High Frequency ToFD Wedge Materials Comparisons

By Jimmy Ellis, May 11, 2021

The following shows the differences in 15MHz ToFD scans taken with different commonly available ToFD wedge materials:

- PMMA, “Poly(methyl methacrylate), also known as acrylic, acrylic glass, or plexiglass, as well as by the trade names Crylux, Plexiglas, Acrylite, Astariglas, Lucite, Perclax, and Perspex, among several others, is a transparent thermoplastic often used in sheet form as a lightweight or shatter-resistant alternative to glass.” From Wikipedia https://en.wikipedia.org/wiki/Poly(methyl_methacrylate)
- Plexiglas, a proprietary product of Arkema, is described as “an acrylic plastic sheet”; https://www.plexiglas.com/en/
- Rexolite, a proprietary product of C-LEC industries, is described as “Rexolite 1422” a cross linked polystyrene; http://www.rexolite.com/

Rexolite is often described as the superior wedge material for phased array and ToFD, because it is described as having better sound transmission and less filtering of higher frequencies than PMMA or plexiglass.

Most wedge manufacturers for shear wave applications usually would describe the wedge material as being either PMMA or plexiglass.

When ToFD for extremely thin-walled applications is done, the amount of travel time in the wedge is small and the scans shown below document the actual differences due to the type of wedge material used.

Each of the wedge materials is used in taking scans of each of the following steel objects:

1. A FAST1 cal block, 0.500” thick, with four 1/32” diameter side drilled holes centered at depths of 0.100”, 0.200”, 0.300” and 0.400” and two narrow EDM (electrical discharge machining) notches of depths 0.100” and 0.050”.
2. A cal block, 0.300” thick, with 8 graduated ID connected EDM notches.
3. The same 0.300” thick cal block as above but the block is flipped with the 8 graduated EDM notches being OD connected.
4. A cal block, 0.300” thick, with 8 midwall EDM slots of narrow width, that are not ID or OD connected. Some of the slots are centered at 50% deep, and some are off-centered at 33% deep.
5. Same cal block of midwall EDM slots as above, but the off-centered slots are centered at 66% deep.
6. 8x188 (8-inch diameter and 0.188” wall) pipe coupon with 6 ID connected and 6 OD connected slanted wafer wheel notches of graduated flaw heights in alternating slant directions, simulating ERW defects in a longitudinal seam weld.
7. 16x375 (16-inch diameter and 0.375” wall) pipe coupon with 6 ID connected and 6 OD connected slanted wafer wheel notches of graduated flaw heights in alternating slant directions, simulating ERW defects in a longitudinal seam weld.

These cal blocks and coupons are further described at **https://UTofPipelineDigs.com**

All the ToFD scans shown below were taken with 15MHz transducers having a very short ring time, transducer element diameters of 0.090”, with ToFD wedge pairs using a PCS (probe center separation) of 0.75”

Contents

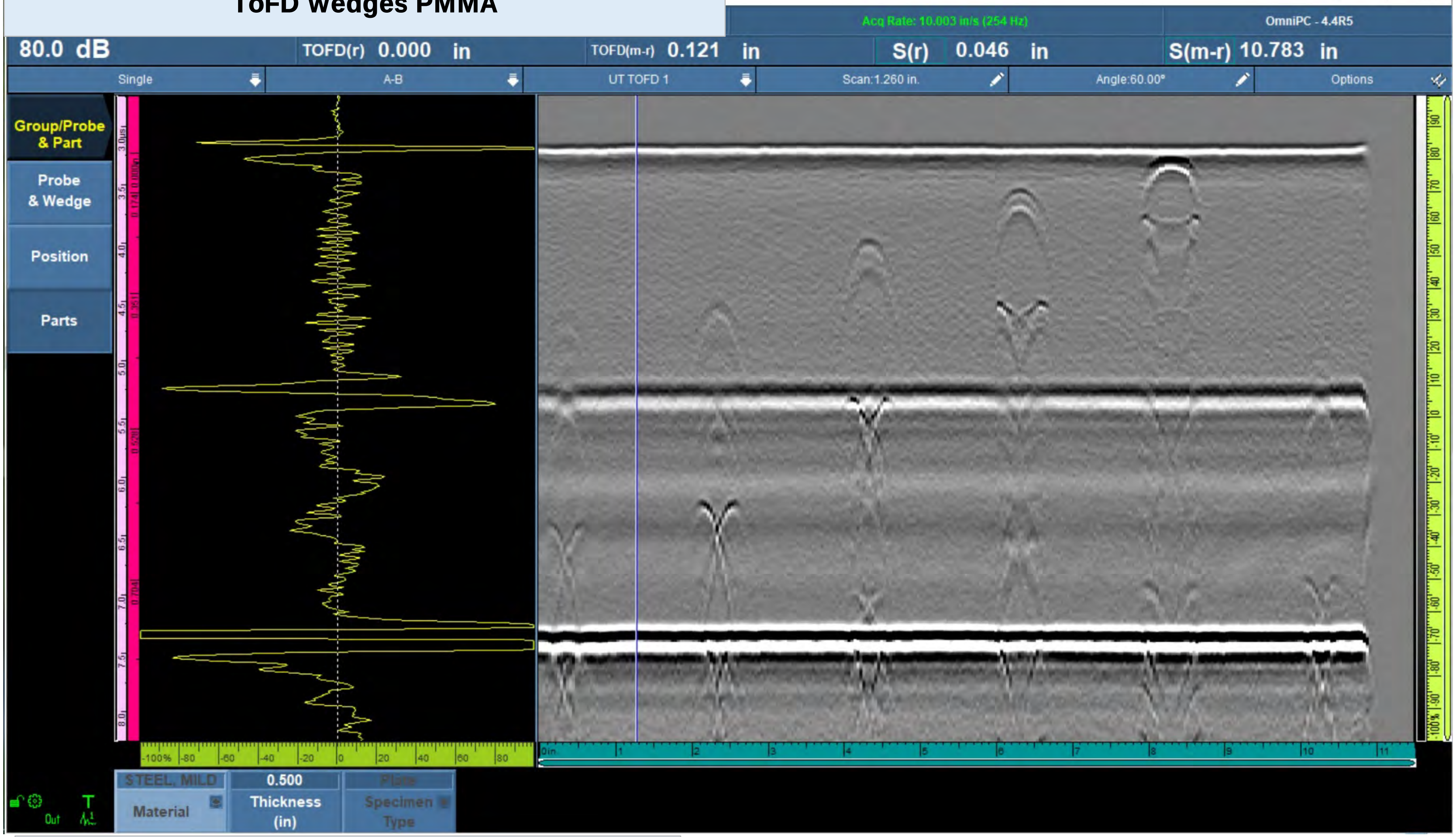
Scans organized by wedge types start here.

The following pages will show ToFD scans of each of the seven scan objects with each of the 9 types of ToFD wedges/materials. The order of scans shown is organized by the type of wedge/material. You are proceeding down each column one at a time. (If you would prefer to review the scans by looking at all the scans grouped by type of object, then skip to page 69.) The reader is invited to print this page and keep track of which wedge materals is preferred by the reader.

	1 ToFD wedges PMMA	2 ToFD wedges Plexiglass 01-012038	3 ToFD wedges Plexiglass 1	4 ToFD wedges Plexiglass 2	5 ToFD wedges Plexiglass 3	6 ToFD wedges Plexiglass 01-012100	7 ToFD wedges Plexiglass 01-013038	8 ToFD wedges Rexolite 362-001-160	9 ToFD wedges Rexolite 01-013037
FAST1 cal block									
ID Notch block									
OD Notch block									
Midwall up									
Midwall down									
8x188									
16x375									

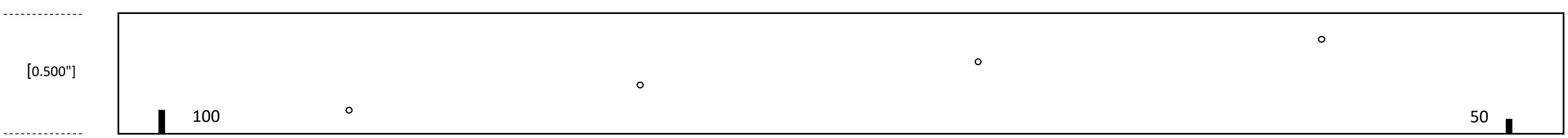
At this point it would be best to set up your Adobe reader, or Adobe Acrobat or other PDF reading app to show your "View/Page Display" menu option as whole page. From this point forward advance your pages with your "page up" and "page down" keys, like a slide show. Viewing in other modes such as "continuous" scrolling are not helpfull in contrasting the differences in the scans.

ToFD wedges PMMA

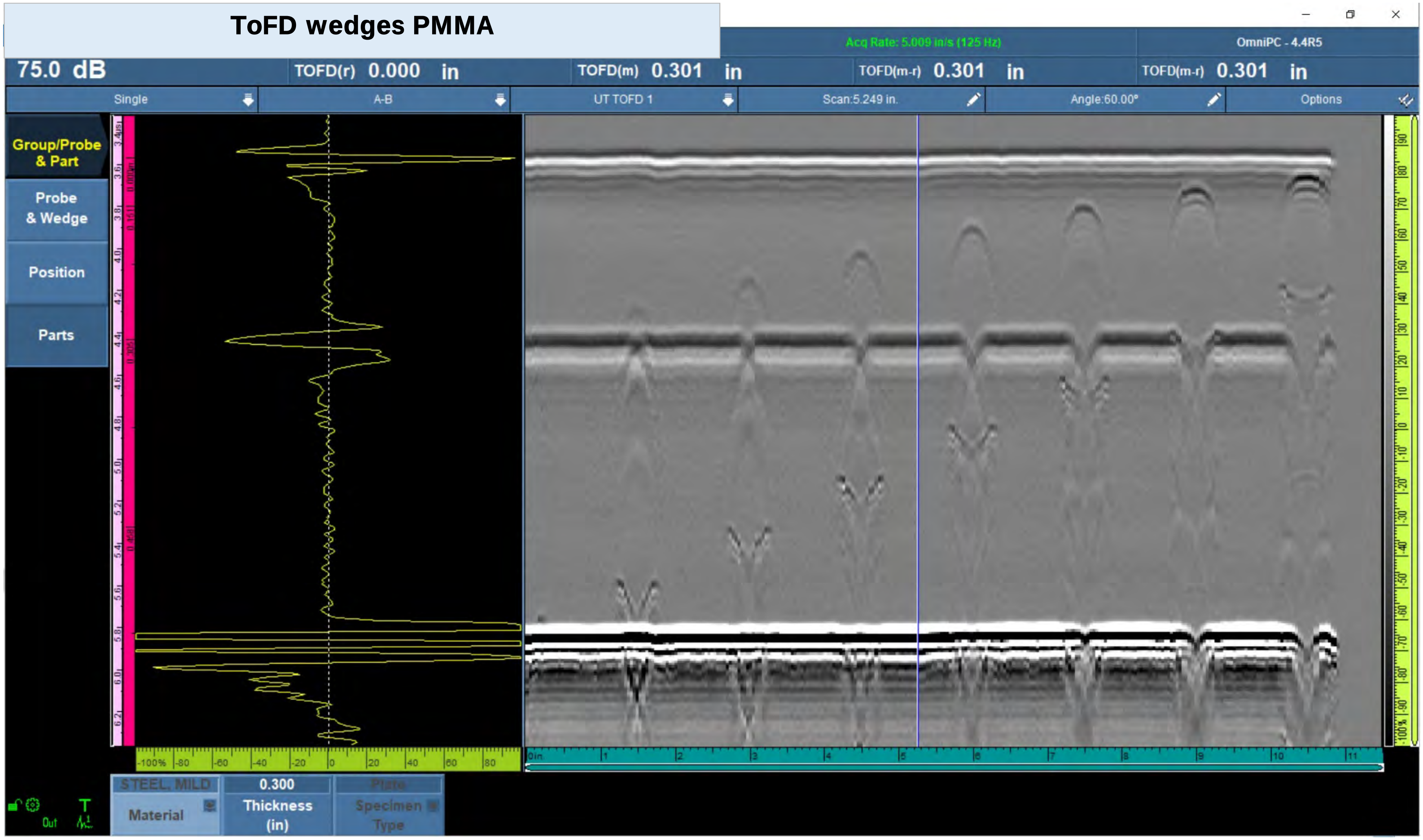


FAST1 cal block

4 side drilled holes, two EDM notoches

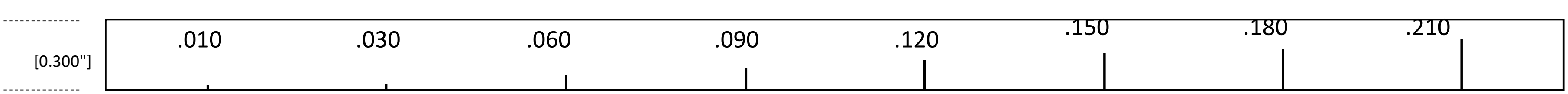


ToFD wedges PMMA

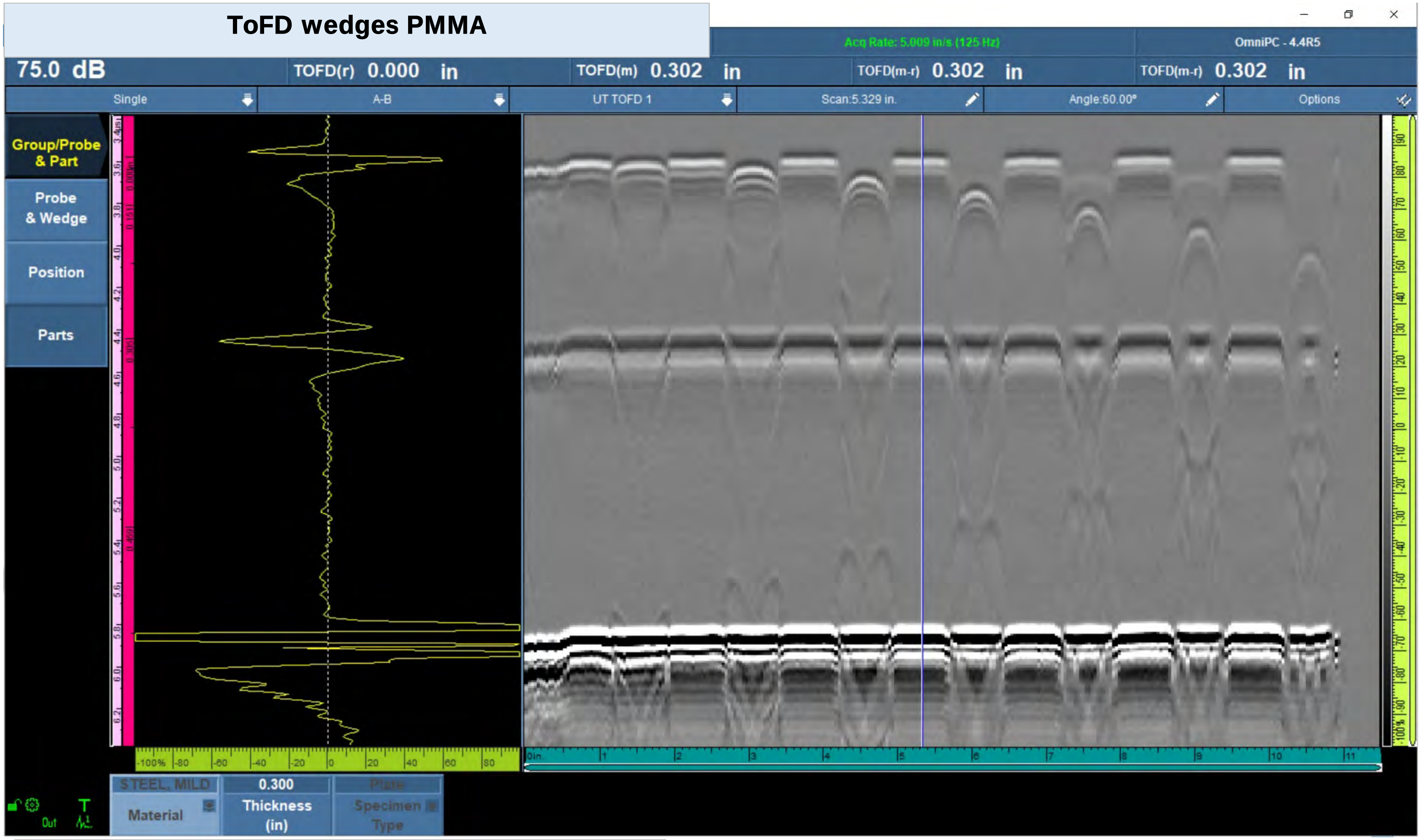


ID notches

8 EDM notoches

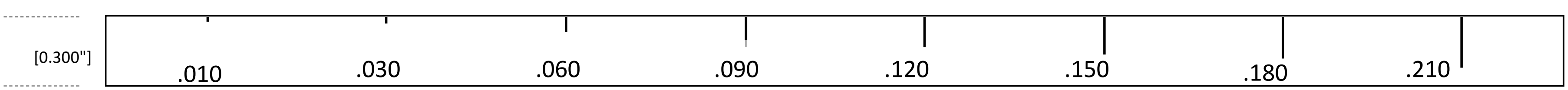


ToFD wedges PMMA

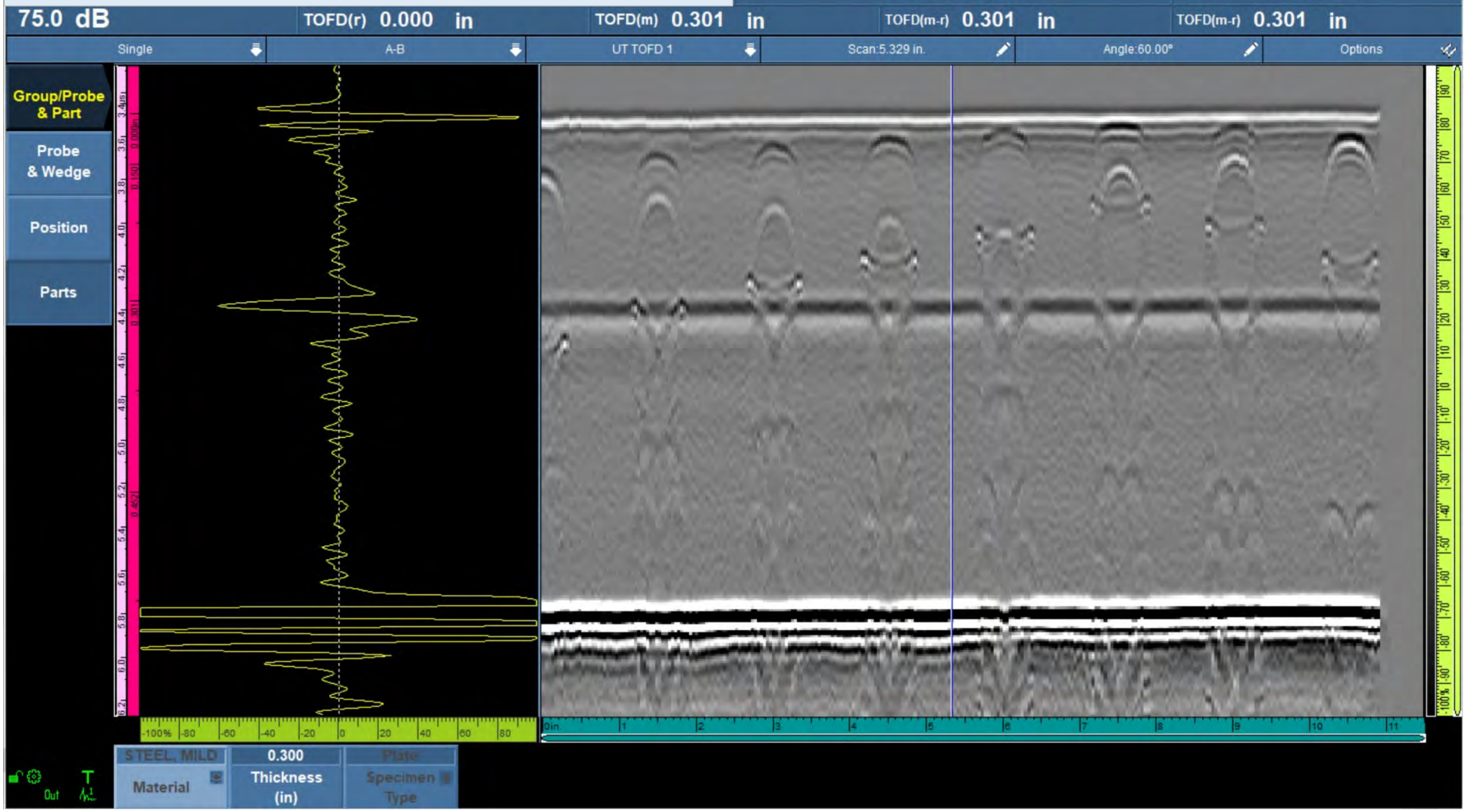


OD notches

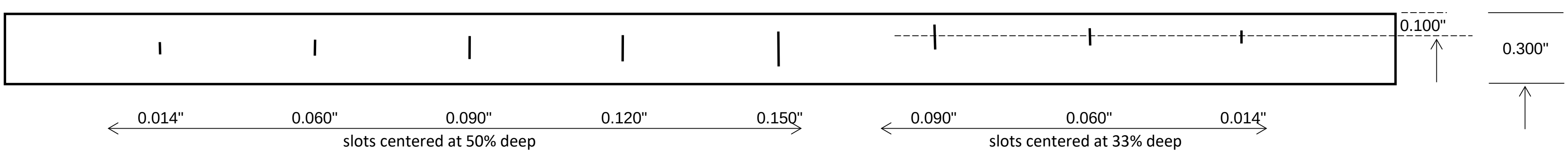
8 EDM notoches



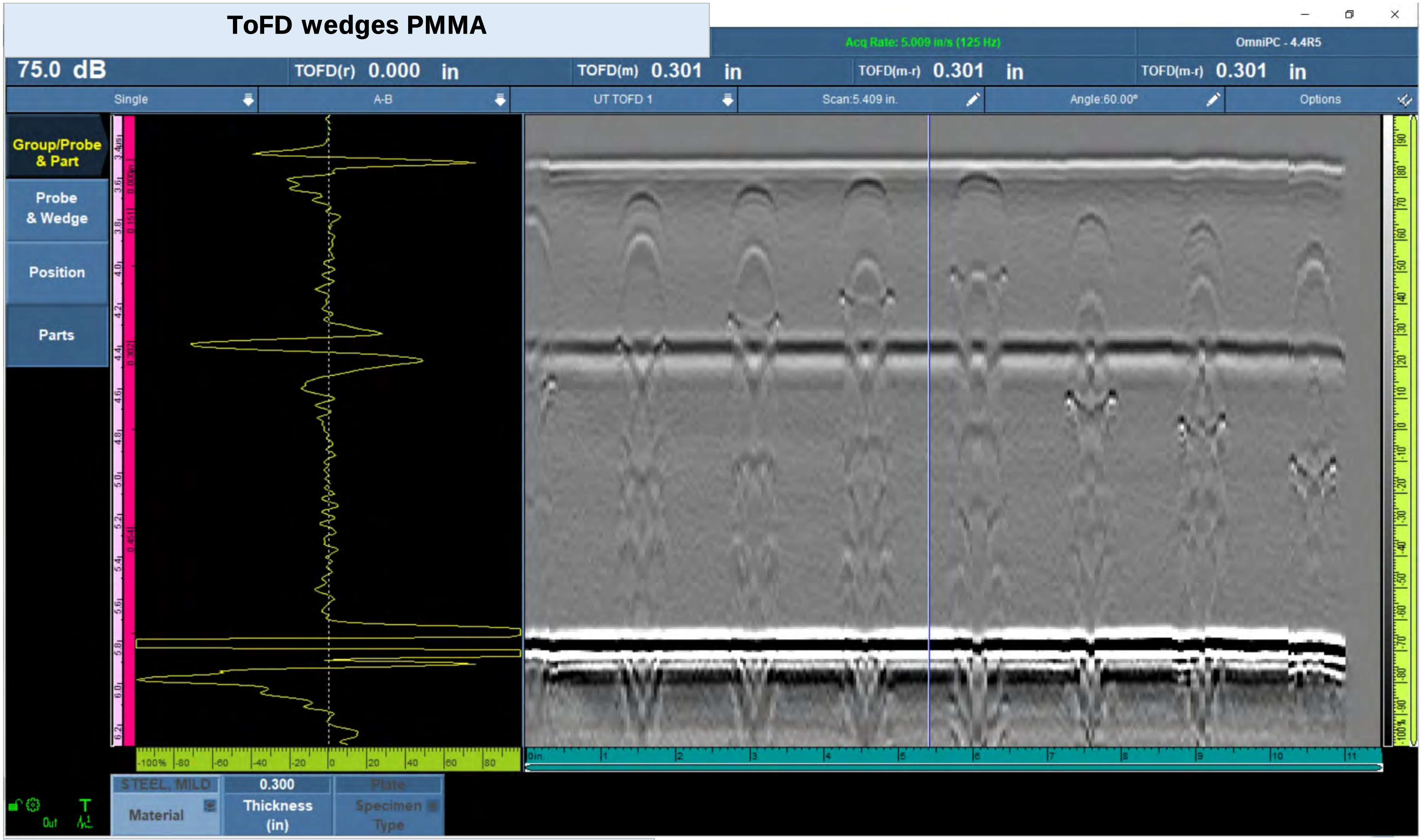
ToFD wedges PMMA



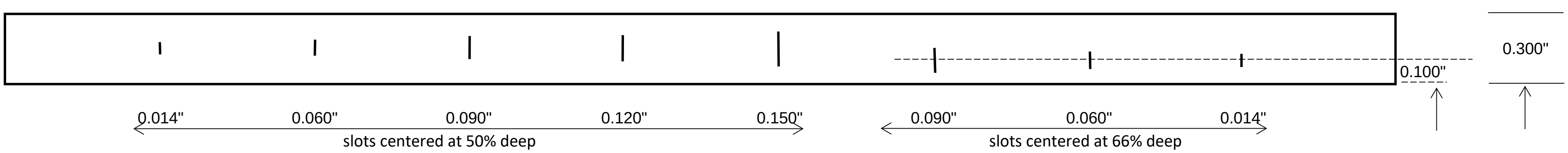
midwall slots, up



ToFD wedges PMMA



midwall slots, down



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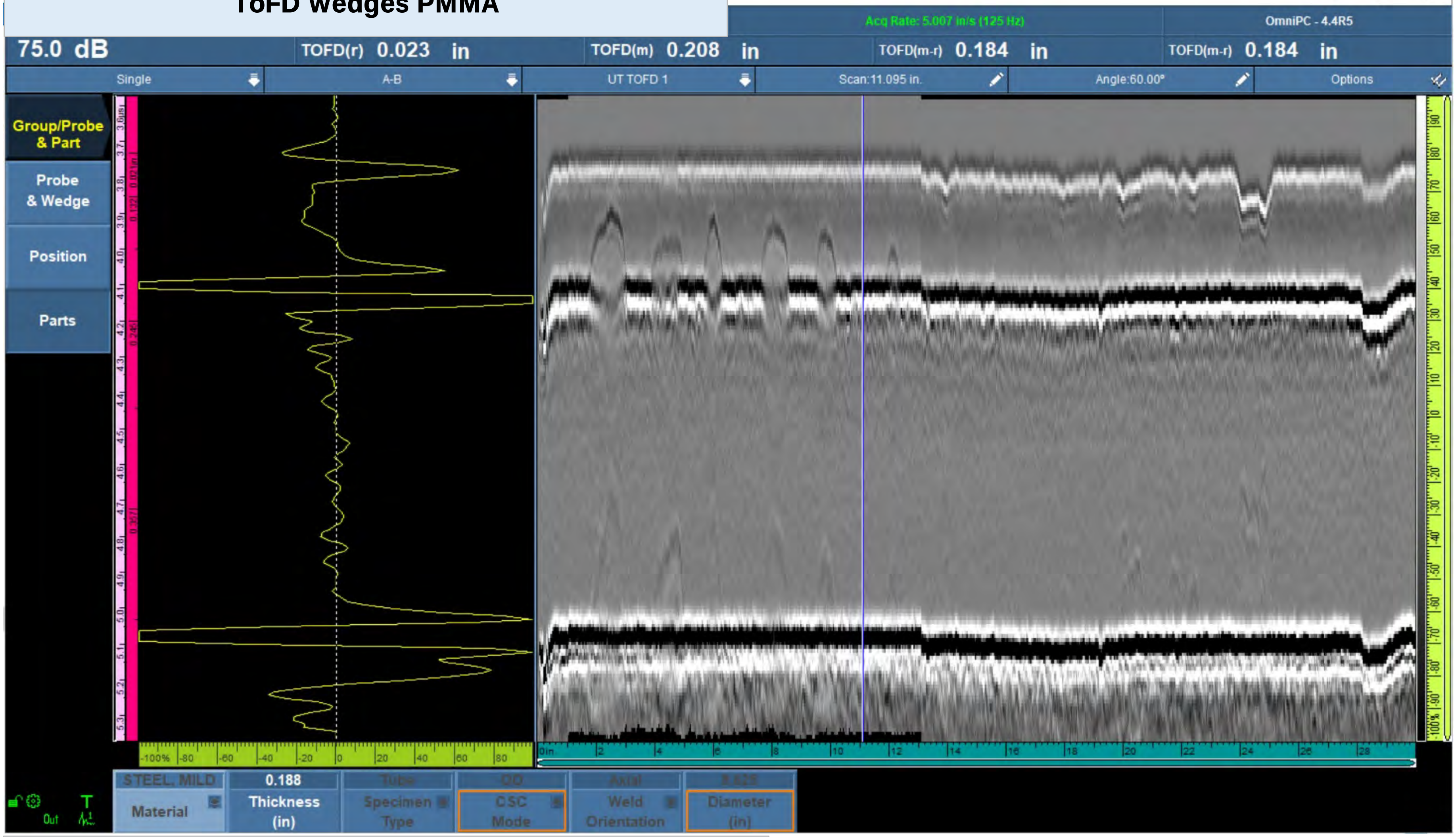
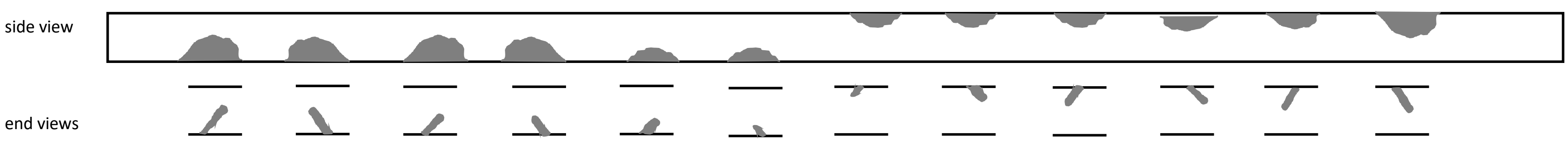


8x188 pipe, long seam, slanted, wafer wheel notches



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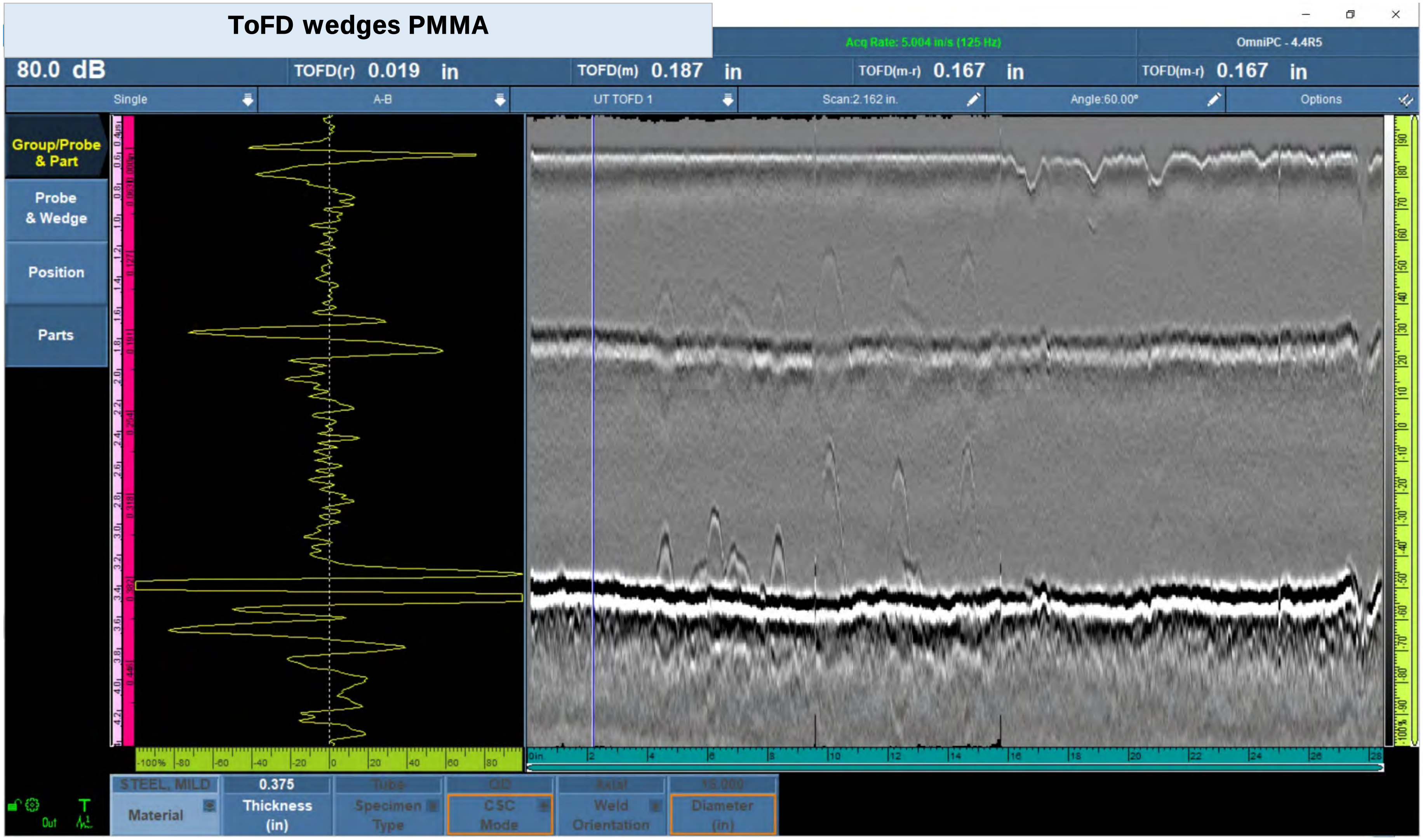
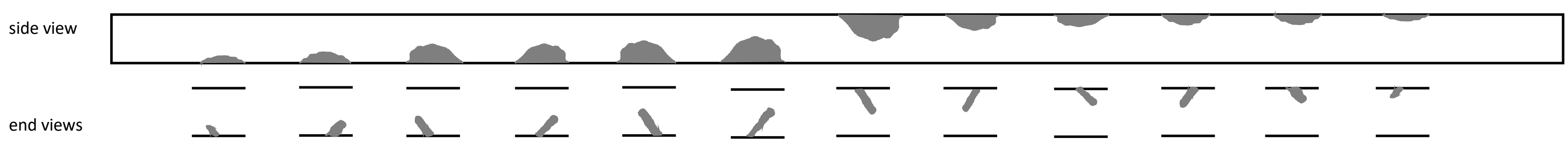
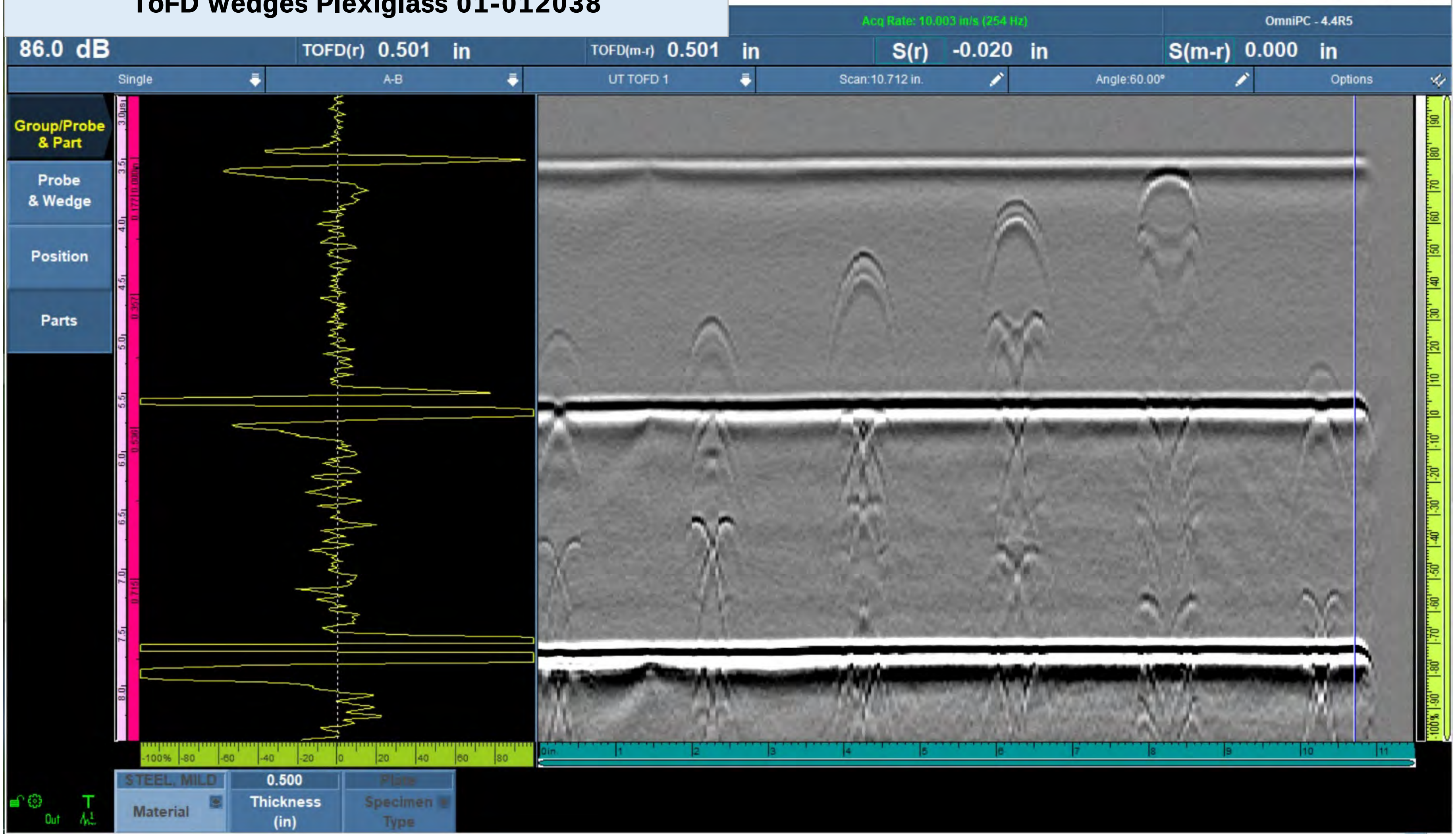


16x375 pipe, long seam, slanted, wafer wheel notches

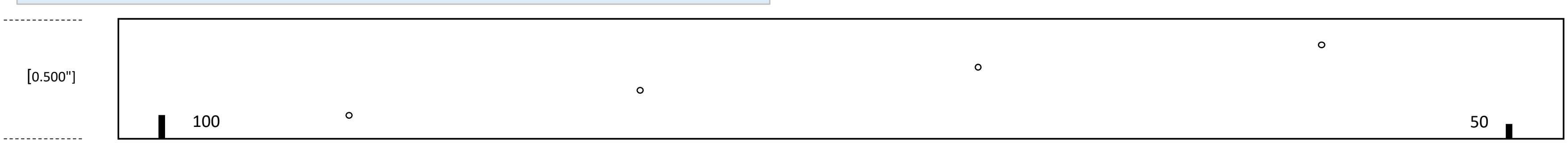


ToFD wedges Plexiglass 01-012038

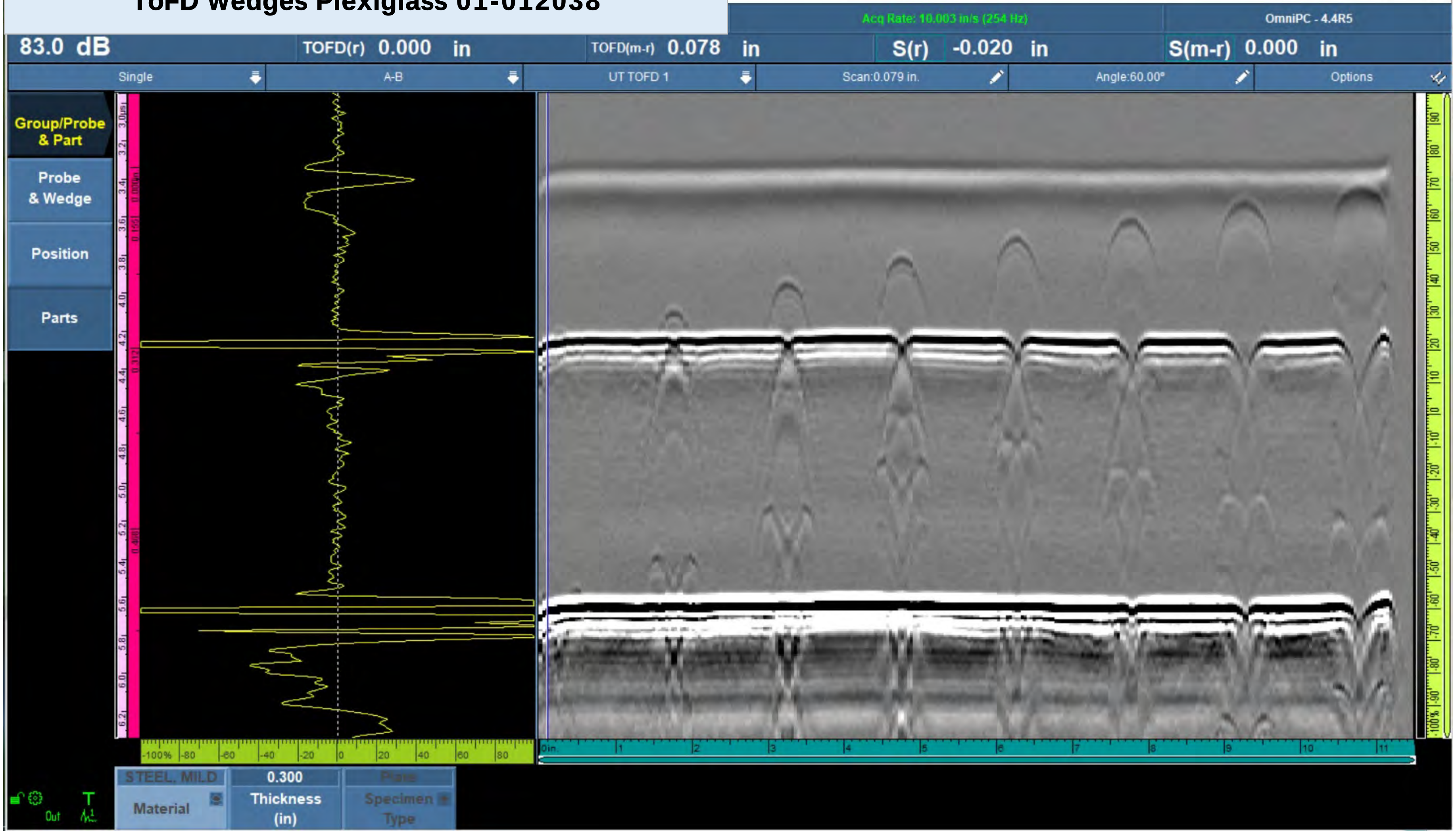


FAST1 cal block

4 side drilled holes, two EDM notoches

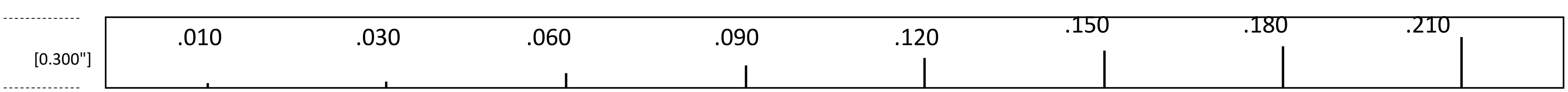


ToFD wedges Plexiglass 01-012038

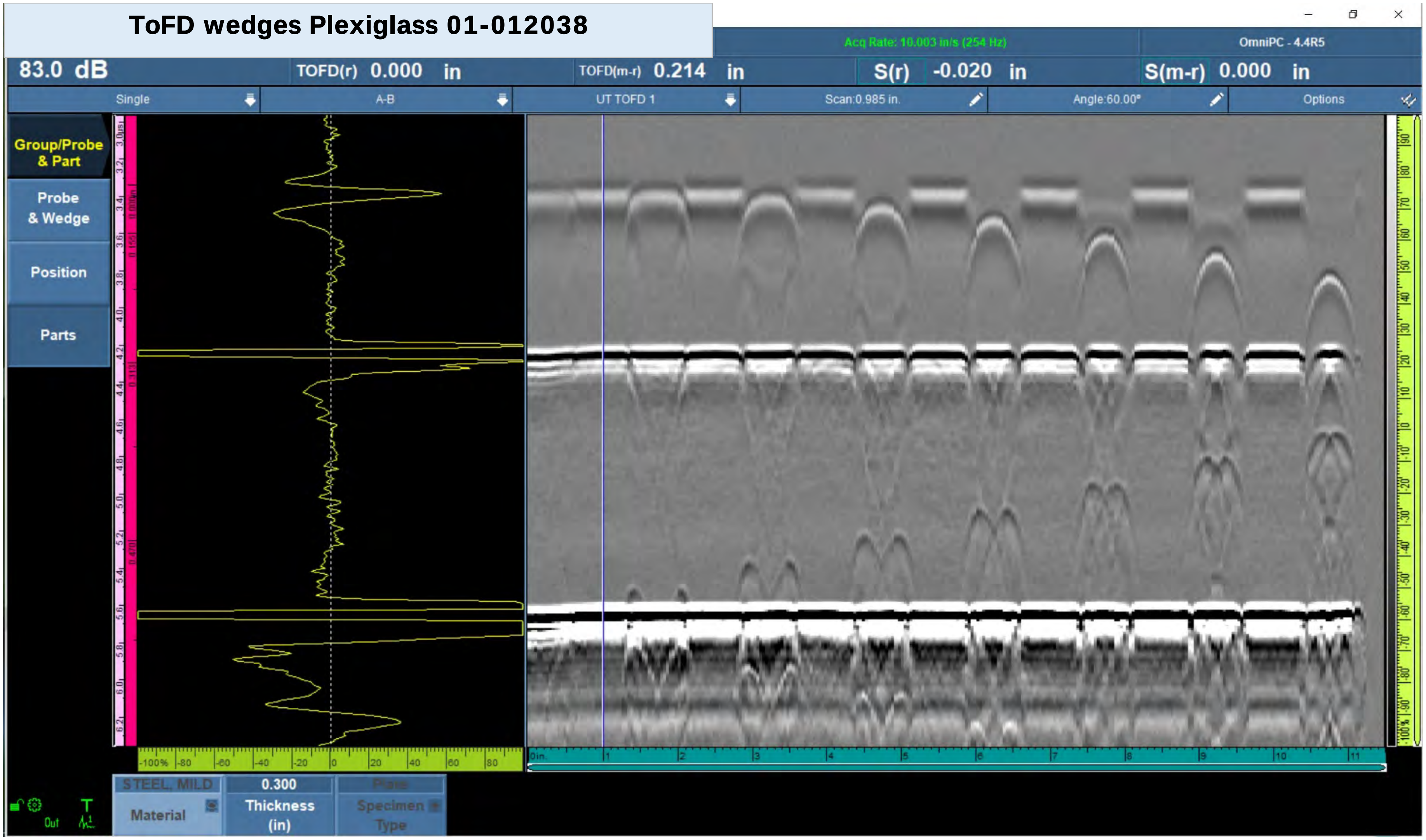


ID notches

8 EDM notoches



ToFD wedges Plexiglass 01-012038



OD notches

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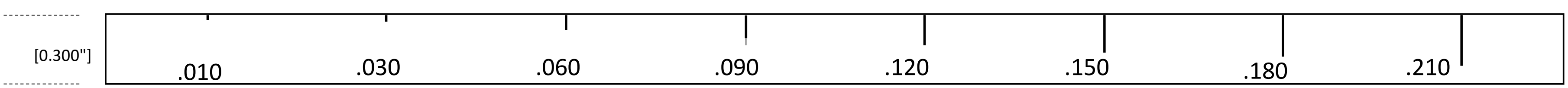
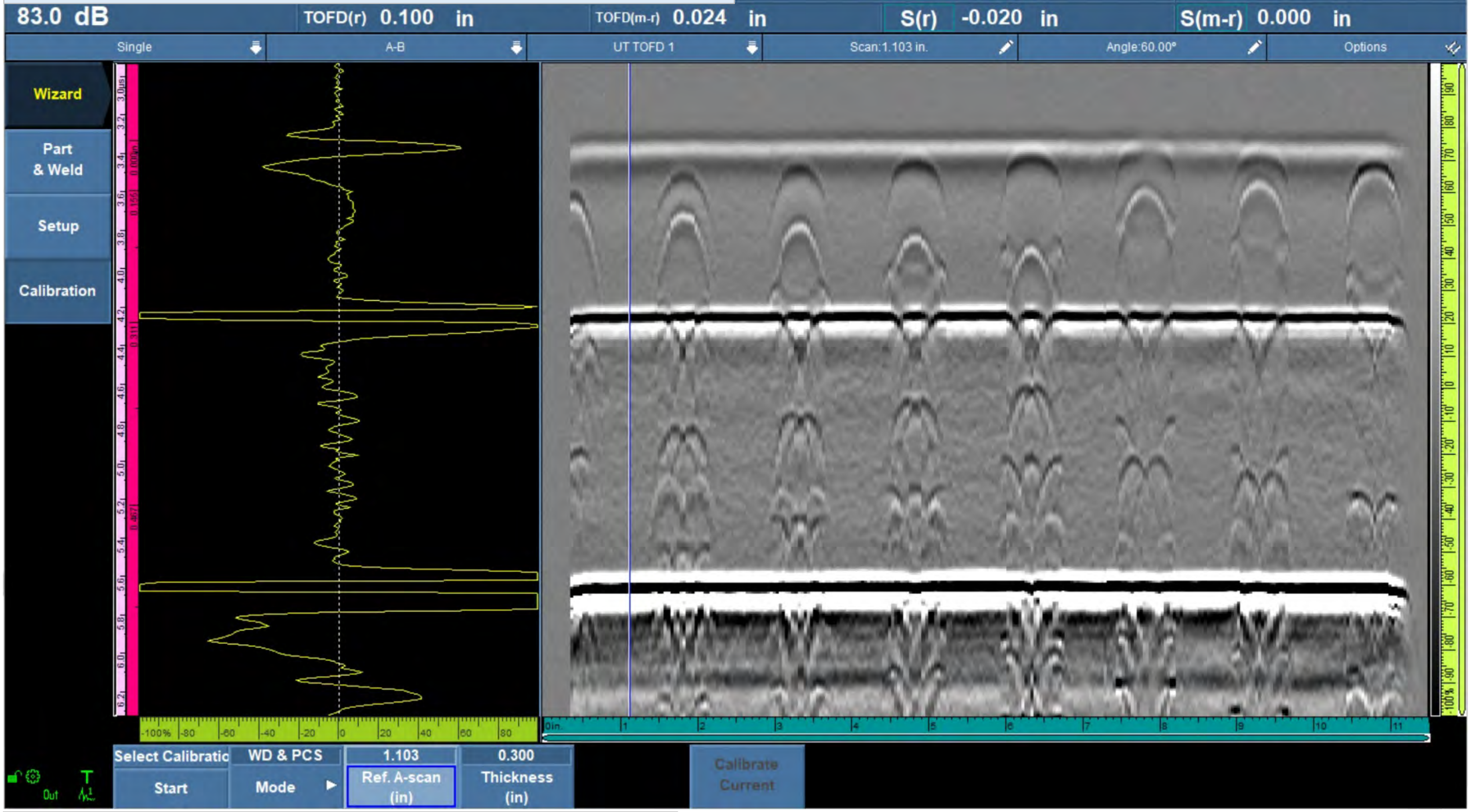
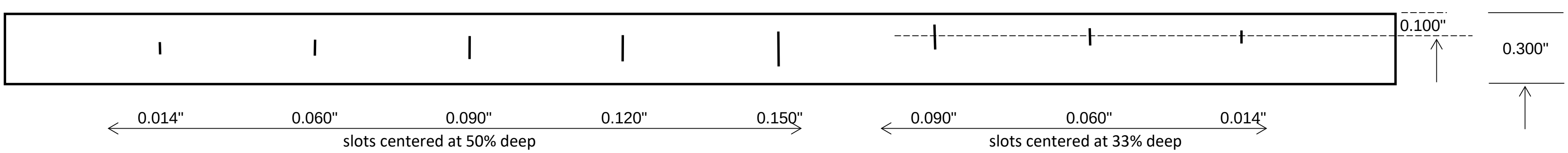


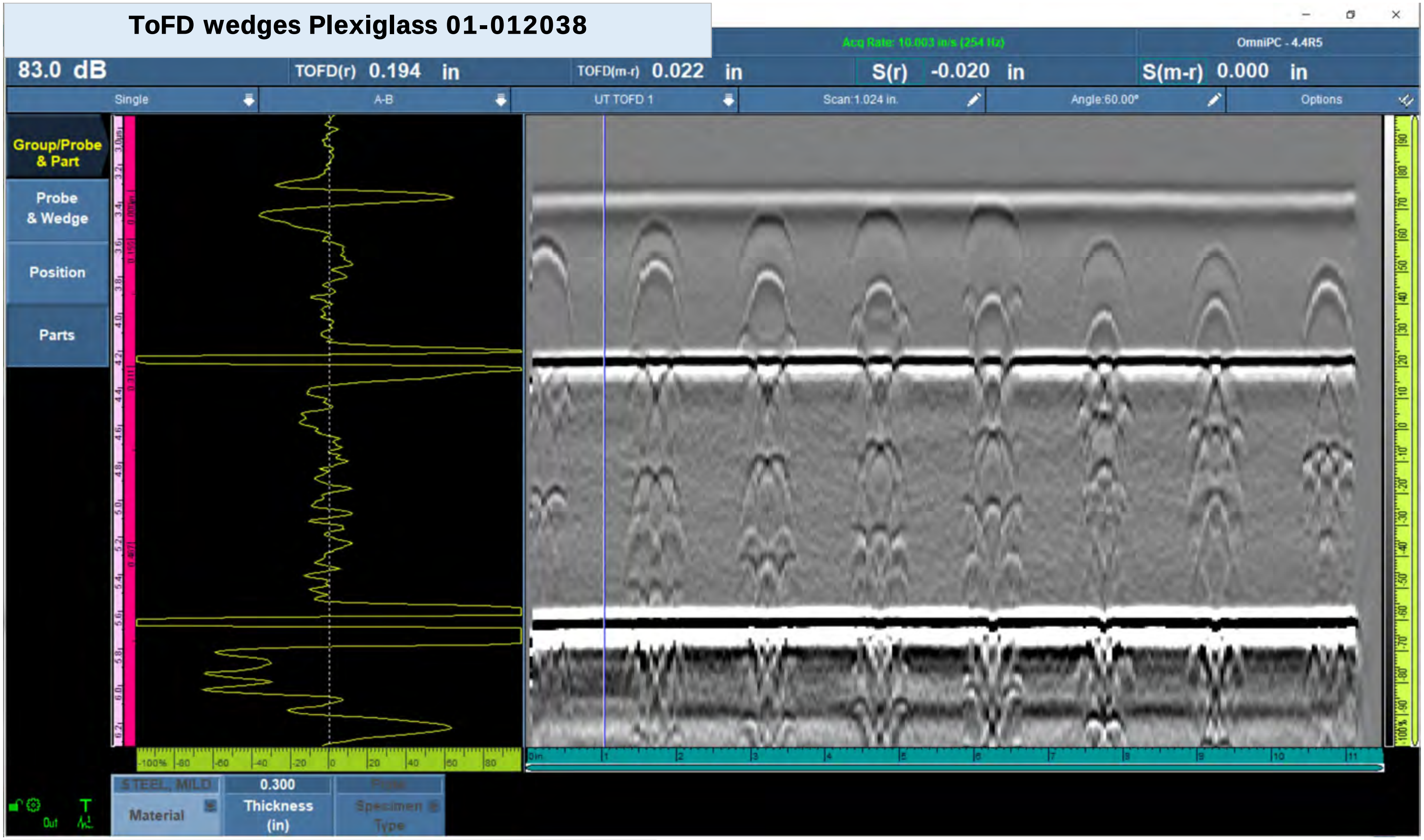
ToFD wedges Plexiglass 01-012038



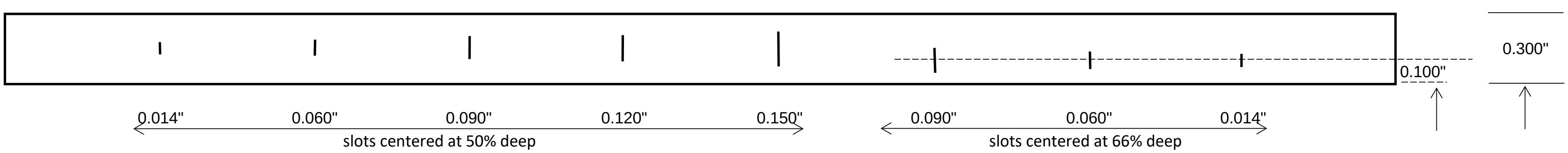
midwall slots, up



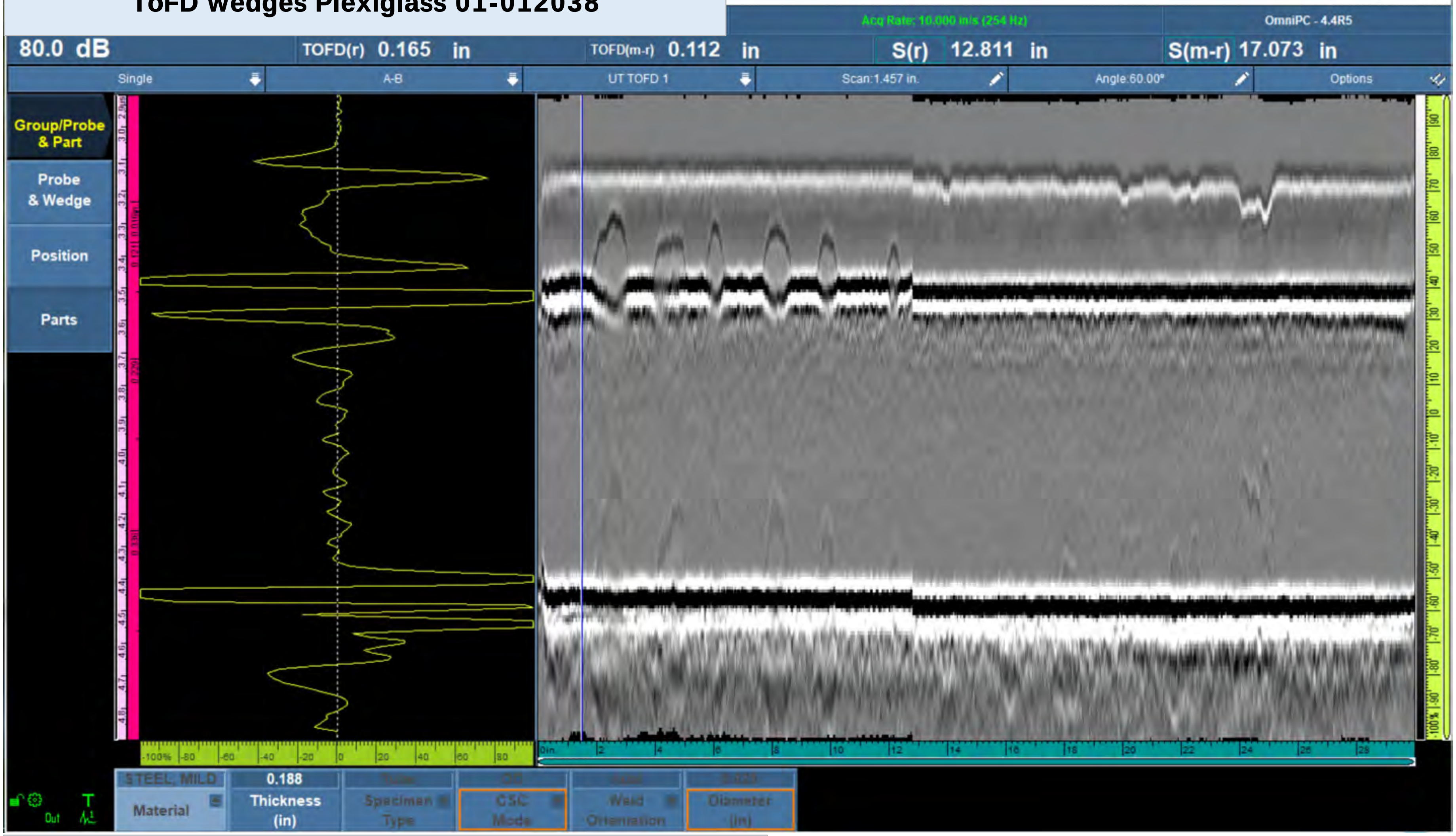
ToFD wedges Plexiglass 01-012038



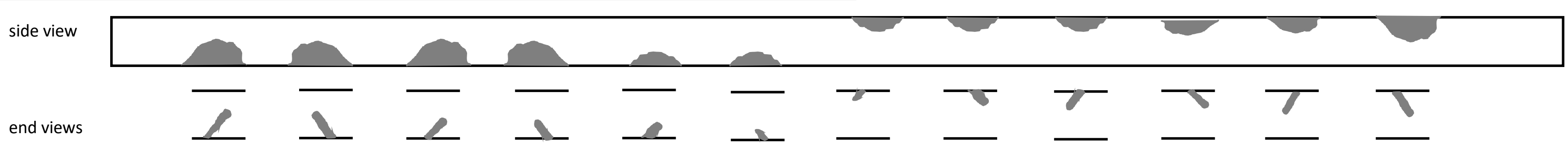
midwall slots, down



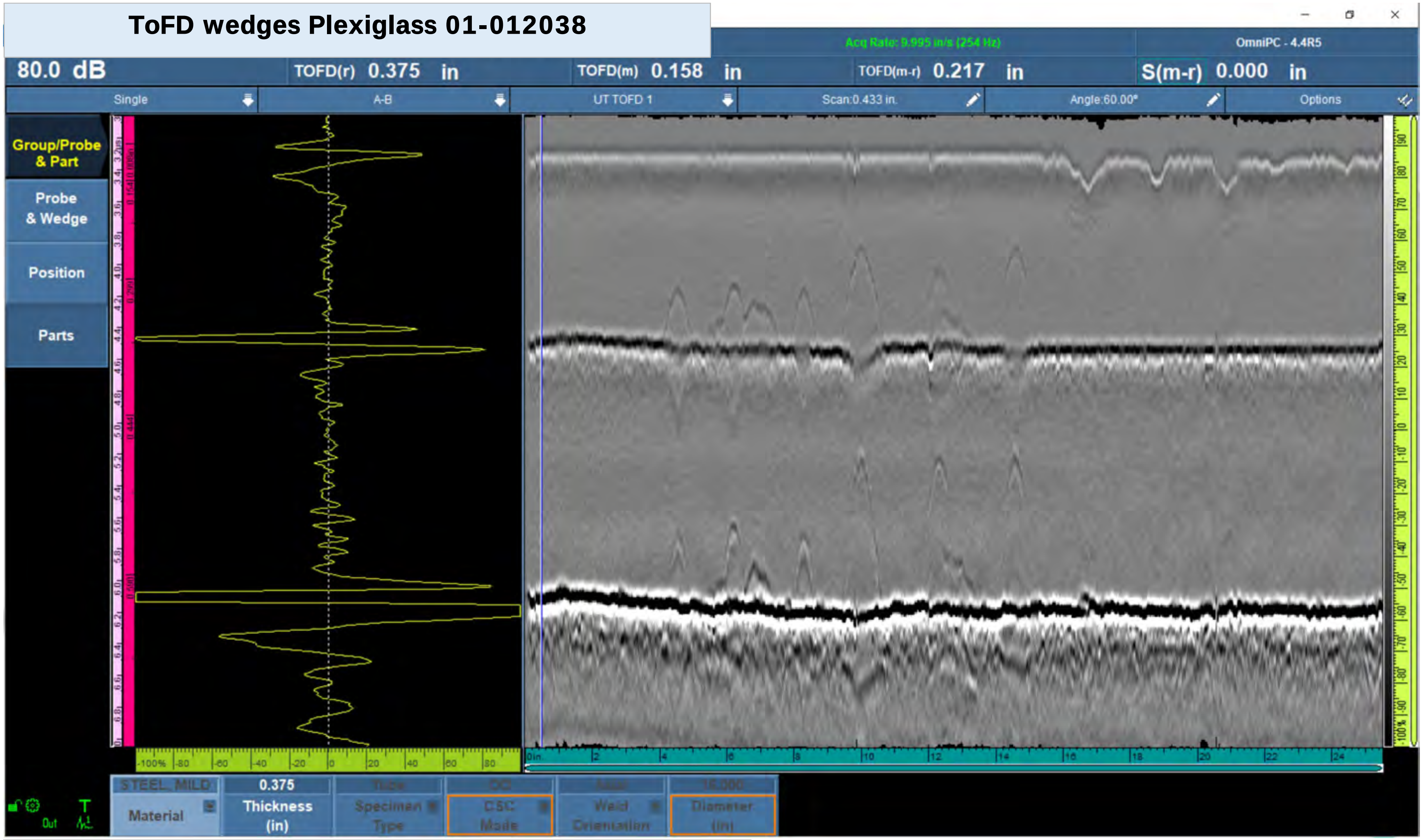
ToFD wedges Plexiglass 01-012038



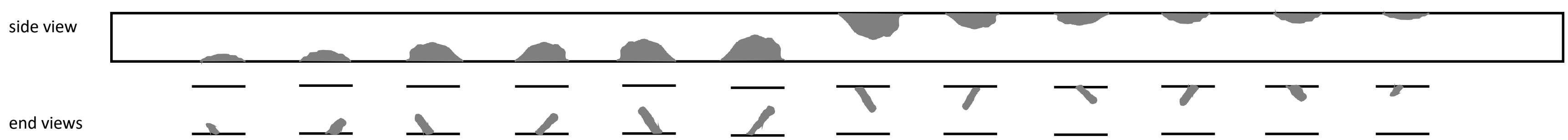
8x188 pipe, long seam, slanted, wafer wheel notches



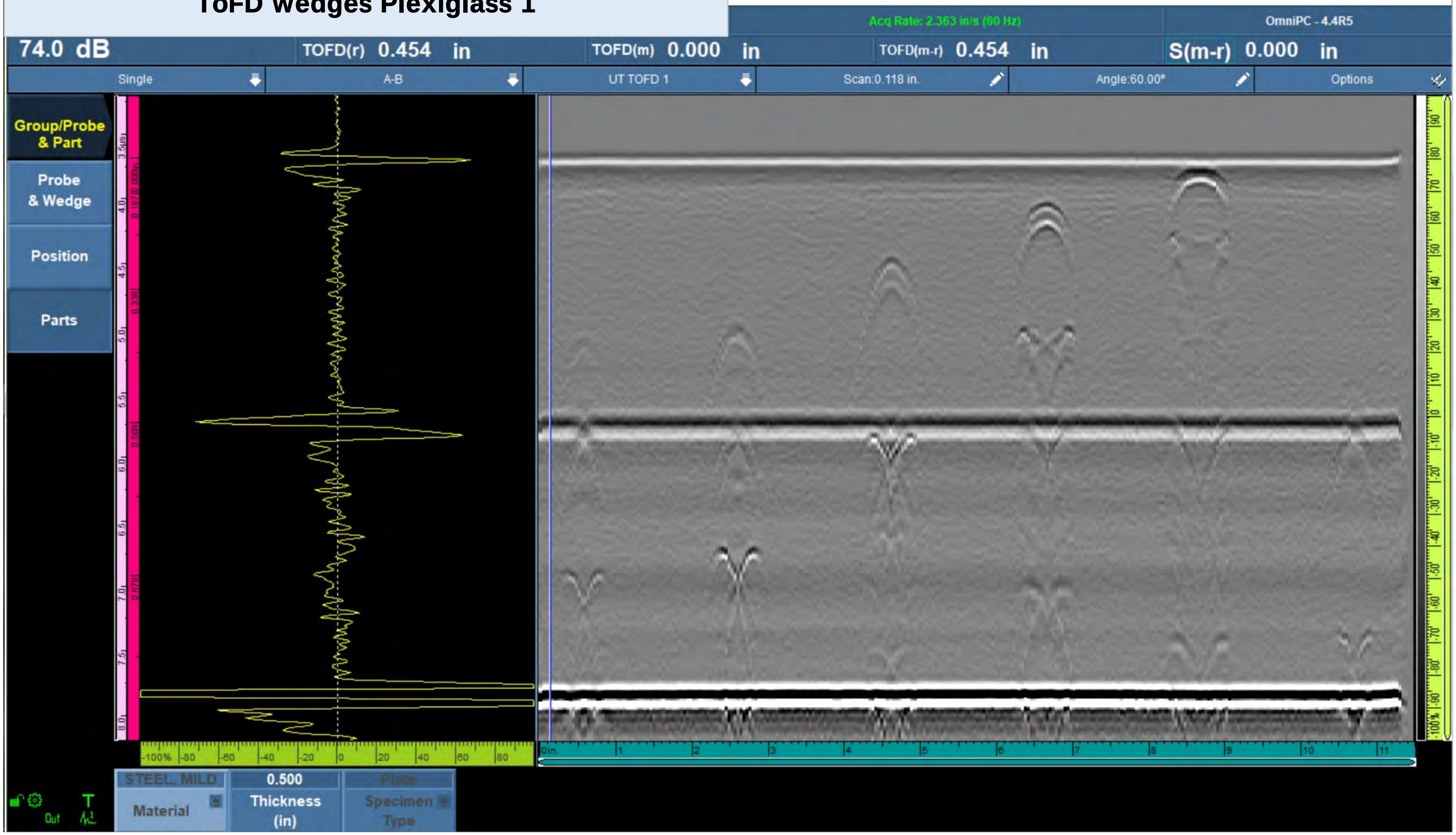
ToFD wedges Plexiglass 01-012038



16x375 pipe, long seam, slanted, wafer wheel notches



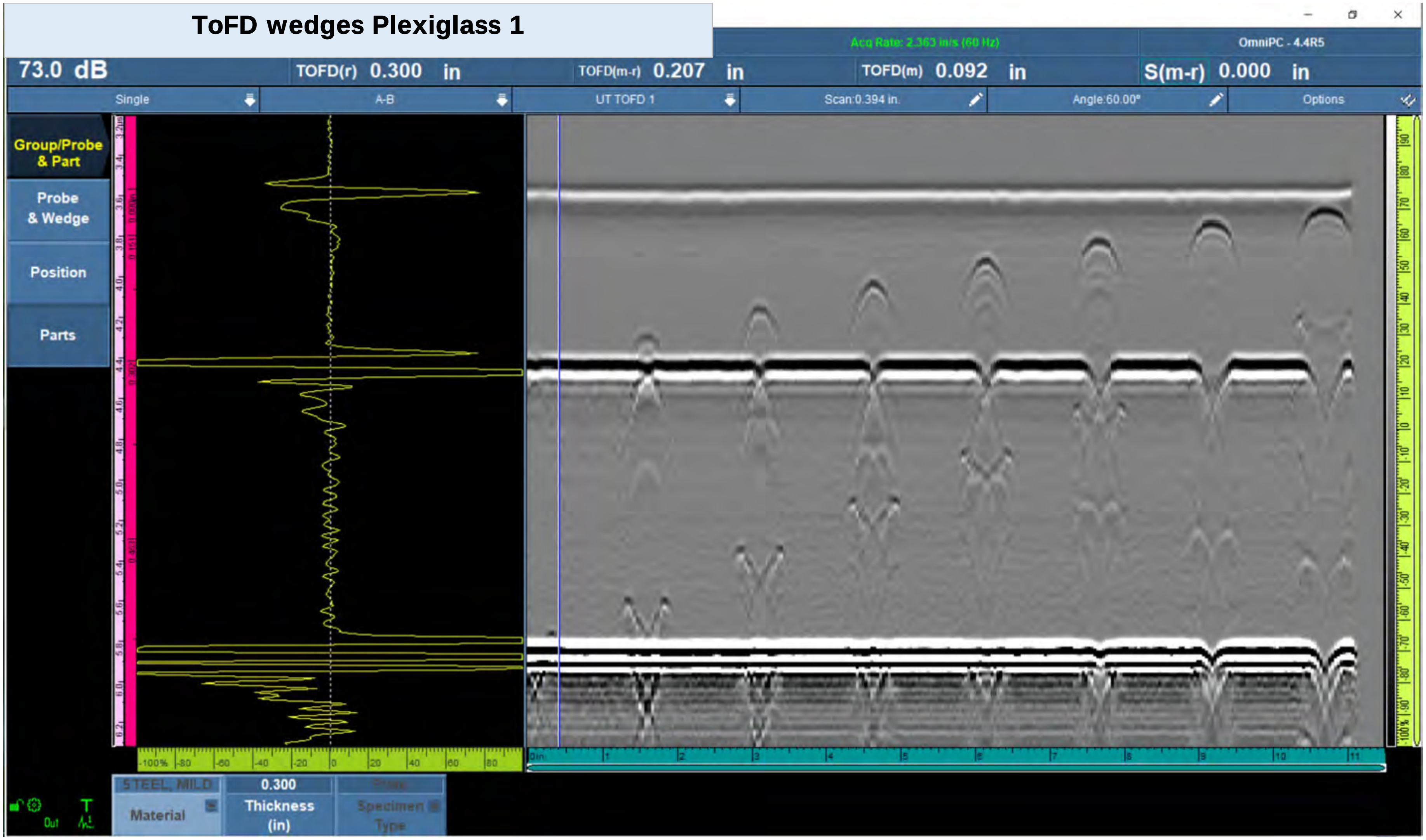
ToFD wedges Plexiglass 1



FAST1 cal block

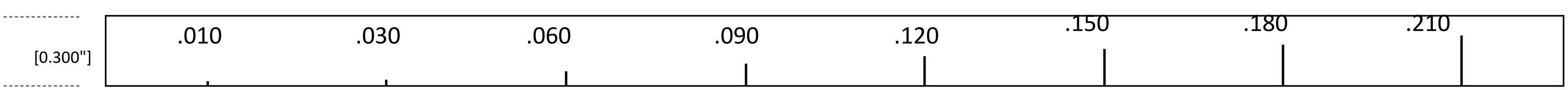
4 side drilled holes, two EDM notoches

ToFD wedges Plexiglass 1

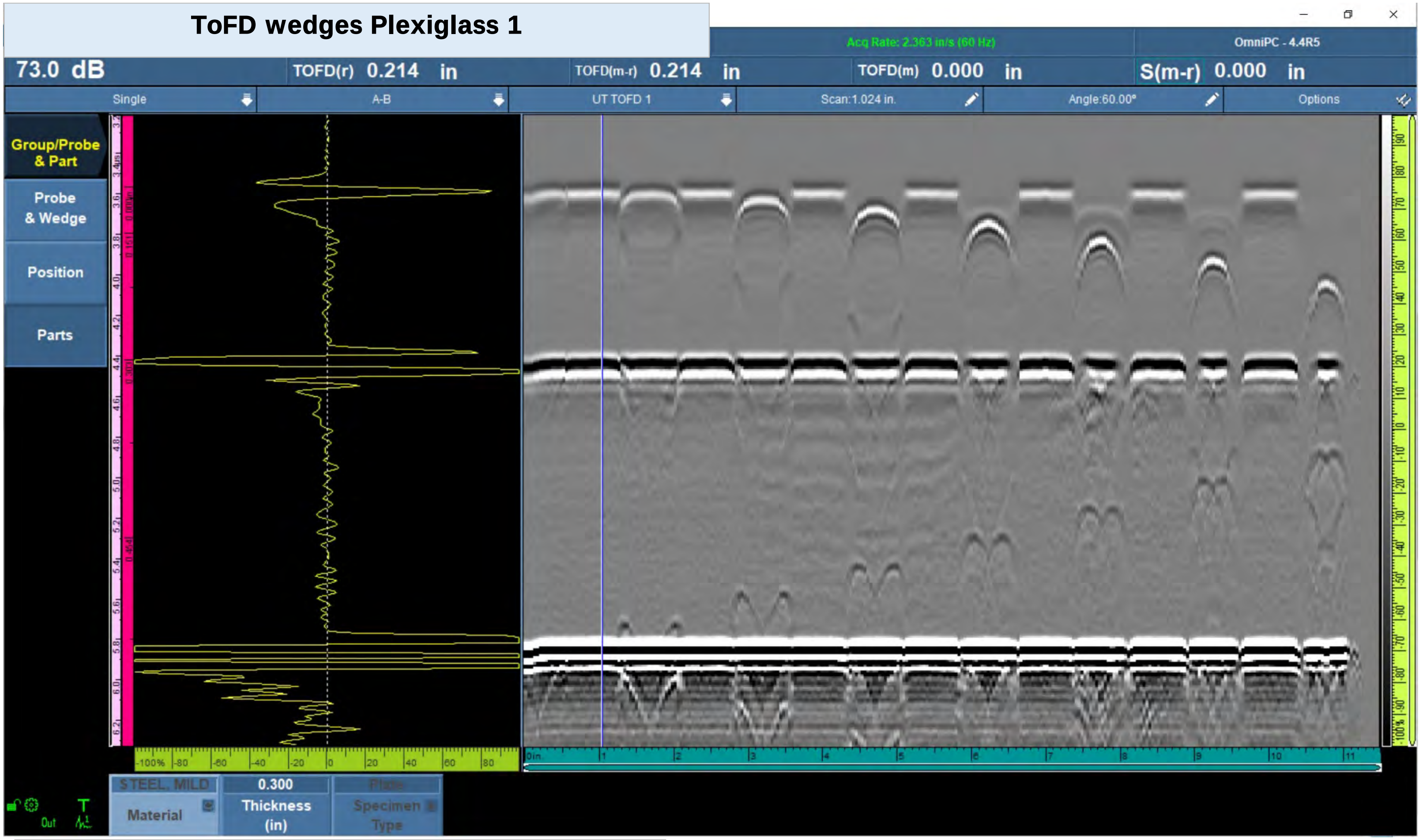


ID notches

8 EDM notoches

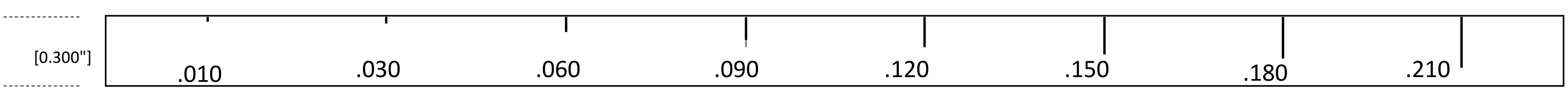


ToFD wedges Plexiglass 1

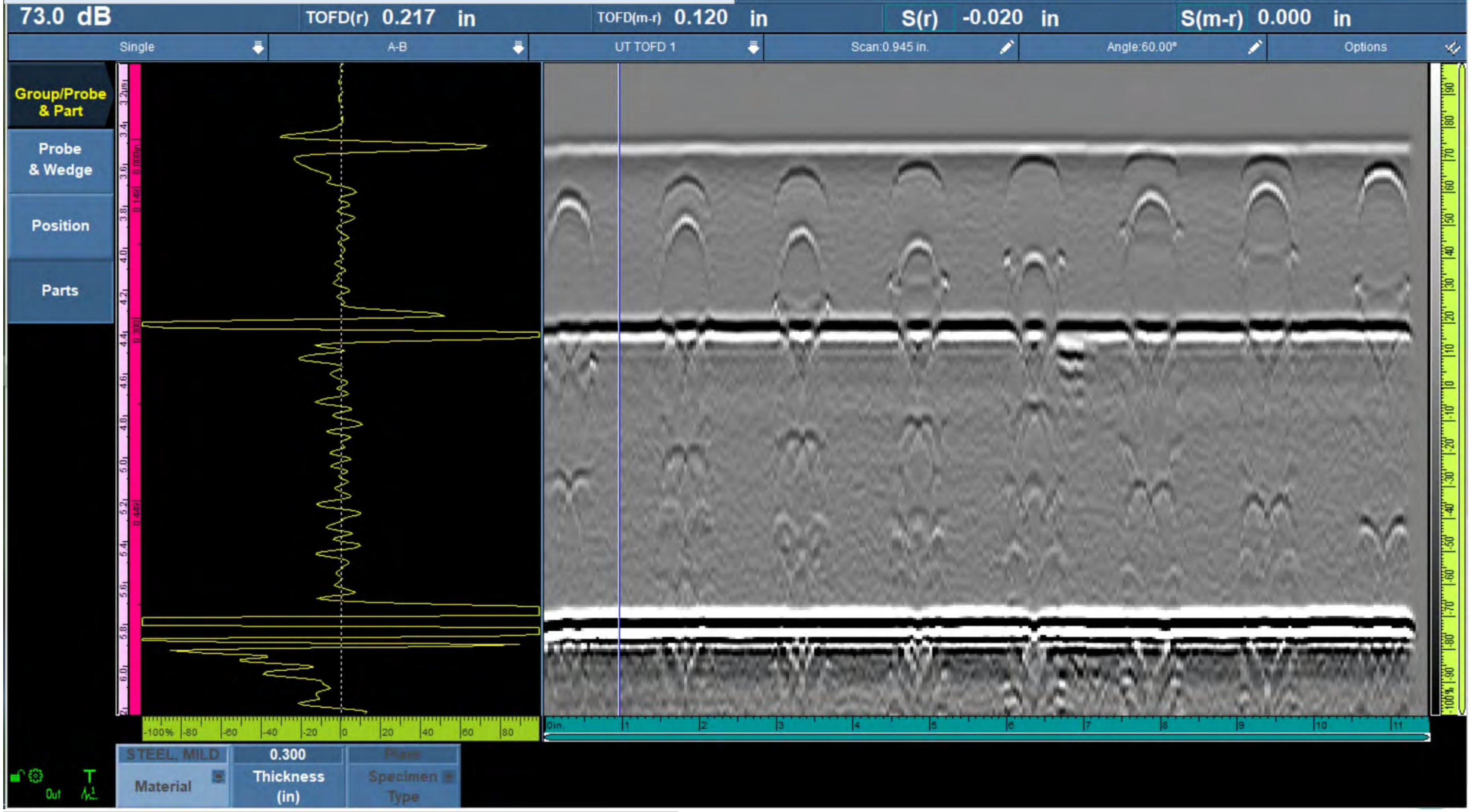


OD notches

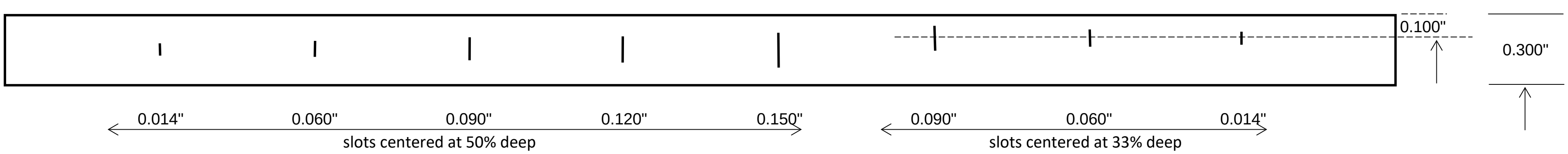
8 EDM notoches



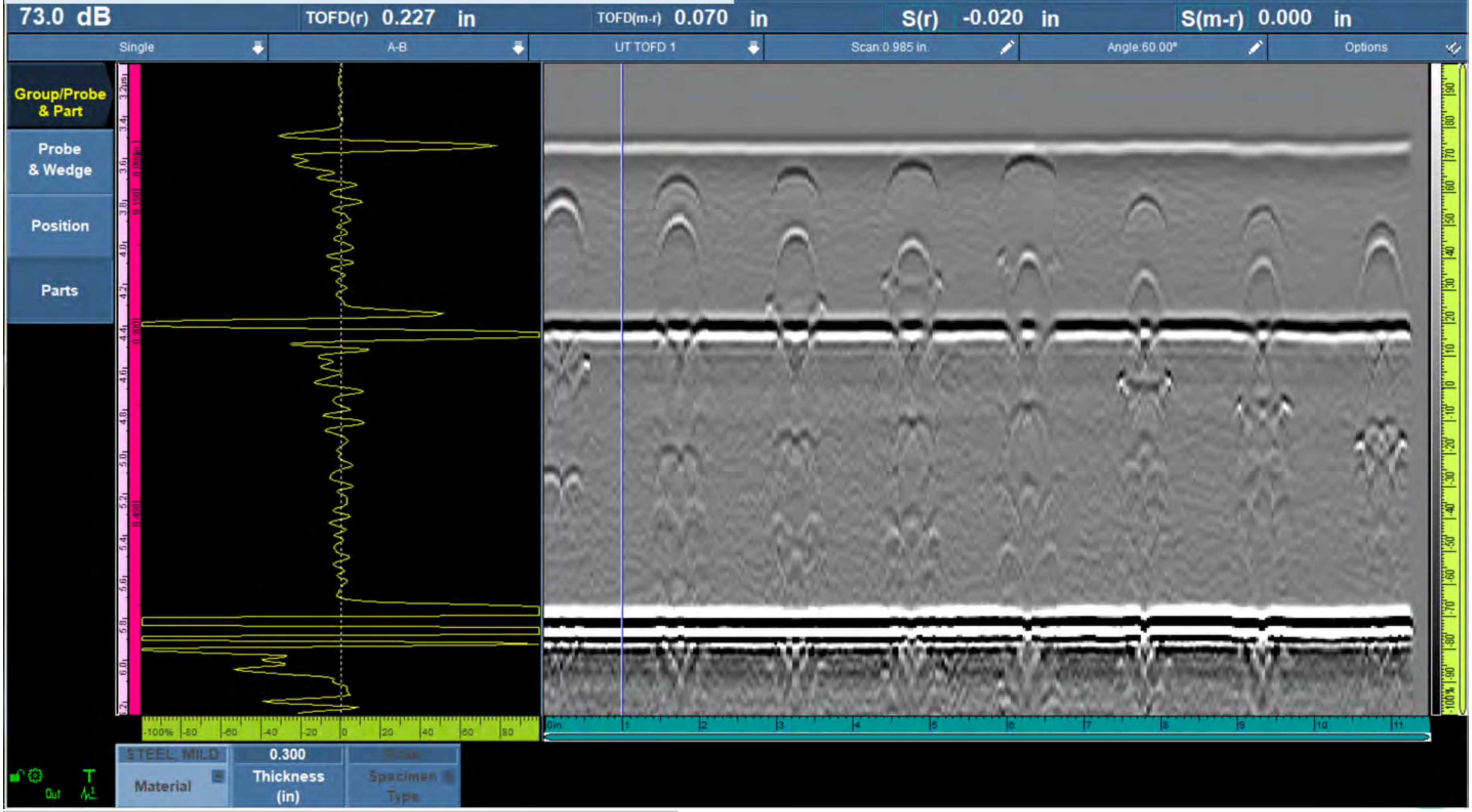
ToFD wedges Plexiglass 1



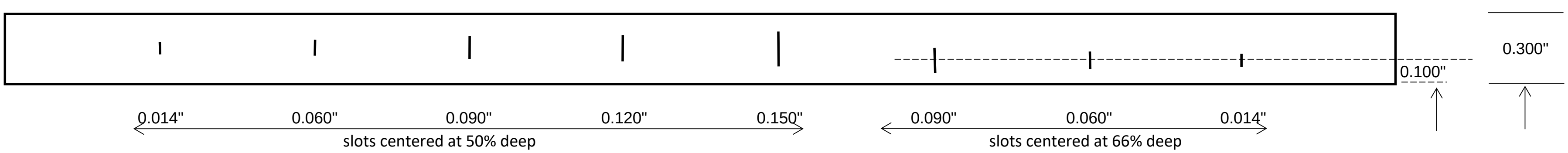
midwall slots, up



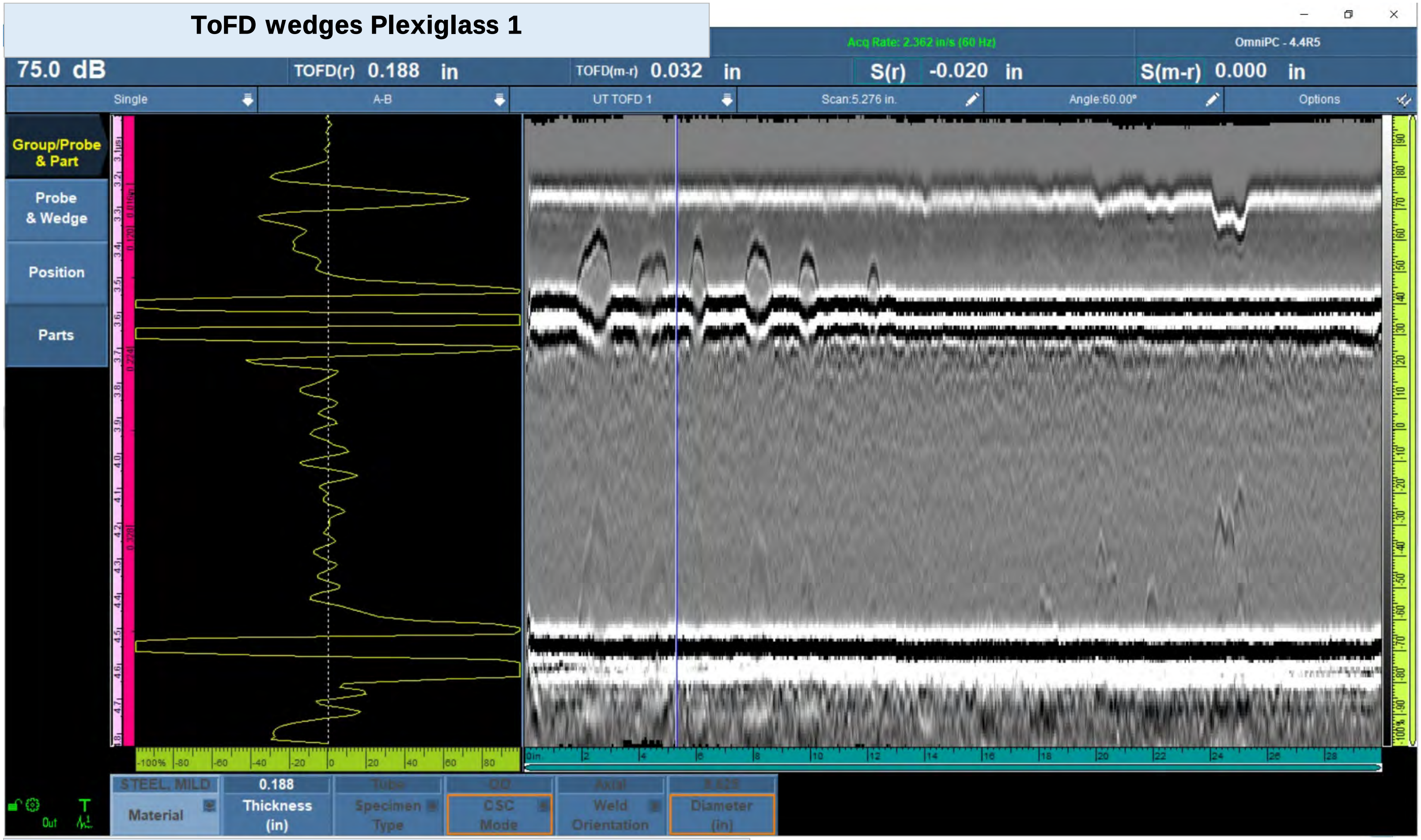
ToFD wedges Plexiglass 1



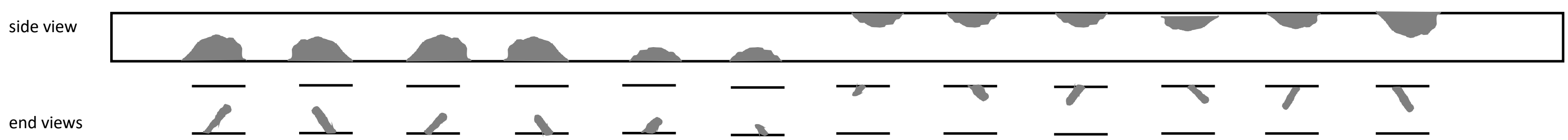
midwall slots, down



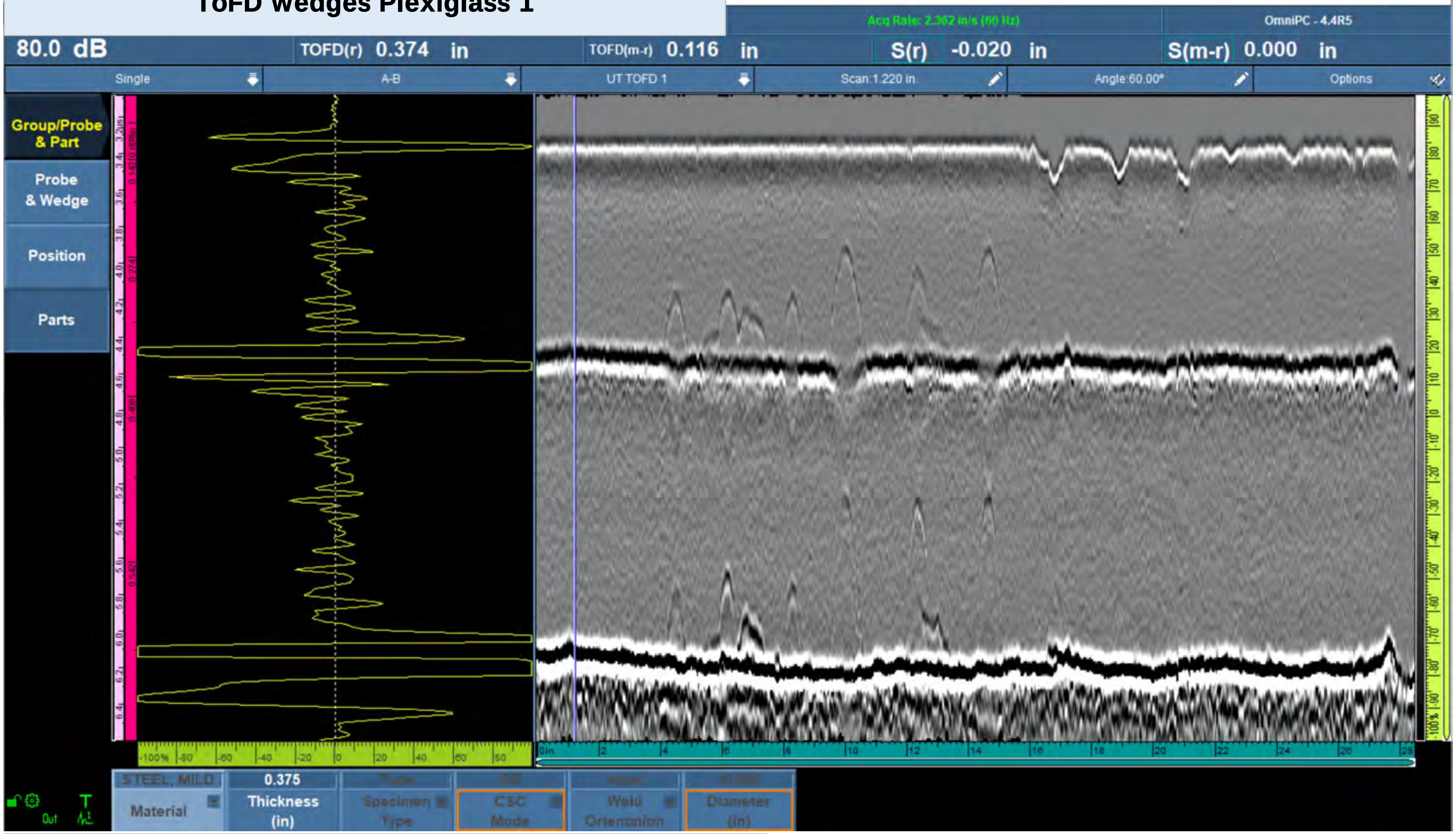
ToFD wedges Plexiglass 1



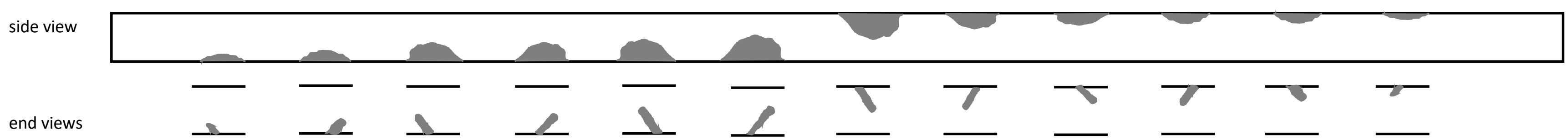
8x188 pipe, long seam, slanted, wafer wheel notches



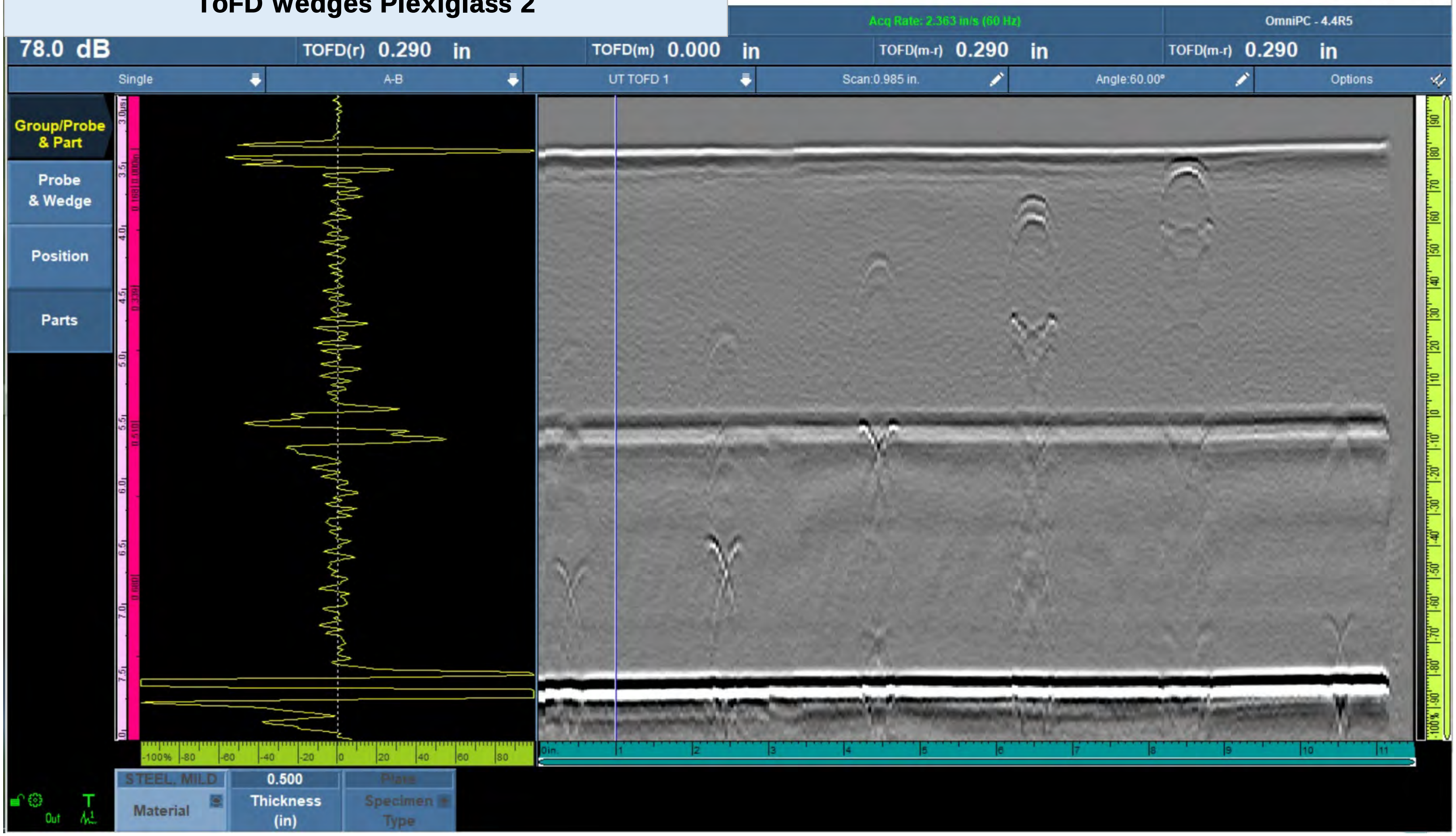
ToFD wedges Plexiglass 1



16x375 pipe, long seam, slanted, wafer wheel notches

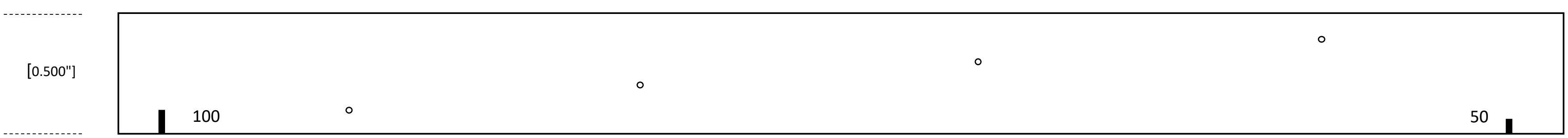


ToFD wedges Plexiglass 2

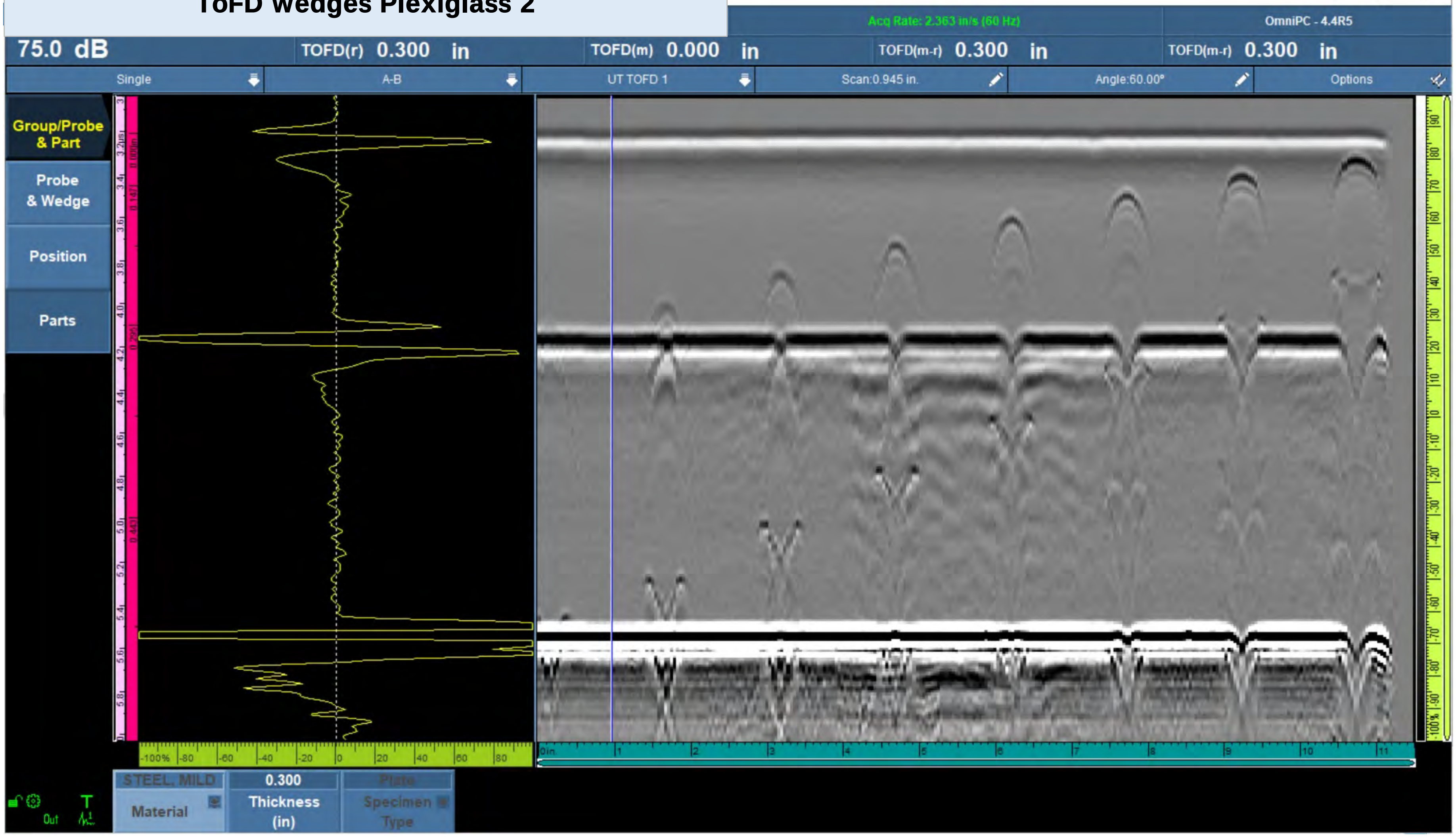


FAST1 cal block

4 side drilled holes, two EDM notoches

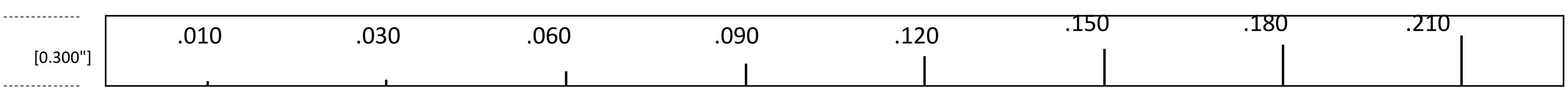


ToFD wedges Plexiglass 2

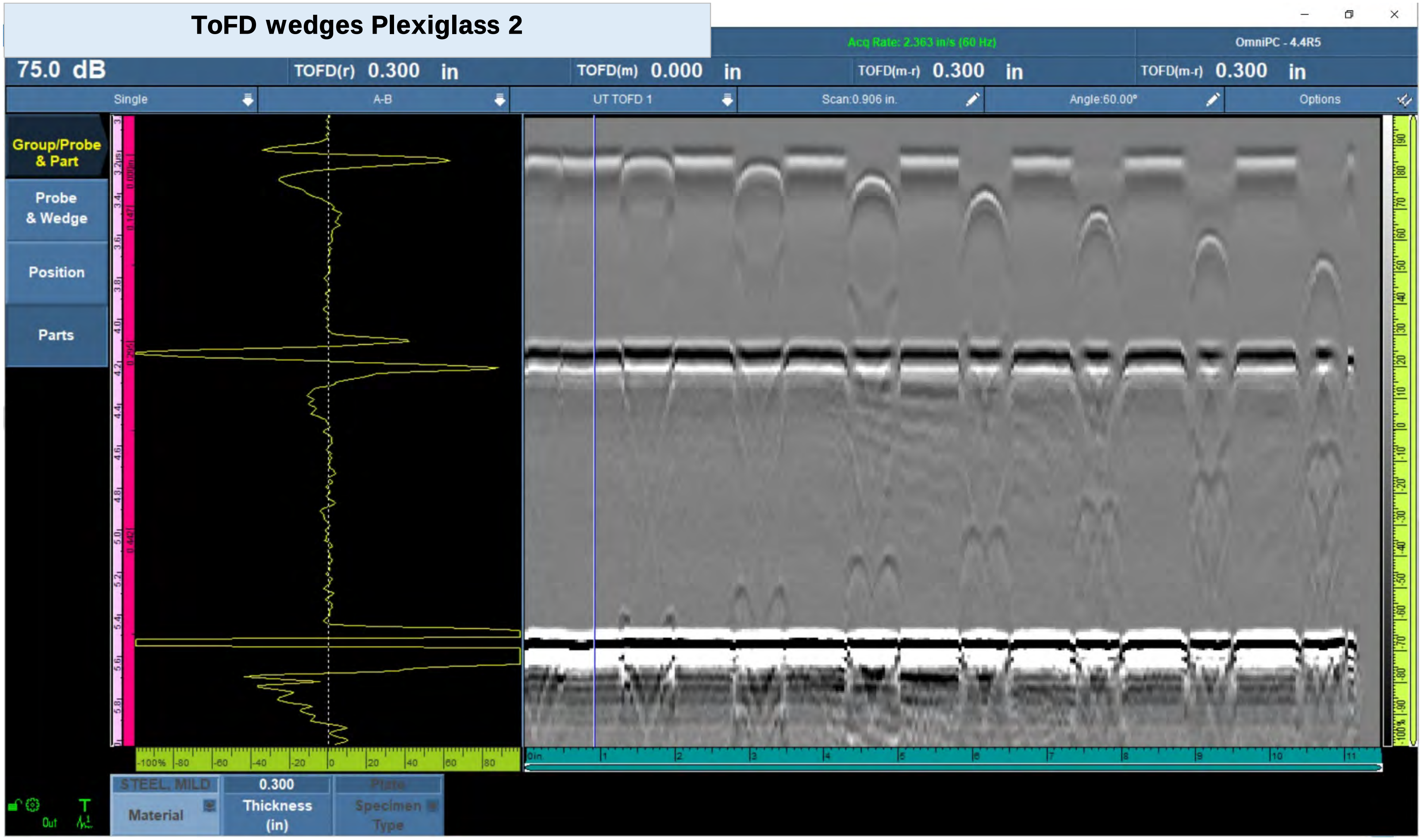


ID notches

8 EDM notoches



ToFD wedges Plexiglass 2



OD notches

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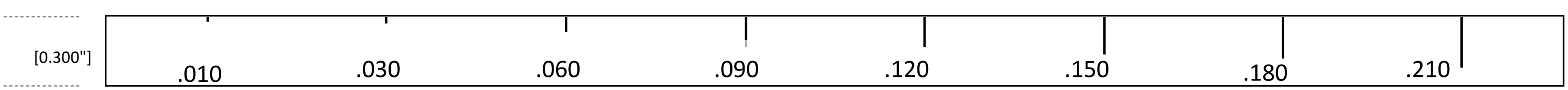
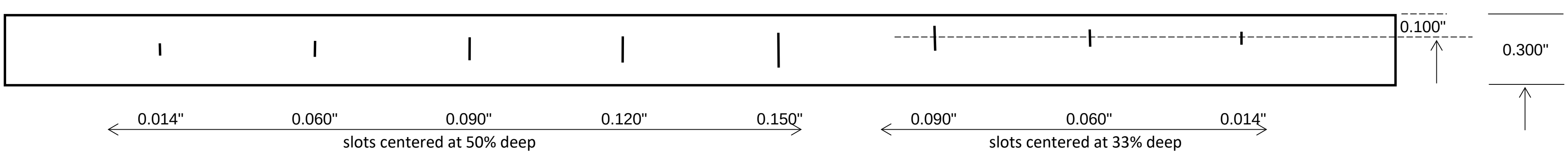
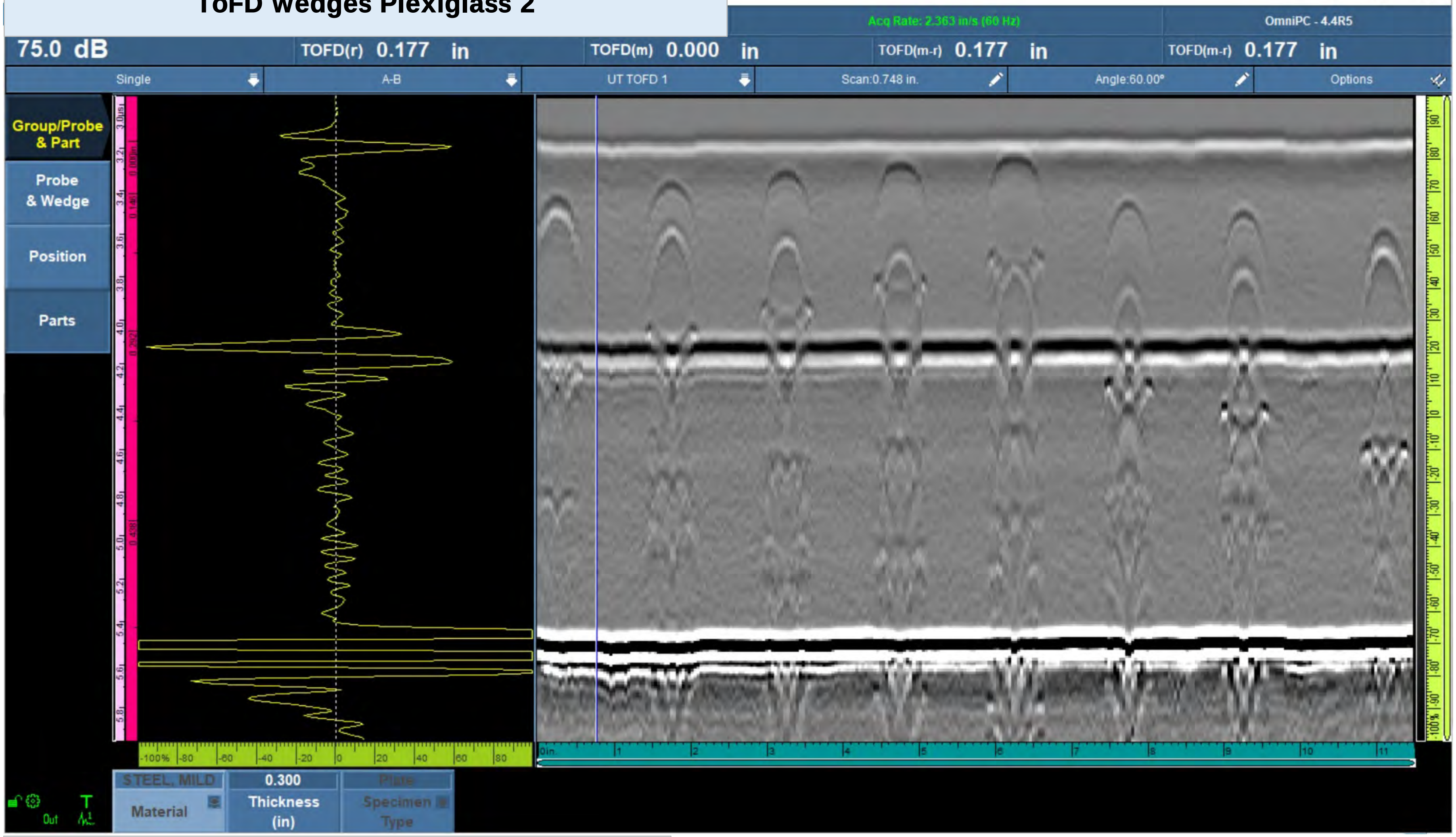


ToFD wedges Plexiglass 2

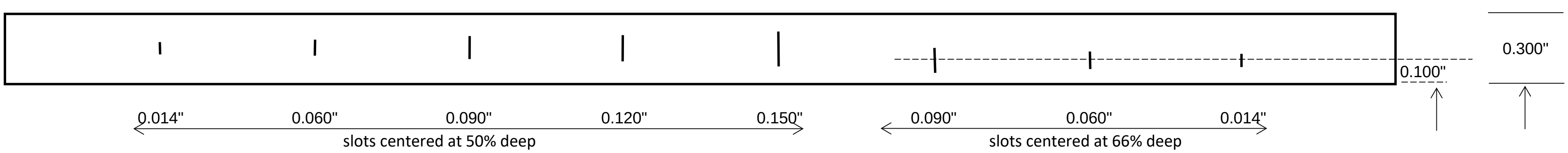
midwall slots, up



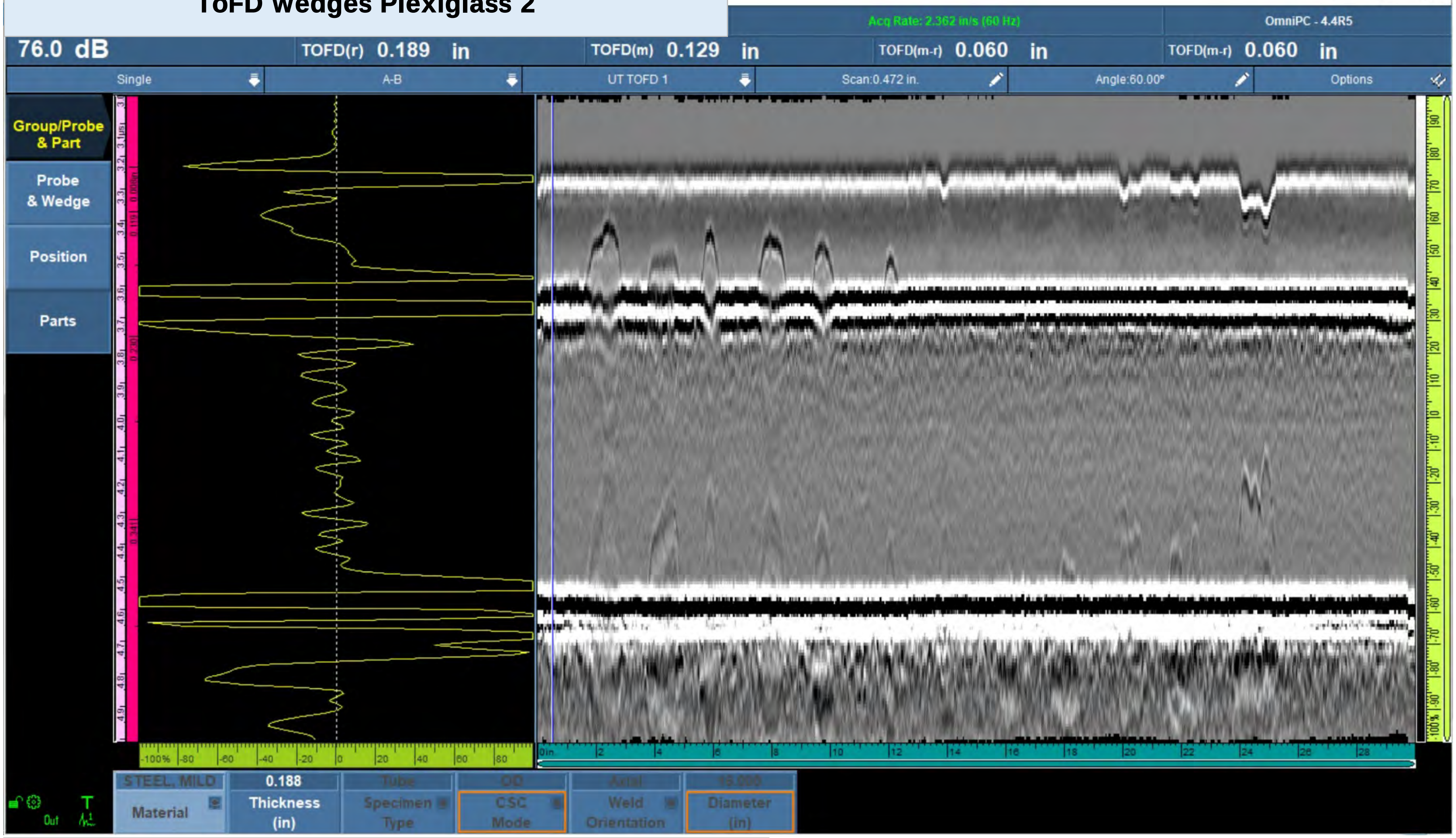
ToFD wedges Plexiglass 2



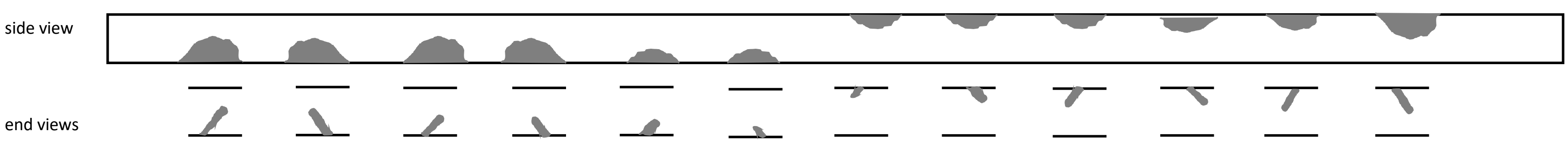
midwall slots, down



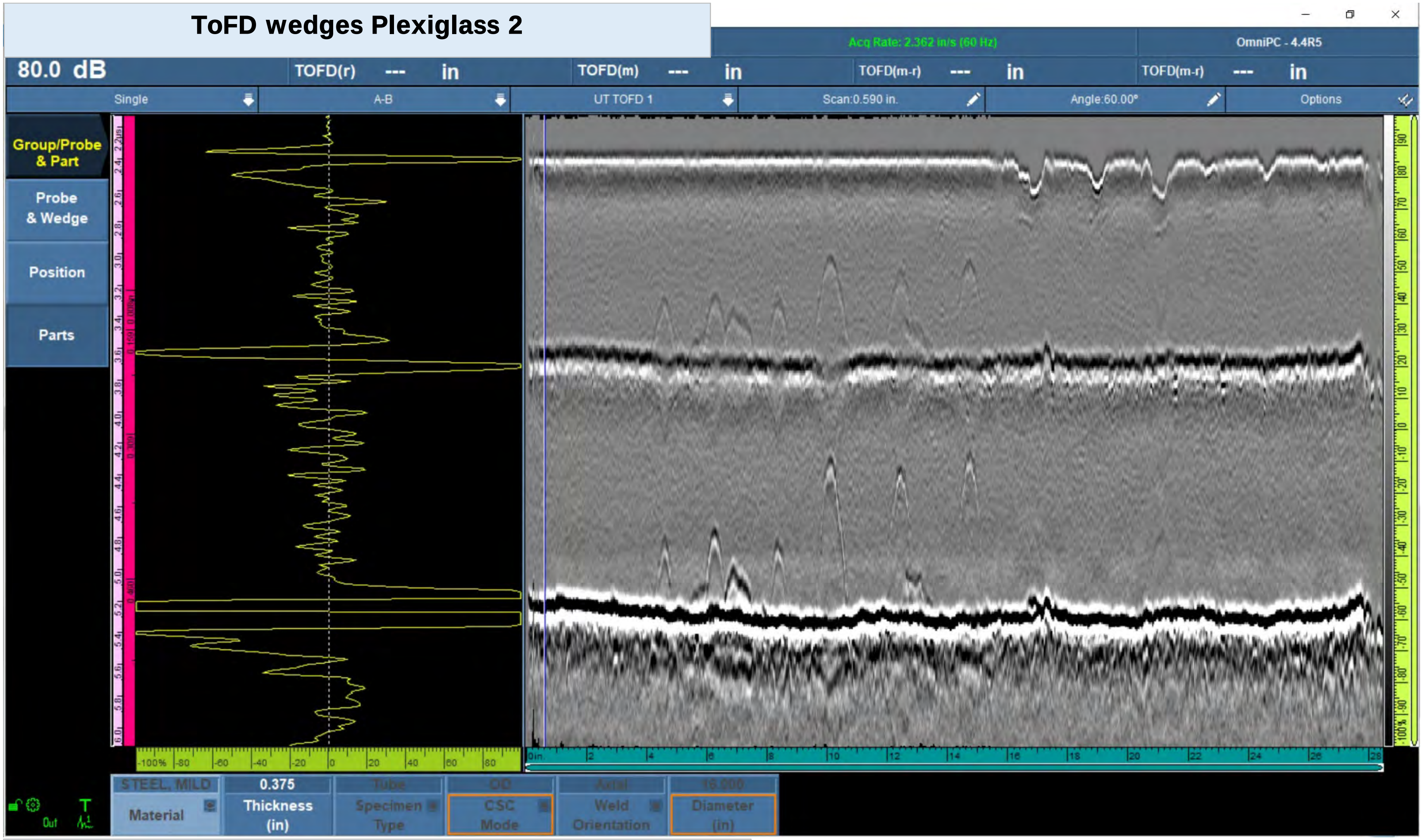
ToFD wedges Plexiglass 2



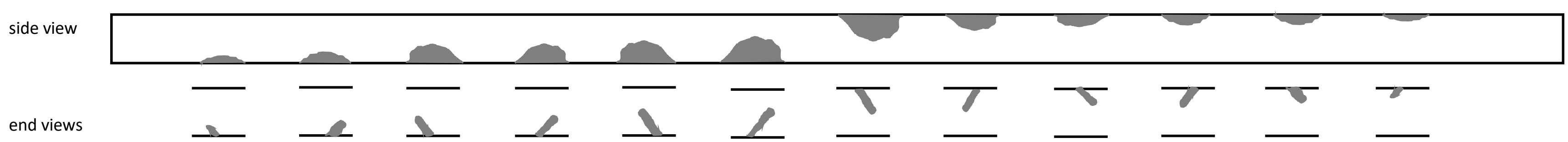
8x188 pipe, long seam, slanted, wafer wheel notches



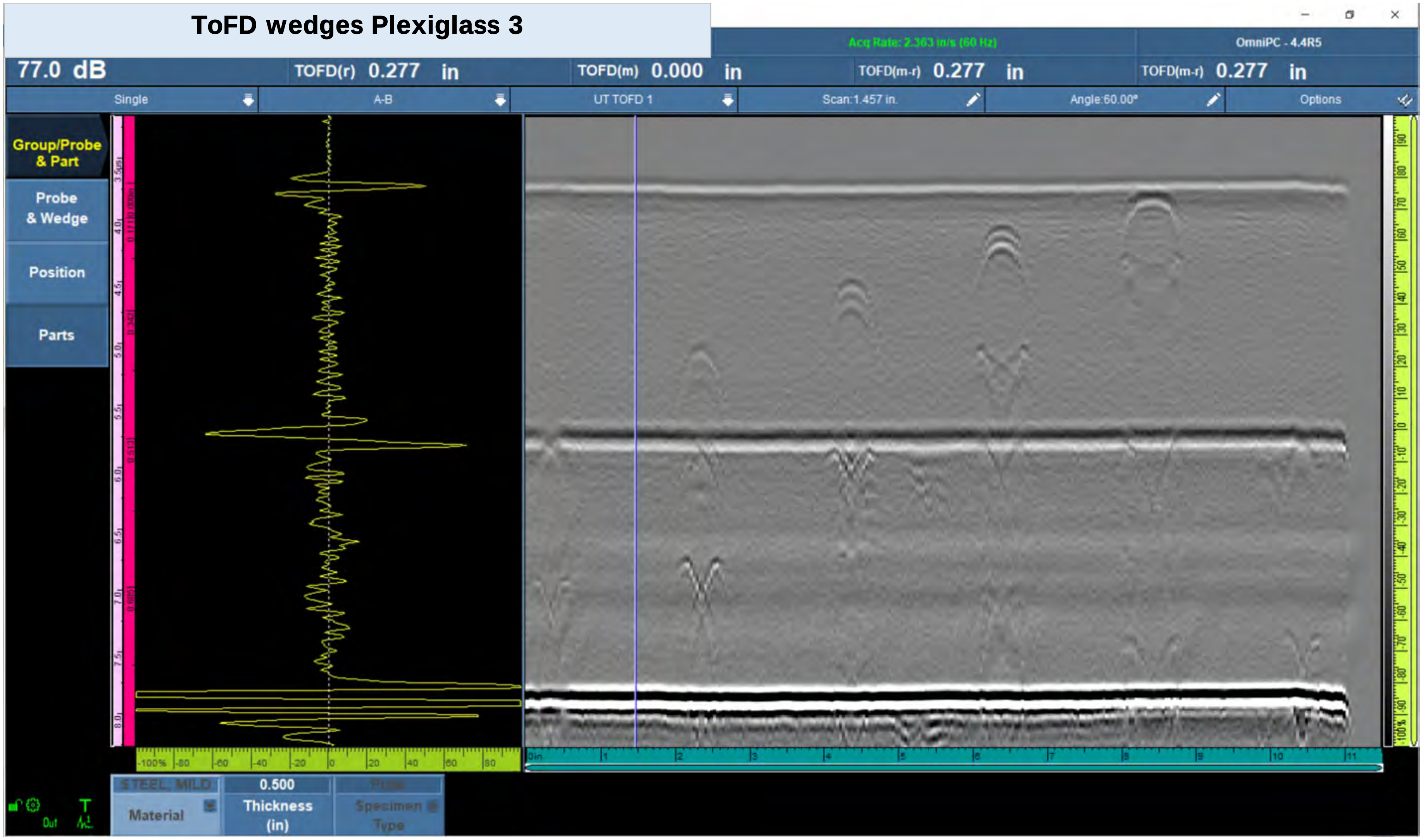
ToFD wedges Plexiglass 2



16x375 pipe, long seam, slanted, wafer wheel notches



ToFD wedges Plexiglass 3



FAST1 cal block

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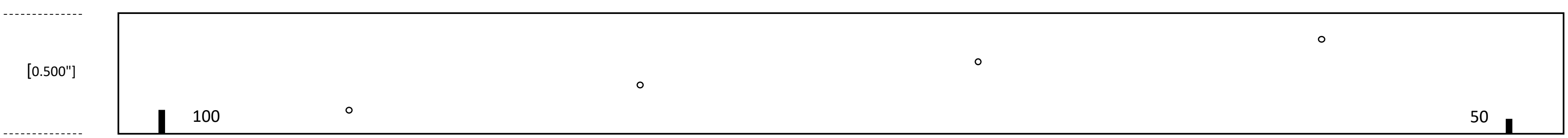
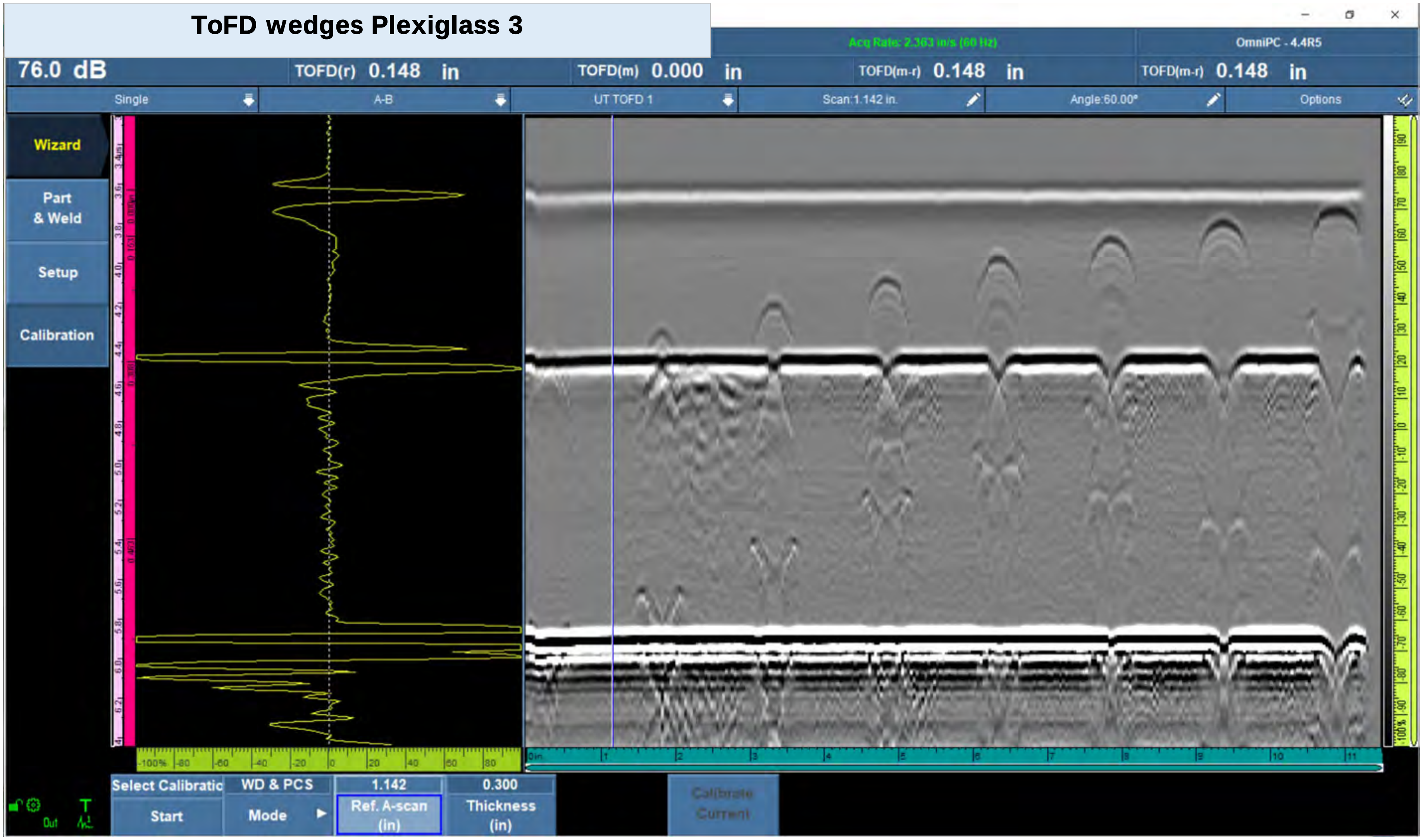


ToFD wedges Plexiglass 3



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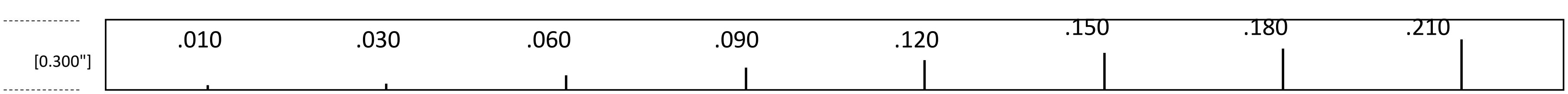
8 EDM notoches



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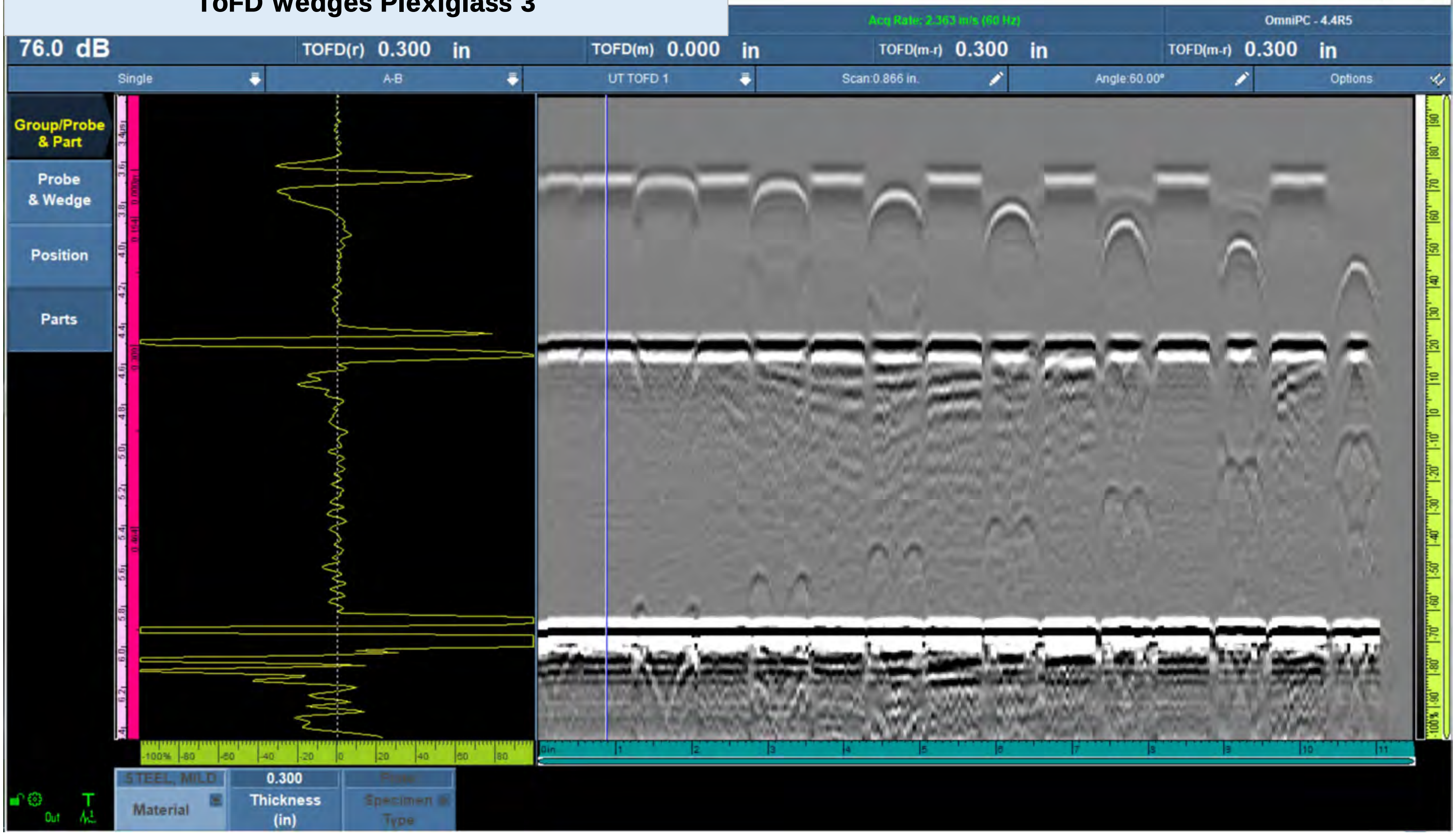

OD notches

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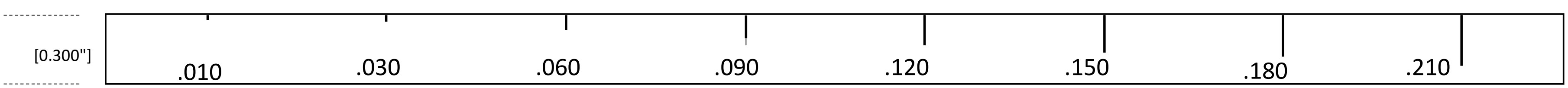
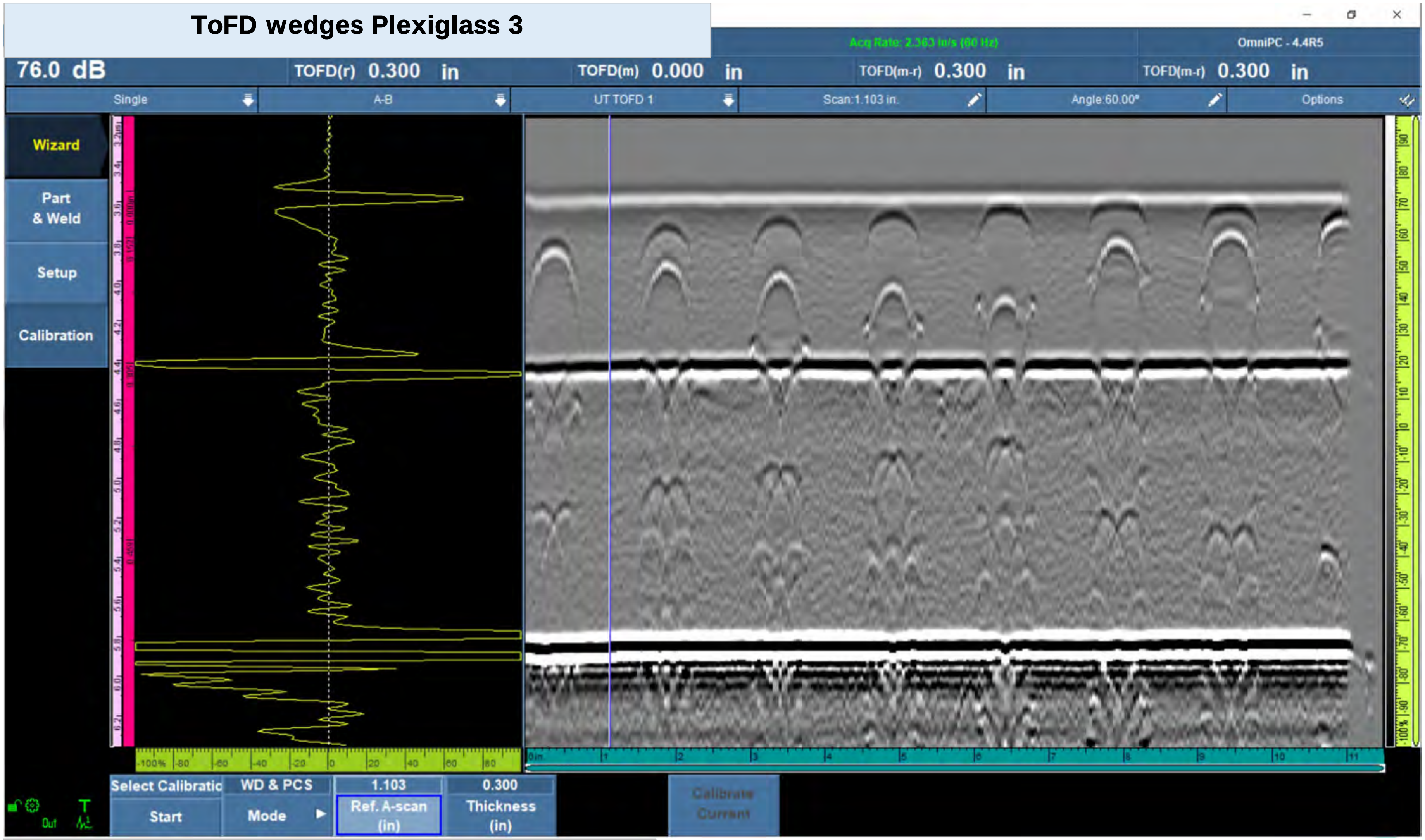
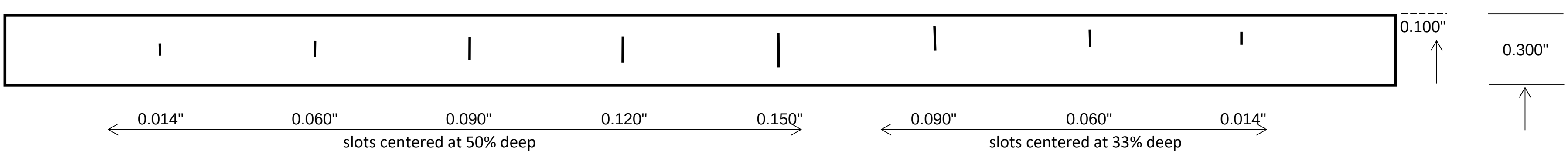


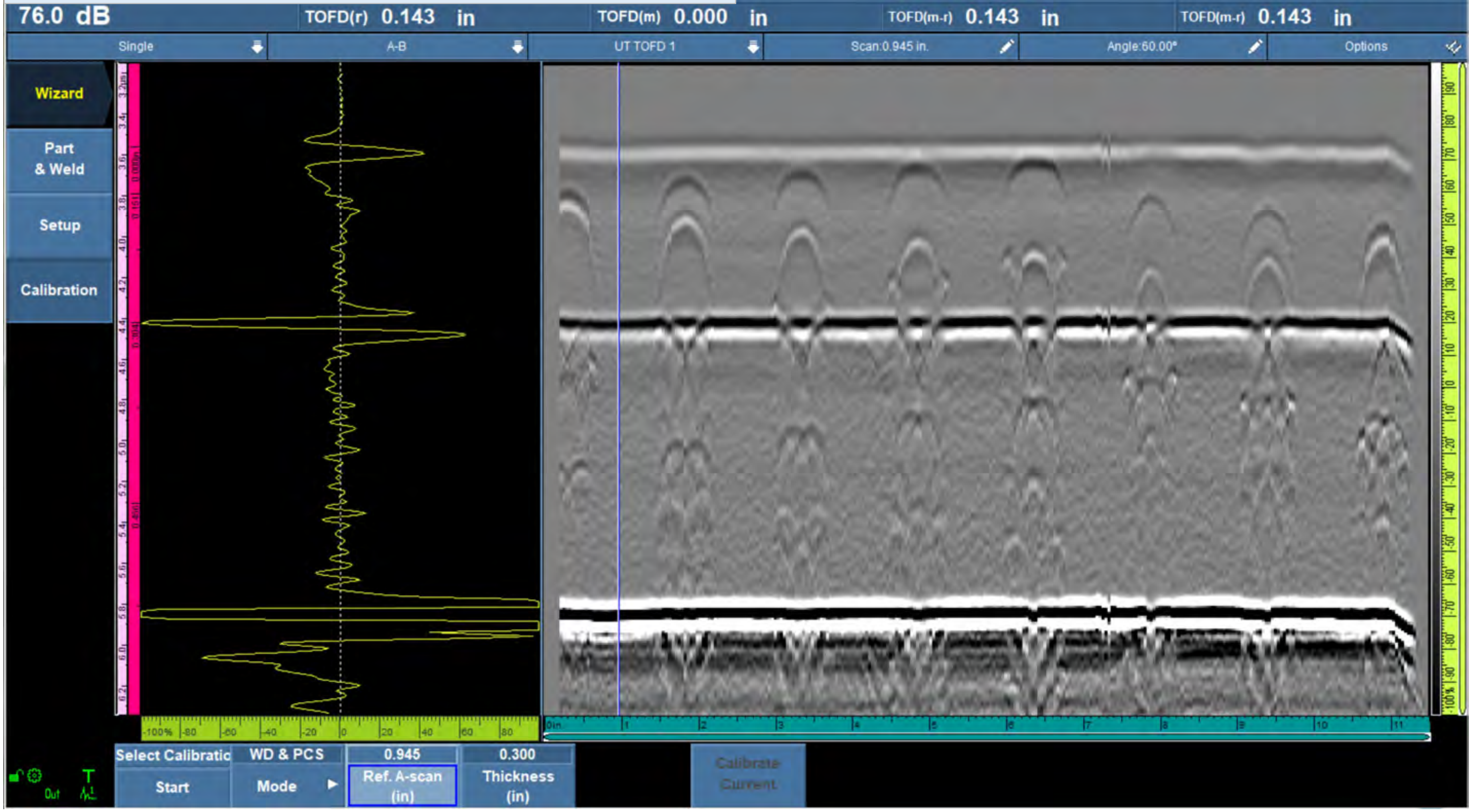
ToFD wedges Plexiglass 3



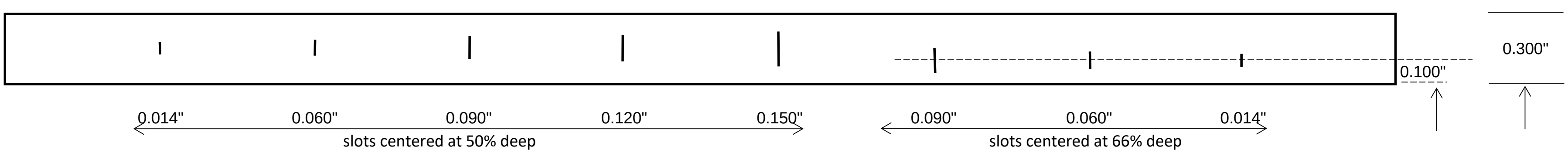
midwall slots, up



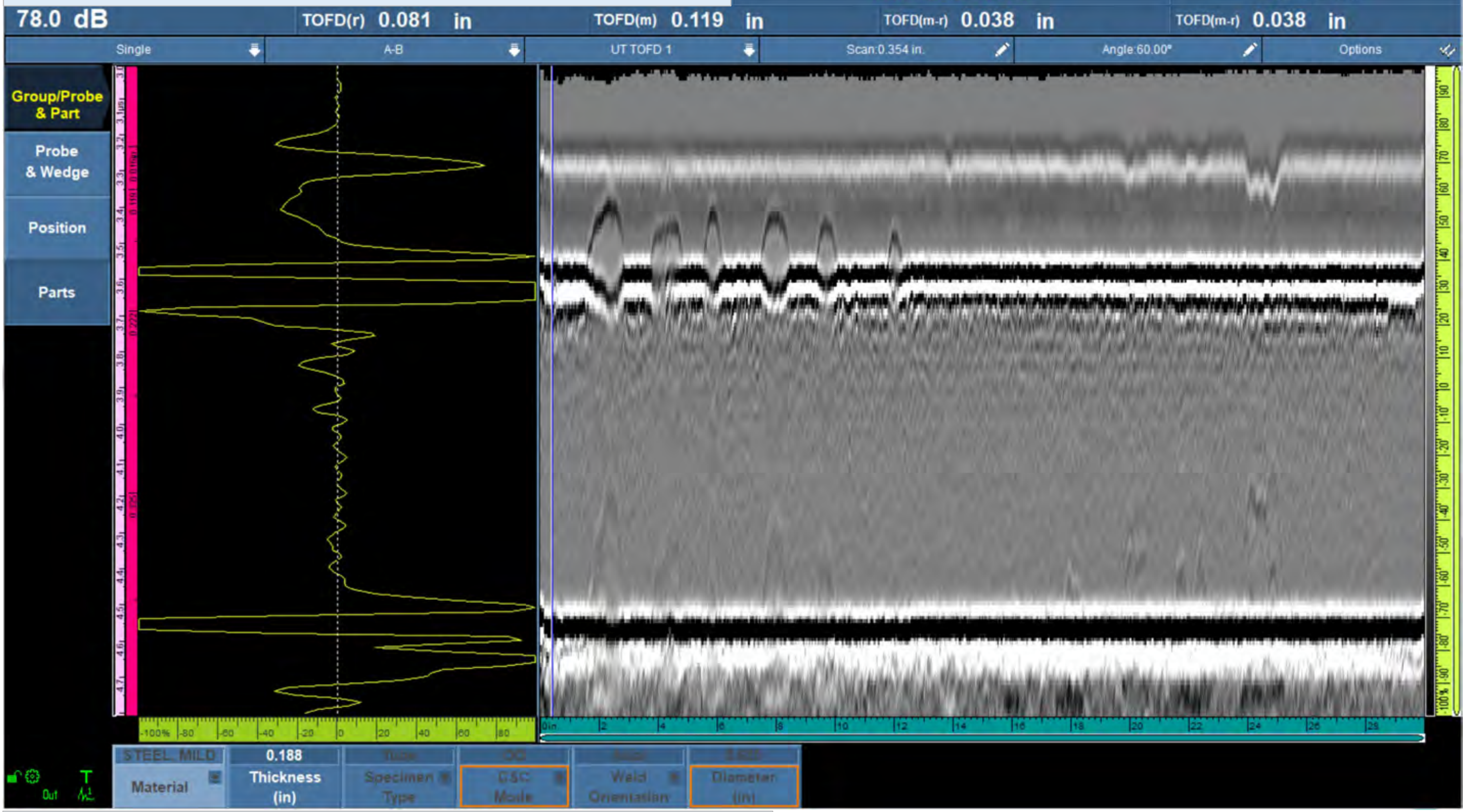
ToFD wedges Plexiglass 3



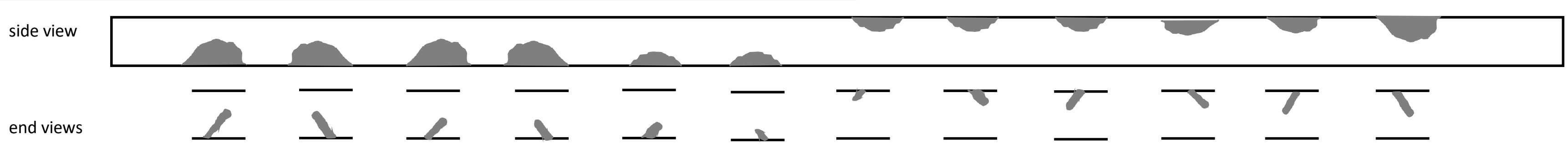
midwall slots, down



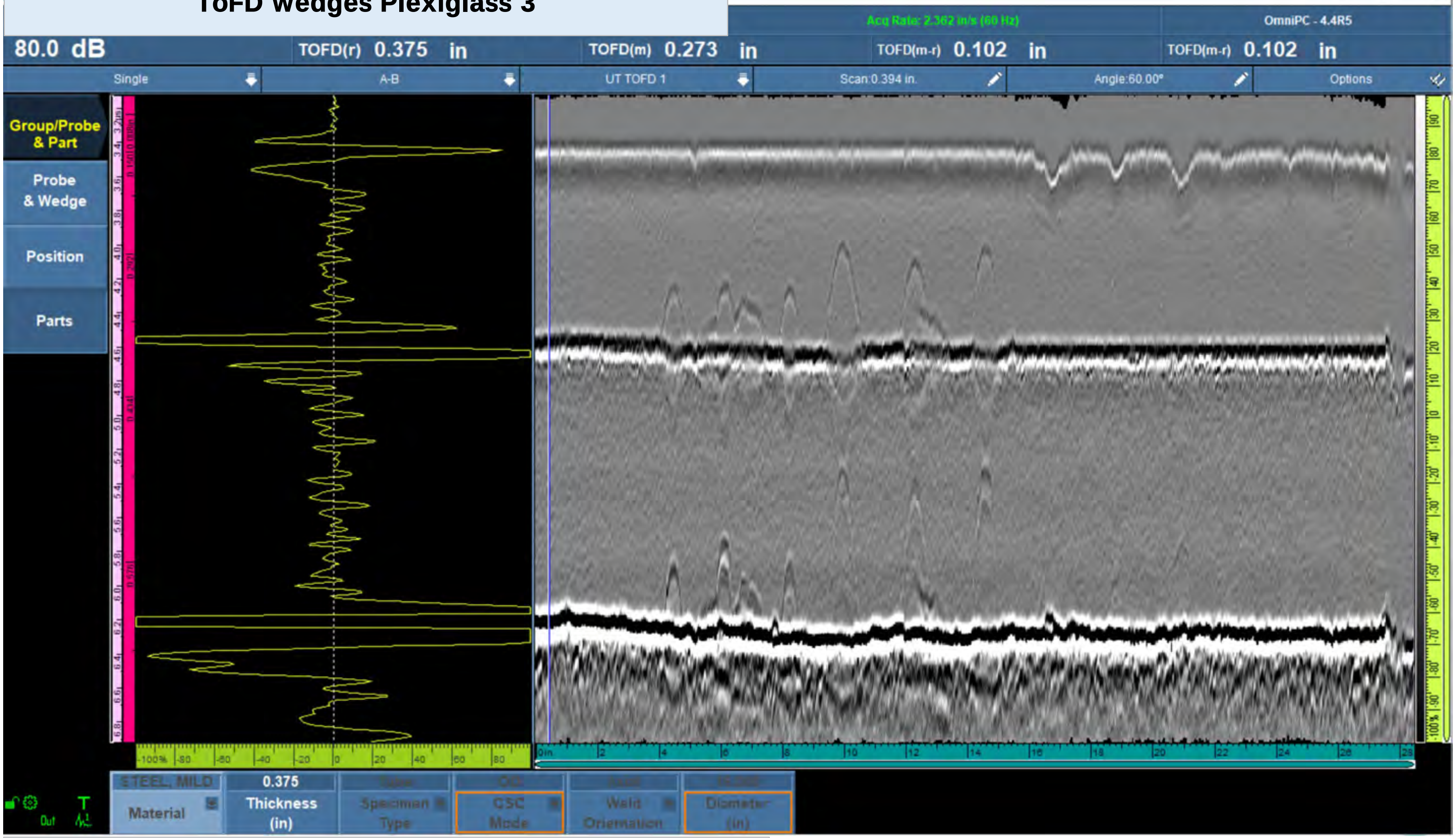
ToFD wedges Plexiglass 3



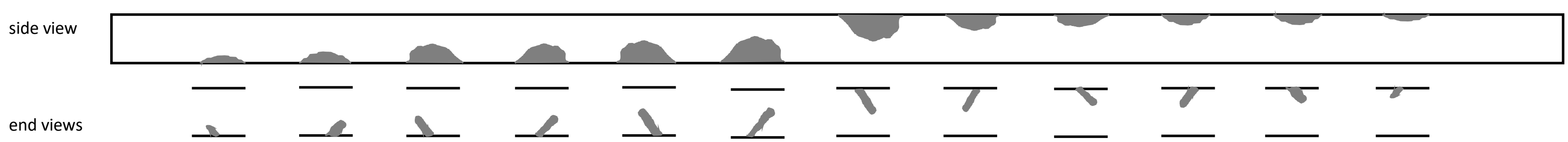
8x188 pipe, long seam, slanted, wafer wheel notches



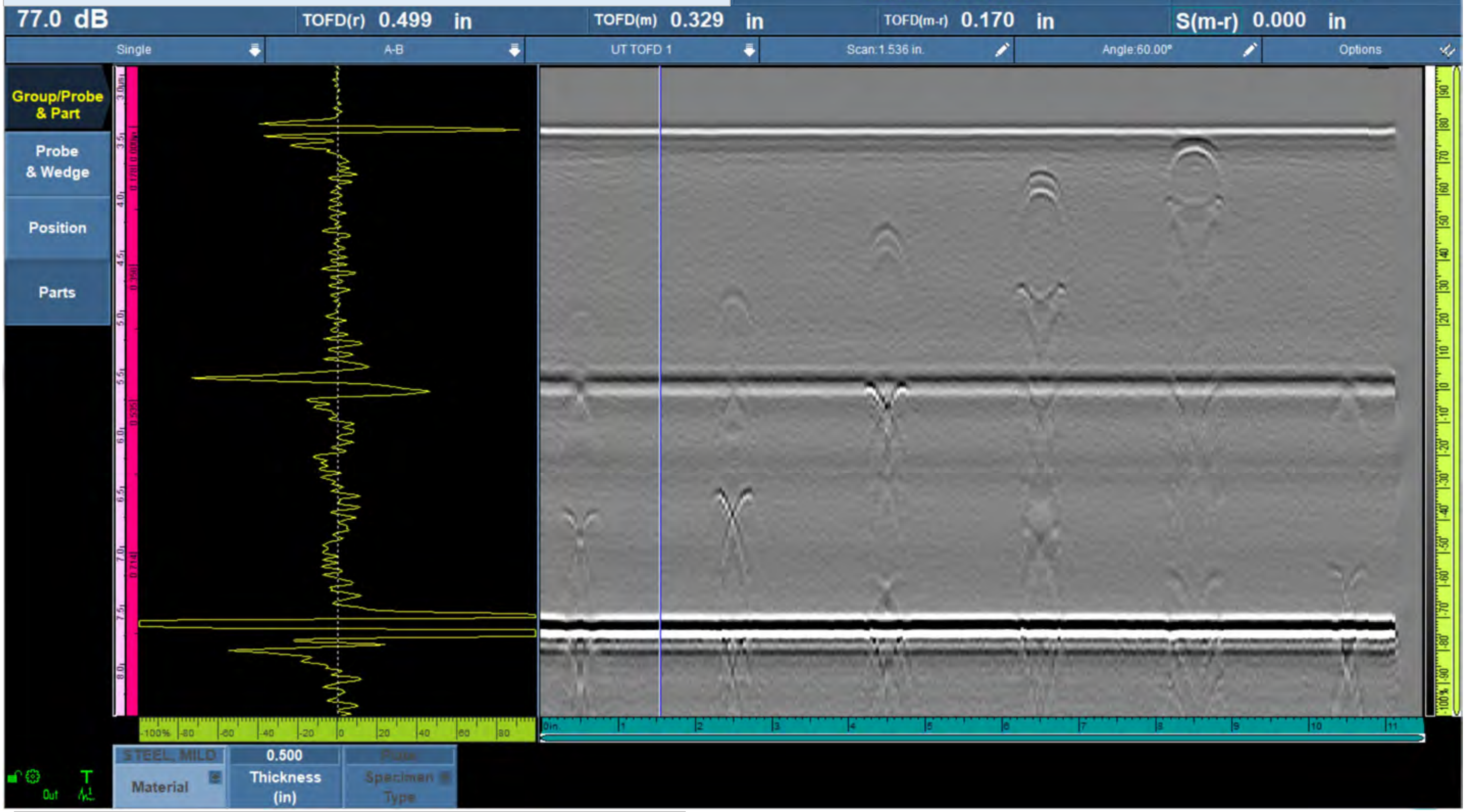
ToFD wedges Plexiglass 3



16x375 pipe, long seam, slanted, wafer wheel notches

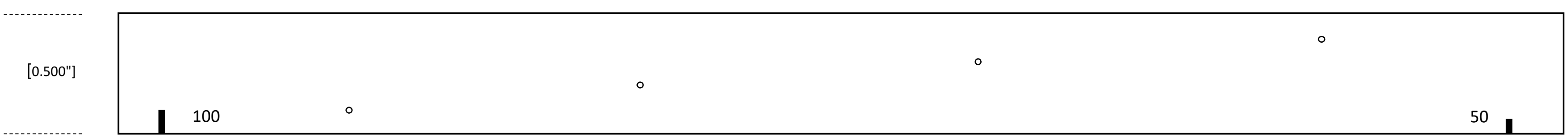


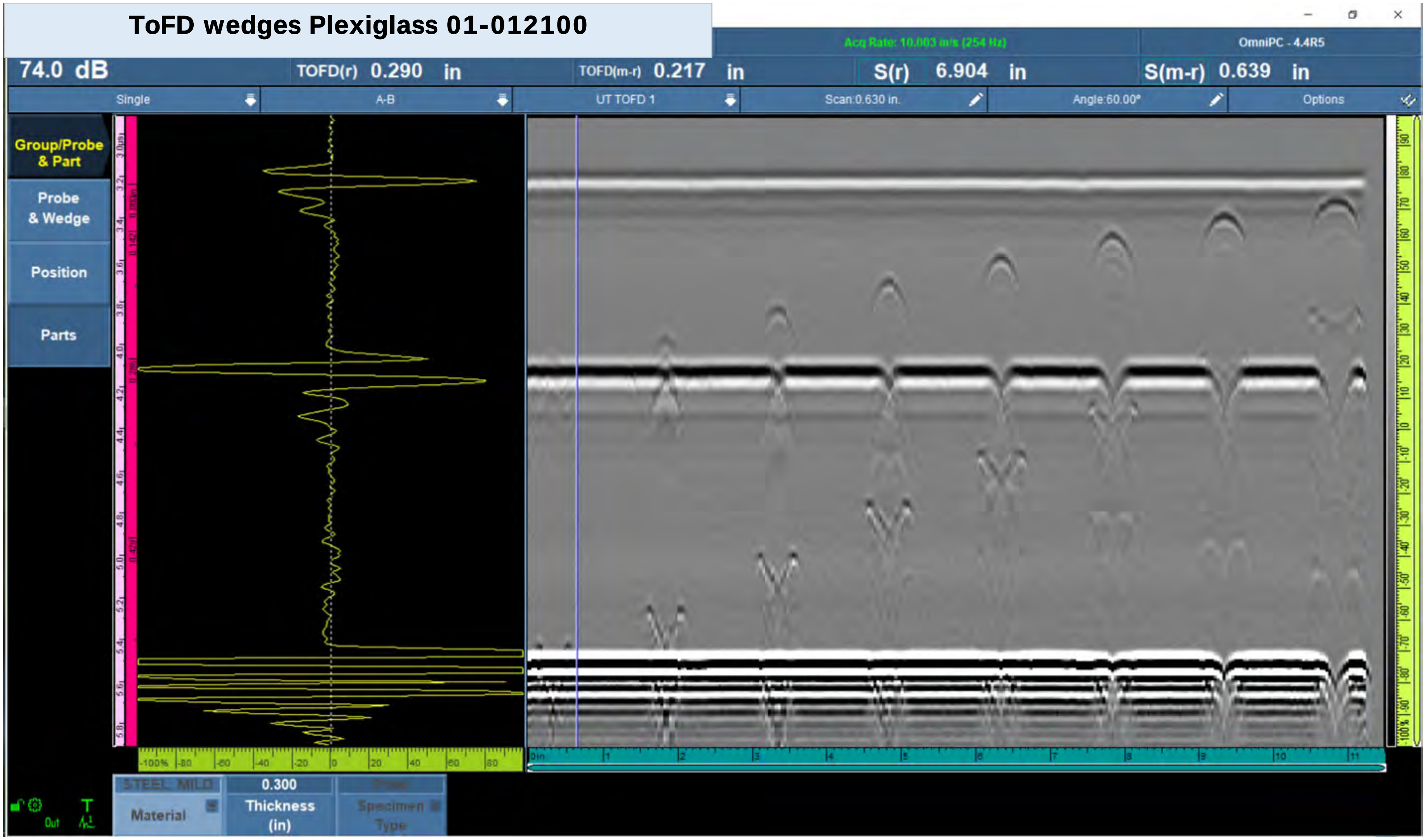
ToFD wedges Plexiglass 01-012100



FAST1 cal block

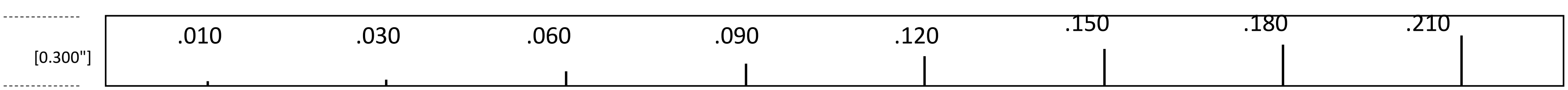
4 side drilled holes, two EDM notoches



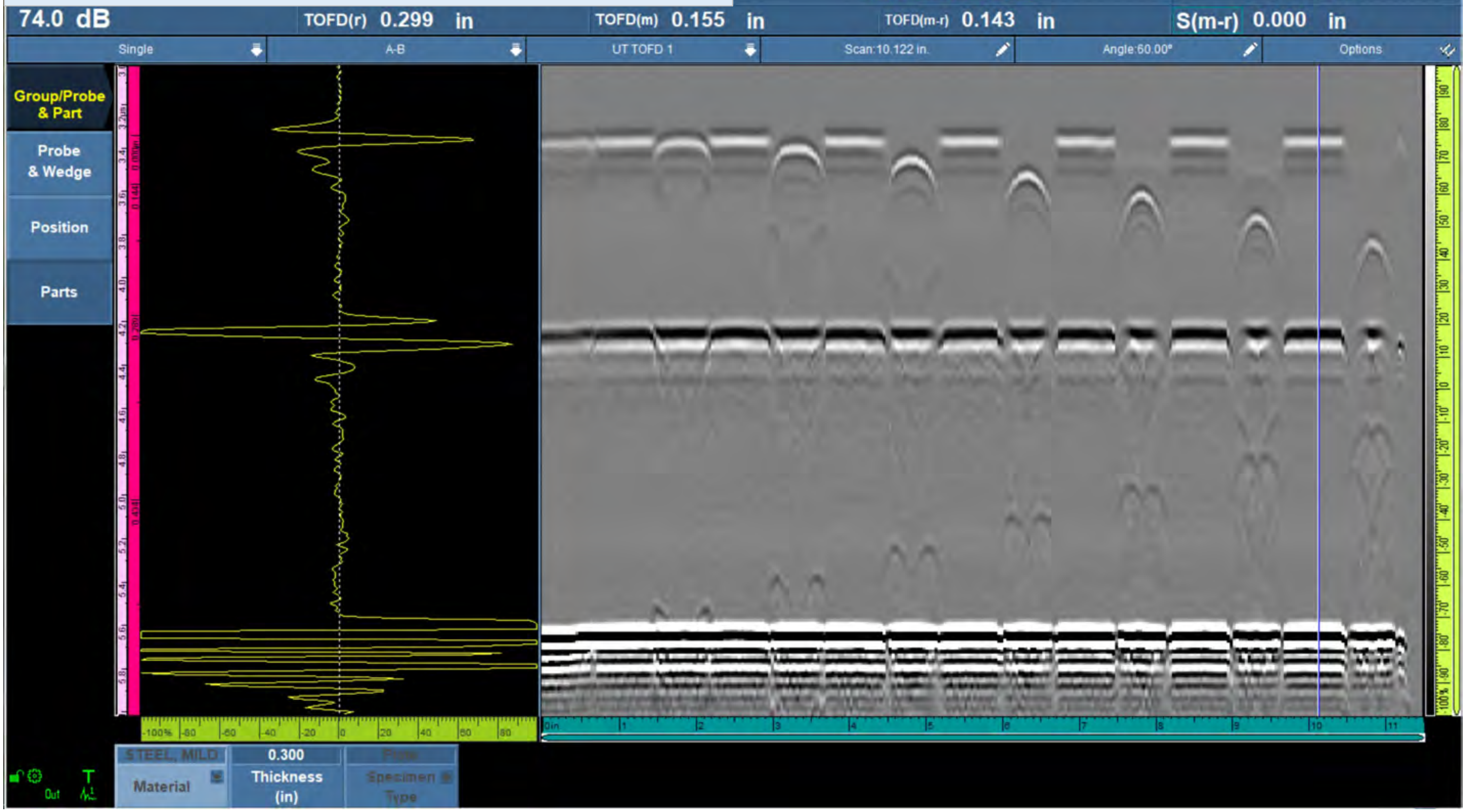


ID notches

8 EDM notoches

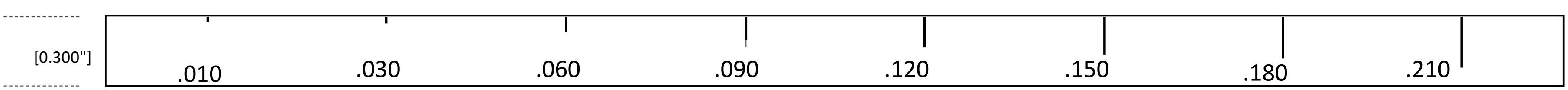


ToFD wedges Plexiglass 01-012100

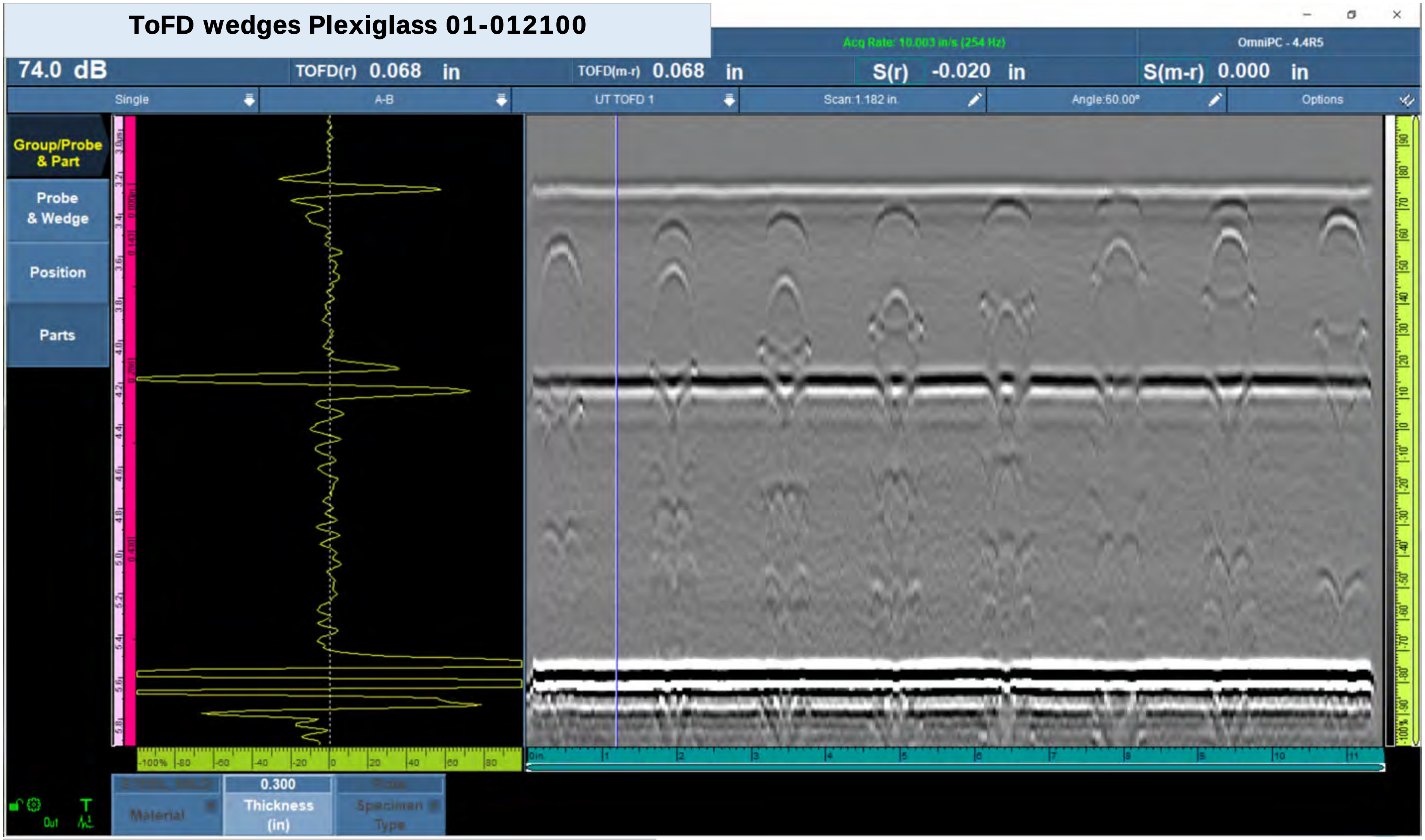


OD notches

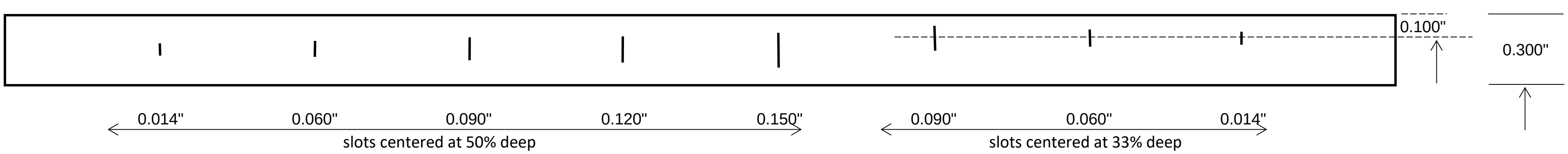
8 EDM notoches



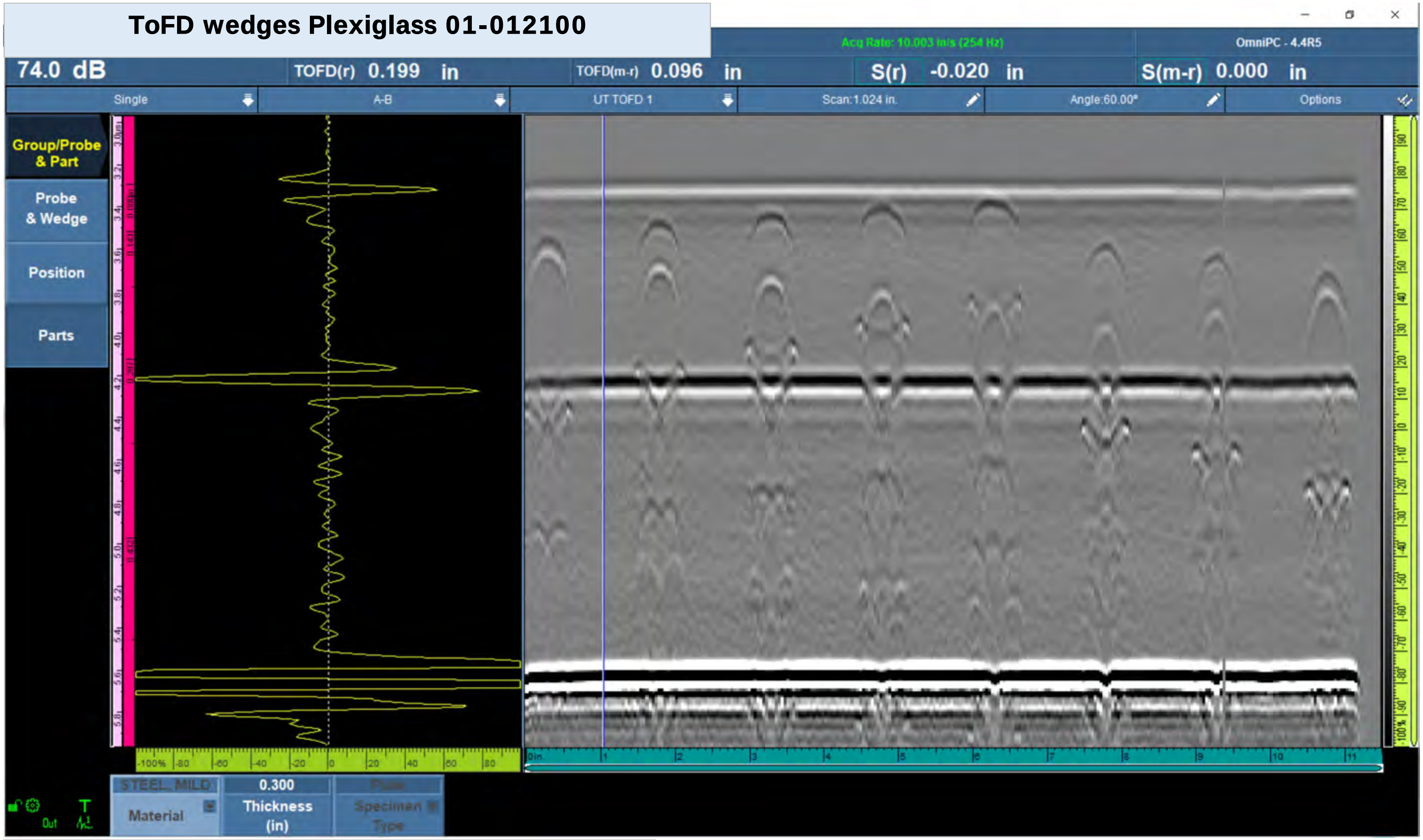
ToFD wedges Plexiglass 01-012100



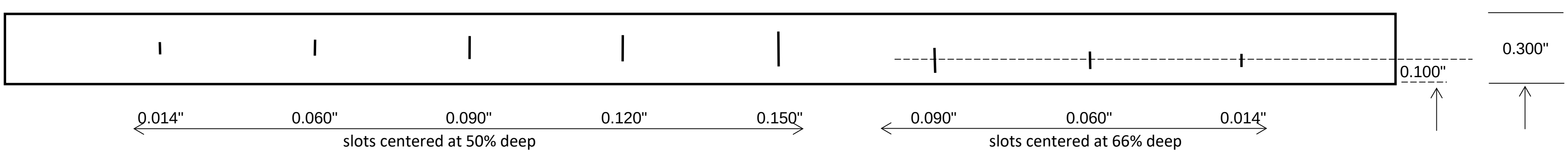
midwall slots, up



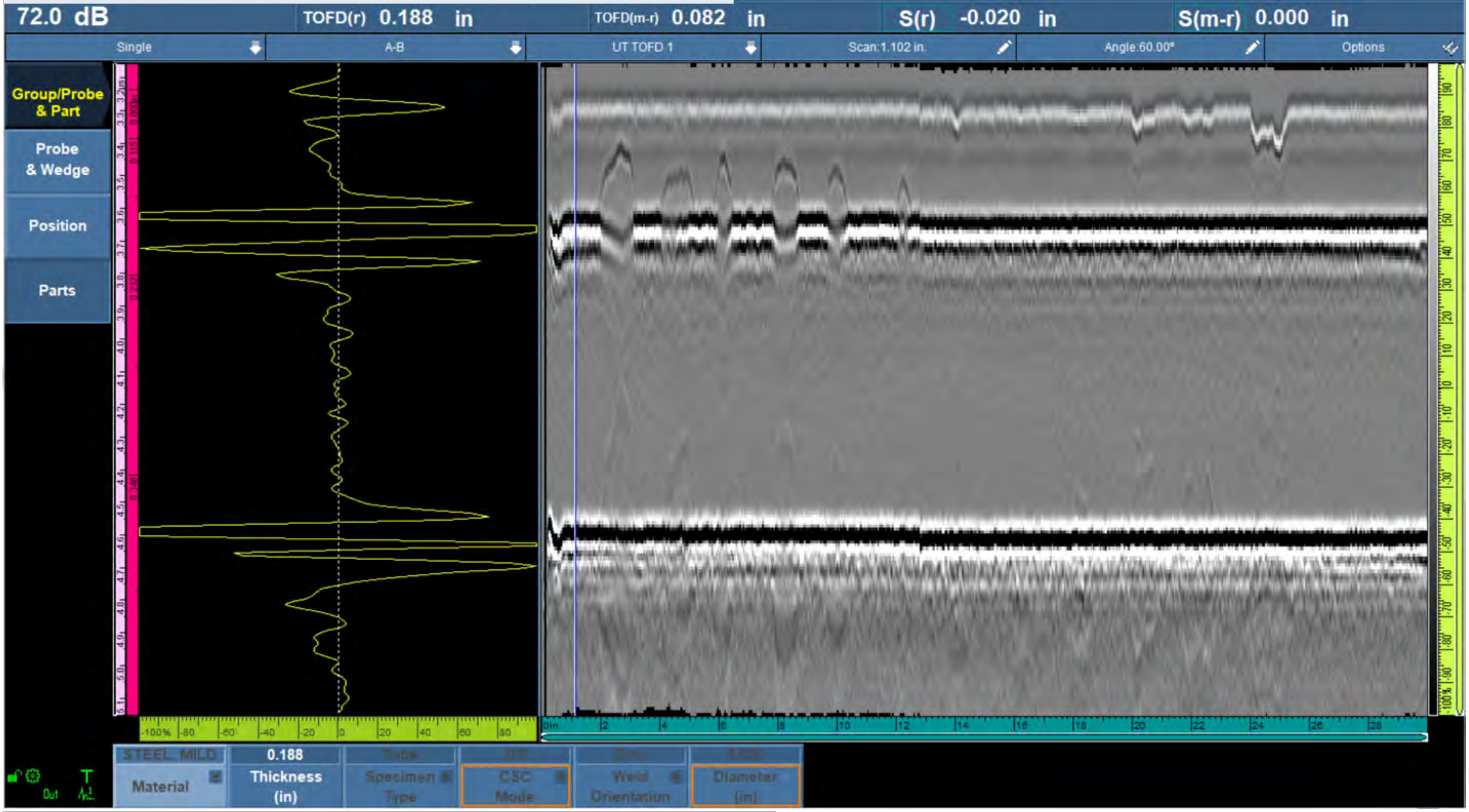
ToFD wedges Plexiglass 01-012100



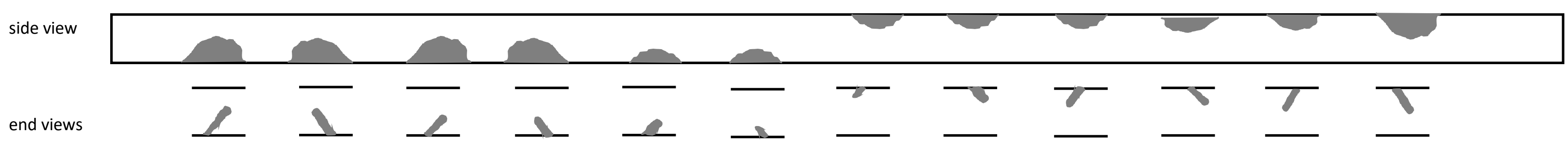
midwall slots, down



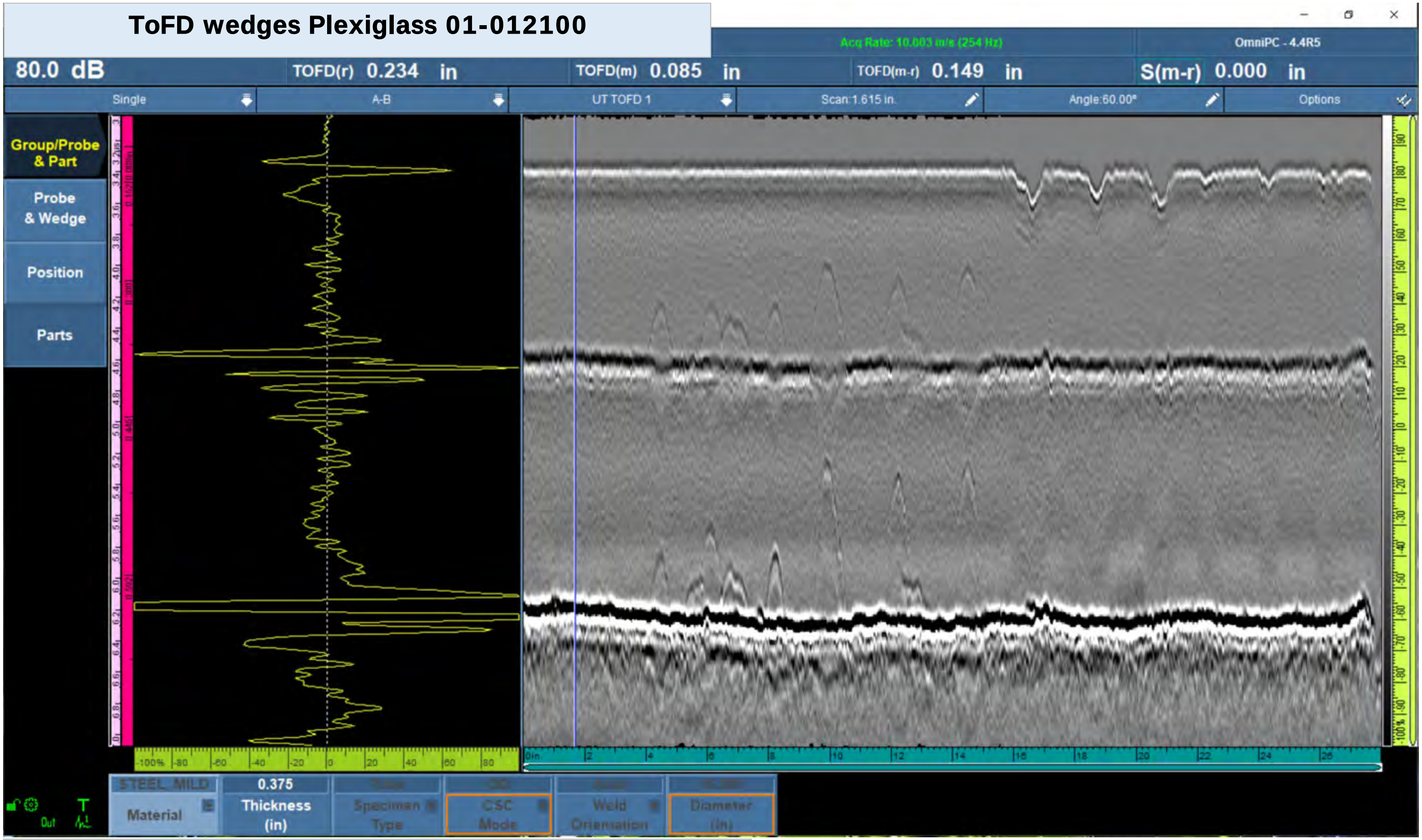
ToFD wedges Plexiglass 01-012100



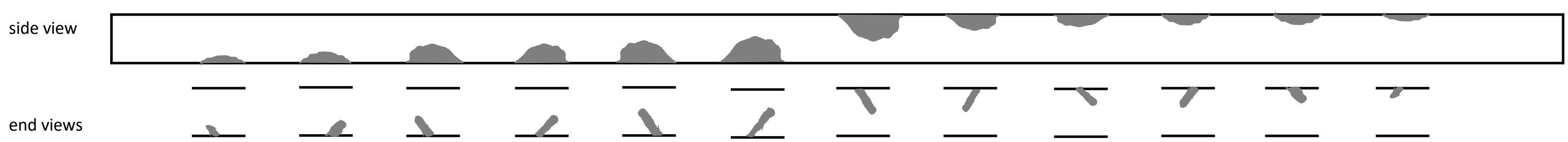
8x188 pipe, long seam, slanted, wafer wheel notches



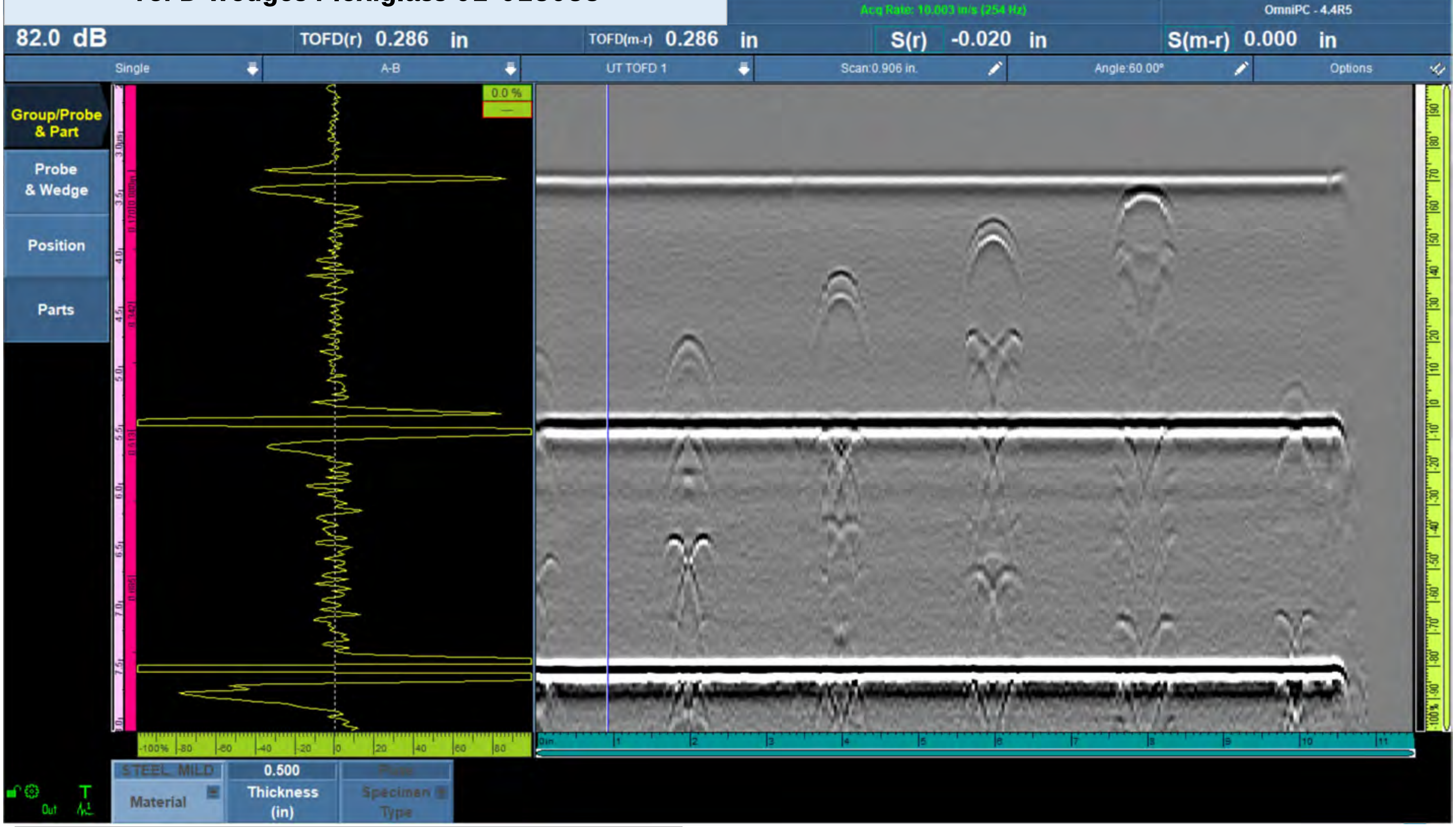
ToFD wedges Plexiglass 01-012100



16x375 pipe, long seam, slanted, wafer wheel notches

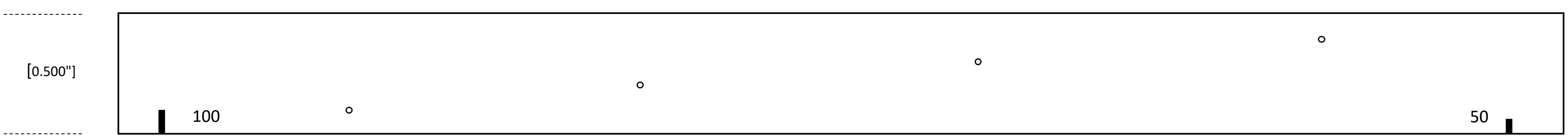


ToFD wedges Plexiglass 01-013038

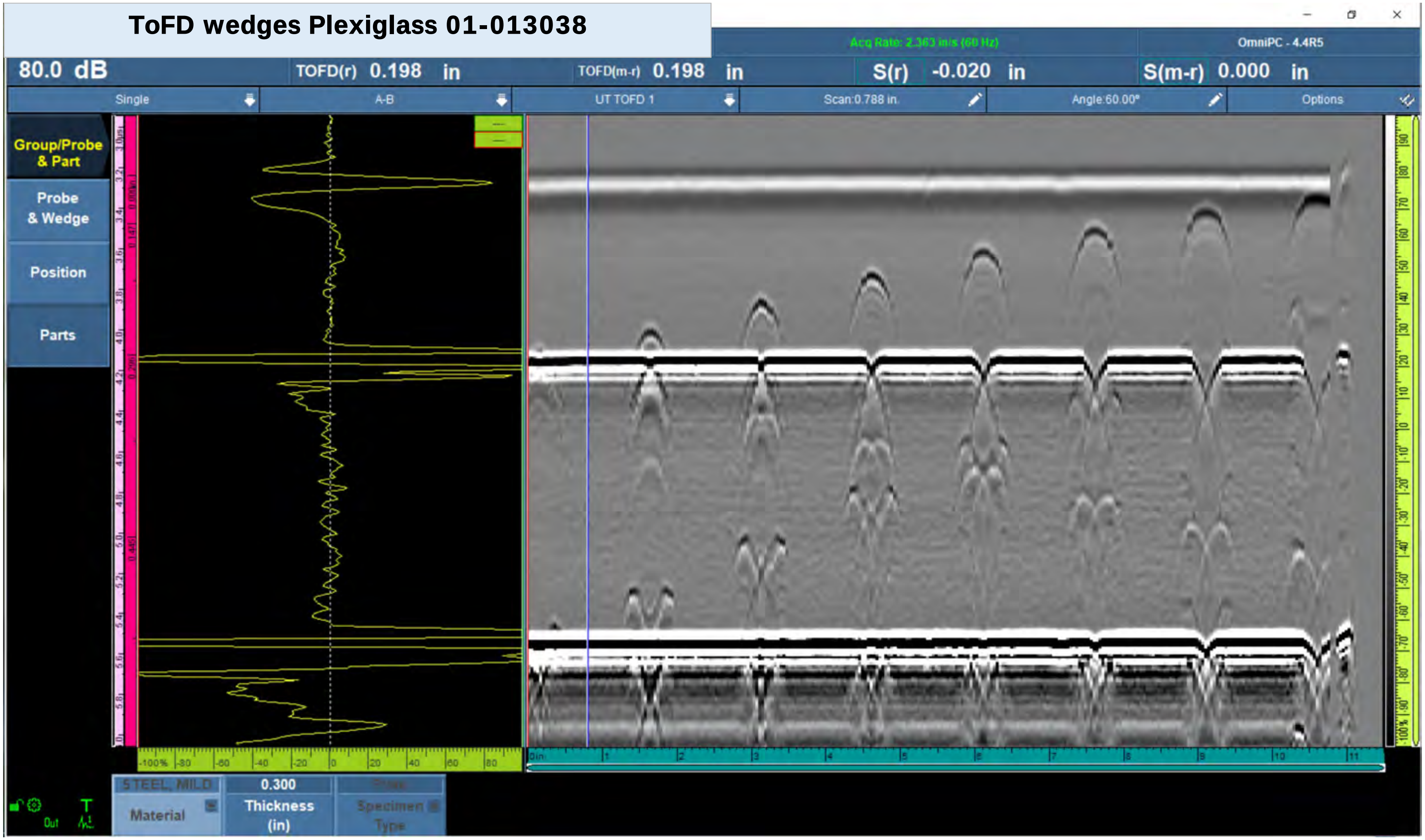


FAST1 cal block

4 side drilled holes, two EDM notoches

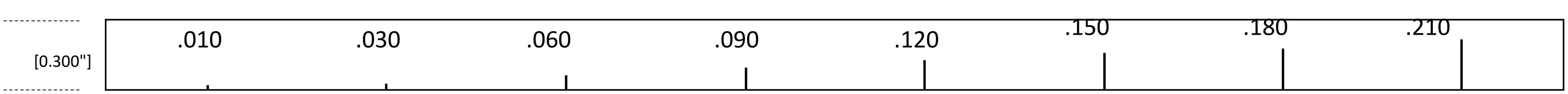


ToFD wedges Plexiglass 01-013038

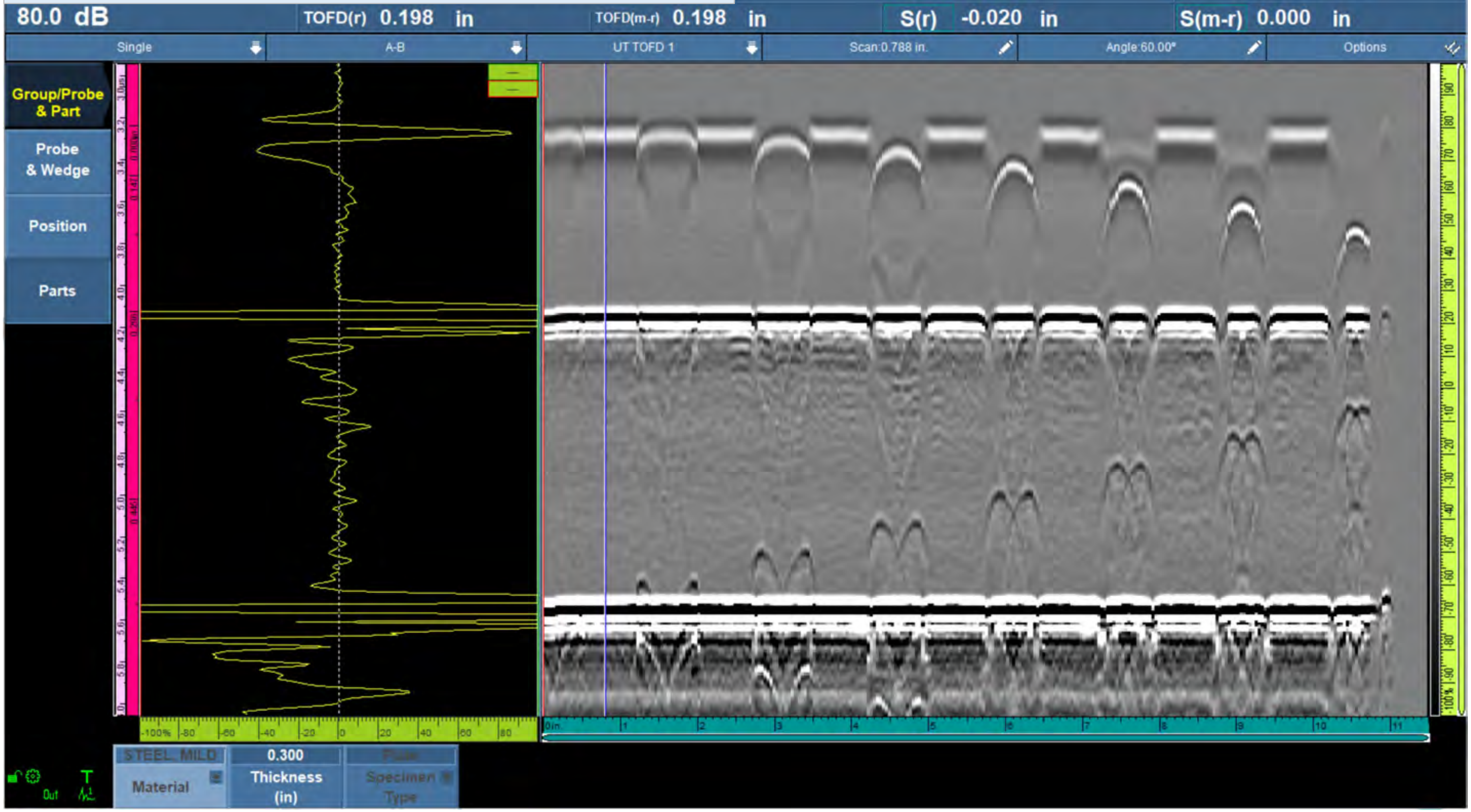


ID notches

8 EDM notoches

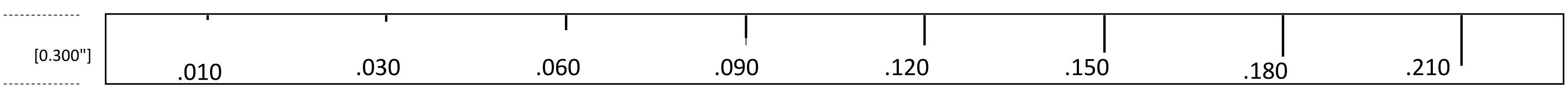


ToFD wedges Plexiglass 01-013038

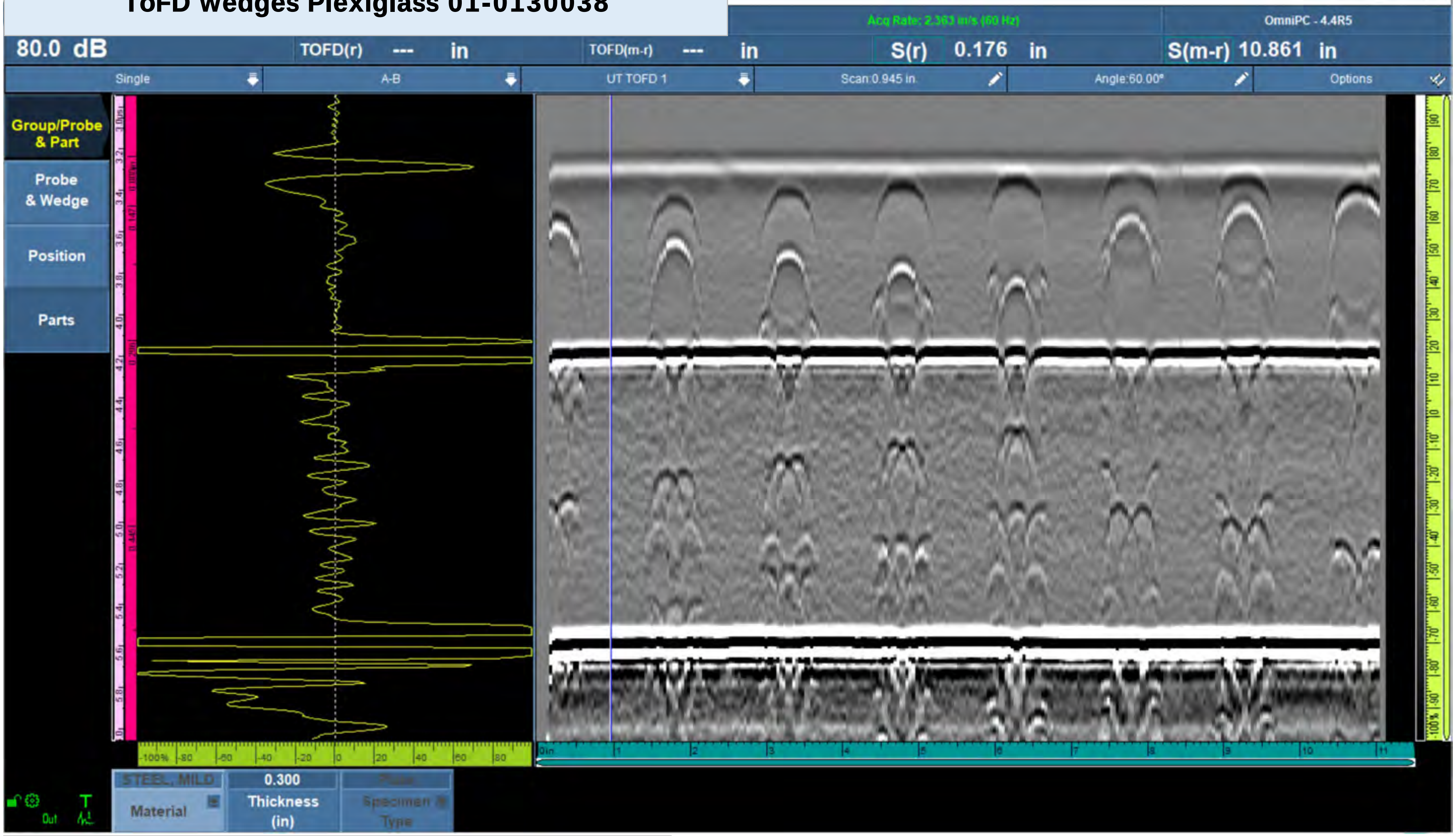


OD notches

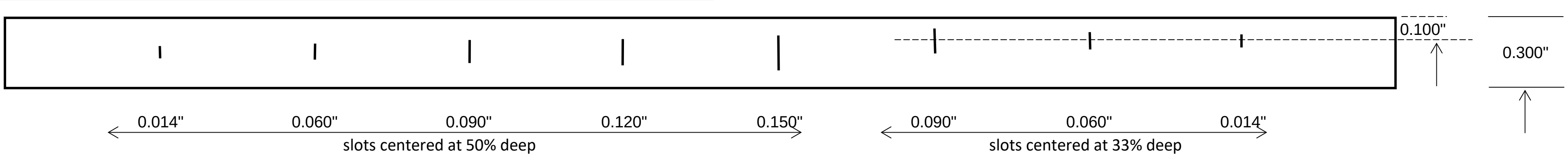
8 EDM notoches



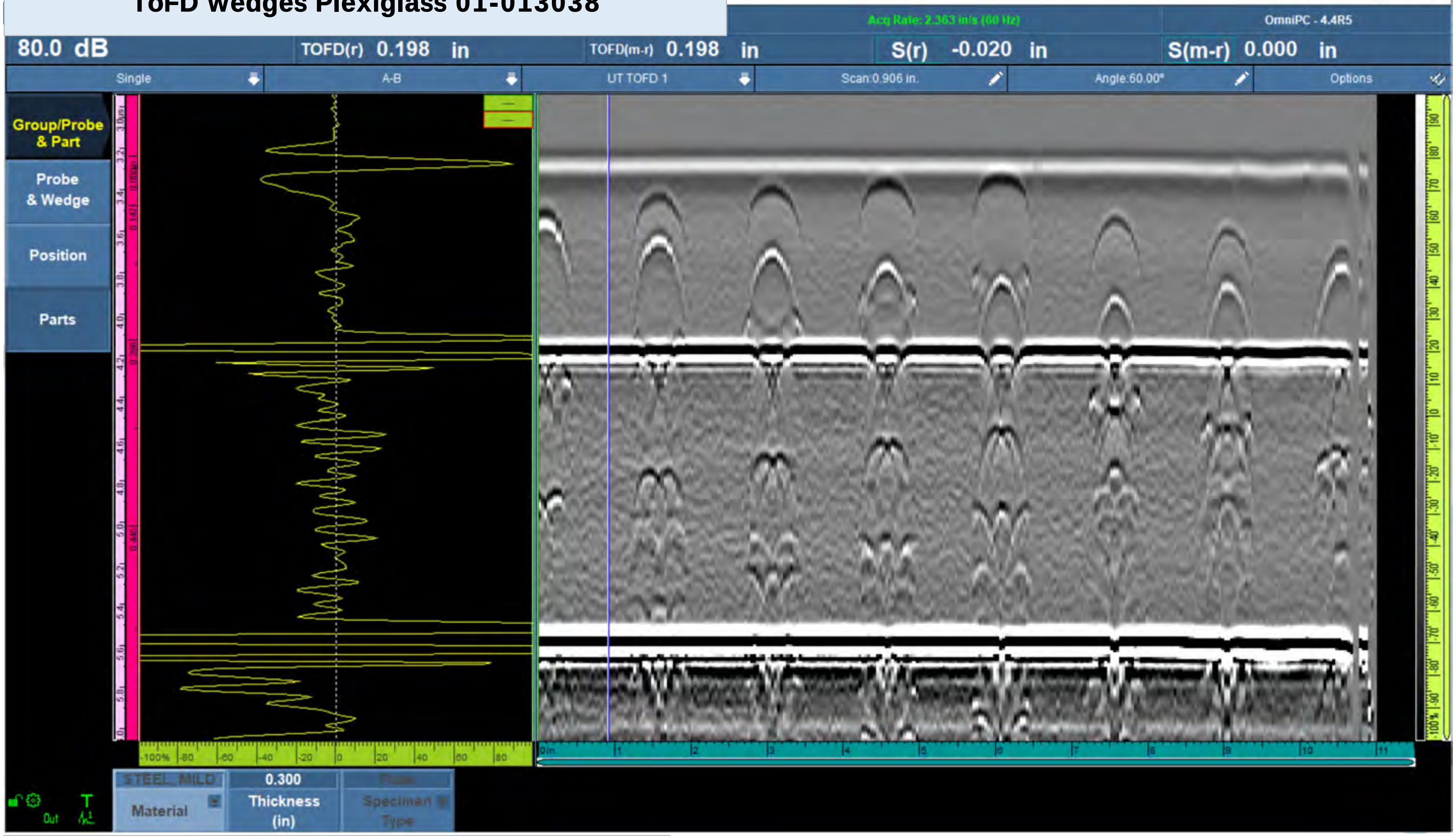
ToFD wedges Plexiglass 01-0130038



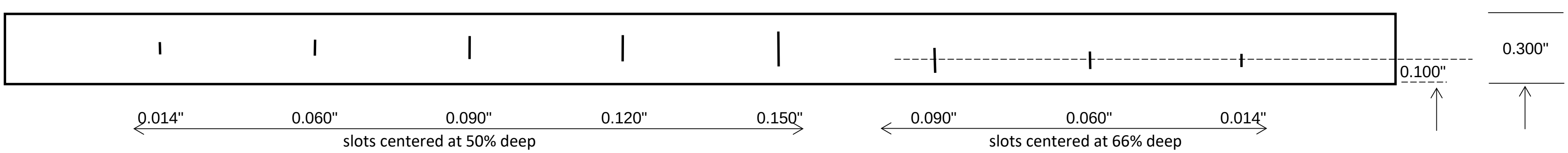
midwall slots, up



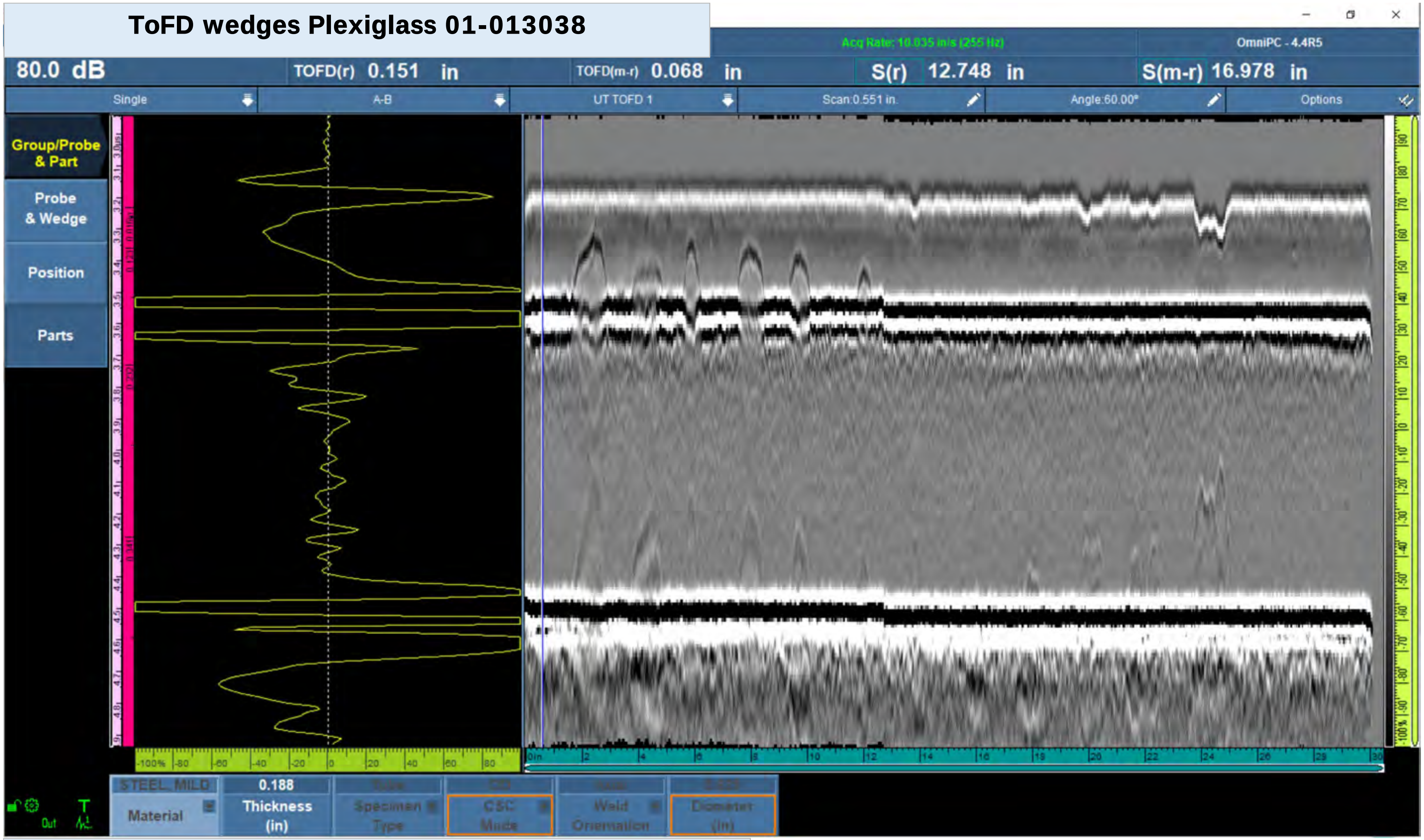
ToFD wedges Plexiglass 01-013038



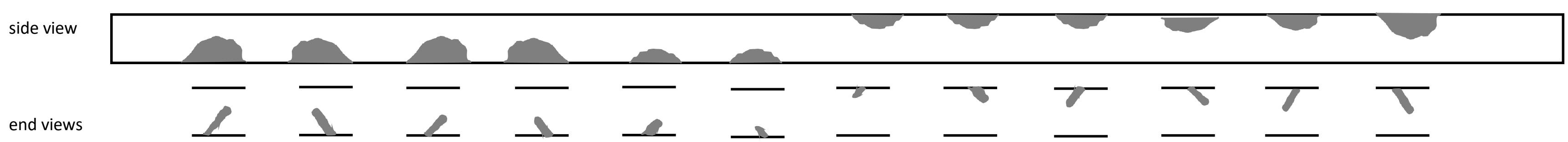
midwall slots, down



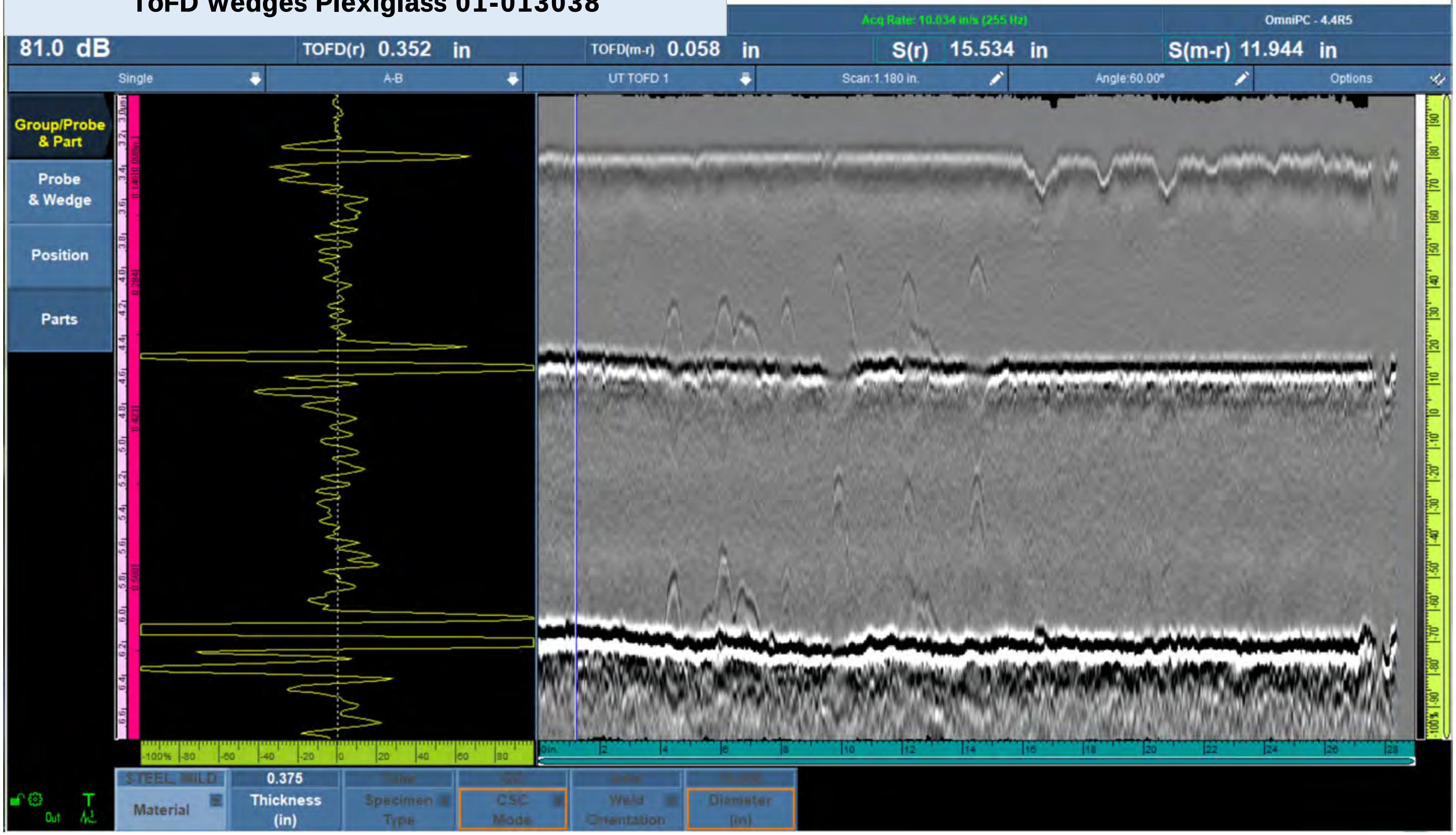
ToFD wedges Plexiglass 01-013038



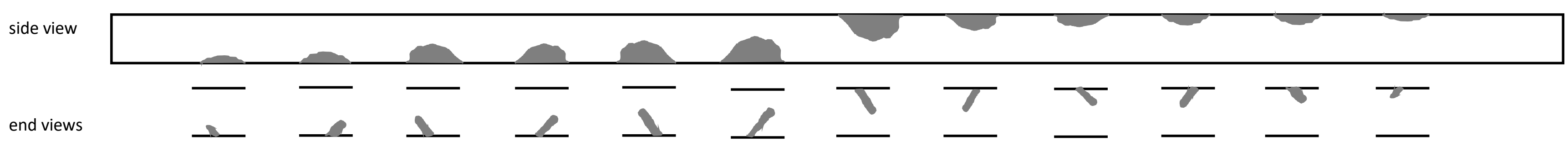
8x188 pipe, long seam, slanted, wafer wheel notches



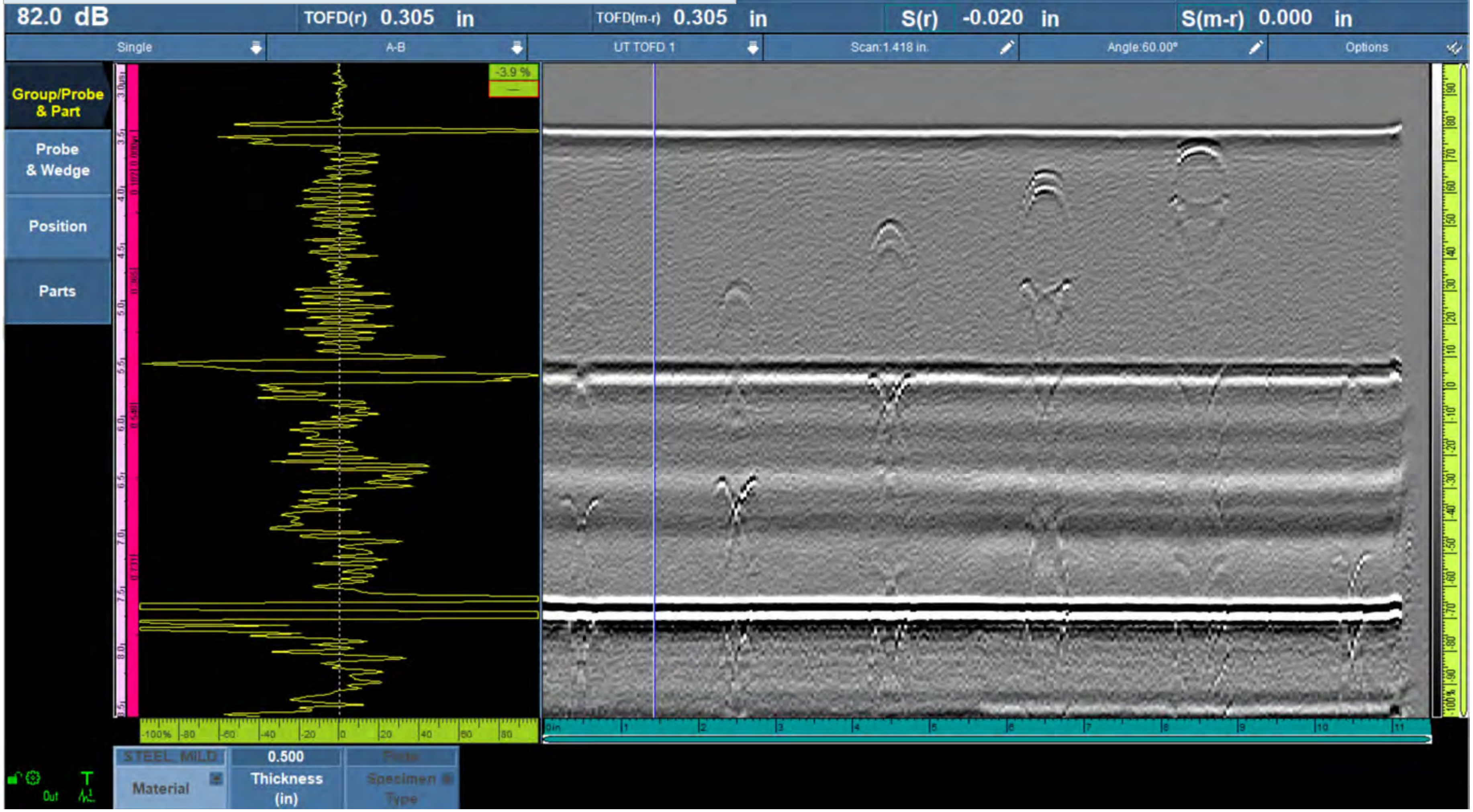
ToFD wedges Plexiglass 01-013038



16x375 pipe, long seam, slanted, wafer wheel notches

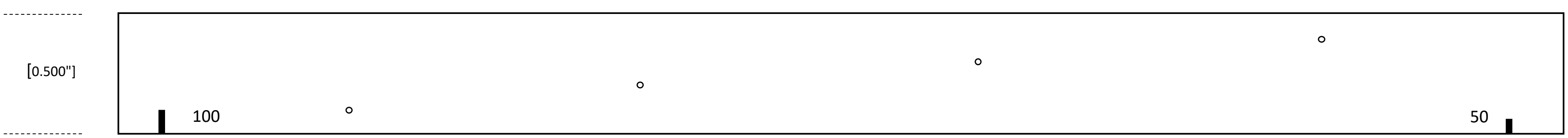


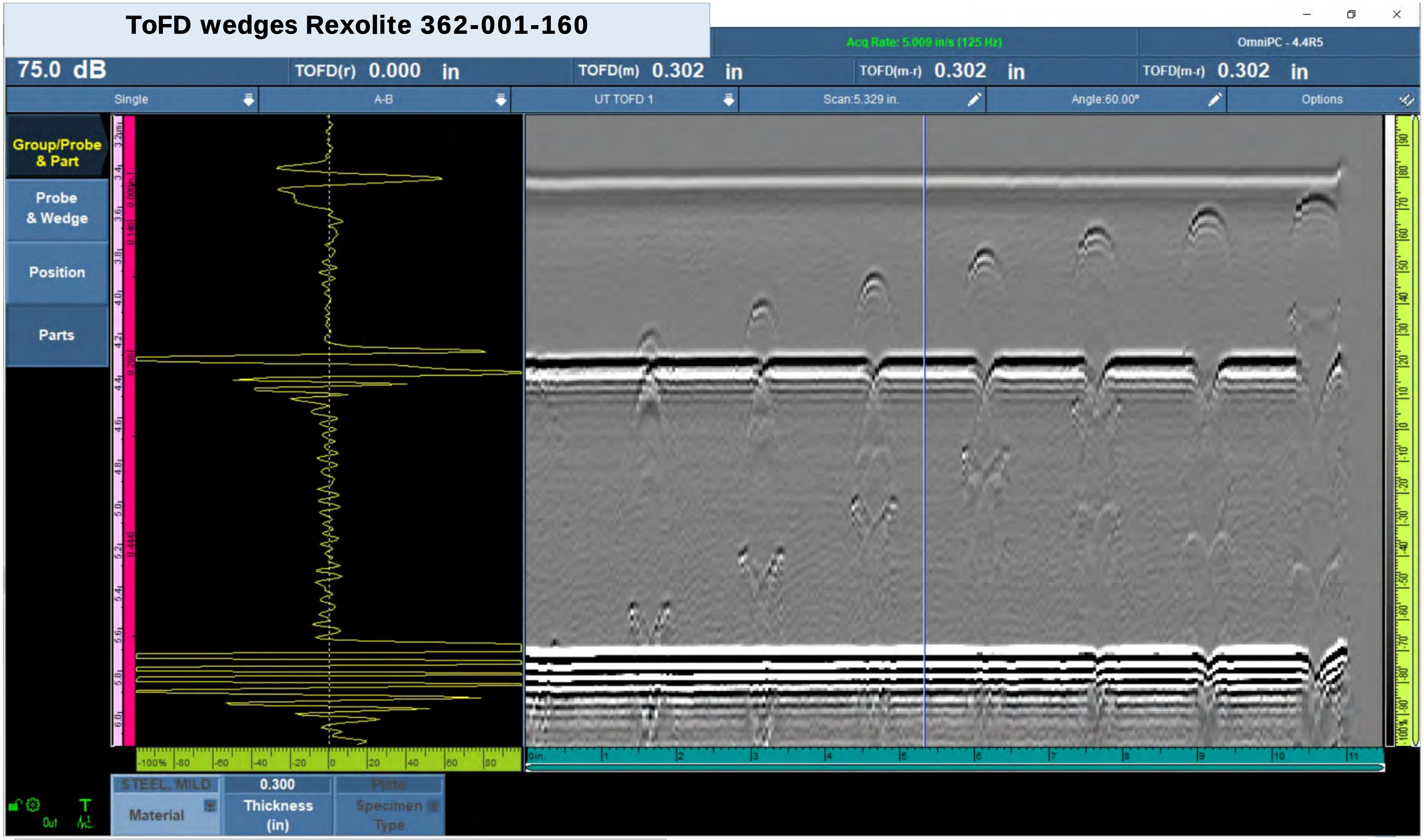
ToFD wedges Rexolite 362-001-160



FAST1 cal block

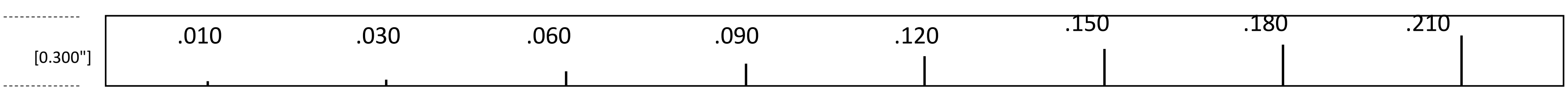
4 side drilled holes, two EDM notoches



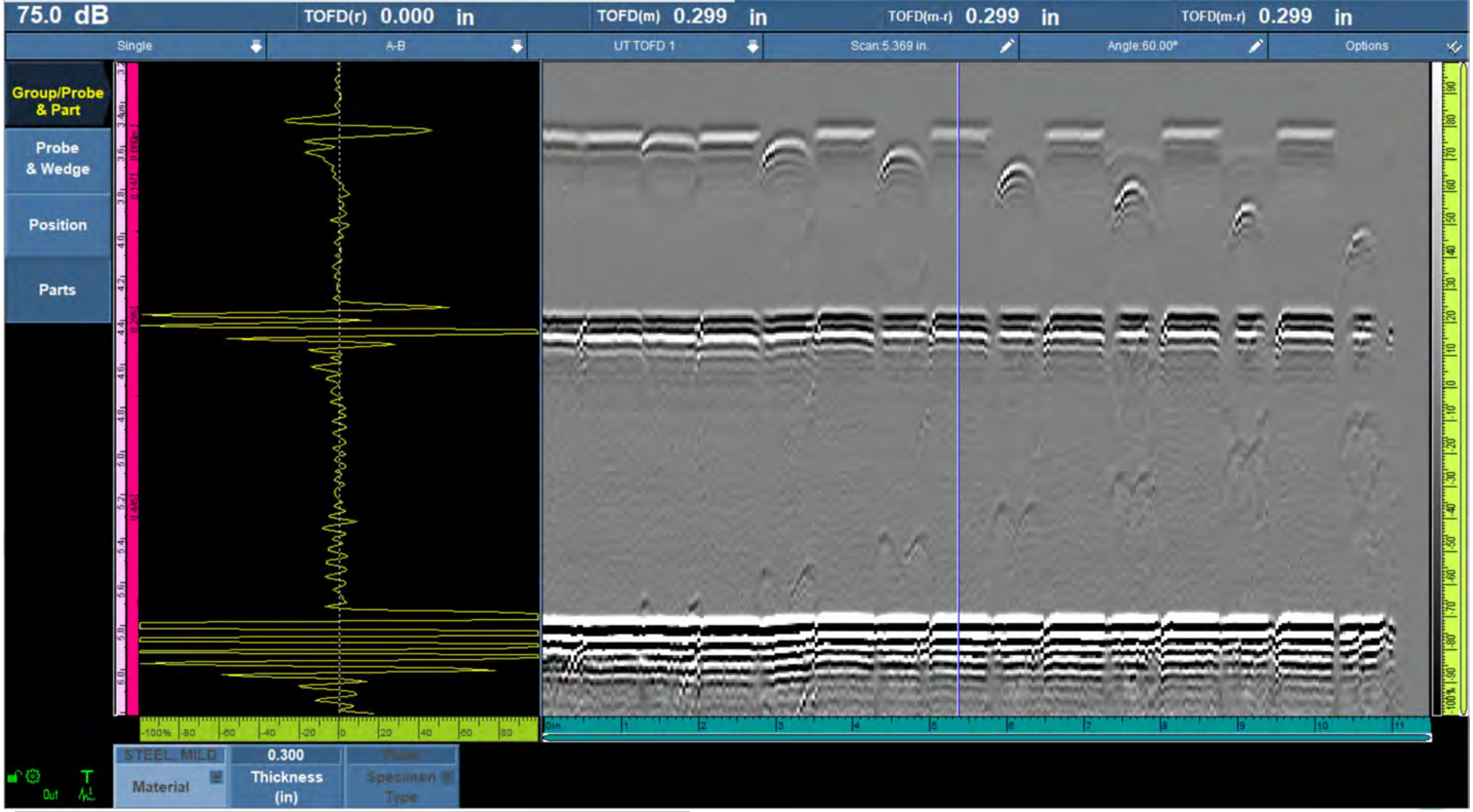


ID notches

8 EDM notoches

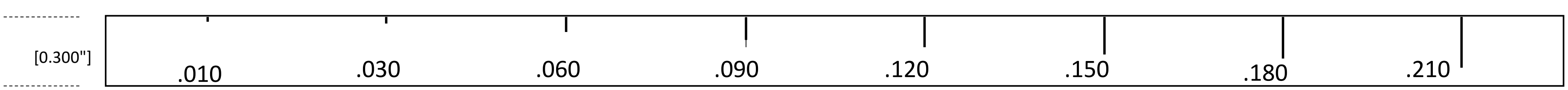


ToFD wedges Rexolite 362-001-160

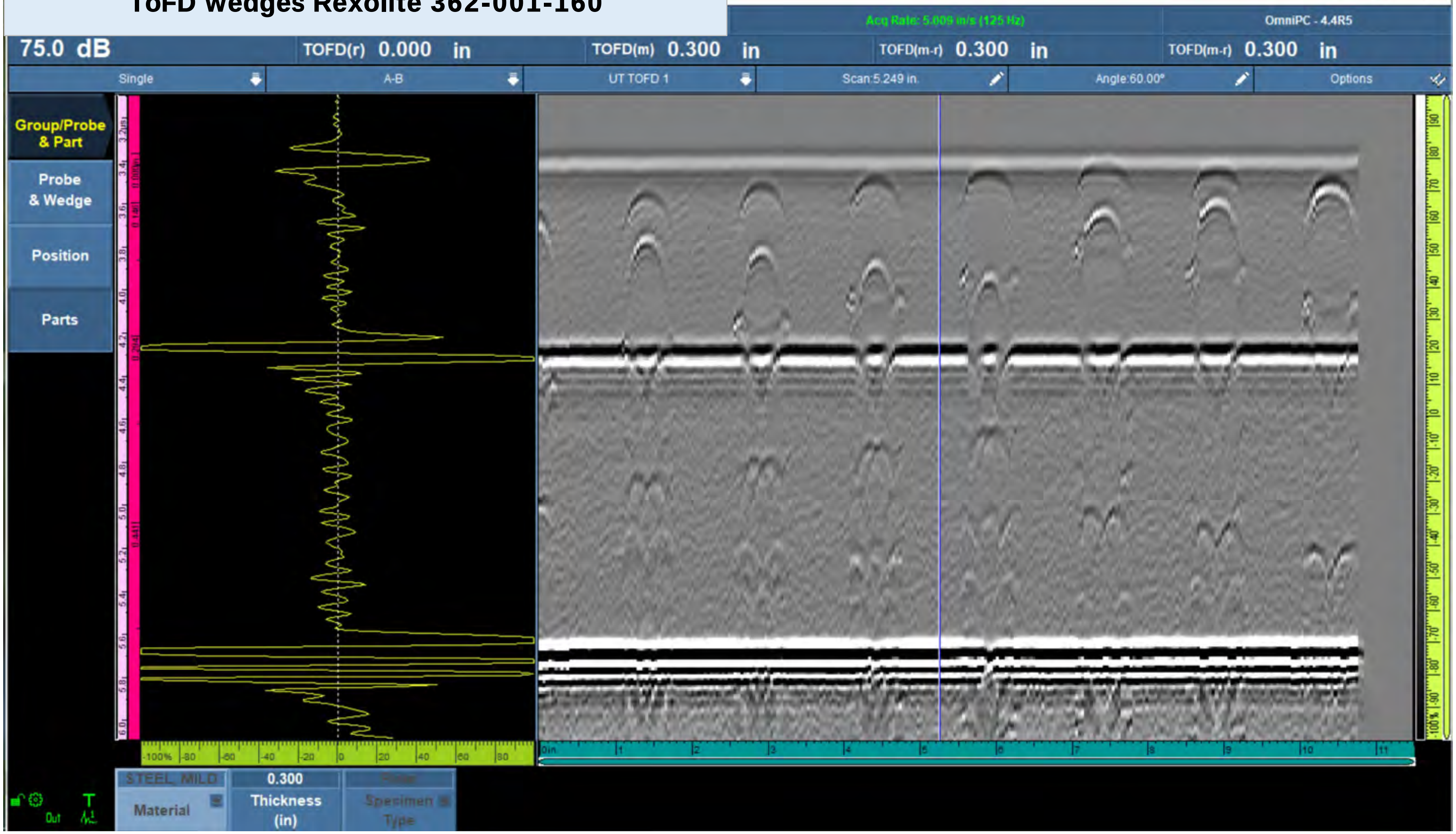


OD notches

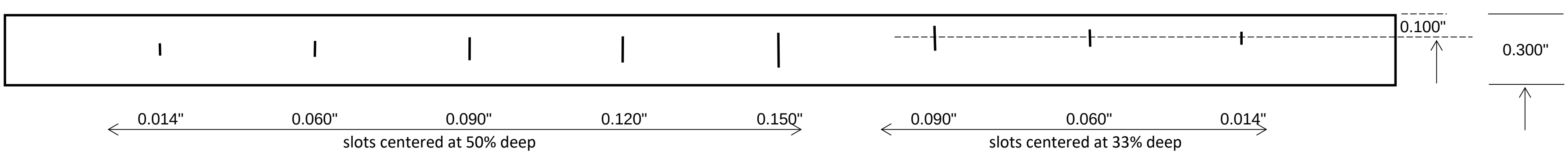
8 EDM notoches



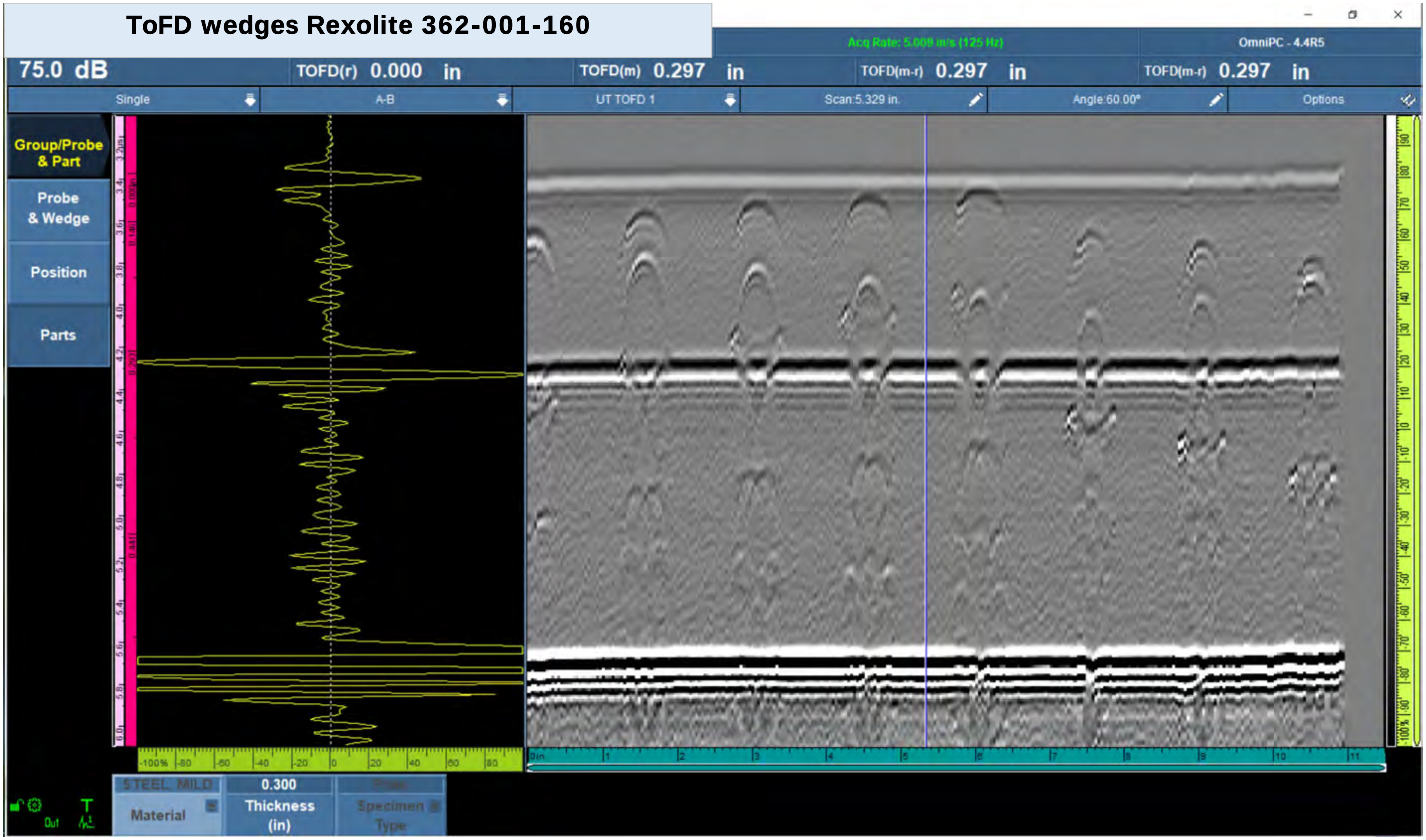
ToFD wedges Rexolite 362-001-160



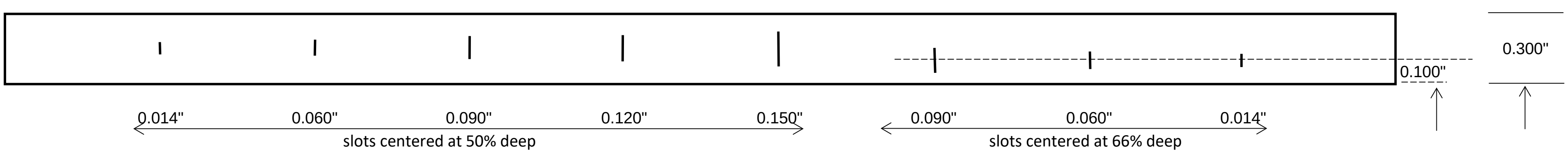
midwall slots, up



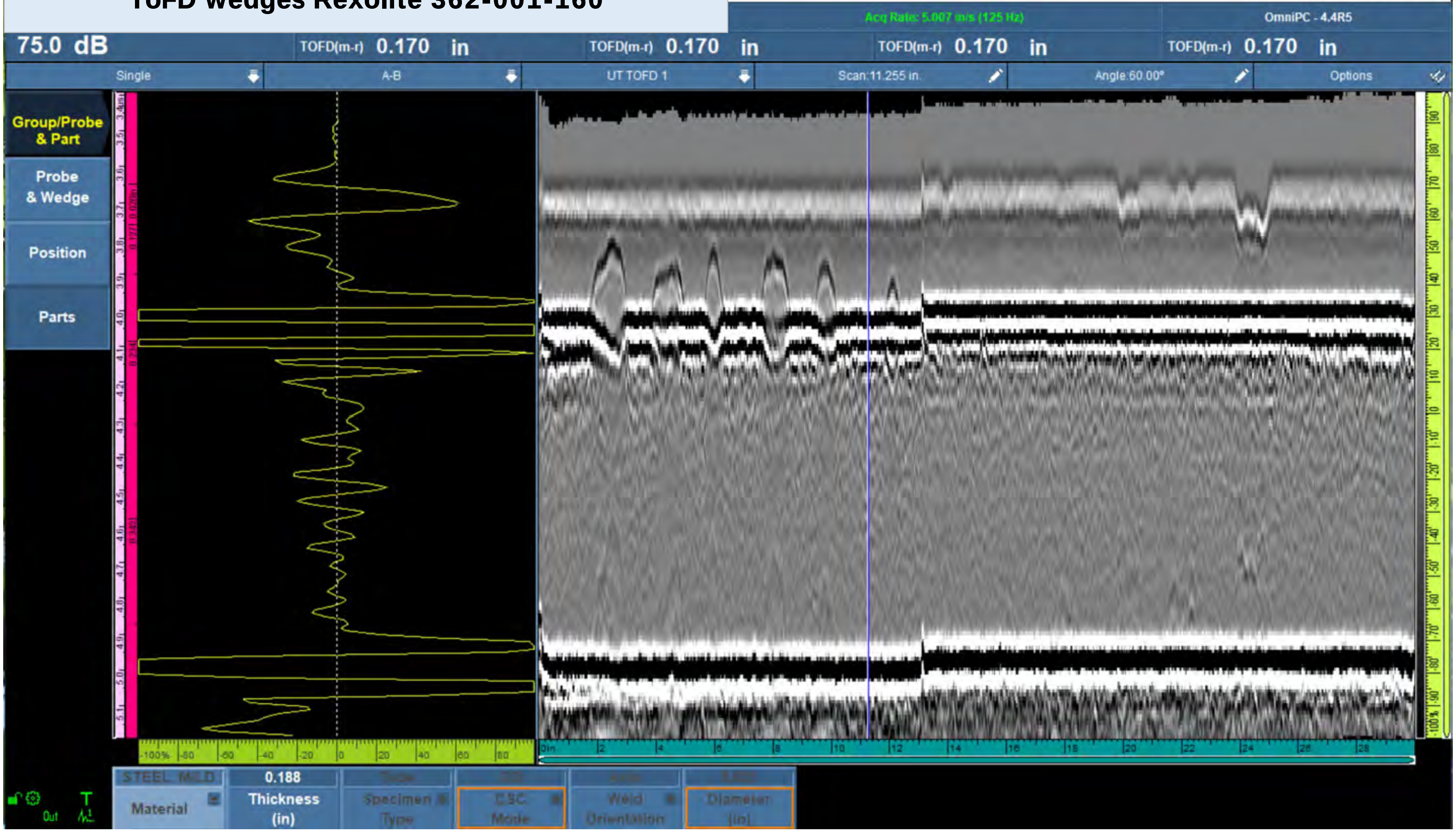
ToFD wedges Rexolite 362-001-160



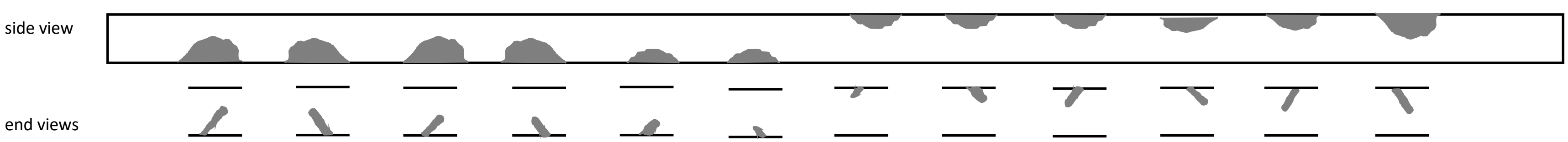
midwall slots, down



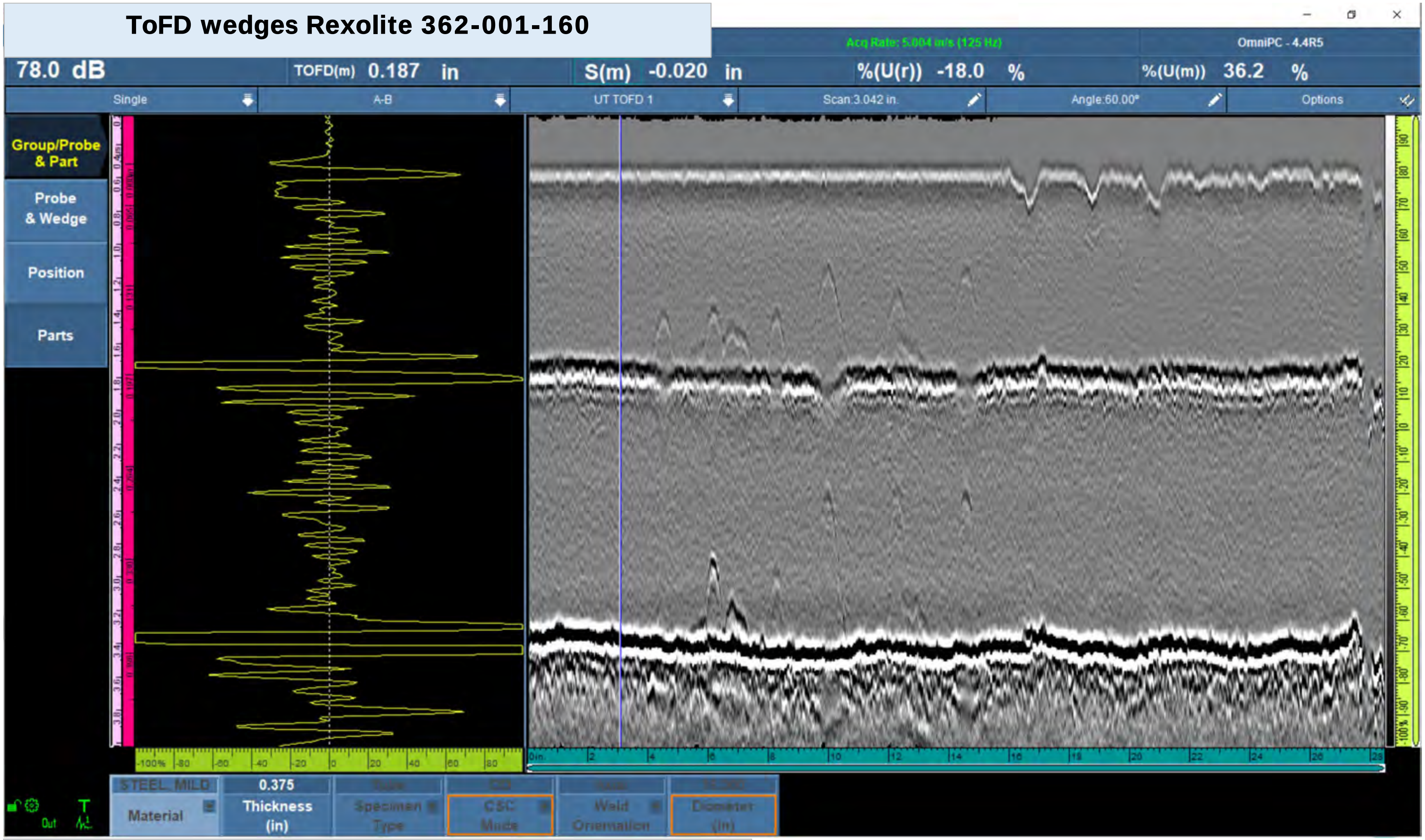
ToFD wedges Rexolite 362-001-160



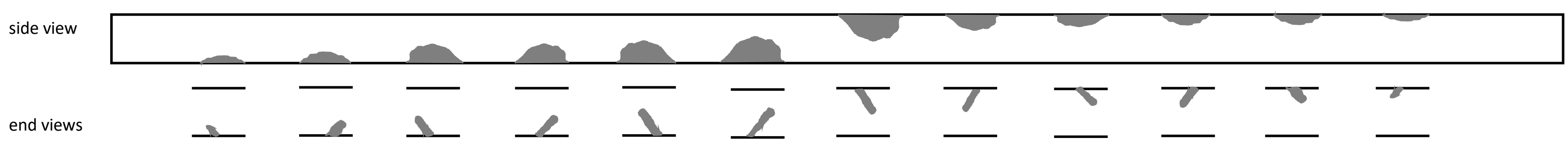
8x188 pipe, long seam, slanted, wafer wheel notches



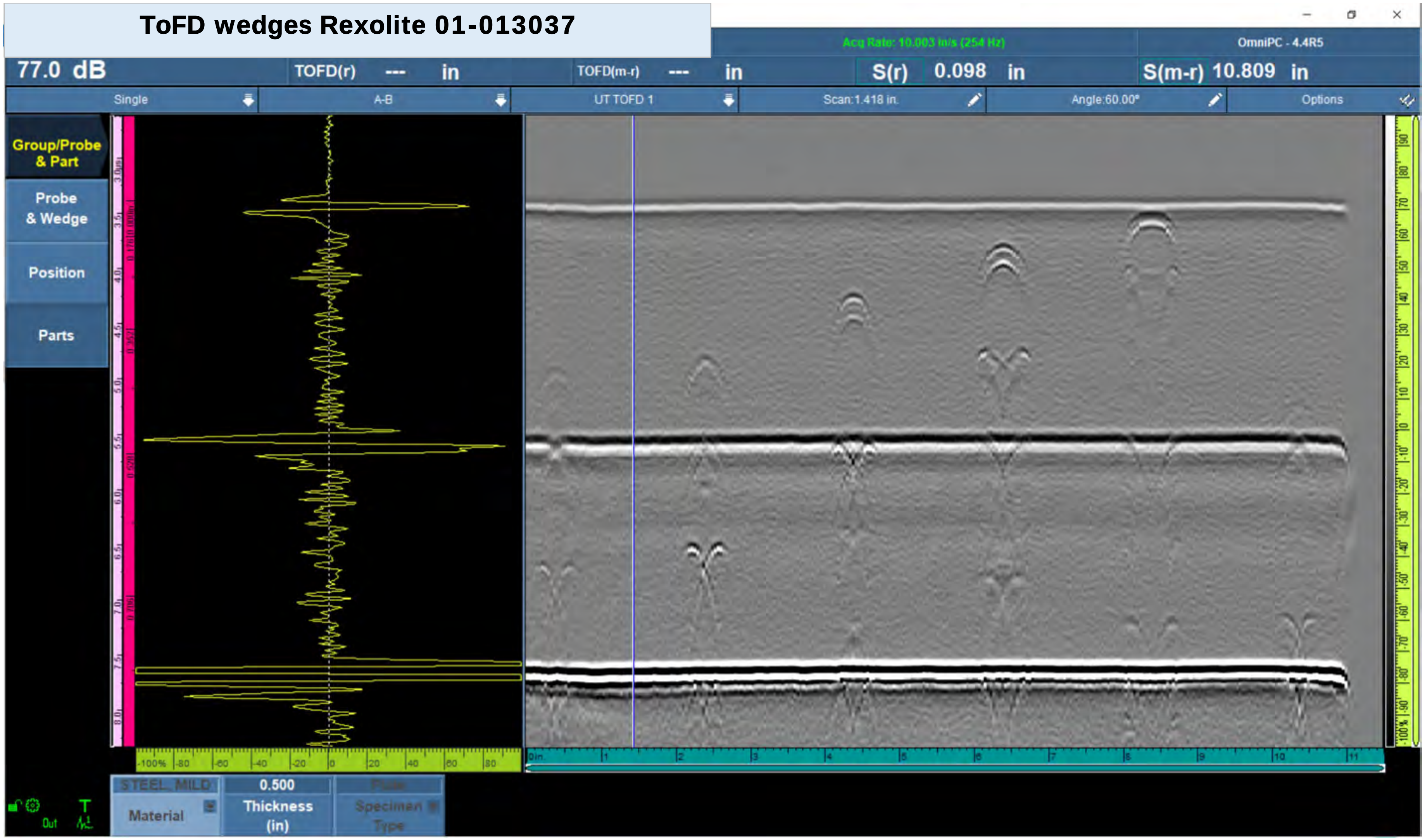
ToFD wedges Rexolite 362-001-160



16x375 pipe, long seam, slanted, wafer wheel notches

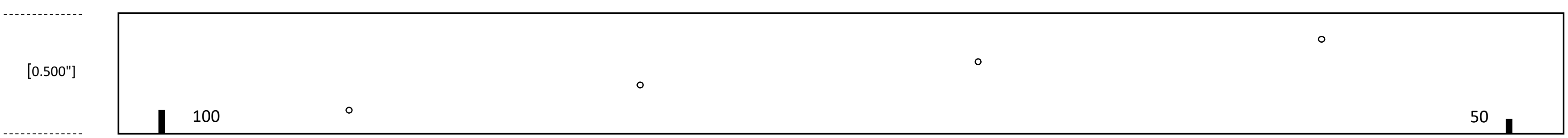


ToFD wedges Rexolite 01-013037

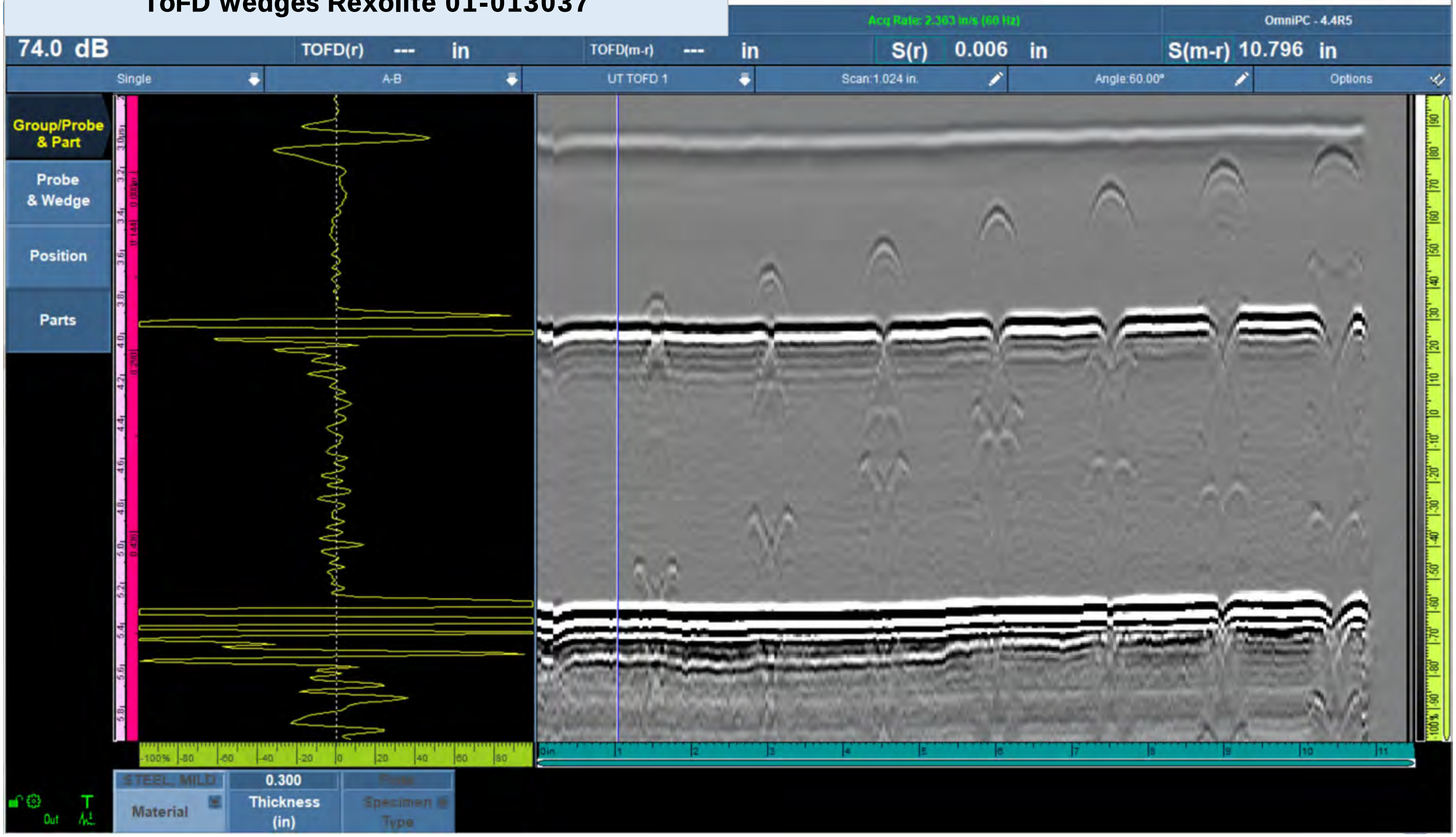


FAST1 cal block

4 side drilled holes, two EDM notoches

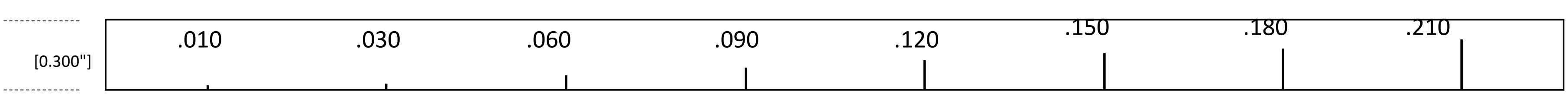


ToFD wedges Rexolite 01-013037

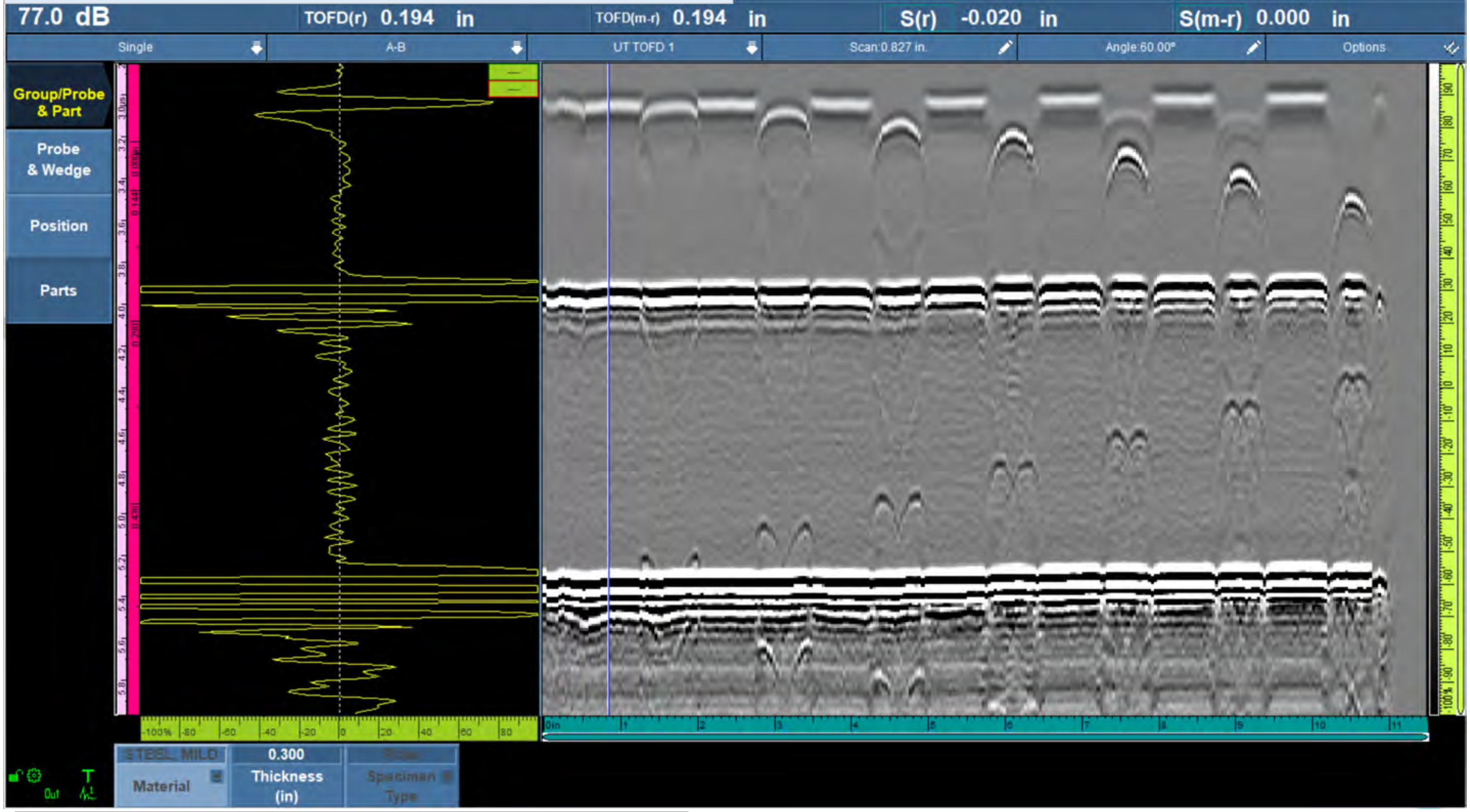


ID notches

8 EDM notoches

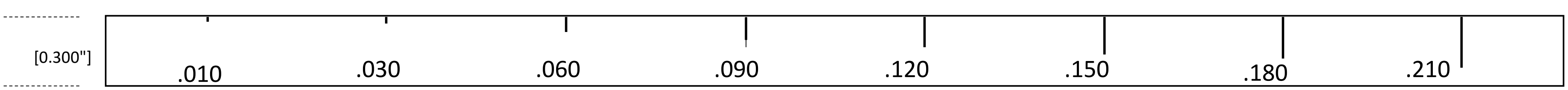


ToFD wedges Rexolite 01-013037

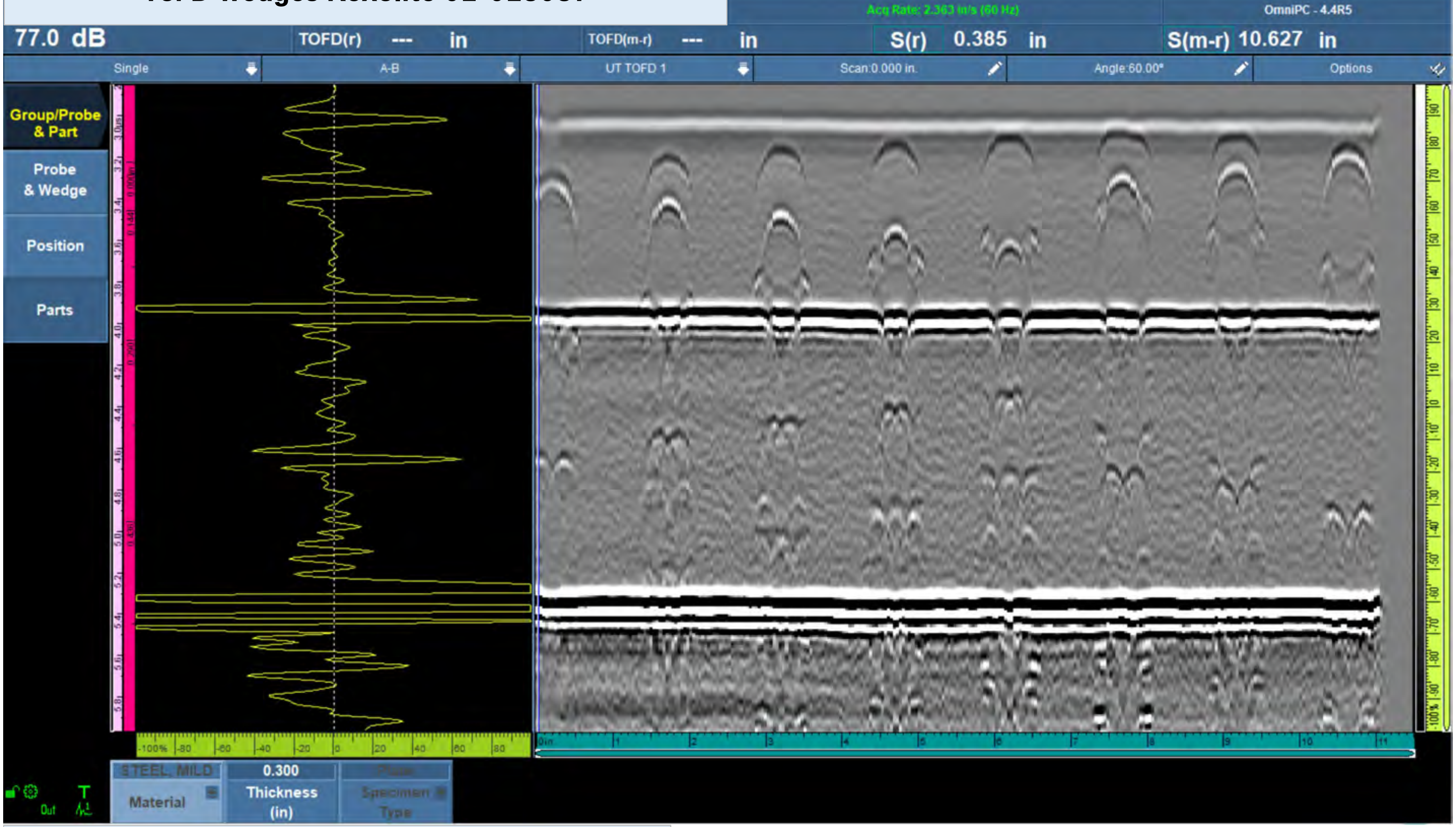


OD notches

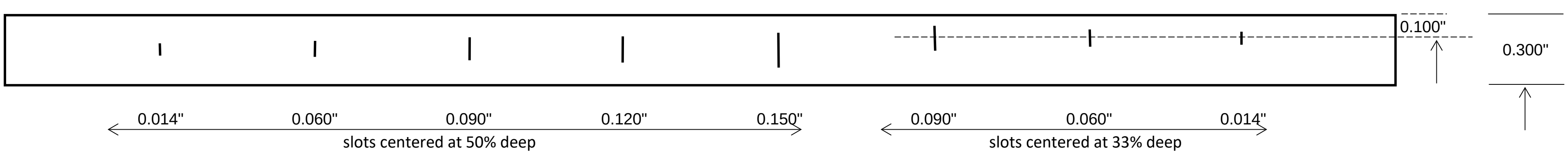
8 EDM notoches



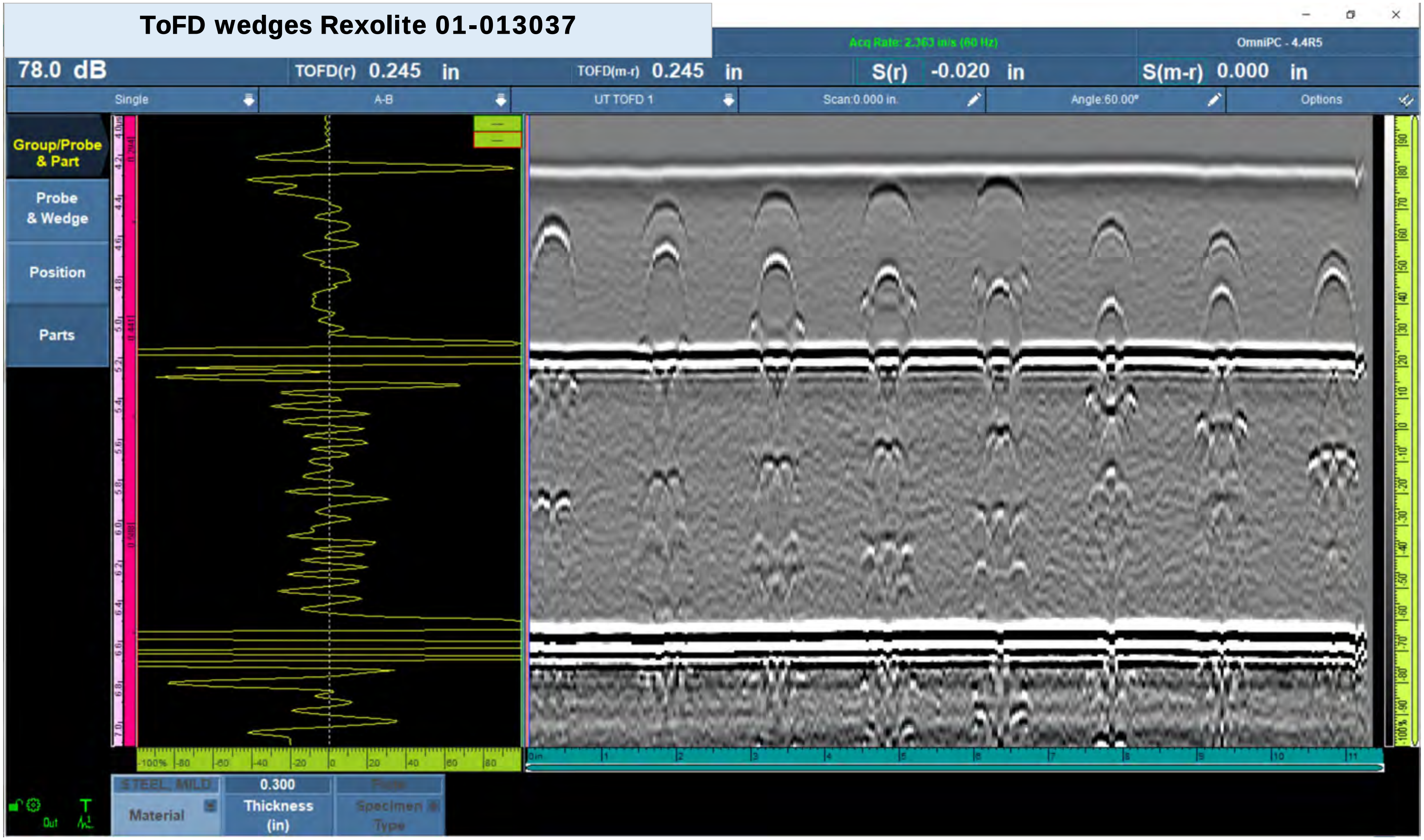
ToFD wedges Rexolite 01-013037



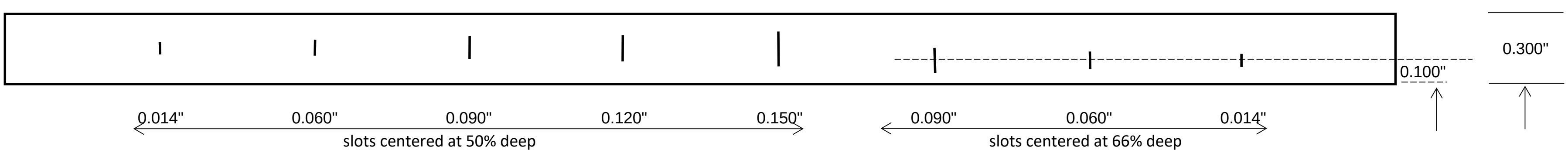
midwall slots, up



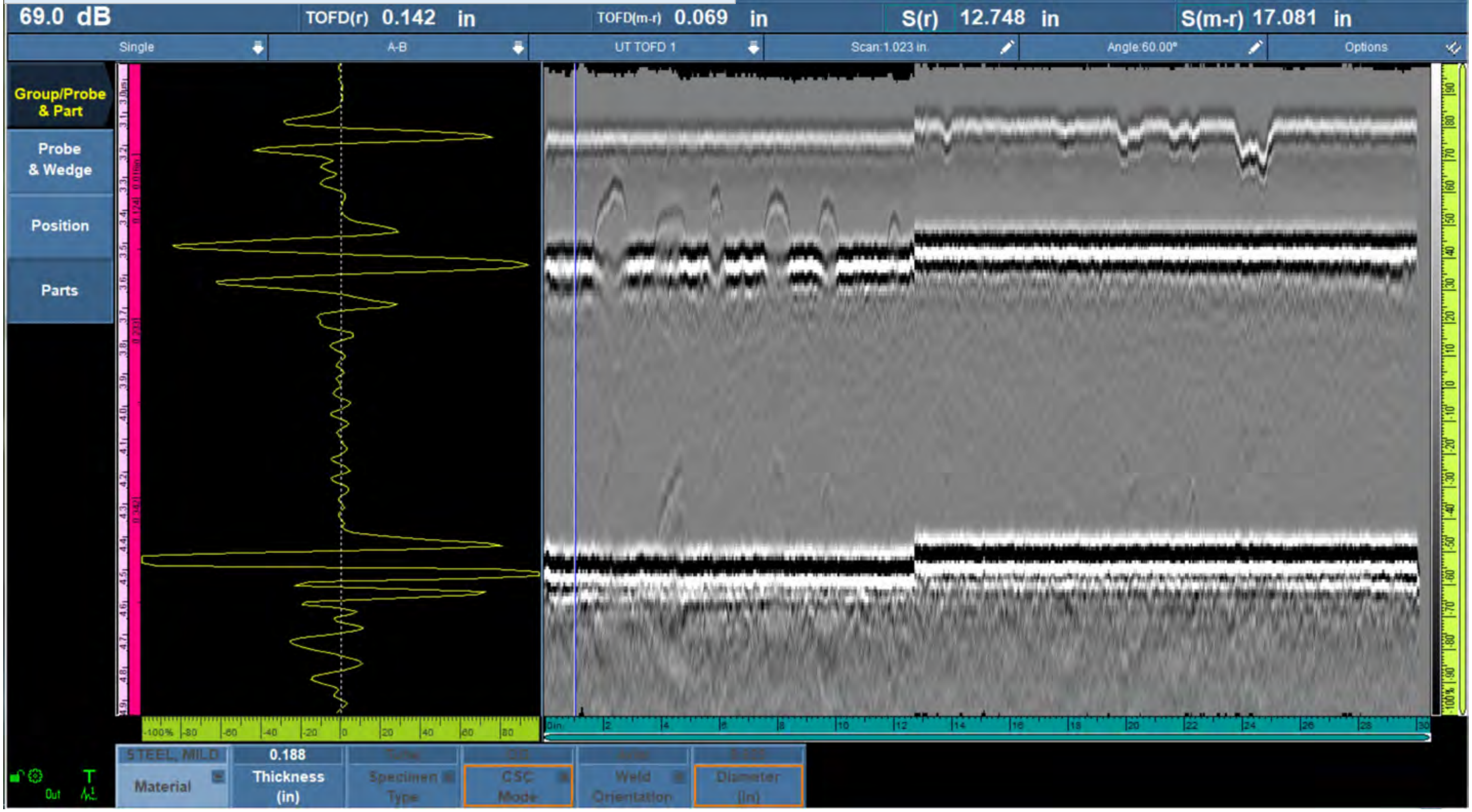
ToFD wedges Rexolite 01-013037



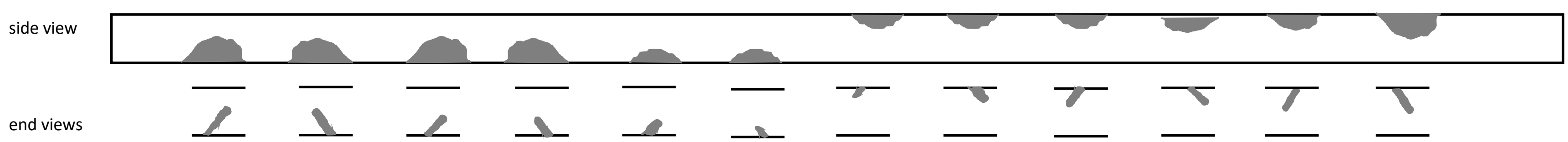
midwall slots, down



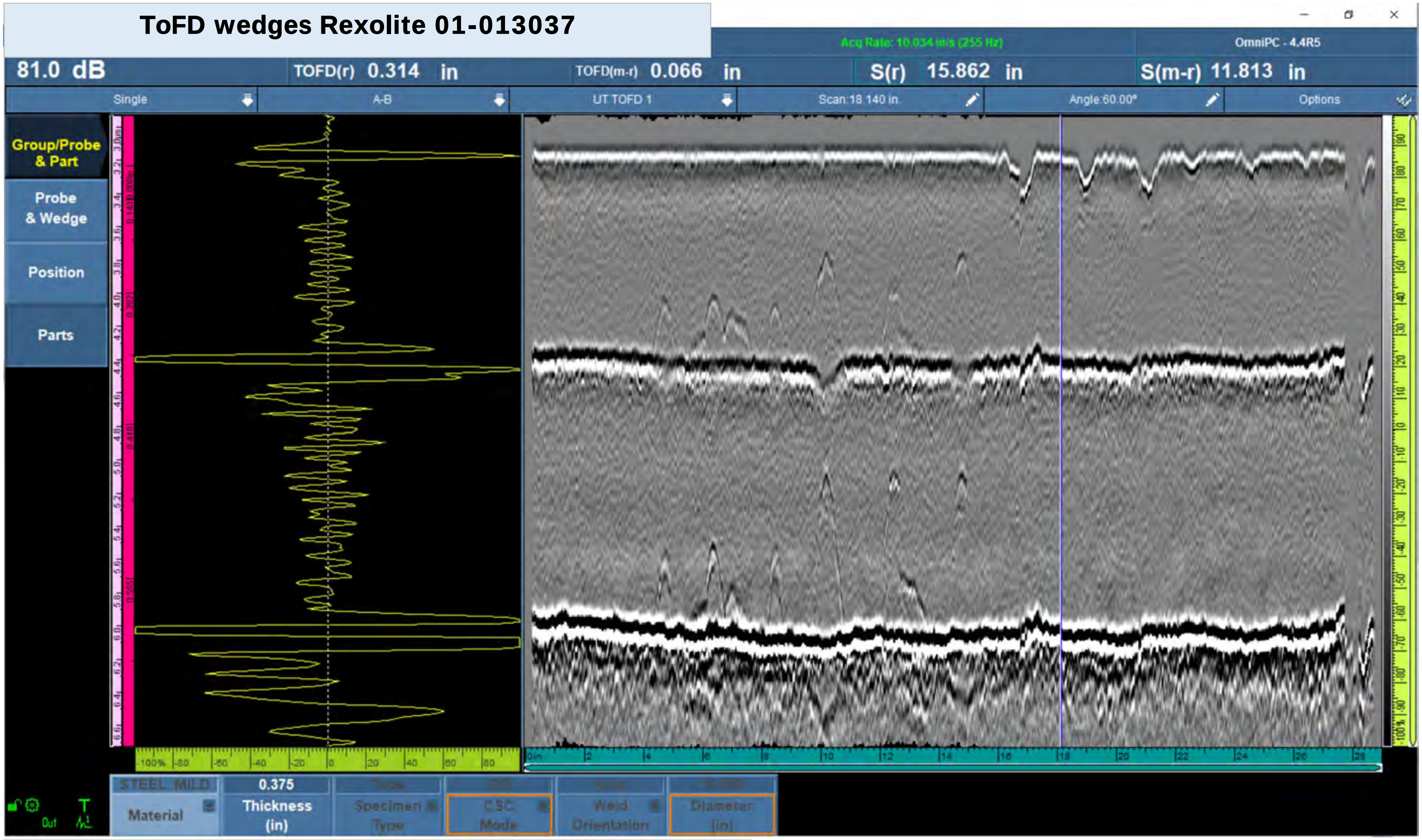
ToFD wedges Rexolite 01-013037



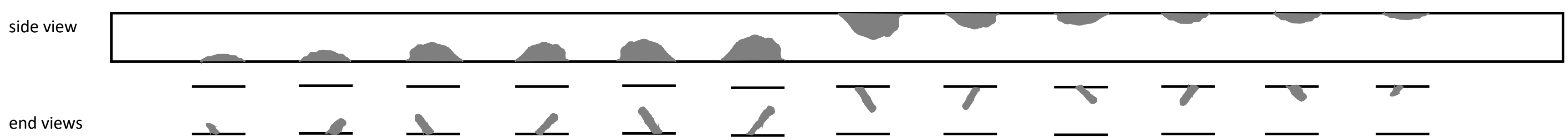
8x188 pipe, long seam, slanted, wafer wheel notches



ToFD wedges Rexolite 01-013037



16x375 pipe, long seam, slanted, wafer wheel notches



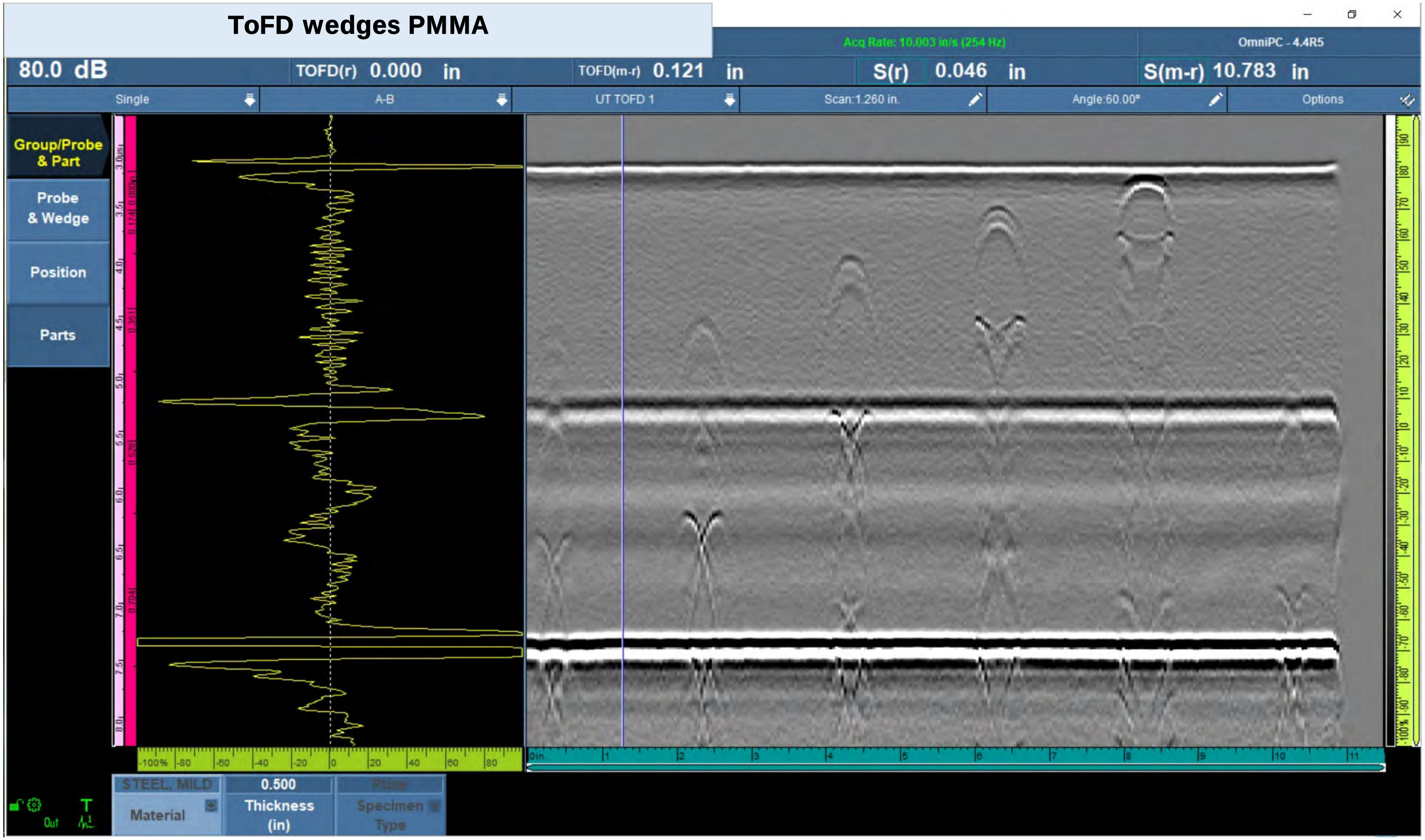
Scans organized type of object scanned start here.

The following pages will show ToFD scans of each of the seven scan objects with each of the 9 types of ToFD wedges/materials. <u>The order of scans shown is organized by the type of object scanned. This can facilitate which wedge type is preferred for each type of scan object</u>. You are moving along each row of the table left to right, one at a time. The reader is invited to print this page and keep track of which wedge materals is preferred by the reader.

	1 ToFD wedges PMMA	2 ToFD wedges Plexiglass 01-012038	3 ToFD wedges Plexiglass 1	4 ToFD wedges Plexiglass 2	5 ToFD wedges Plexiglass 3	6 ToFD wedges Plexiglass 01-012100	7 ToFD wedges Plexiglass 01-013038	8 ToFD wedges Rexolite 362-001-160	9 ToFD wedges Rexolite 01-013037
FAST1 cal block									
ID Notch block									
OD Notch block									
Midwall up									
Midwall down									
8x188									
16x375									

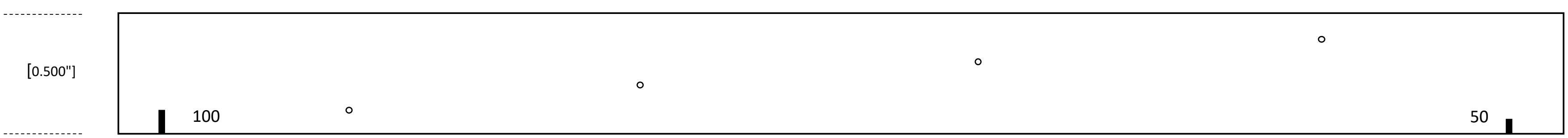
At this point it would be best to set up your Adobe reader, or Adobe Acrobat or other PDF reading app to show your "View/Page Display" menu option as <u>whole page</u>. From this point forward advance your pages with your "page up" and "page down" keys, like a slide show. Viewing in other modes such as "continuous" scrolling are not helpfull in contrasting the differences in the scans.

ToFD wedges PMMA

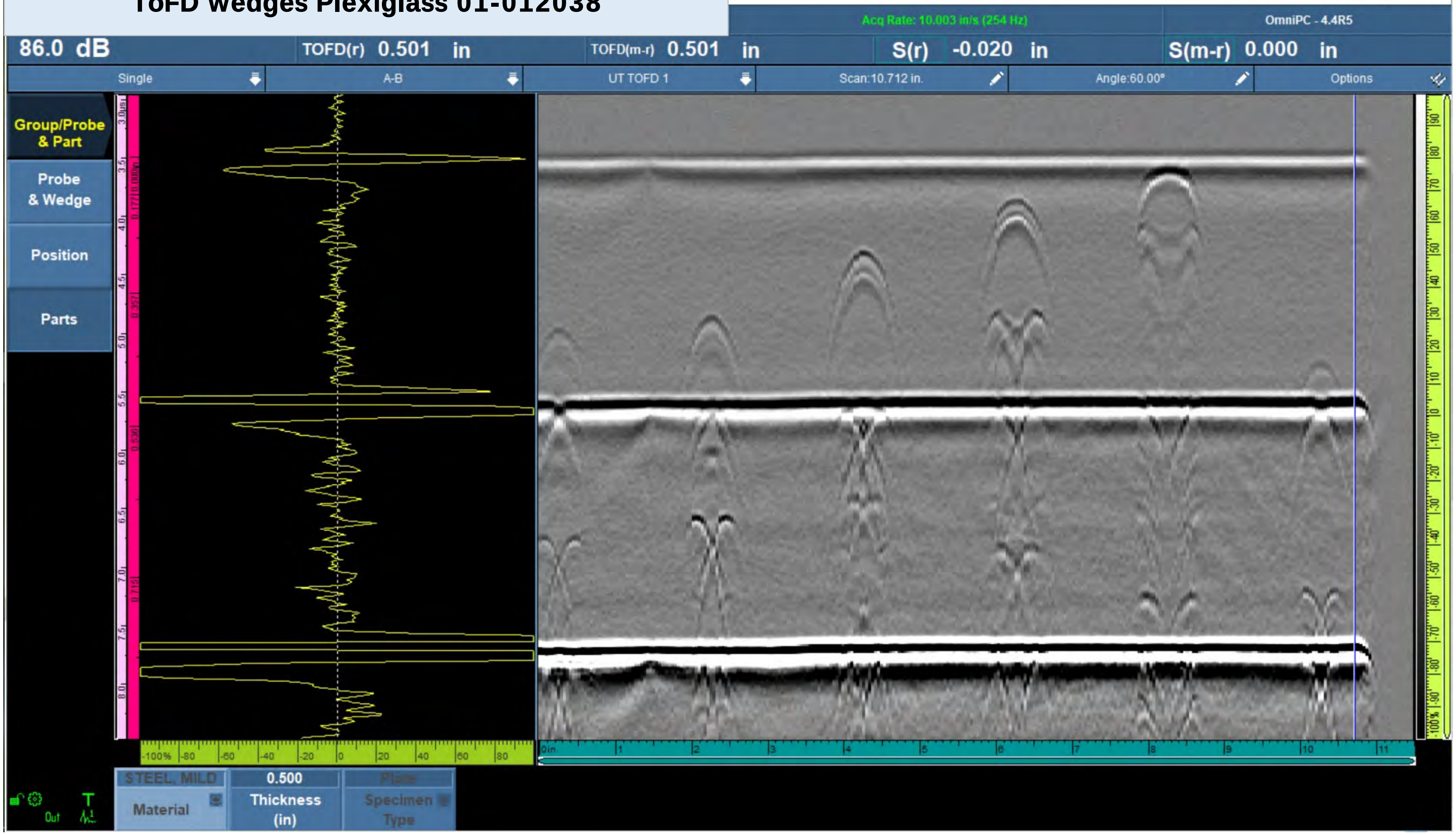


FAST1 cal block

4 side drilled holes, two EDM notoches



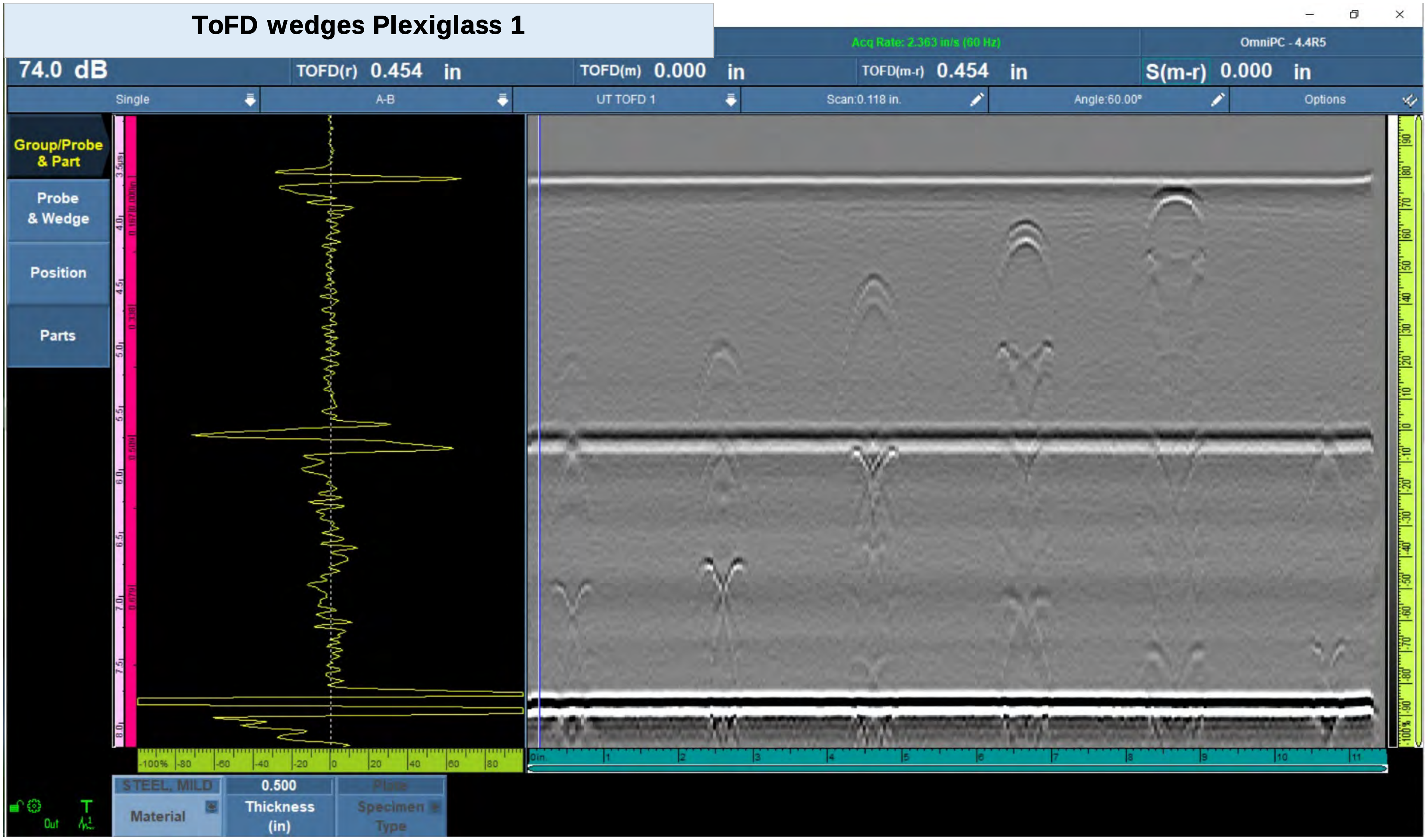
ToFD wedges Plexiglass 01-012038



FAST1 cal block

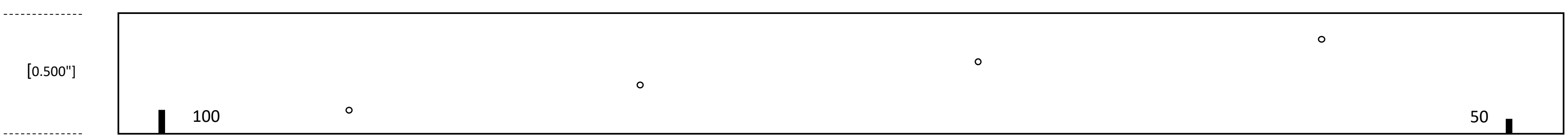
4 side drilled holes, two EDM notoches

ToFD wedges Plexiglass 1

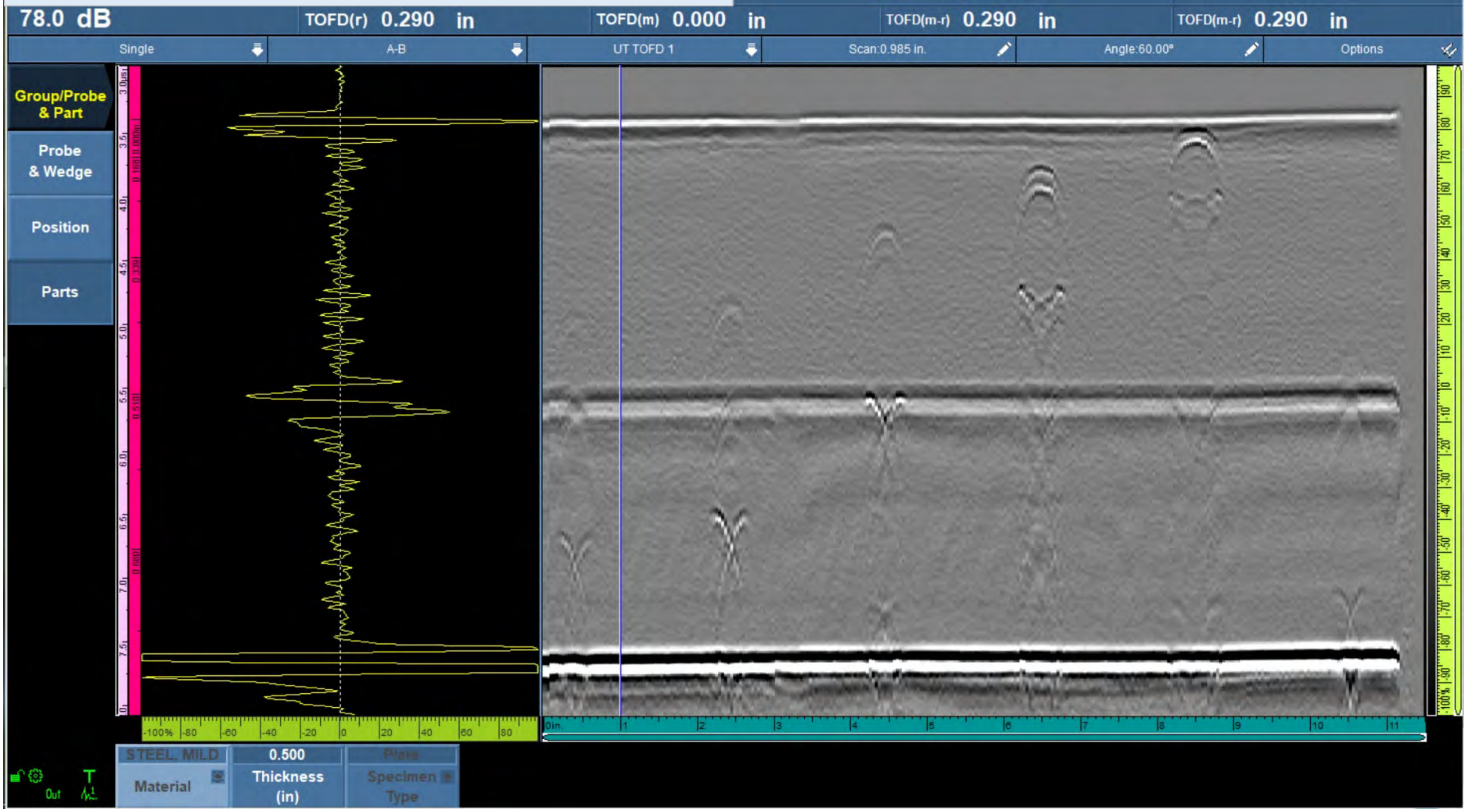


FAST1 cal block

4 side drilled holes, two EDM notoches

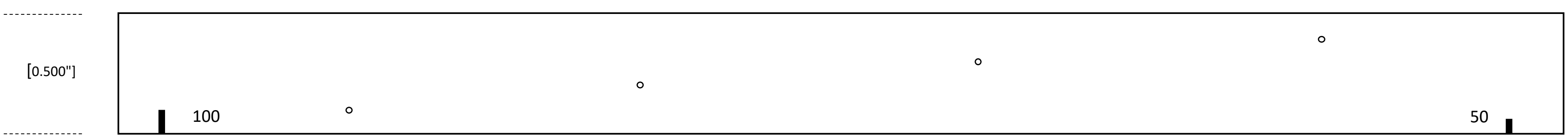


ToFD wedges Plexiglass 2

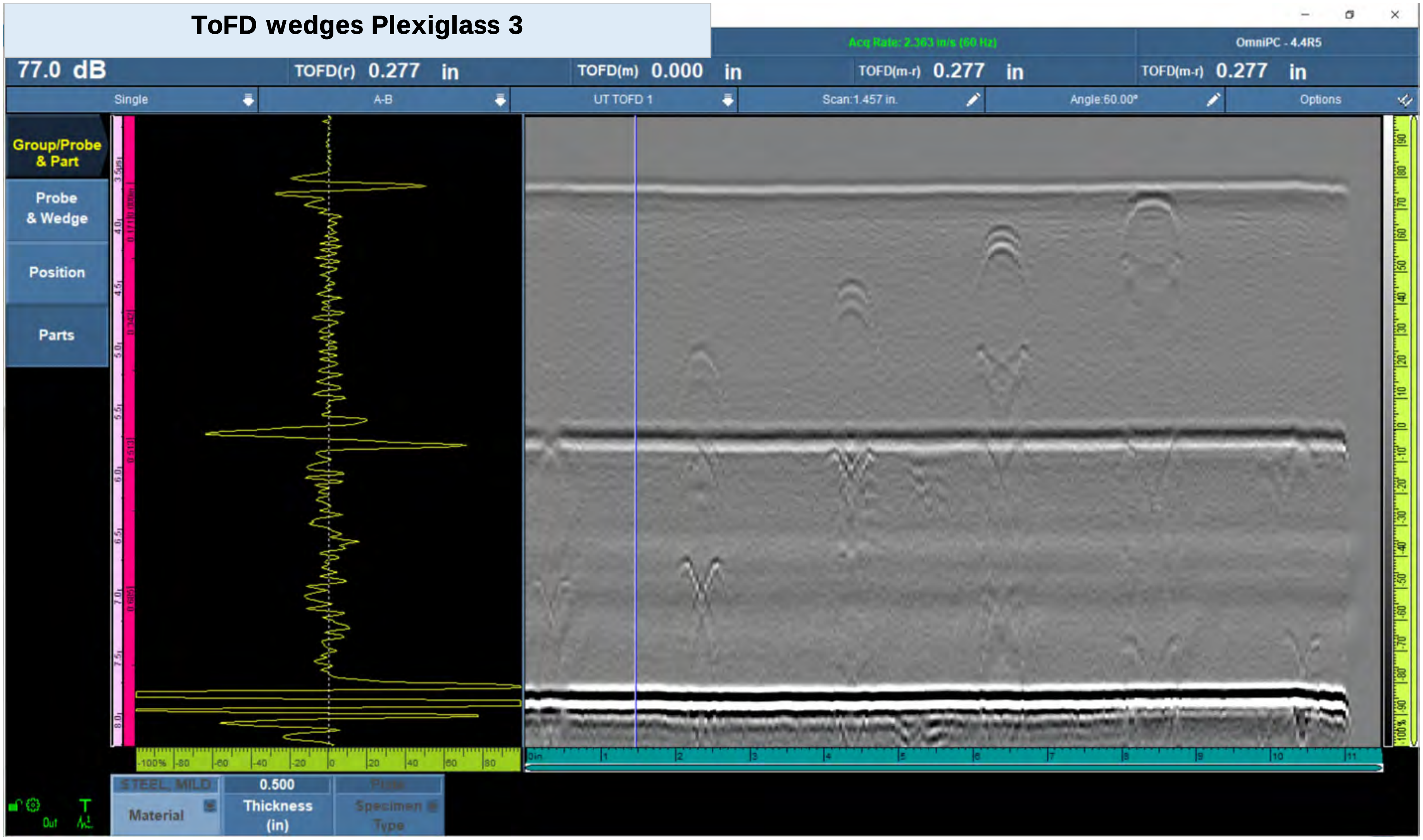


FAST1 cal block

4 side drilled holes, two EDM notoches



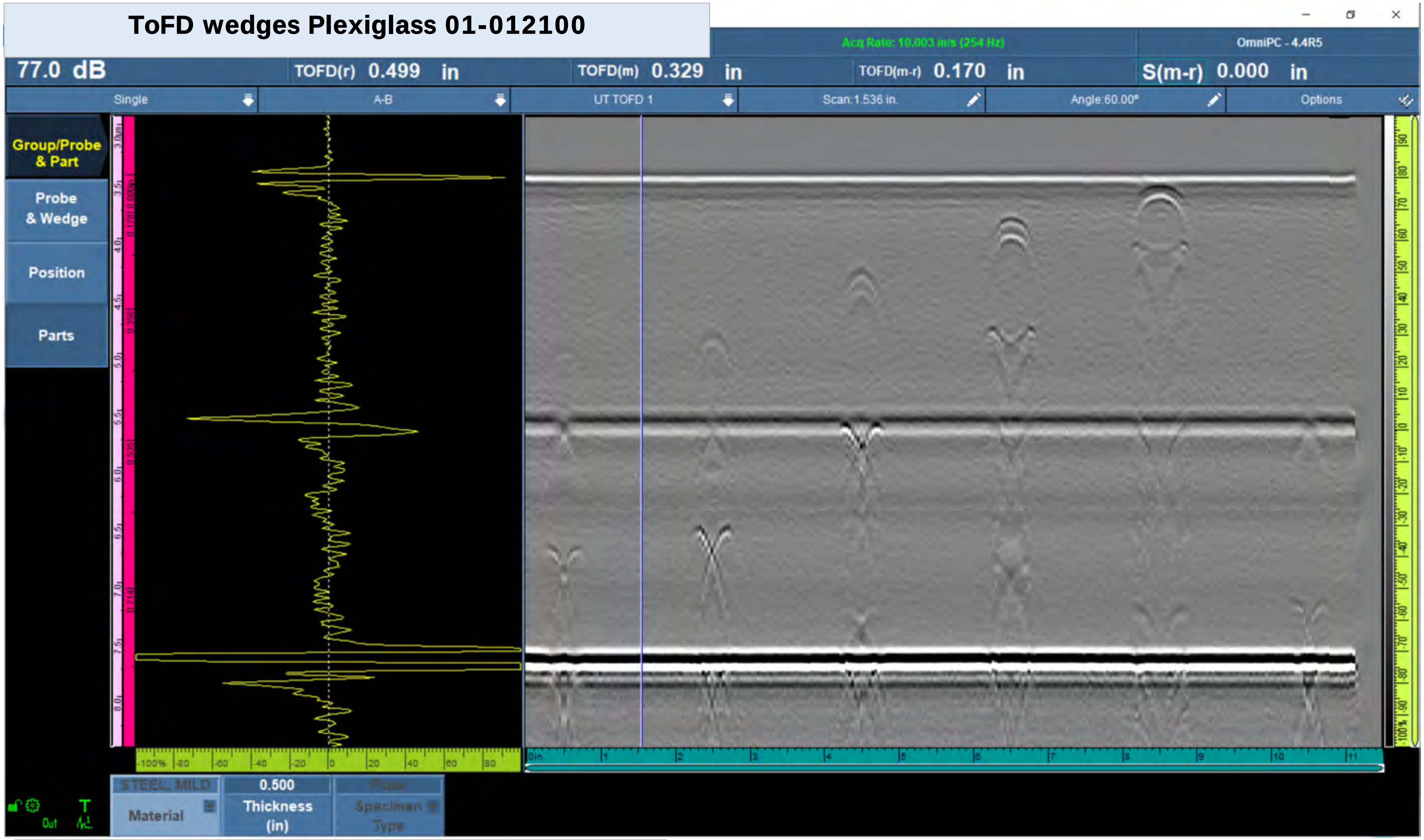
ToFD wedges Plexiglass 3



FAST1 cal block

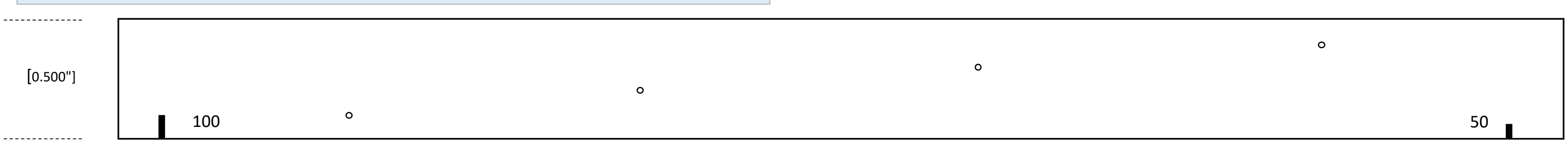
4 side drilled holes, two EDM notoches

ToFD wedges Plexiglass 01-012100

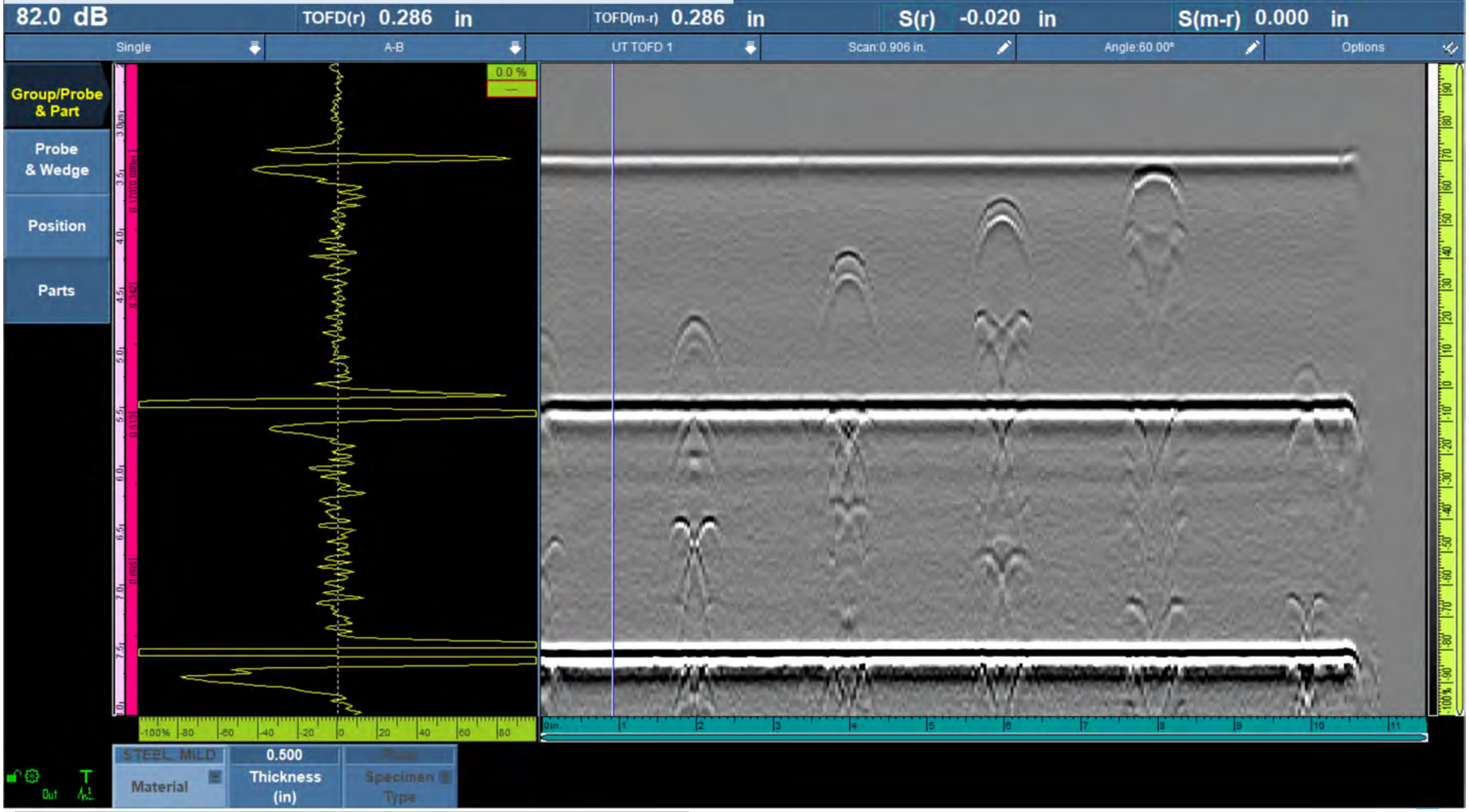


FAST1 cal block

4 side drilled holes, two EDM notoches

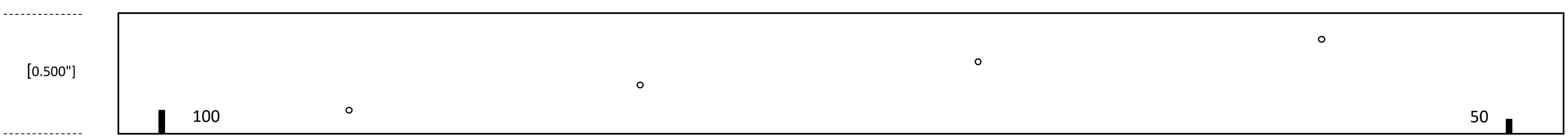


ToFD wedges Plexiglass 01-012038

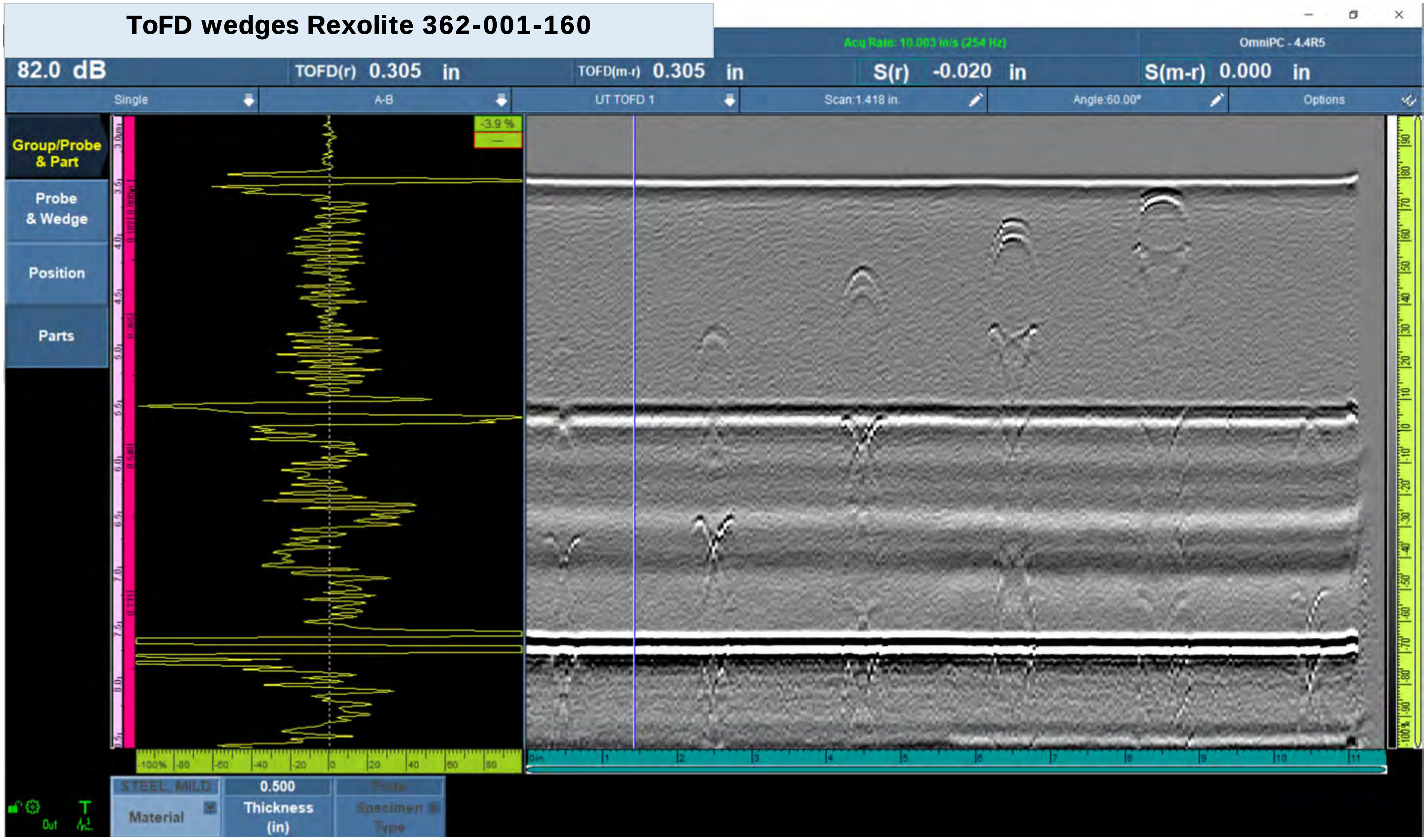


FAST1 cal block

4 side drilled holes, two EDM notoches

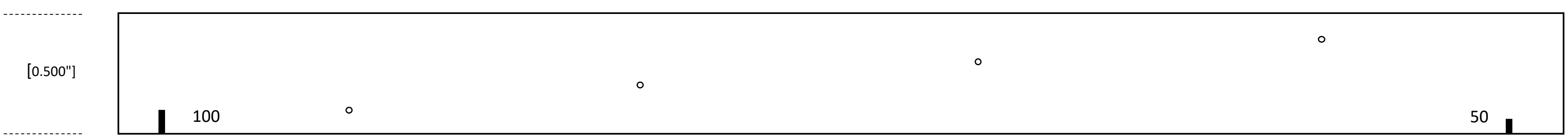


ToFD wedges Rexolite 362-001-160

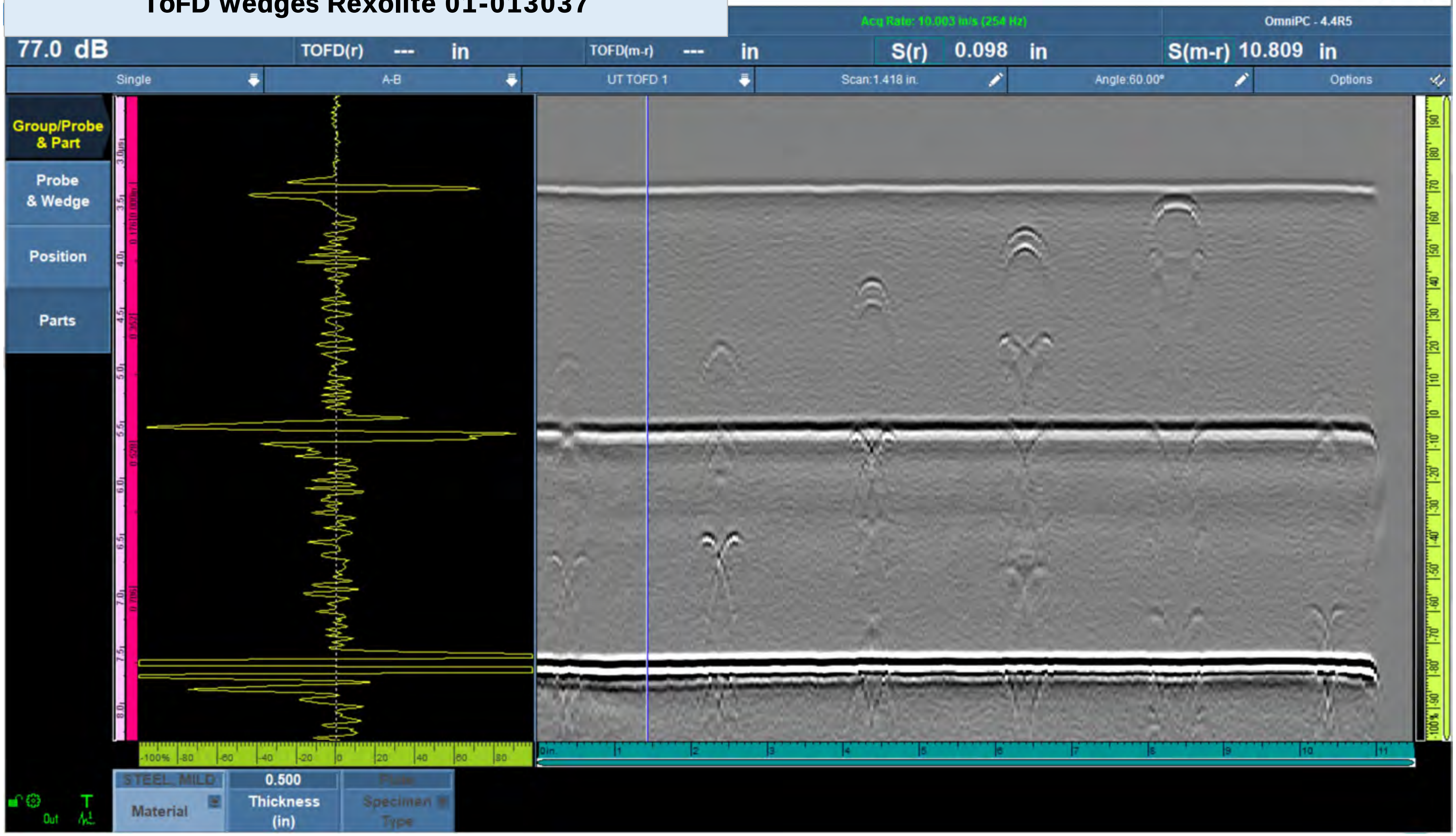


FAST1 cal block

4 side drilled holes, two EDM notoches

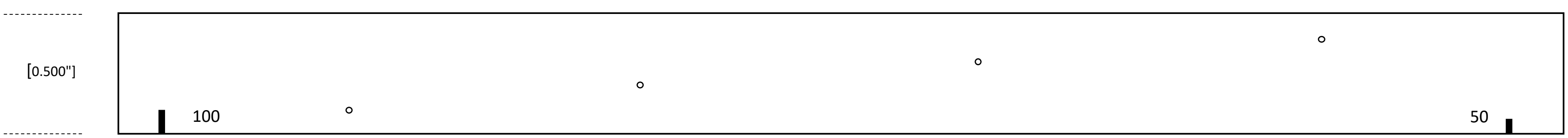


ToFD wedges Rexolite 01-013037

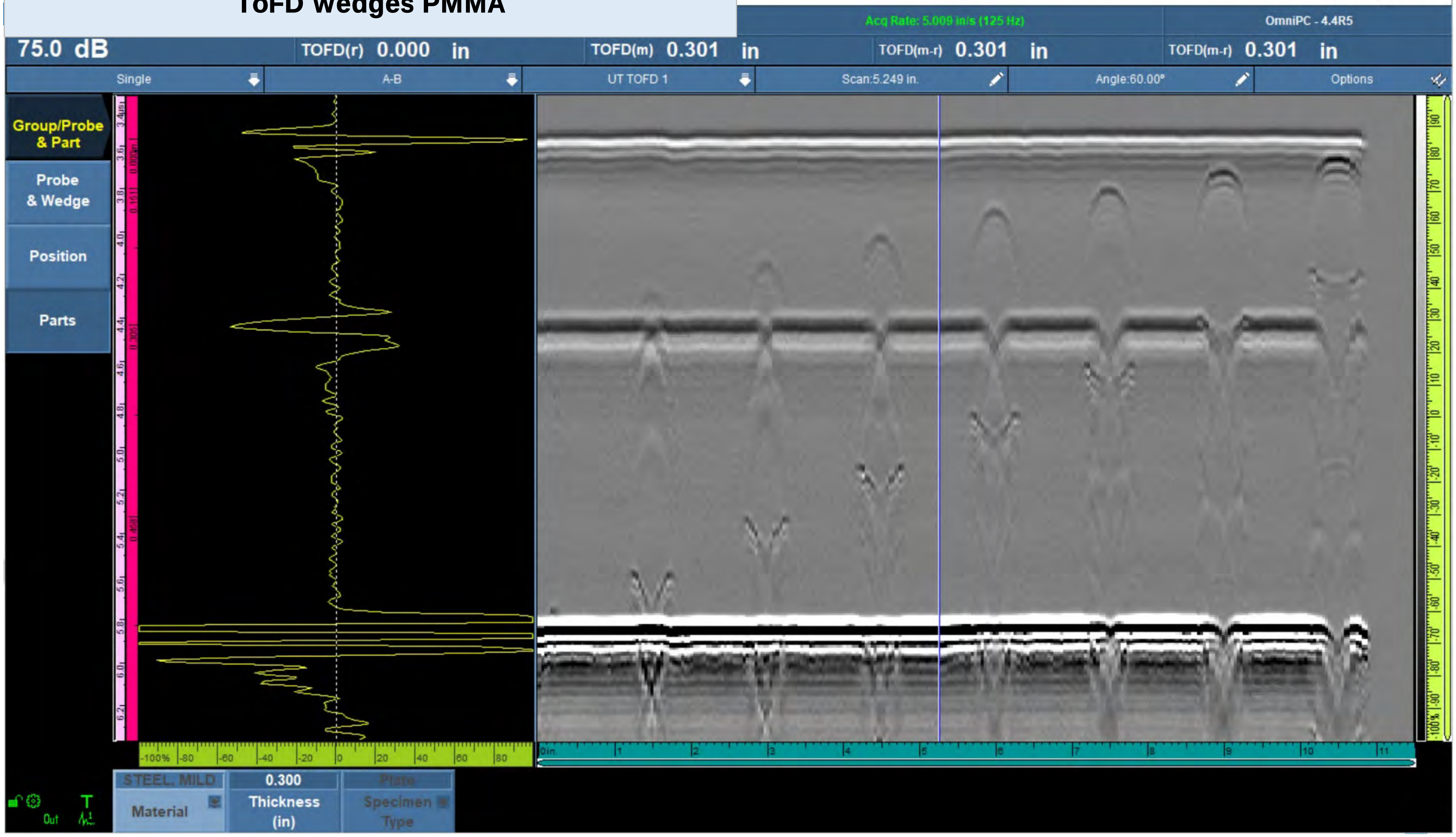


FAST1 cal block

4 side drilled holes, two EDM notoches

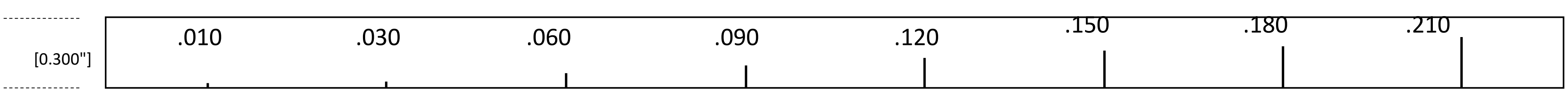


ToFD wedges PMMA

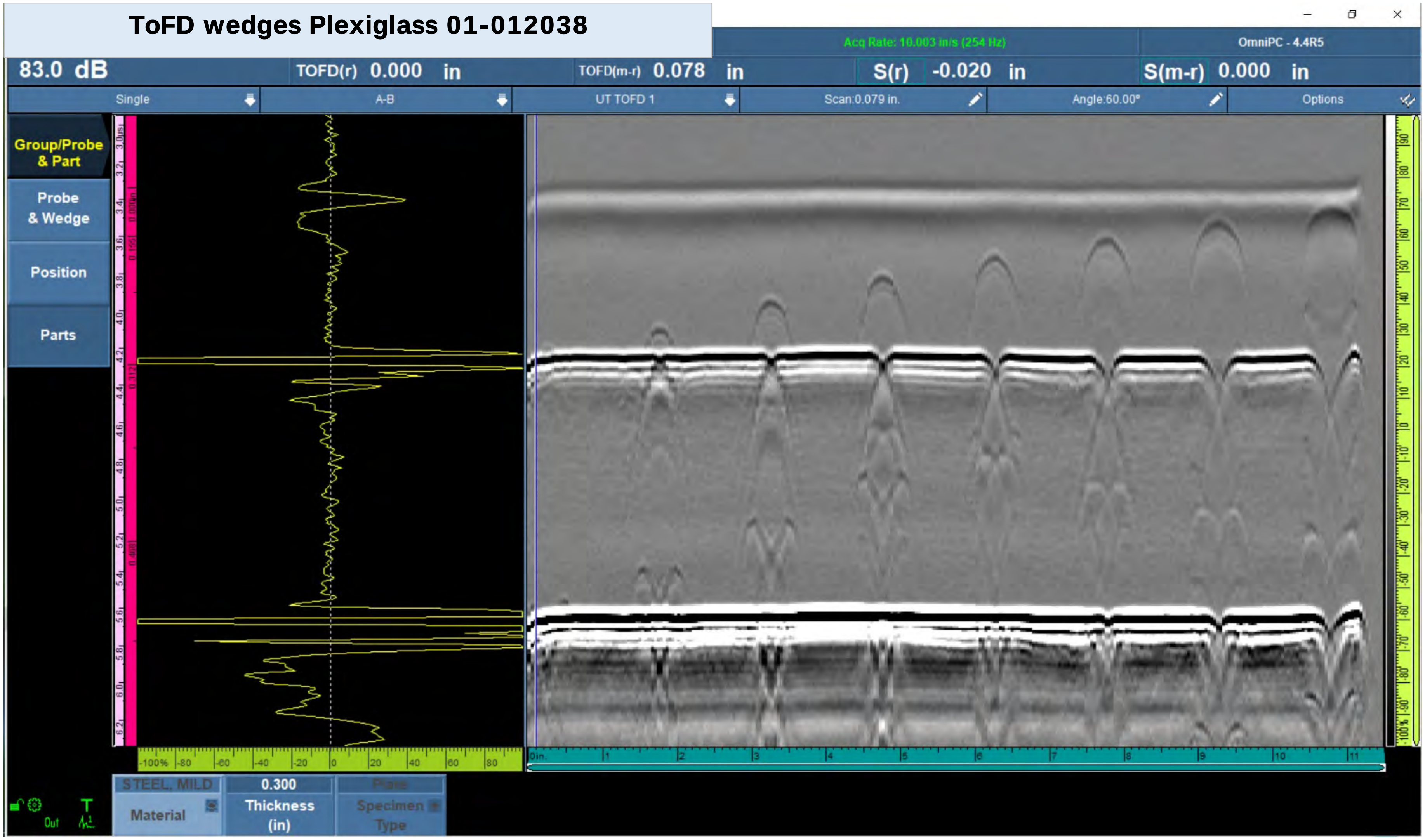


ID notches

8 EDM notoches

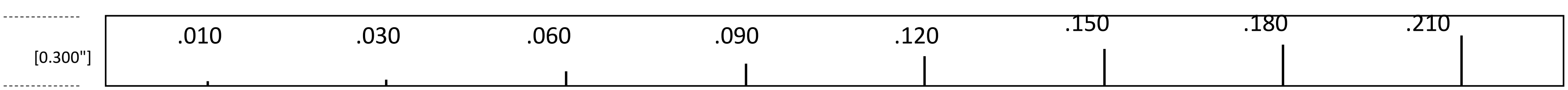


ToFD wedges Plexiglass 01-012038

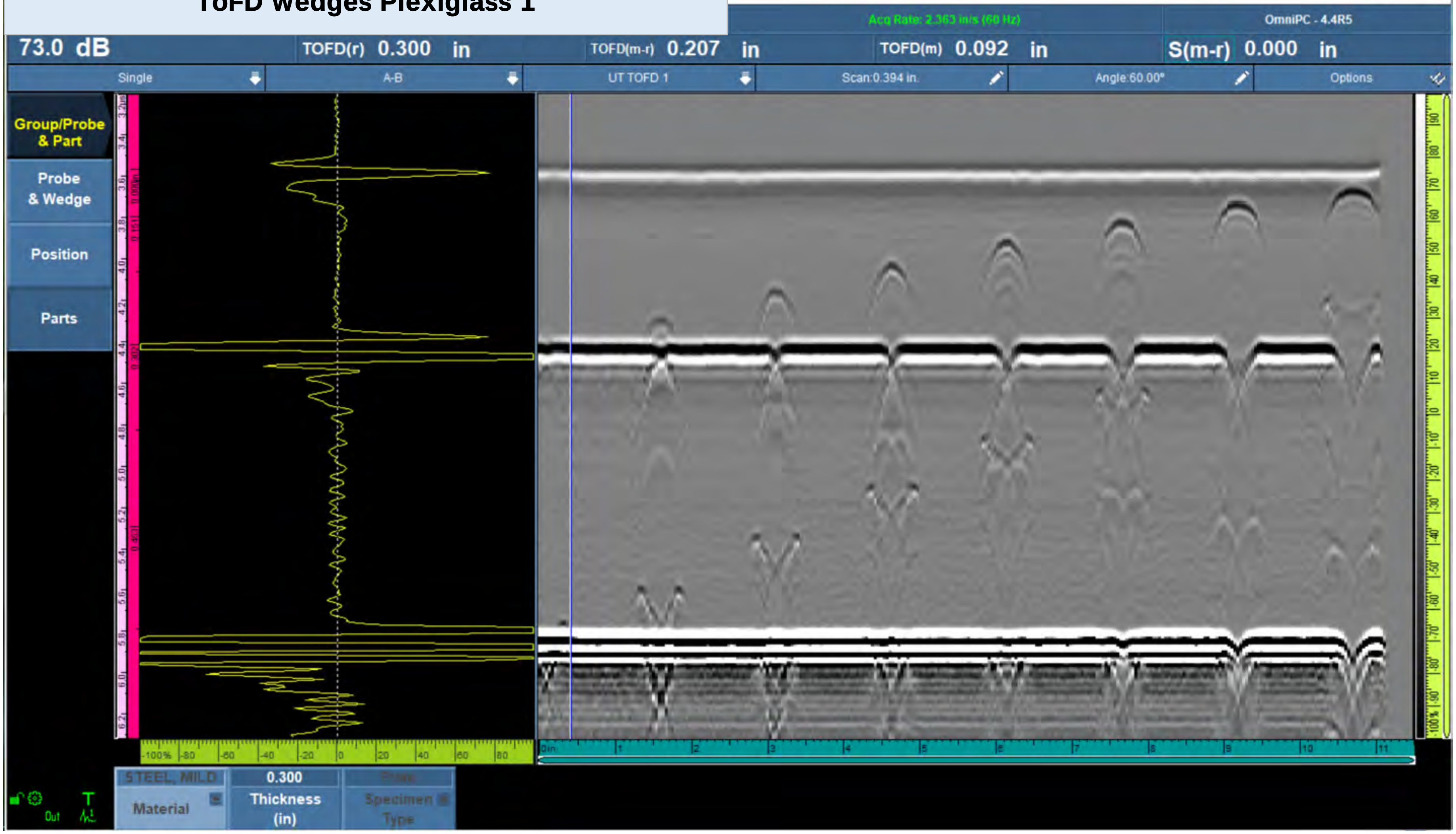


ID notches

8 EDM notoches

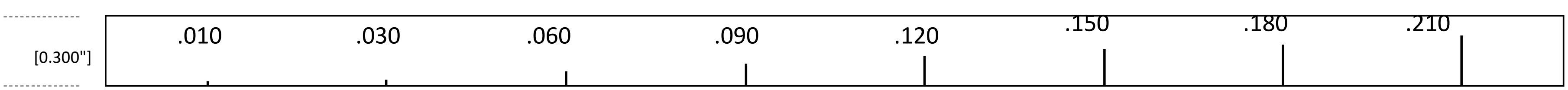


ToFD wedges Plexiglass 1

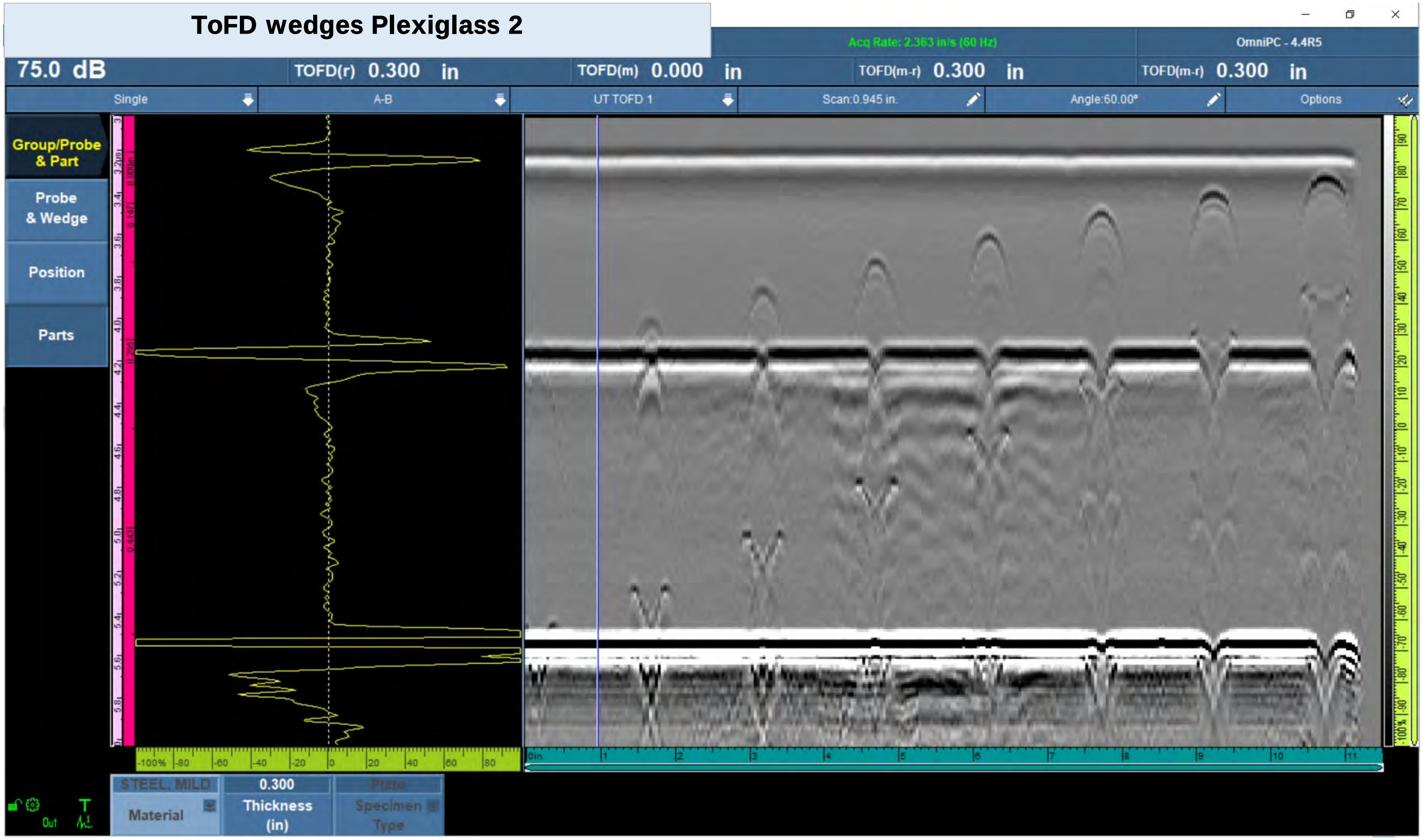


ID notches

8 EDM notoches

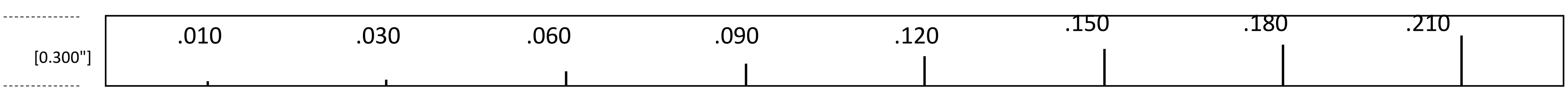


ToFD wedges Plexiglass 2

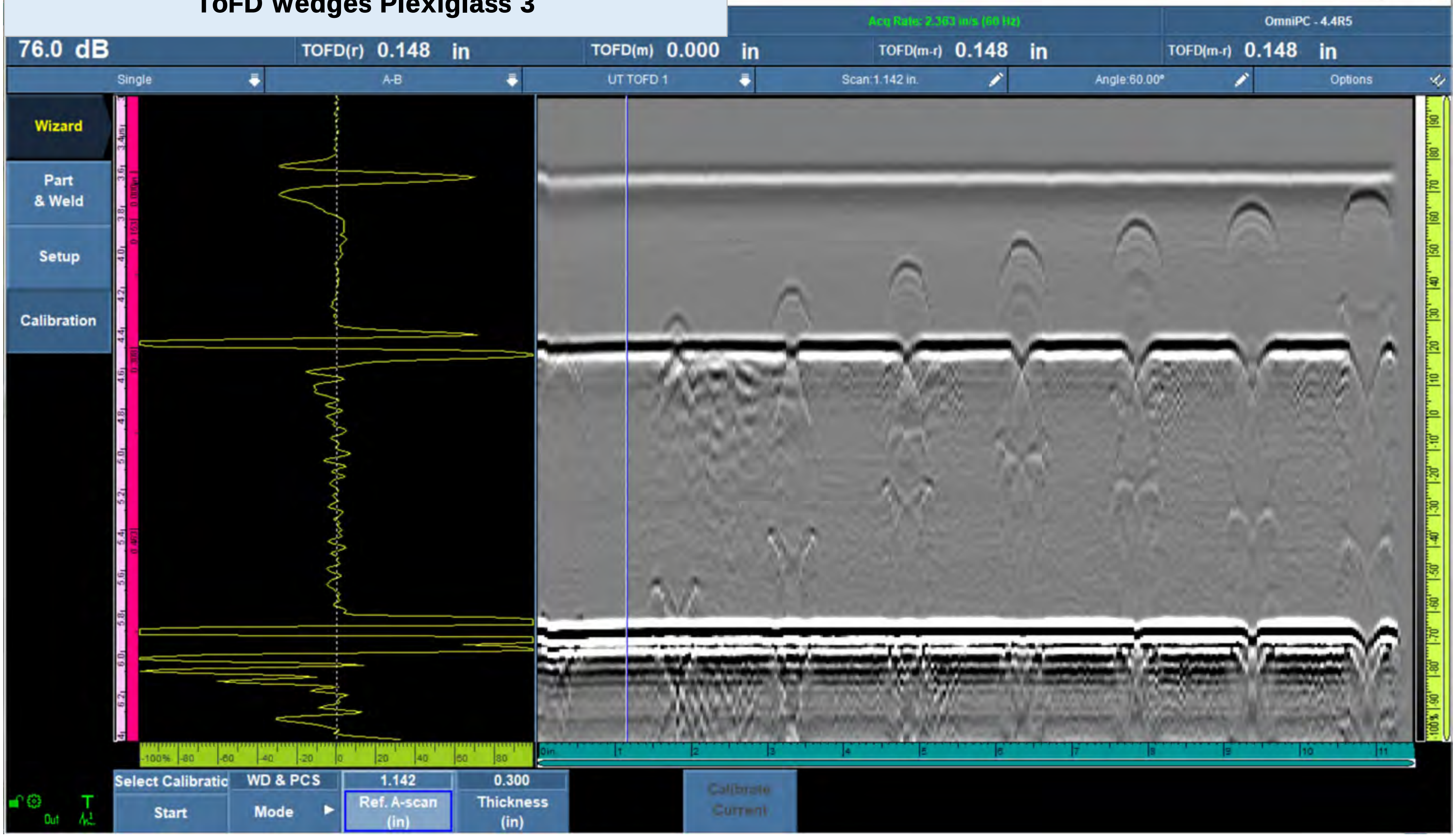


ID notches

8 EDM notoches

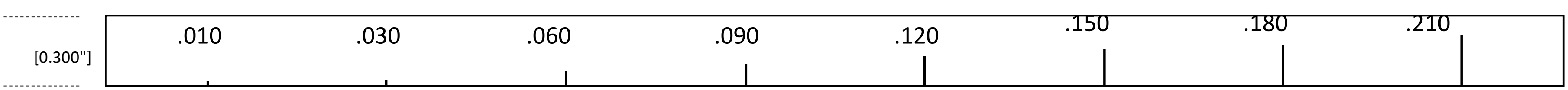


ToFD wedges Plexiglass 3

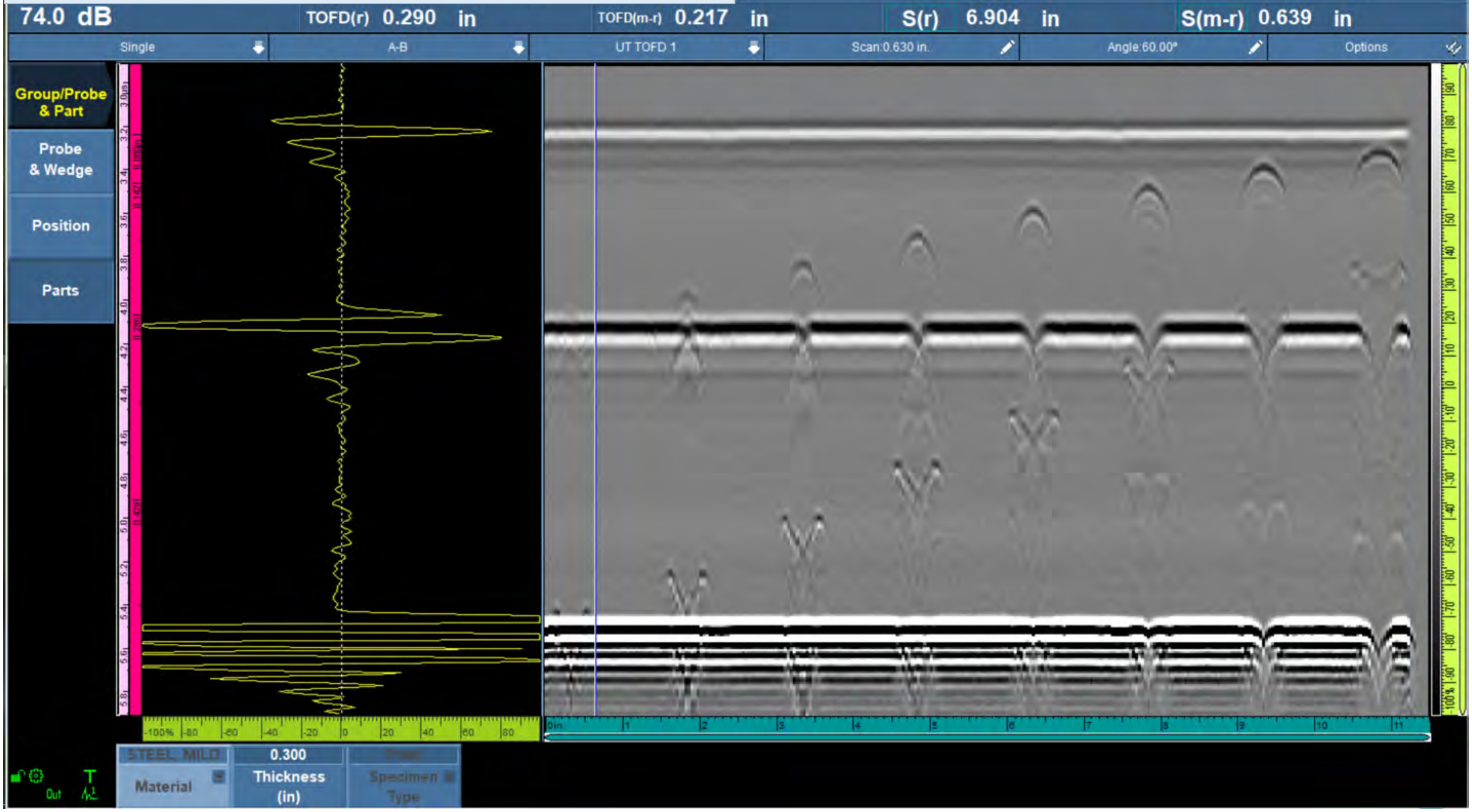


ID notches

8 EDM notoches

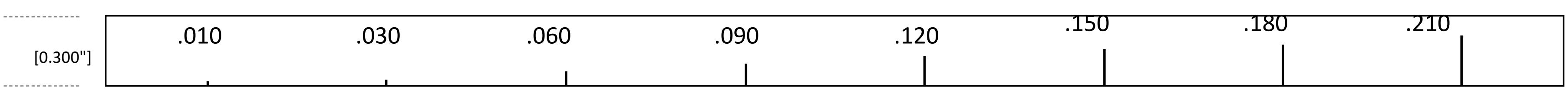


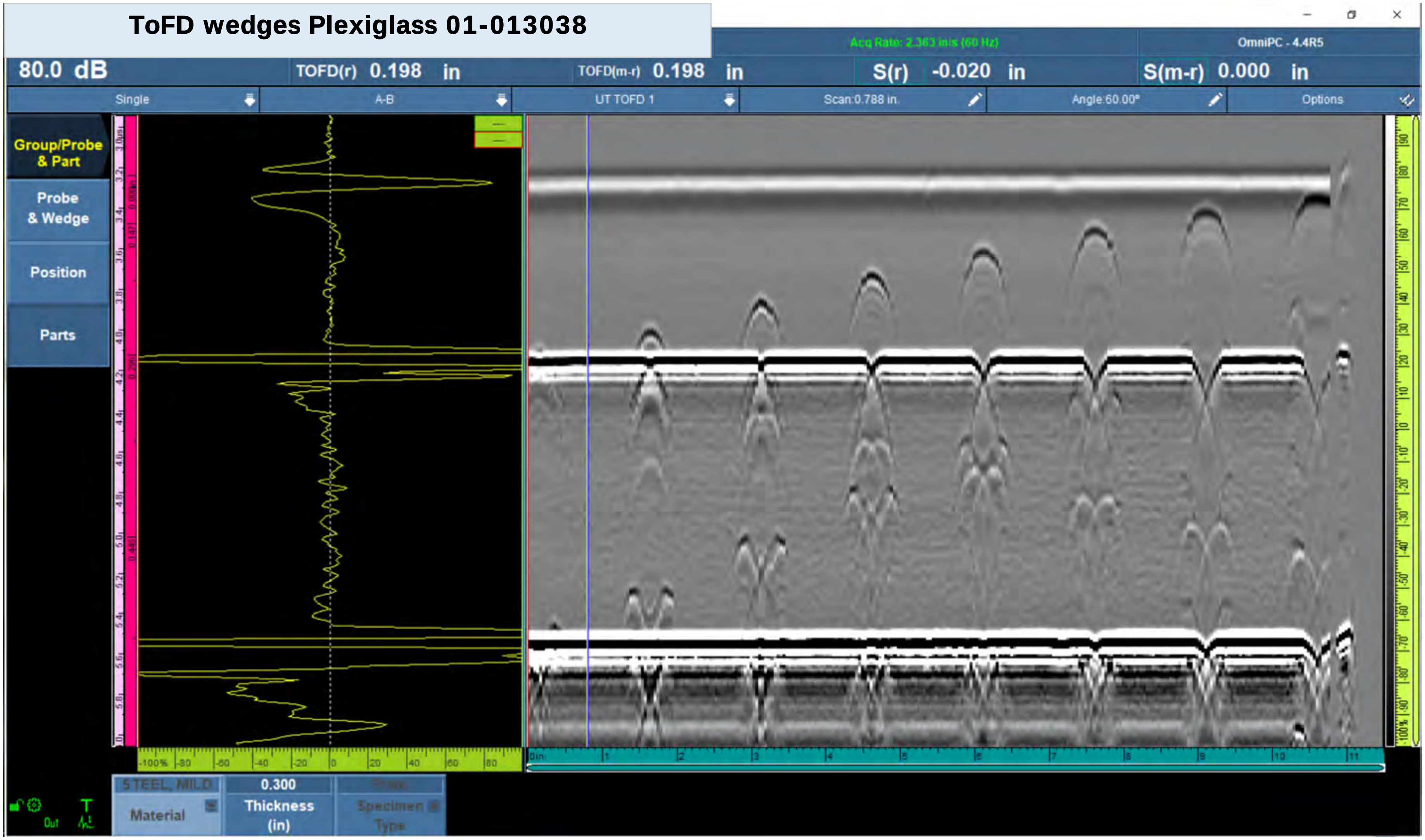
ToFD wedges Plexiglass 01-012100



ID notches

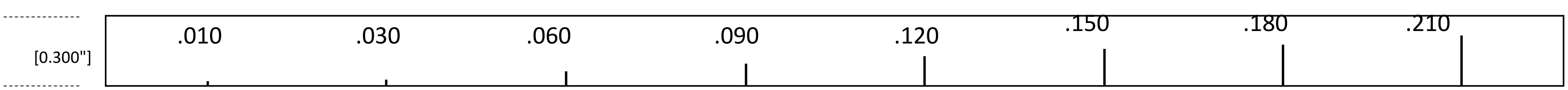
8 EDM notoches



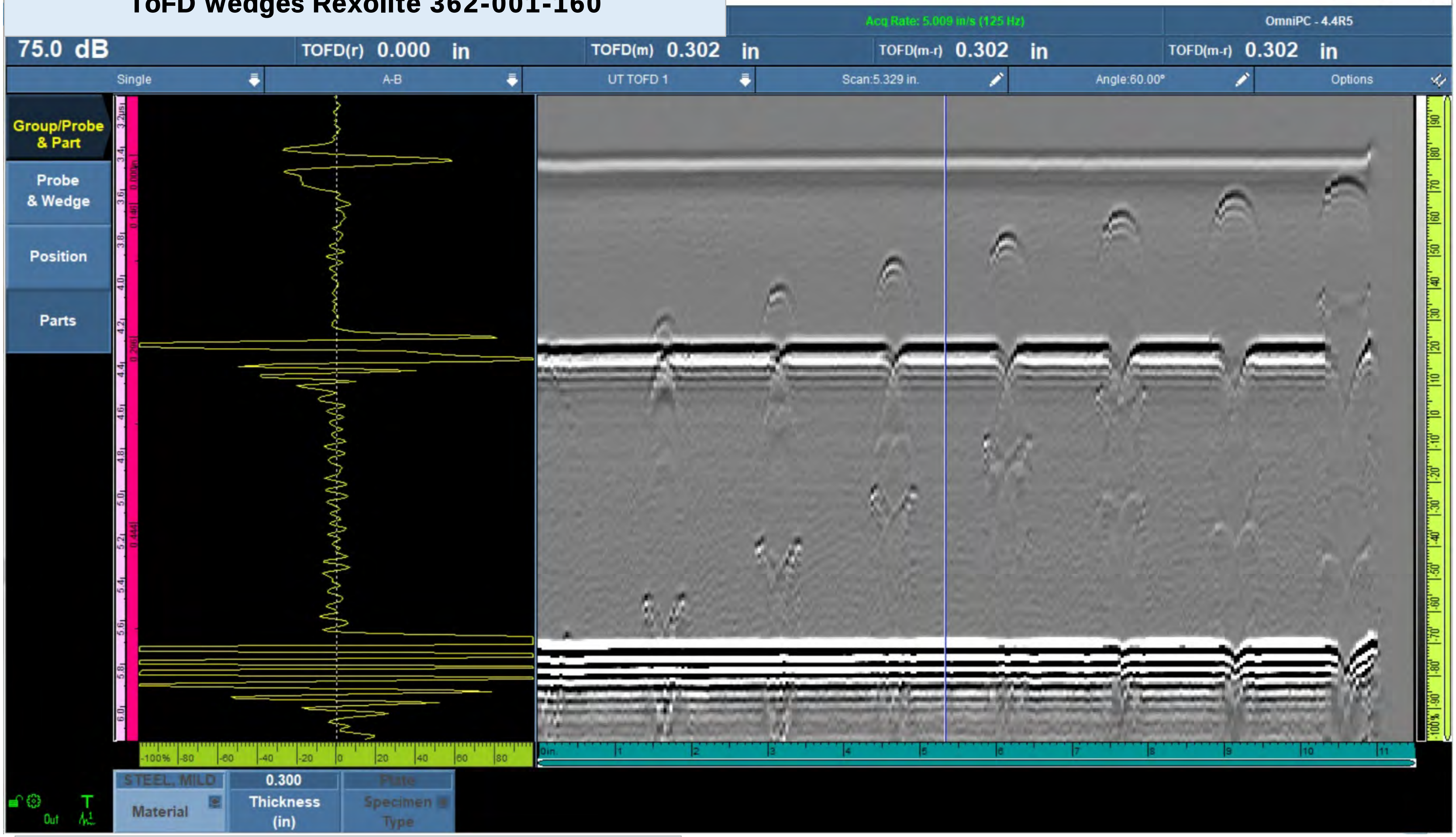


ID notches

8 EDM notoches

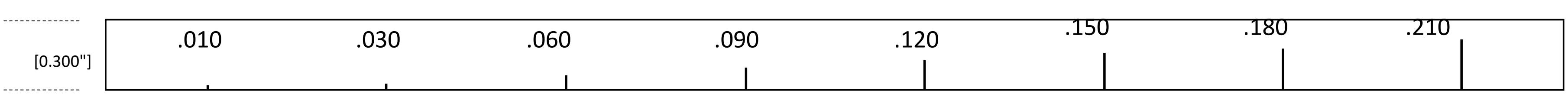


ToFD wedges Rexolite 362-001-160

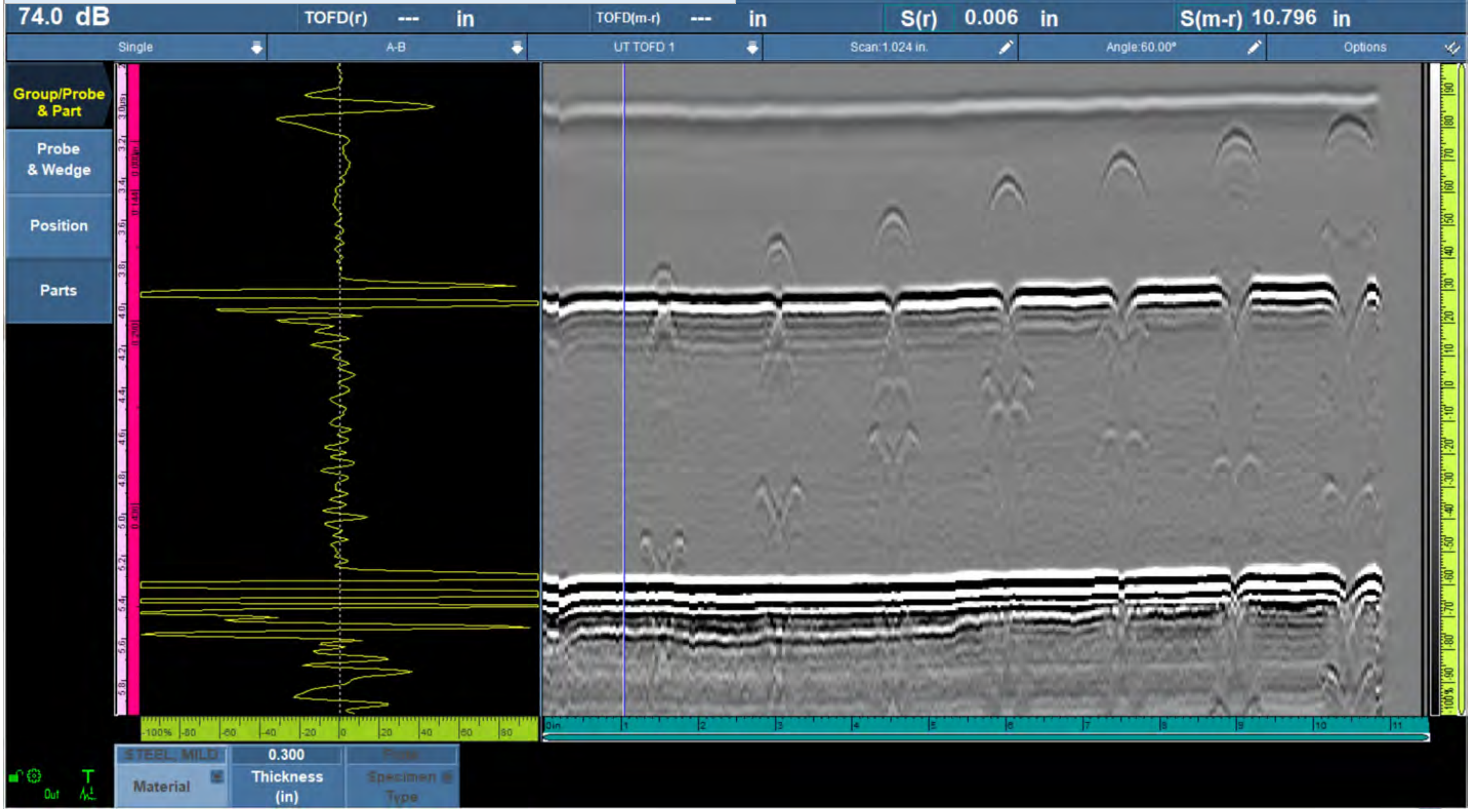


ID notches

8 EDM notoches

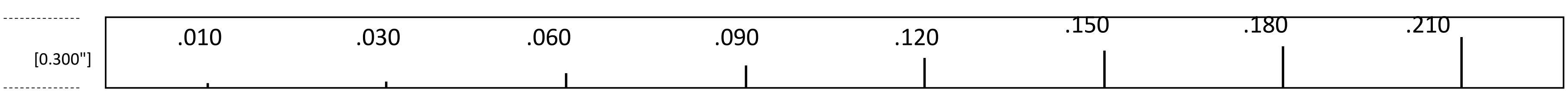


ToFD wedges Rexolite 01-013037

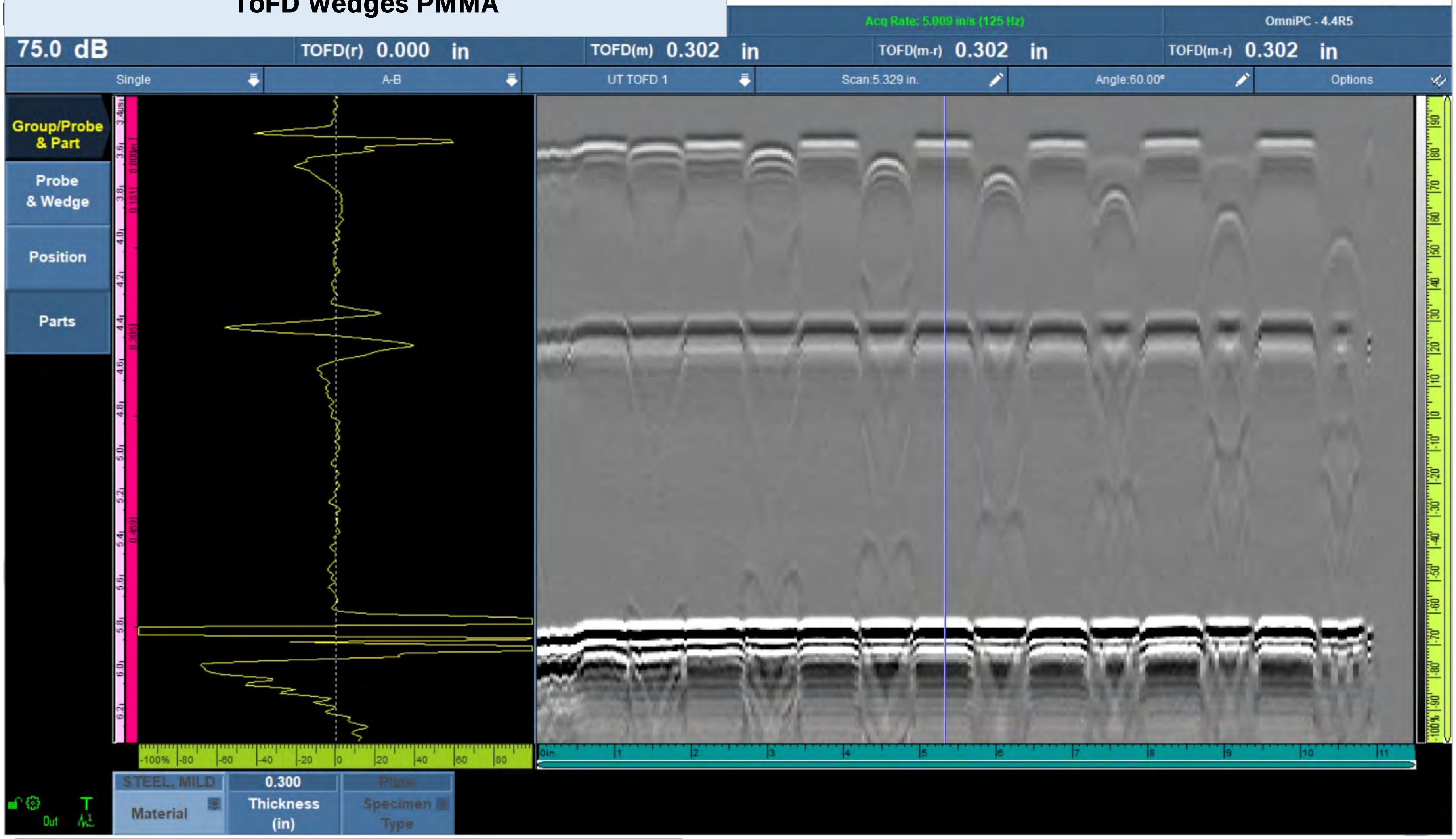


ID notches

8 EDM notoches

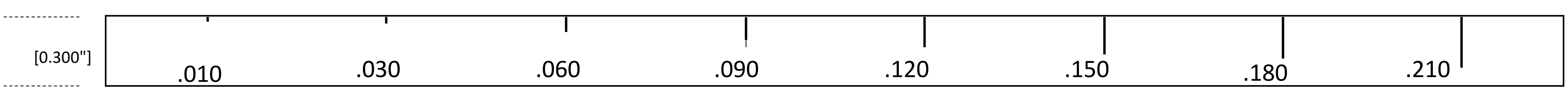


ToFD wedges PMMA

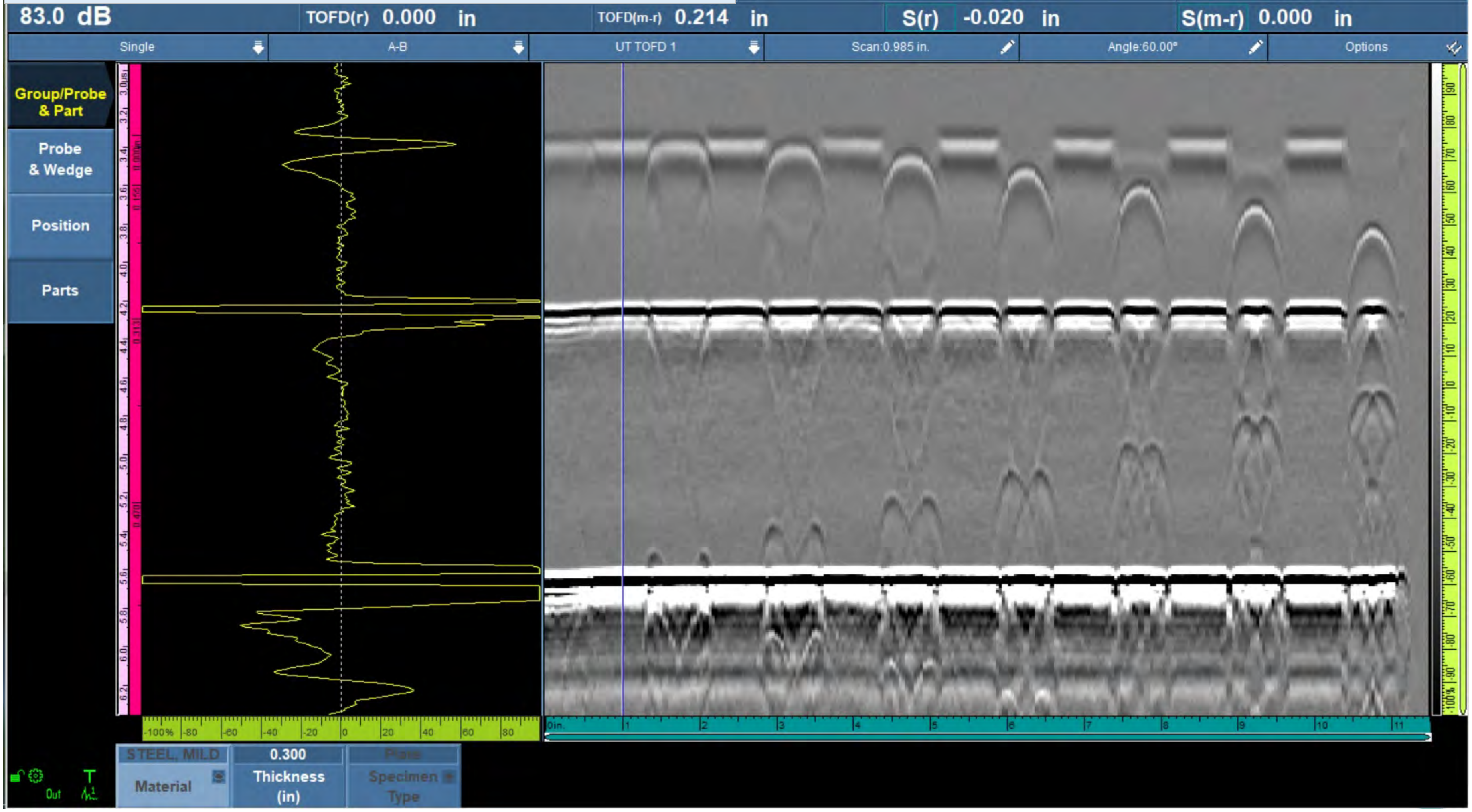


OD notches

8 EDM notoches

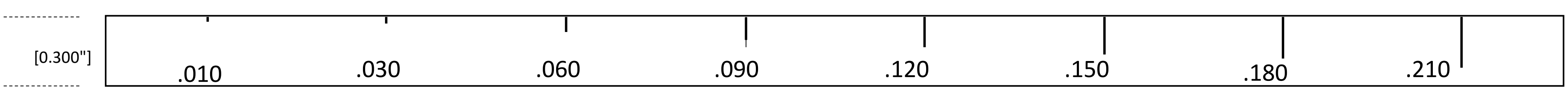


ToFD wedges Plexiglass 01-012038

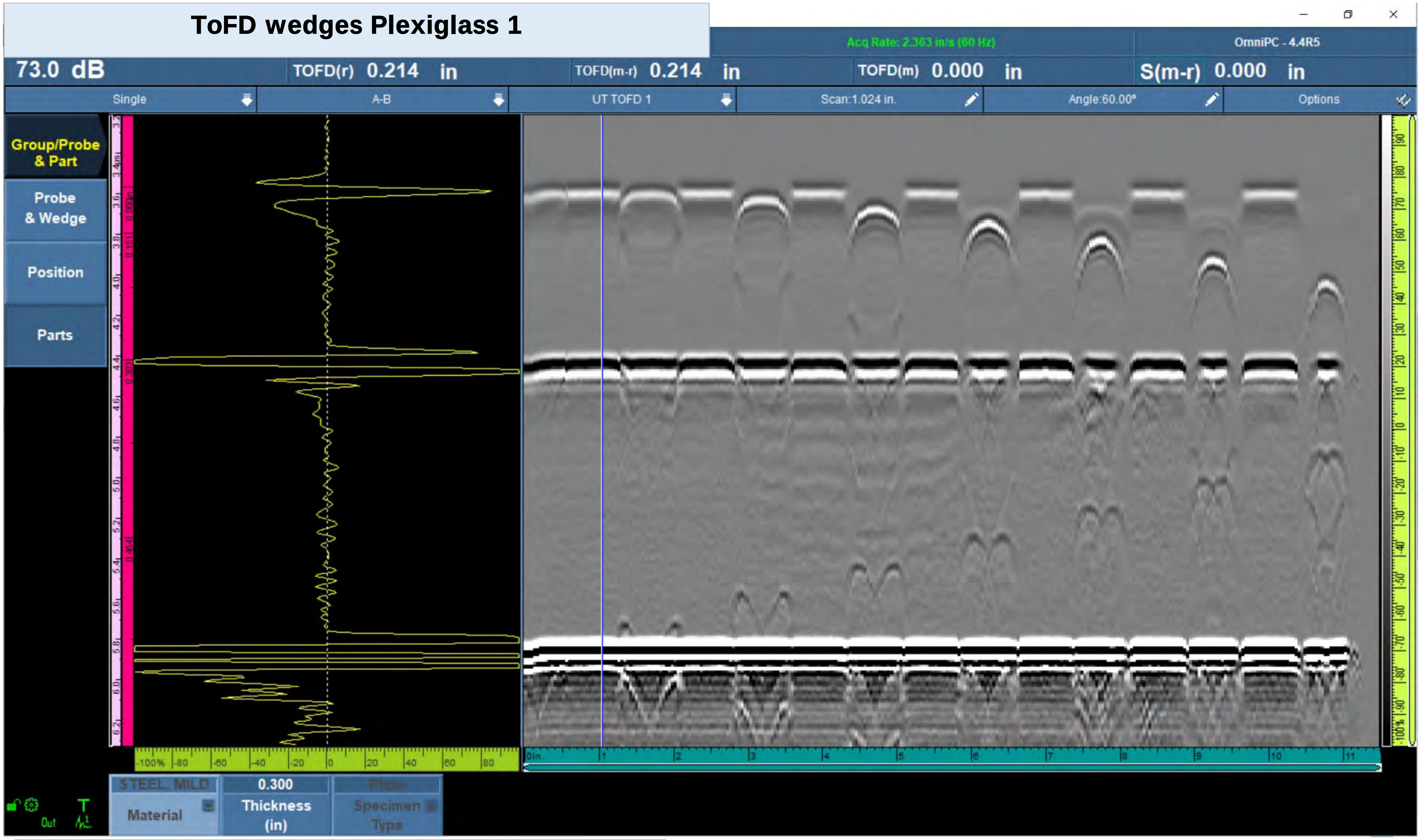


OD notches

8 EDM notoches

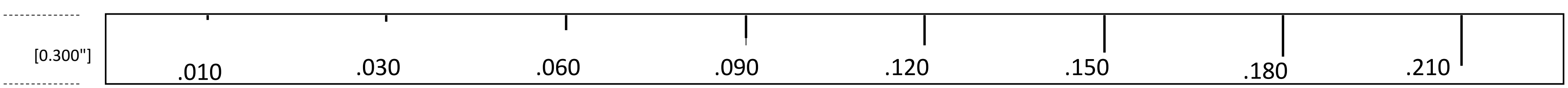


ToFD wedges Plexiglass 1

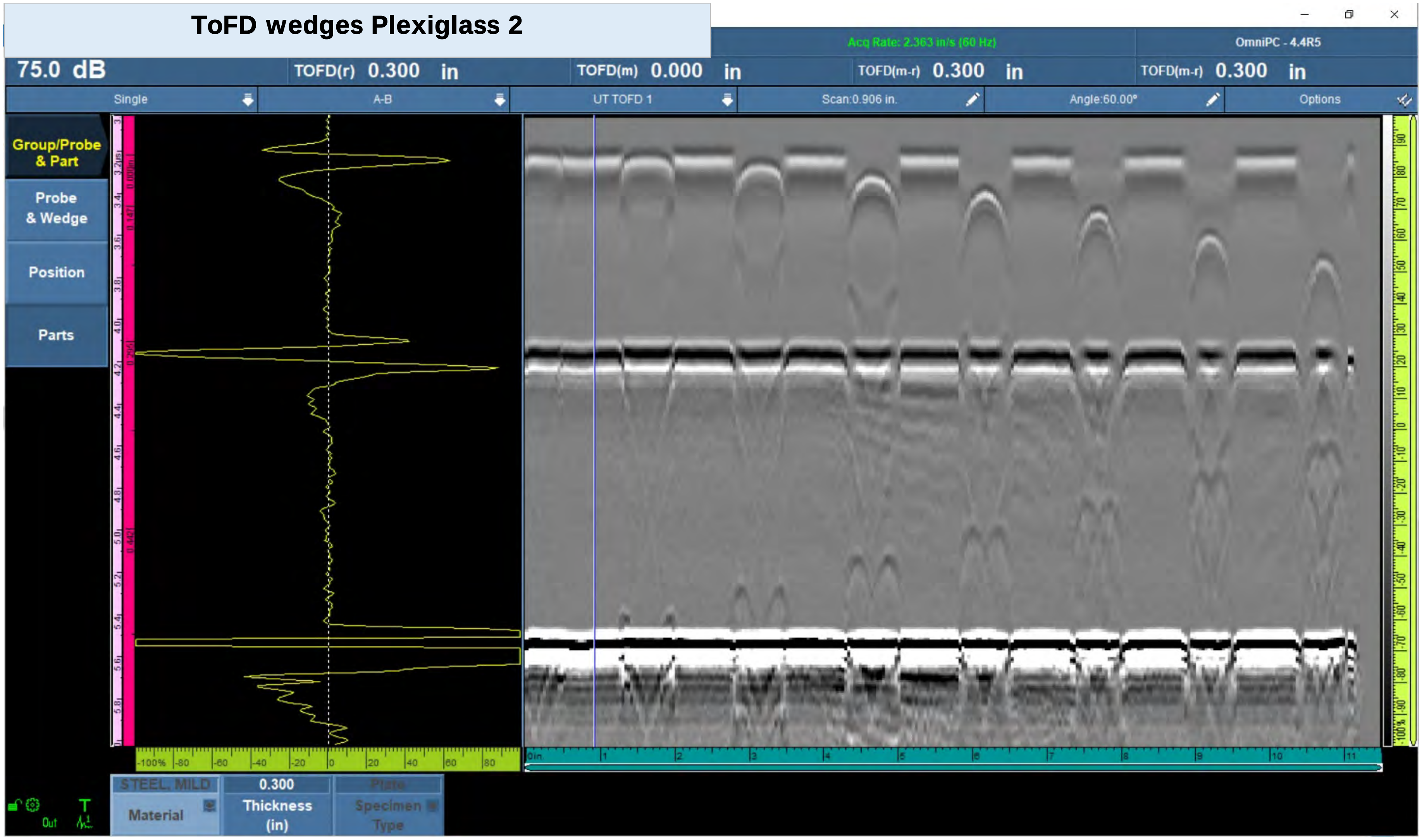


OD notches

8 EDM notoches

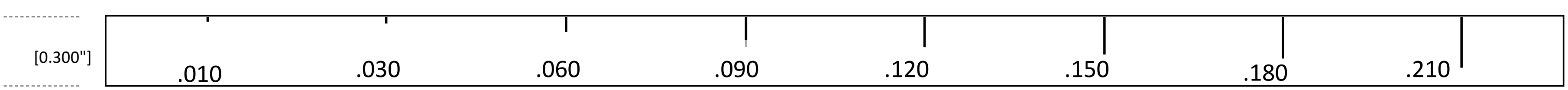


ToFD wedges Plexiglass 2

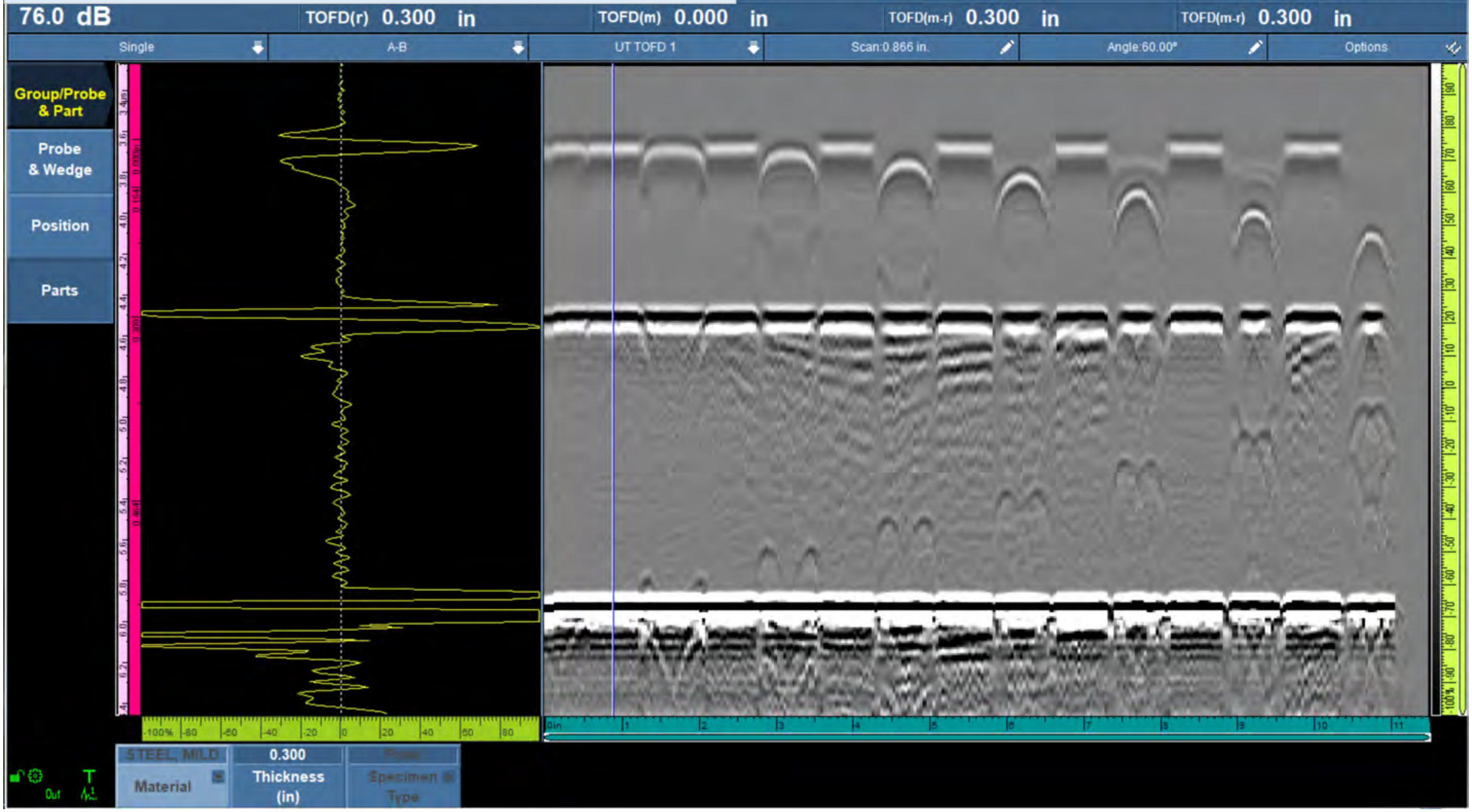


OD notches

8 EDM notoches

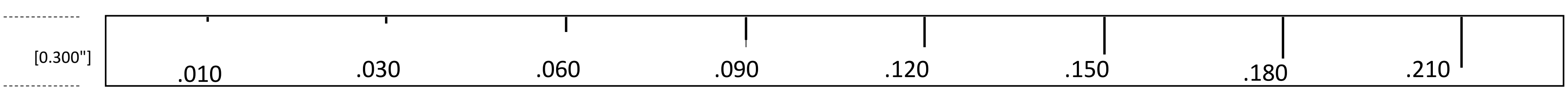


ToFD wedges Plexiglass 3

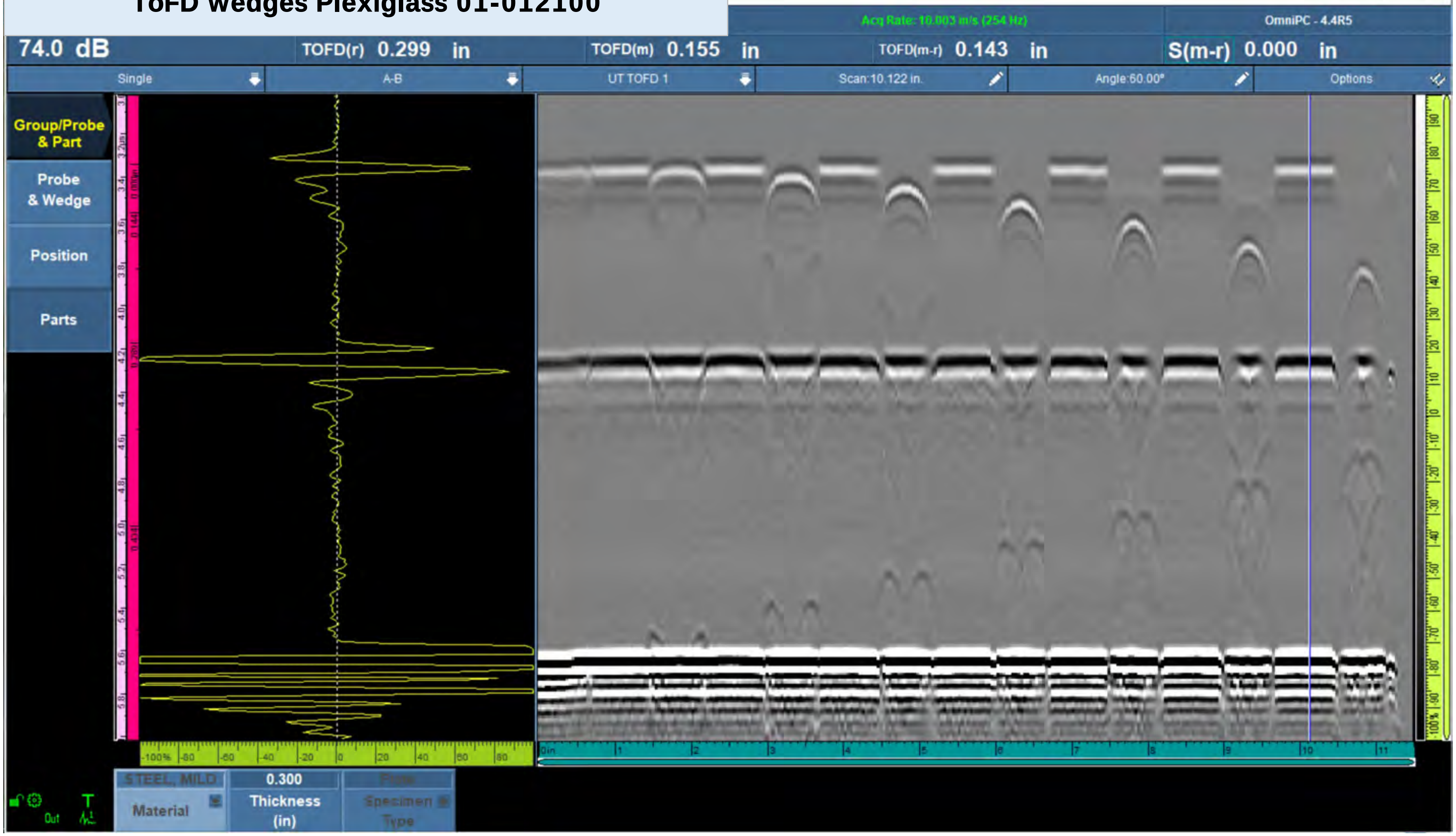


OD notches

8 EDM notoches

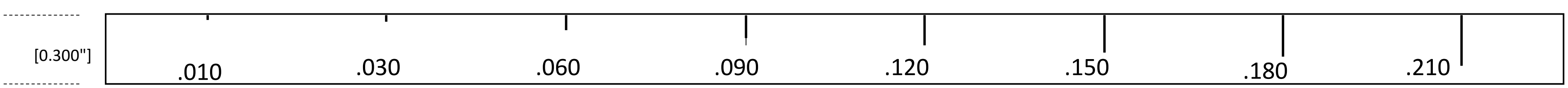


ToFD wedges Plexiglass 01-012100

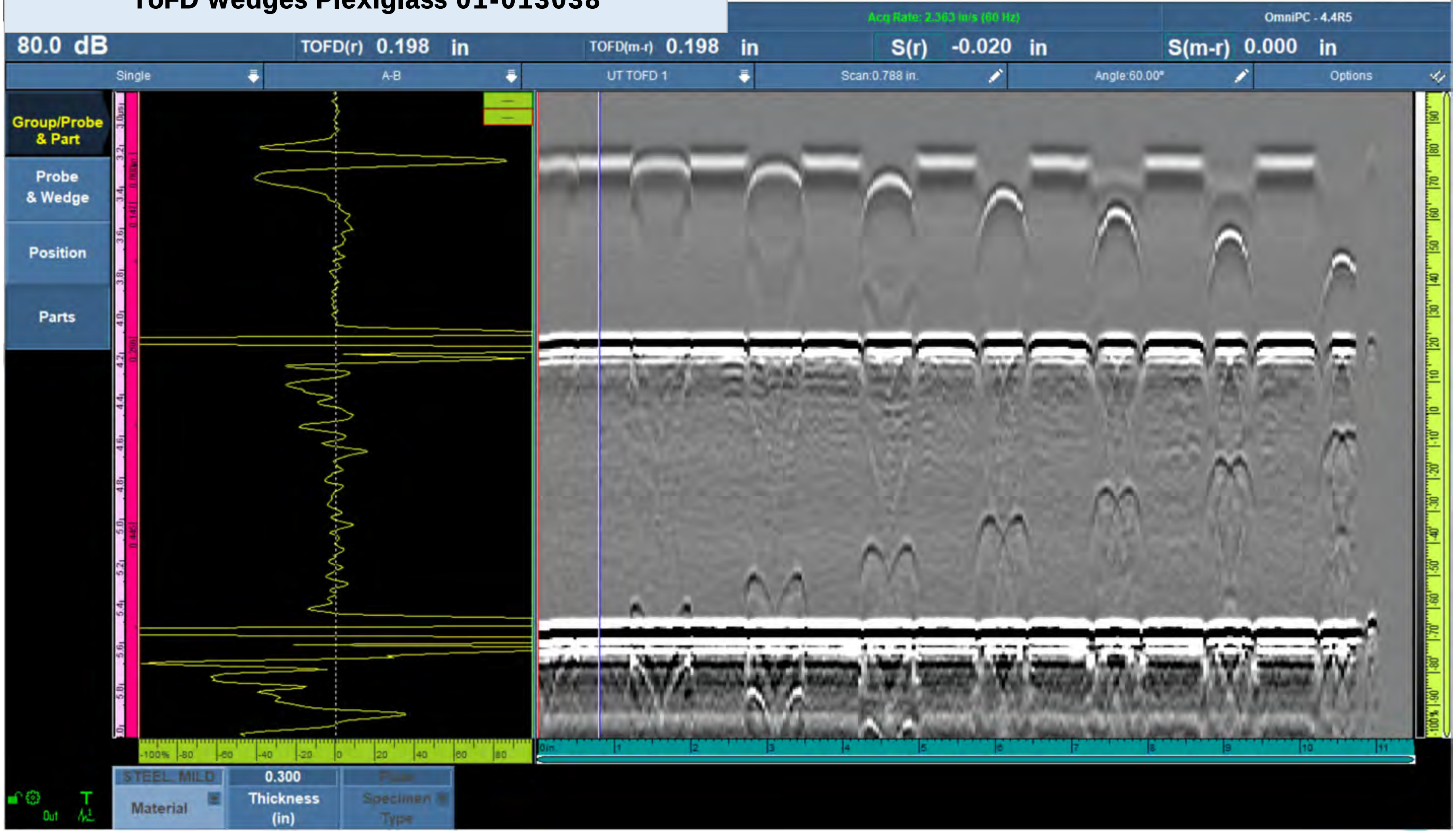


OD notches

8 EDM notoches

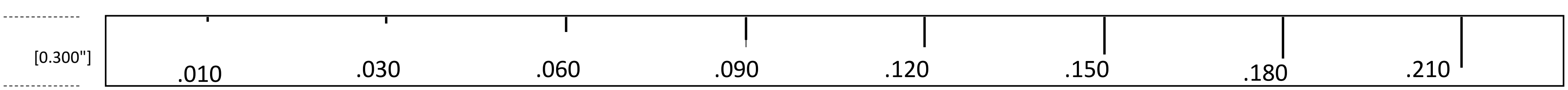


ToFD wedges Plexiglass 01-013038

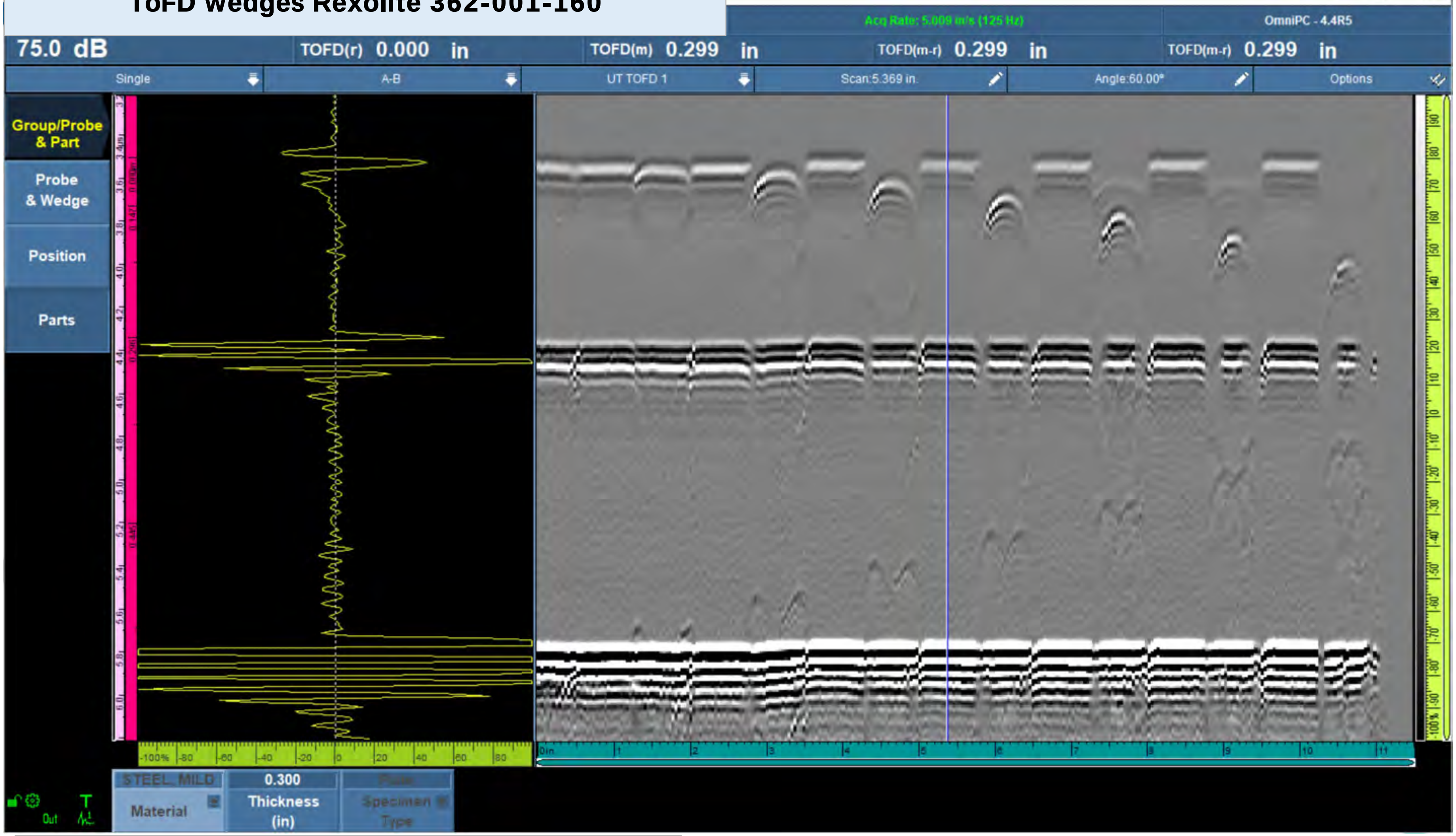


OD notches

8 EDM notoches

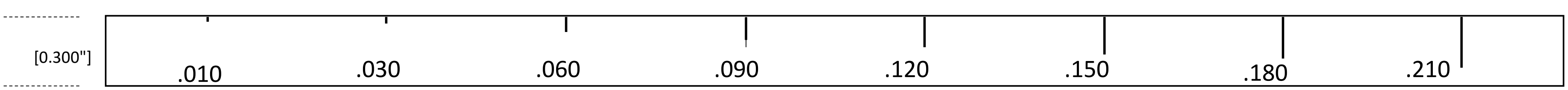


ToFD wedges Rexolite 362-001-160

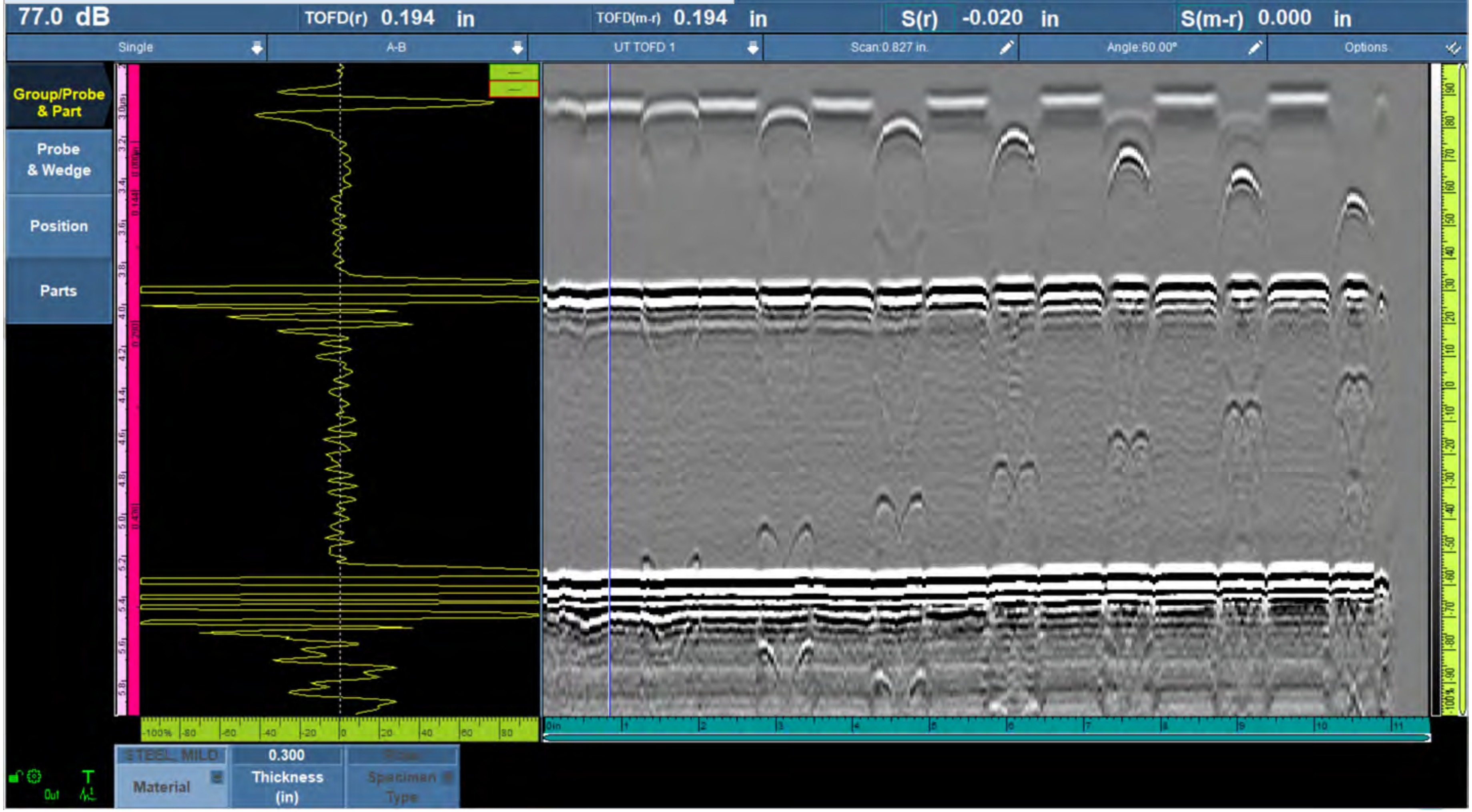


OD notches

8 EDM notoches

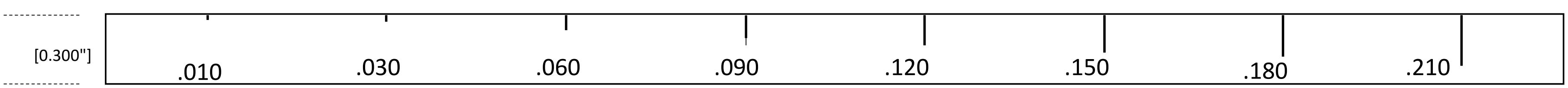


ToFD wedges Rexolite 01-013037

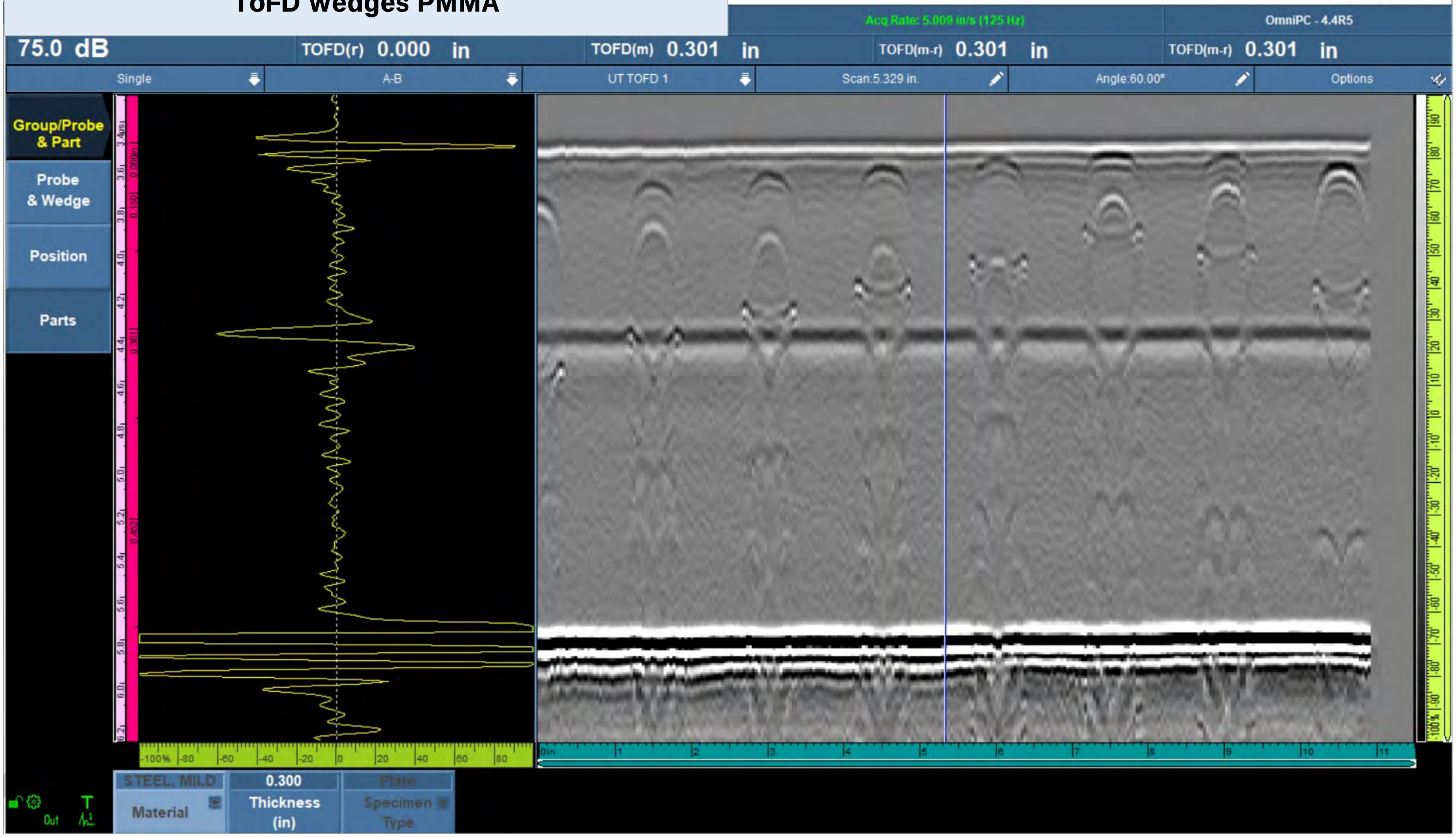


OD notches

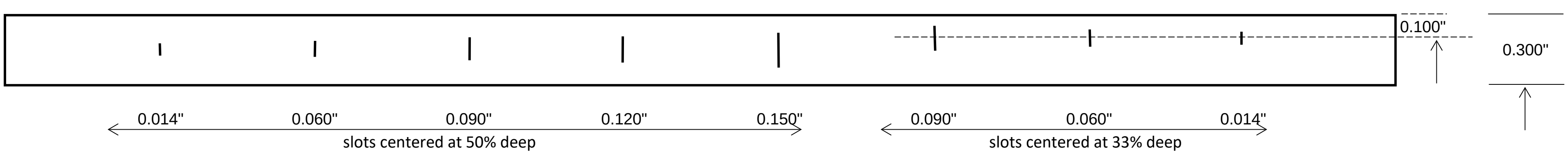
8 EDM notoches



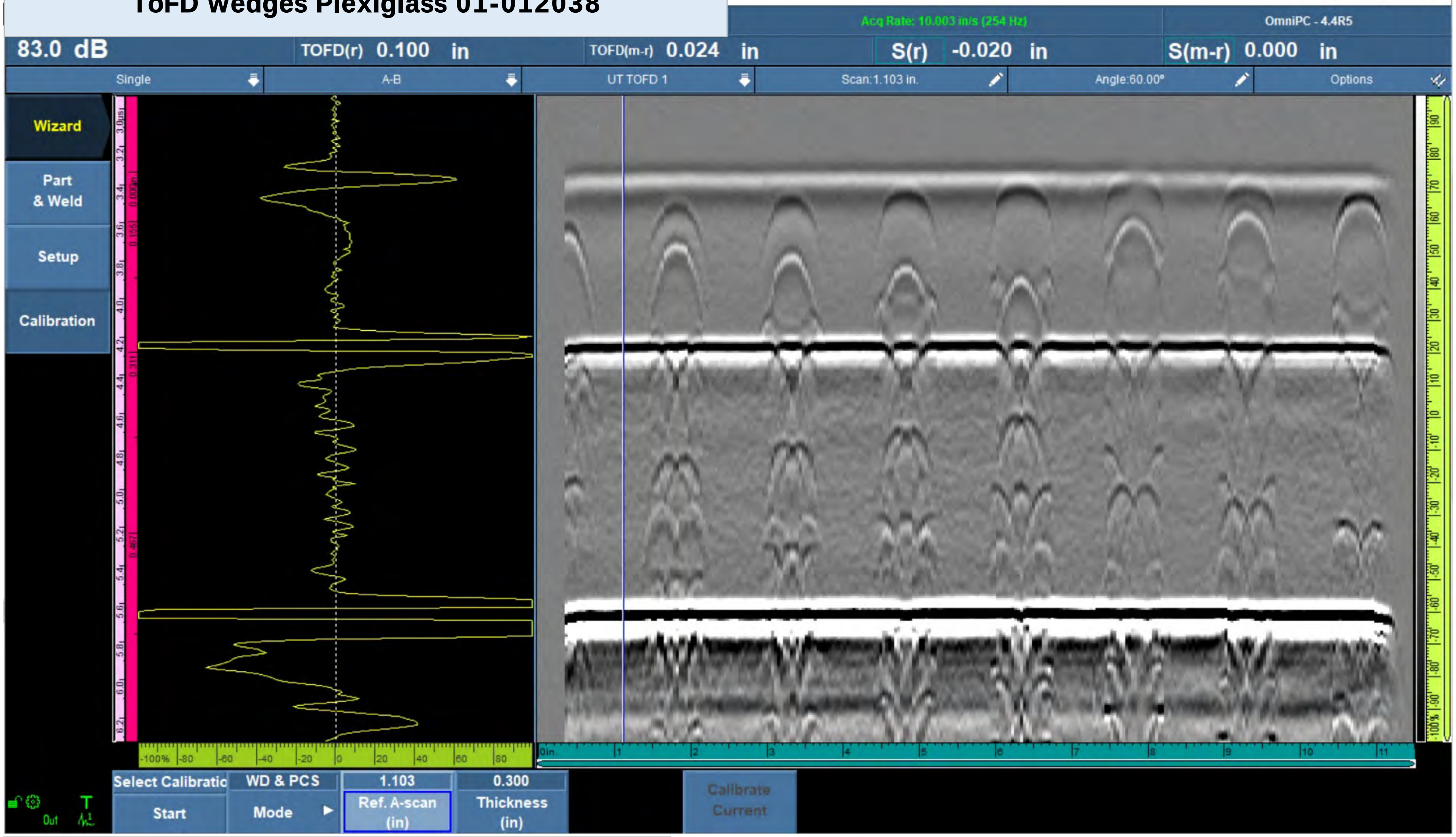
ToFD wedges PMMA



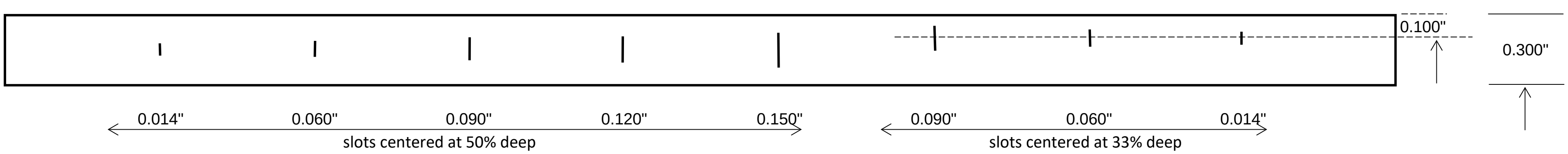
midwall slots, up



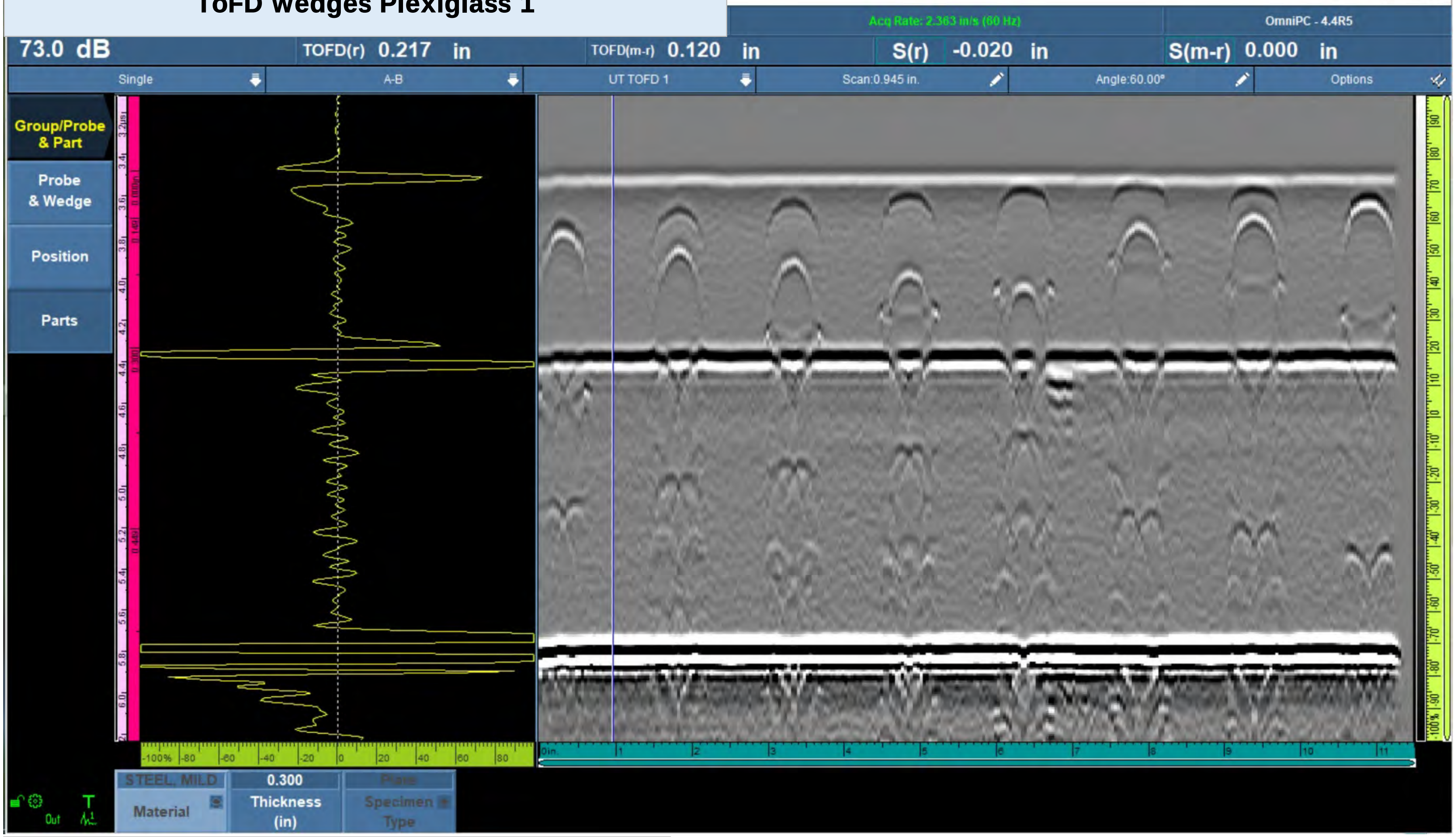
ToFD wedges Plexiglass 01-012038



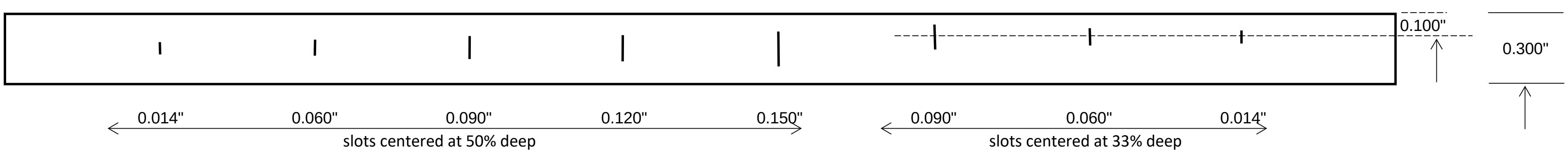
midwall slots, up



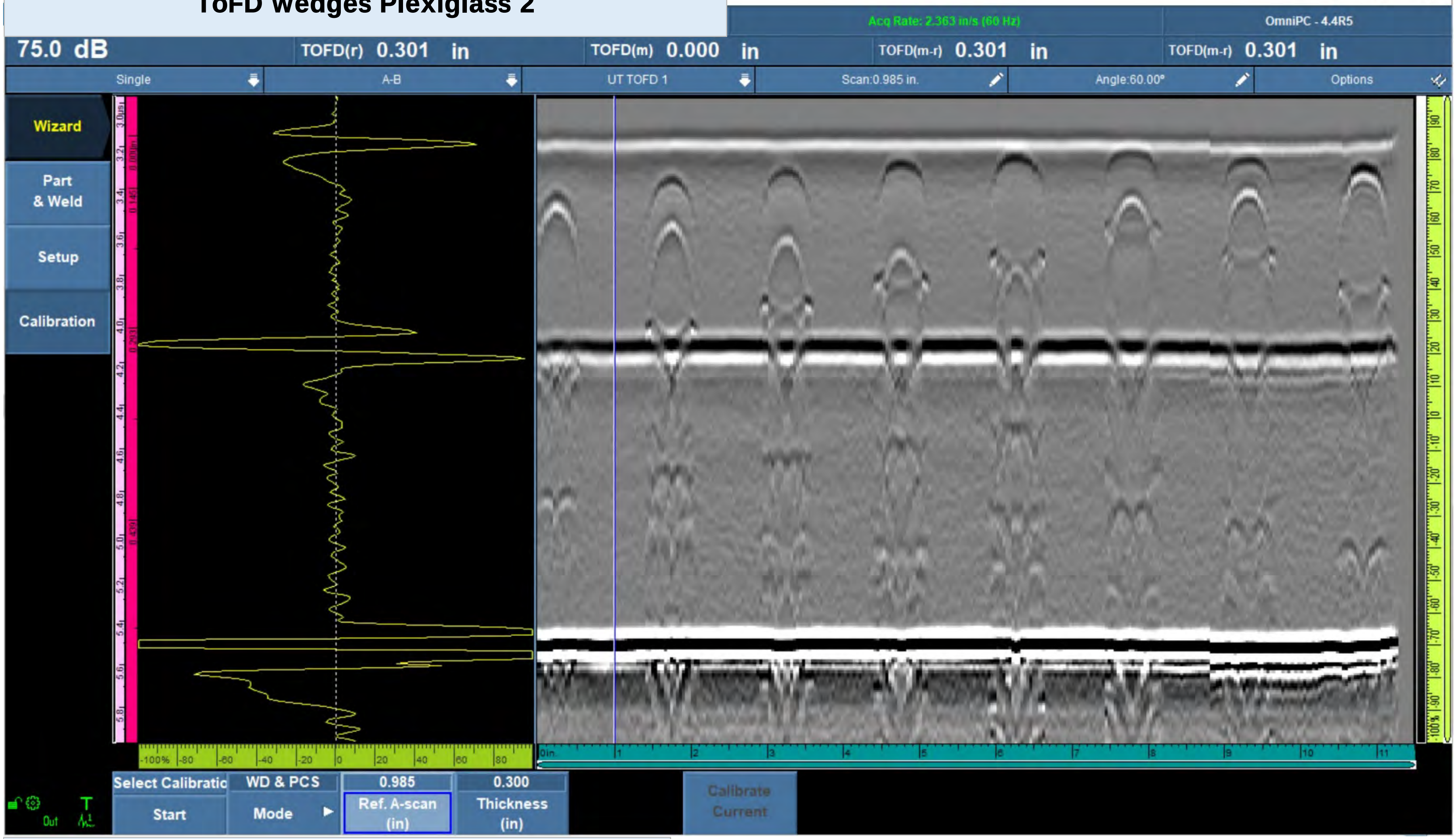
ToFD wedges Plexiglass 1



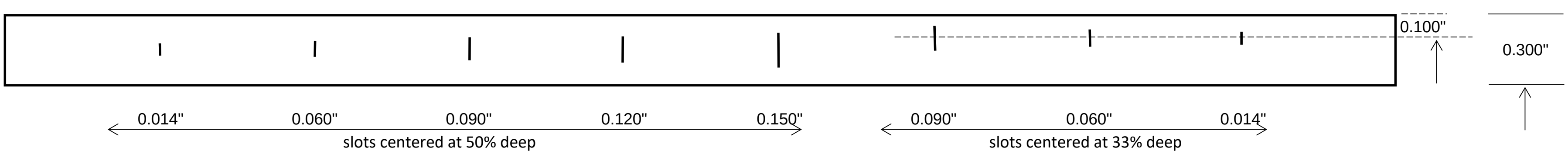
midwall slots, up



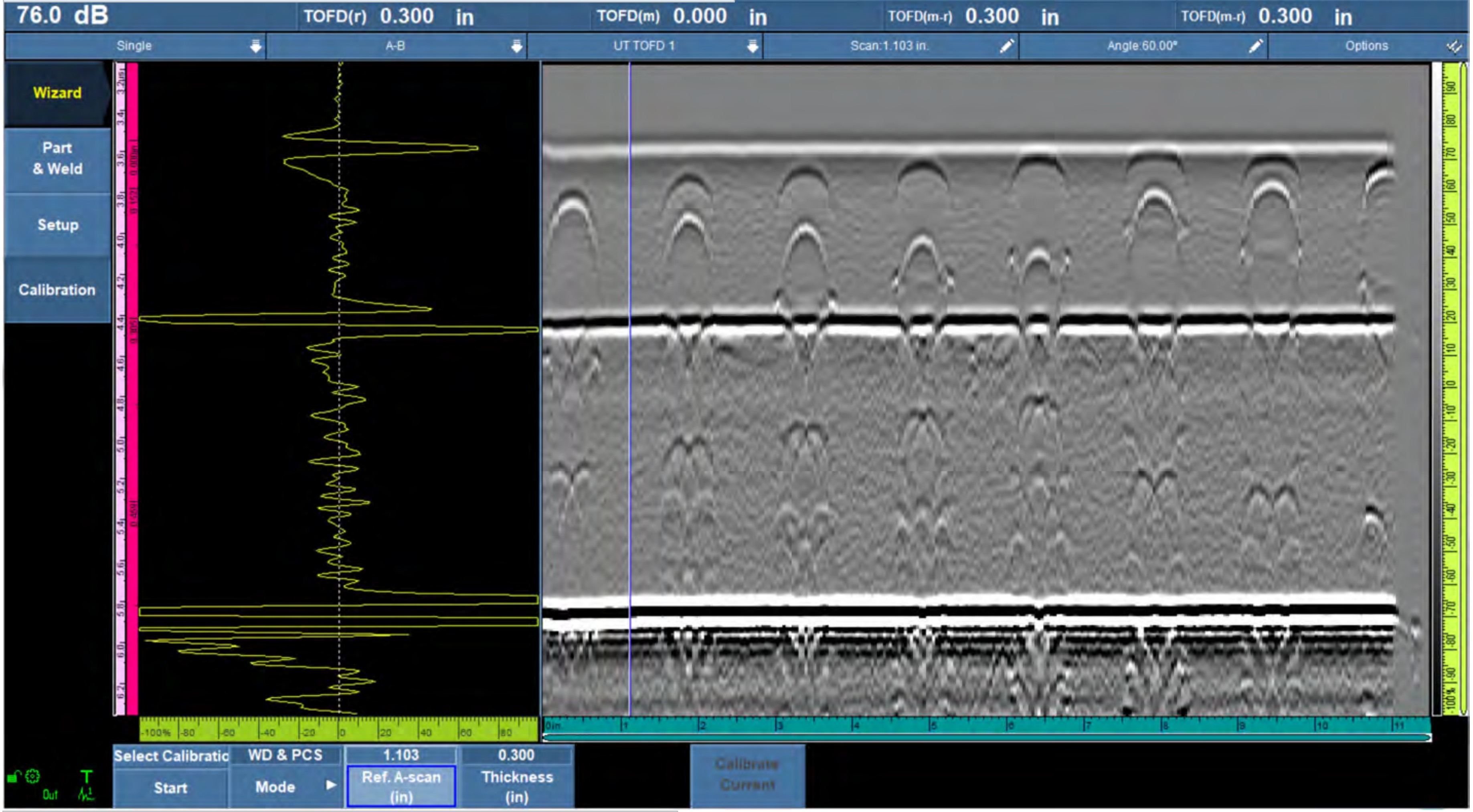
ToFD wedges Plexiglass 2



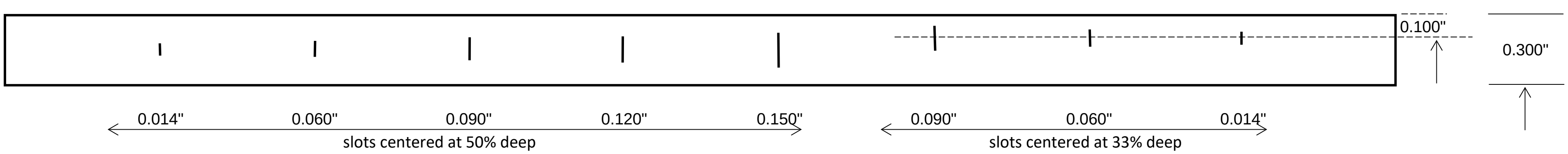
midwall slots, up



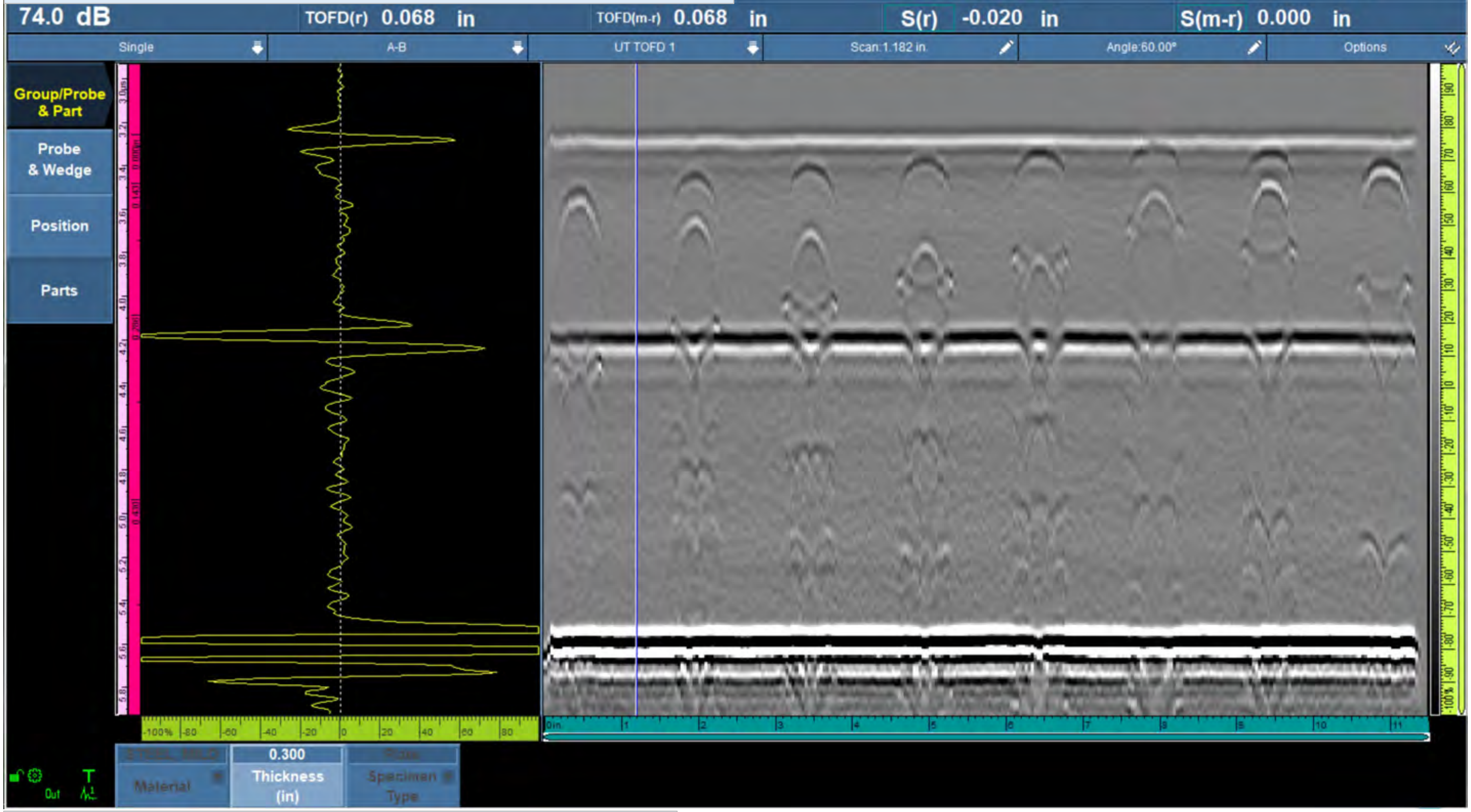
ToFD wedges Plexiglass 3



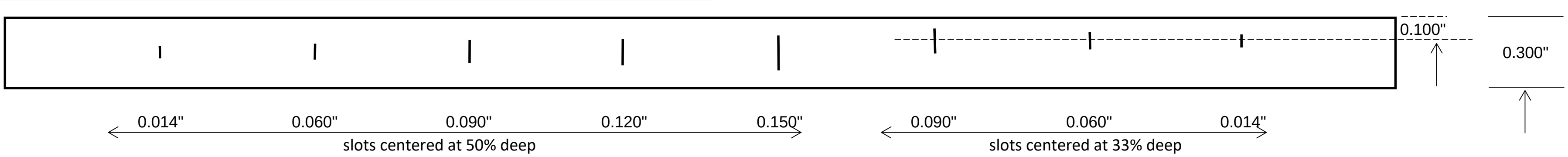
midwall slots, up



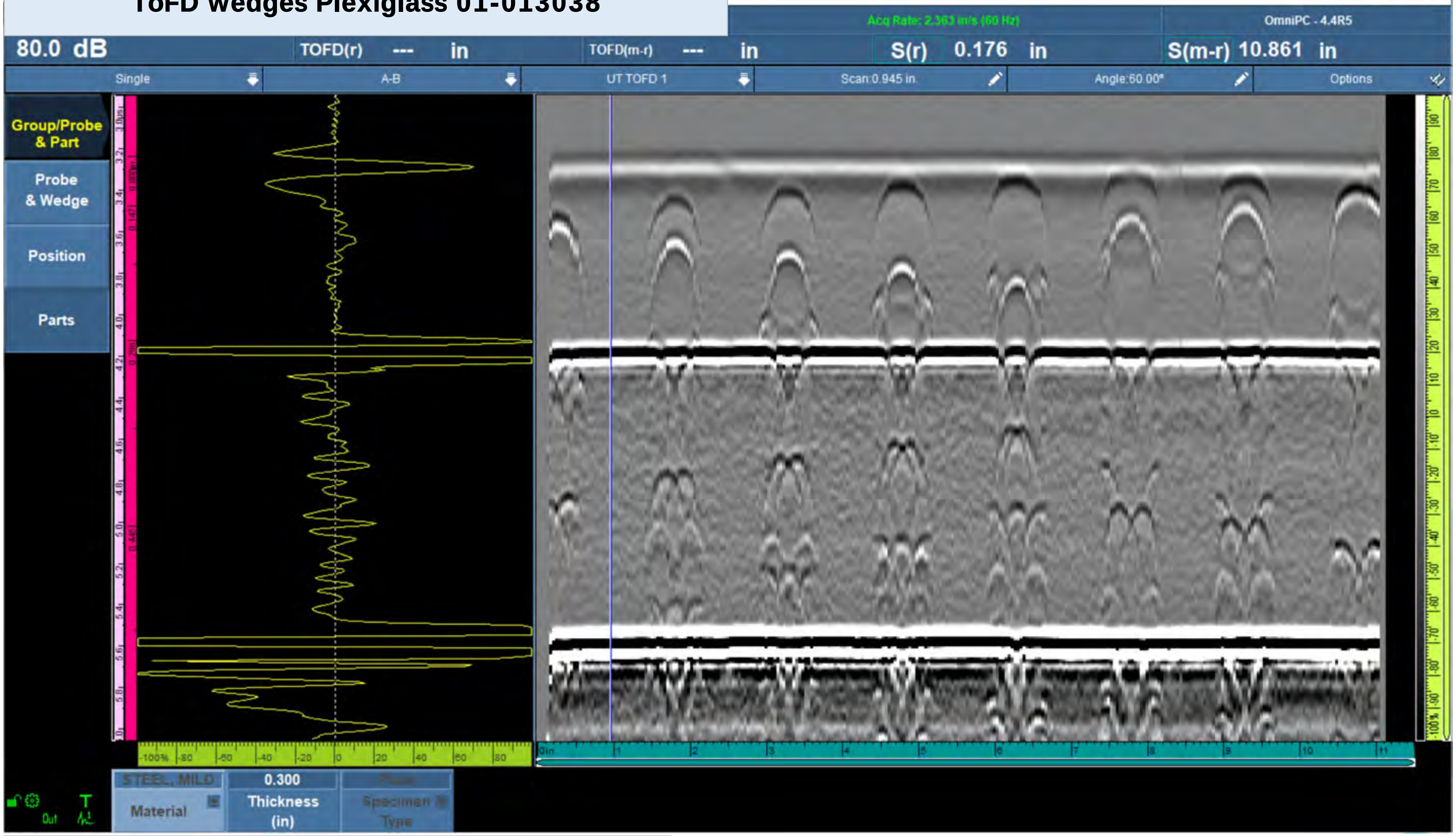
ToFD wedges Plexiglass 01-012100



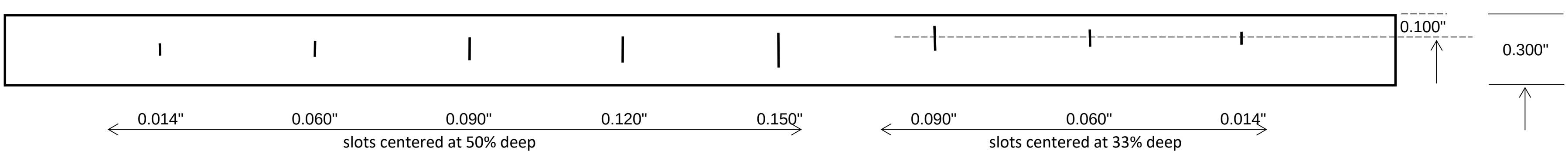
midwall slots, up



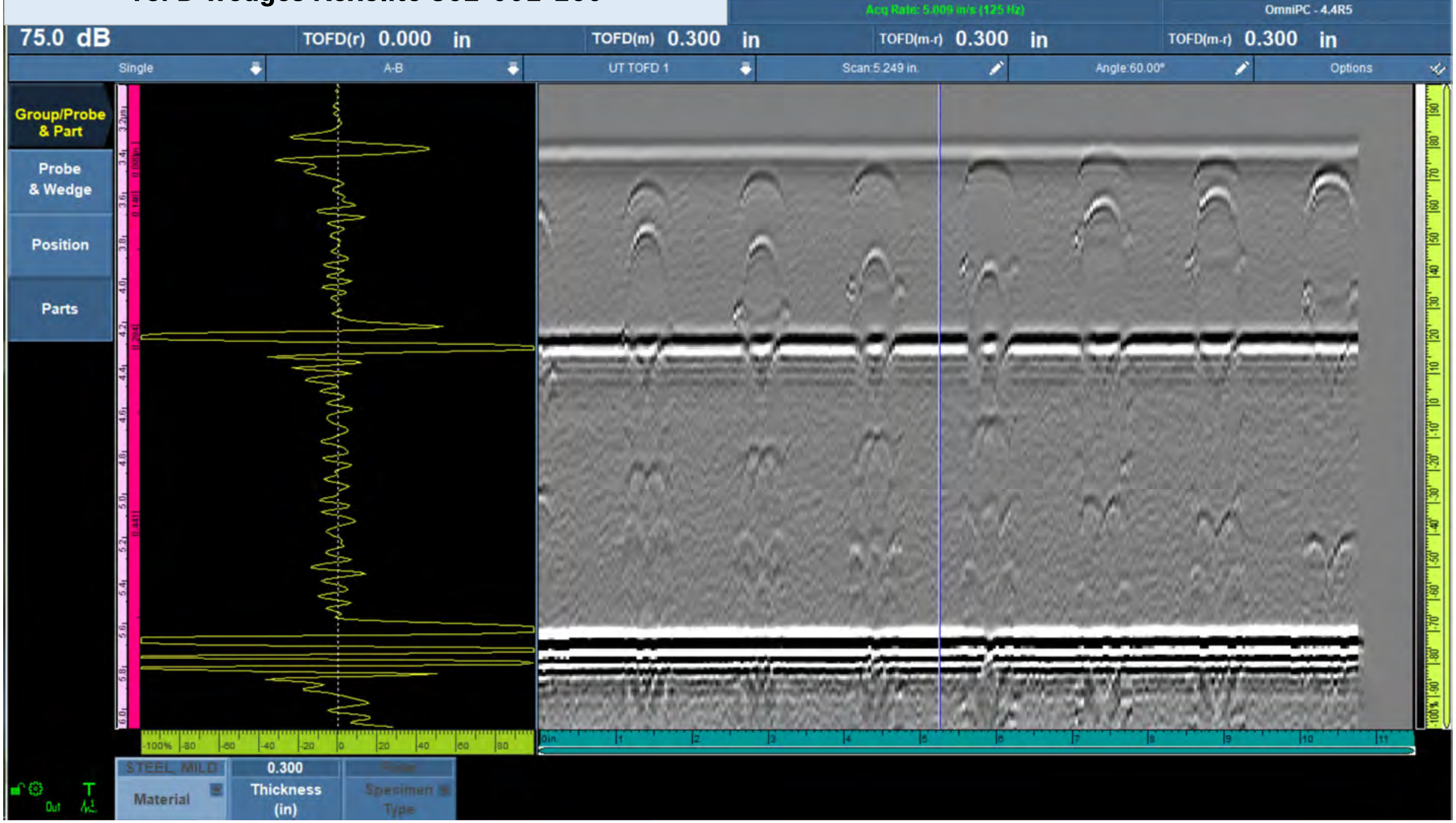
ToFD wedges Plexiglass 01-013038



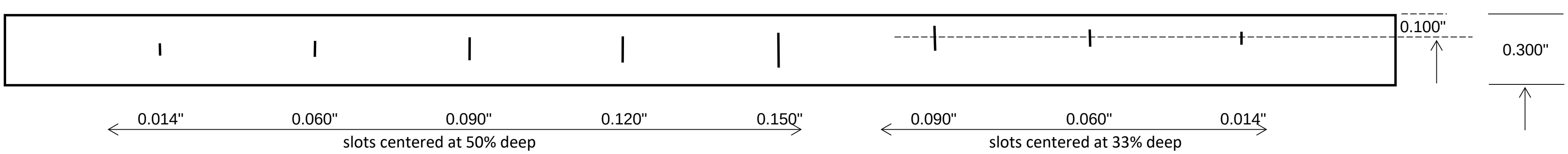
midwall slots, up



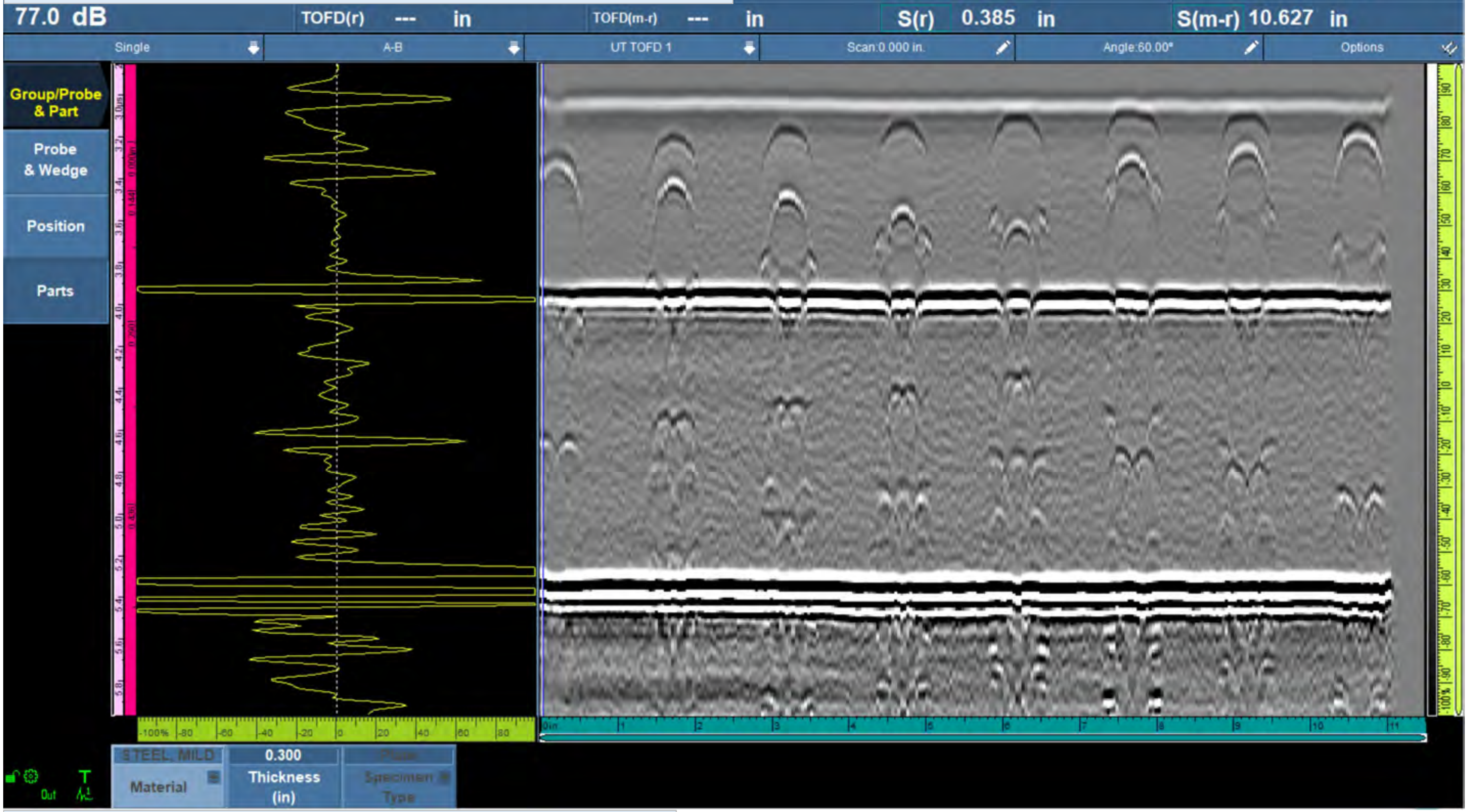
ToFD wedges Rexolite 362-001-160



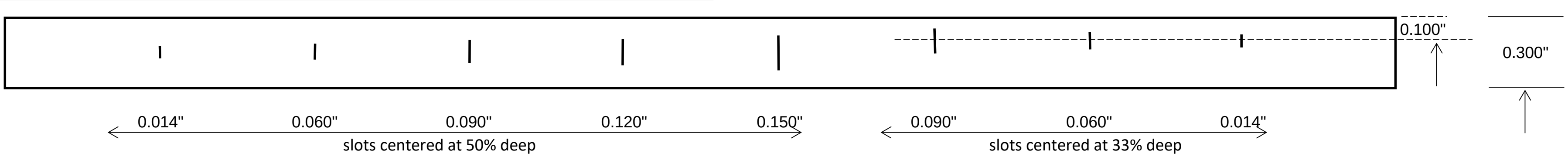
midwall slots, up



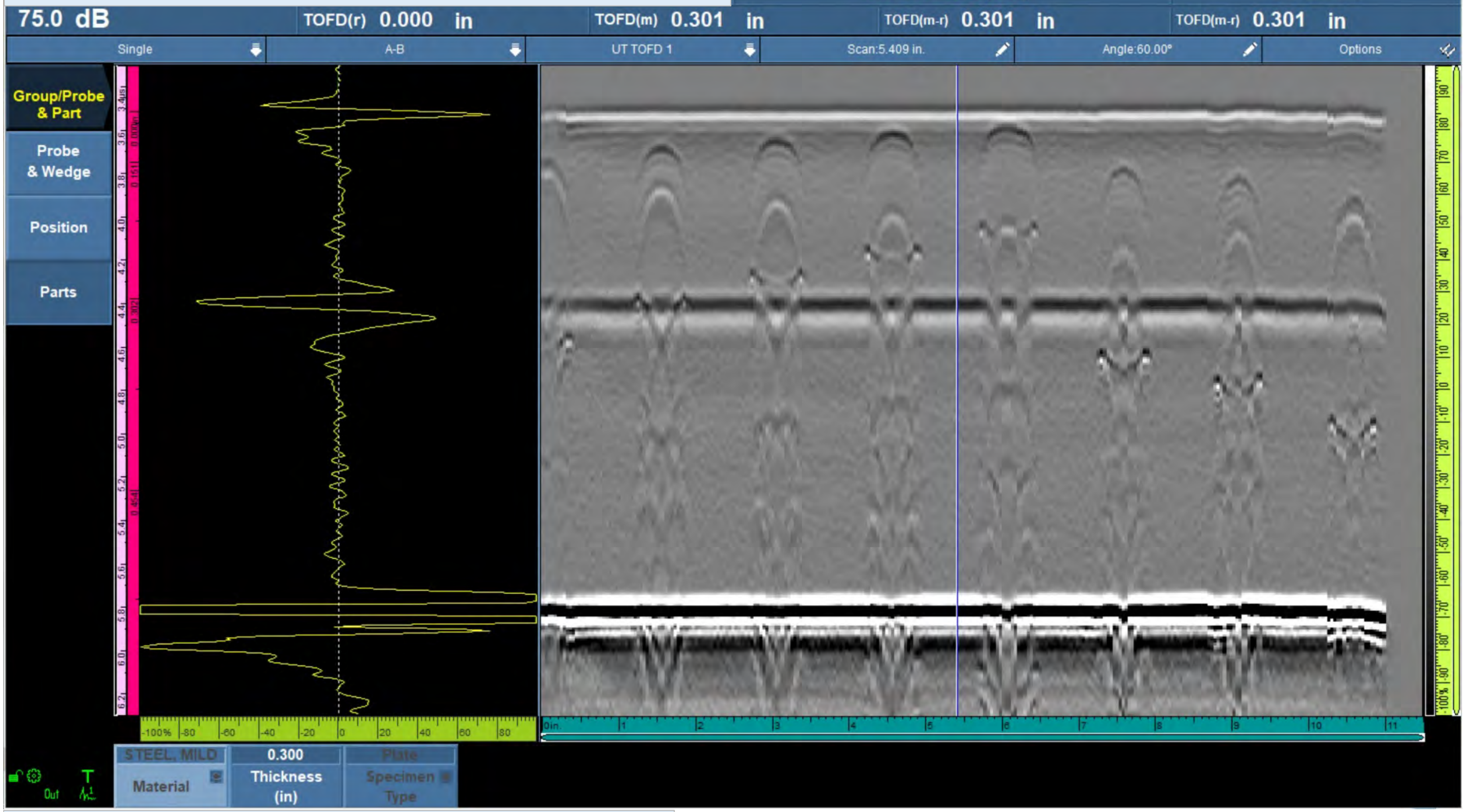
ToFD wedges Rexolite 01-013037



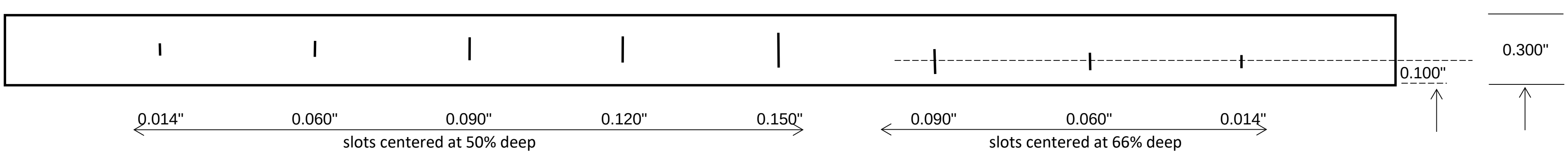
midwall slots, up

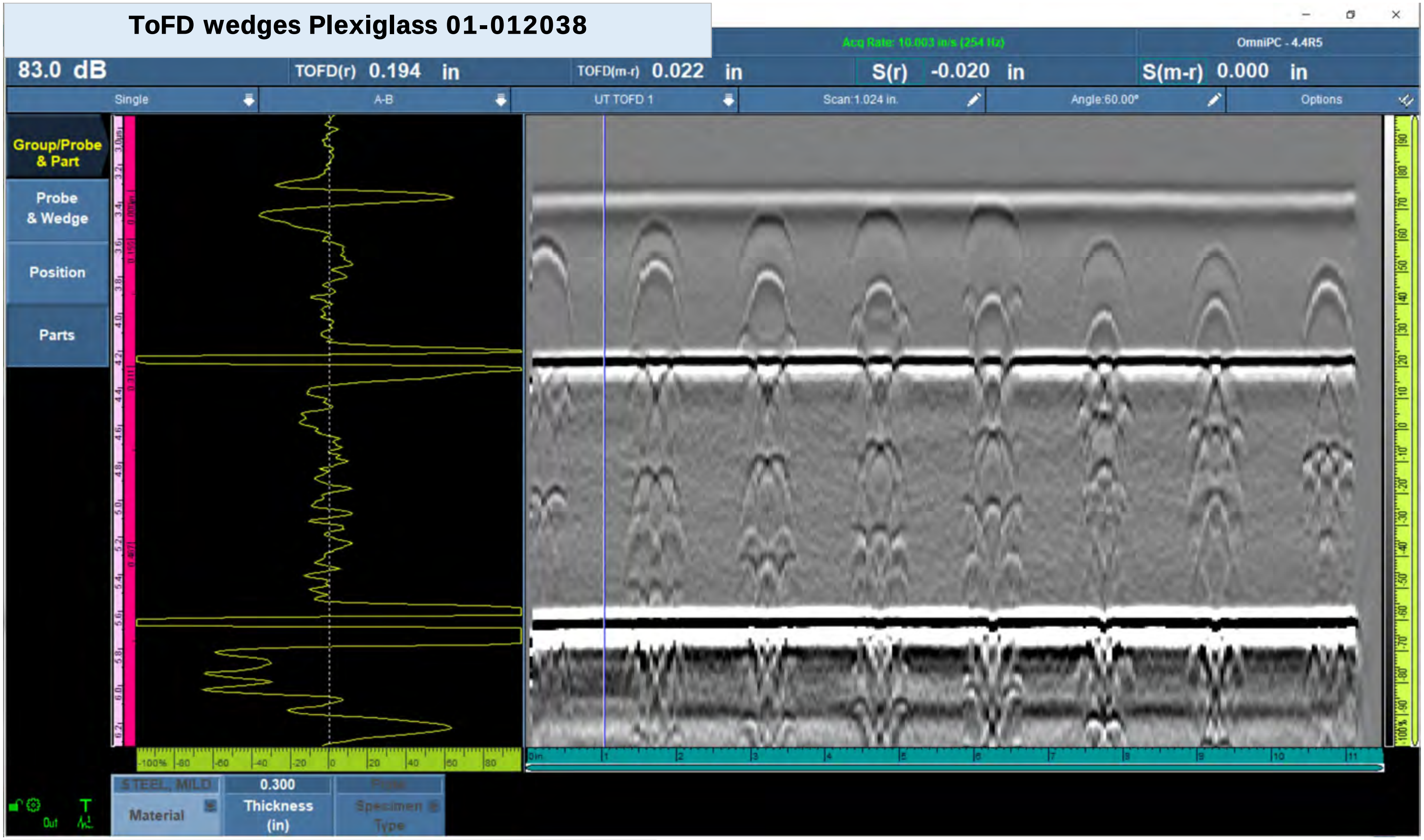


ToFD wedges PMMA

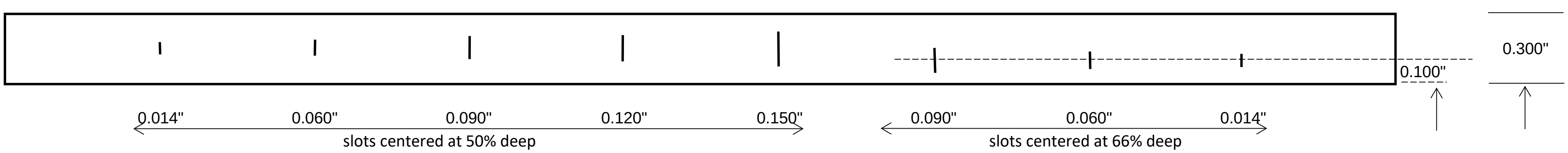


midwall slots, down

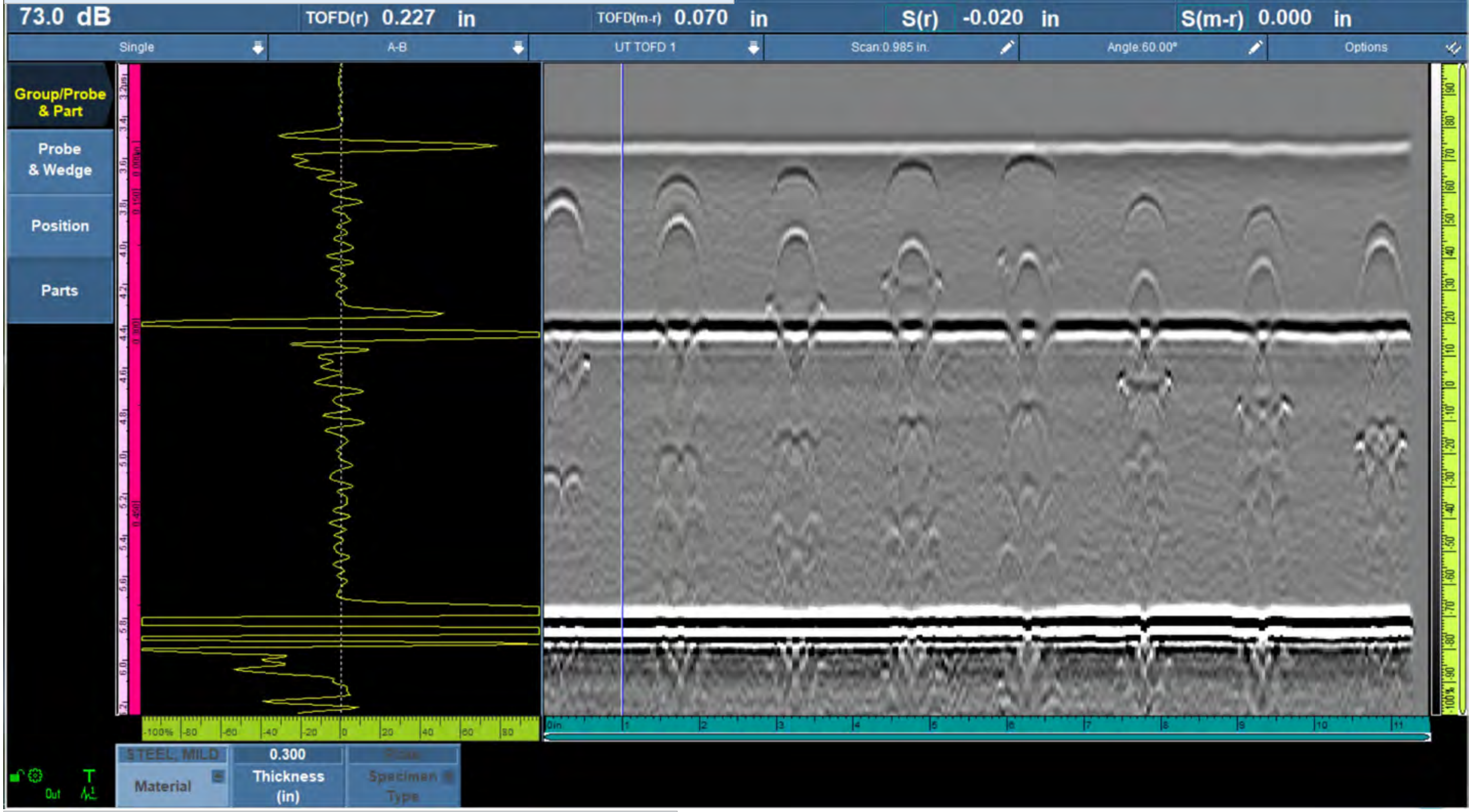




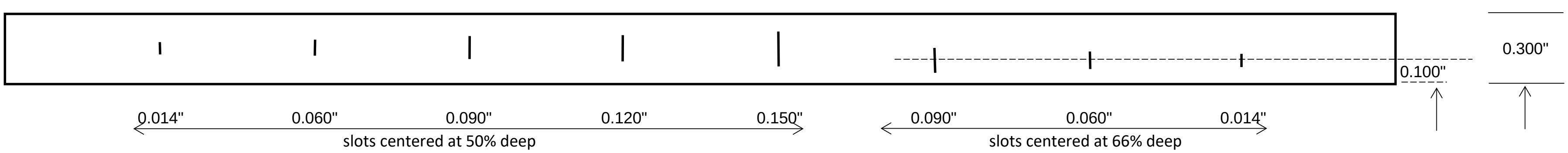
midwall slots, down



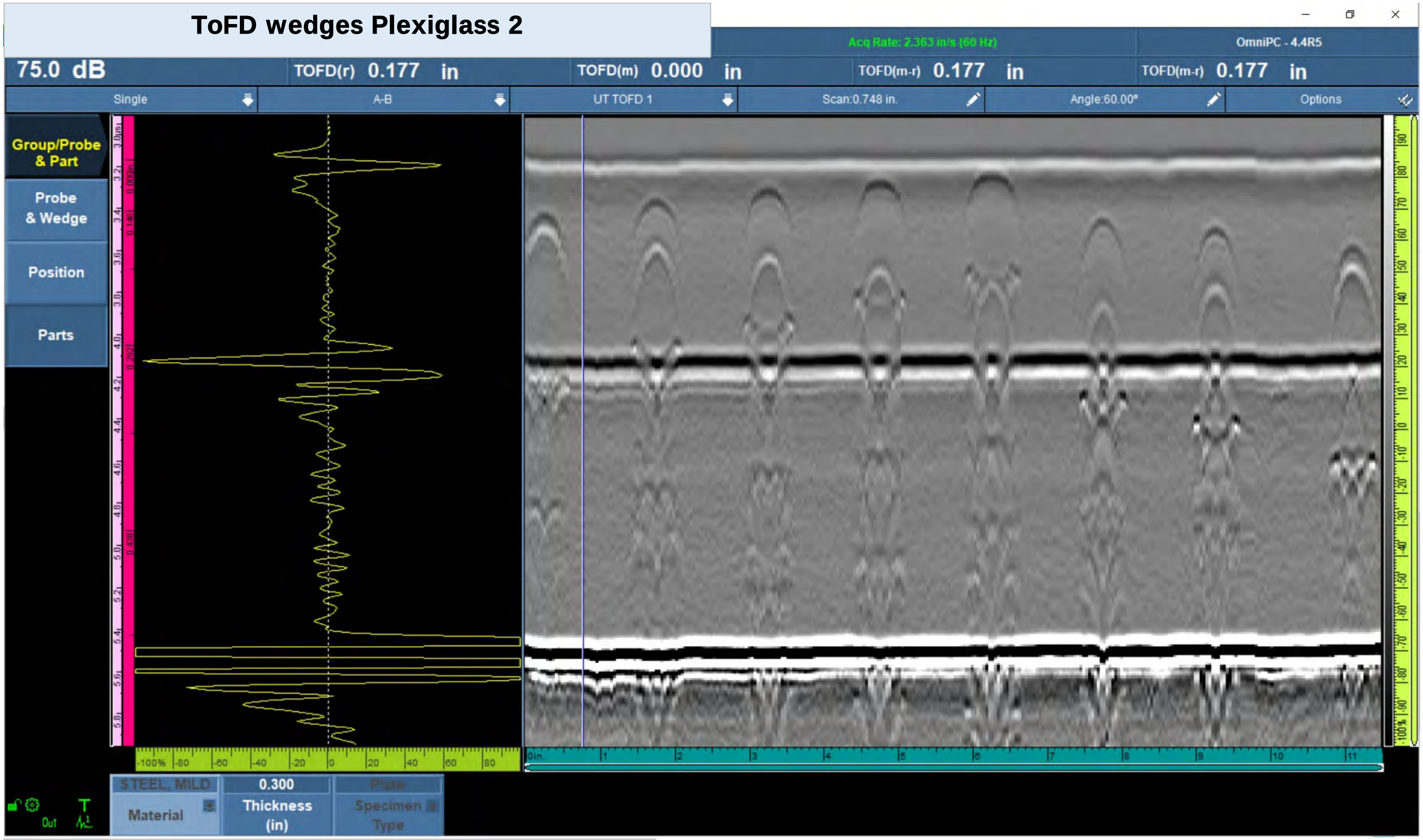
ToFD wedges Plexiglass 1



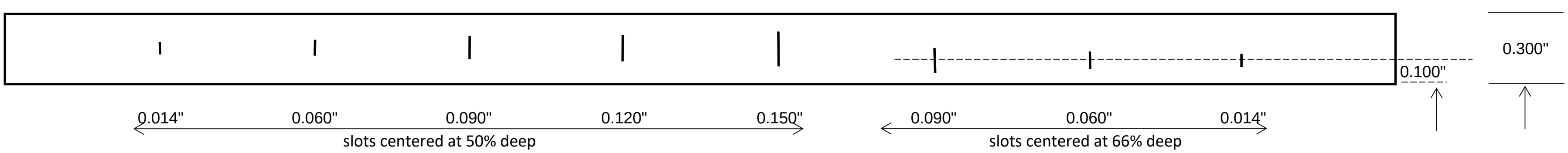
midwall slots, down



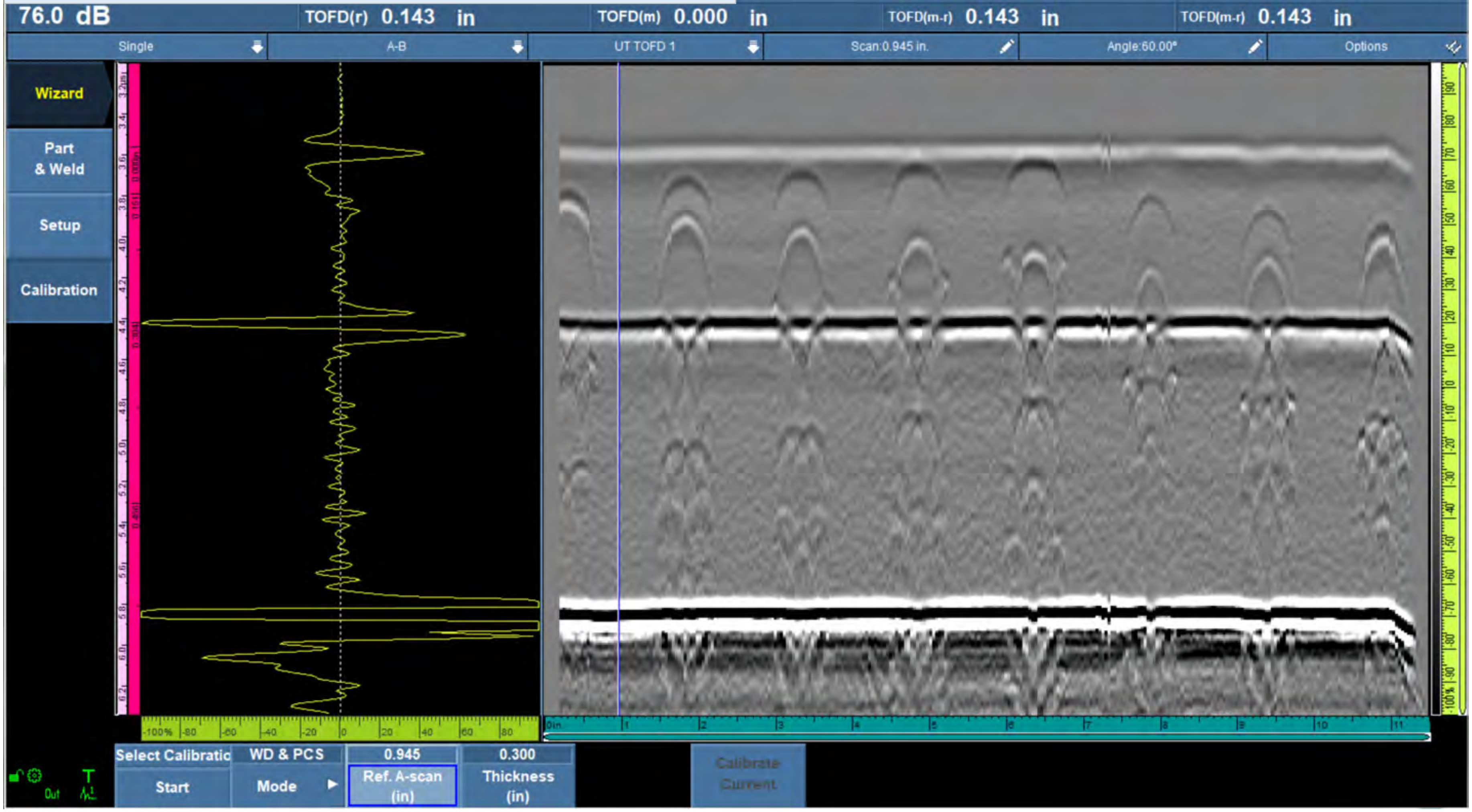
ToFD wedges Plexiglass 2



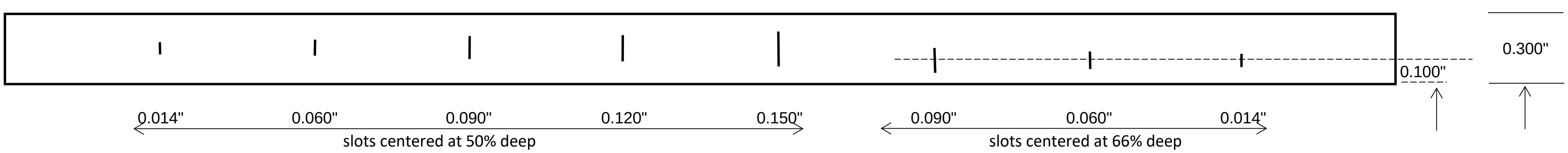
midwall slots, down



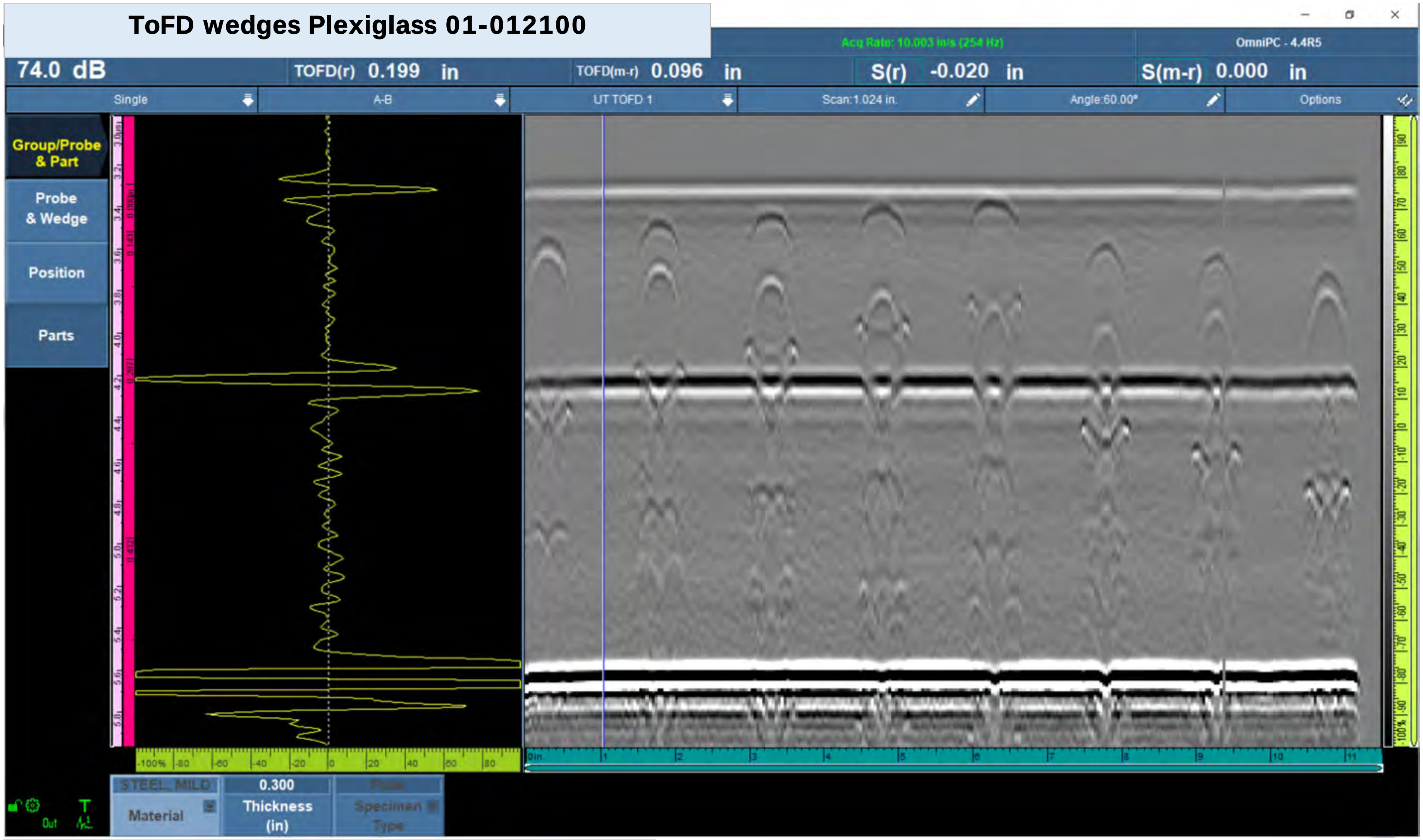
ToFD wedges Plexiglass 3



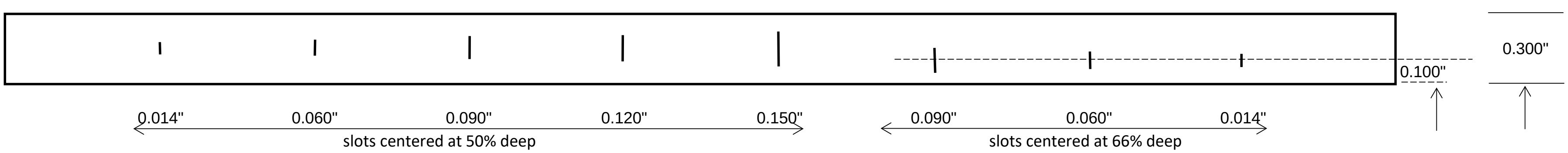
midwall slots, down



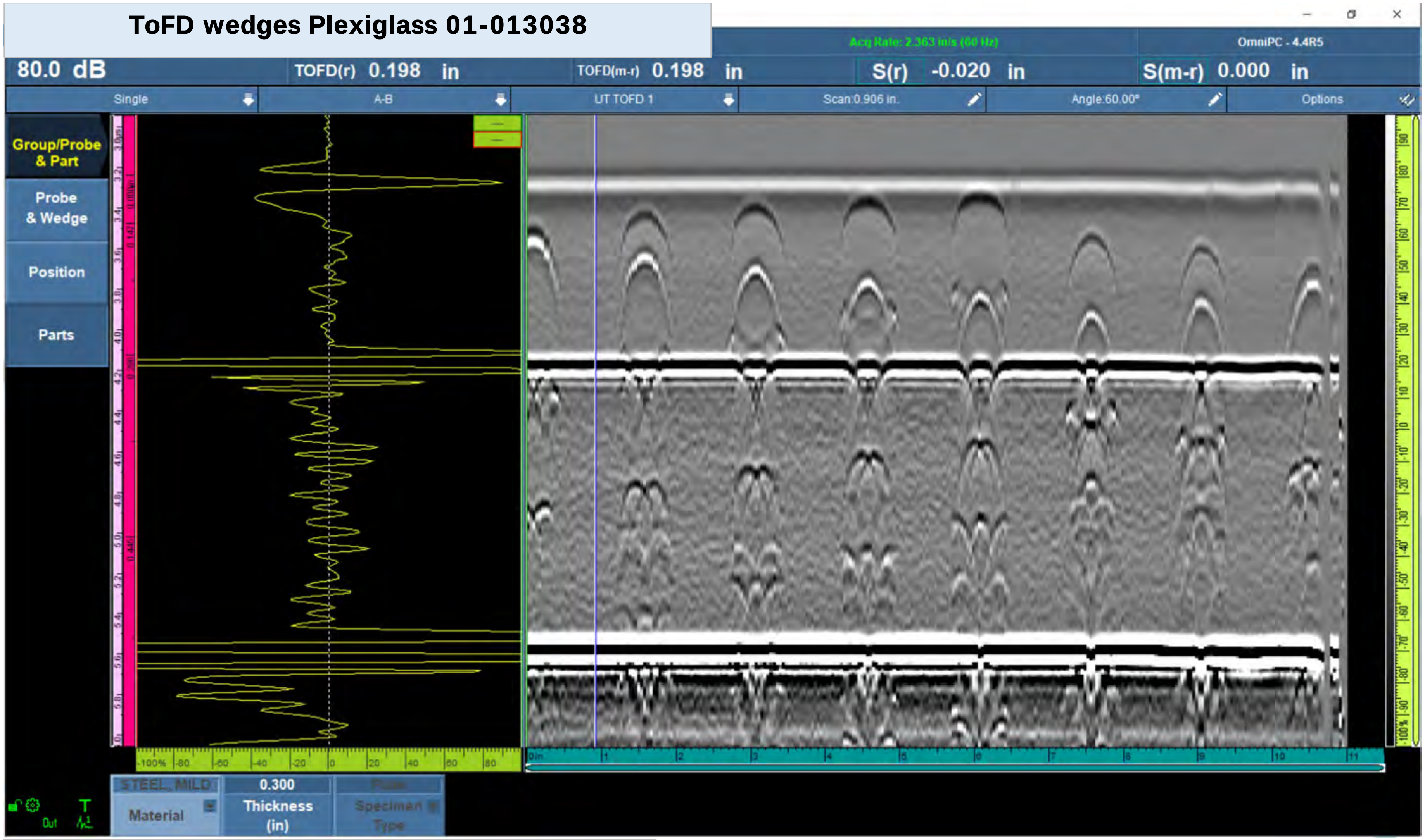
ToFD wedges Plexiglass 01-012100



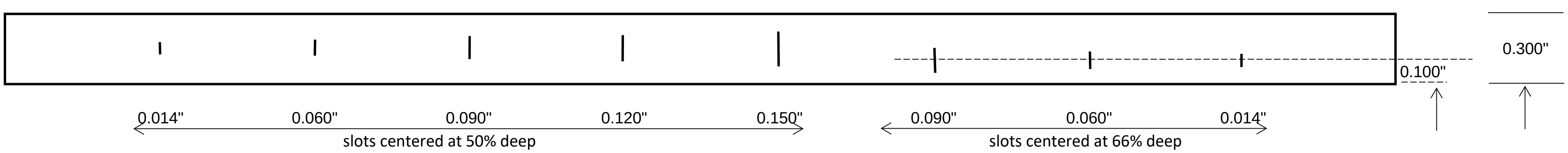
midwall slots, down



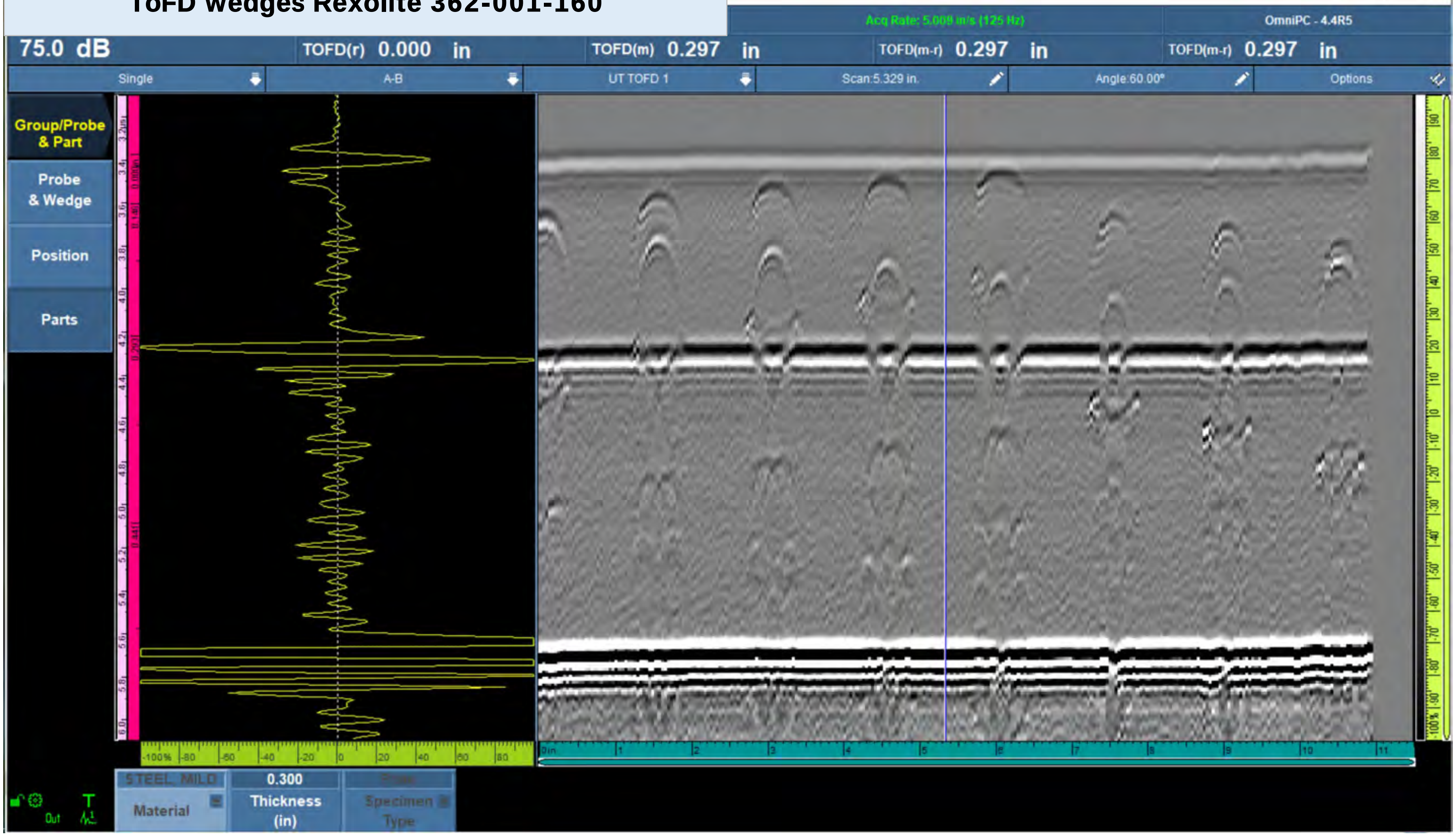
ToFD wedges Plexiglass 01-013038



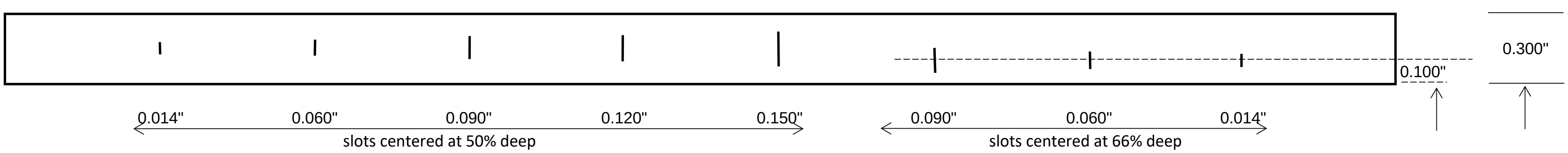
midwall slots, down



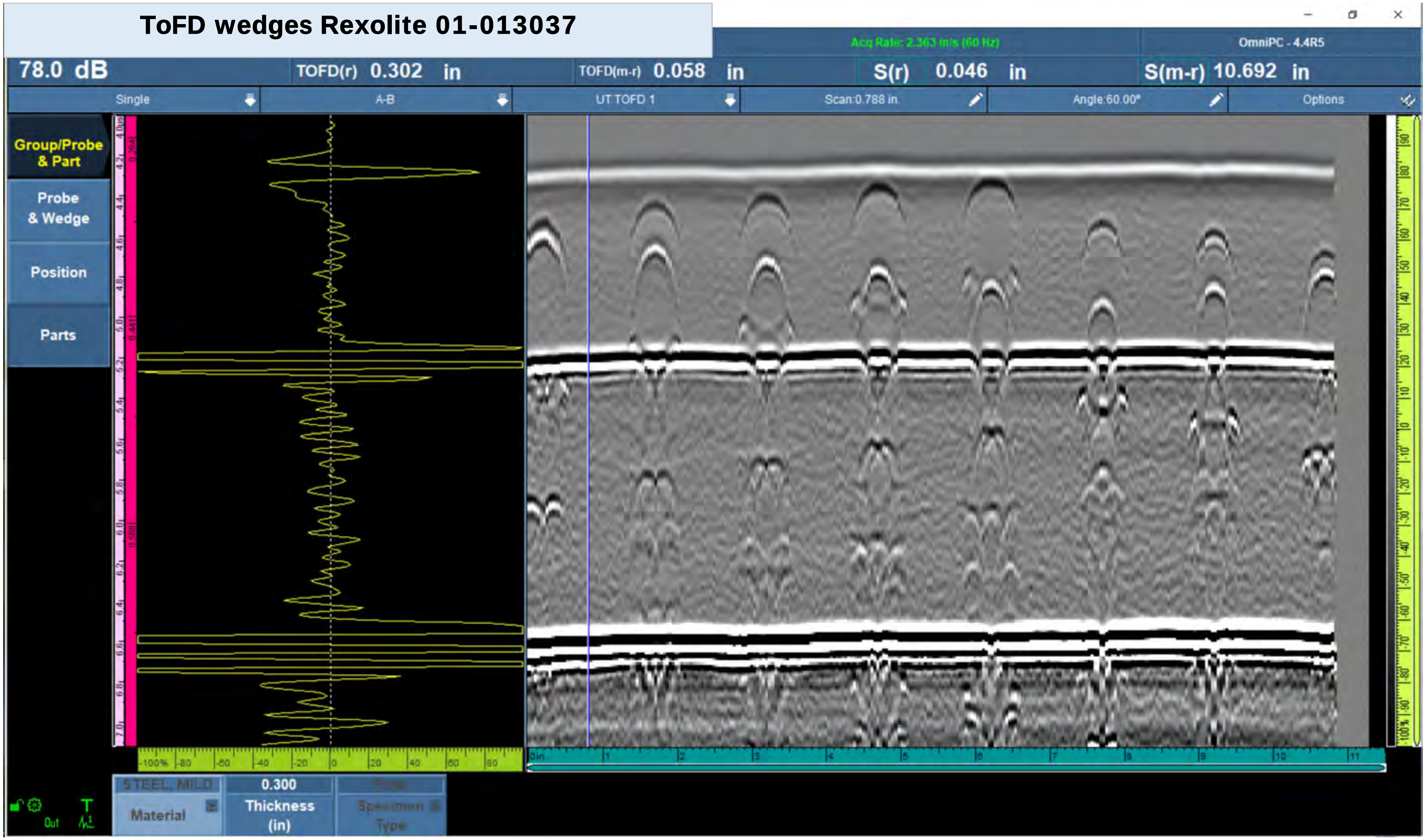
ToFD wedges Rexolite 362-001-160



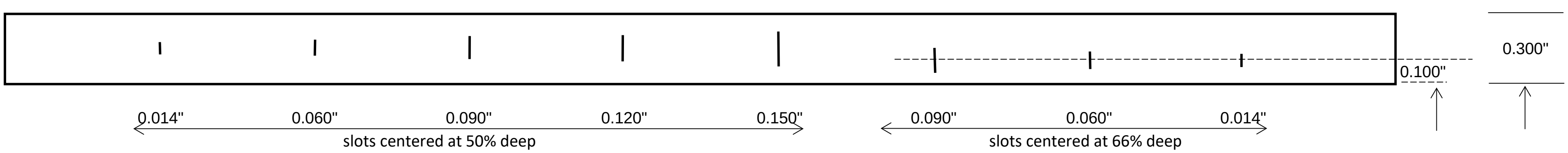
midwall slots, down



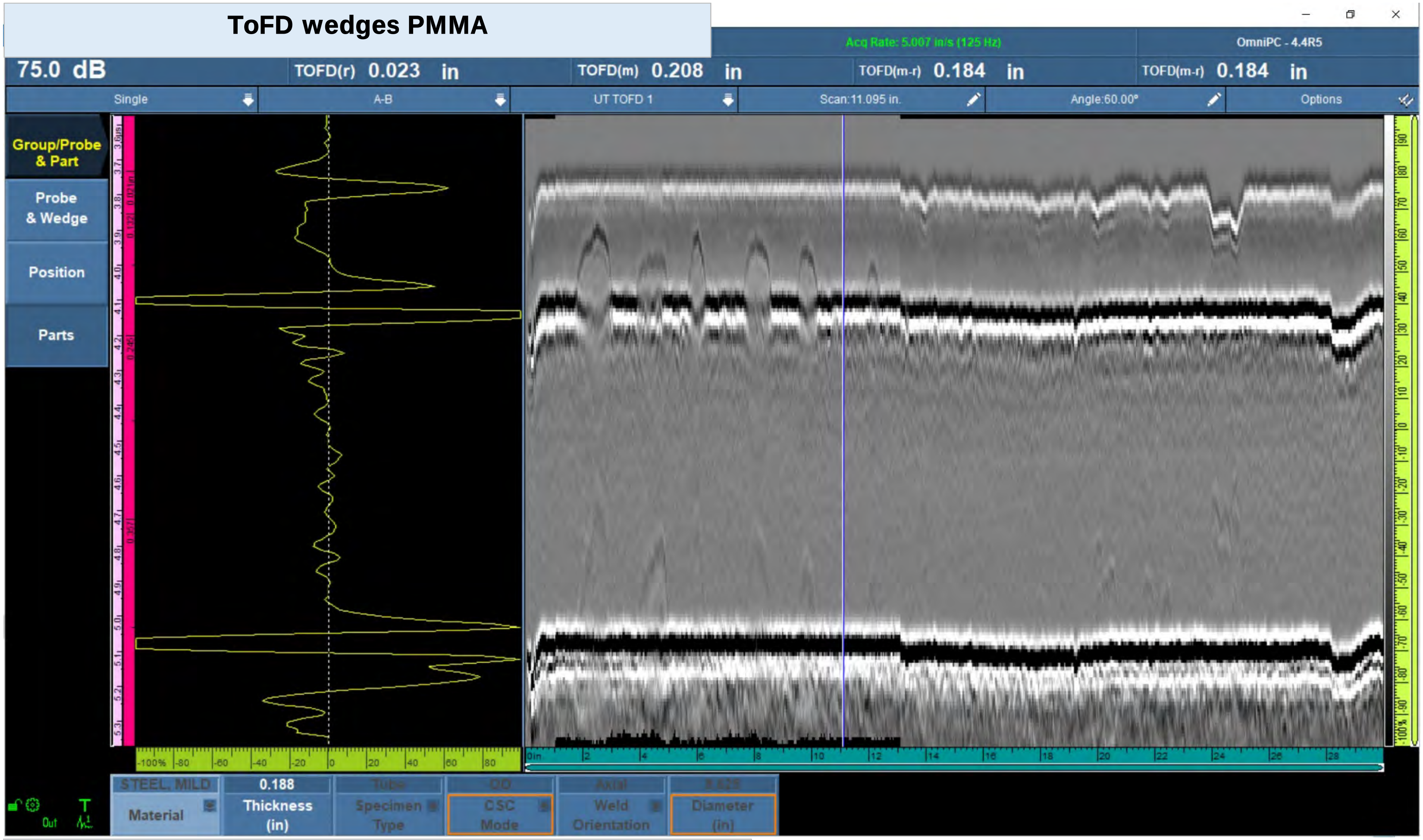
ToFD wedges Rexolite 01-013037



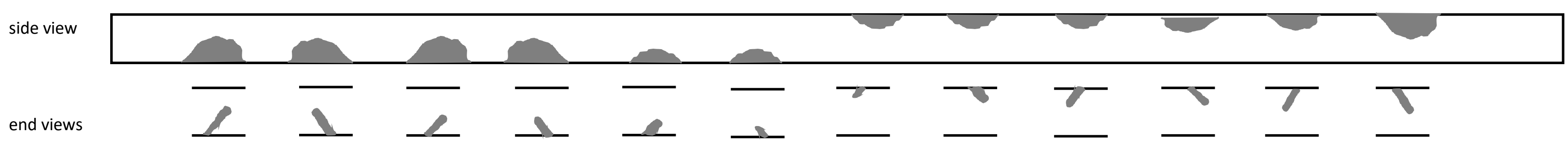
midwall slots, down



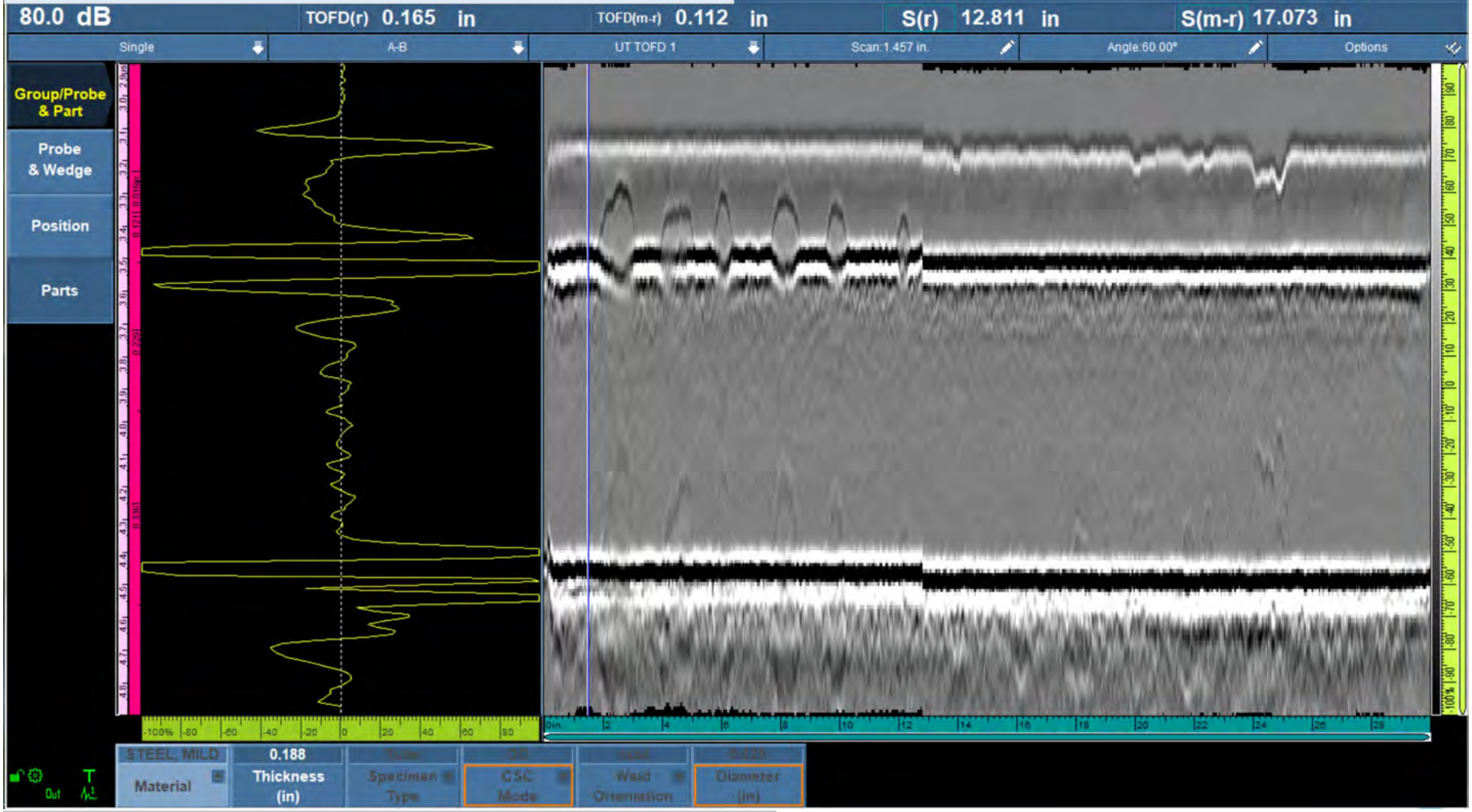
ToFD wedges PMMA



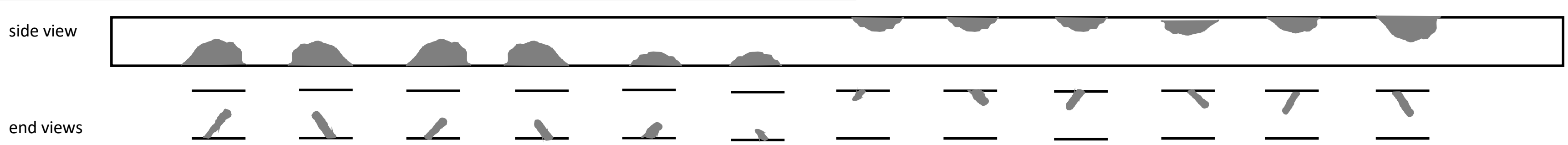
8x188 pipe, long seam, slanted, wafer wheel notches



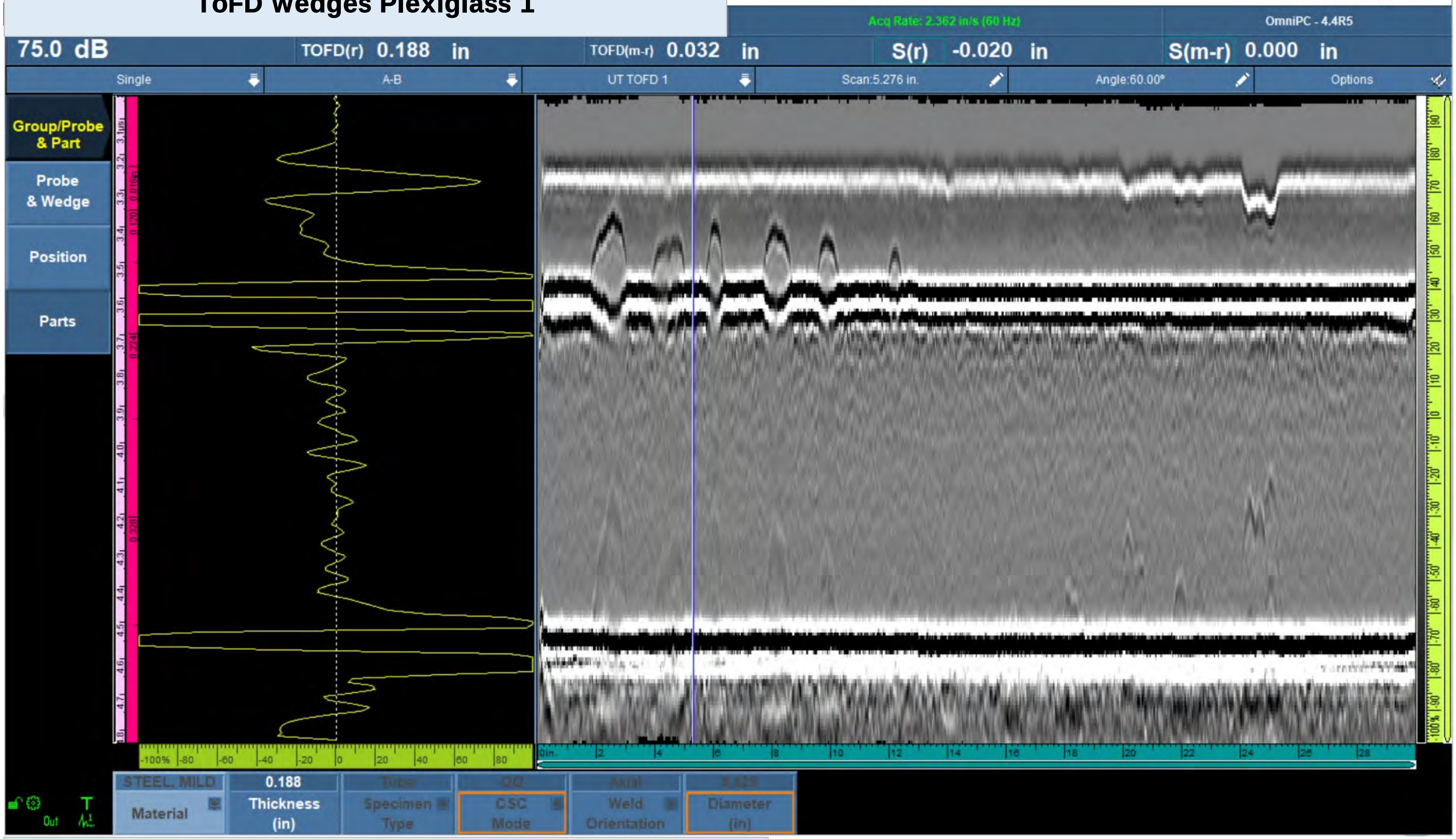
ToFD wedges Plexiglass 01-012038



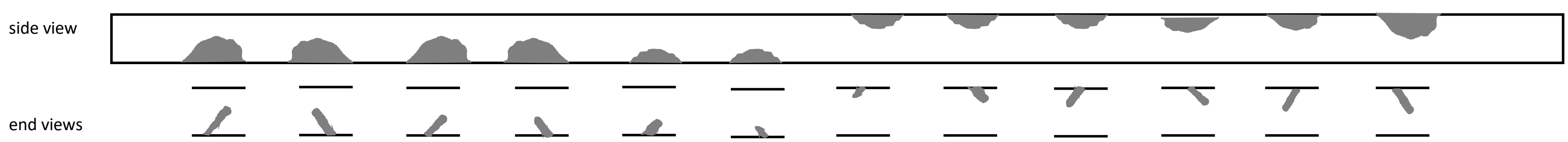
8x188 pipe, long seam, slanted, wafer wheel notches



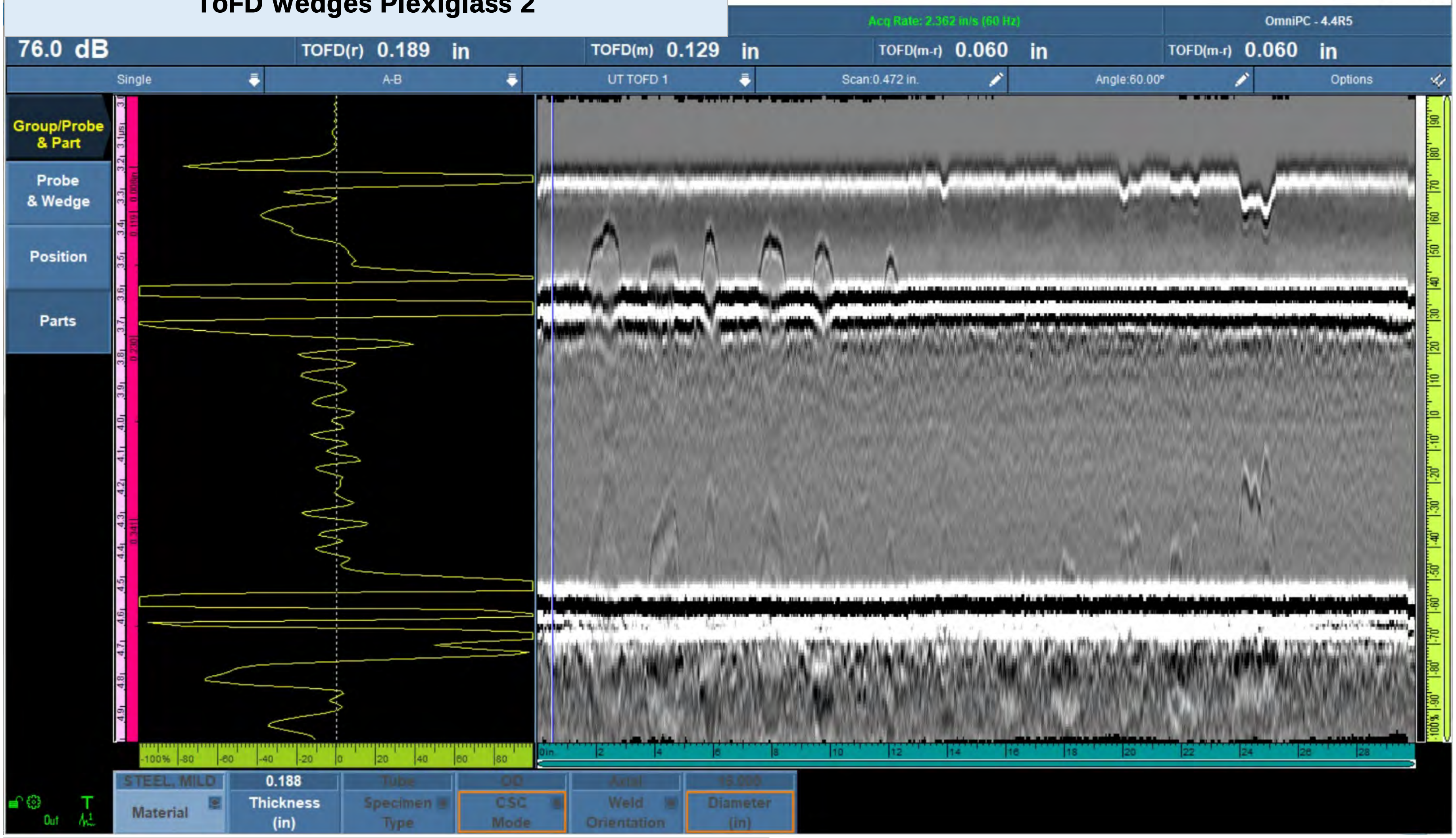
ToFD wedges Plexiglass 1



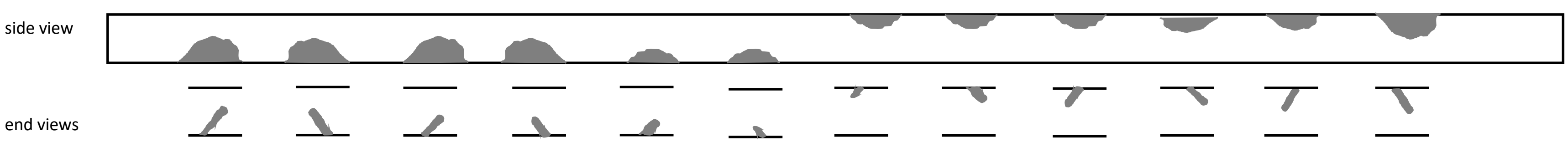
8x188 pipe, long seam, slanted, wafer wheel notches



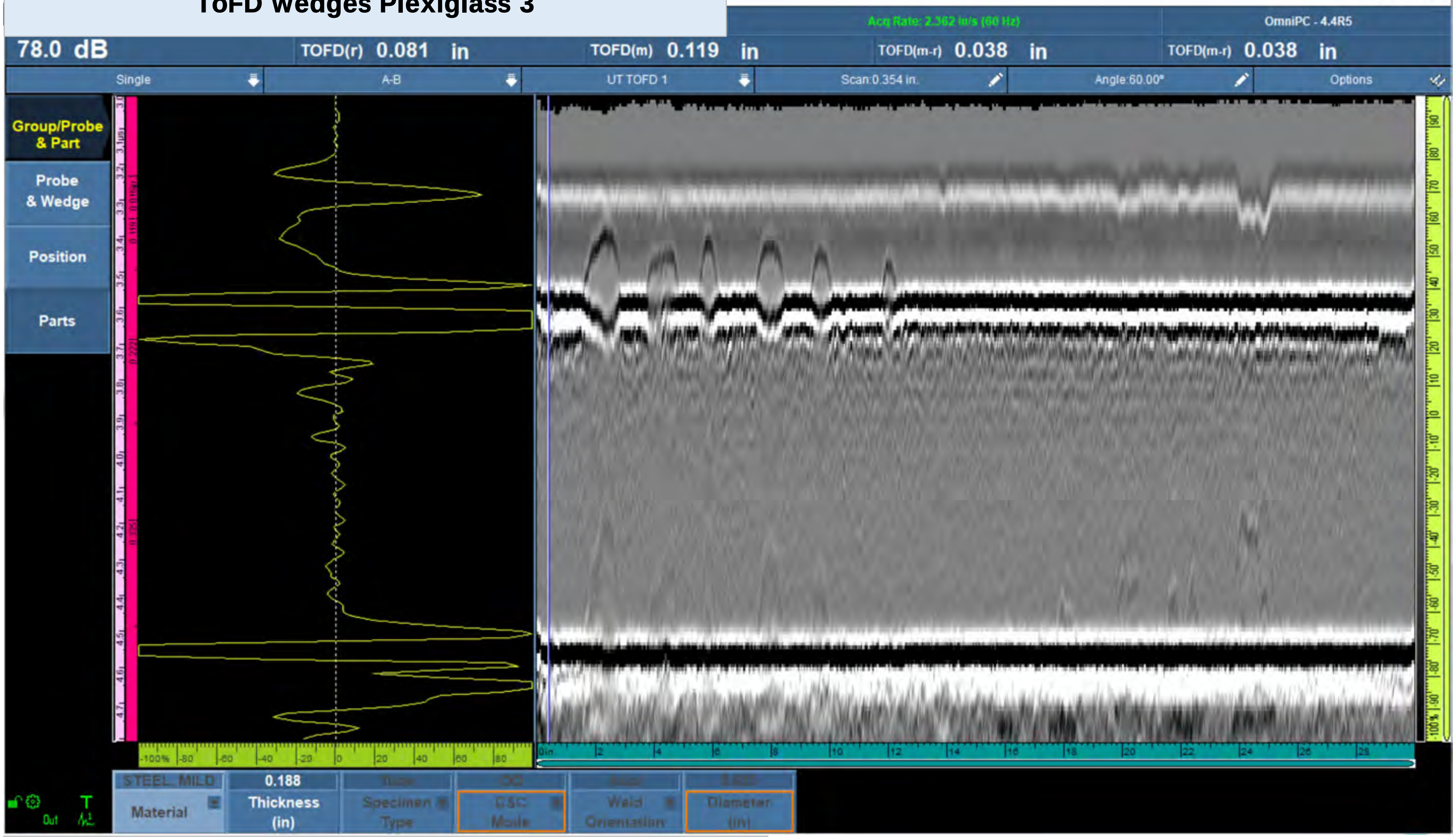
ToFD wedges Plexiglass 2



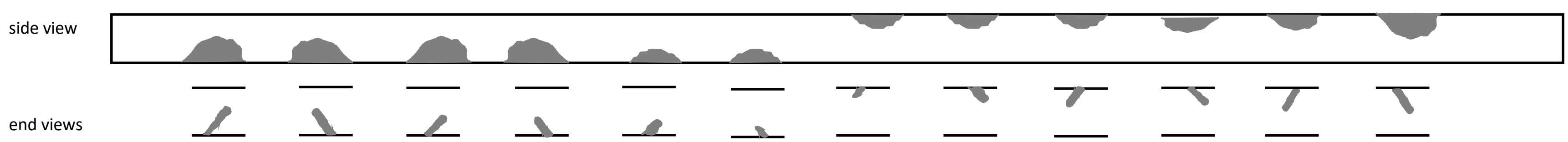
8x188 pipe, long seam, slanted, wafer wheel notches



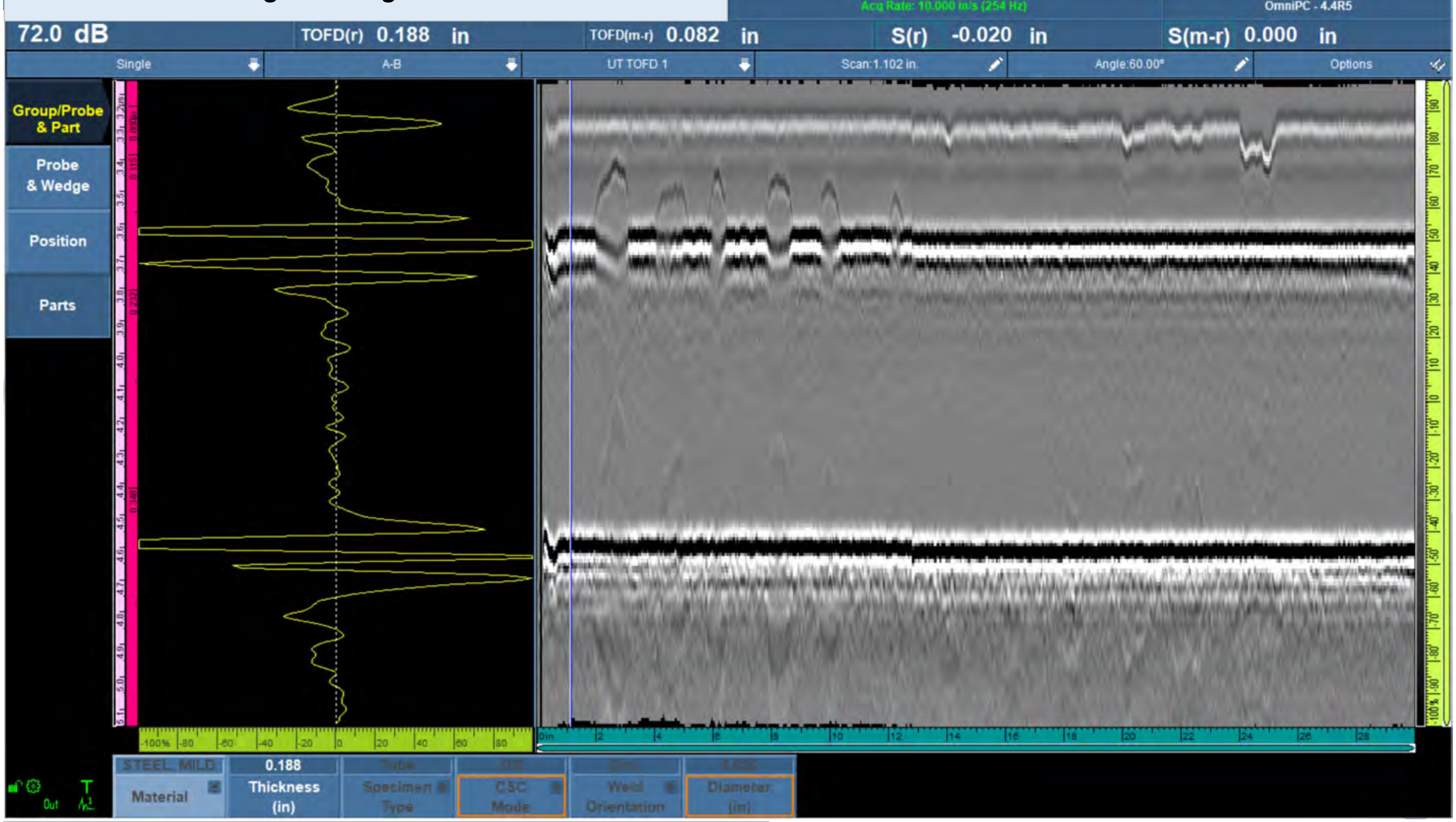
ToFD wedges Plexiglass 3



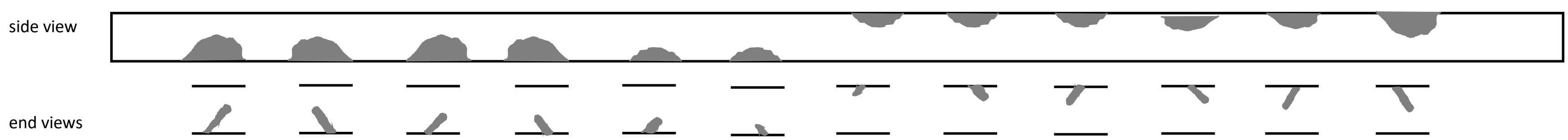
8x188 pipe, long seam, slanted, wafer wheel notches



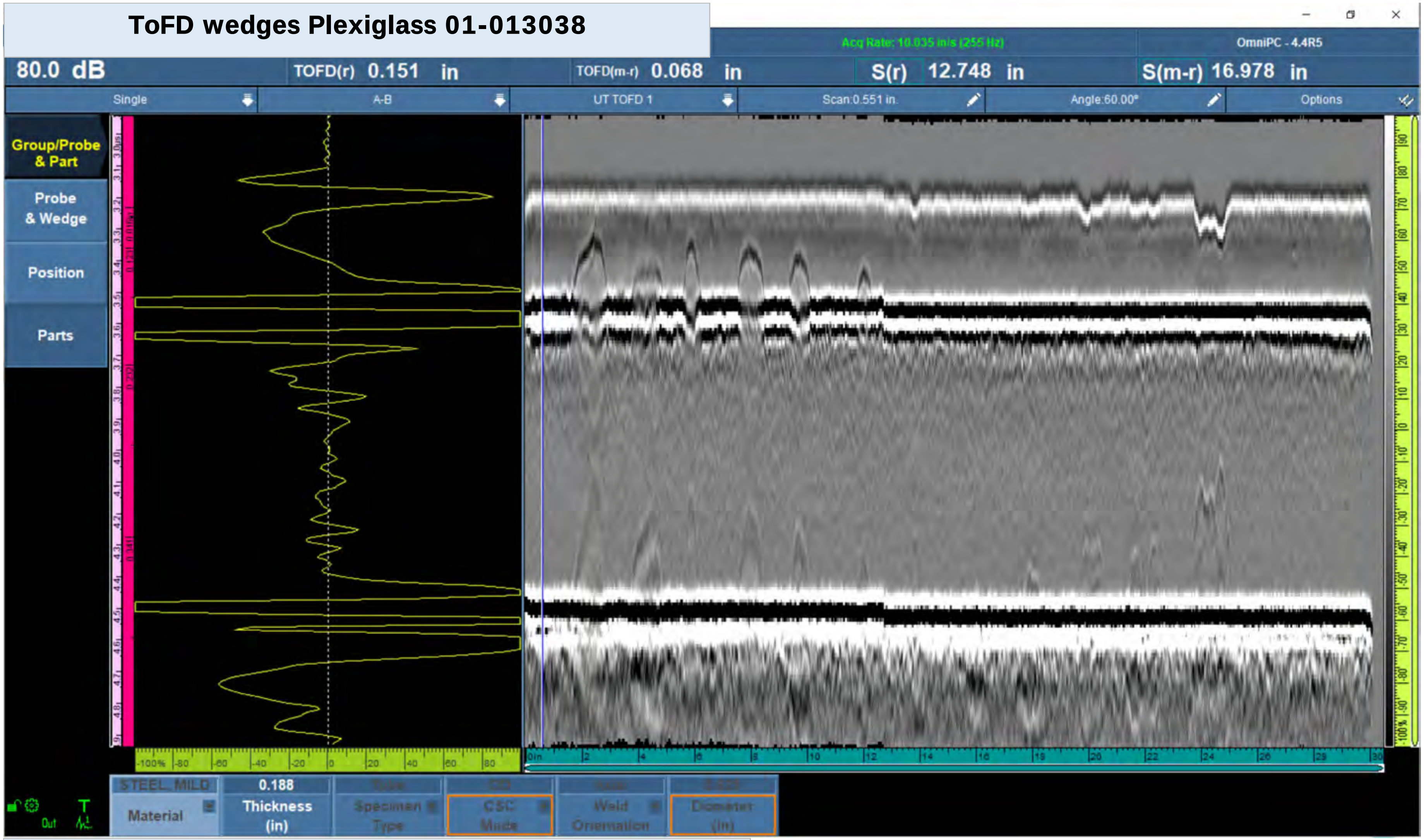
ToFD wedges Plexiglass 01-012100



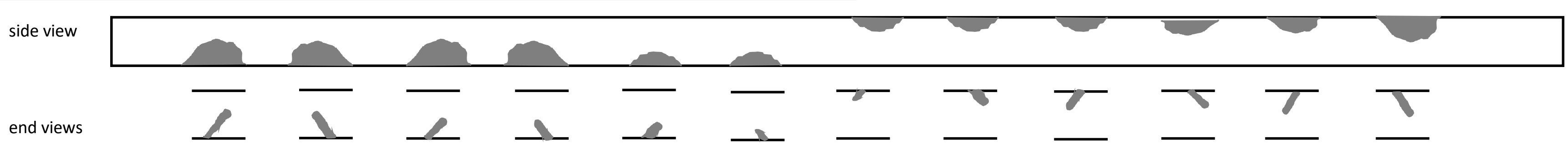
8x188 pipe, long seam, slanted, wafer wheel notches



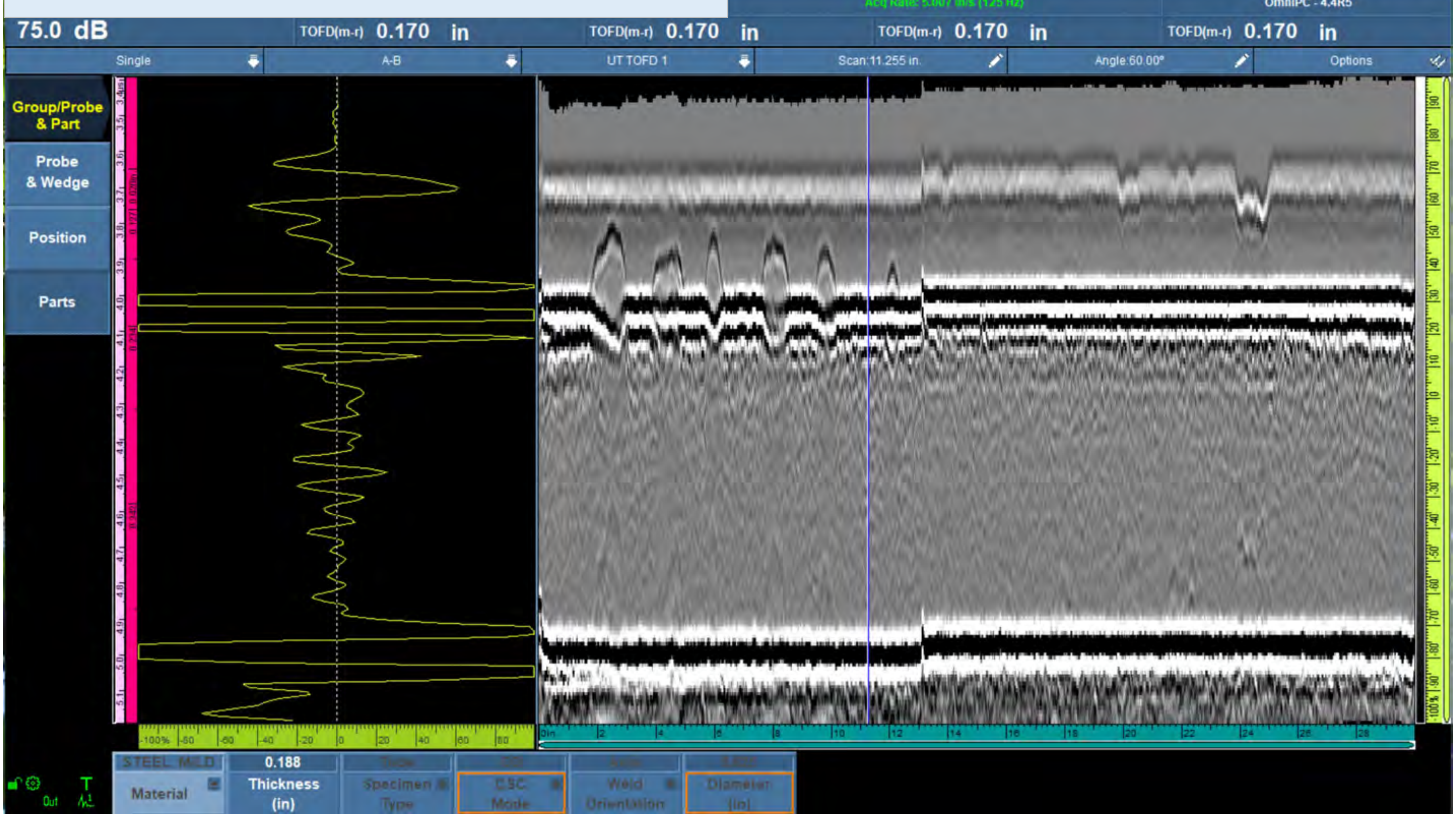
ToFD wedges Plexiglass 01-013038



8x188 pipe, long seam, slanted, wafer wheel notches



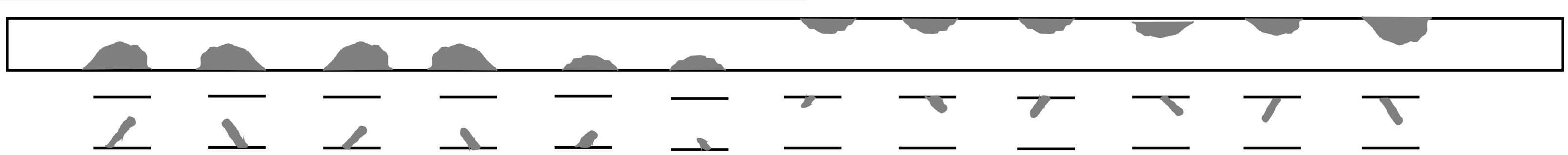
ToFD wedges Rexolite 362-001-160



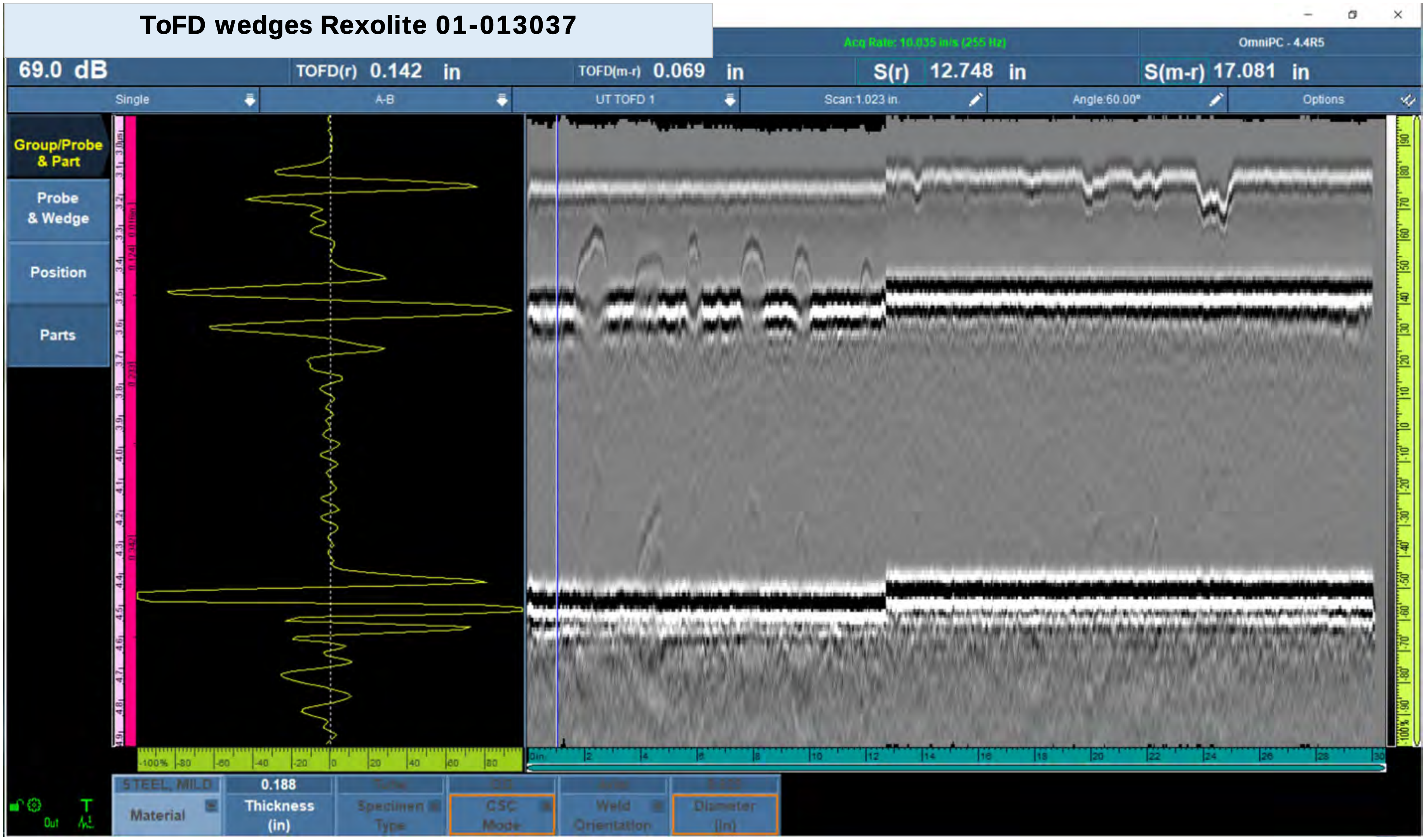
8x188 pipe, long seam, slanted, wafer wheel notches

side view

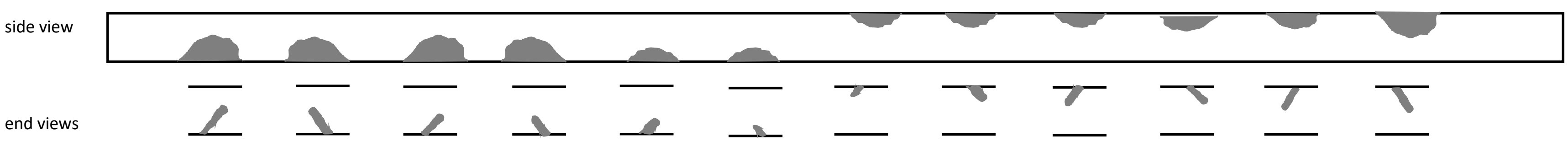
end views



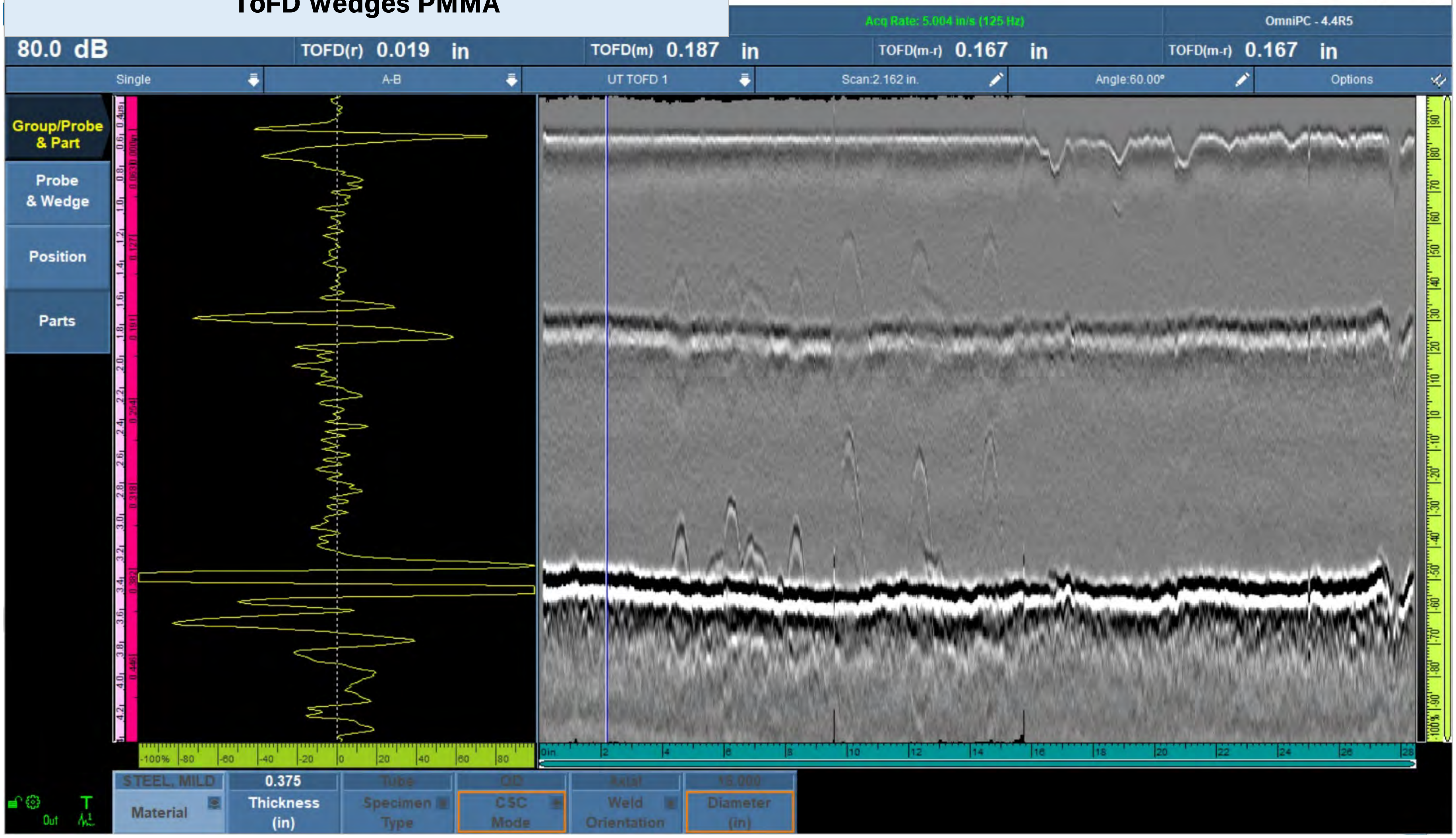
ToFD wedges Rexolite 01-013037



8x188 pipe, long seam, slanted, wafer wheel notches



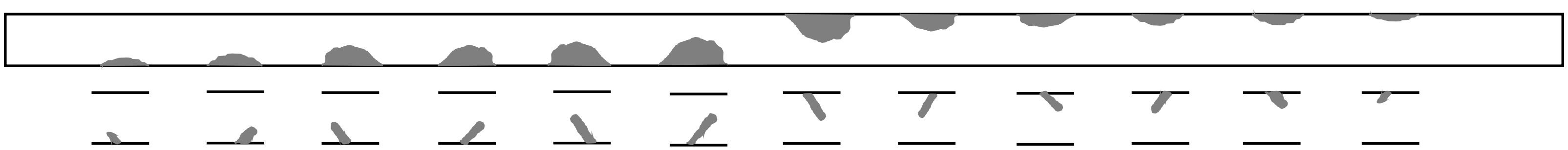
ToFD wedges PMMA



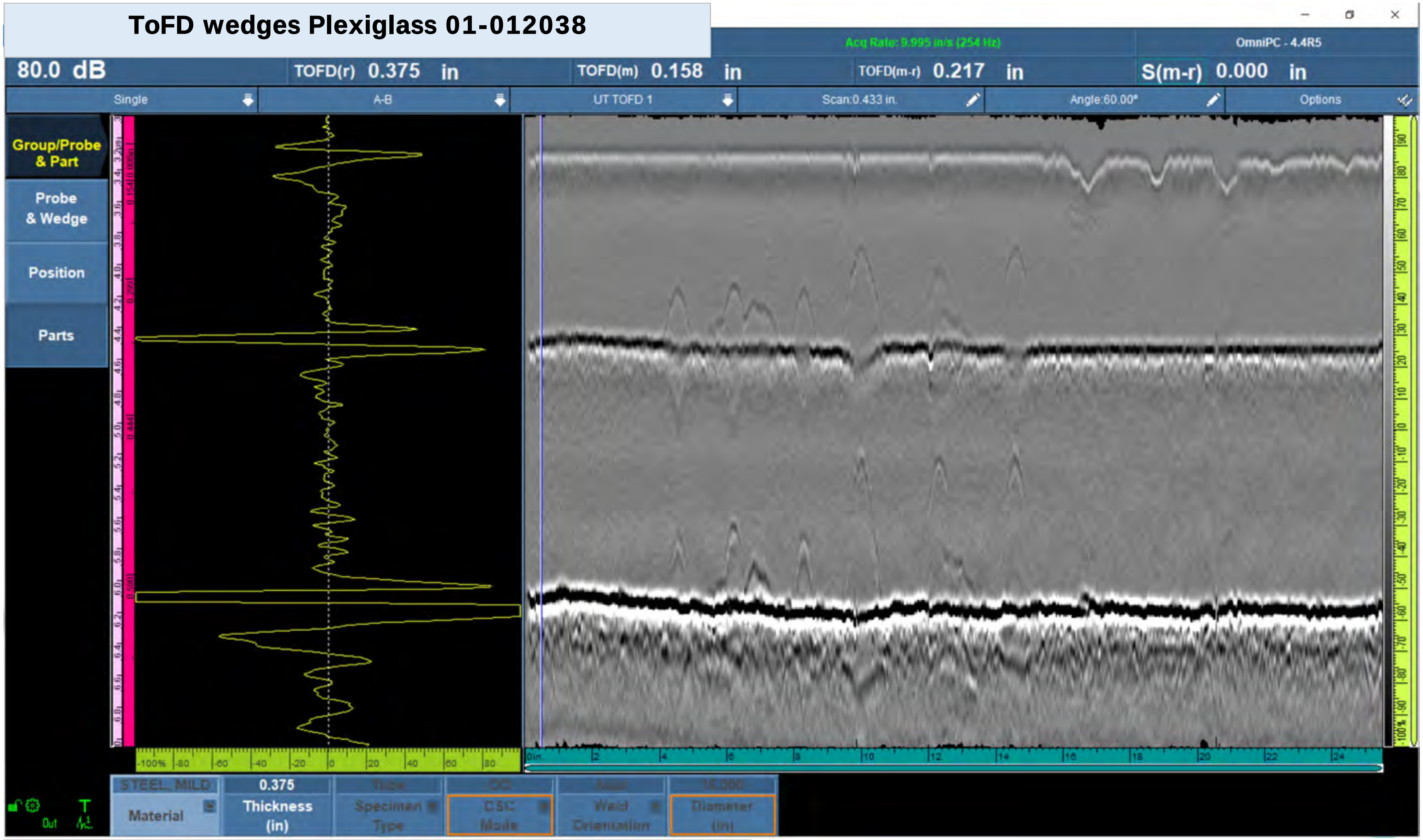
16x375 pipe, long seam, slanted, wafer wheel notches

side view

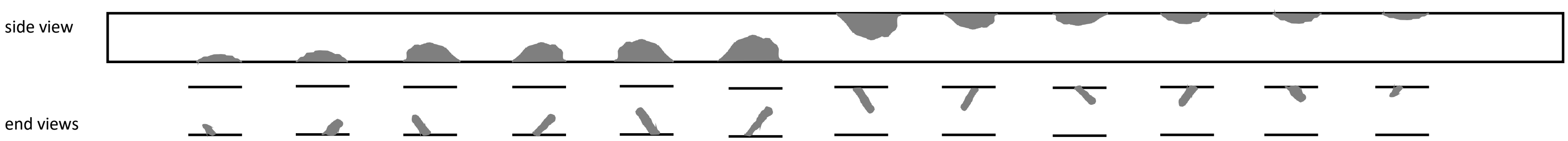
end views



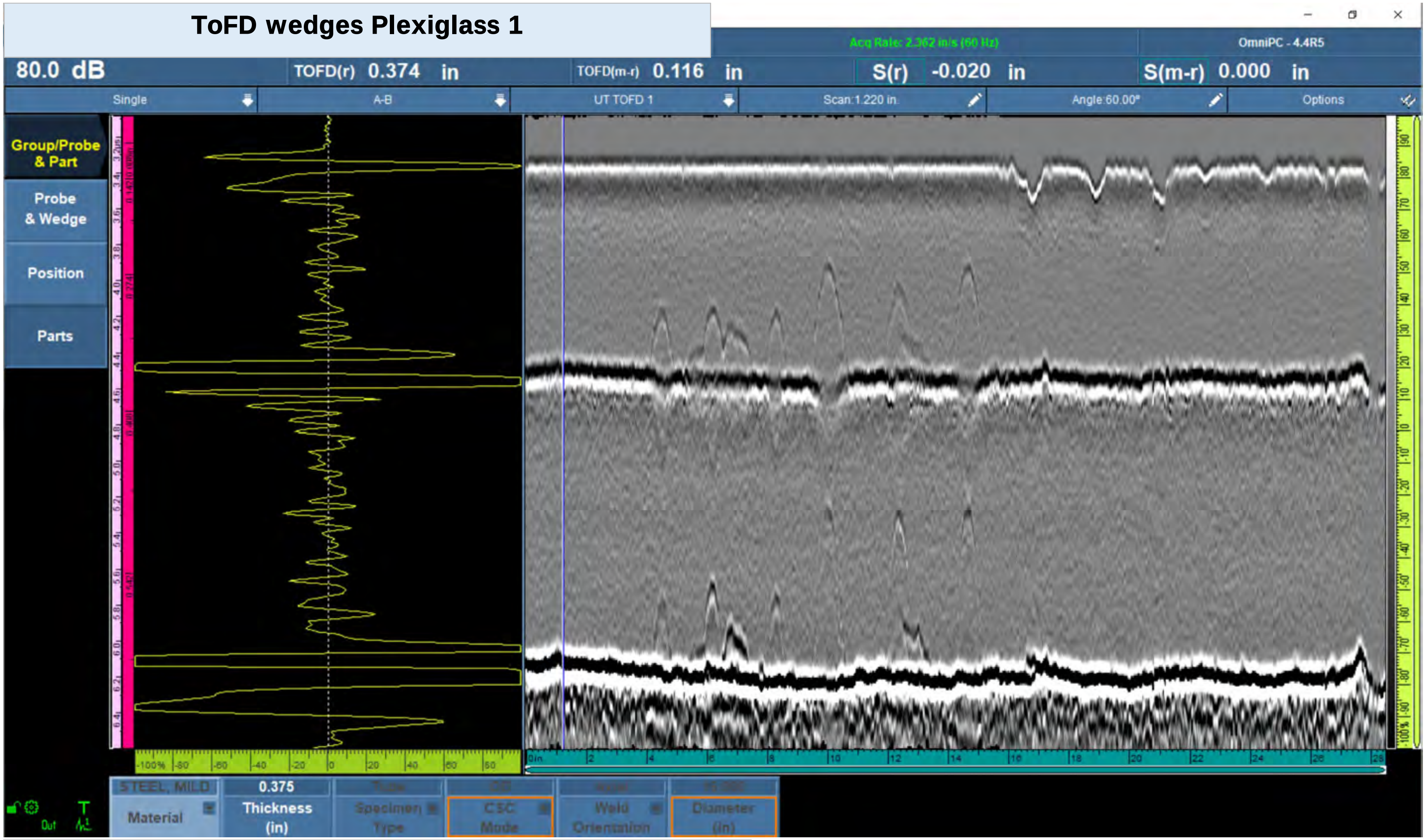
ToFD wedges Plexiglass 01-012038



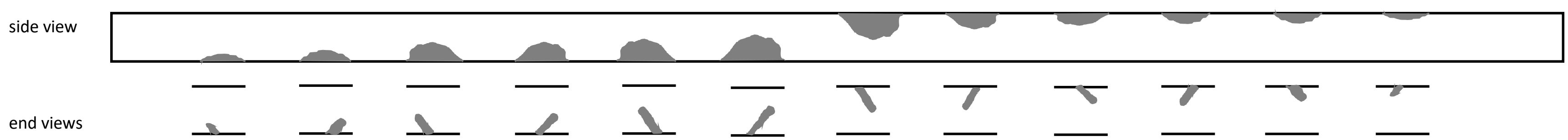
16x375 pipe, long seam, slanted, wafer wheel notches



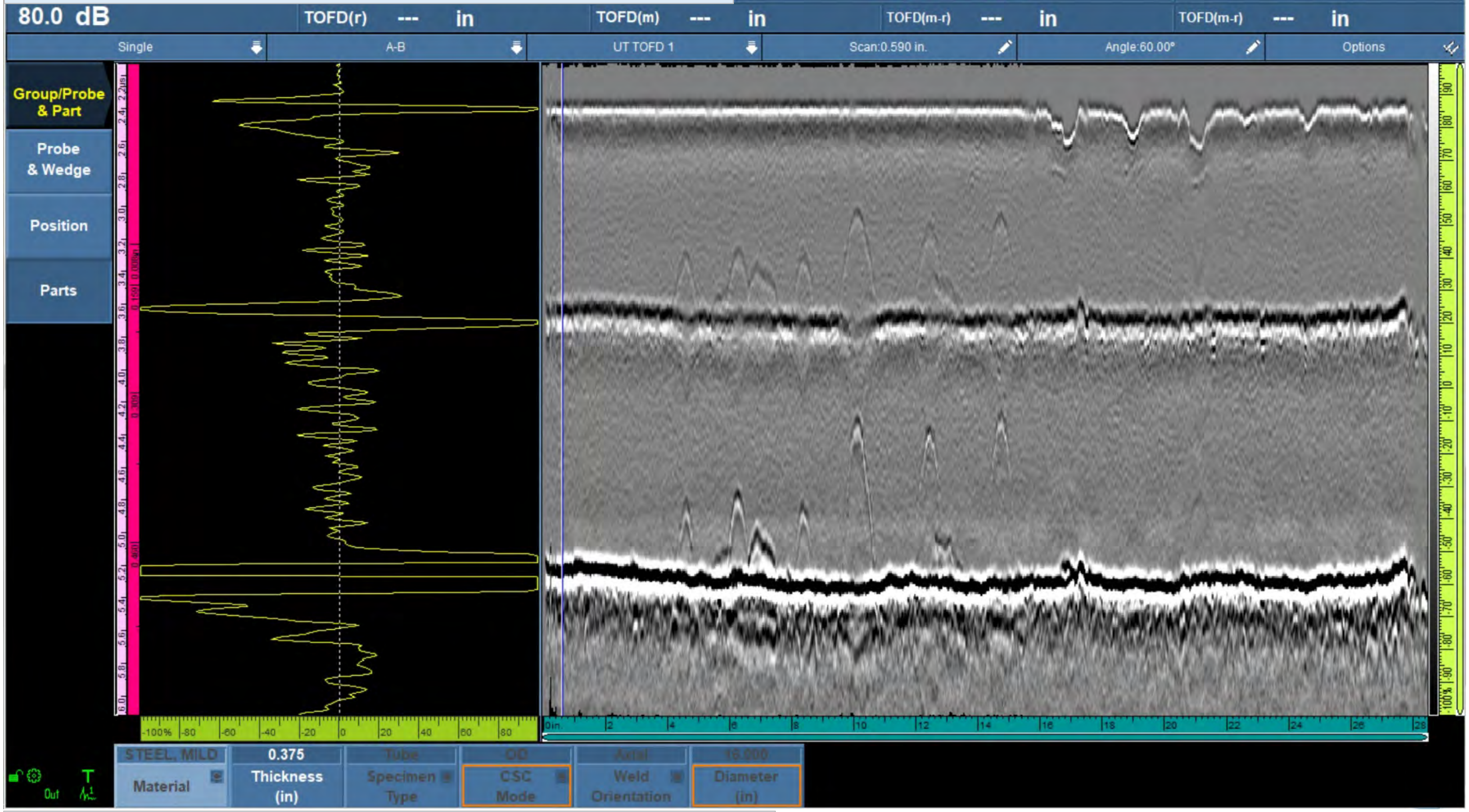
ToFD wedges Plexiglass 1



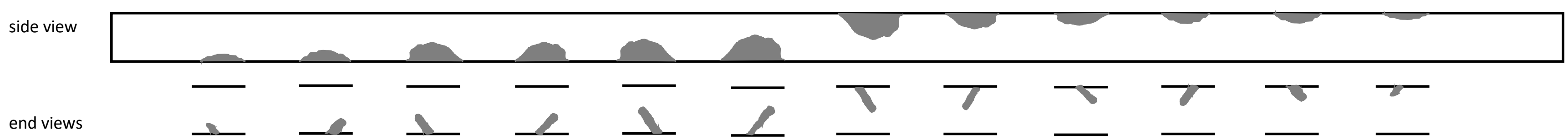
16x375 pipe, long seam, slanted, wafer wheel notches



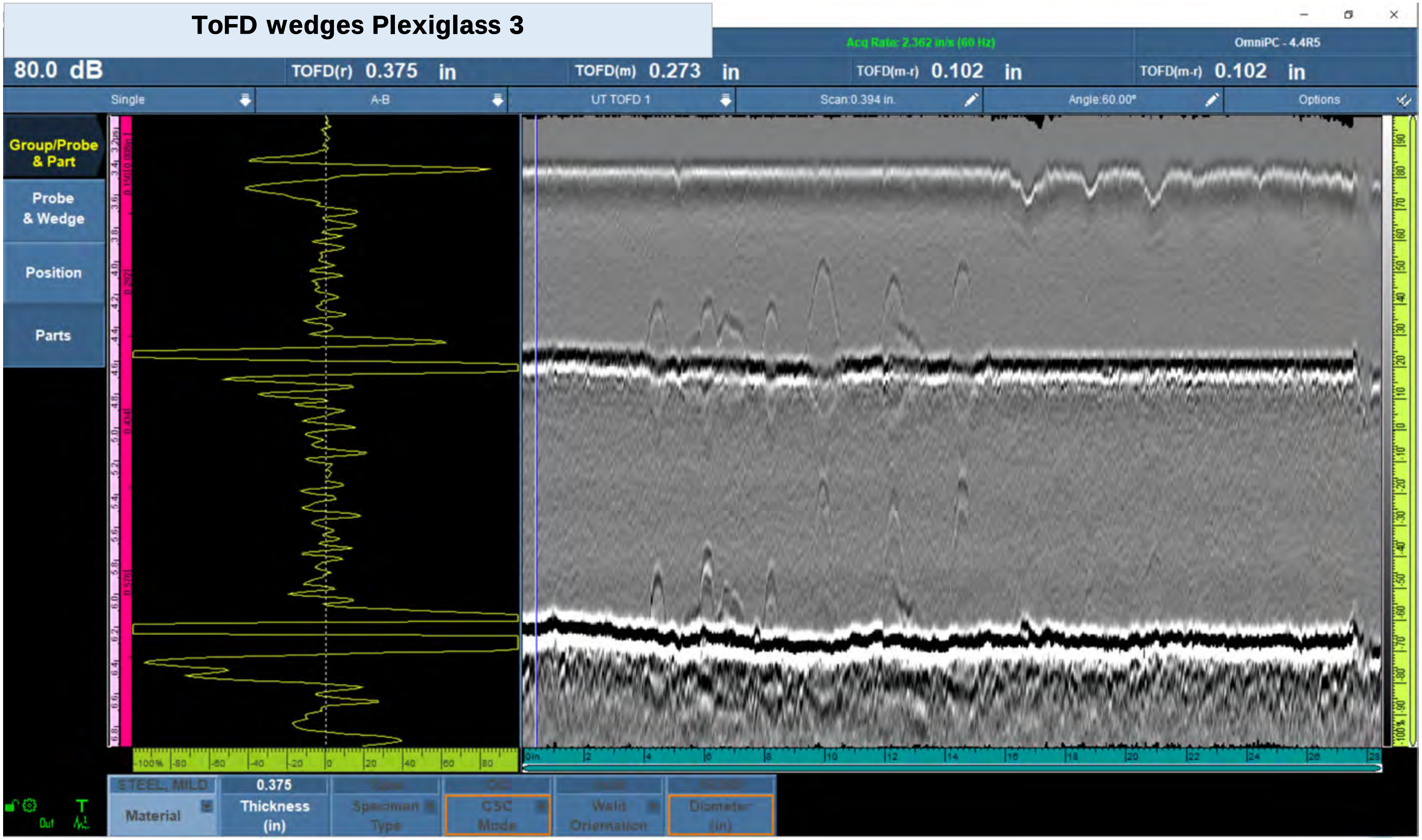
ToFD wedges Plexiglass 2



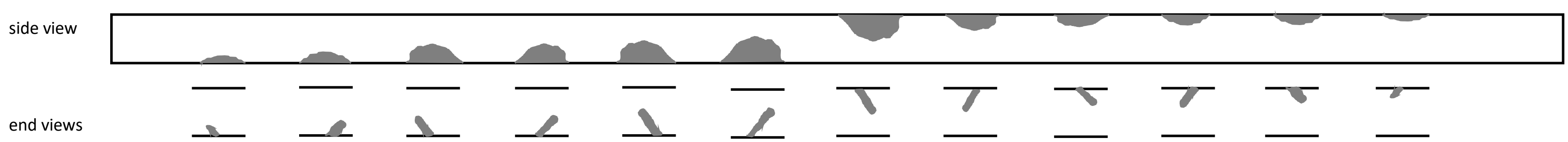
16x375 pipe, long seam, slanted, wafer wheel notches



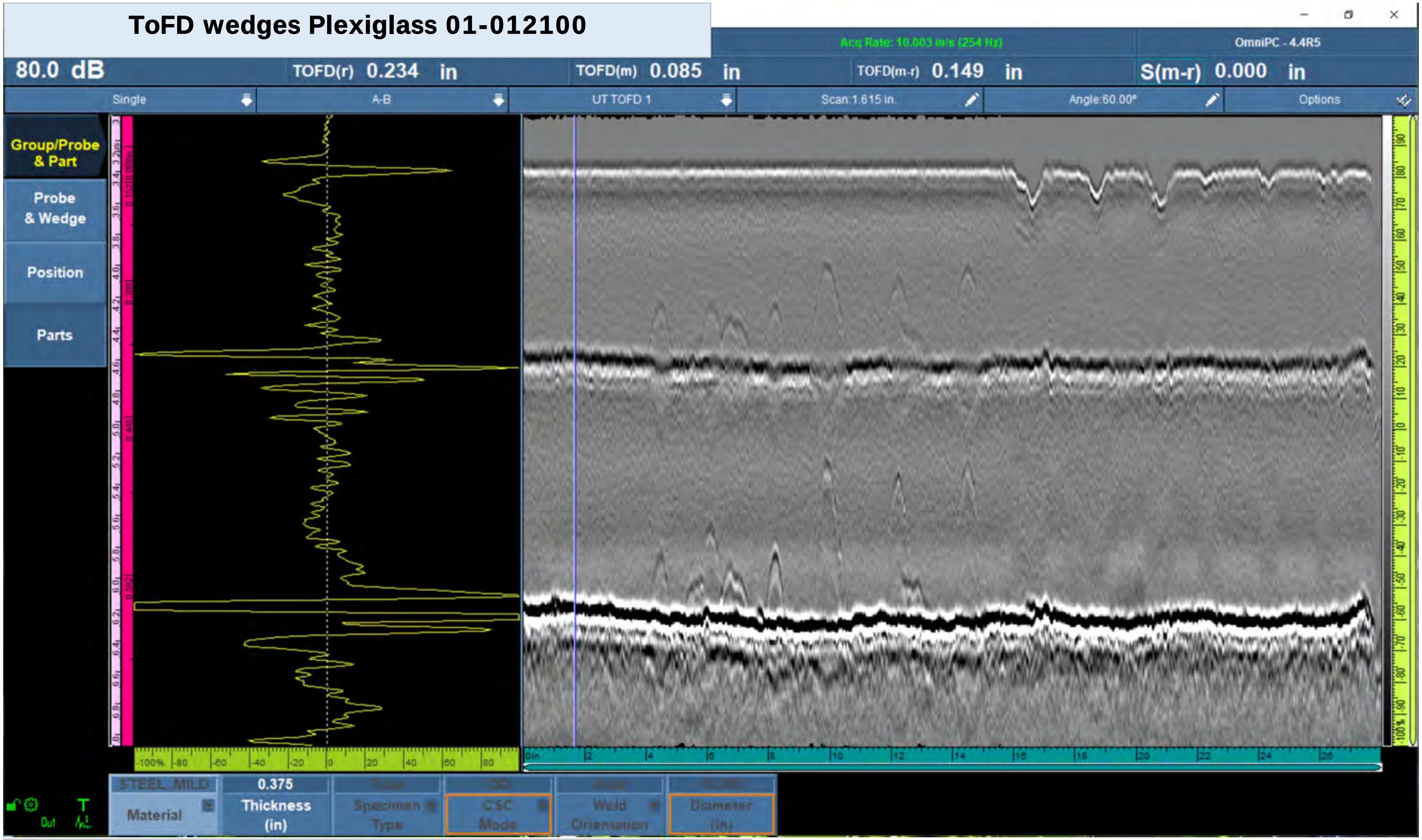
ToFD wedges Plexiglass 3



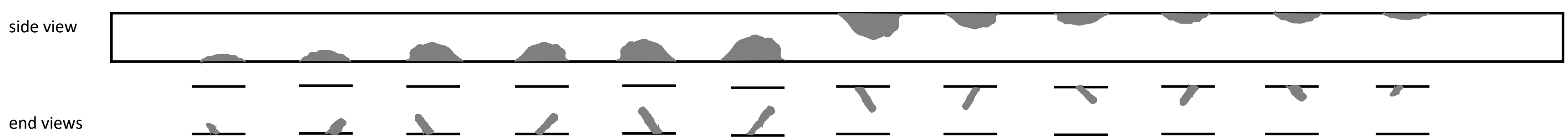
16x375 pipe, long seam, slanted, wafer wheel notches



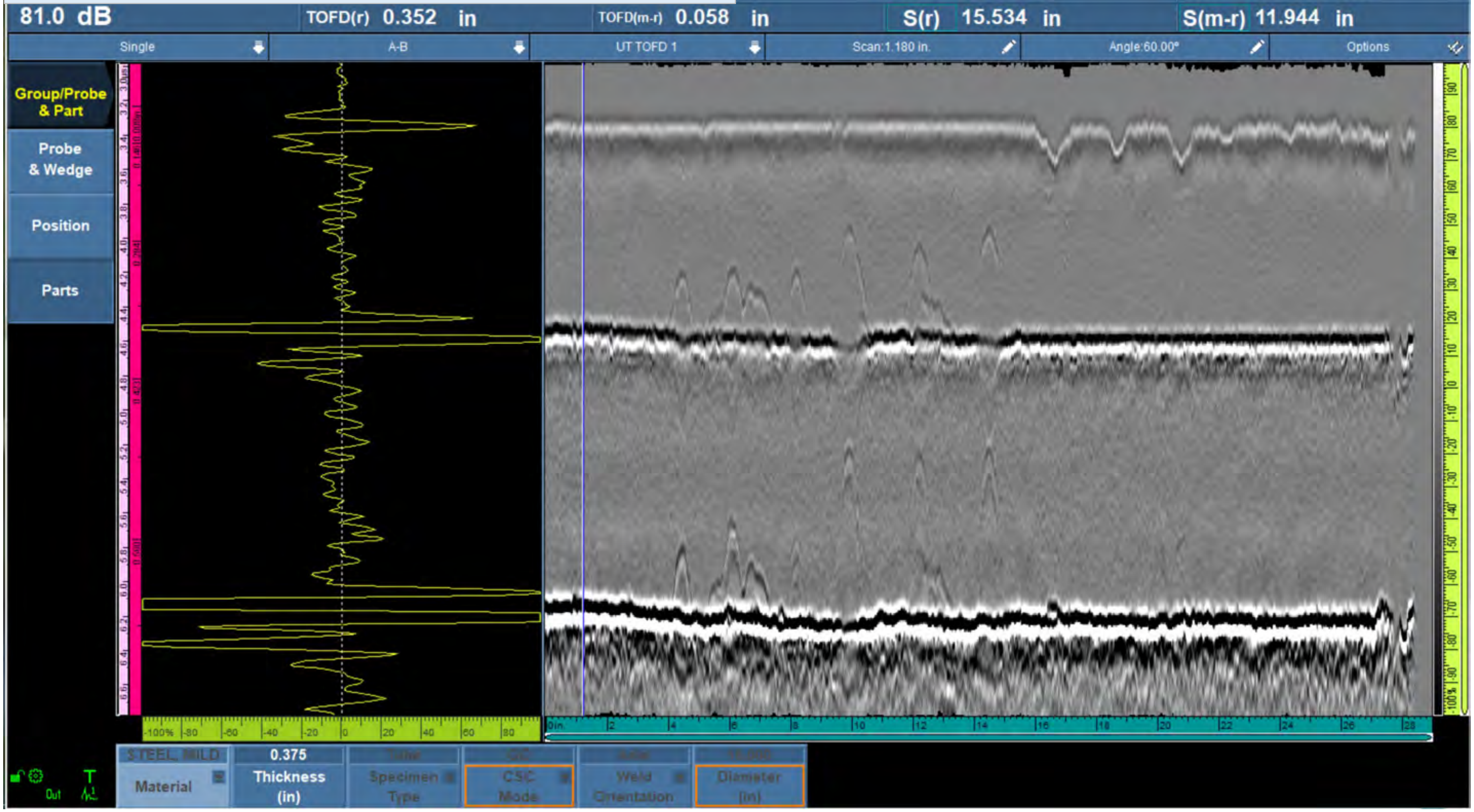
ToFD wedges Plexiglass 01-012100



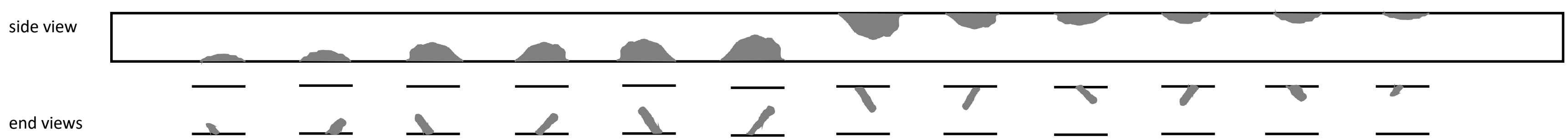
16x375 pipe, long seam, slanted, wafer wheel notches



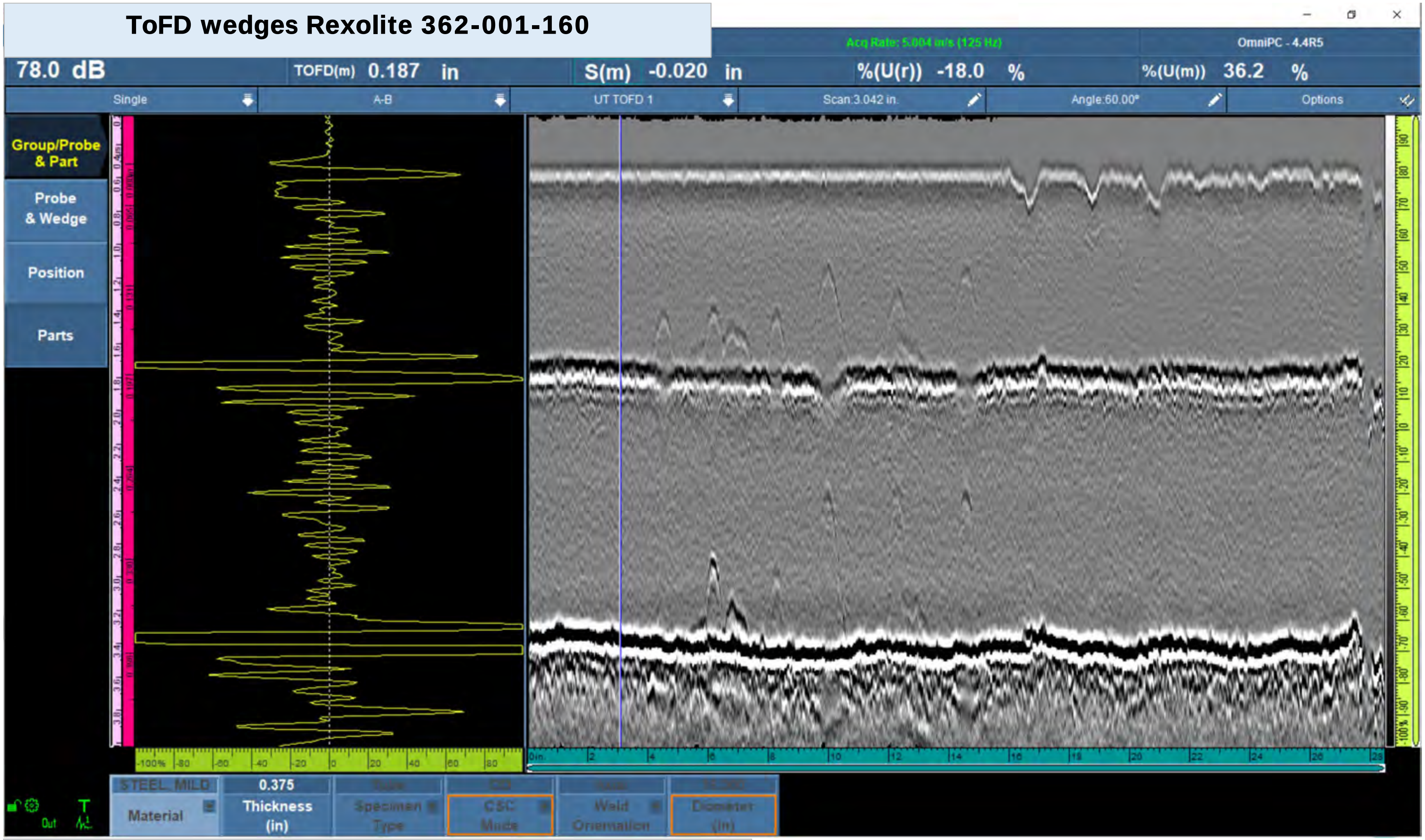
ToFD wedges Plexiglass 01-013038



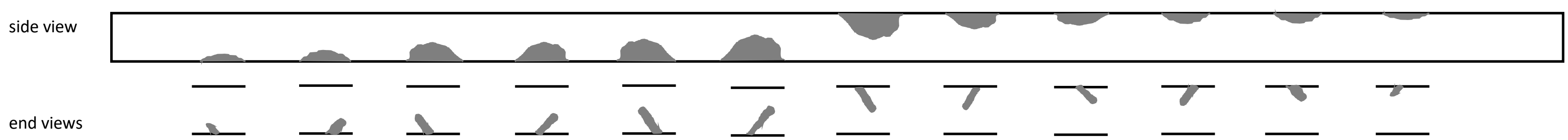
16x375 pipe, long seam, slanted, wafer wheel notches



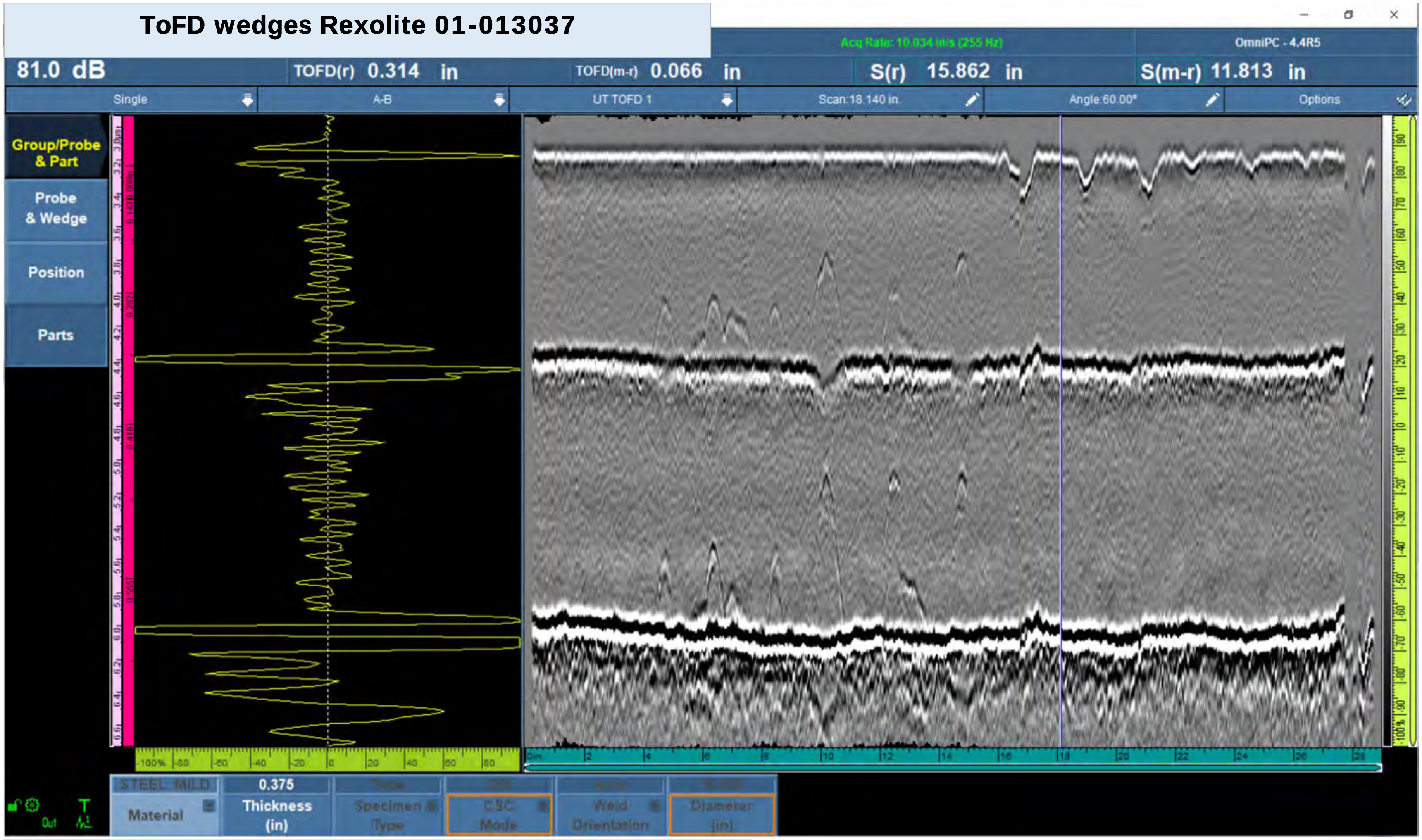
ToFD wedges Rexolite 362-001-160



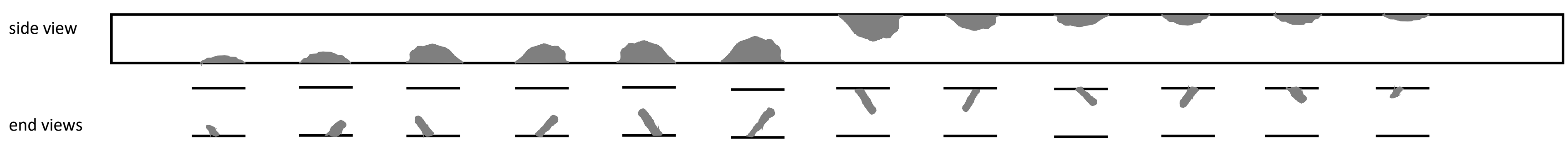
16x375 pipe, long seam, slanted, wafer wheel notches

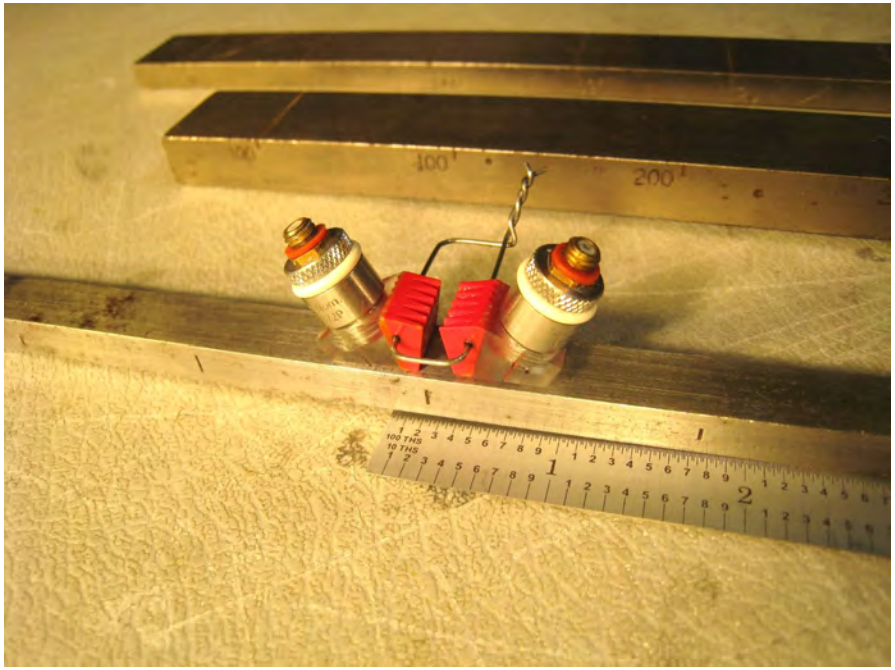


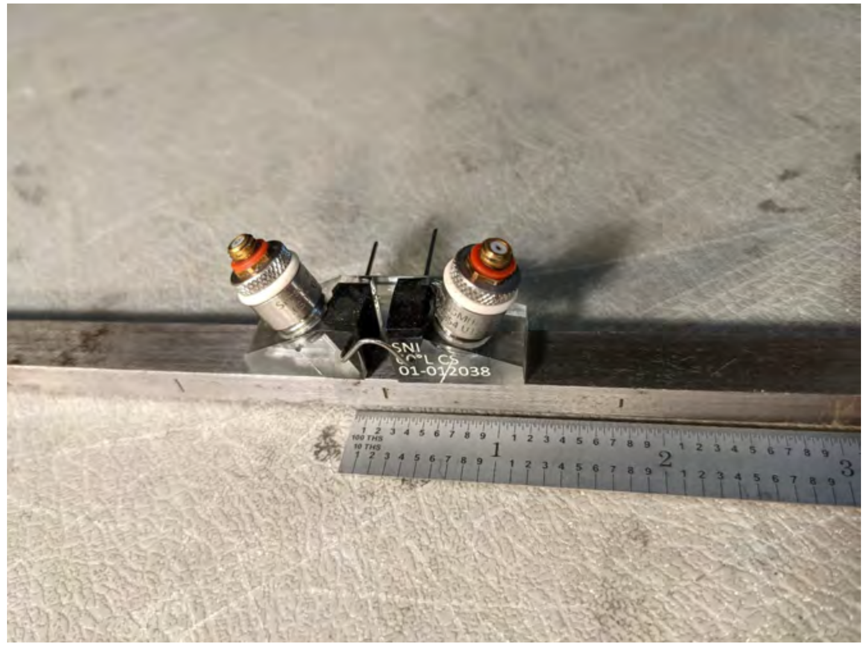
ToFD wedges Rexolite 01-013037



16x375 pipe, long seam, slanted, wafer wheel notches





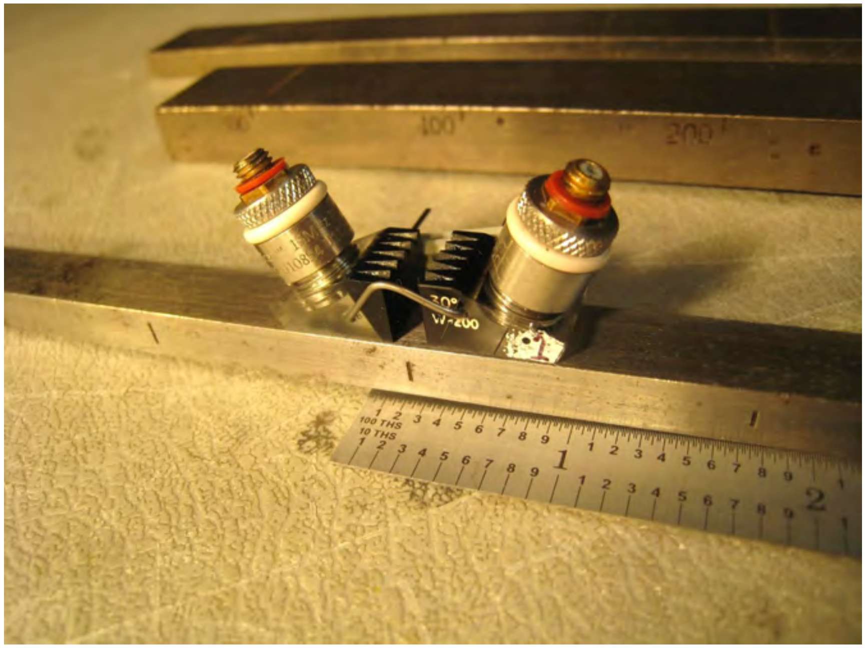


PMMA ToFD wedges

These are Olympus 45 degree shear wave short approach wedges with the angle changed to result in producing a 60 degree L-wave in steel.

Plexiglass 01-012038

These are Sensor Networks model 01-012038 wedges designed to produce 60 degree L-waves in steel.

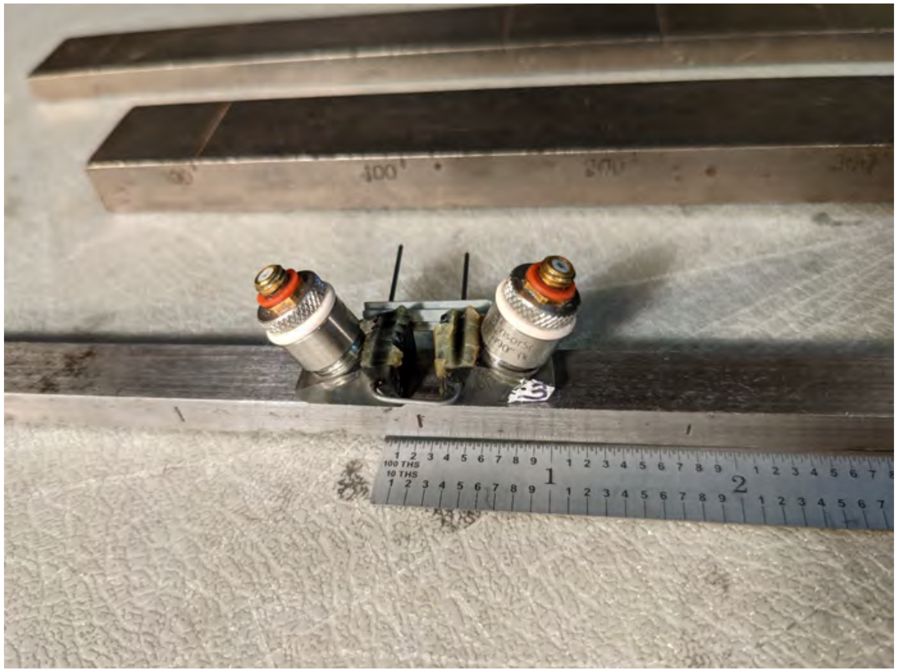


Plexiglass 1

These are GEIT or Krautkramer model W-200 wedges designed to produce 30 degree shear in steel, which also produce an L-wave in steel near 60 degrees.

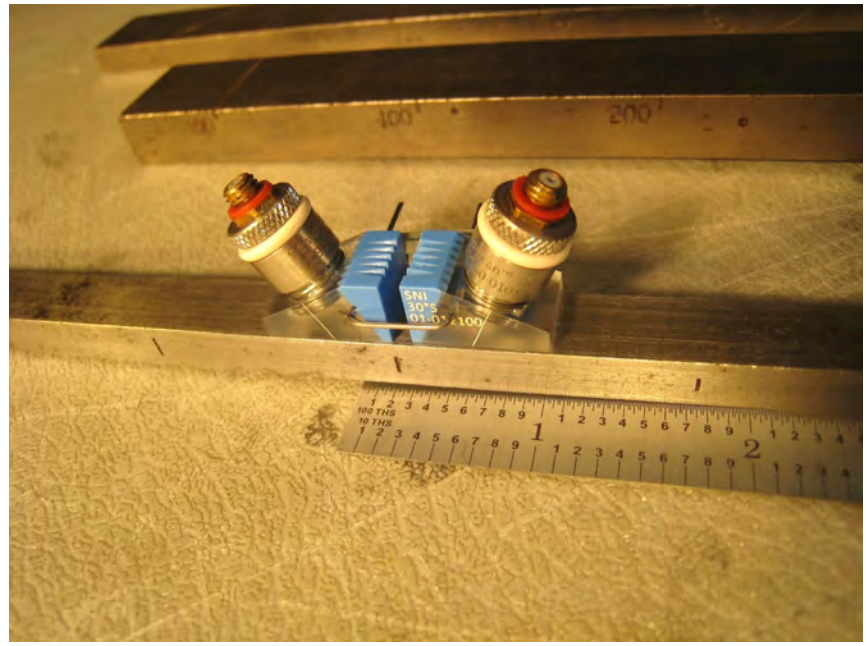
Plexiglass 2

These are GEIT or Krautkramer model W-200 wedges designed to produce 30 degree shear in steel, which also produce an L-wave in steel near 60 degrees.



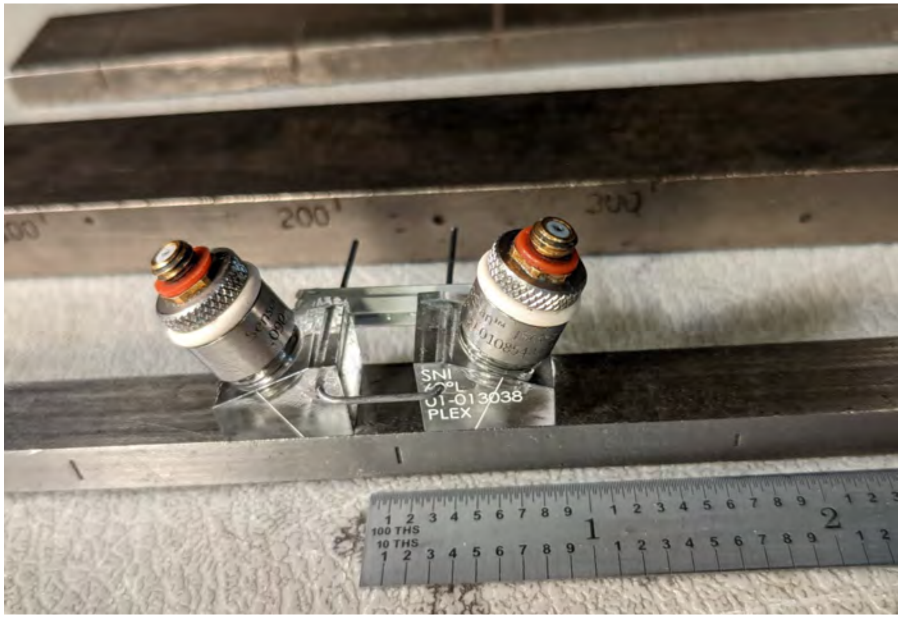
Plexiglass 3

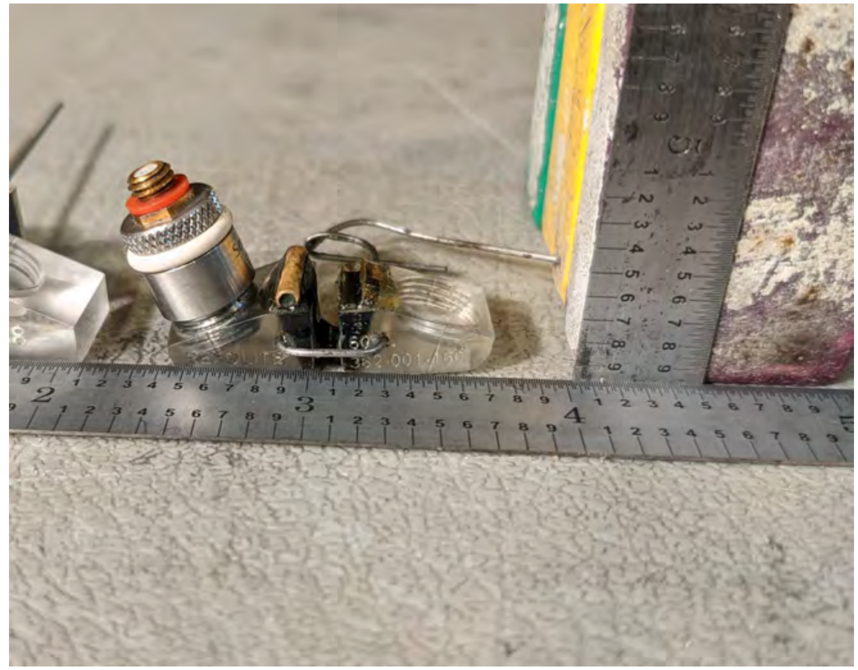
These are GEIT or Krautkramer model W-200 wedges designed to produce 30 degree shear in steel, which also produce an L-wave in steel near 60 degrees.



Plexiglass 01-012100

These are Sensor Networks model 01-012100 wedges designed to produce 30 degree shear in steel which also produce L-waves in steel close to 60 degrees.



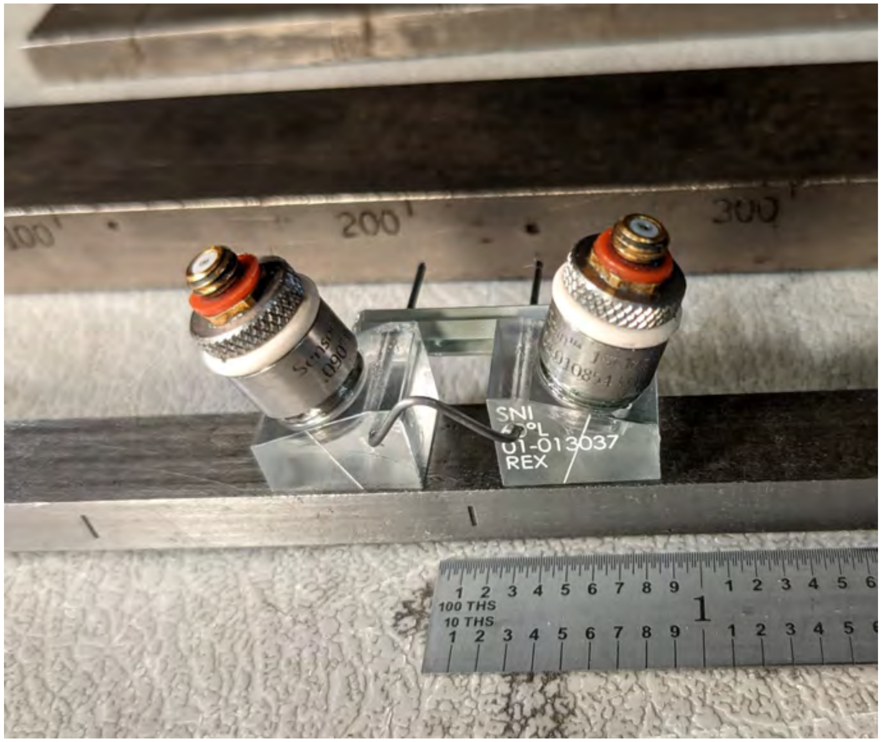


Plexiglass 01-013038

These are Sensor Networks model 01-013038 wedges designed to produce 60 degree L-waves in steel.

Rexolite 362-001-160

These are GEIT or Krautkramer model 362-001-160 designed to produce 60 degree L-wave in steel.

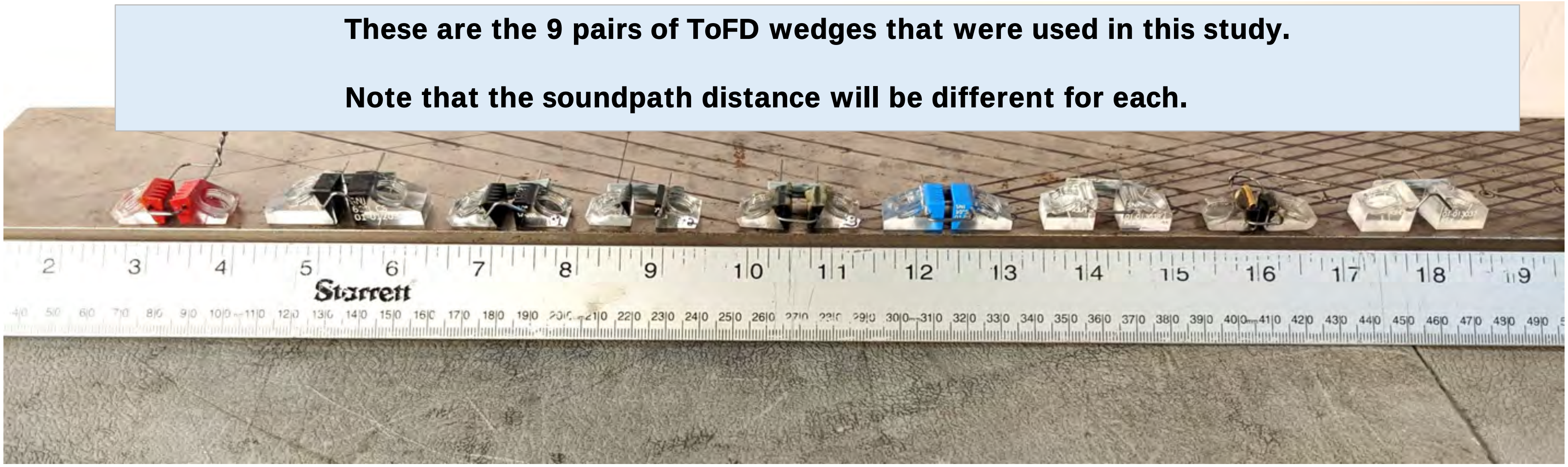


Rexolite 01-013037

These are Sensor Networks model 01-013037 designed to produce 60 degree L-wave in steel.

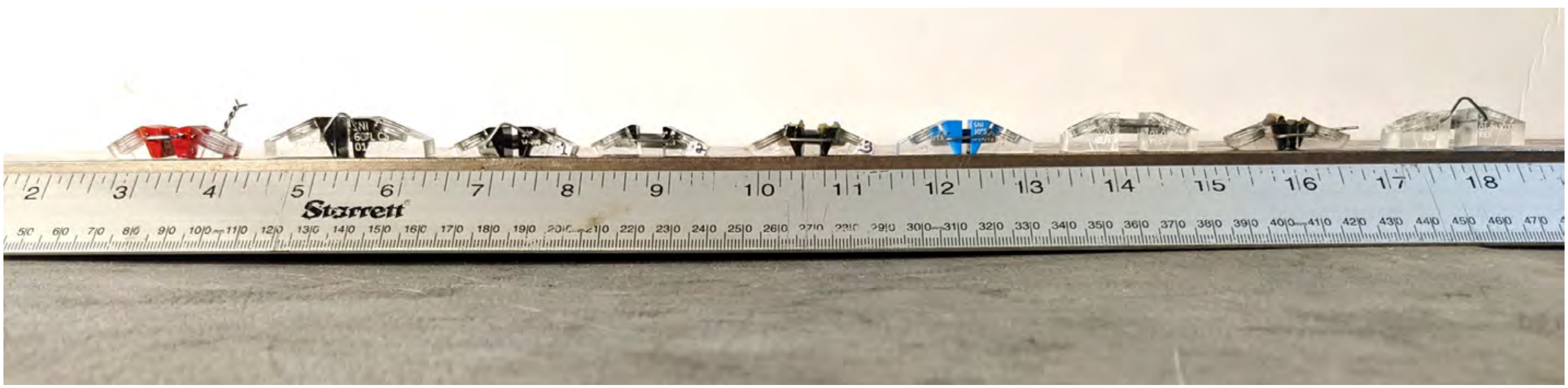
These are the 9 pairs of ToFD wedges that were used in this study.

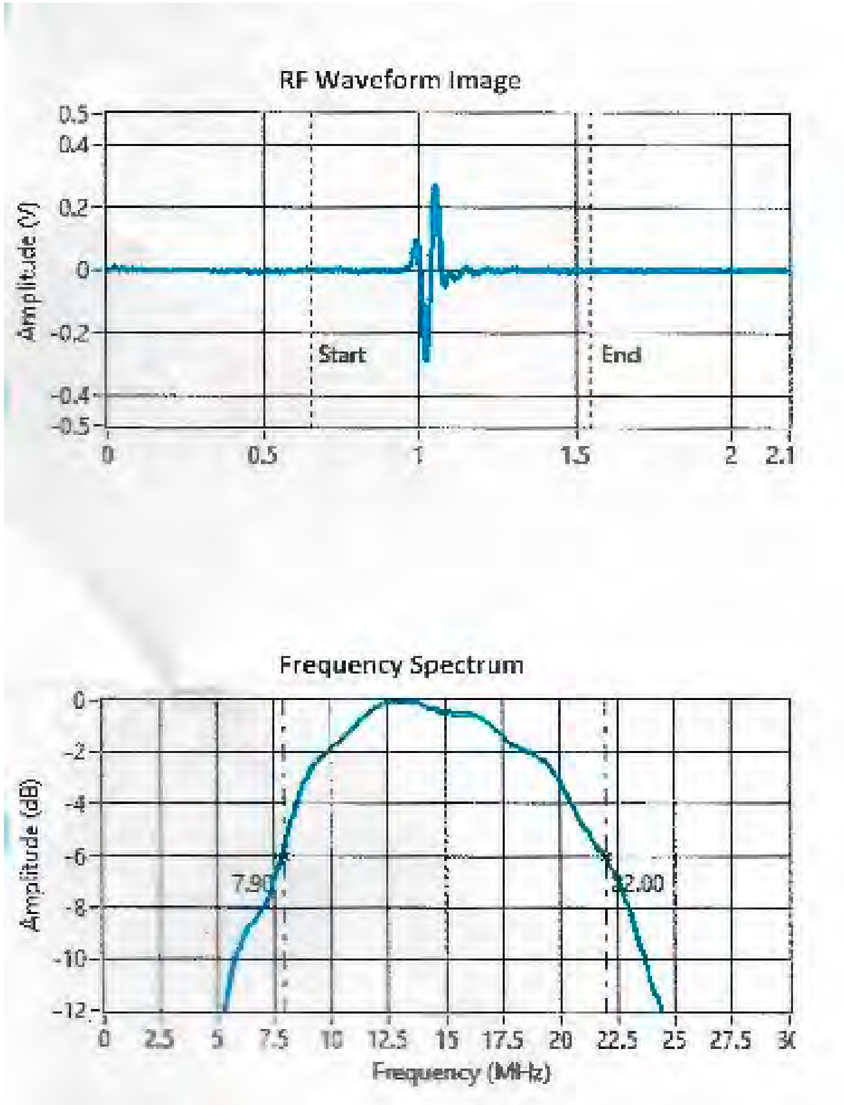
Note that the soundpath distance will be different for each.

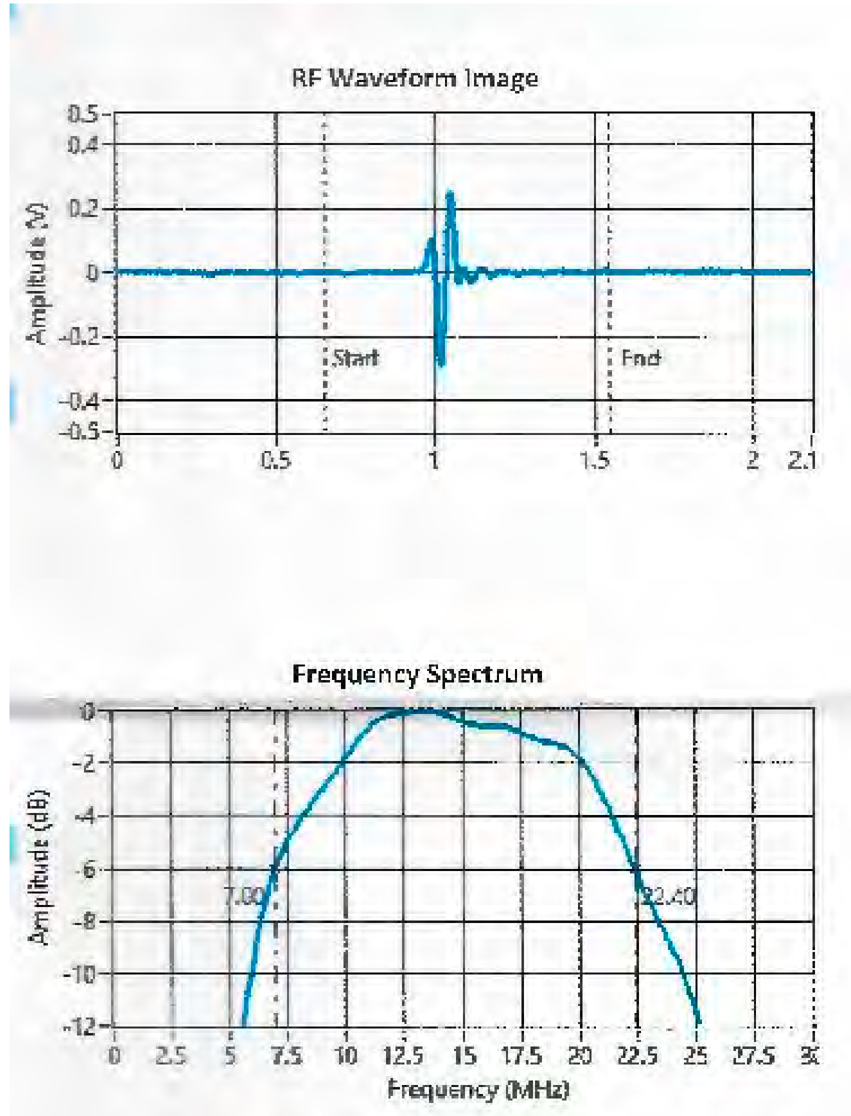


	1 ToFD wedges PMMA	2 ToFD wedges Plexiglass 01-012038	3 ToFD wedges Plexiglass 1	4 ToFD wedges Plexiglass 2	5 ToFD wedges Plexiglass 3	6 ToFD wedges Plexiglass 01-012100	7 ToFD wedges Plexiglass 01-013038	8 ToFD wedges Rexolite 362-001-160	9 ToFD wedges Rexolite 01-013037
Soundpath each wedge	0.152"	0.292"	0.140"	0.152"	0.142"	0.221"	0.275"	0.132"	0.277"
Soundpath for both wedges	0.304"	0.584"	0.280"	0.304"	0.284"	0.442"	0.550"	0.264"	0.554"

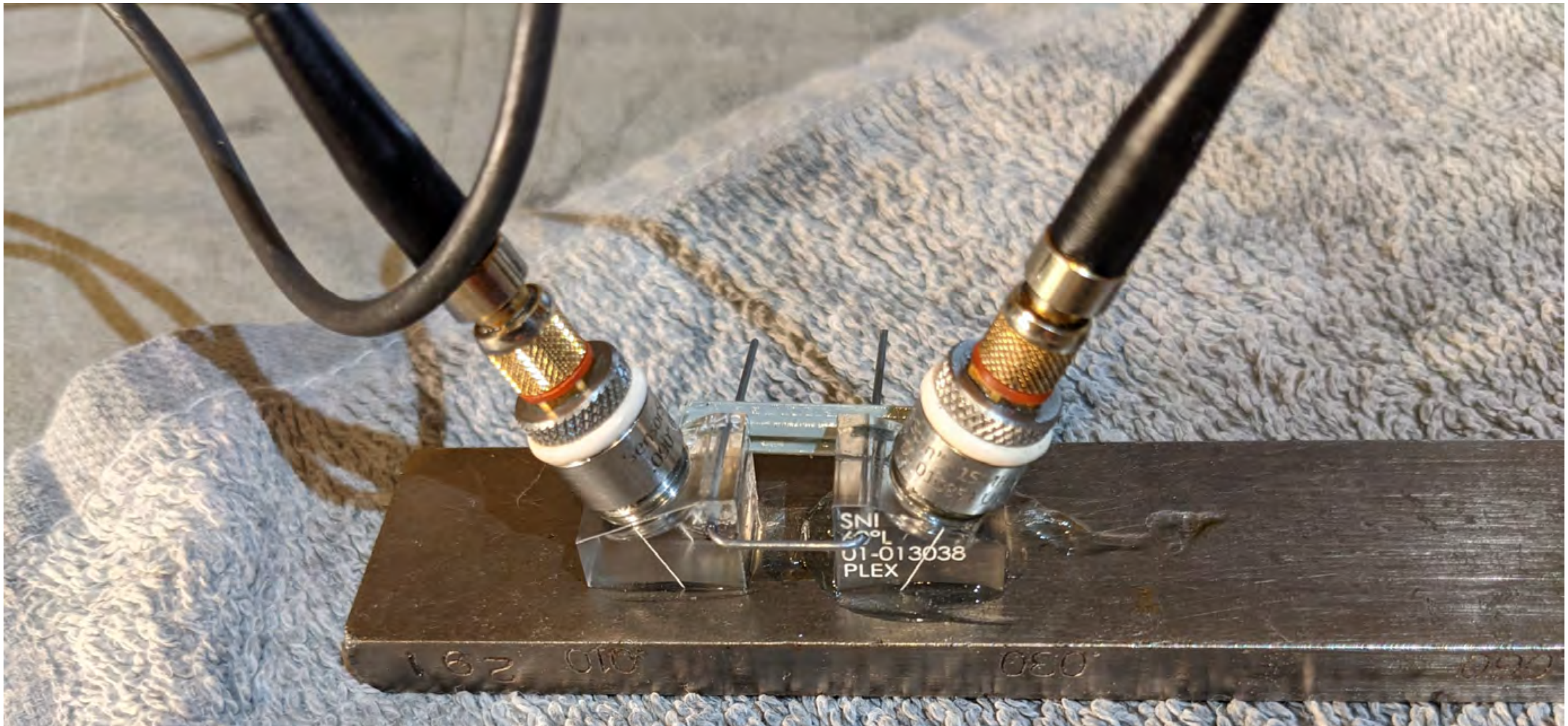
1 2 3 4 5 6 7 8 9







These are the waveforms from the transducer manufacturer for the two 15MHz transducers used in the previously shown scans.



Typical setup for taking FFT waveforms

The ToFD setup was used on the 0.300" thick notch block at a location that was between the notches so the three waveforms of lateral wave, backwall L-wave, and mode converted backwall were all visible. The FFT function was gated only on the backwall L-wave.

Again, note that the travel time in the steel almost the same for all 9 wedge pairs but due to the differing designs the amount of travel time in the wedges is different for each pair.

ToFD wedge pair #1, PMMA

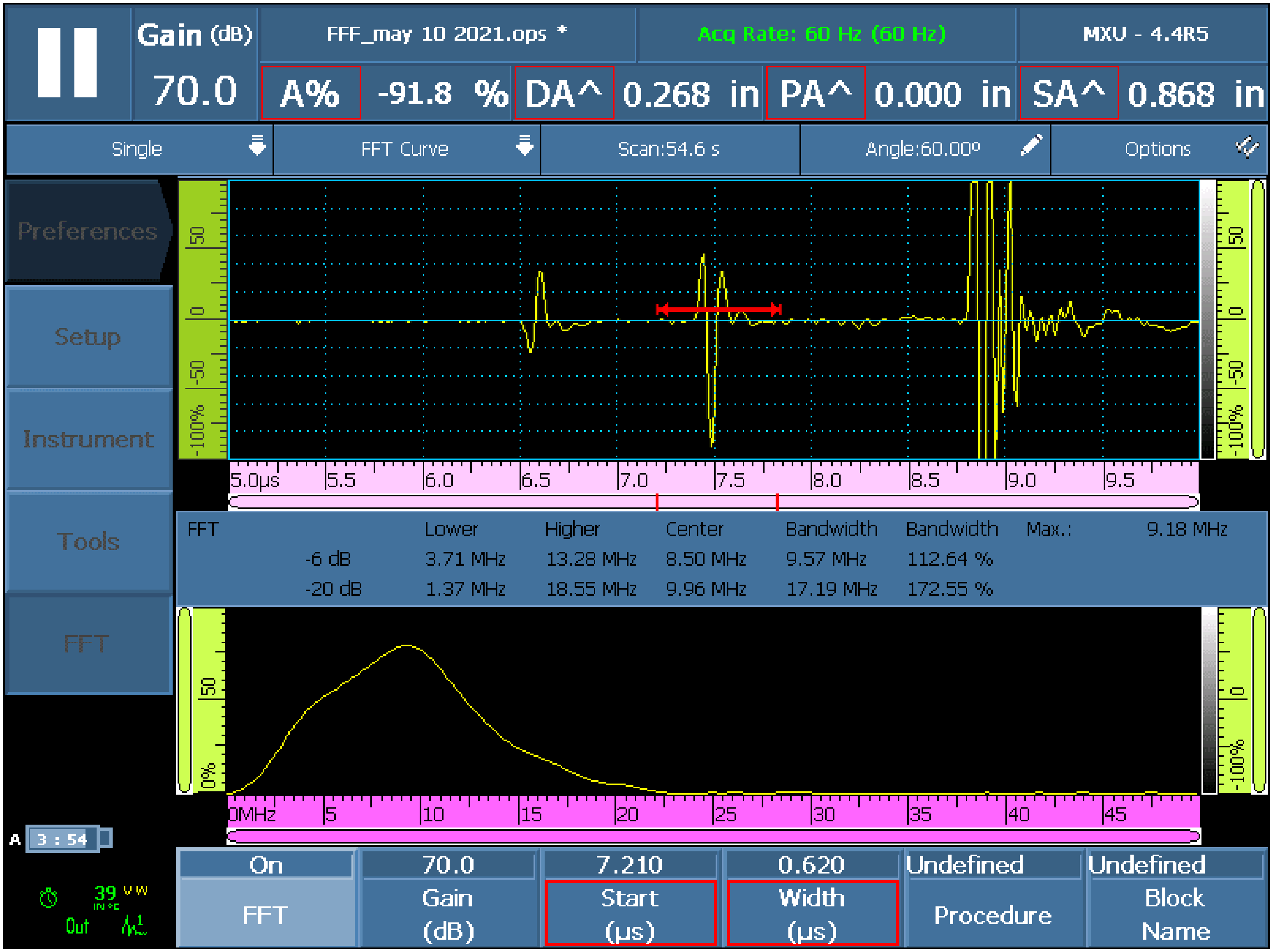
Note the presence of higher frequencies near 15MHz.

ToFD wedge pair #2, plexiglass 01-012038

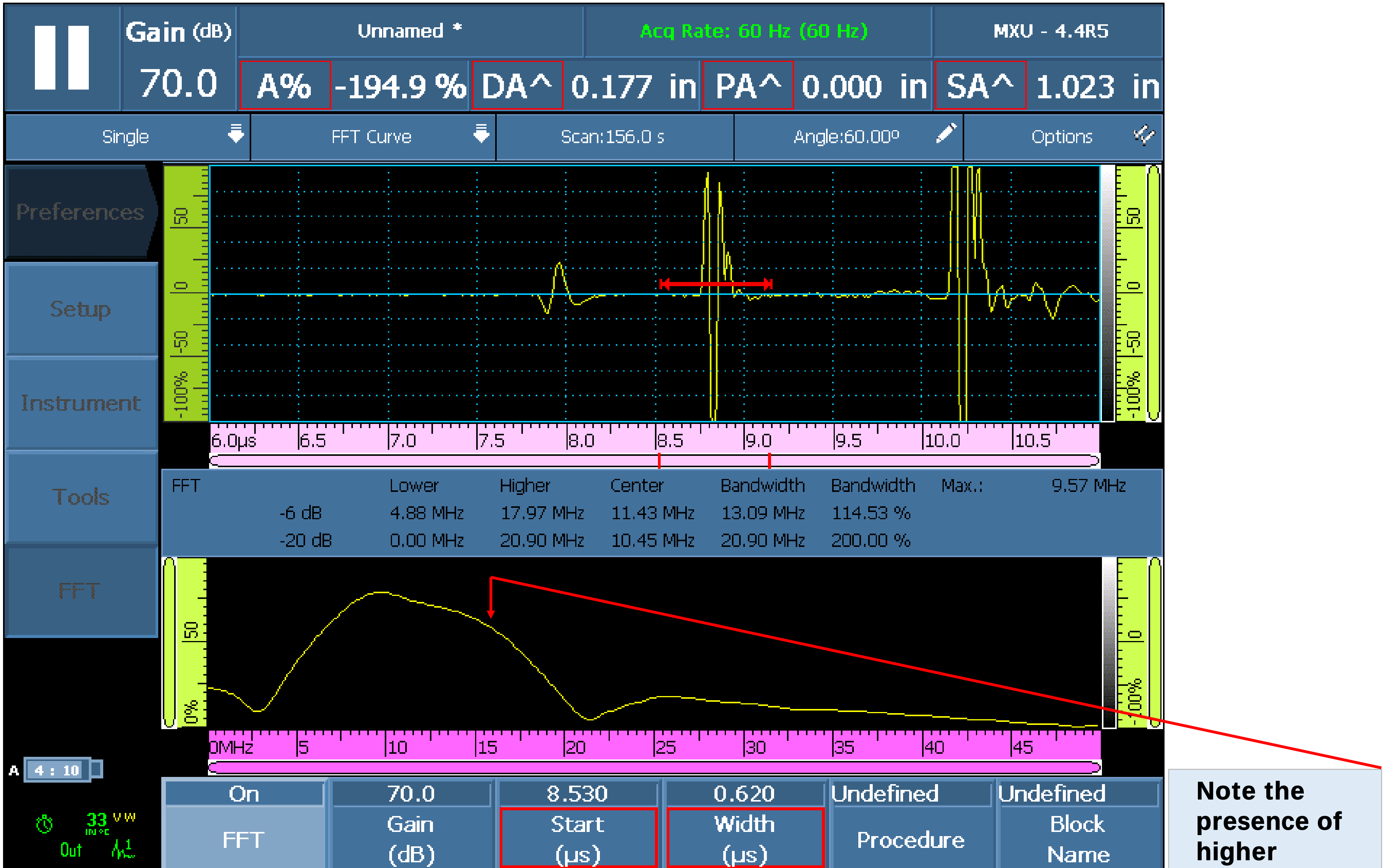
ToFD wedge pair #3, plexiglass 1

ToFD wedge pair #4, plexiglass 2

ToFD wedge pair #5, plexiglass 3



ToFD wedge pair #6, plexiglass 01-012100



Note the presence of higher frequencies near 15MHz.

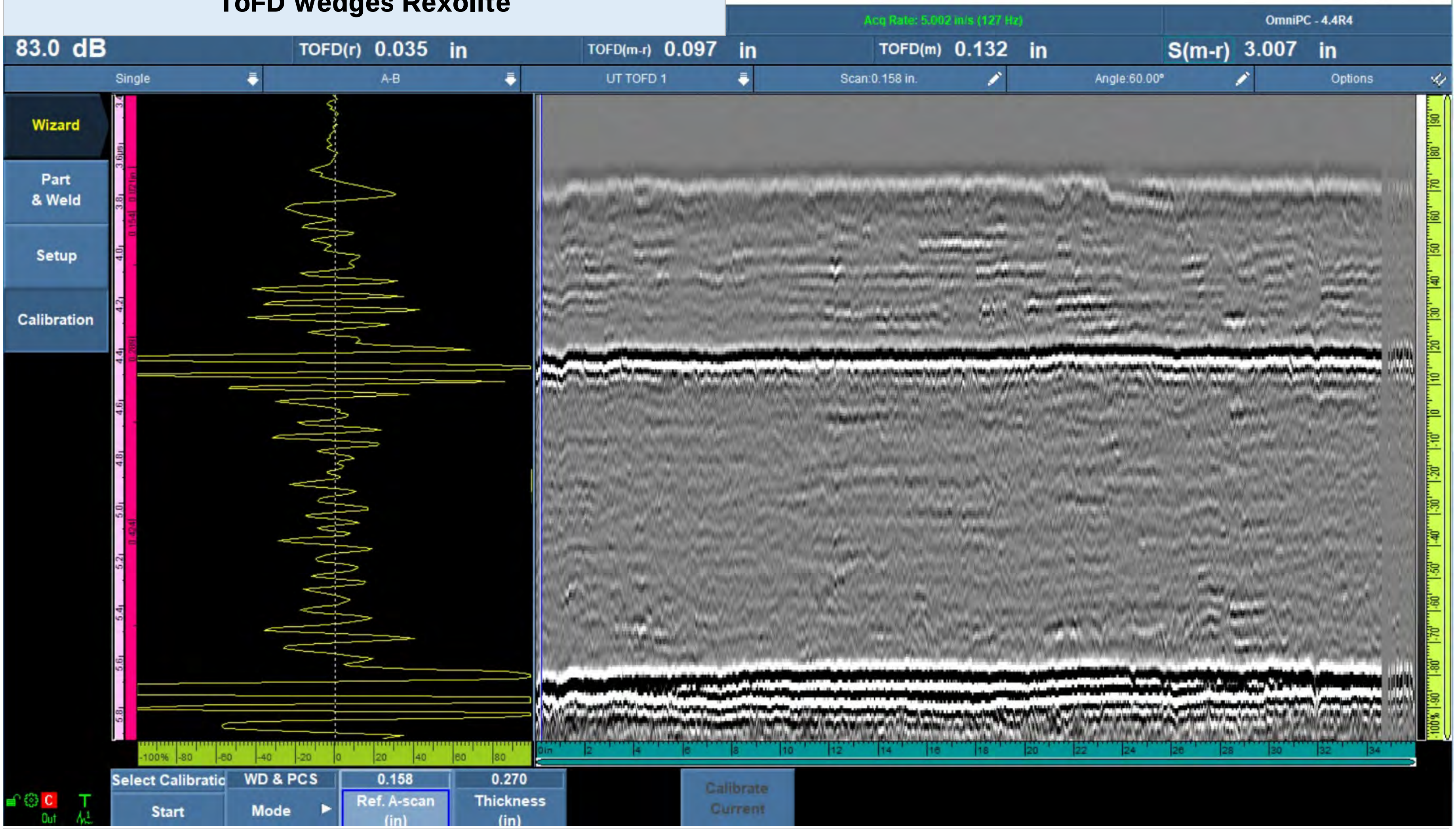
ToFD wedge pair #7, plexiglass 01-013038

ToFD wedge pair #8, Rexolite

Note the presence of higher frequencies near 15 MHz.

ToFD wedge pair #9, Rexolite 01-013037

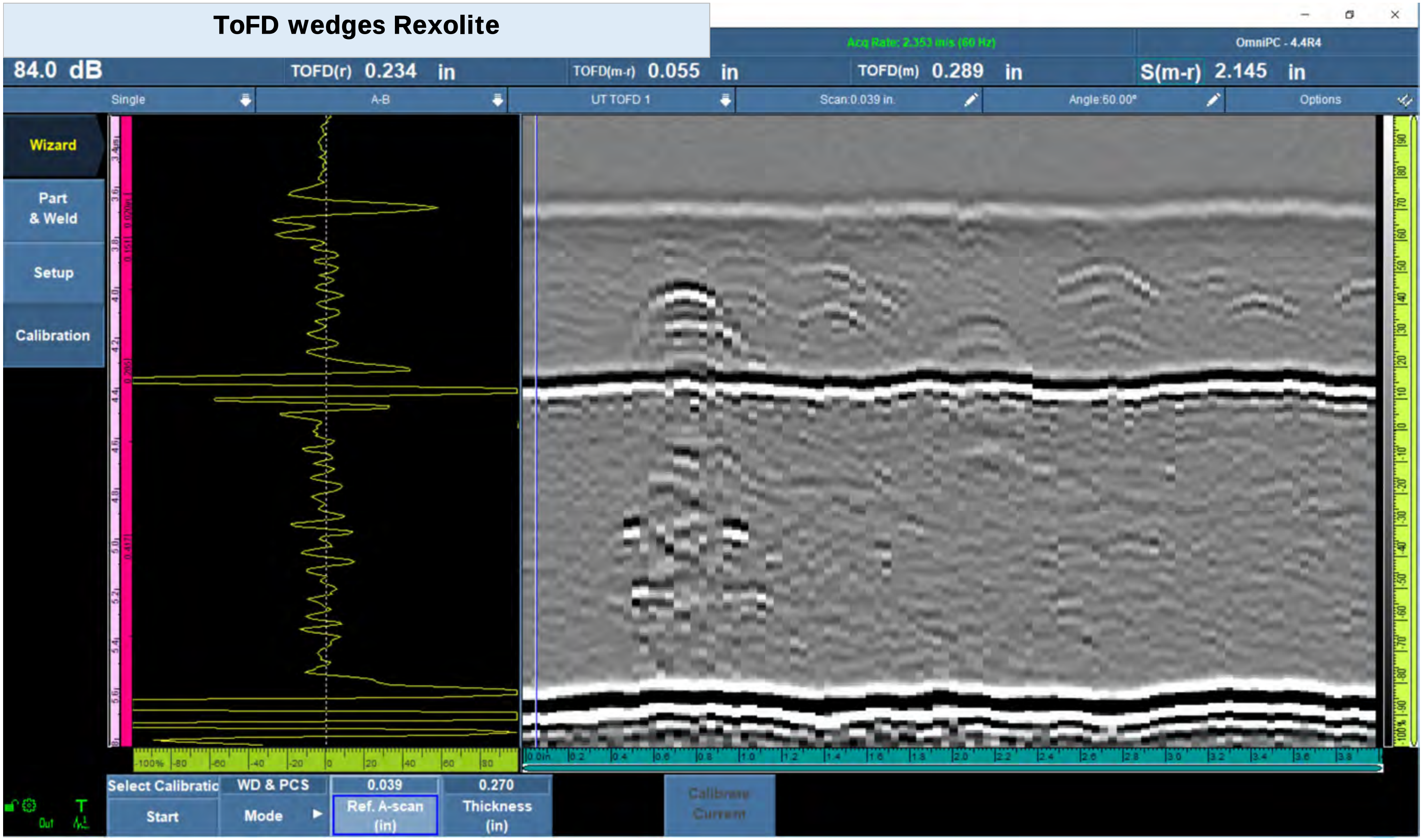
ToFD wedges Rexolite



Example of a non-parrallel ToFD scan of an ERW longitudinal weld seam that has a lot of inclusions in the ERW seam and the plate that the pipe was made from.

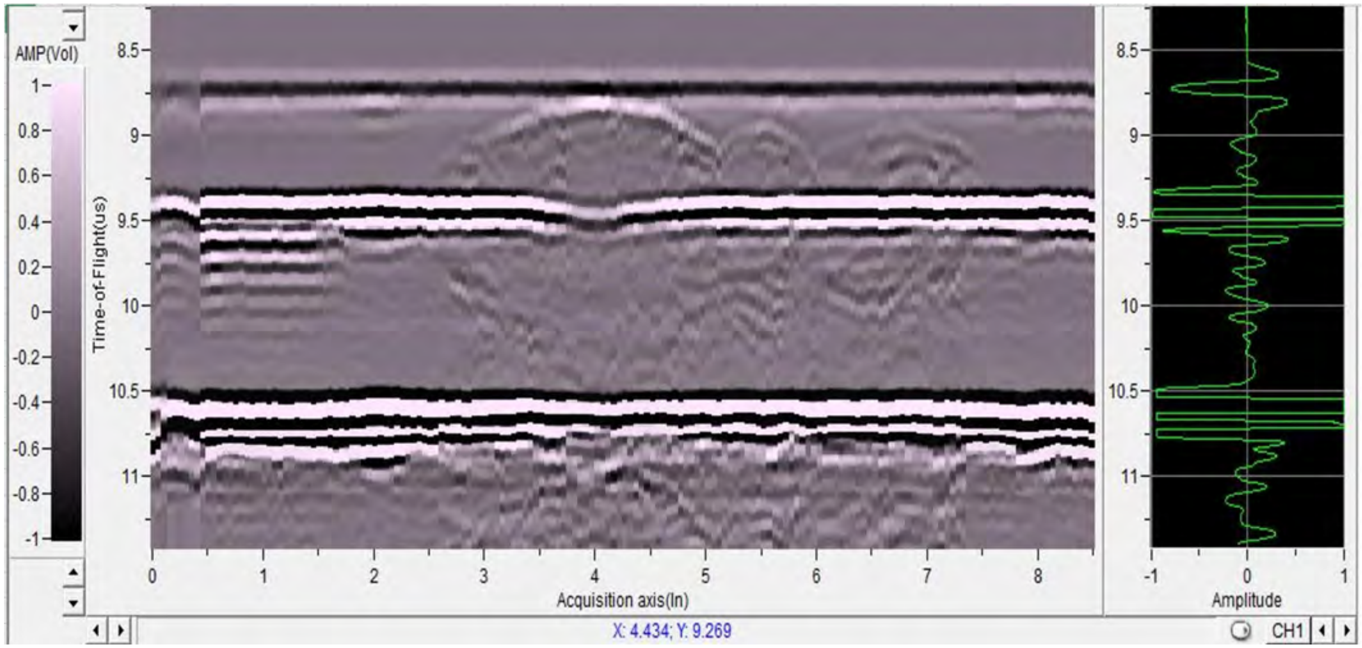
8" x 0.270" ERW
non-Parrallel, 15MHz, 0.090" element diameter, 60 degree wedges, 0.75" PCS

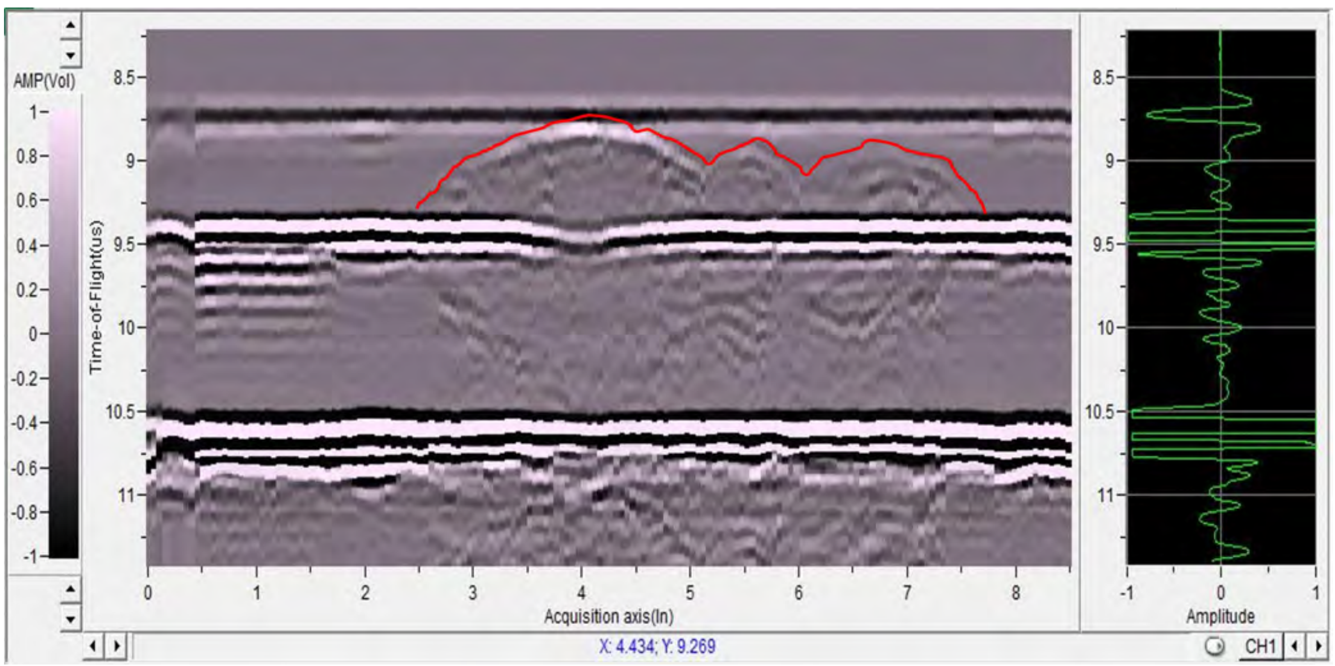
ToFD wedges Rexolite



Example of a parrallel ToFD scan of an ERW longitudinal weld seam that has a lot of inclusions in the ERW seam and the plate that the pipe was made from.

8" x 0.270" ERW
Parrallel, 15MHz, 0.090" element diameter, 60 wedges, 0.75" PCS





Example of a parrallel ToFD scan of an SMAW manual welded girth weld that was diagnosed from metallurgical analysis as having 5 individual overlapping internal HAZ cracks parrallel to the girth weld.

Above; non-Parrallel ToFD scan.

Below; scan with crack growth boundary oulined in red.

12" x 0.255" SMAW girth weld

non-Parrallel ToFD scan
10MHz
0.250" element diameter
70 degree wedges
1.200" PCS

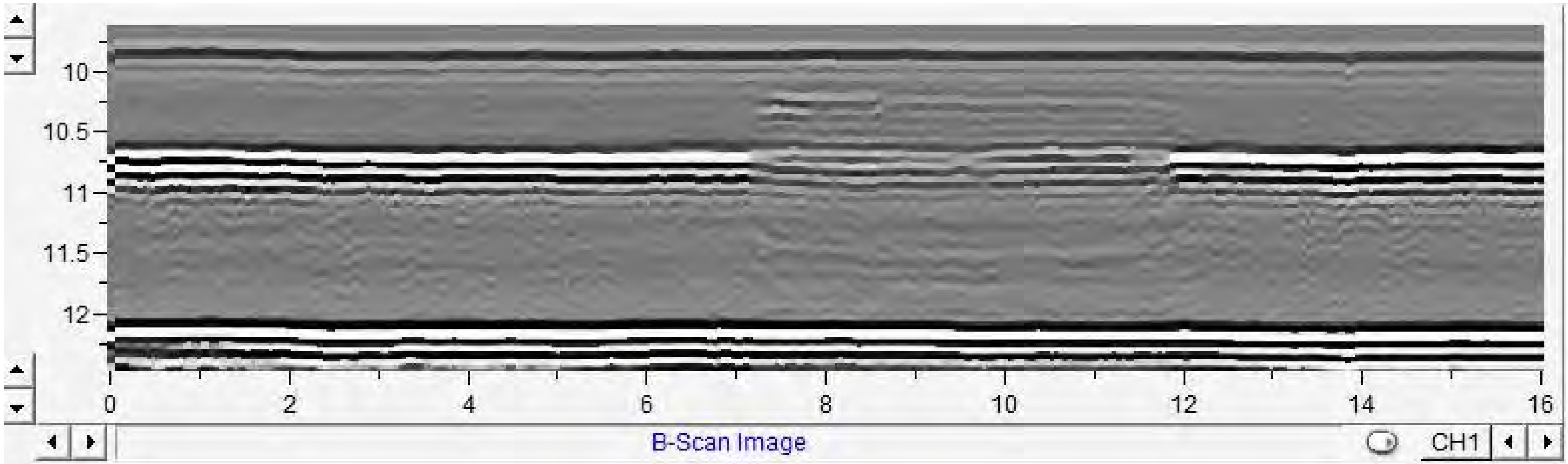
Example of a non-Parrallel ToFD scan of an ERW longitudinal weld seam with an ID connected flaw.

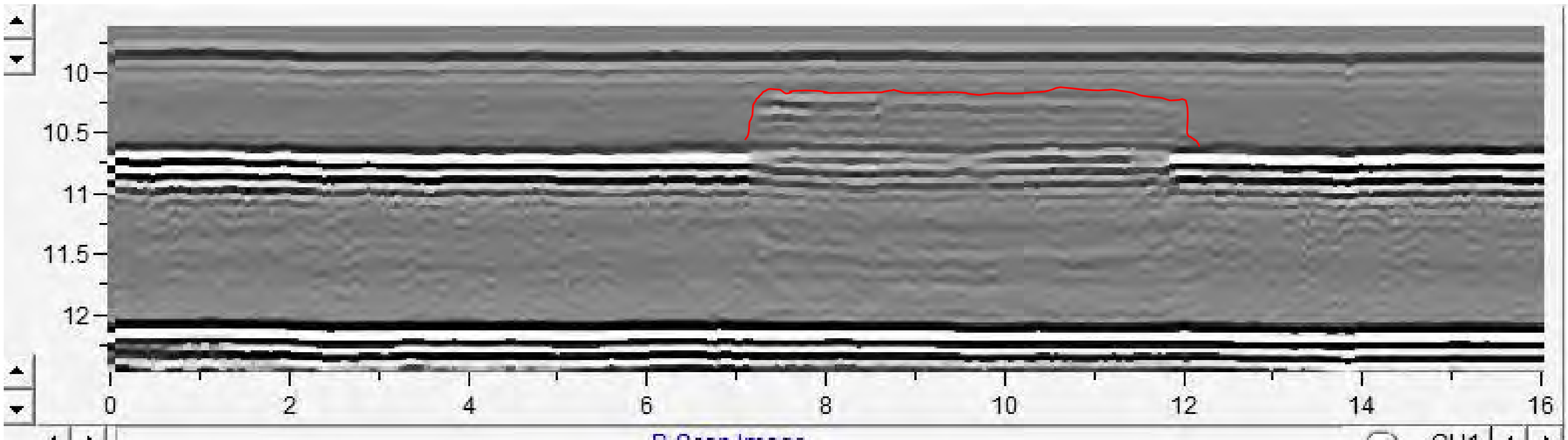
Above; original scan

Below: flaw boundary edge highlighted in red

10" x 0.222" ERW

non-Parrallel ToFD
10 MHz
0.250" element diameter
70 degree wedges
1.200" PCS

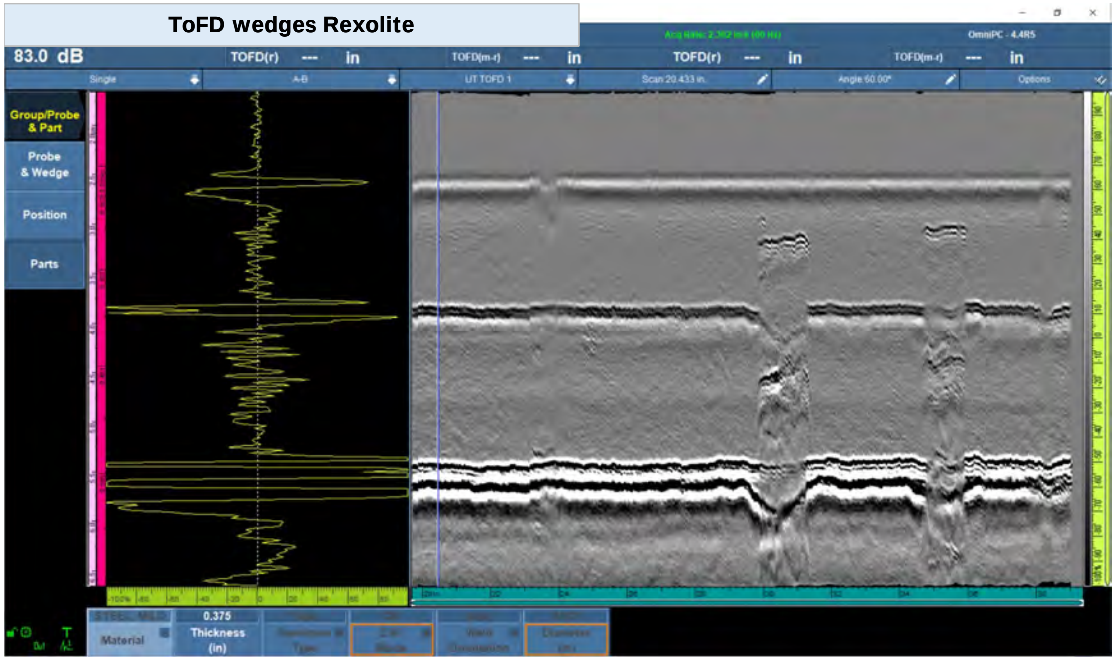


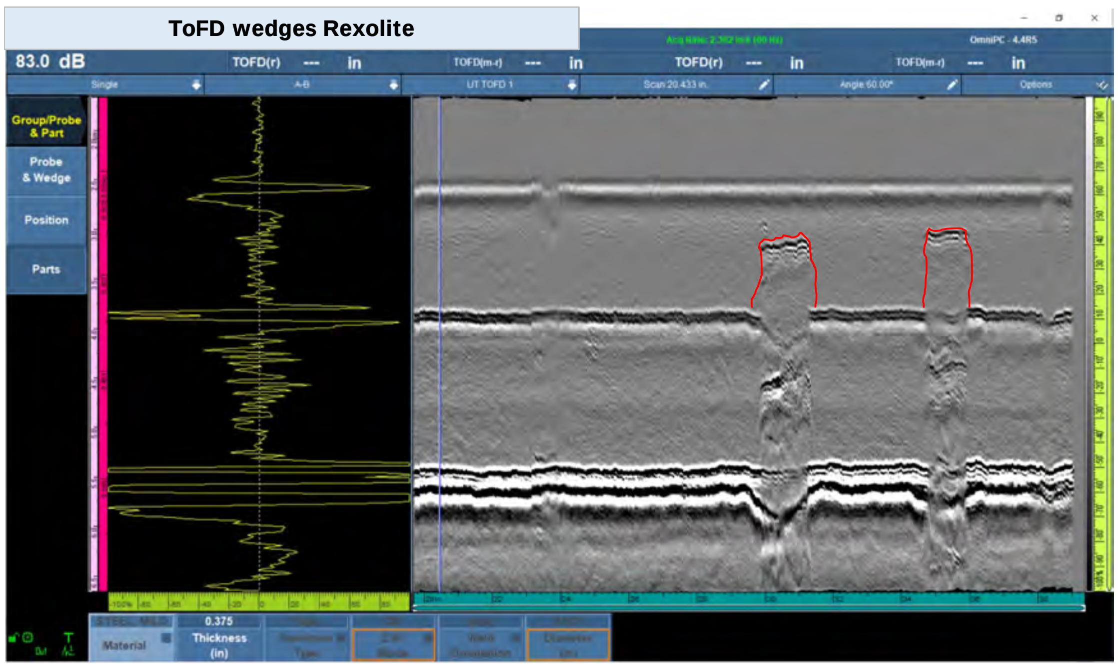


Example of a non-Parrallel ToFD scan of a Flash Weld longitudinal weld seam with an ID connected hook crack.

Above; original scan **Below; same scan with crack boundary in red**

20" x 0.312" FlashWeld
non-Parrallel ToFD, 10MHz, 0.250" element diameter, 70 degree wedges, 1.200" PCS





Example of a non-Parrallel ToFD scan of an ERW longitudinal weld seam that has two ID connected cracks.

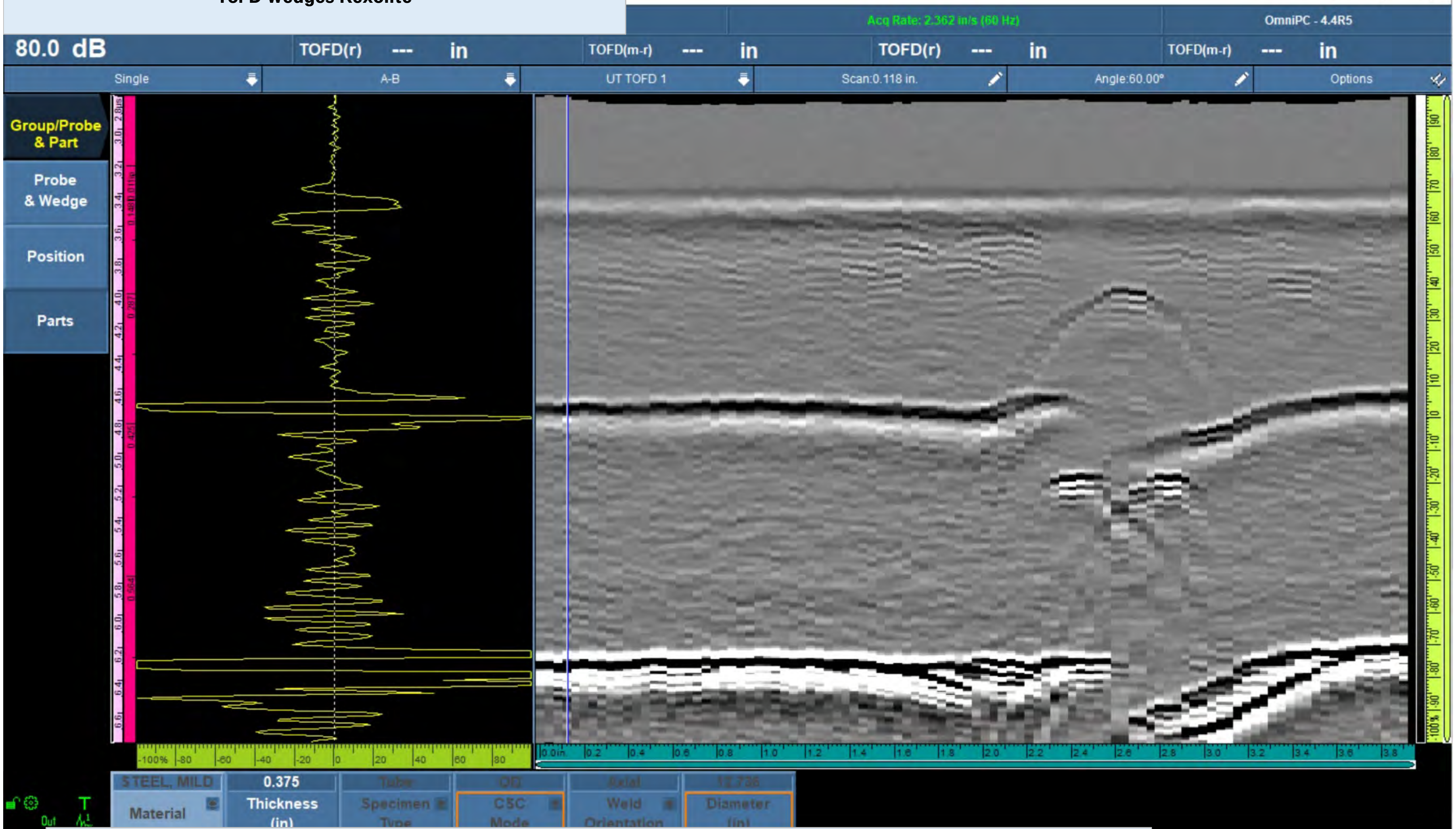
Above; original ToFD scan

Below; cracks boundary edges highlighted in red

12" x 0.375" ERW

non-Parrallel ToFD
15 MHz
0.125" element diameter
60 degree wedges
0.560" PCS

ToFD wedges Rexolite



Parrallel flaw height sizing scan of the crack on the left in the previous example.

12" x 0.375" ERW
Parrallel, 15MHz, 0.125" element diameter, 60 wedges, 0.750" PCS

Conclusions:

ToFD of thin walled (0.188” to 0.375”) pipe longitudinal seam welds can be done with 60° L-wave wedges made from various wedge materials if a small enough PCS (probe center separation) is used with a very short soundpath in the wedge material. A very small PCS means that this technique will only work for pipe material where the seam weld is flush with the adjacent base material; no weld crown or reinforcement present.

A single PCS may work for the entire range of thickness 0.188” to 0.375”. All the scans in this study used a PCS of about 0.75”.

There is some filtering of higher frequencies by the wedge material. PMMA appears to filter more than Plexiglass, and Plexiglass appears to filter slightly more than Rexolite. All three of these wedge materials appeared to be able to acquire useful scans when the following parameters were used:

- 15MHz probes with a very short ring time, about 1.5 cycles, and an element diameter of 0.090”
- PCS of 0.75”
- Nominal wedge angles close to 60° L-waves

ToFD of thin walled ERW seam welds does not always provide useful data. When it does work, it provides very good sizing data. The experience with high frequency ToFD and thin-walled ERW longitudinal seam welds has been that it is usually not very effective for the older pre-1970s ERW pipe because there were often excessive inclusions in the plate that the pipe was made from. These tiny inclusions, whether in new pipe or old pipe, can often become small hook flaws in the area of plastic flow of the ERW seam. These small base metal inclusions and small ERW hook flaws often result in scattered diffractions in the ToFD scans. See figures on pages 150-151. When the discontinuities in any type of long seam have a defined boundary edge as in the case of cracks with growth, then ToFD can provide precise flaw sizing measures. See figures on pages 152-156 for examples of ToFD taken over the last 15 years.

Additional notes:

The pipe coupon scans appear to show the ID connected flaws with consistent length and flaw heights. The OD connected flaws do not look as though they have consistent lengths and flaw heights because slight differences in index offset (distance from seam weld centerline) have large influences on ToFD indications for OD flaws with non-parrallel scans. OD flaws are normally detected with MT (magnetic particle testing) or ECA (eddy current array testing) and visual examination. For OD flaws, length sizing should primarily be done with MT or ECA. Flaw height sizing for longitudinal seam weld flaws with ToFD should be done with parallel scans, especially for OD connected flaws.

Most procedures would recommend using high frequency ToFD transducers with an element diameter of 1/8" (0.125") for thin-walled material. The transducers used here have element diameters of 0.090" which will result in greater beam spread.

Frequency spectrum waveforms for wedge pair #9, Rexolite 01-013037 most closely resembled the waveforms provided by the transducer manufacturer.

Frequency spectrum waveforms for wedge pair #2, plexiglass 01-012038 and wedge pair #7, plexiglass 01-013038 also had a large amount of higher frequency transmitted.