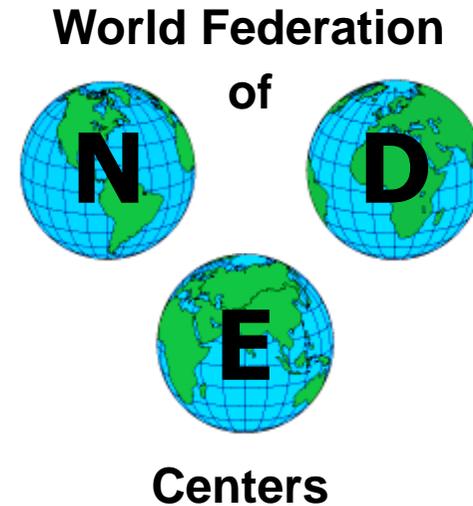


2015 WFNDEC UT BENCHMARK



Abstract: On previous years WFNDEC UT benchmarks have mostly addressed pulse echo mode. This year the proposed benchmark concerns **TOFD** technique. TOFD is today commonly used for locating and sizing cracks from tip diffraction echoes. This technique relies on an arrangement of two probes of opposite beam directions. Simulation may be helpful for optimizing the design of the set up and evaluating the performances of the inspection . One influential parameter is of course the distance between the two probes which commands on the performances in depth of the technique. Experiments have been carried out a planar block containing one vertical planar surface breaking flaw of 15mm height. L45°, L60° and L70° acquisitions of top and bottom tip diffraction echoes have been performed with various PCSs (probe center spacing) .

WFNDEC 2015 UT benchmark: TOFD notch response

- This proposition of benchmark addresses the modelling of tip diffraction echoes detected by TOFD.
- The experiments have been performed on a planar block containing one vertical surface 15 mm breaking notch.
- Acquisitions have been carried out using a pair of 5MHz, $\varnothing 6,35$ mm contact probes. Three different sets of wedges have been used in order to generate waves at L45°, L60° and L70°.
- By reThe diffraction echoes from the top edge and the bottom edge of the notch have been recorded.
- The PCS (probe center spacing) varies on intervals which depend on the echo under study:

Echo from notch top edge (backwall breaking flaw) :

- L45°: from 25mm to 60mm (5mm step)
- L60°: from 35mm to 85mm (5mm step)
- L70°: from 40mm to 120mm (5mm step)

Echo from bottom edge (surface breaking flaw) :

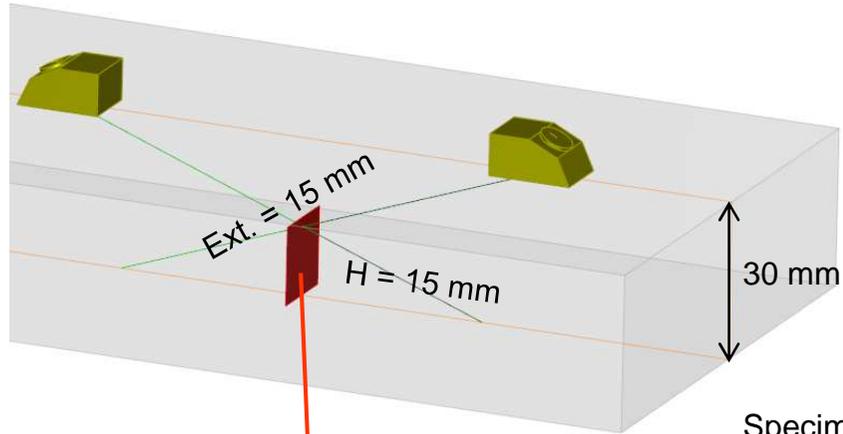
- L45°: from 23mm to 58mm (5mm step)
- L60°: from 38mm to 78mm (5mm step)
- L70°: from 38mm to 93mm (5mm step)

- In this document are reported:
 - The description of the experimental set up:
 - specimen and defect
 - scanning
 - probes
 - The values of recorded relative maximal amplitude for the studied echoes
 - L diffraction echoes for the the backwall breaking notch (top edge diffraction)
 - L diffraction echoes for the surface breaking notch (bottom edge diffraction)
 - The references of the txt files corresponding to various representative Ascans and available on the WFNDEC site .

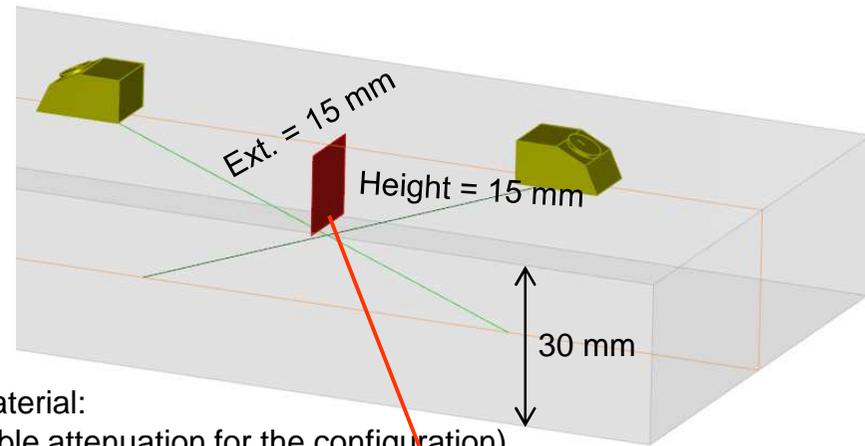
Description of the configurations

Specimen and defect

Backwall breaking flaw (top edge inspection)

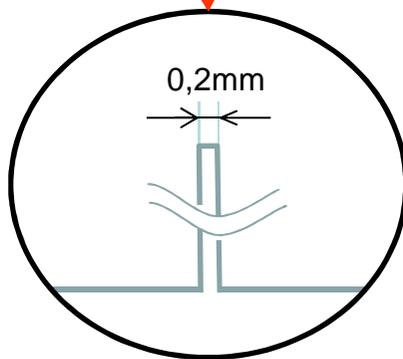


Surface breaking flaw (bottom edge inspection)

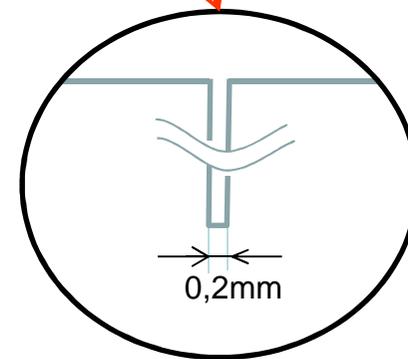


Specimen material:
Steel (negligible attenuation for the configuration)
Density: $7,8 \text{ g cm}^{-3}$
 c_L : 5900 m, s^{-1}
 c_T : 3230 m, s^{-1}

Flaw



- 1 rectangular notch (0,2mm thick) :
- Height : 15mm
 - Extension : 15mm

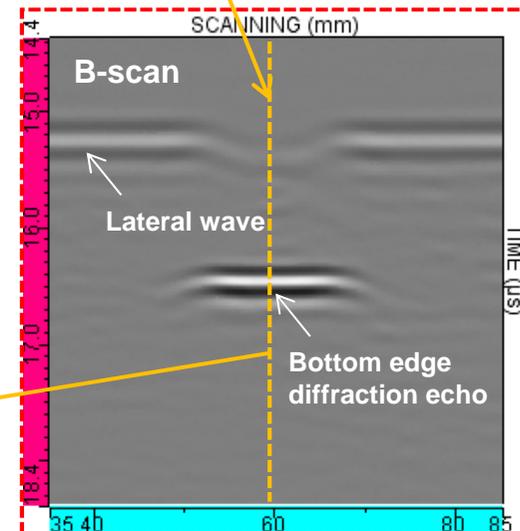
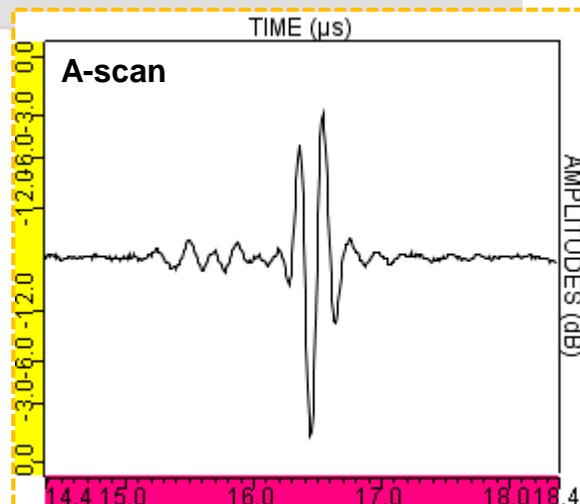
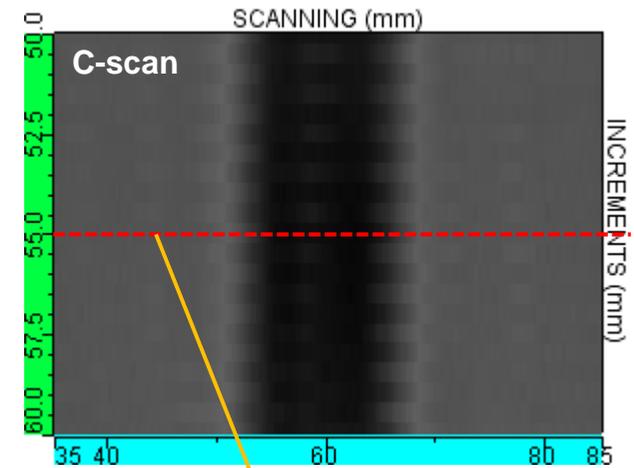
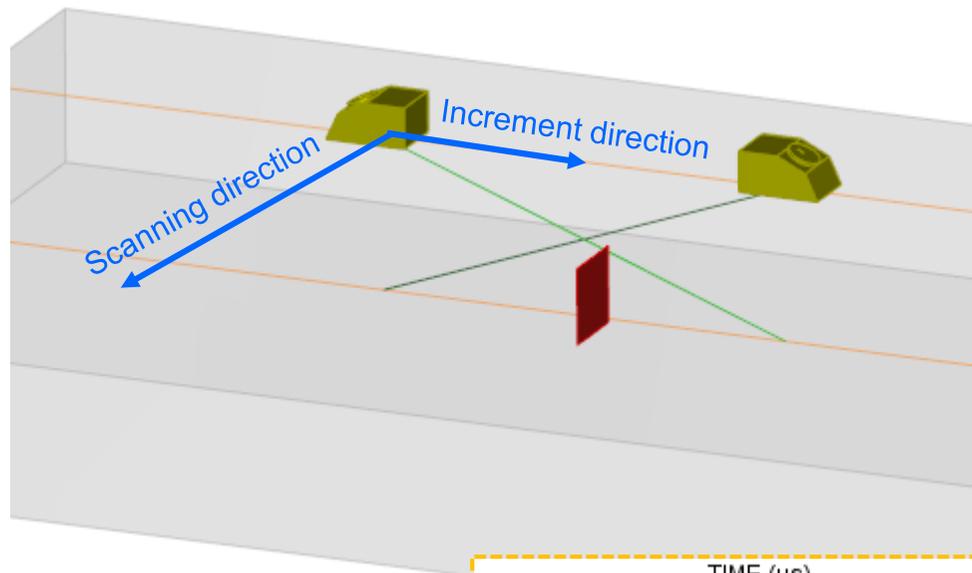


Description of the configurations

Displacement and stored echoes

Transducers were moved together in two perpendicular directions over the defect,

The wave forms received at each position of the transducer have been stored (C-scans)



Description of the configurations

Probes

Ø6,35mm probe 5MHz

Crystal shape : circular

Aperture : Ø6,35mm

Center frequency: 5 MHz

Frequency bandwidth: 65%

Wedges dimensions :

L45°:

Incidence angle I: 18,924°

L1 = 8 mm

L2 = 8 mm

L3 = 11,3 mm

L4 = 6,31 mm

L60°:

Incidence angle I: 23,367°

L1 = 7,5 mm

L2 = 7,5 mm

L3 = 11,5 mm

L4 = 7,43 mm

L70°:

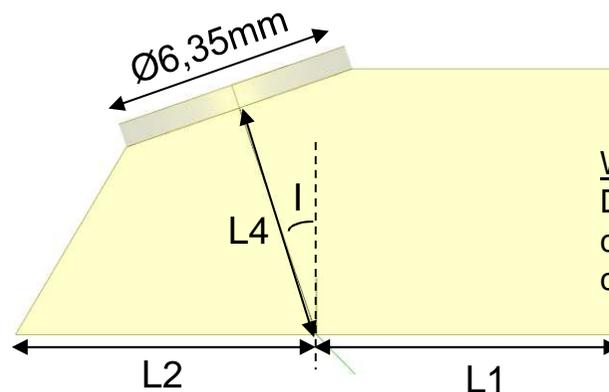
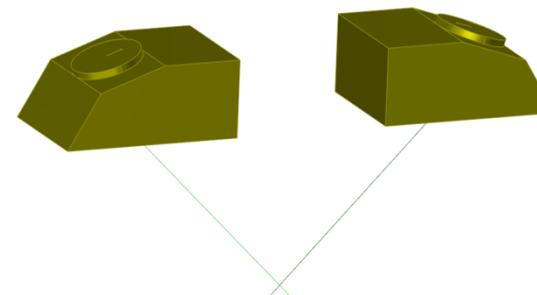
Incidence angle I: 25,773°

L1 = 7,5 mm

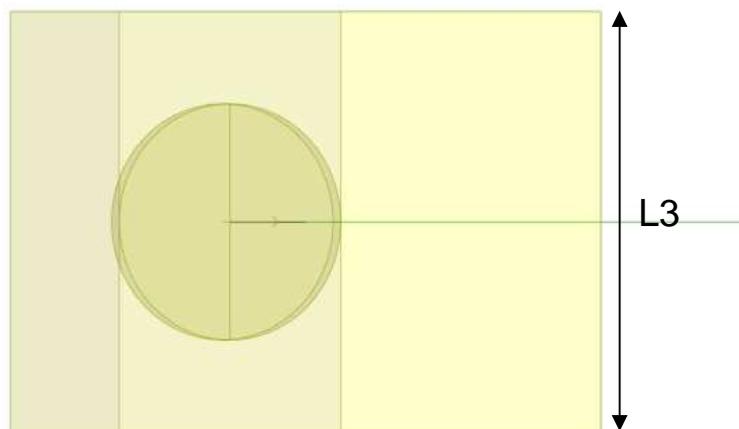
L2 = 8,5 mm

L3 = 11,5 mm

L4 = 7,34 mm



Wedges material:
Density: 1,18 g cm⁻³
 c_L : 2730 m, s⁻¹
 c_T : 1340 m, s⁻¹



Experimental data

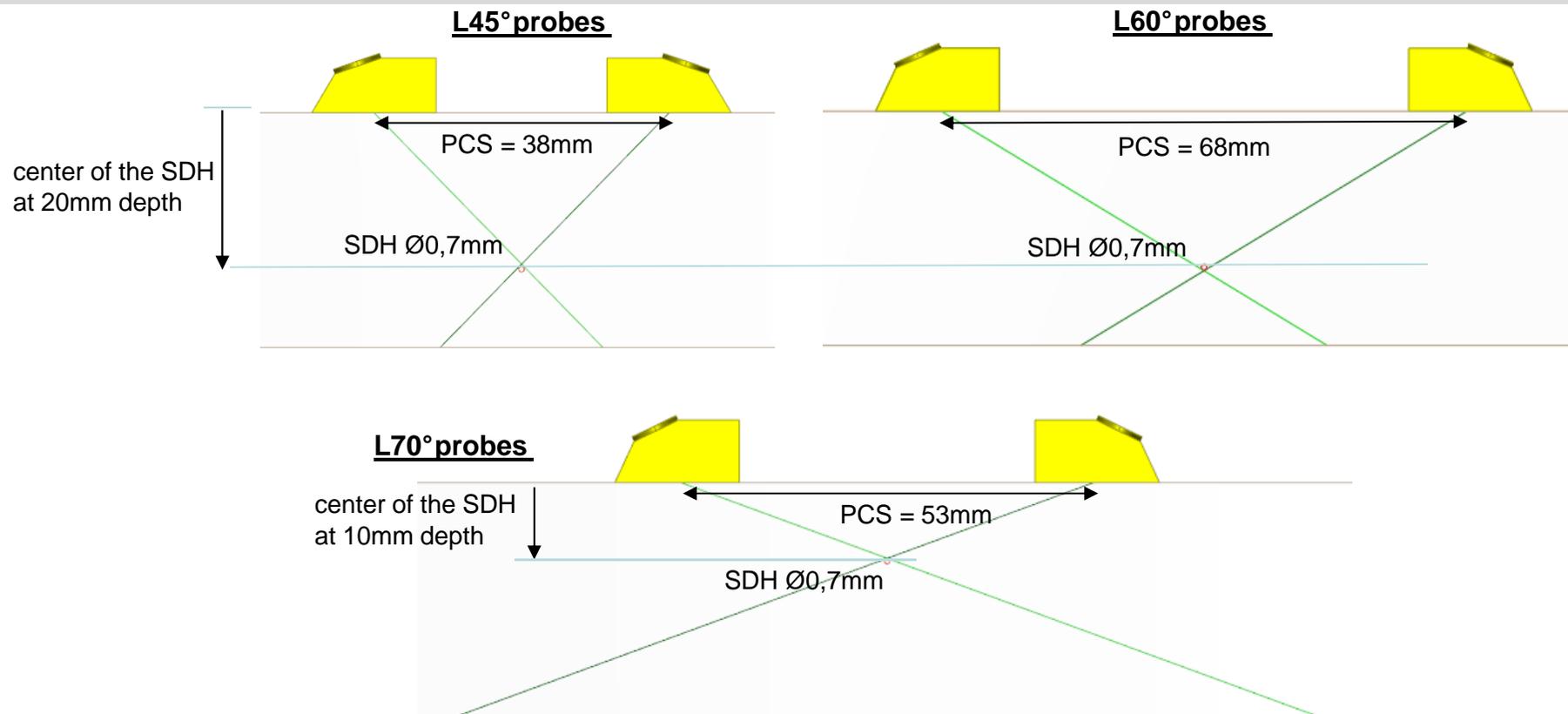
L TOFD echoes of Side drilled holes

We send:

- **The 3 A-scans** corresponding to the maximal amplitude of the **L TOFD direct echoes** obtained for **side drilled hole** $\varnothing 0,7\text{mm}$ located at 10mm or 20mm depth and obtained for different PCSs as following :

- L45°: txt files named « TOFD-SDH_D0p7mm-**p20mm**_C6p35mm-5MHz_L45_PCS**38mm**.txt »)
- L60°: txt files named « TOFD-SDH_D0p7mm-**p20mm**_C6p35mm-5MHz_L60_PCS**68mm**.txt »)
- L70°: txt files named « TOFD-SDH_D0p7mm-**p10mm**_C6p35mm-5MHz_L70_PCS**53mm**.txt »)

The amplitude of these echoes are used as reference for each couple of probes (see later)



Experimental data, case of: TOFD L diffraction echoes from the **top edge** of the notch

We send:

- **The 9 Ascans** corresponding to the maximal amplitude of the **L TOFD echo** obtained on the **top edge** of the notch

The corresponding txt files are named « TopEdge_H15mm_C6p35mm-5MHz_**X**_PCS**XX**.txt »
where **X** is : L45°, L60° or L70°
and **XX** is the PCS in mm

- **The amplitude in dB** of the L diffraction echoes of the top edge are given next slide

Experimental data, case of:

TOFD L diffraction echoes from the **top edge** of the notch

Relative amplitudes

L45° probes

PCS (mm)	Relative amplitude (dB)
25	-6,1
30	-5,8
35	-9,4
40	-18,2
45	-22,5
50	-25,9
55	-29,2
60	-30,8

L60° probes

PCS (mm)	Relative amplitude (dB)
35	-9,0
40	-6,1
45	-4,4
50	-4,3
55	-5,3
60	-6,4
65	-7,0
70	-8,4
75	-9,4
80	-10,2
85	-10,5

L70° probes

PCS (mm)	Relative amplitude (dB)
40	-21,5
45	-17,2
50	-16,1
55	-14,5
60	-13,4
65	-13,3
70	-12,9
75	-13,0
80	-13,1
85	-13,4
90	-13,8
95	-14,2
100	-14,5
105	-15,3
110	-15,8
115	-16,2
120	-16,5

As written previously, the amplitude of the reference A_{REF} are the maximum amplitude of the SDH echoes

The relative amplitude A_R printed in the table is in dB: $20 \log(A / A_{REF})$

Experimental data, case of: TOFD L diffraction echoes from the **bottom edge** of the notch

We send:

- **The 9 Ascans** corresponding to the maximal amplitude of the **L TOFD echo** obtained on the **bottom edge** of the notch

The corresponding txt files are named « BottomEdge_H15mm_C6p35mm-5MHz_**X**_PCS**XX**.txt »
where **X** is : L45°, L60° or L70°
and **XX** is the PCS in mm

- **The amplitude in dB** of the L diffraction echoes of the bottom edge are given next slide

Experimental data, case of:

TOFD L diffraction echoes from the **bottom edge** of the notch

Relative amplitudes

L45° probes

PCS (mm)	Relative amplitude (dB)
23	-8,3
28	-4,8
33	-6,0
38	-10,6
43	-14,9
48	-20,3
53	-23,9
58	-26,8

L60° probes

PCS (mm)	Relative amplitude (dB)
38	-4,3
43	-1,4
48	-0,5
53	-1,6
58	-1,7
63	-3,4
68	-4,0
73	-5,2
78	-7,0

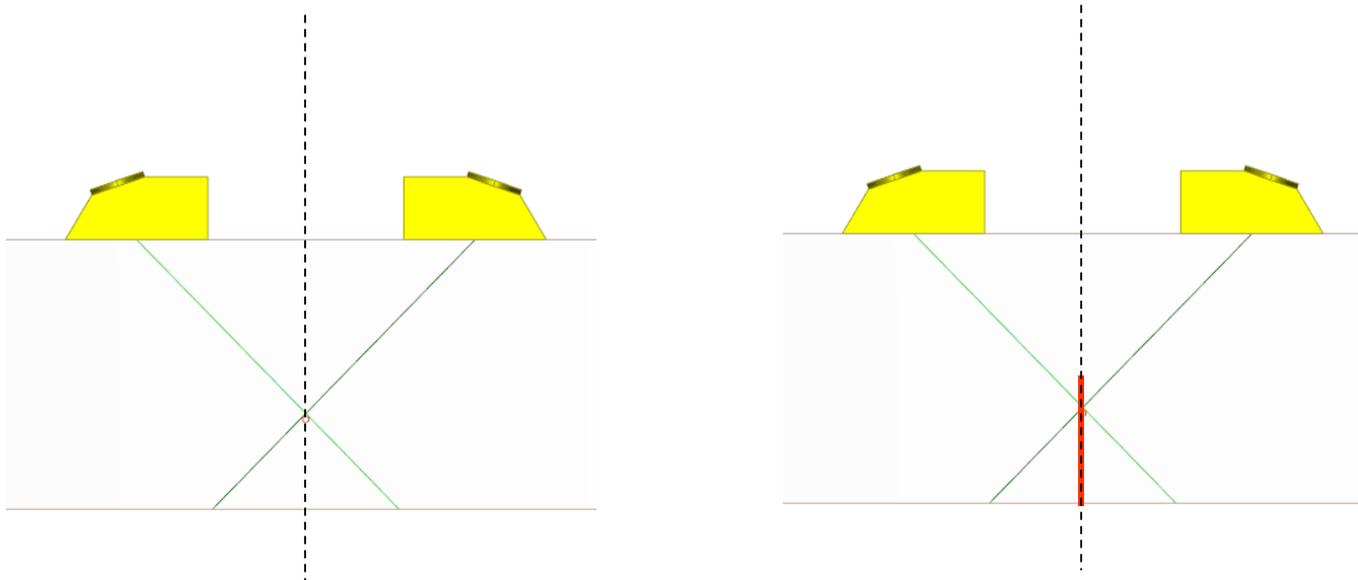
L70° probes

PCS (mm)	Relative amplitude (dB)
38	-17,9
43	-12,3
48	-12,0
53	-8,3
58	-8,4
63	-8,4
68	-7,1
73	-9,4
78	-9,2
83	-8,6
88	-9,2
93	-10,7

As written previously, the amplitude of the reference A_{REF} are the maximum amplitude of the SDH echoes

The relative amplitude A_R printed in the table is in dB: $20 \log(A / A_{REF})$

For a given PCS, we sent the amplitudes of the L direct echoes obtained when the probes are symmetrical to the defect plan

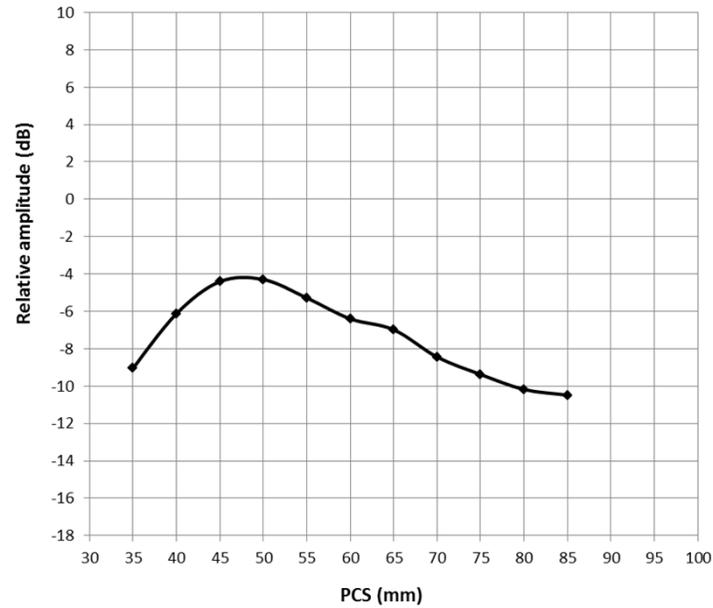


APPENDIX

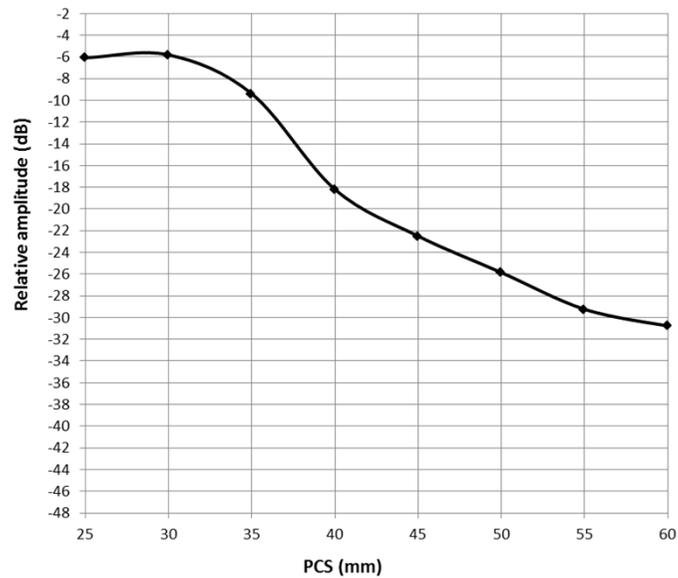
Experimental data, case of: TOFD L diffraction echoes from the **top edge** of the notch

Relative amplitudes

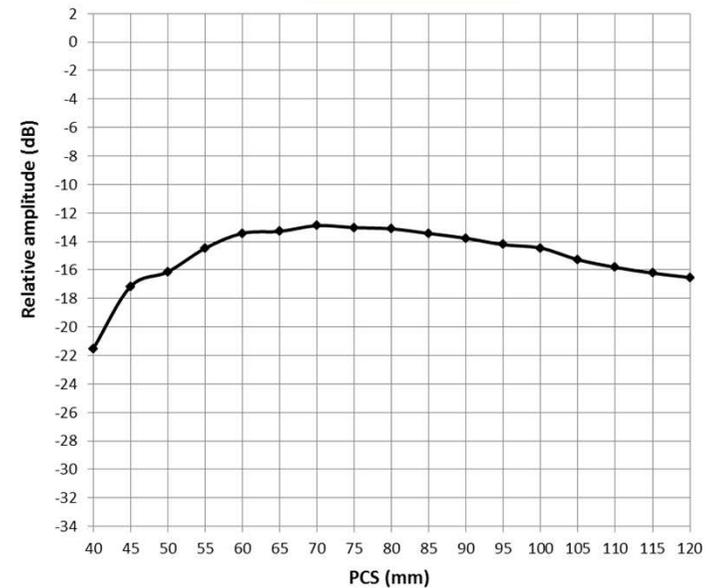
L60° probes



L45° probes



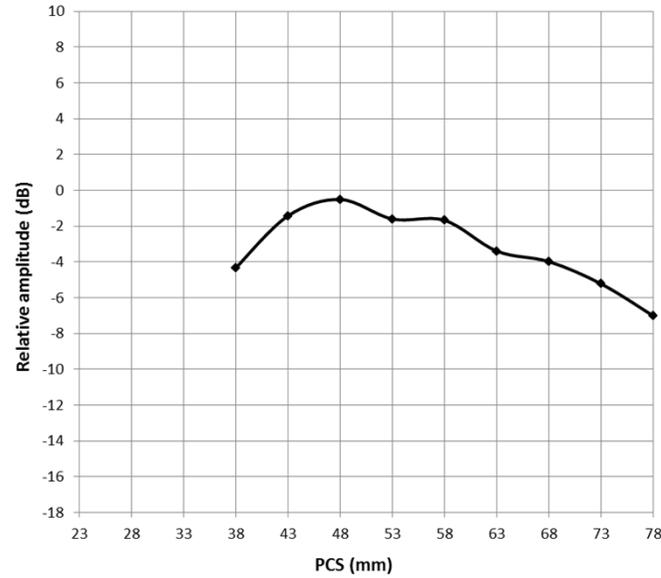
L70° probes



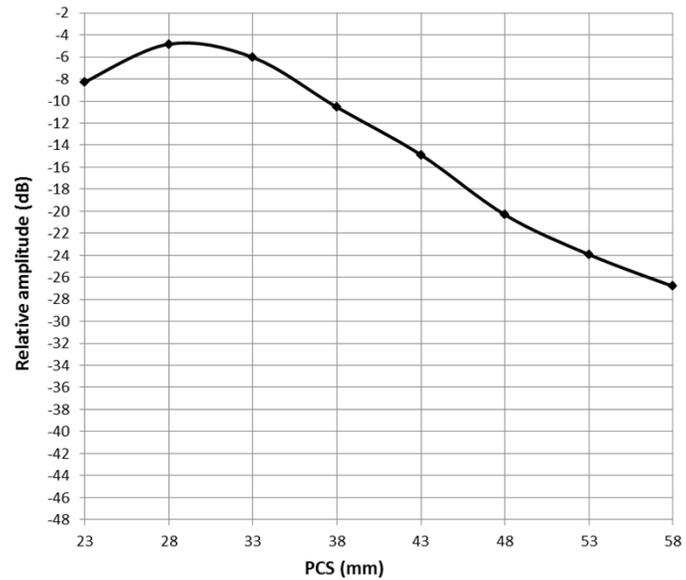
Experimental data, case of: TOFD L diffraction echoes from the **bottom edge** of the notch

Relative amplitudes

L60° probes



L45° probes



L70° probes

