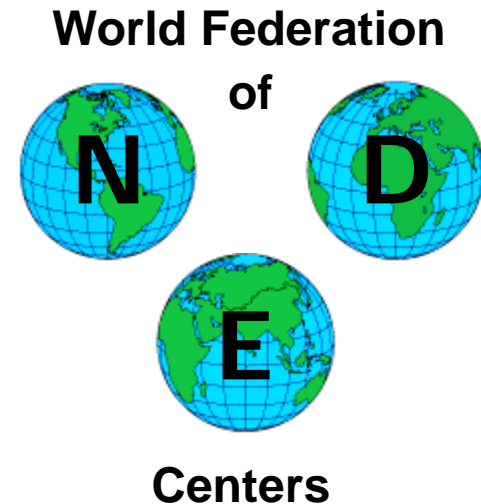


2009 ULTRASONIC BENCHMARKS PART II -PROBLEMS



Addition to the 2009 Benchmark

We previously requested that ultrasonic modelers present an update of their ultrasonic modeling capabilities at the 2009 RPQNDE ultrasonic benchmark session (see www.wfndec.org).

Enclosed is a second component of the 2009 benchmark consisting of experimentally measured responses of slots, side-drilled holes, and flat-bottom holes. These responses can be compared to modeling simulations, as done in past benchmarks.

The experimental data for these studies have been obtained by the Commissariat à l'énergie atomique (CEA) in France. We would like to thank the researchers at CEA for their efforts in designing these benchmarks and for obtaining the responses.

If you wish to participate in this second component of the 2009 benchmark, please submit an abstract for these studies that is separate from an abstract on your update of your ultrasonic modeling capabilities. See the end of this announcement for more details

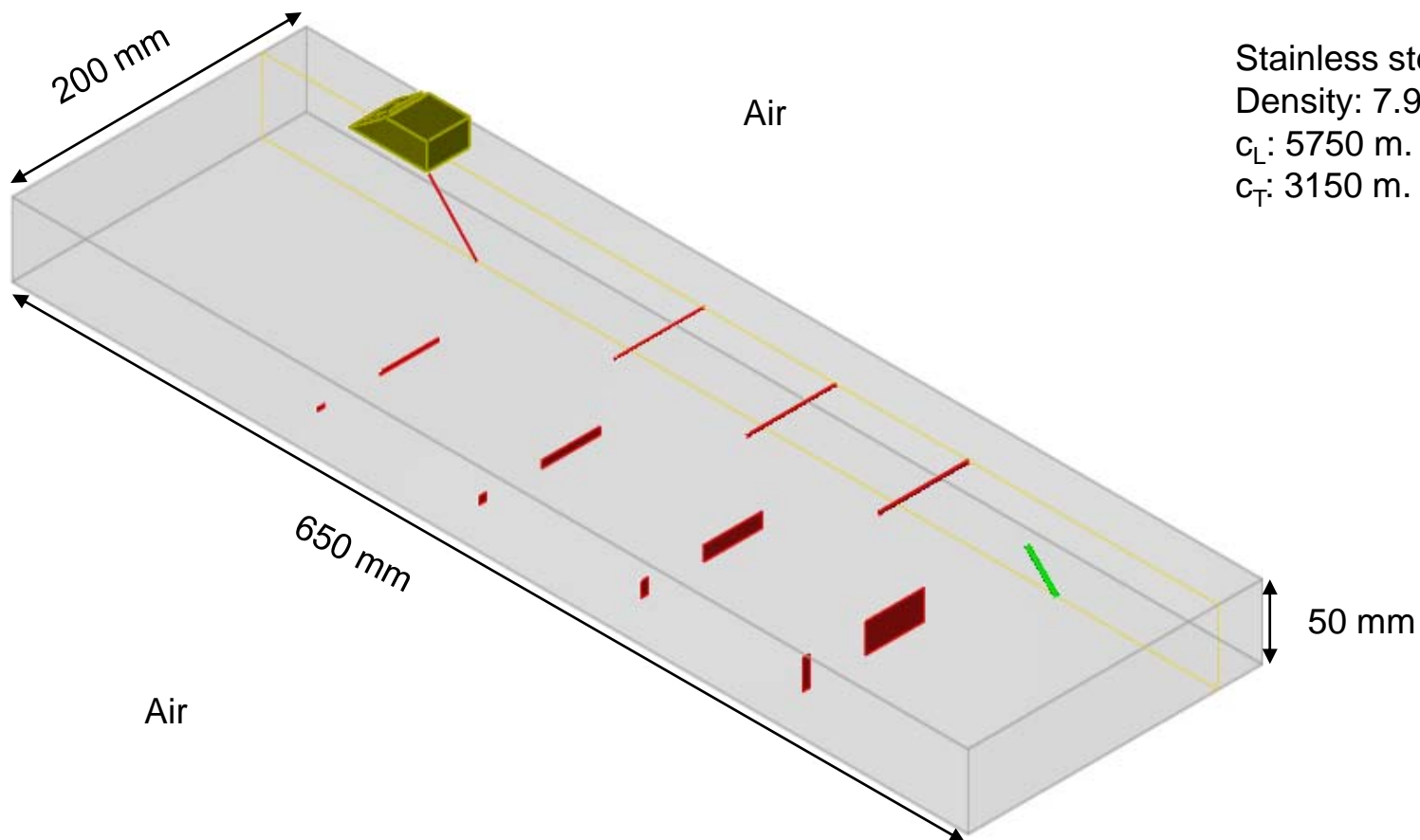
Some experimental tests were performed on a planar block containing vertical planar back wall breaking flaws of different heights and end extensions.

Side drilled holes and flat bottom holes were also present in the block for comparison.

Data acquisitions were carried out either with monolithic standard contact probes (2 probes of different apertures) radiating 45° T (Transverse) wave and with a linear phased array radiating 45° L (Longitudinal) wave

The experimental data is on the CNDE ftpsite: [ftp.cnde.iastate.edu](ftp://cnde.iastate.edu) (see the end of this announcement for more details)

Description of the configurations

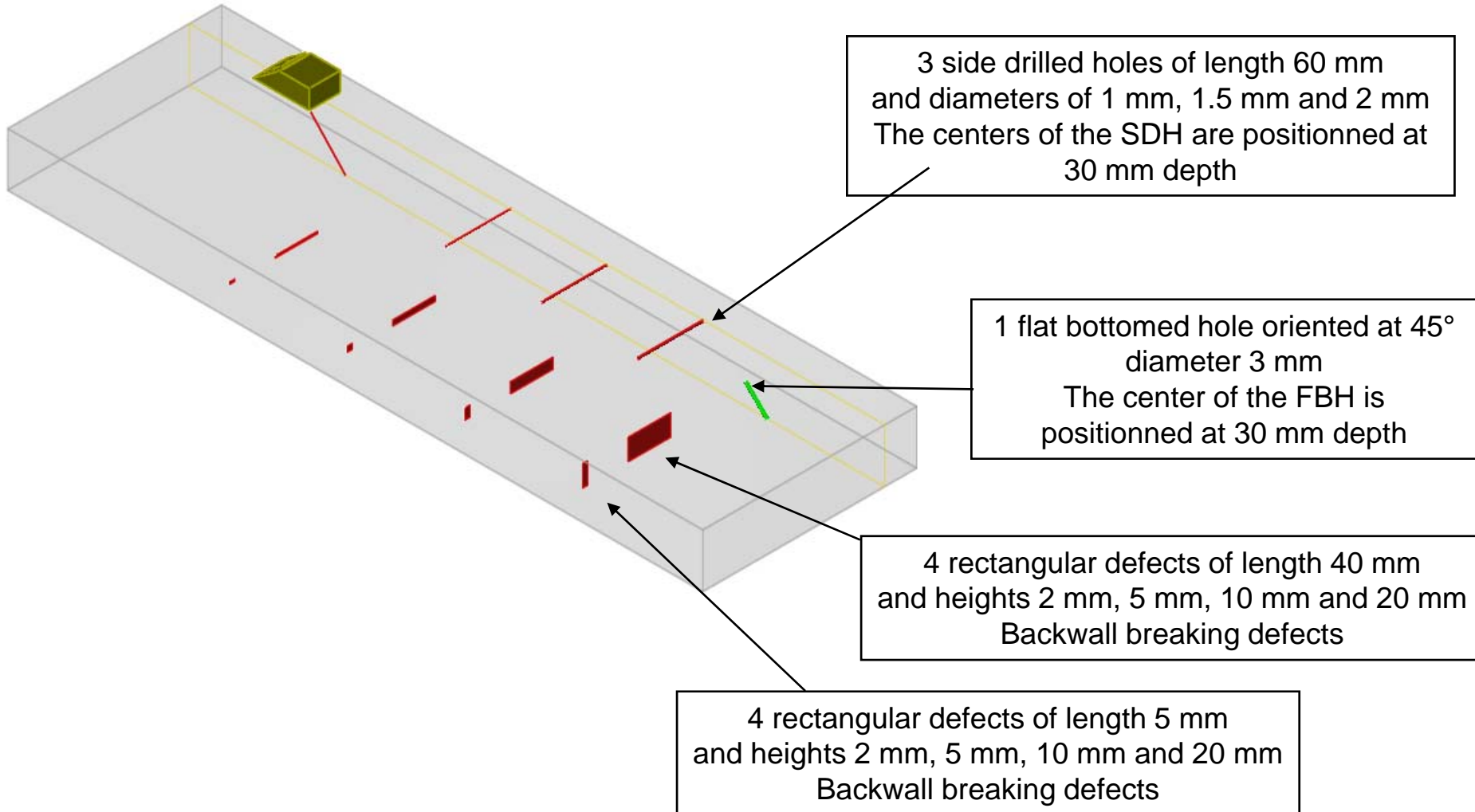


Specimen

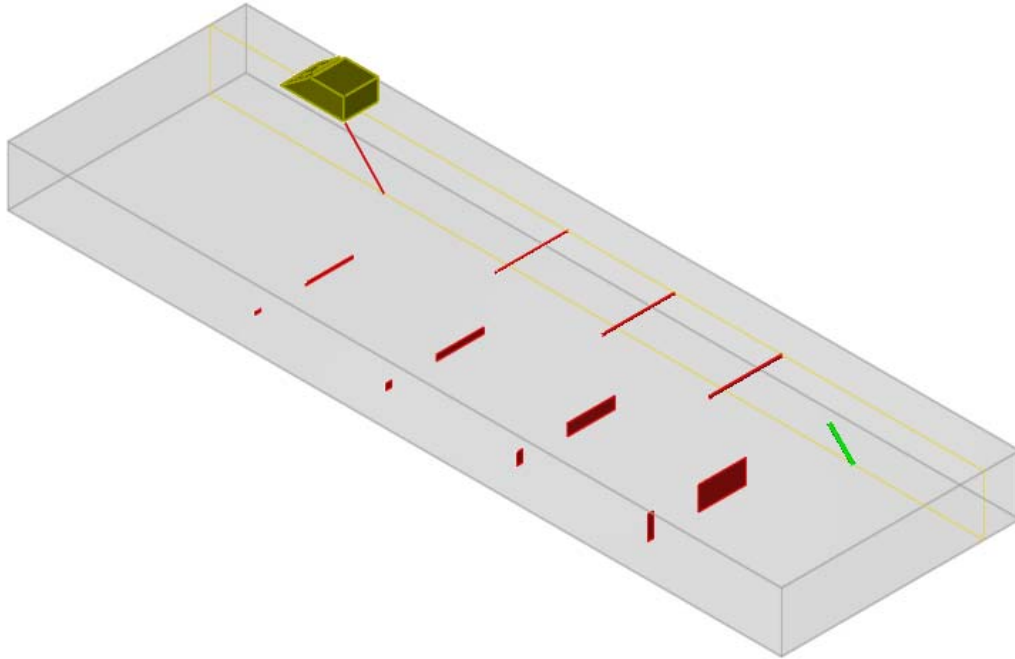
Stainless steel
Density: 7.95 g cm^{-3}
 c_L : 5750 m. s^{-1}
 c_T : 3150 m. s^{-1}

Description of the configurations

Flaws



Description of the configurations



Displacement

Each transducer was moved in two perpendicular directions over each defect.

The wave forms received at each position of the transducer have been stored (experimental Cscans)

The maximum amplitude of the rectified echo was also recorded for each « mode » of echos (L(Longitudinal) wave direct mode, T(Transverse) wave direct mode, L wave corner echo...)

Description of the configurations

Probe WB45

T(Transverse) 45°, contact planar probe

Dimension of the rectangular crystal:

22 mm

20 mm (in the incident plane)

Center frequency: 2 MHz

Frequency bandwidth: 41%

Incidence angle I : 36°

Wedge dimension:

$L_1 = 27$ mm

$L_2 = 26$ mm

$L_3 = 29$ mm

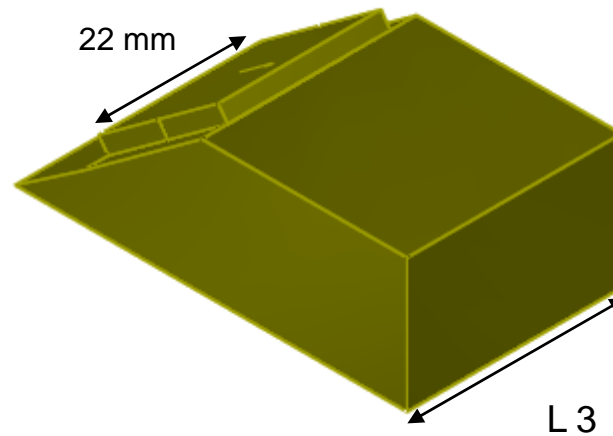
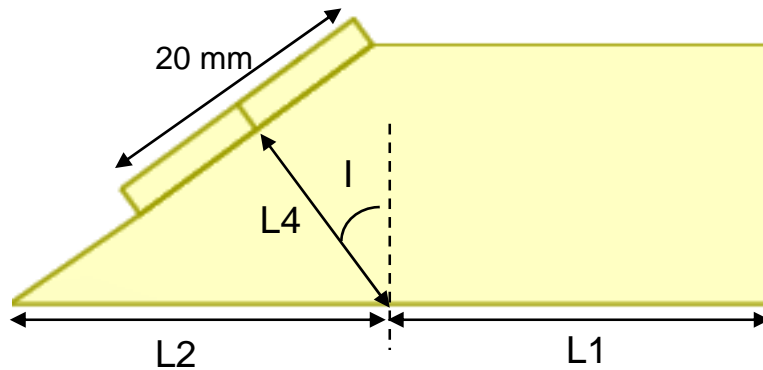
$L_4 = 15$ mm

Wedge material:

Density: 1.8 g cm⁻³

c_L : 2730 m. s⁻¹

c_T : 1320 m. s⁻¹



Description of the configurations

Probe MSWQC45

T(Transverse) 45°, contact planar probe

Diameter of the circular crystal:

6.35 mm

Center frequency: 2.25 MHz

Frequency bandwidth: 44%

Incidence angle I : 35.5°

Wedge dimension:

$L1 = 9$ mm

$L2 = 8.5$ mm

$L3 = 11$ mm

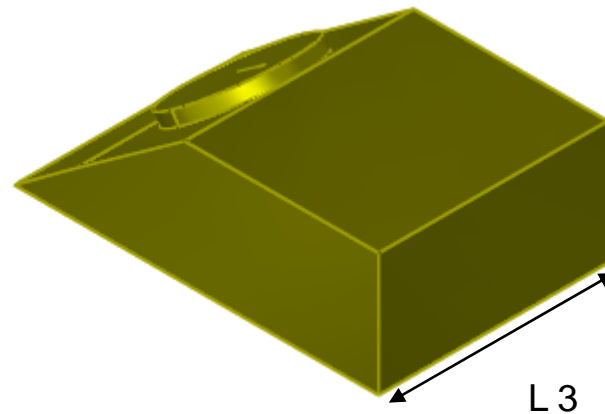
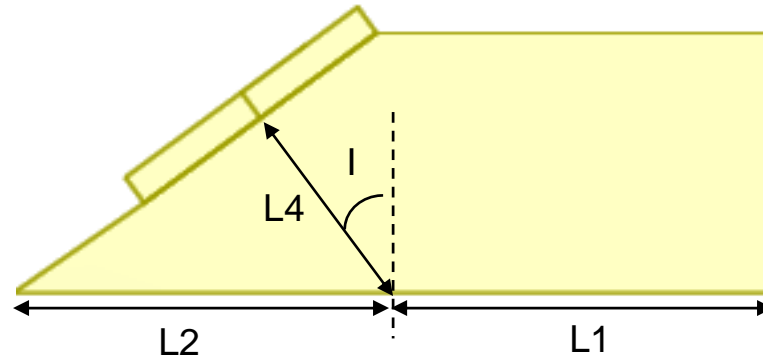
$L4 = 5$ mm

Wedge material:

Density: 1.8 g cm^{-3}

c_L : 2730 m. s^{-1}

c_T : 1320 m. s^{-1}



Description of the configurations

PA probe

Phased array linear probe

Dimension of the whole aperture:
10 mm in the perpendicular plane
33.5 mm (in the incident plane)

Number of elements: 48

Gap between element: 0.1 mm

Dimension of each element:

0.6 mm (in the incidence plane)
10 mm (in the orthogonal plane)

Center frequency: 5 MHz

Frequency bandwidth: 45%

Incidence angle I : 21°

Wedge dimension:

$L1 = 34$ mm

$L2 = 26$ mm

$L3 = 29$ mm

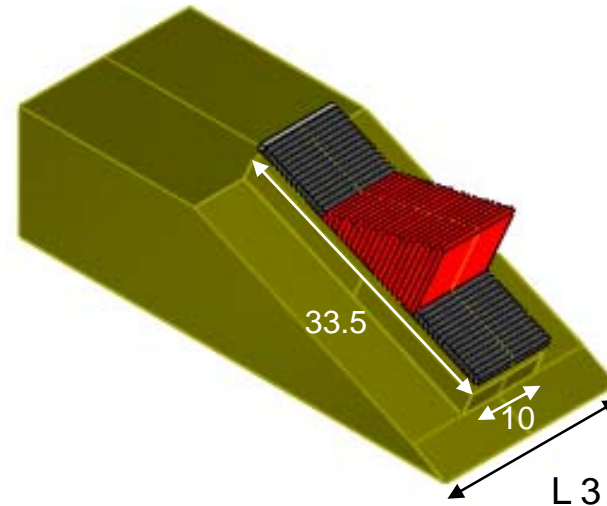
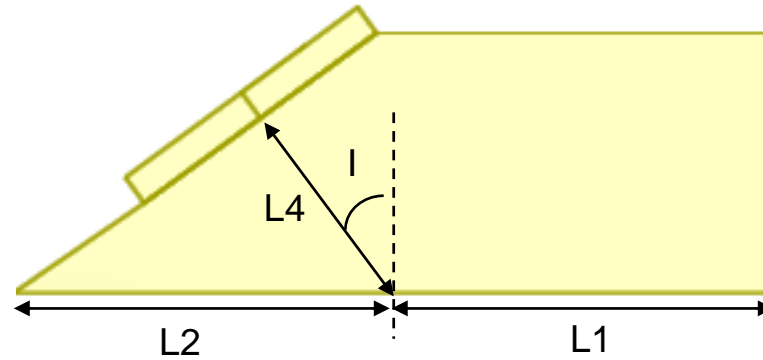
$L4 = 10$ mm

Wedge material:

Density: 1.8 g cm^{-3}

c_L : 2320 m. s^{-1}

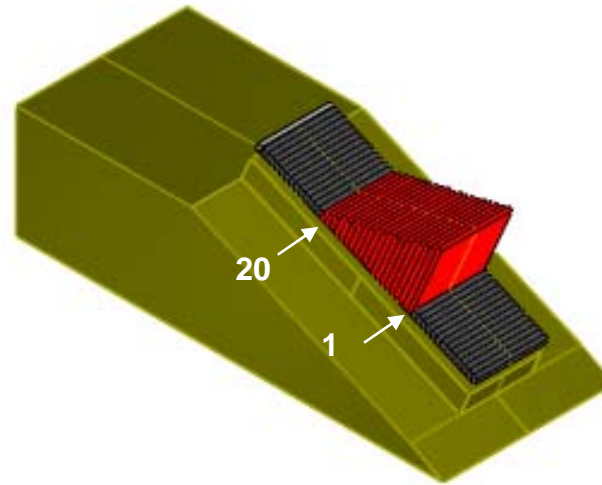
c_T : 1320 m. s^{-1}



Only the 20 central elements are active and delay laws were calculated to obtain a $L45^\circ$ beam in a ferritic steel block.
The delay law obtained are given next slide

Delay laws

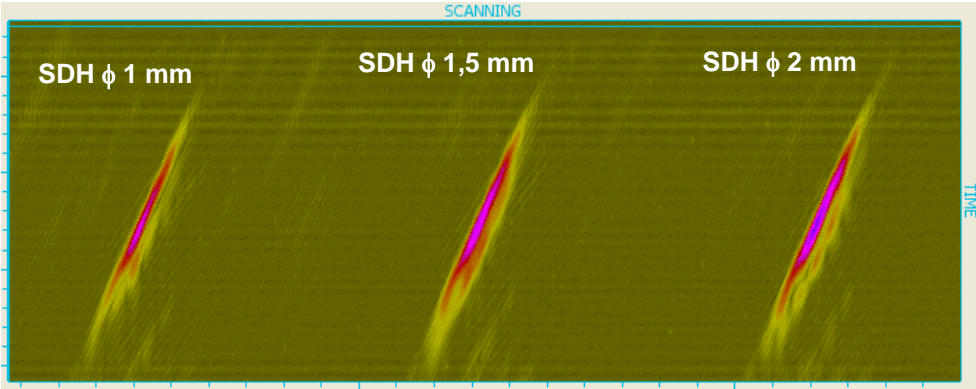
Active channel 1: 0.475
Active channel 2: 0.45
Active channel 3: 0.425
Active channel 4: 0.4
Active channel 5: 0.375
Active channel 6: 0.35
Active channel 7: 0.325
Active channel 8: 0.3
Active channel 9: 0.275
Active channel 10: 0.25
Active channel 11: 0.225
Active channel 12: 0.2
Active channel 13: 0.175
Active channel 14: 0.15
Active channel 15: 0.125
Active channel 16: 0.1
Active channel 17: 0.075
Active channel 18: 0.05
Active channel 19: 0.025
Active channel 20: 0



Description of the data given, case of the WB and MSWQC probes

Side drilled holes

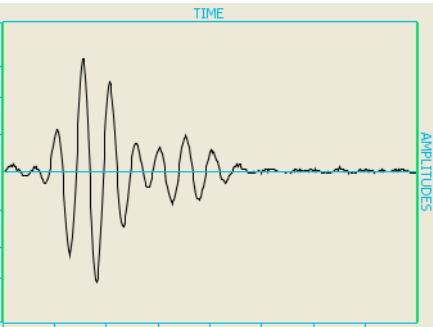
Example of an experimental B-scan obtained with the side drilled holes:



Datat given:

- **The 6 A-scans** corresponding to the maximal amplitude of the **T direct mode** obtained for each of the 3 side drilled holes and for the 2 contact probes (txt files named « SDH_Xmm_WB » or « SDH_Xmm_MSQC » where X is the diameter of the side drilled hole). The amplitudes of the waveform are given in arbitrary units versus time, while the absolute amplitudes (including gain settings) are given in a table (given later). Example:

« SDH_2mm_WB »

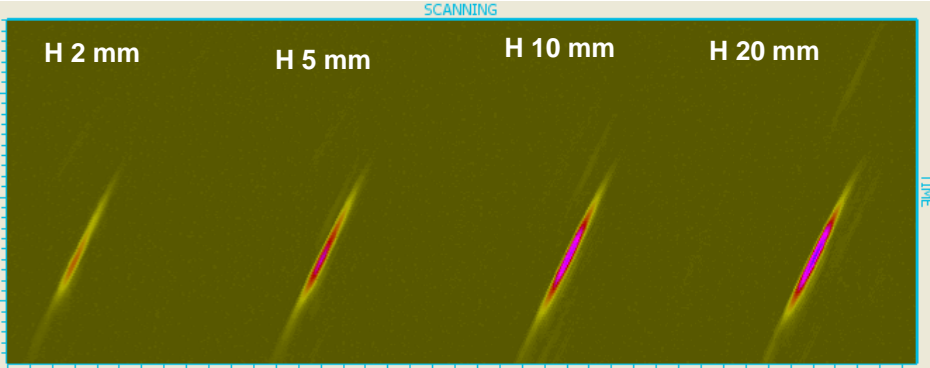


- **The amplitude in dB** of the T direct echoes relative to the 2 mm diameter SDH (see table given later)

Description of the data given, case of the WB and MSWQC probes

Rectangular defects of 40 mm and 5 mm extension

Example of an experimental B-scan obtained with the 40mm extension rectangular defects:

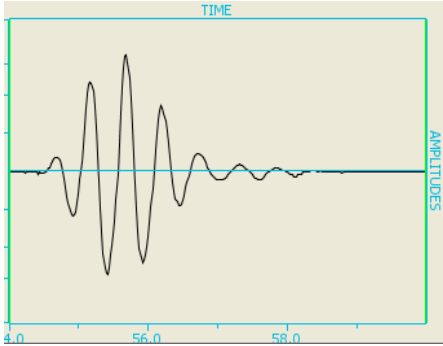


Data given:

- **The 16 A-scans** corresponding to the maximal amplitude of the **T corner mode** obtained for each of the 8 planar defect and for the 2 probes (txt files named « Planar_EYmm_HXmm_WB » or « Planar_EY_HX_MSQC » where X is the height of the defect (2, 5, 10 or 20mm) and Y is the extension of the defect (5 or 40 mm).

Example:

« planar_E40mm_H20mm_WB »

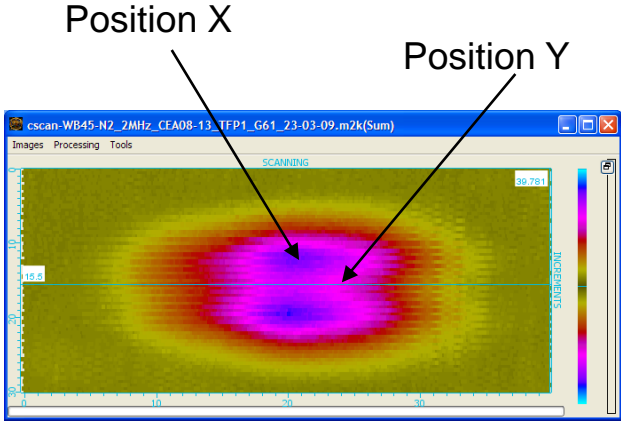
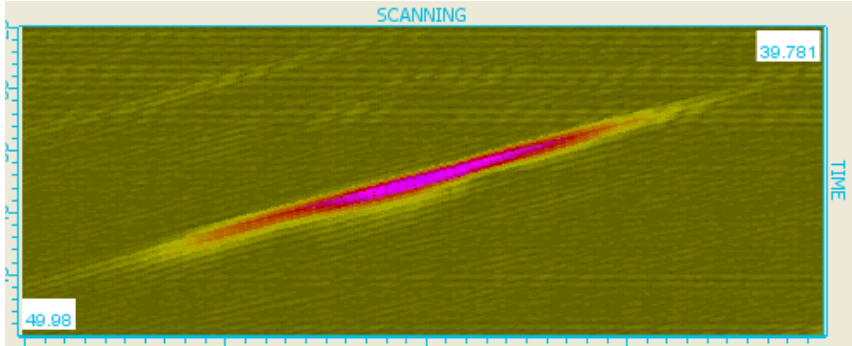


- **The amplitude in dB** of the T corner echoes relative to the 2 mm diameter SDH (see later table)

Description of the data given, case of the WB and MSWQC probes

Flat bottomed hole

Experimental B-scan obtained with the FBH for the WB probe:



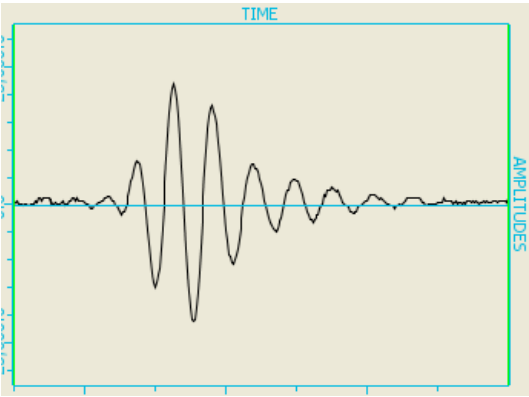
Data given:

- **The 2 A-scans** corresponding to the maximal amplitude of the **T direct mode** obtained for the 45° FBH and for the 2 probes (txt files named « FBH_3mm_WB » and « FBH_3mm_MSWQC »)

NB: in the case of the WB45 probe, the results are not given for the maximal echo (obtained for position X due to nearfield position) but instead for the echo obtained when the center of the probe and the center of the FBH are in the same plane (position Y on the Cscan)

Example:

BH_3mm_WB

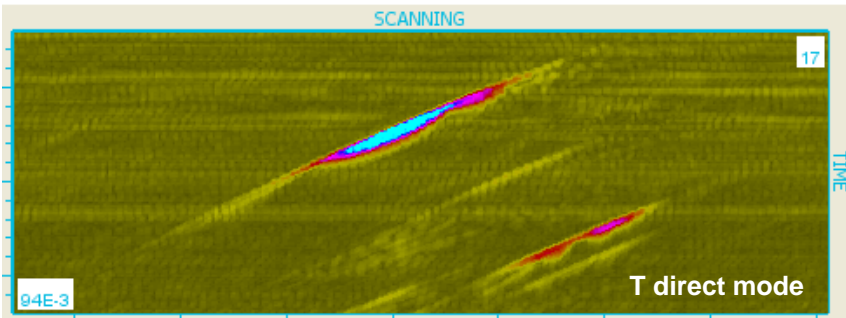
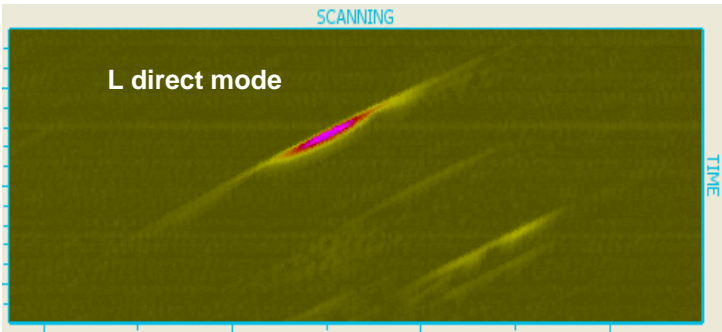


- **The amplitude in dB** of the T direct echoes relative to the 2 mm diameter SDH (see later table)

Description of the data given, case of the PA probe

Side drilled holes

Example of an experimental B-scan obtained with the side drilled holes:

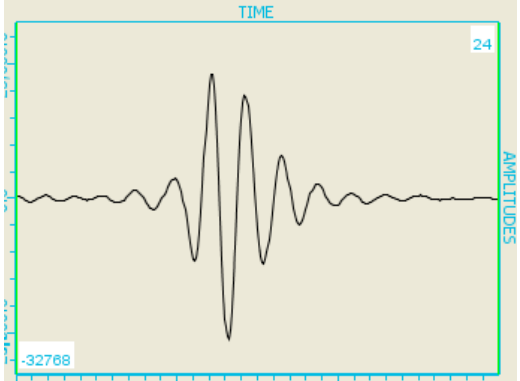


Data given:

- **The 8 A-scans** corresponding to the maximal amplitude of the **L direct mode** obtained for each of the 3 side drilled holes (txt files named « SDH_Xmm_Ldirect_PA » where X is the diameter of the side drilled hole).
- **The 4 A-scans** corresponding to the maximal amplitude of the **T direct mode** obtained for each of the 3 side drilled holes (txt files named « SDH_Xmm_Tdirect_PA » where X is the diameter of the side drilled hole).

Example:

L direct mode



T direct mode

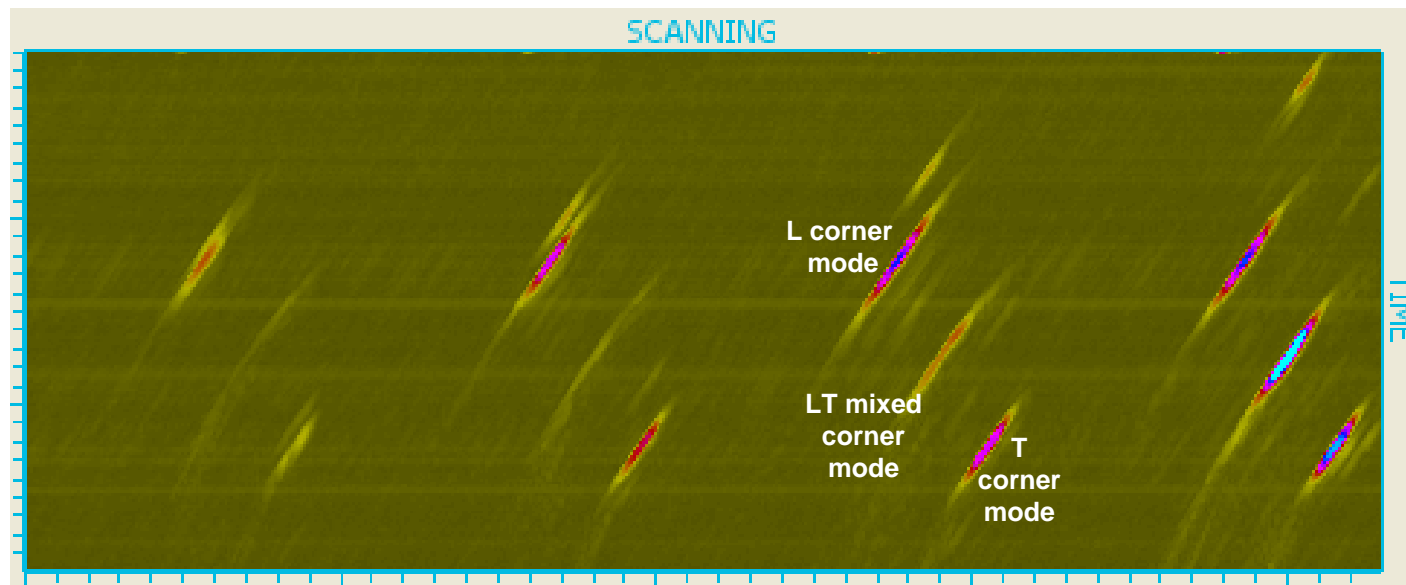


- **The amplitude in dB** of the L direct and T direct echoes of the SDH relative to the L direct echo of the 2 mm diameter SDH (see later table)

Description of the data given, case of the PA probe

Rectangular defects of 40 mm extension

Example of an experimental B-scan obtained with the rectangular defects:



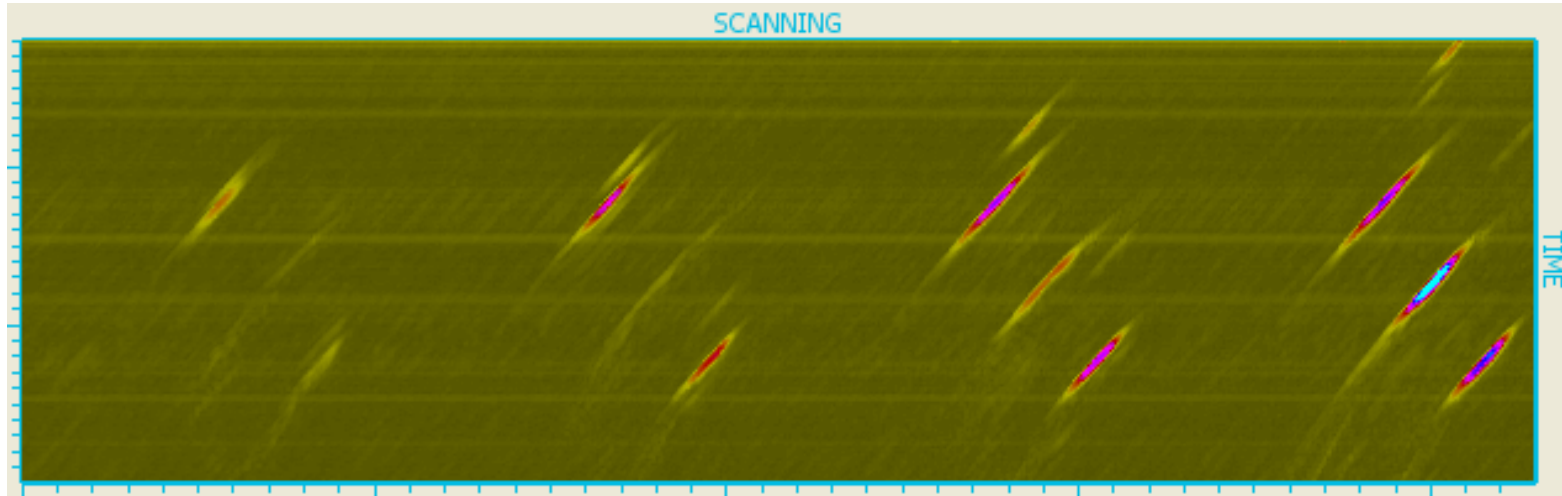
Data given:

- **The 4 A-scans** corresponding to the maximal amplitude of the **L corner mode** obtained for each of the 3 side drilled holes (txt files named « Planar_EYmm_HXmm_Lcorner_PA » where X is the diameter of the side drilled hole).
- **The 4 A-scans** corresponding to the maximal amplitude of the **T corner mode** obtained for each of the 3 side drilled holes (txt files named « Planar_EYmm_HXmm_Tcorner_PA » where X is the diameter of the side drilled hole).
- **The 4 A-scans** corresponding to the maximal amplitude of the **LT mixed corner mode** obtained for each of the 3 side drilled holes (txt files named « Planar_EYmm_HXmm_LTcorner_PA » where X is the diameter of the side drilled hole).
- **The amplitude in dB** of the L corner and T corner and LT corner echoes of the rectangular defect relative to the L direct echo of the 2 mm diameter SDH (see later table)

Description of the data given, case of the PA probe

Rectangular defects of 5 mm extension

Example of an experimental B-scan obtained with the rectangular defects:



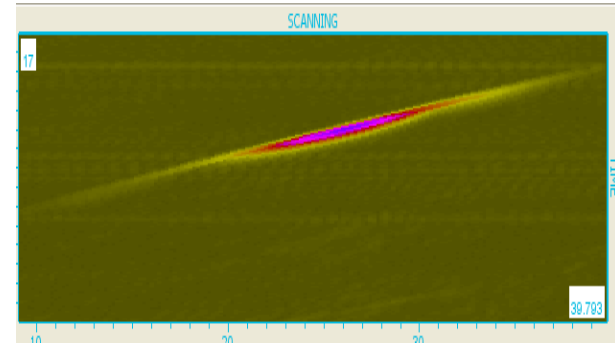
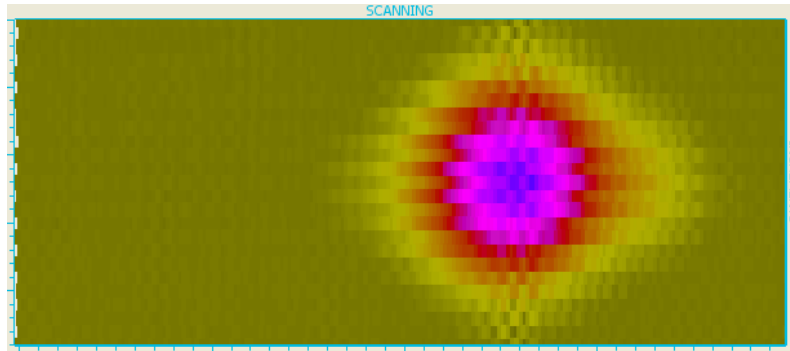
Data given:

-**The amplitude in dB** of the L corner and T corner and LT corner echoes of the rectangular defect relative to the L direct echo of the 2 mm diameter SDH (see later)

Description of the data given, case of the PA probe

Flat bottomed hole

Experimental C-scan and B-scans obtained with the FBH:



Data given:

- **The A-scan** corresponding to the maximal amplitude of the **L direct mode** obtained for the 45° FBH (txt files named « FBH45_3mm_PA »)
- **The amplitude in dB** of the L direct echoes relative to the 2 mm diameter SDH (see later table)

Probe WB	Side drilled holes diameter (mm)			Flat Bottom hole 45°	Planar defect extension of 40 mm Height (mm)				Planar defect extension of 5 mm Height (mm)			
	1	1.5	2		2	5	10	20	2	5	10	20
T Direct echo	-2.6	-1.2	0 (ref)	-6.0								
T Corner echo					13.0	18.1	21.2	22.3	5.5	11.1	13.7	14.7

Relative amplitudes in dB of the different echos and defect obtained with the WB transducer

The amplitude of reference A_{ref} = amplitude maximum of the echo of the SDH of diameter 2 mm at 30 mm depth
The relative amplitude A_R printed in the table is in dB: $20 \log(A / A_{REF}) - (G - G_{REF})$
Where G and G_{REF} are the gains in dB.

Probe MSWQC	Side drilled holes diameter (mm)			Flat Bottom hole 45°	Planar defect extension of 40 mm Height (mm)				Planar defect extension of 5 mm Height (mm)			
	1	1.5	2		2	5	10	20	2	5	10	20
T Direct echo	-4.3	-1.8	0 (ref)	3.9								
T Corner echo					8.0	13.3	13.7	13.5	5.6	9.0	10.5	11.3

Relative amplitudes in dB of the different echos and defect obtained with the MSWQC transducer

The amplitude of reference A_{ref} = amplitude maximum of the echo of the SDH of diameter 2 mm at 30 mm depth
The relative amplitude A_R printed in the table is in dB: $20 \log(A / A_{REF}) - (G - G_{REF})$
Where G and G_{REF} are the gains in dB.

Probe PA	Side drilled holes diameter (mm)			Flat Botto m hole 45°	Planar defect extension of 40 mm Height (mm)				Planar defect extension of 5 mm Height (mm)			
	1	1.5	2		2	5	10	20	2	5	10	20
L Direct echo	-2.6	-1.3	0 (ref)	2.8								
T Direct echo	-16.5	-16.3	-14.8									
L Corner echo					-10.5	-3.6	-1.4	-1.3	-13.7	-6.8	-4.5	-3.9
TL Corner echo					-23.9	-21.7	-10.8	6.5	To low	-24.2	-12.5	2.4
T Corner echo					-16.2	-7.3	-3.7	-0.5	-20.5	-9.8	-5.2	-3

Relative amplitudes in dB of the different echos and defect obtained with the PA transducer

The amplitude of reference A_{ref} = amplitude maximum of the echo of the SDH of diameter 2 mm at 30 mm depth
The relative amplitude A_R printed in the table is in dB: $20 \log(A / A_{REF}) - (G - G_{REF})$
Where G and G_{REF} are the gains in dB.

PARTICIPATION IN THE STUDY

The files for this benchmark study have been placed on the CNDE ftp site <ftp://cnde:Bruce@ftp.cnde.iastate.edu>. They are in the directory pub in the folder named 2009 UT Benchmark. The results of these benchmark studies will be presented at the 36th Annual Review of Progress in Quantitative Nondestructive Evaluation (RPQNDE) meeting, which will be held July 26-31, 2009 at the University of Rhode Island, Kingston, Rhode Island. We plan to hold an ultrasonics benchmark session at that meeting for papers on modeling capabilities as originally requested and for papers on these problems. To present your benchmark results at that session, please note that the deadline for submitting an abstract is May 1, 2009 (mark on your abstract that it is for the UT benchmark session). However, feel free to work on these problems even if you are not presenting at that meeting. Also, note that the advance registration deadline for the conference is Friday, July 3, 2009. For more details of the RPQNDE conference, visit the website at www.cnde.iastate.edu/qnde/qnde.html.

For any questions, please e-mail Prof. Schmerr at lschmerr@cnde.iastate.edu .

Les Schmerr
Permanent Secretary, World Federation of NDE Centers
April, 2009