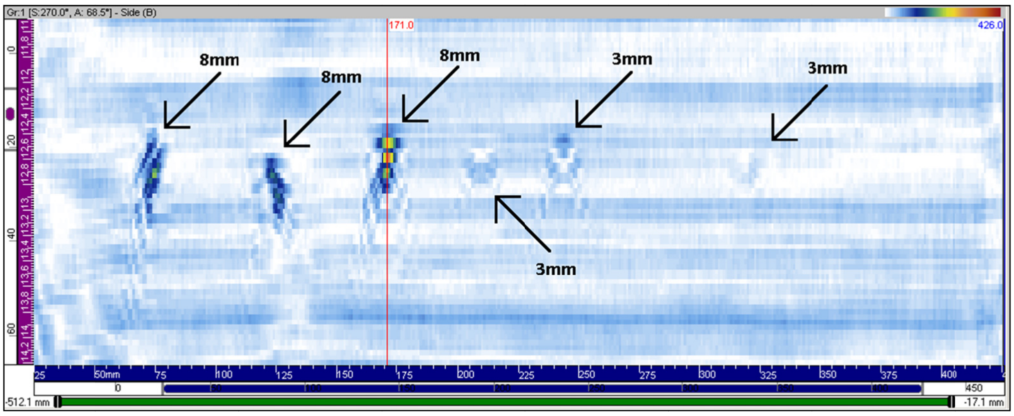

Figure 57 The B-scan image shows the recorded data over the length of the weld. Five aluminium discs with different diameters were placed in the weld. All aluminium discs were detected.

Table 5 PAUT inspection results

Weld ID	Sheet Thickness, mm	Joint Type	No Flaw	Full discs (mm)						25mm discs at distance from root (mm)					Cold Weld %
				2	3	4	8	15	25	2	4	6	8	10	
2	15	Double-V butt	NFF												
3	15	Double-V butt	NFF												
6	15	Double-V butt		5 (5)	5 (5)	5 (5)	5 (5)								
8	15	Double-V butt													50 LORF
9	15	Double-V butt													100 LORF
10	15	T-joint	NFF												
11	15	T-joint		6 (10)	7 (10)	7 (10)	9 (10)								
12	15	T-joint								5 (5)	4 (6)	4 (5)	1 (3)	1 (4)	
13	15	T-joint													0 (2)
25	15	Pipe-in-sheet													
27	15	Pipe-in-sheet													
28	15	Pipe-in-sheet		(4)	(4)	(4)	(4)								
33	15	Pipe-in-sheet								(2)	(2)	(2)	(2)	(2)	
39	15	Pipe-in-sheet													
42	25	Double-V butt	(1)												
43	25	Double-V butt	(2)												
46	25	Double-V butt		5 (5)	5 (5)	5 (5)	5 (5)	5 (5)							
48	25	Double-V butt													100 LORF
49	25	Double-V butt													100 LORF
50	25	T-joint	NFF												
51	25	T-joint		3 (5)	4 (5)	4 (5)	5 (5)	5 (5)							
52	25	T-joint								4 (4)	4 (4)	3 (3)	3 (3)	4 (4)	
53	25	T-joint													0 (2)
65	25	Pipe-in-sheet													

Weld ID	Sheet Thickness, mm	Joint Type	No Flaw	Full discs (mm)						25mm discs at distance from root (mm)					Cold Weld %
				2	3	4	8	15	25	2	4	6	8	10	
67	25	Pipe-in-sheet													
68	25	Pipe-in-sheet		(4)	(4)	(4)	(4)								
73	25	Pipe-in-sheet								(2)	(2)	(2)	(2)	(2)	
79	25	Pipe-in-sheet													
82	40	Double-V butt	(3)												
83	40	Double-V butt	(4)												
86	40	Double-V butt		3 (3)	3 (3)	3 (3)	3 (3)	3 (3)	3 (3)						
88	40	Double-V butt													100 LORF
89	40	Double-V butt													100 LORF
90	40	T-joint	NFF												
91	40	T-joint		0 (3)	1 (3)	1 (3)	2 (4)	2 (3)	3 (3)						
92	40	T-joint								0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
93	40	T-joint													0 (2)
105	40	Pipe-in-sheet													
107	40	Pipe-in-sheet													
108	40	Pipe-in-sheet		(4)	(4)	(4)	(4)								
113	40	Pipe-in-sheet								(2)	(2)	(2)	(2)	(2)	
119	40	Pipe-in-sheet													

Notes:
(?) = Number of artificial flaw inserts present in the joint.
(?) = Number of artificial flaw inserts detected.
(1) 100% Lack of Root Fusion plus 35mm of Lack of Weld
(2) 100% Lack of Root Fusion
(3) 100% Lack of Root Fusion plus 60mm Lack of Side wall Fusion
(4) 100% Lack of Root Fusion

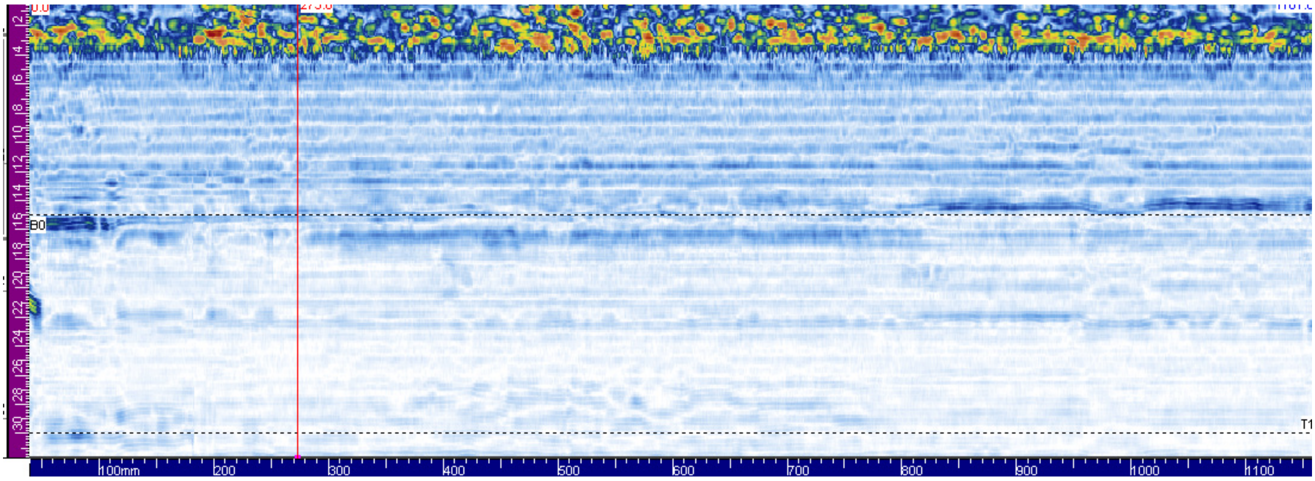

Figure 58 Typical scan of butt welded sample with no flaws.

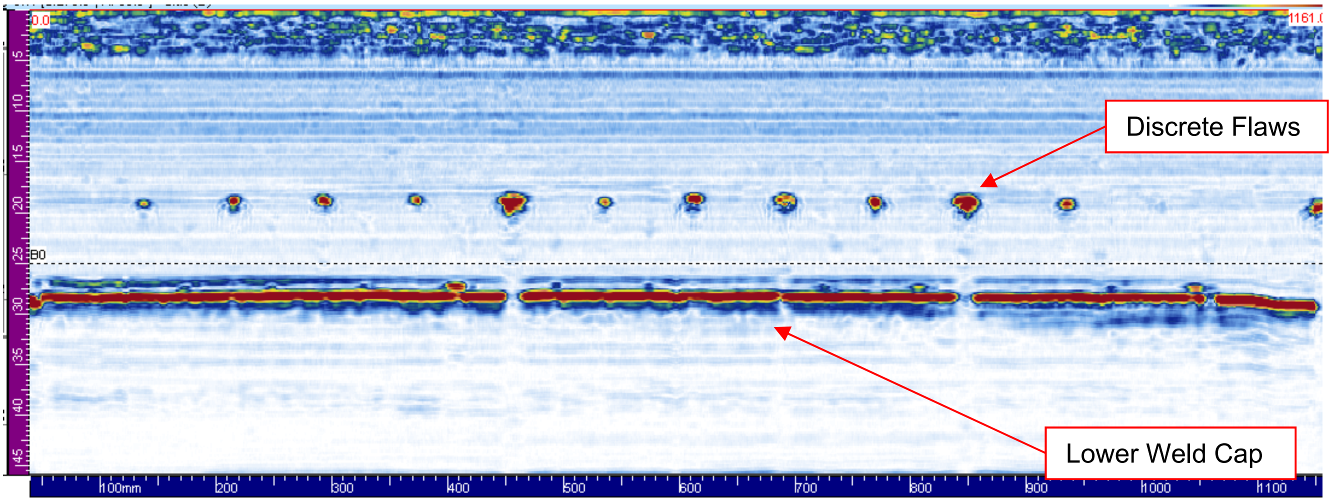

Figure 59 Typical scan of butt welded sample with discrete flaws.

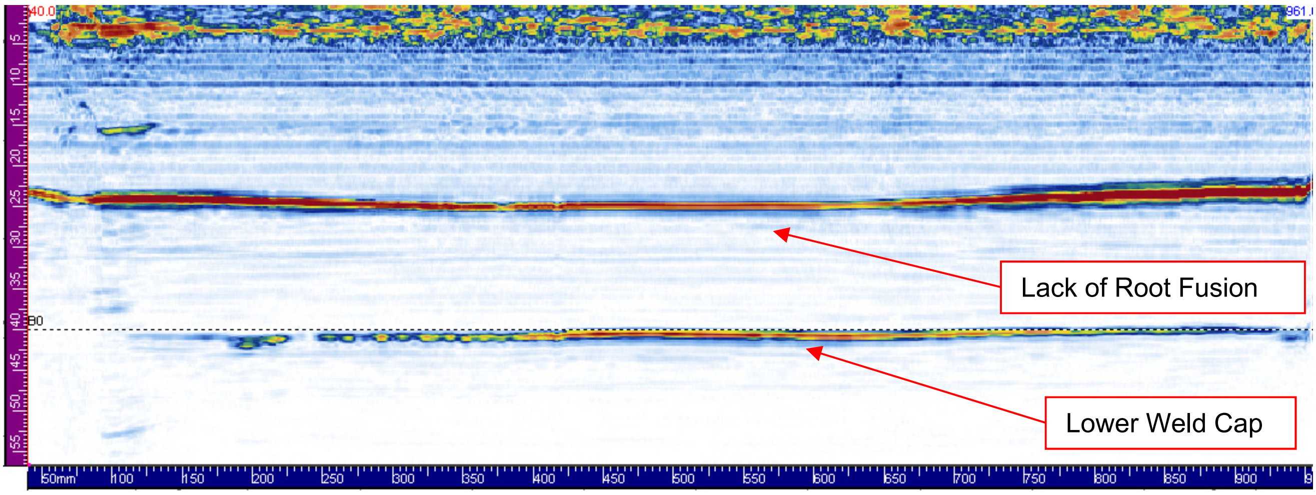

Figure 60 Typical scan of butt welded sample with cold weld flaw showing lack of root fusion.

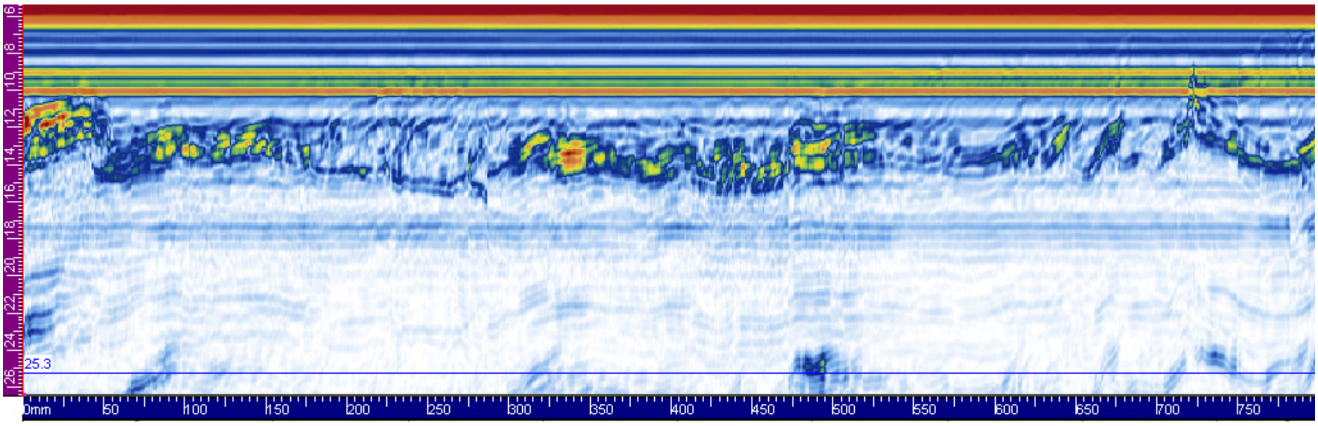

Figure 61 Typical scan of T-joint welded sample with no flaws.

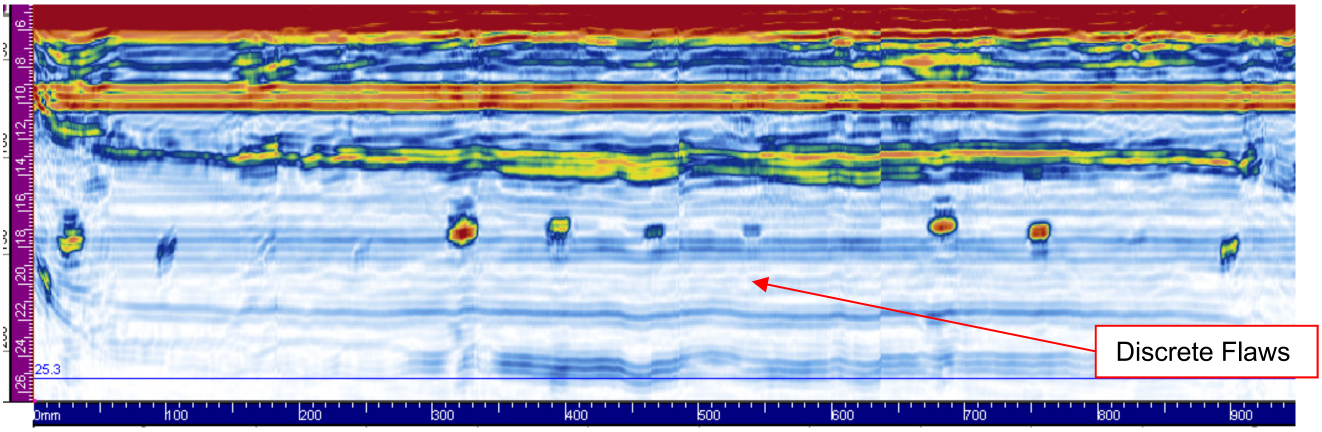

Figure 62 Typical scan of T-joint welded sample with discrete flaws.

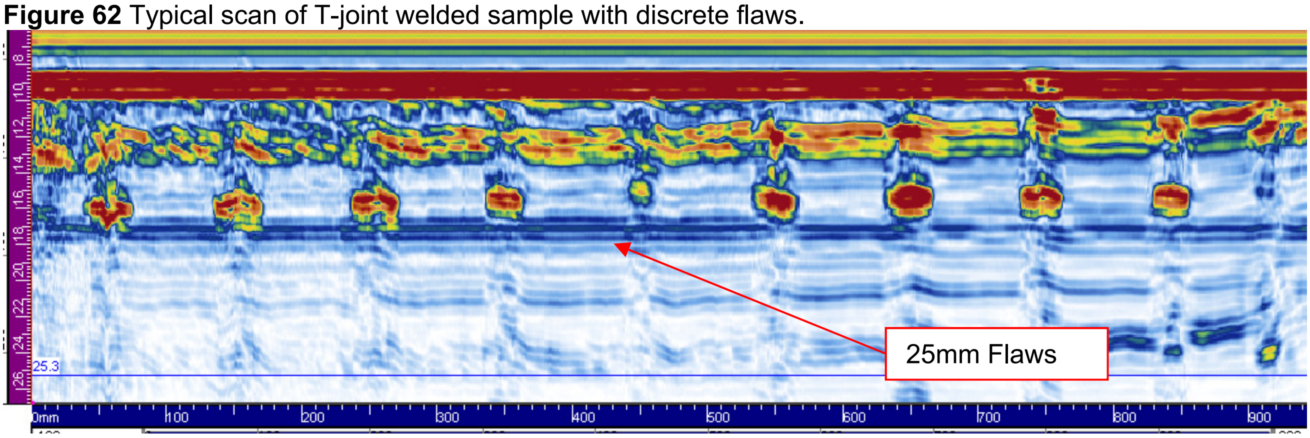

Figure 63 Typical scan of T-joint welded sample with 25mm flaws at varying distances from the root.

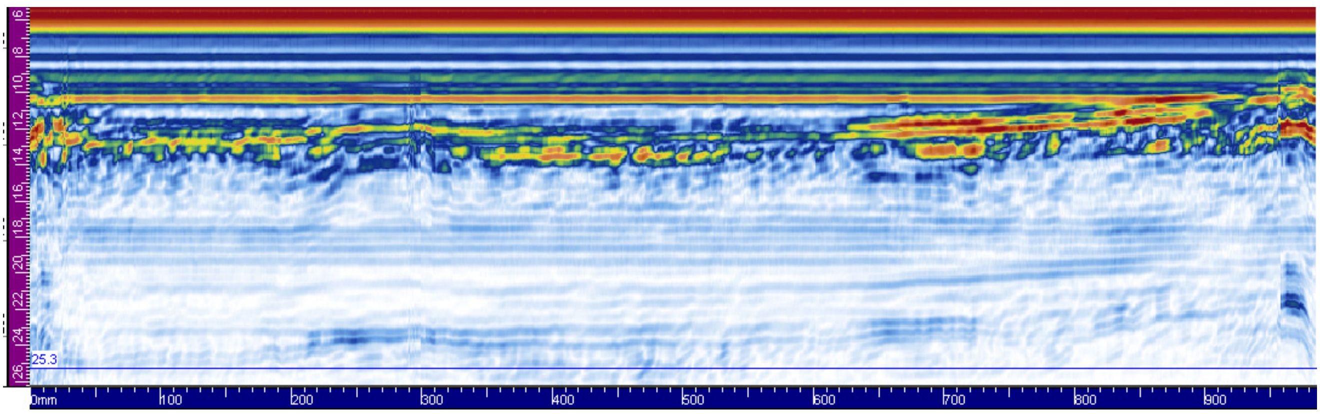

Figure 64 Typical scan of T-joint welded sample with cold weld flaw showing no evidence of a cold weld.

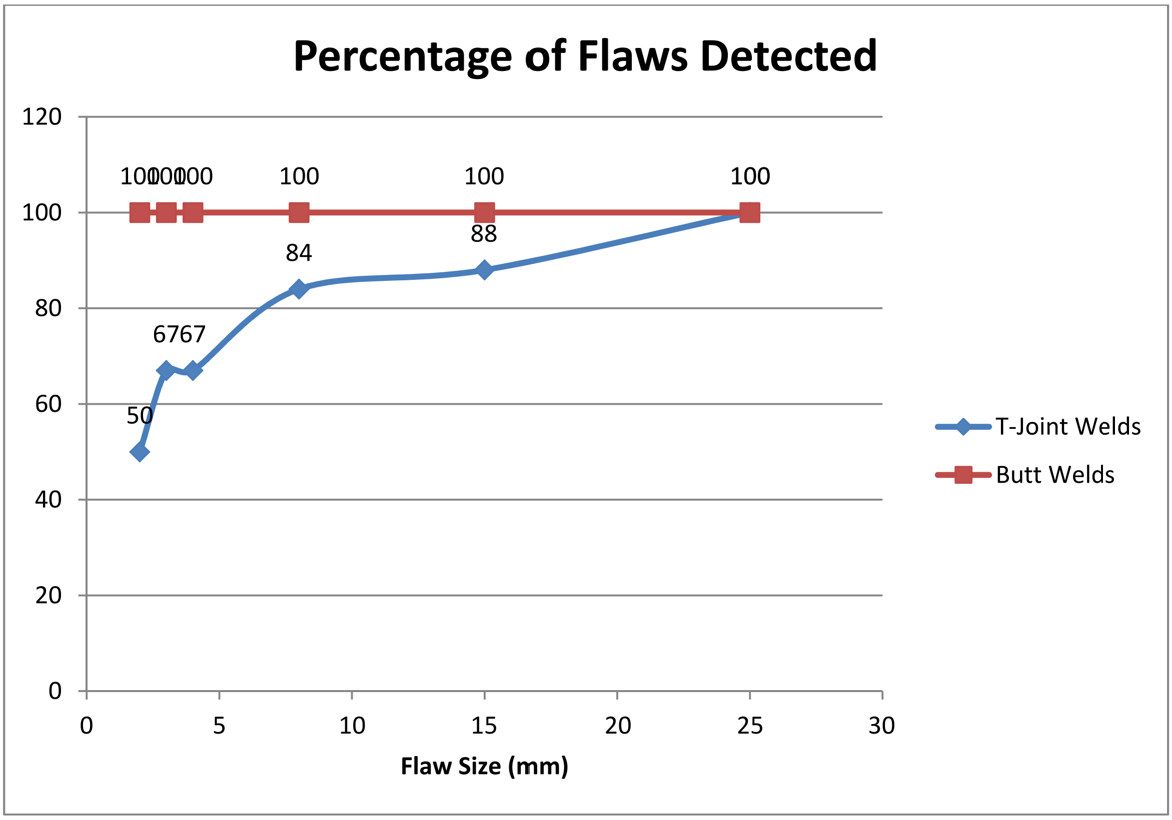

Figure 65 Percentage of discrete flaws detected in butt welds and T-joint welds

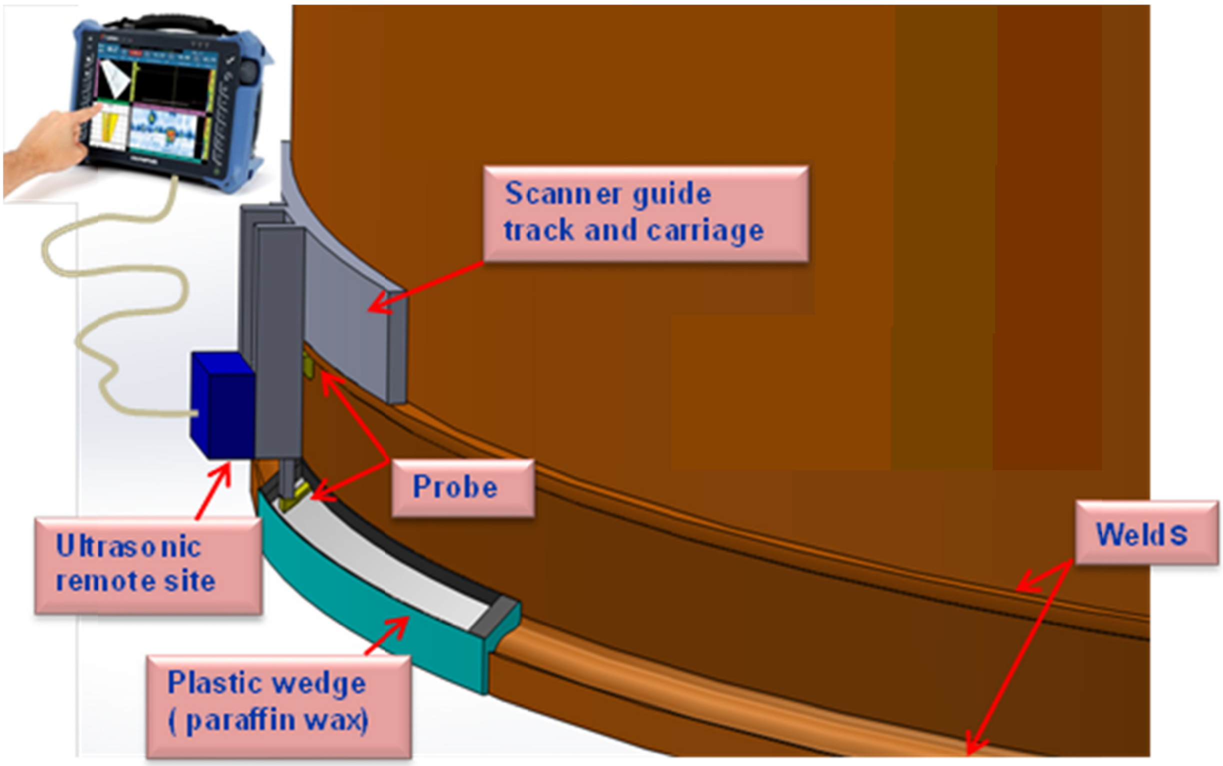

Figure 66 Scanner Carriage with preformed plastic wedge coupling material.

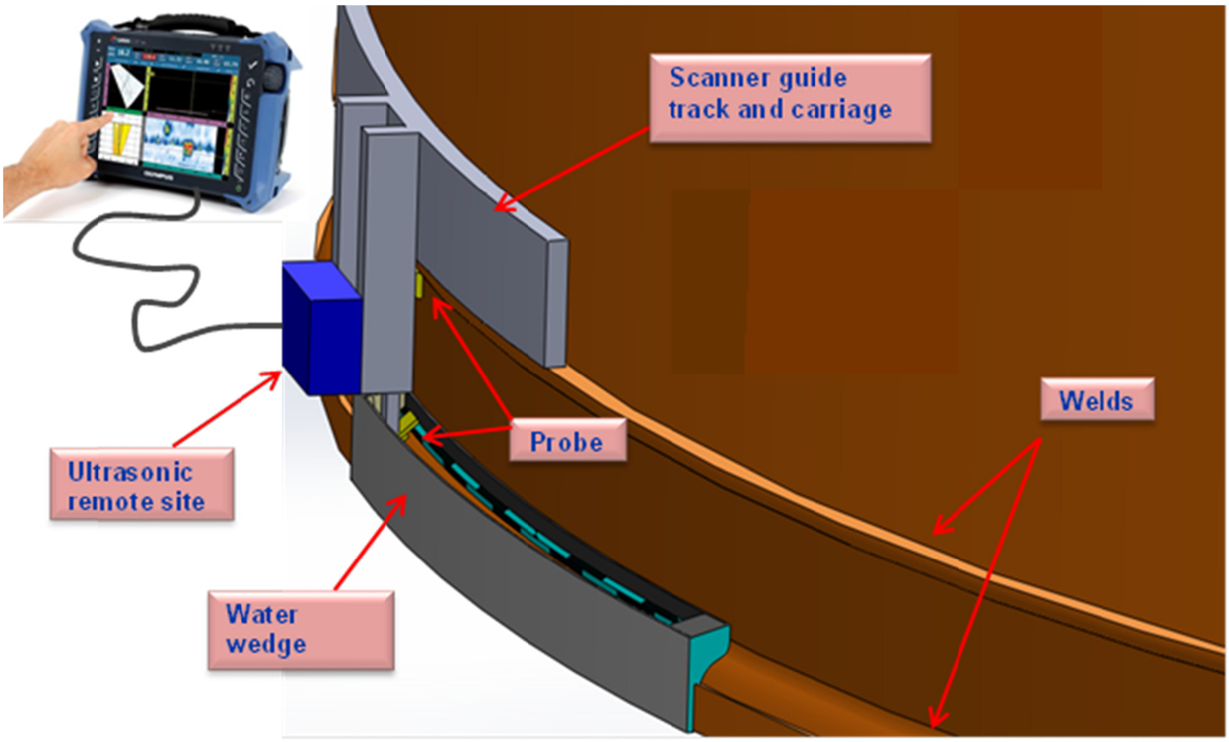

Figure 67 Scanner Carriage with preformed water trough for probe coupling.

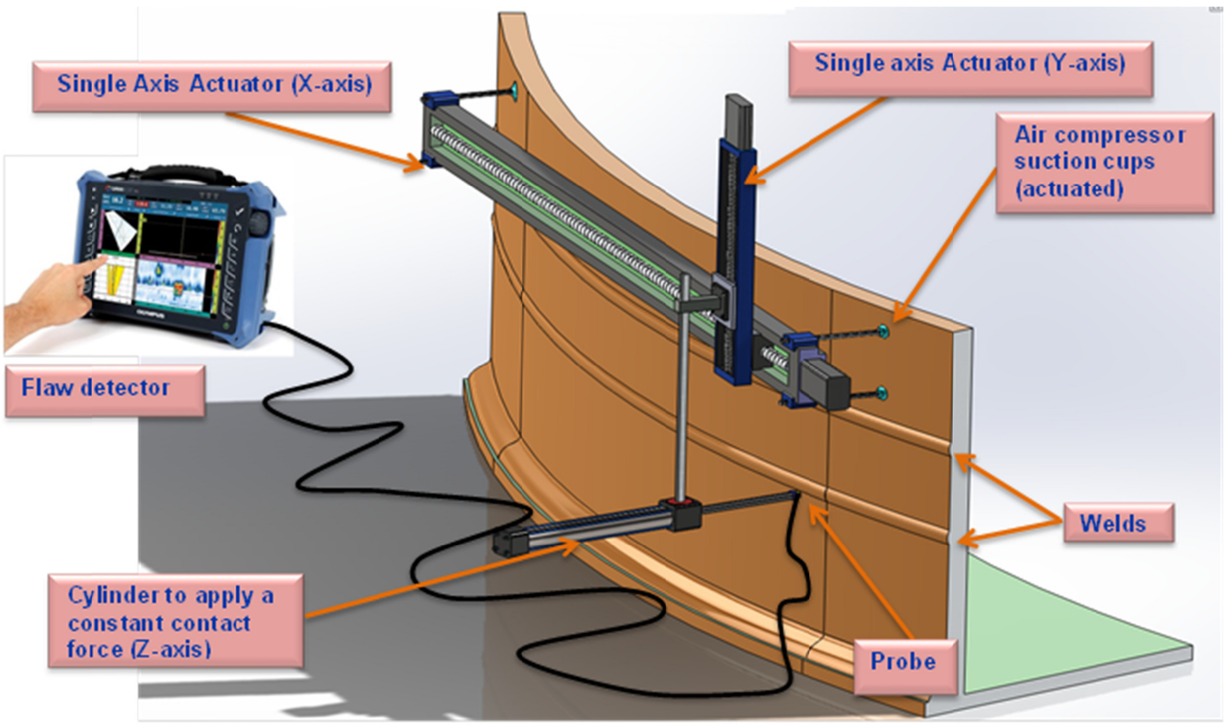

Figure 68 Three axis scanner with suction cup mounting

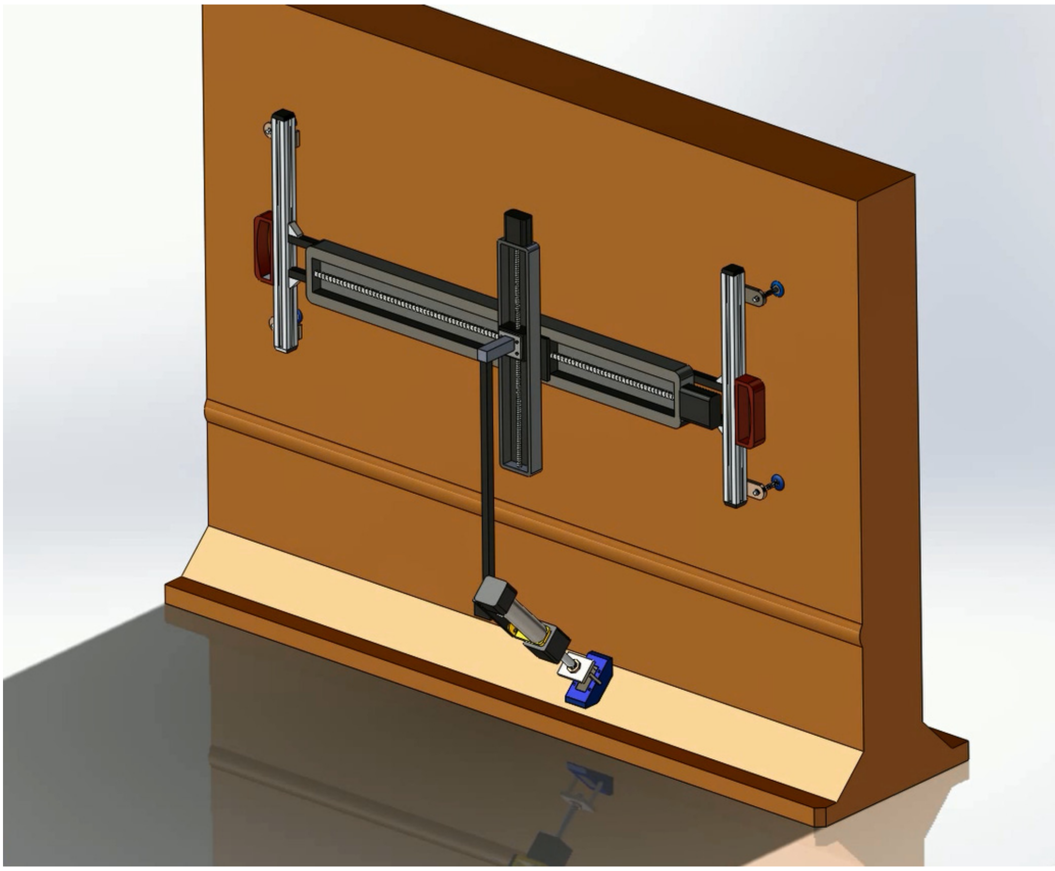

Figure 69 Final PolyTank scanner concept design for the base fillet weld.

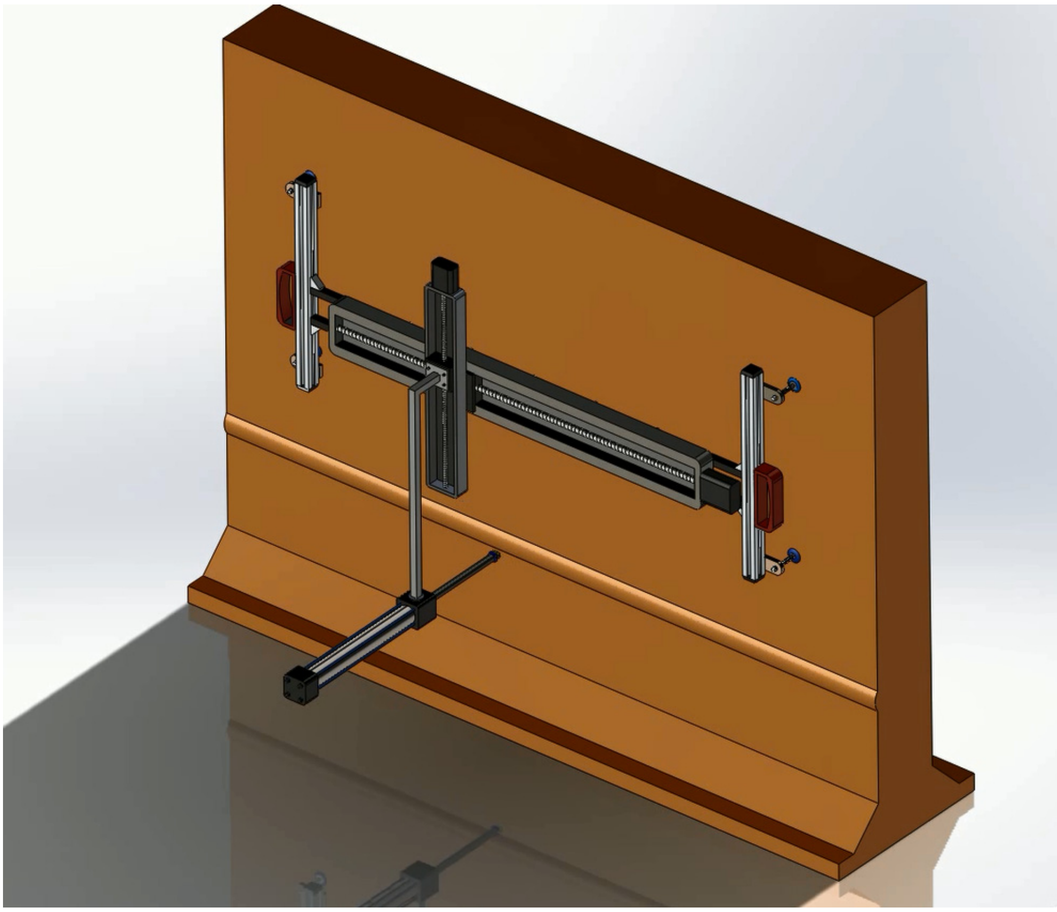

Figure 70 Final PolyTank scanner concept design for the side wall and pipe welds.

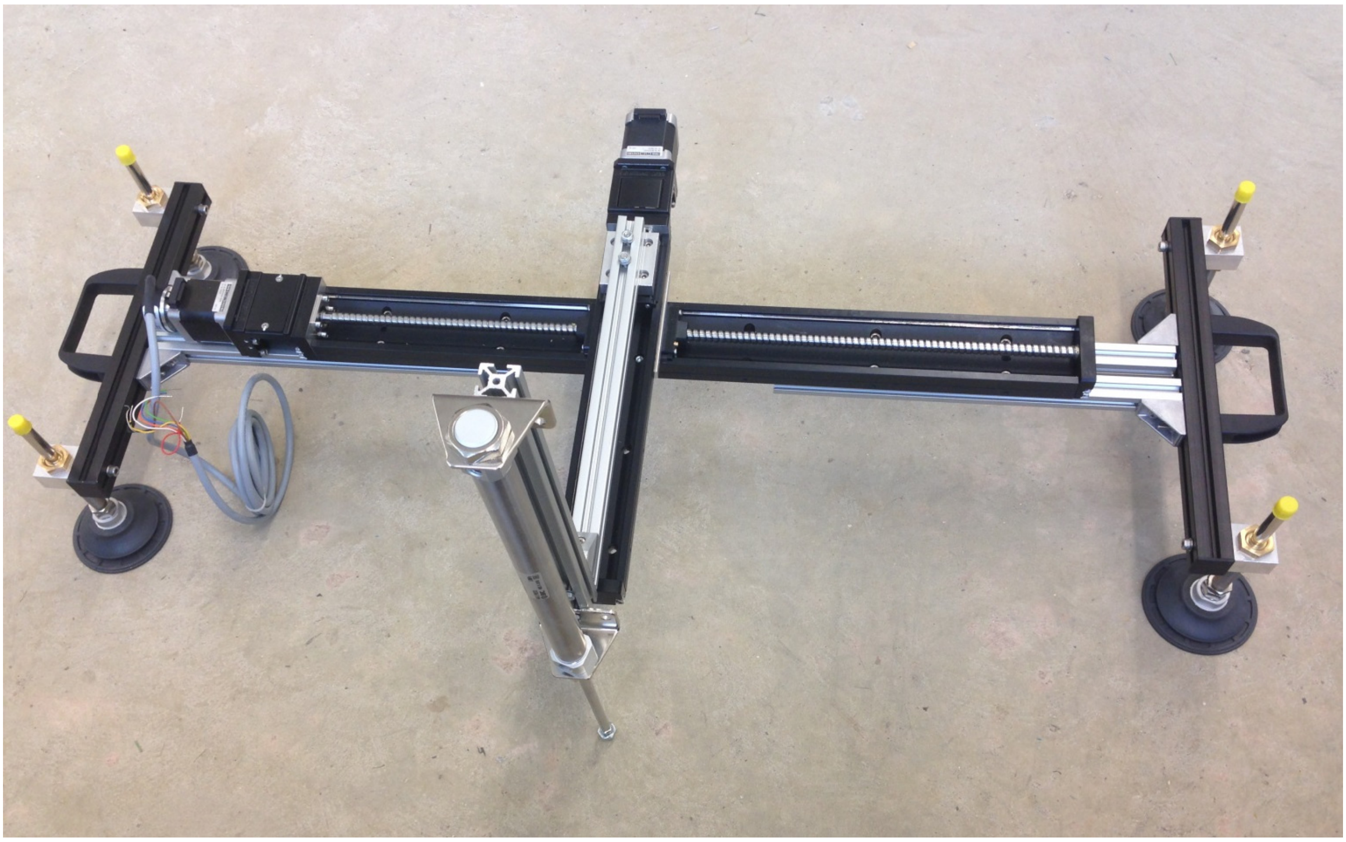

Figure 71 The assembled PolyTank Scanner.

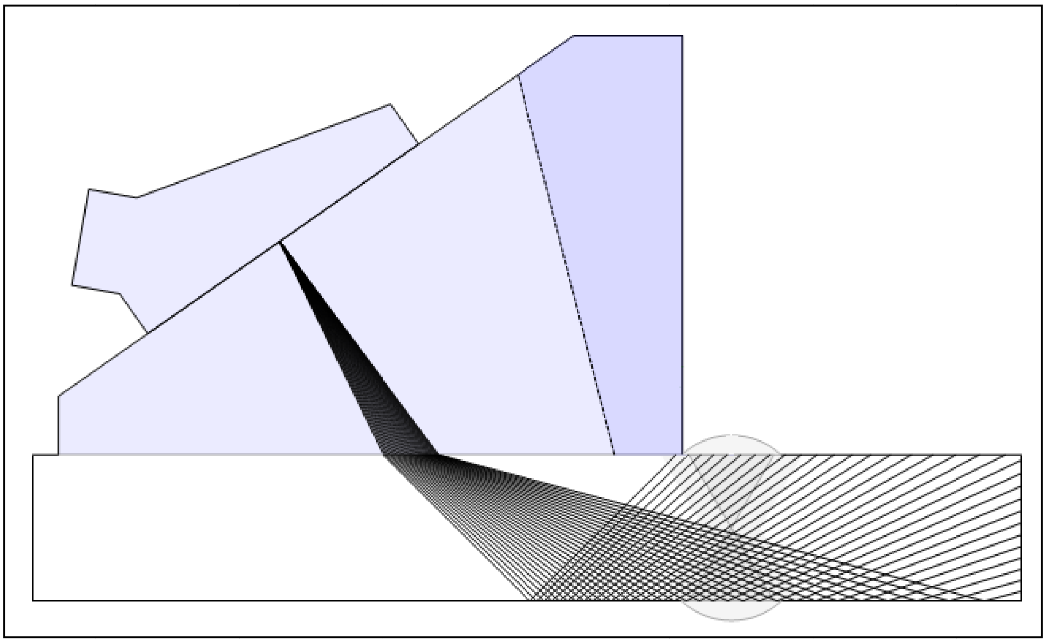

Figure 72 The sector pulse-echo configuration for the butt welds.

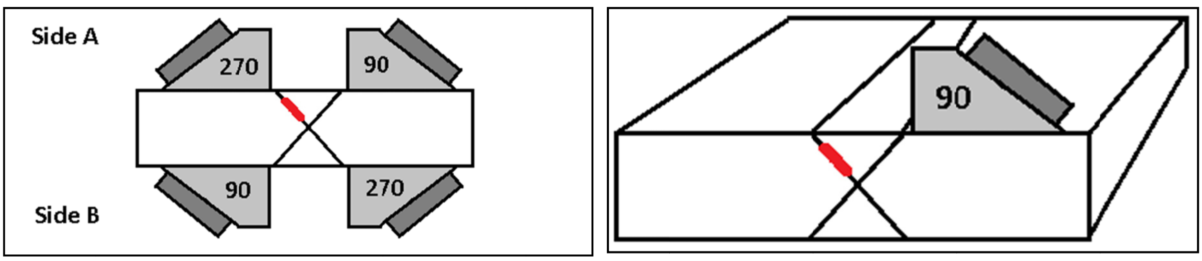

Figure 73 The scanning of the butt fusion joints.

Table 6. Butt fusion Plate, Probe and Focal Law parameters.

Plate	Wall thickness [mm]		**15**	**25**	**40**
Probe	Type		1D Linear	1D Linear	1D Linear
	Elements		64	64	64
	Pitch [mm]		0.6	0.6	0.6
	Gap [mm]		0.1	0.1	0.1
	Frequency [MHz]		2.25	2.25	2.25
Focal Law	**Sector pulse-echo**	Angle [°]	30-70	55-83	45-83
		Apeture [No. els]			
		1st element			
		Focal depth [mm]			
	Scan resolution [mm]		1	1	1
	Angle resolution [˚]		1	1	1
	Start [mm]				
	Range [mm]				
	Standoff [mm]				

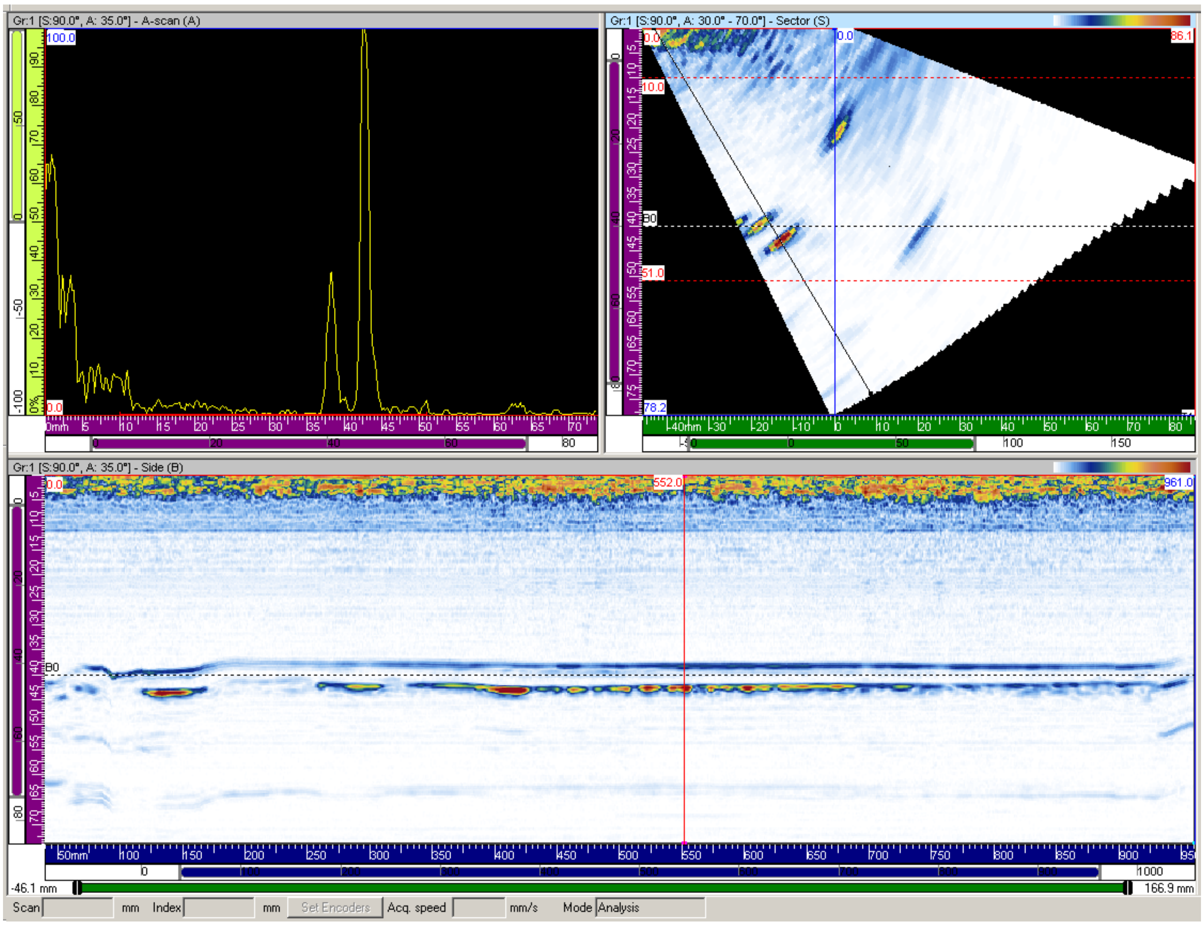

Figure 74 Example of a BF joint inspection screen setup

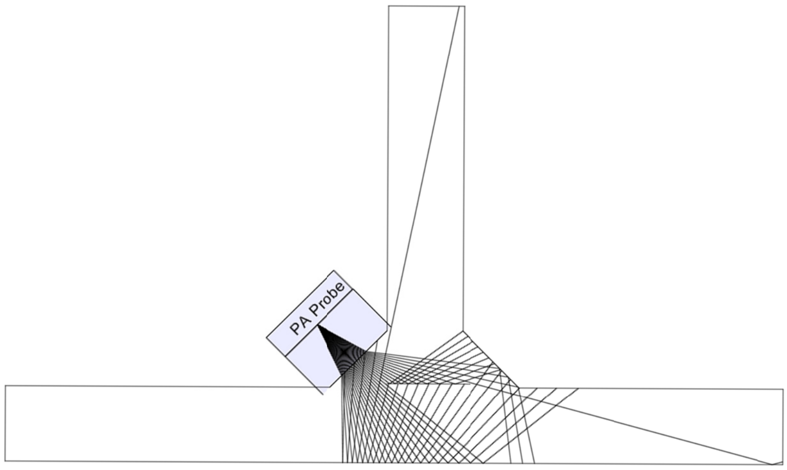

Figure 75 The electronic scan configuration for the T-joint fillet welds.

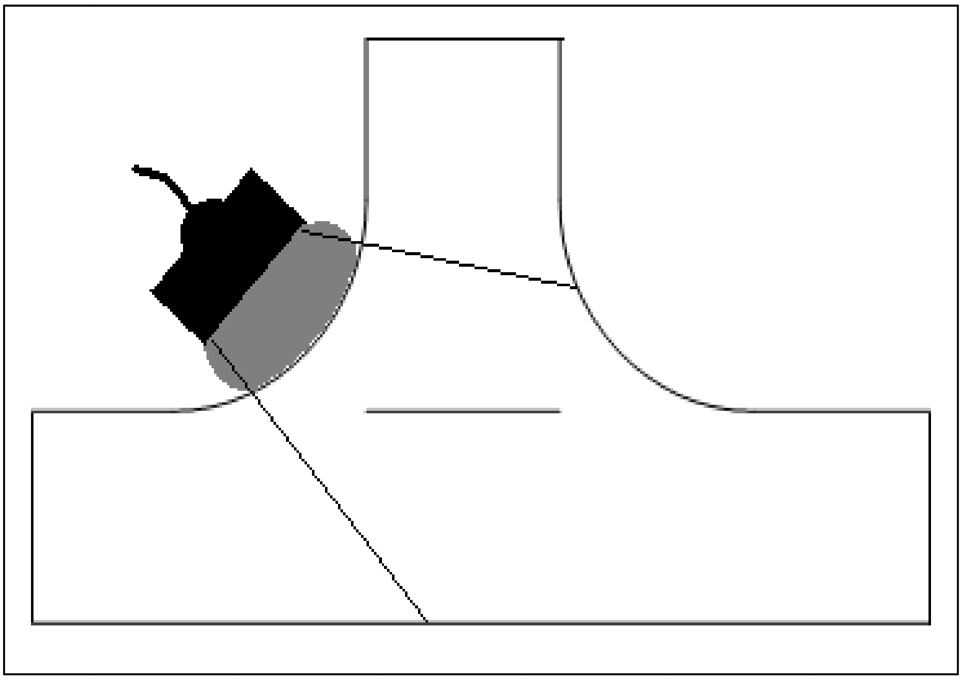

Figure 76 General drawing of the cross section of a T-joint showing the probe position.

Table 7. T-joint Plate, Probe and Focal Law parameters.

Plate	Wall thickness [mm]		**15**	**25**	**40**
Probe	Type		1D Linear	1D Linear	1D Linear
	Elements		16	16	16
	Pitch [mm]		1	1	1
	Gap [mm]		0.1	0.1	0.1
	Frequency [MHz]		2.25	2.25	2.25
Focal Law	**Sector pulse-echo**	Angle [°]	-10 - +10	-10 - +10	-10 - +10
		Apeture [No. els]	16	16	16
		1st element	1	1	1
		Focal depth [mm]	30	30	30
	Scan resolution [mm]		1	1	1
	Angle resolution [˚]		1	1	1
	Start [mm]		5	0	5
	Range [mm]		15	25	15

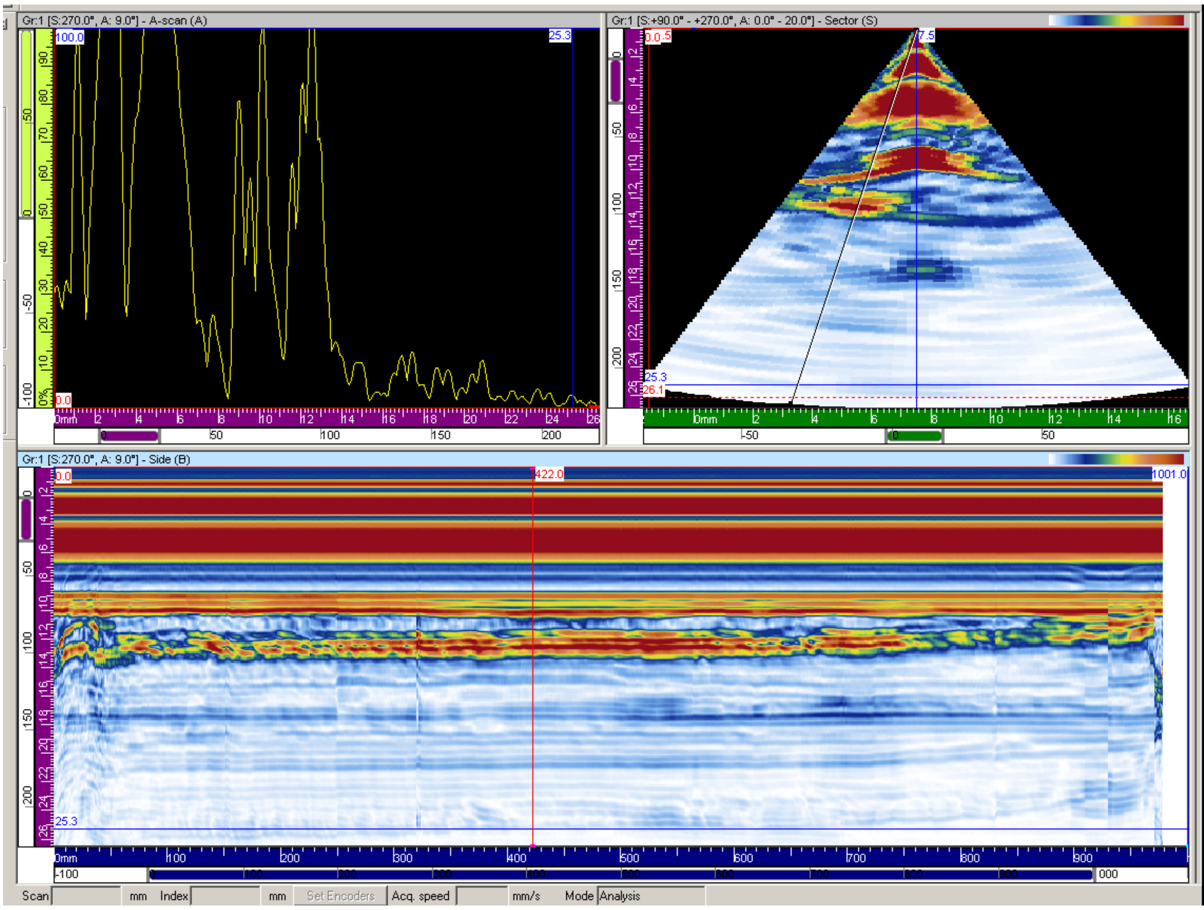
Figure 77 Example of a T joint inspection screen setup.

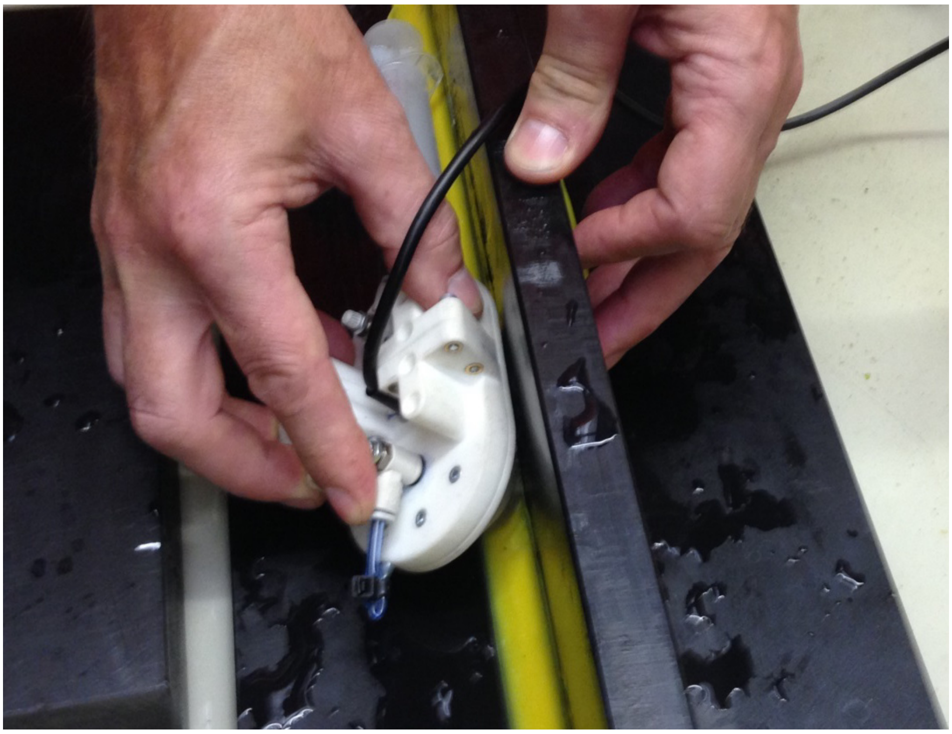
Figure 78 Example of the PolyTank water wedge and probe in use

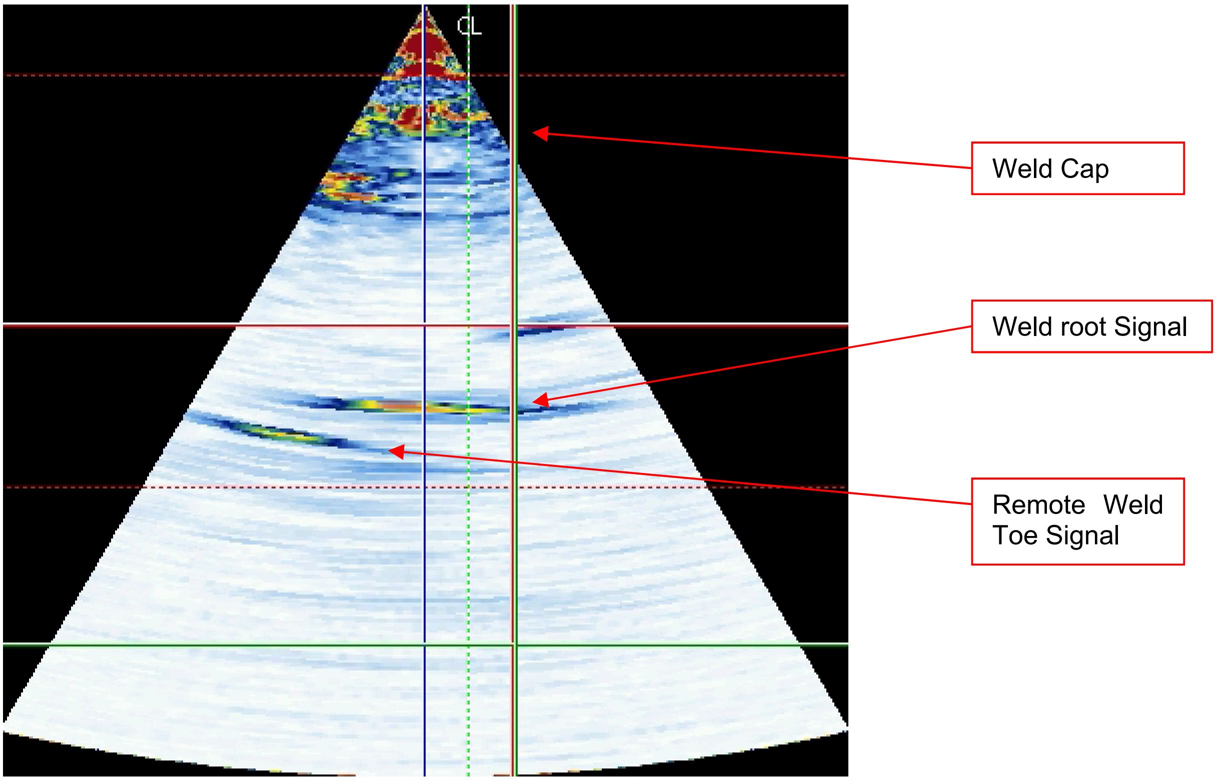

Figure 79 S-scan of Base-T1 fillet weld

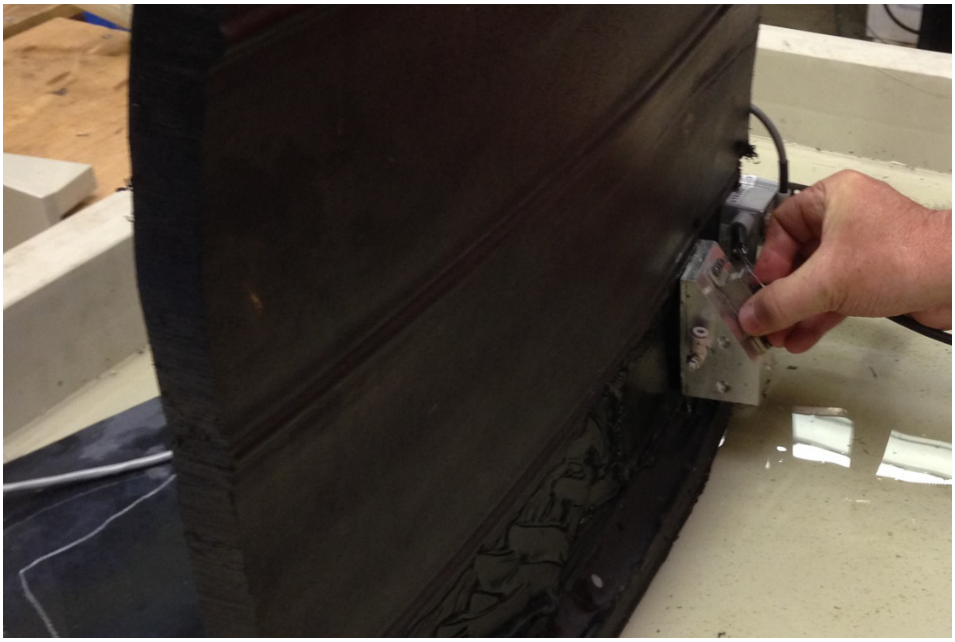

Figure 80 Scanning of sample Base-T1

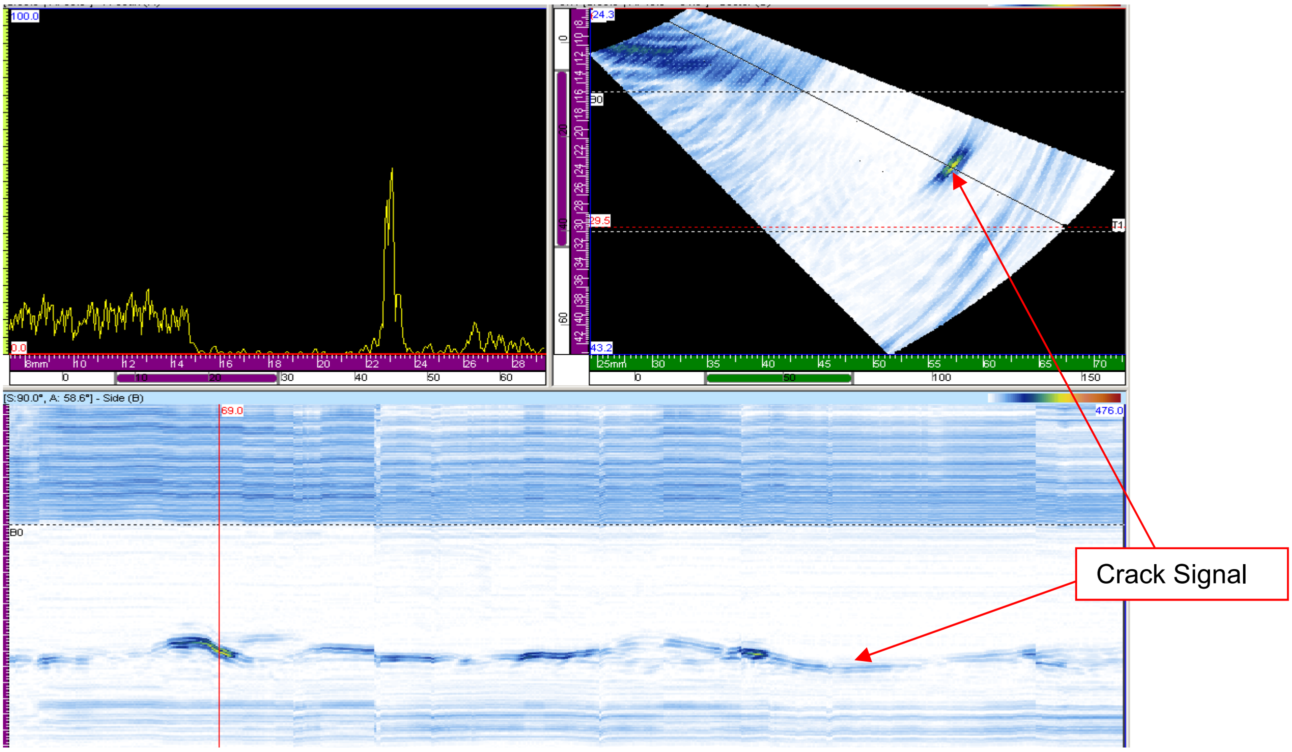

Figure 81 Resultant scan of sample Base-T1 showing crack indication

Figure 82 Scanning the base of sample Base-T1.

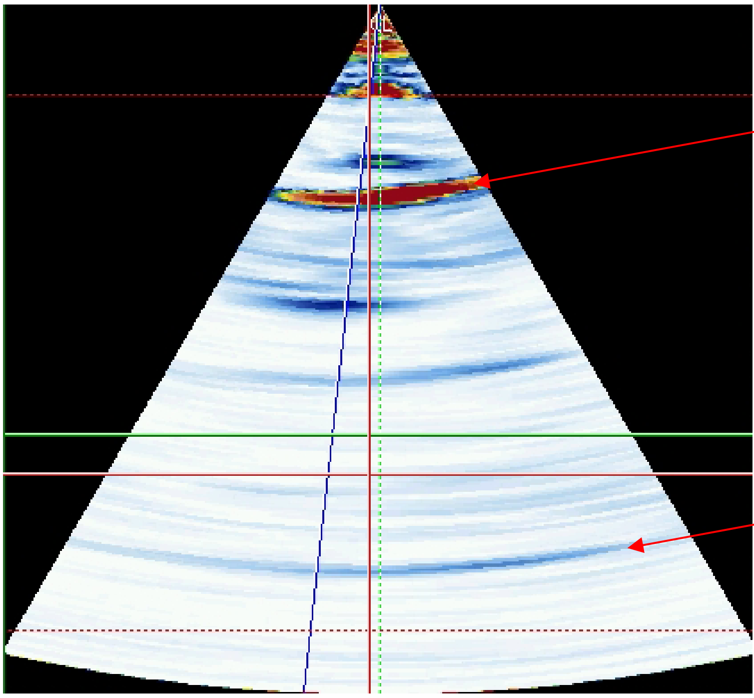

Figure 83 S-scan of tank base of sample Base-T1 showing possible indication of crack in remote fillet weld toe.

Figure 84 Inspection of full tank sample T1 on site at Chemresist.

Table 8 Summary of tanks inspected at Univar

TANK OR EQUIPMENT	MANUFACTURER	DATE OF MAN OR	CAPACI TY	PRODUCT	GRP PLASTIC	INSPECTION AND SERVICE

NUMBER		YEAR INST		LITRES			
WL 2R	CHEMRESIST	1.1	*1994*	20000	BATTERY ACID,	*HDPE	UNIVAR ENGINEERING
WL 22	ALLIBERT	1.2	*1976*	8182	DEMIN (Phos)	*	UNIVAR ENGINEERING
WL 23	CHEMRESIST	1.3	*1994*	20000	DEMIN (BA dilution m/c)	*	UNIVAR ENGINEERING

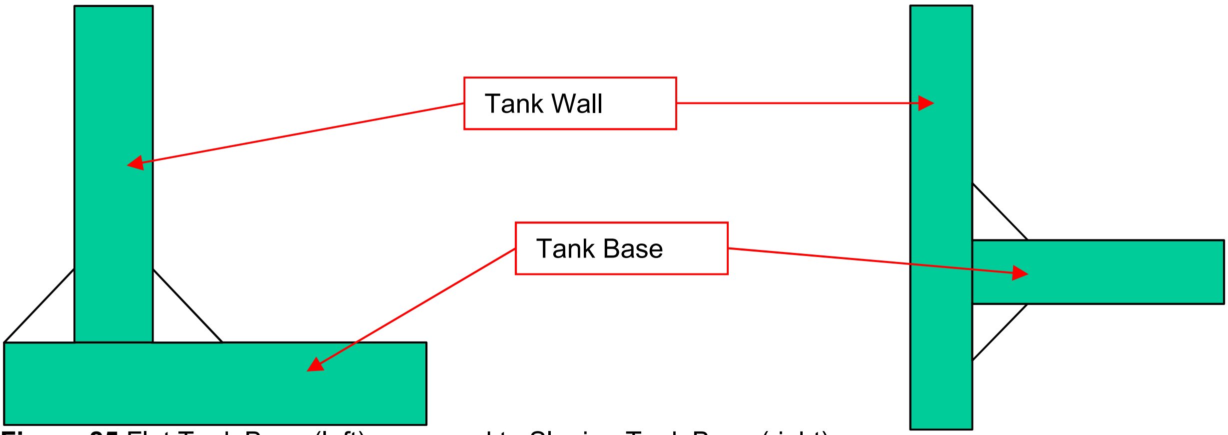

Figure 85 Flat Tank Base (left) compared to Sloping Tank Base (right).

Figure 86 Position of internal base and upper fillet weld plotted on tank WL23 wall.

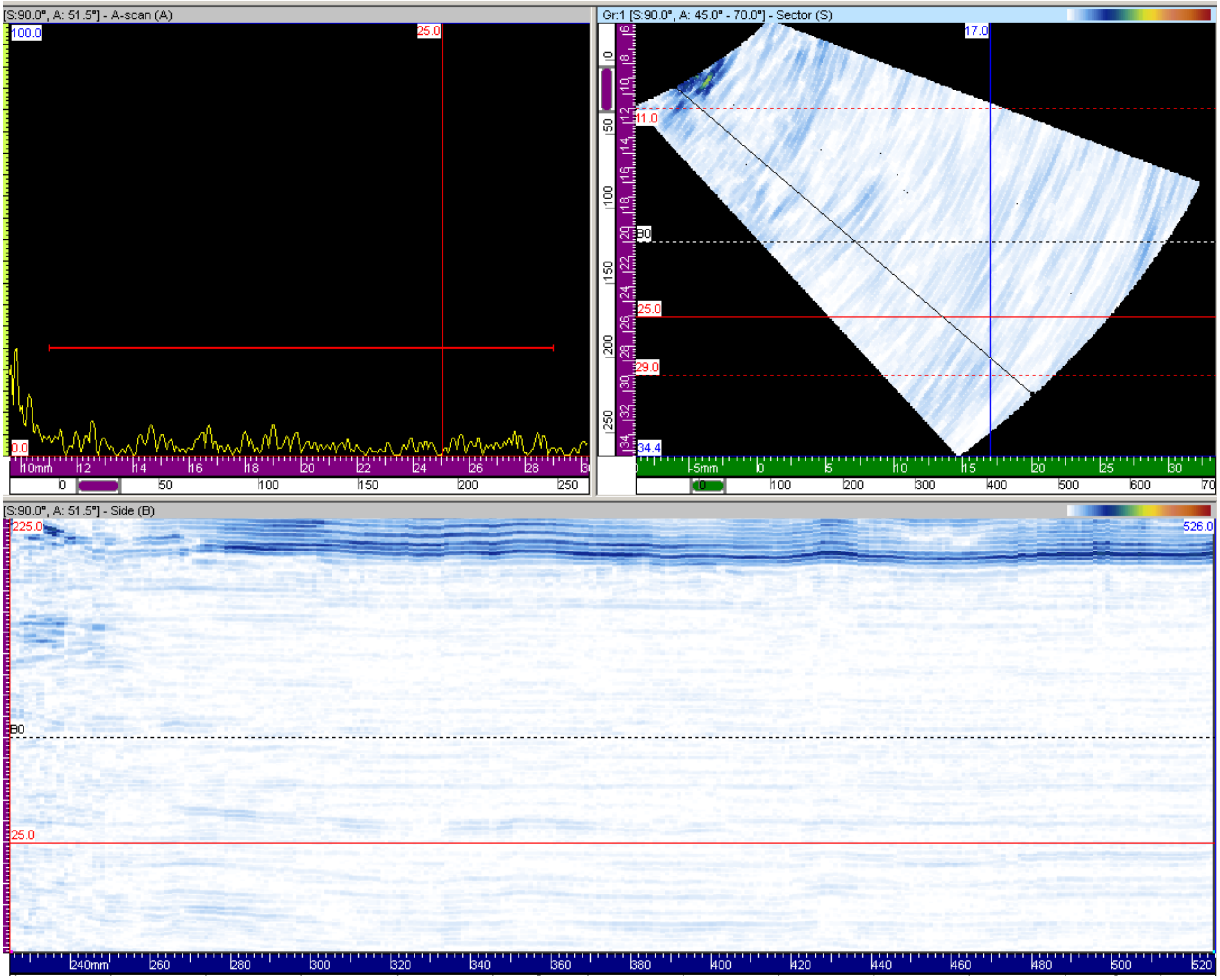

Figure 87 Example scan of base weld of tank WL23 showing no defect indications.

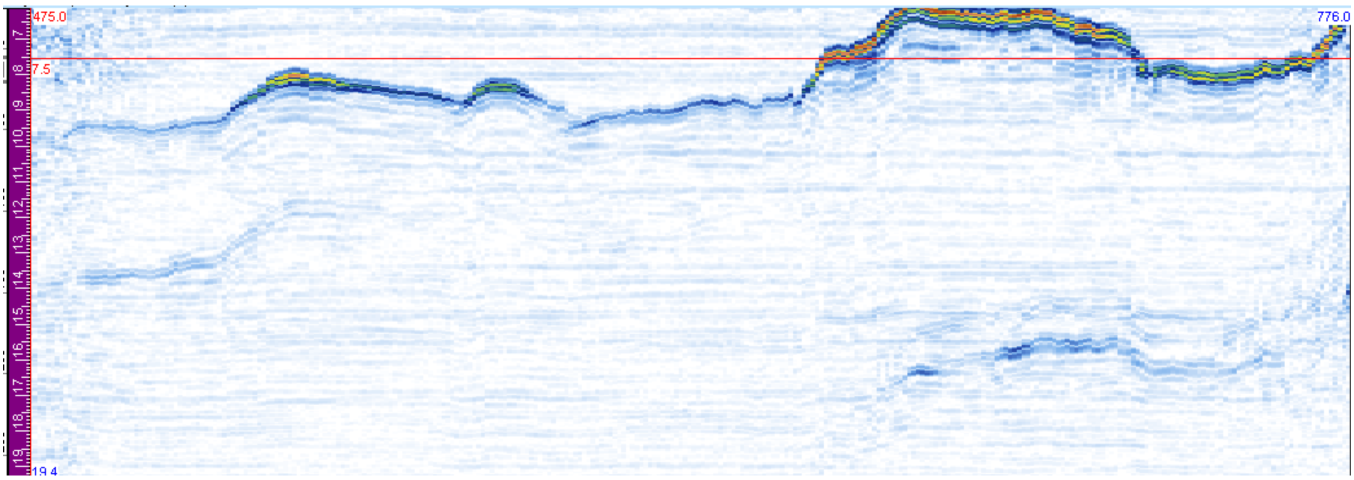

Figure 88 B-scan of a section of base weld of tank WL23 showing a lack of inter-wrap fusion at approximately 7.5mm wall thickness.

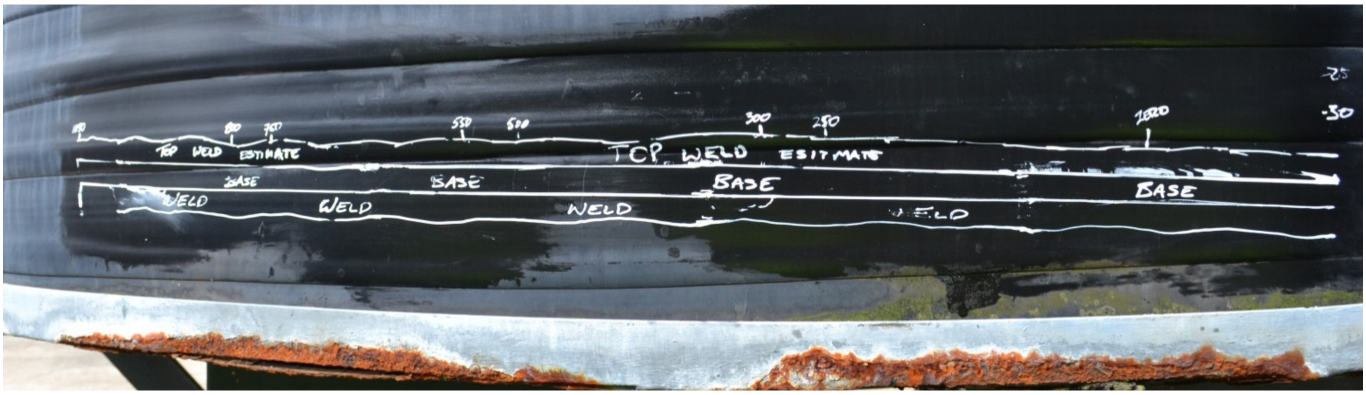

Figure 89 Position of internal base and both fillet welds plotted on tank WL2R wall.

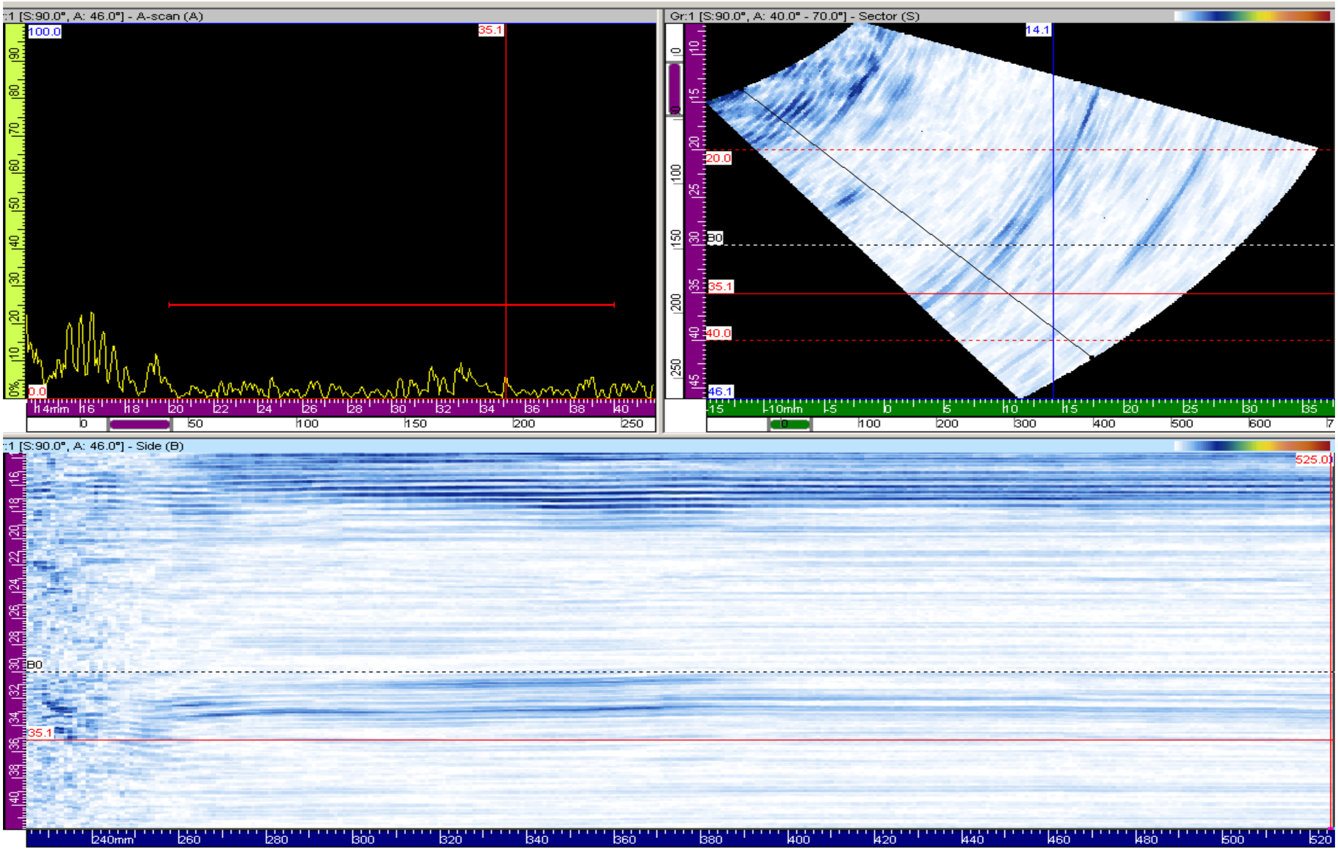

Figure 90 Example scan of base weld of tank WL2R showing no defect indications.

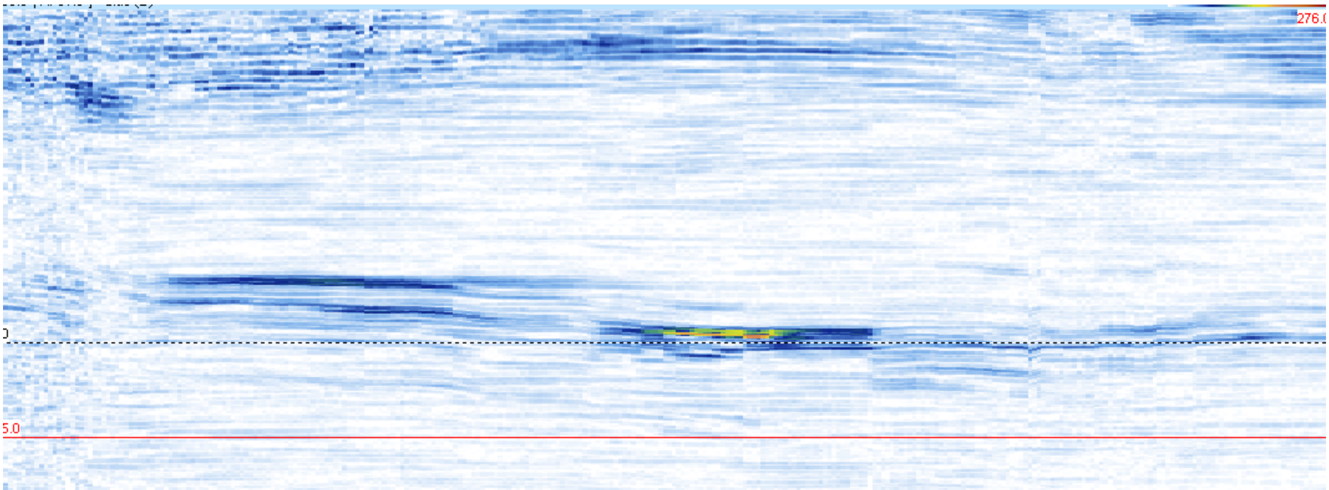

Figure 91 B-scan of a section of base weld of tank WL2R showing a lack of inter-wrap fusion at approximately 30mm wall thickness.

Figure 92 Scan area of tank WL22.

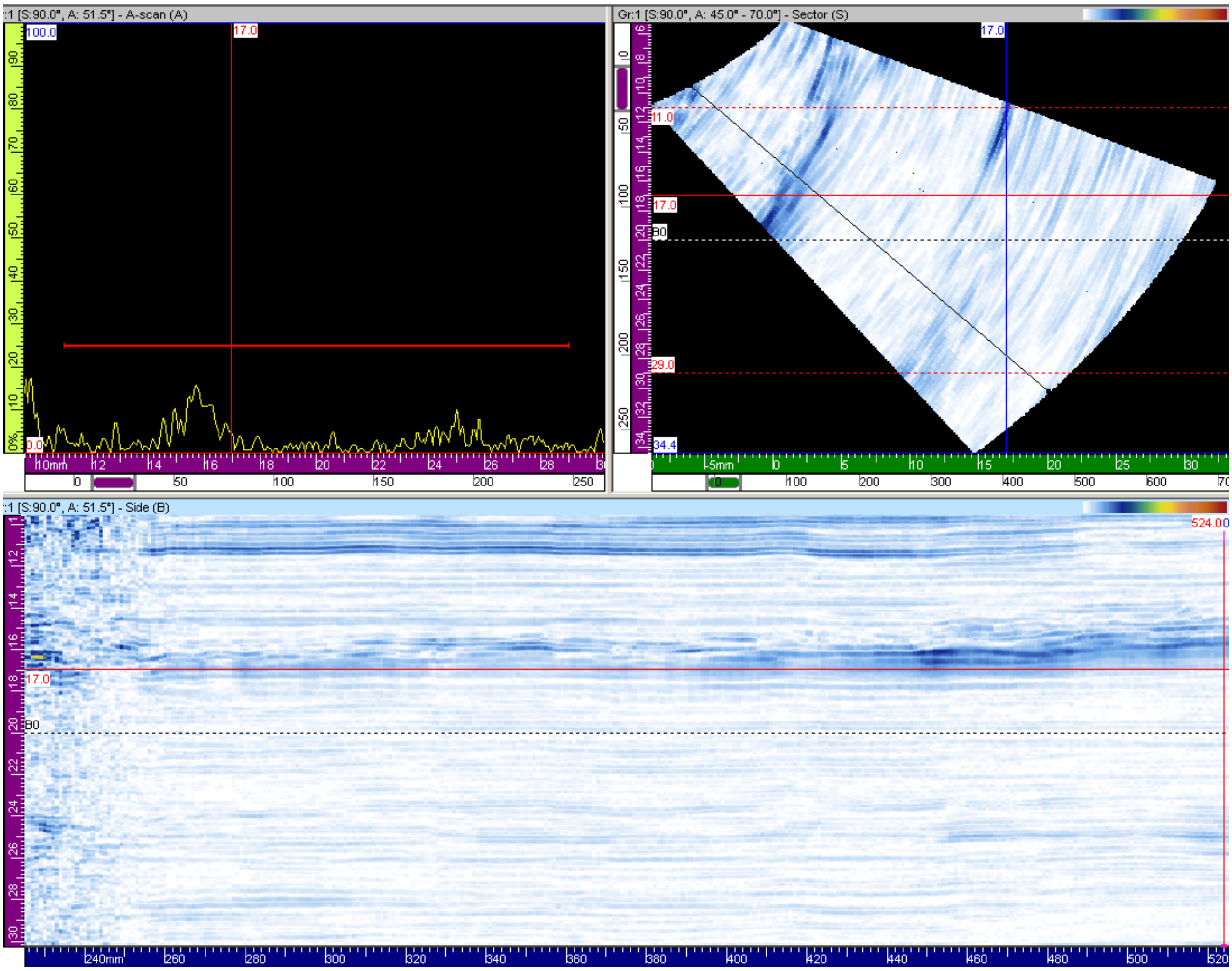

Figure 93 Example scan of tank wall of WL22 showing no reportable defects.

Figure 94 Artificial crack insertion.

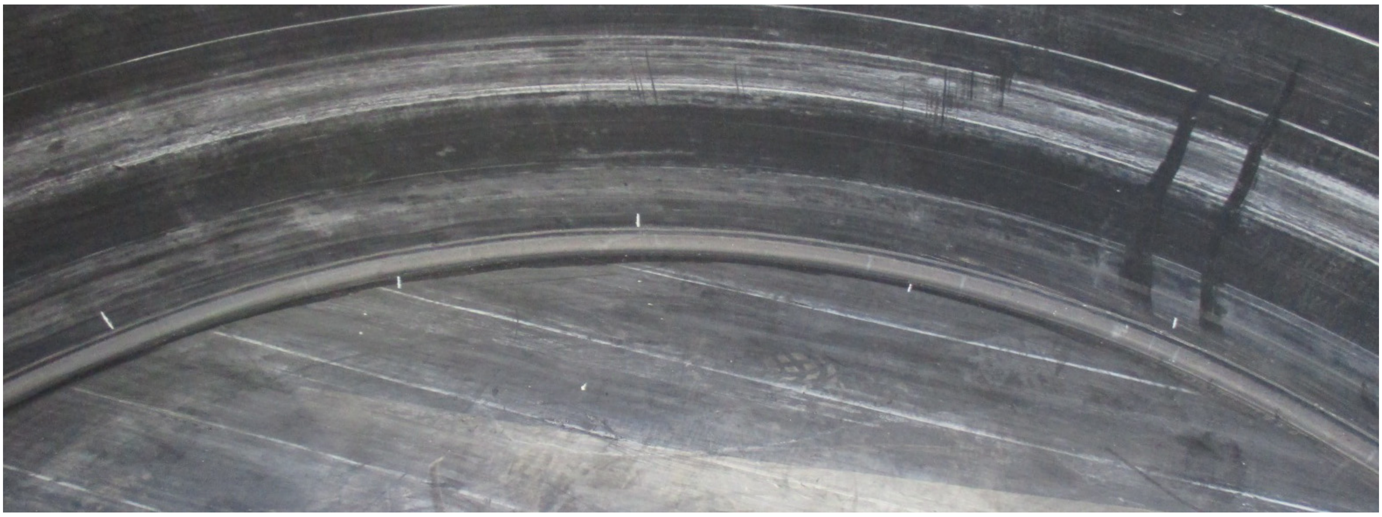

Figure 95 Artificial cracks in Area 1 indicated by small white marks.

Figure 96 Artificial cracks in Area 2 indicated by small white marks.

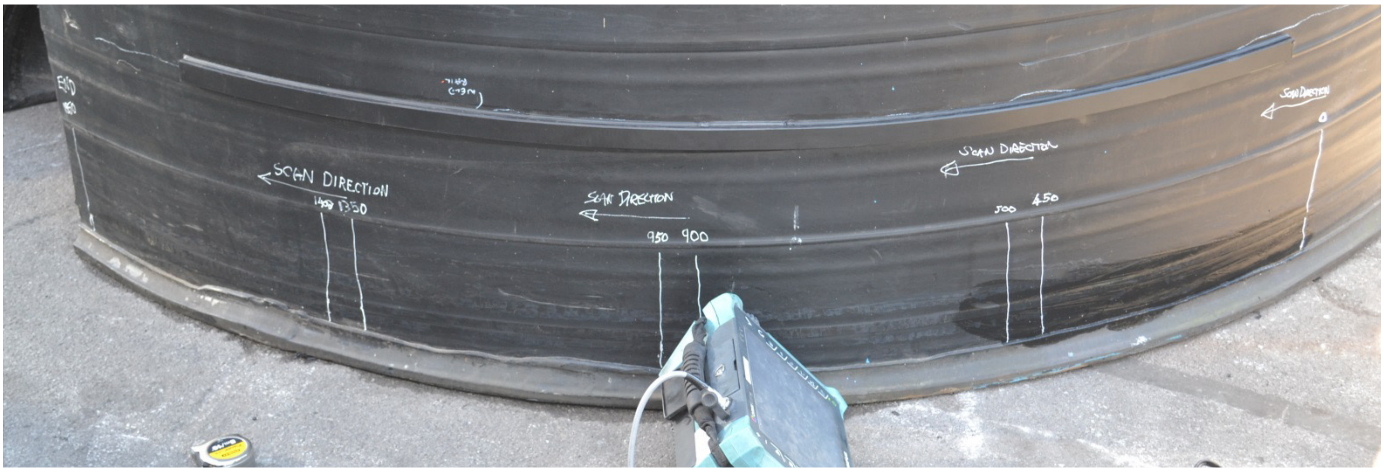

Figure 97 Area 1 marked out for scanning.

Figure 98 Area 2 marked out for scanning.

Table 9 Summary of Blind Trial results

Defect No.	Inspection Area	Weld Toe	Defect Depth (mm)	Distance from Datum (mm)	Length (mm)
1	1	Wall	24	70	120
2	1	Wall	30	720	100
3	1	Wall	25	1388	50
4	2	Wall	30	515	75
5	2	Wall	26	780	100
6	2	Wall	30	1235	125
7	1	Base	76	465	55
8	1	Base	77	1145	25
9	2	Base	82	280	30
10	2	Base	79	1110	40

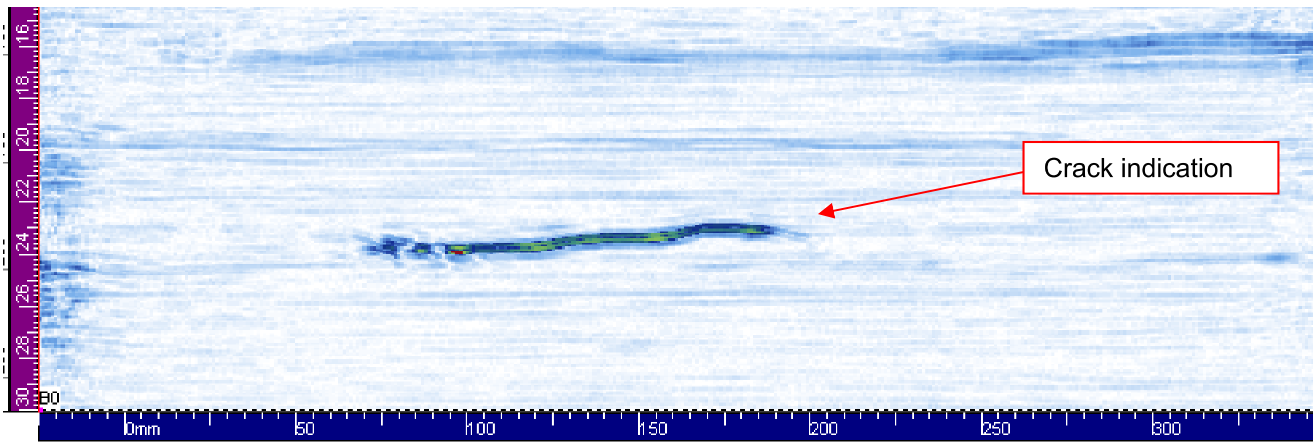

Figure 99 Indication of defect number 1.

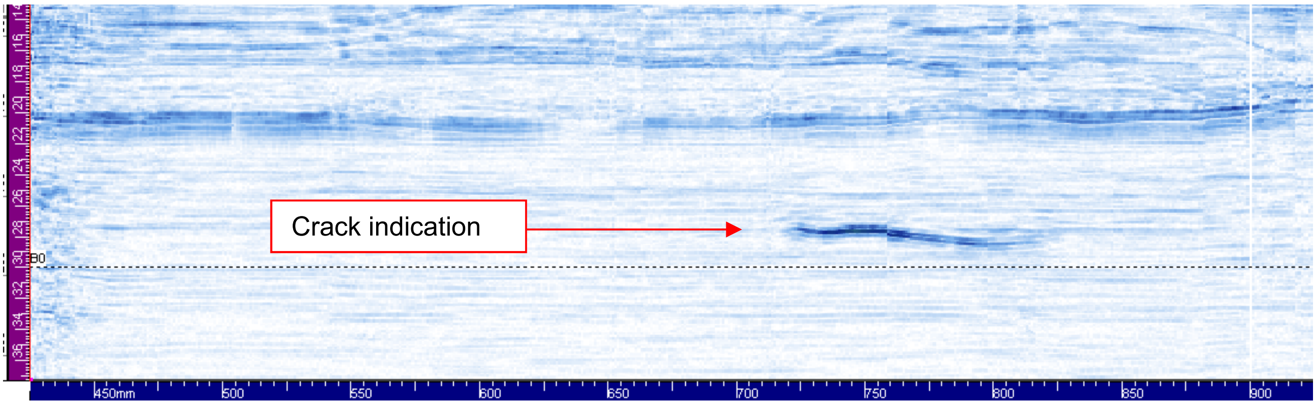

Figure 100 Indication of defect number 2.

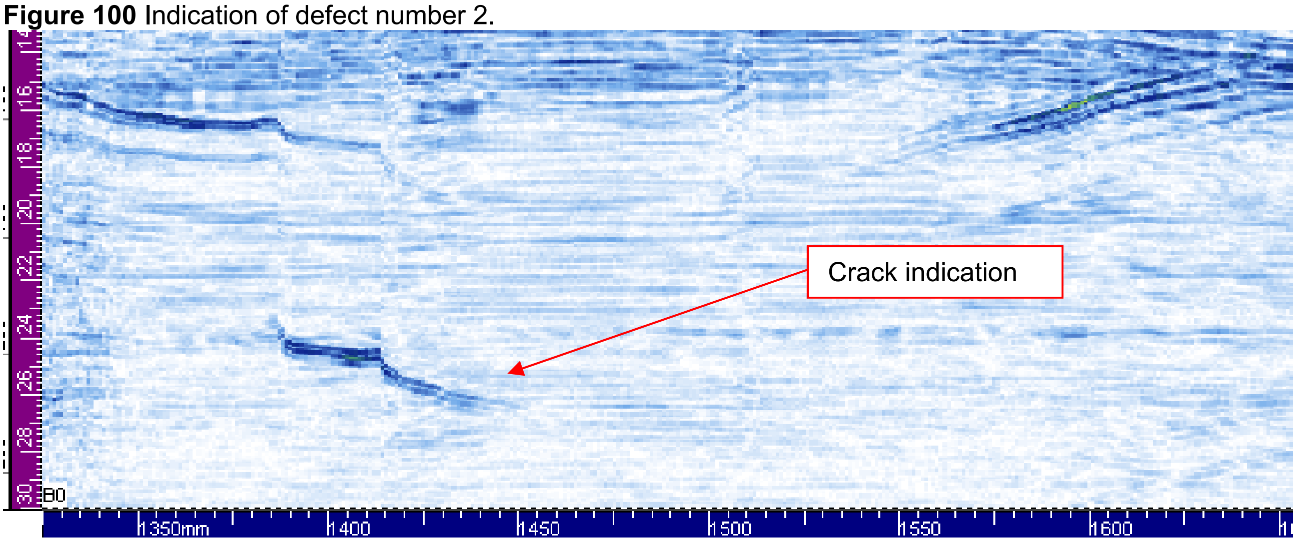

Figure 101 Indication of defect number 3.

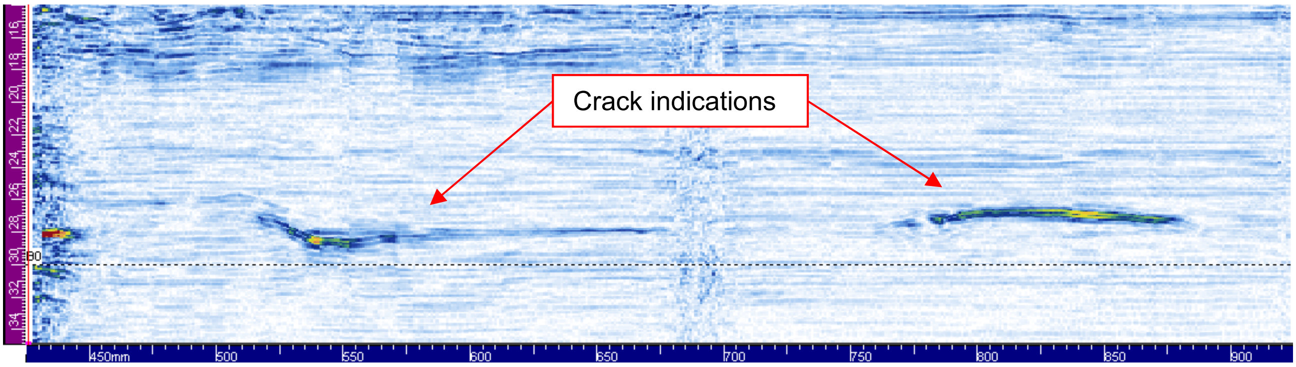

Figure 102 Indication of defect numbers 4 and 5.

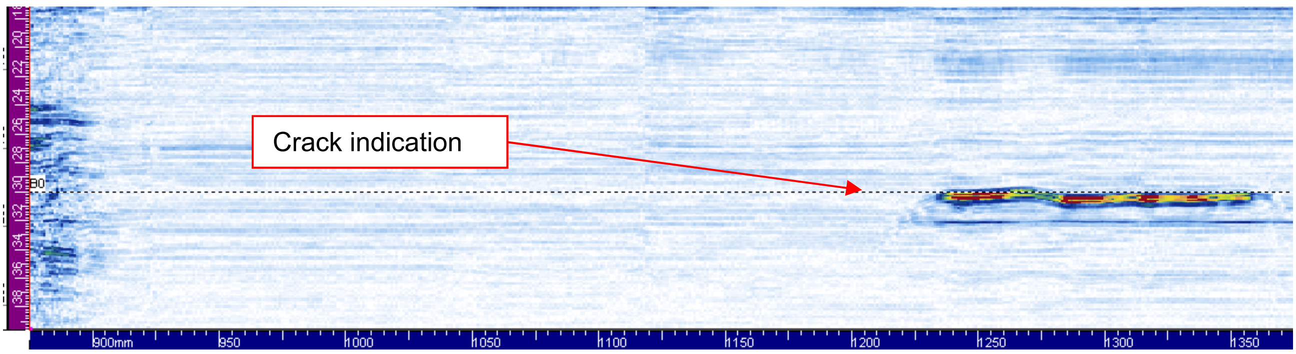

Figure 103 Indication of defect number 6.

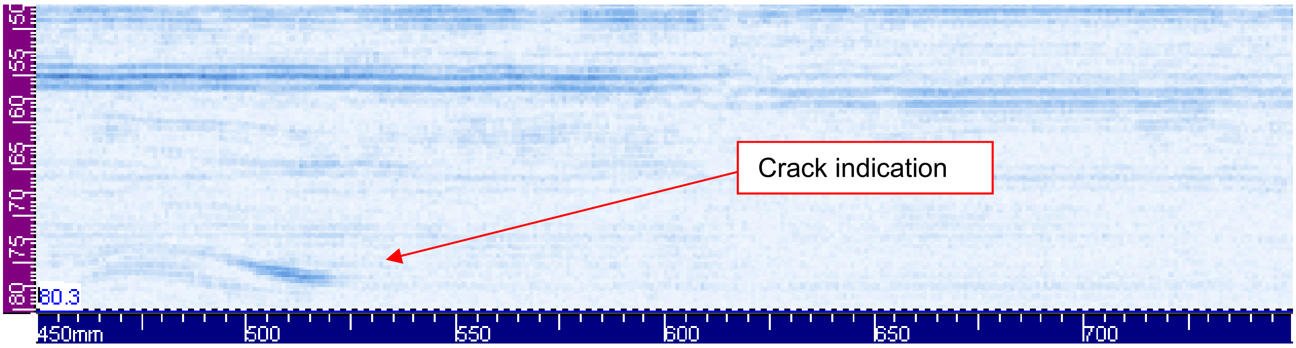

Figure 104 Indication of defect number 7.

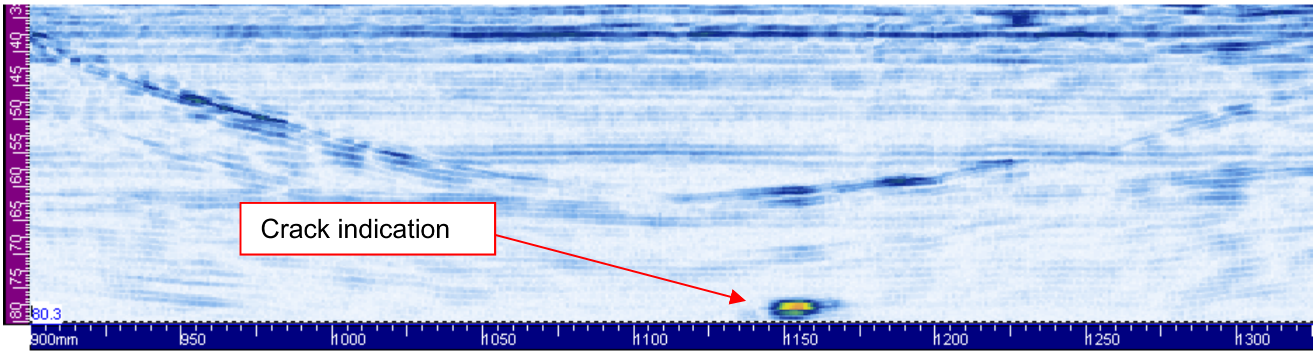

Figure 105 Indication of defect number 8.

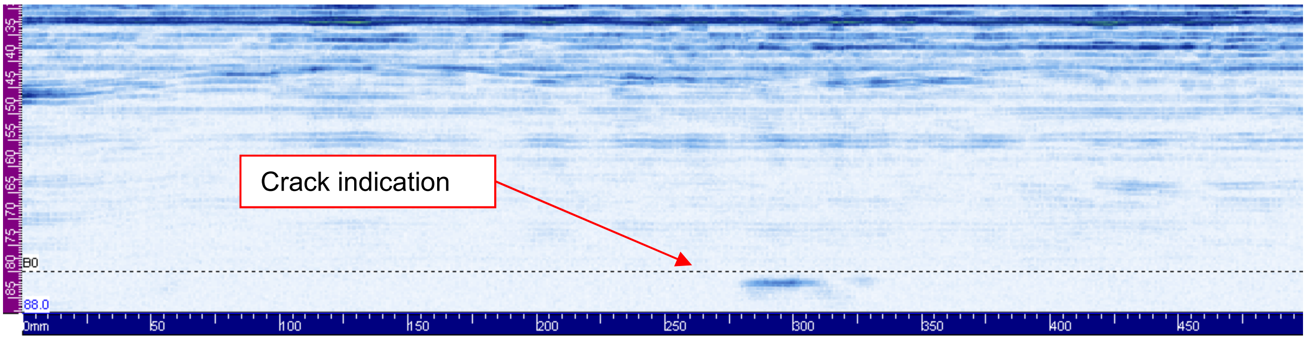

Figure 106 Indication of defect number 9.

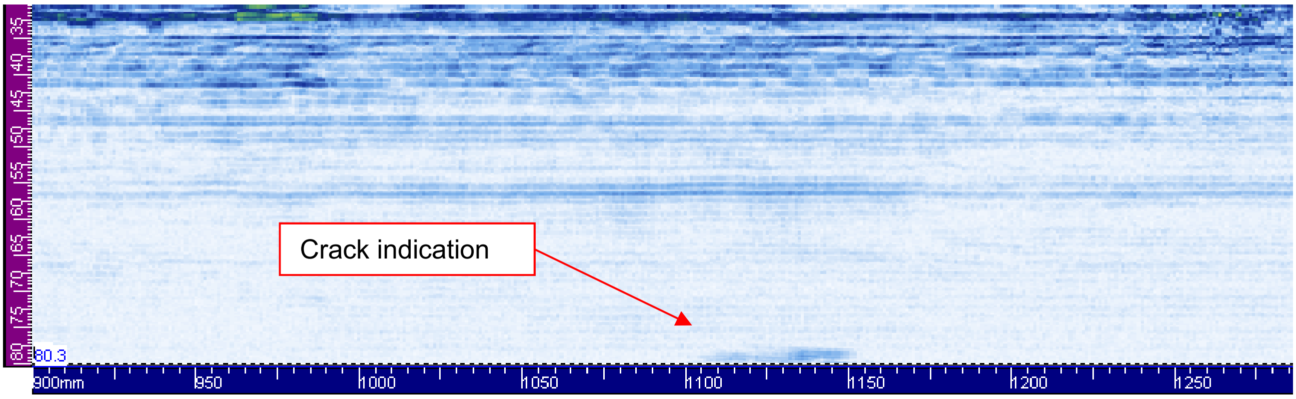

Figure 107 Indication of defect number 10.

POLYTANK

Figure 108 Project Logo

POLYTANK

http://www.polytank.eu

Development and Validation of an Automated Ultrasonic System for the Non-Destructive Evaluation of Welded Joints in Thermoplastic Storage Tanks

Thermoplastic tanks are an attractive alternative to metal tanks for the containment of many products, including hazardous chemicals. Such tanks are normally designed for a finite life, usually between 15 and 25 years. However, due to economic pressure, many of these tanks are still in operation beyond their design life, often with little or no engineering justification. It is also not uncommon for plastics tanks to be used for storing chemicals that they were not designed to contain. For these reasons it is very important that operators of plastics tanks and vessels inspect them throughout their life. An issue at hand is that there are currently no standards for the in-service inspection of plastics tanks. There is also very limited expertise available on the visual examination of plastics tanks and virtually no use of non-destructive examination (NDE).

The 2-year PolyTank project, launched in the frame of European Seventh Framework Programme, in November 2012 will determine the potential failure mechanisms in plastics tanks and storage vessels and develop ultrasonic NDE procedures, techniques and systems to be able to identify these. An important aim of the project will be to develop an inspection system that is site-rugged and simple to operate.

Existing NDE Methods and Limitations

The majority of visual inspections are external and can therefore only identify cracks that break the outside surface of the tank. Since many of the cracks initiate from the inside of the tank there is already a leak path through the tank wall if and when the crack is detected. Internal inspections are carried out less frequently, if at all, because they are expensive, potentially dangerous to the inspector, and result in a shut-down because the tank has to be emptied. Until now, full volumetric examination of tank welds has not been possible.

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Technical Project Objectives

To develop a new approach for testing welded joints in thermoplastic storage tanks and storage vessels using automated non-destructive evaluation
To create a database of critical defect sizes and contamination levels that cause a reduction in the long-term integrity of each type of welded joint
To develop acceptance criteria for different types of flaws in welded joints based on both short-term and long-term testing
To design and develop of NDE system for the reliable volumetric examination of plastics tanks and storage vessels

Potential Benefits of PolyTank Technology

A new technology based on ultrasonic examination of the full weld volume,
from the outside surfaces of the tank
Not necessary to open up a tank to prepare the inside for examination
Replace unreliable periodic visual inspection
Reduce the risk of catastrophic failures

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement No. 313950

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Figure 111 PolyTank banner