Enclosure 18

Memo from Donald G. Naujock

To

Terence L. Chan

Dated August 26, 2008

PDI/NRC Meeting

Status of HDPE NDE Studies at PNNL

Steven Doctor and Susan Crawford

May 12, 2008

Work Supported by the U.S. NRC RES program JCN N6398 - Wallace Norris the NRC Program Manager

Overview of Presentation

- Background on Specimens
- 3408 base material NDE responses and cross section of base material
- 3408 “Good fusion Joint” NDE responses and cross sections of joint
- 3408 NDE responses of Lack of Fusion (LOF) and sectioning of fusion joint
- 3408 material selected for tensile testing
- NDE response of 4710 base material and cross sections
- Mechanical testing results
- Summary
- Planned activities

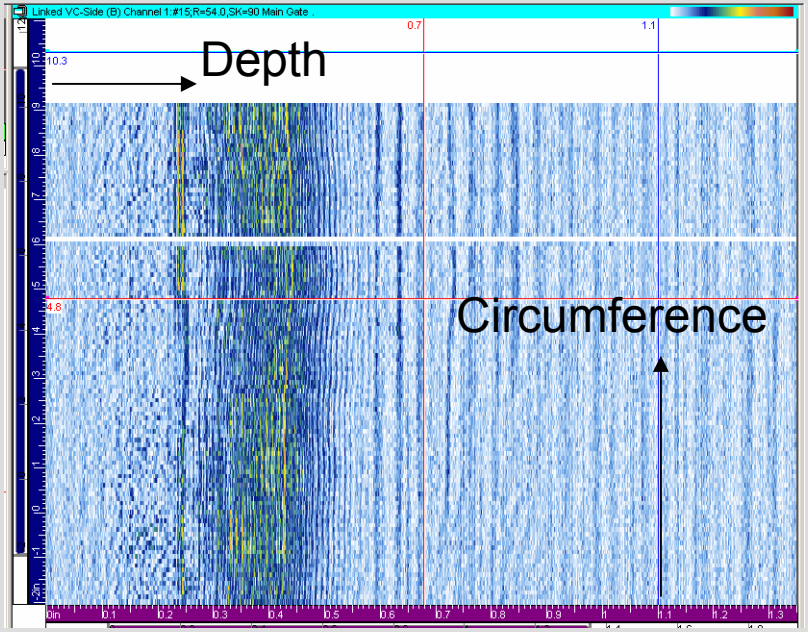
HDPE Test Samples

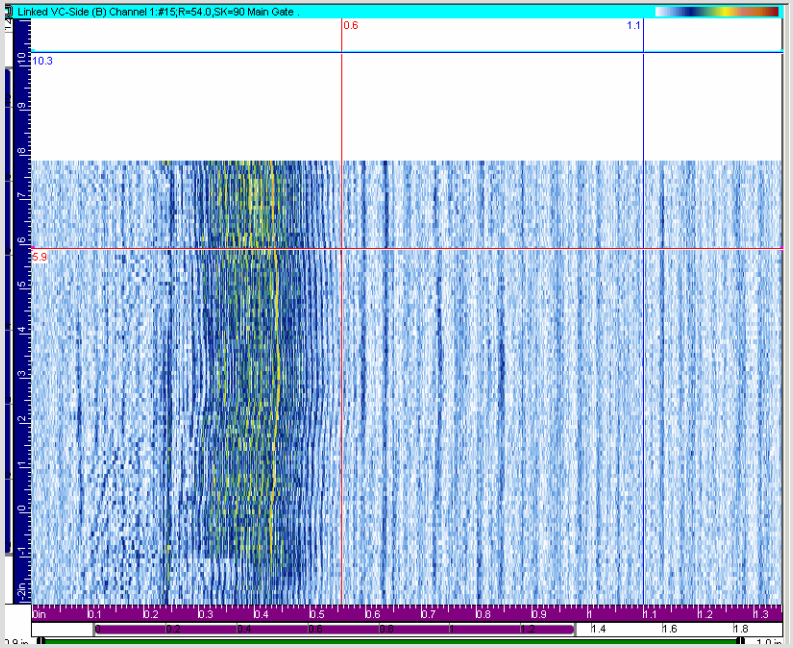
- Manufactured by McElroy
- Used 3408 material
- 24 samples were fabricated with a butt fusion weld in the middle of a 2 foot long pipe
- 6 fabrication conditions were selected to provide “good” joints as well as LOF under a variety of fabrication parameters
- NDE inspections were conducted by PNNL and Fluor/NDT Innovations, Inc.
- Destructive and mechanical testing started

3408 Base Material NDE Responses and Cross Sections of Material

- Phased Array response
- TOFD Responses
- Cross Section of base material

Base Material Pipe 125, Phased Array

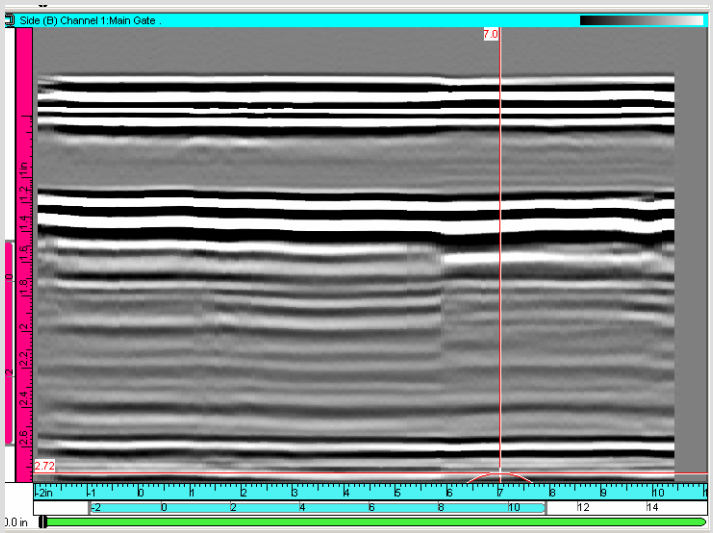


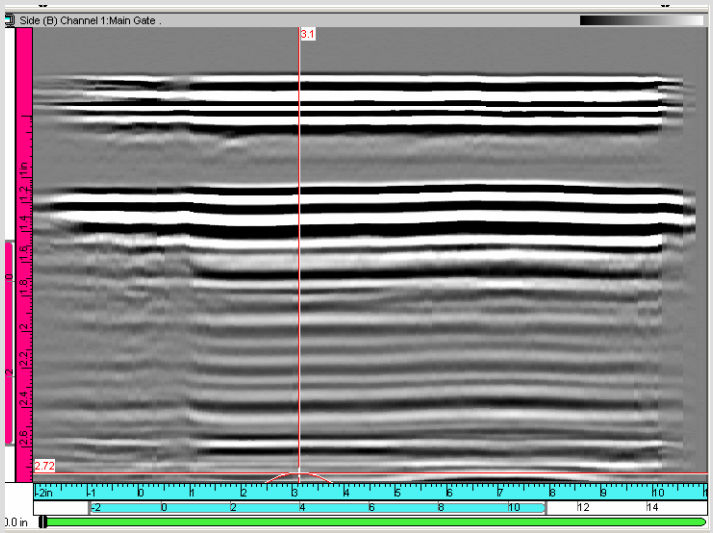


Base Material Pipe125, TOFD - PNNL

OD

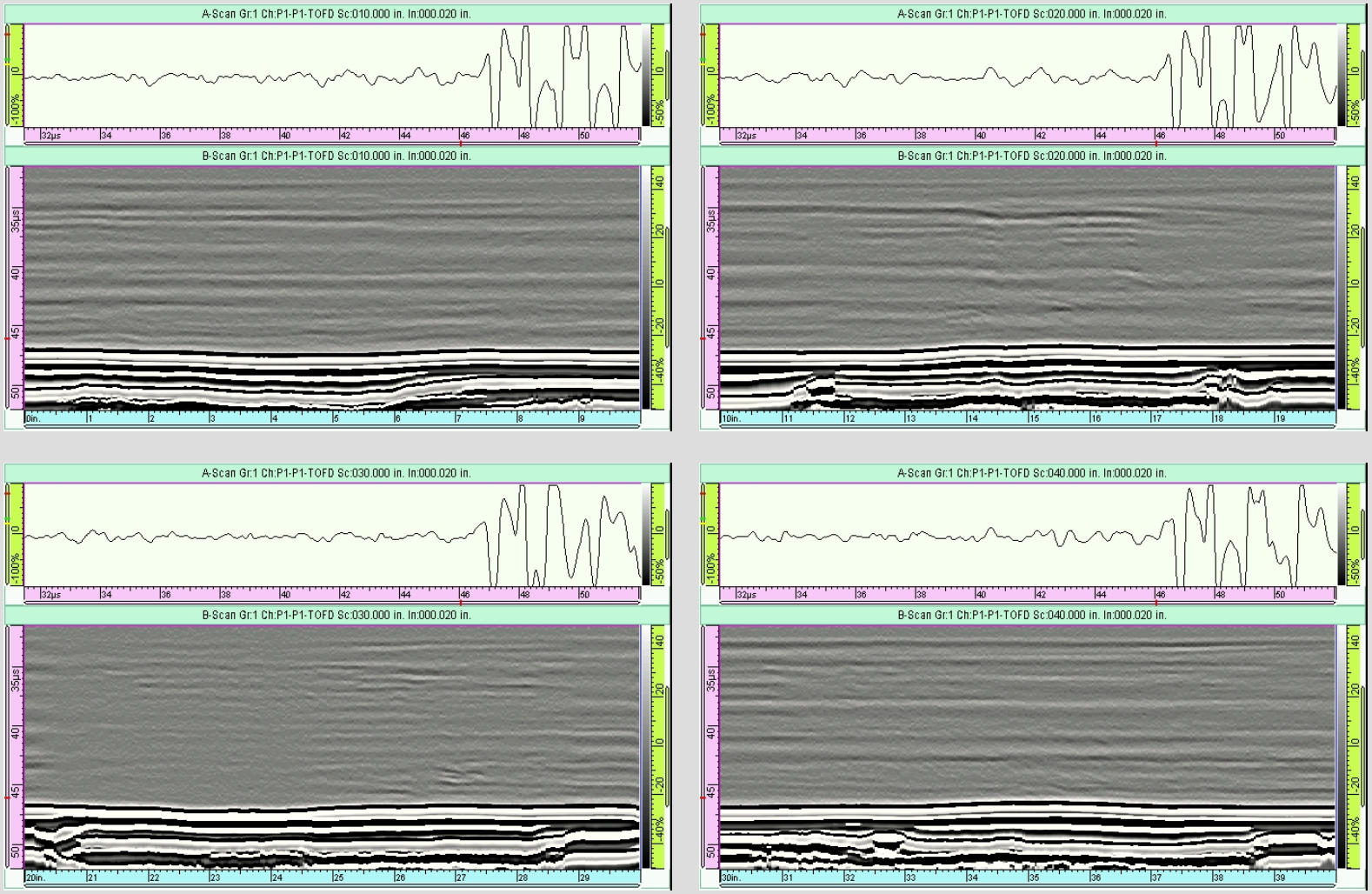
ID





→ Circumference

Base Material Pipe 125 (TOFD, Fluor)



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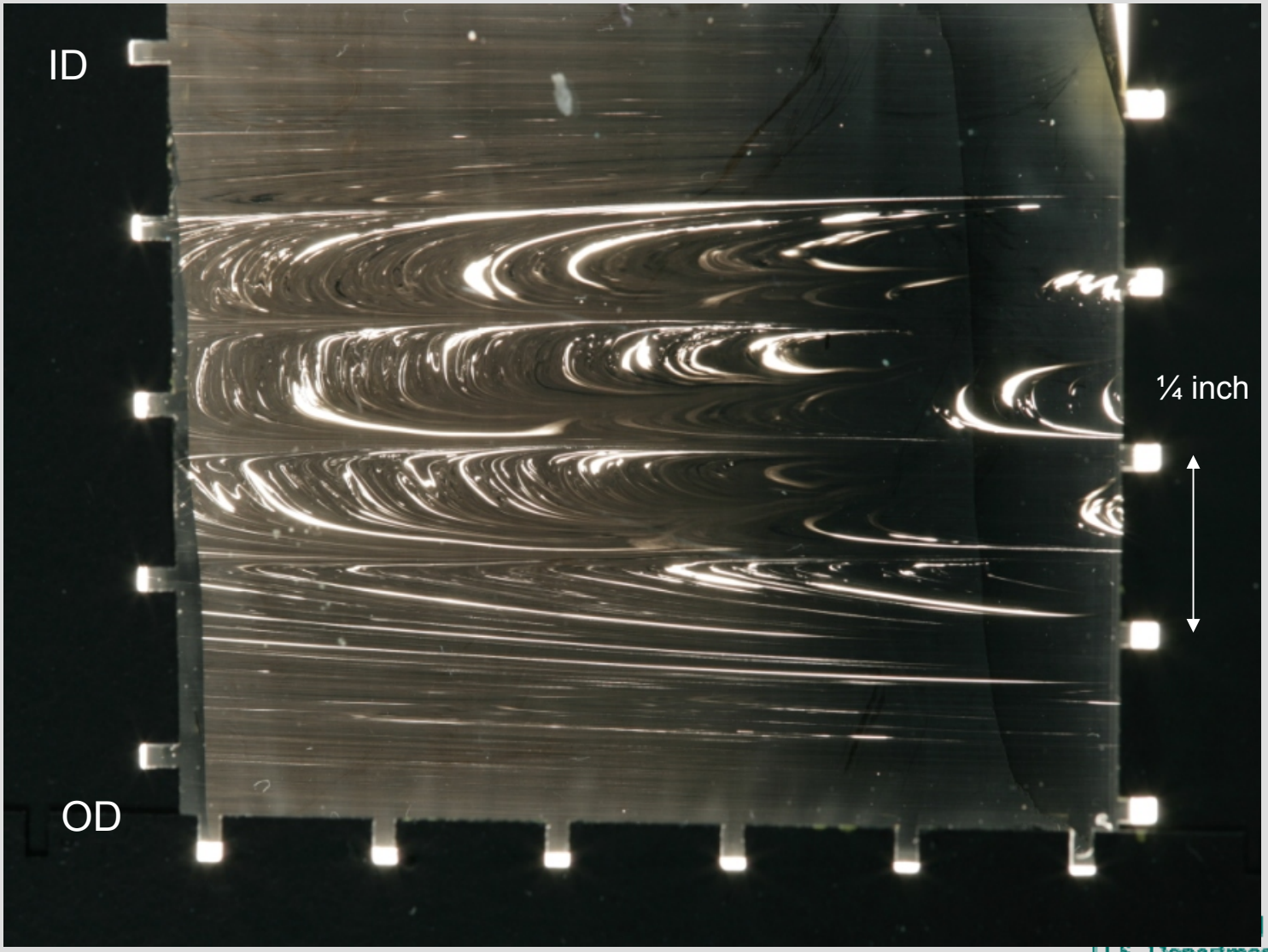
Circumference

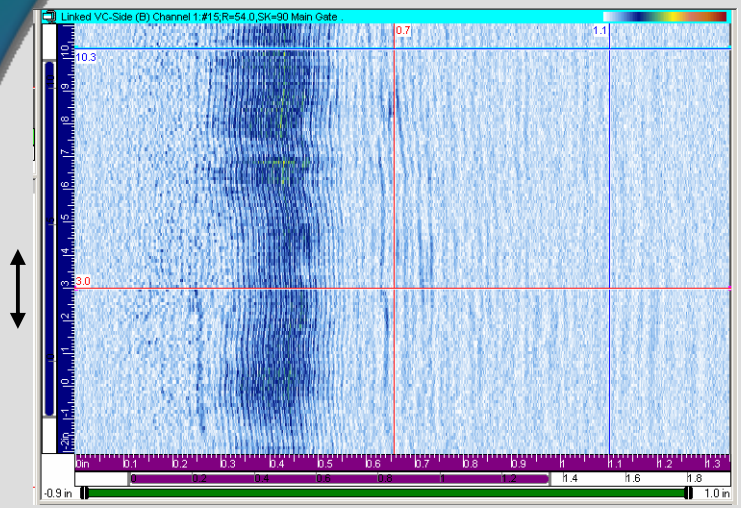
3408 Base Material

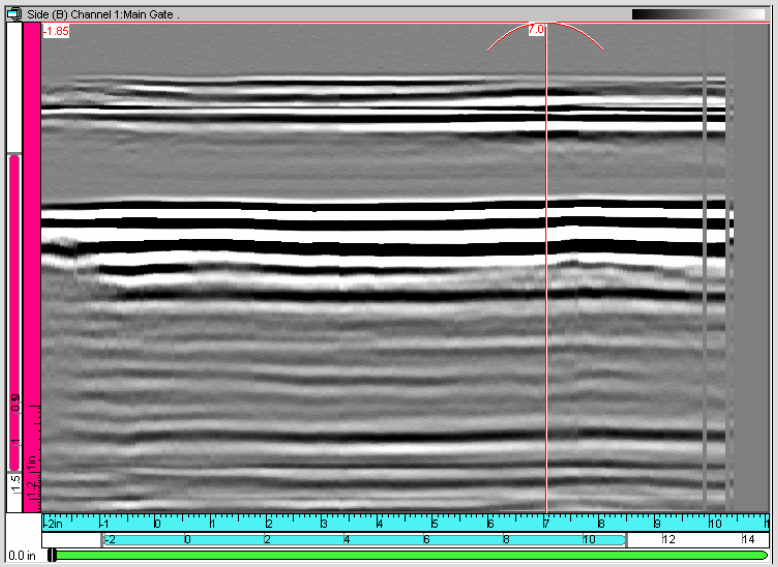


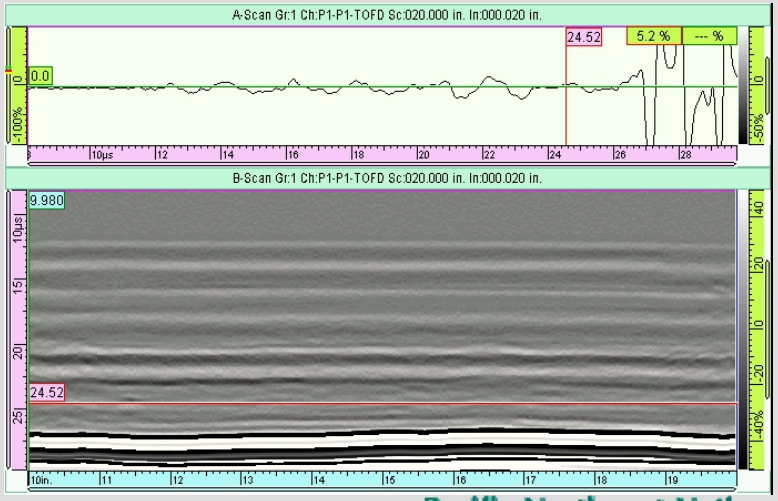
Good Fusion Joint

- NDE Responses
- For comparison - results from thin slice
- Optical picture of the cross section

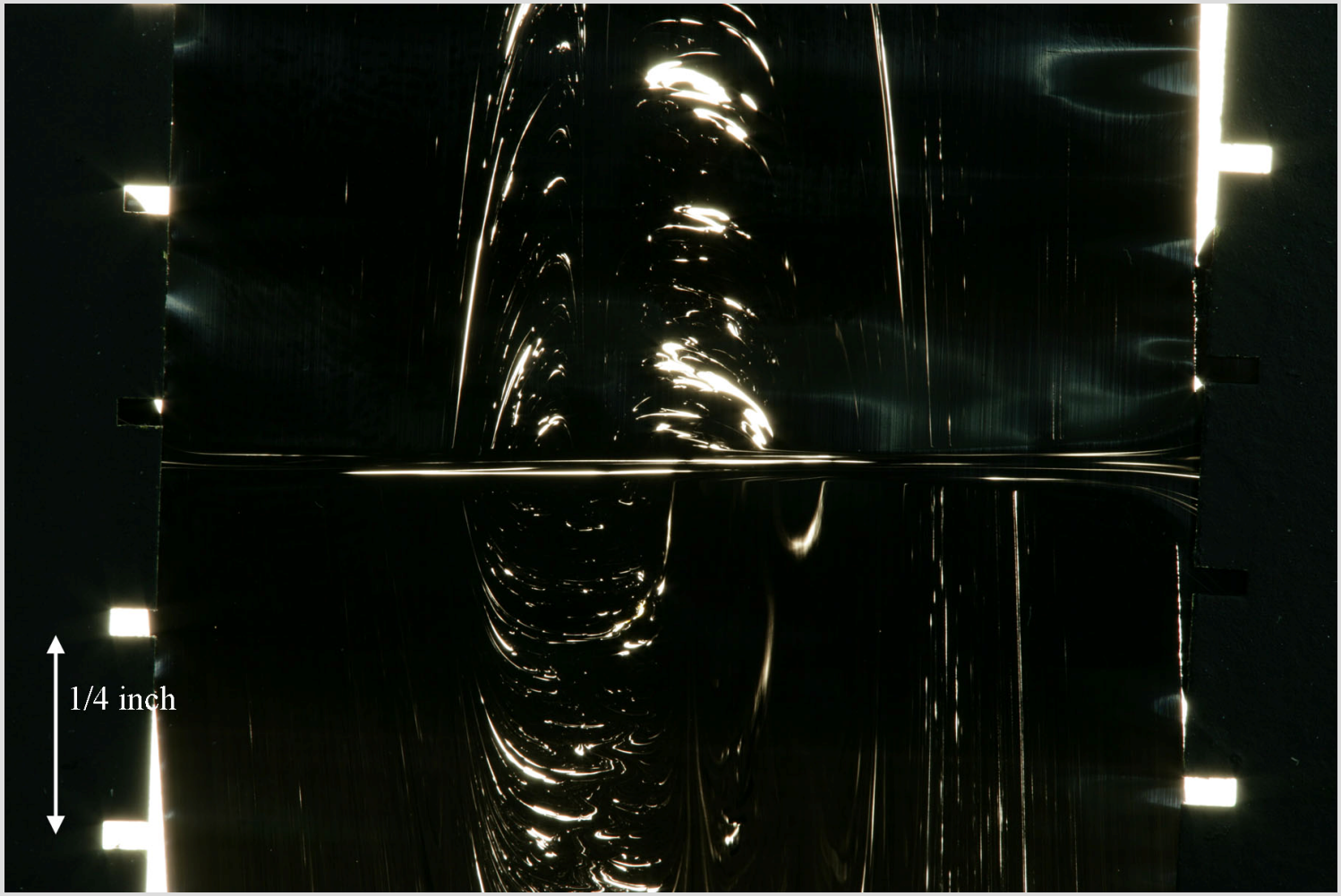
1224 Quad 2, showing area for tensile test



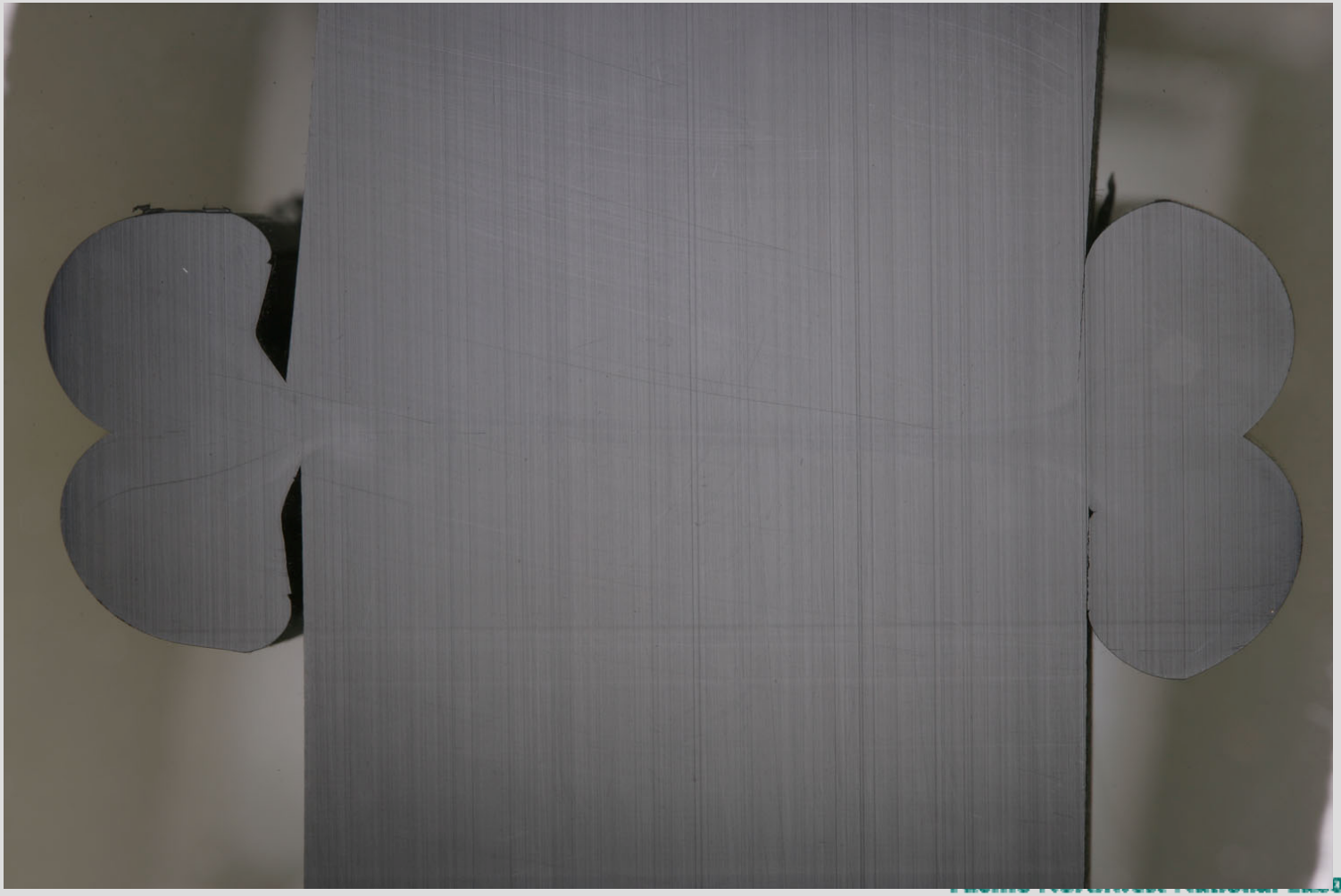




Pipe 1224 Quad 4 at 3.4 inch – good weld



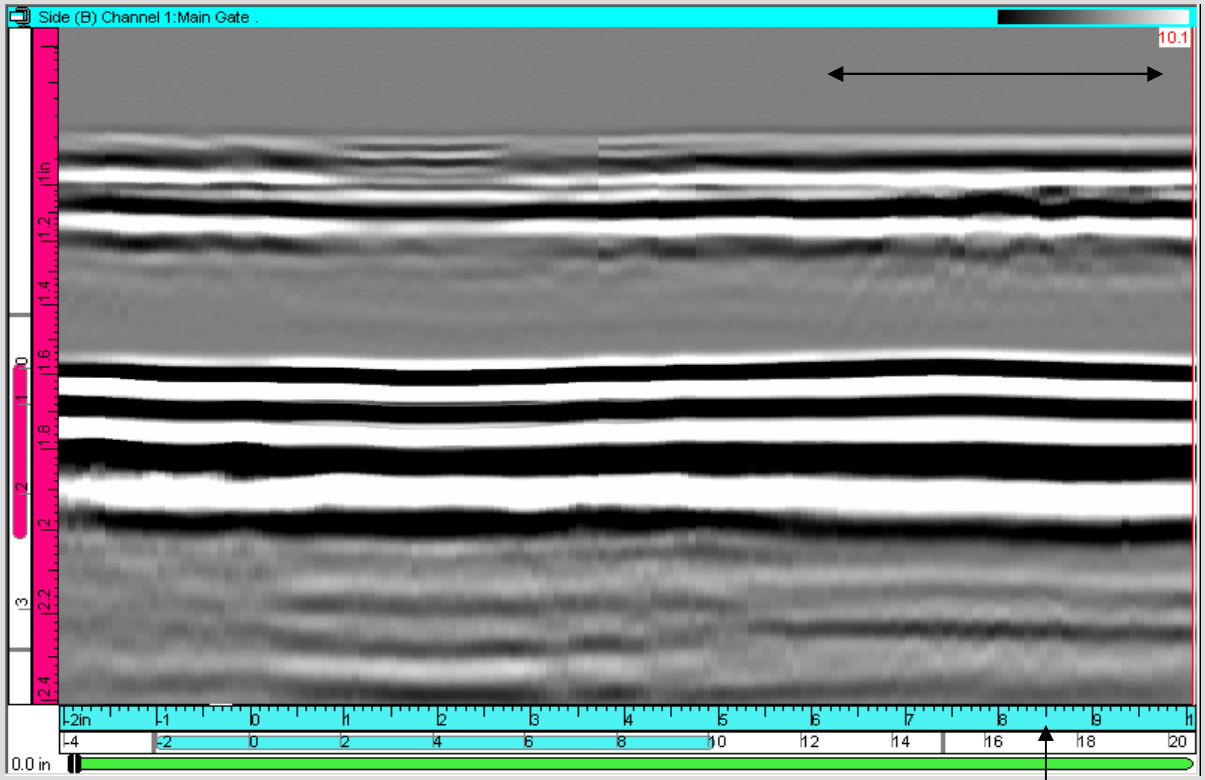
Pipe 1224 Quad 4 at 3.4 inch – no LOF



3408 LOF Sample

- TOFD Results
- Phased Array
- Thin Slice of joint
- Optical Picture of joint

PNNL TOFD on Pipe 125, Quad 4



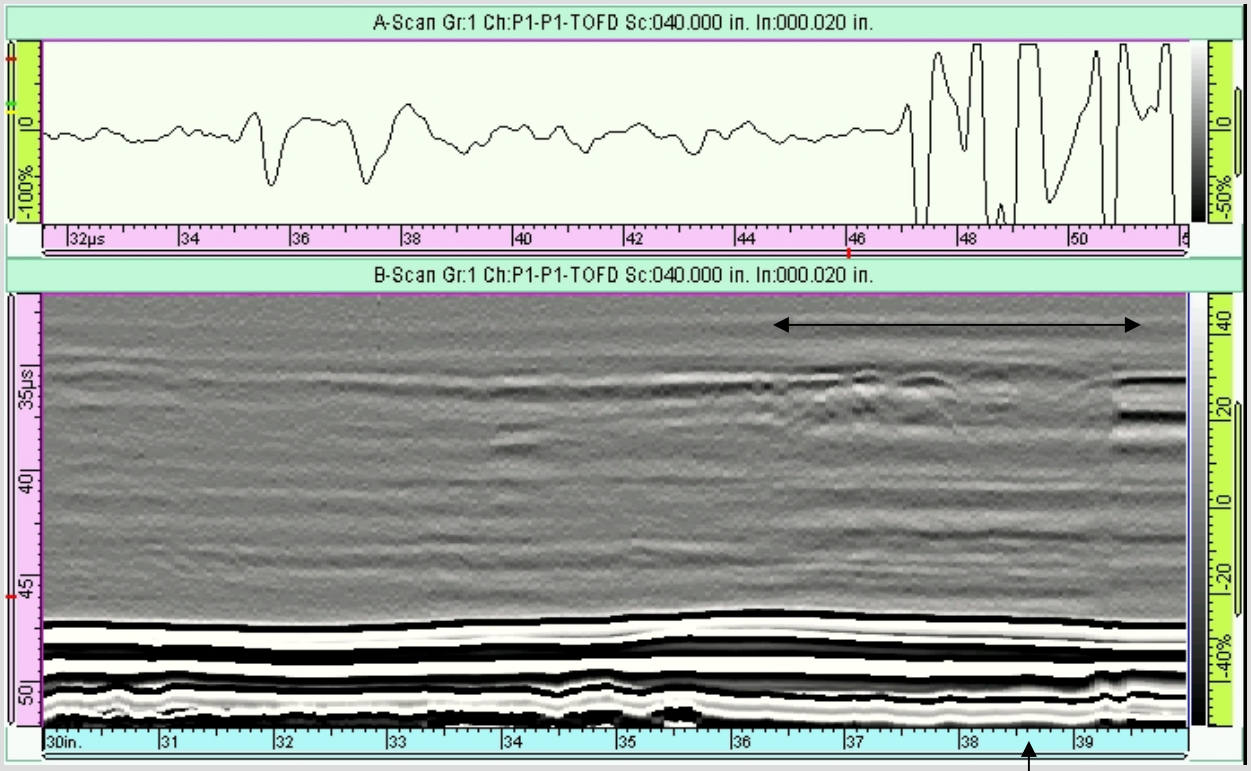
OD

ID

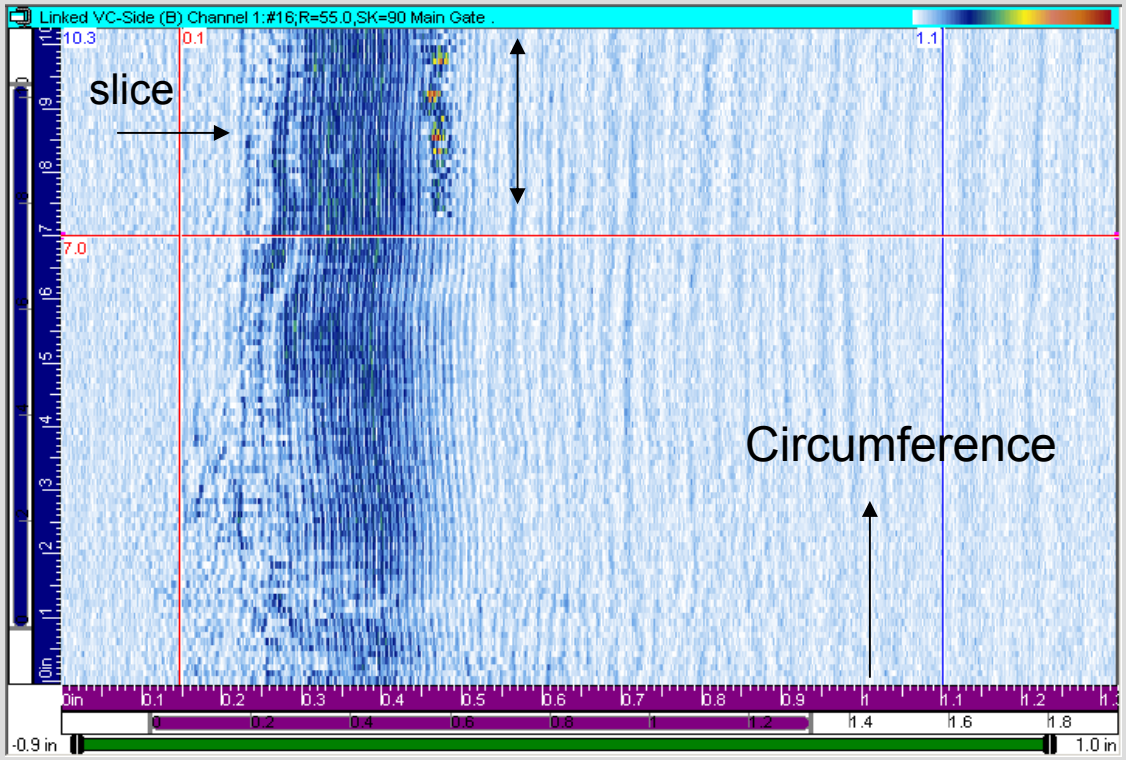
Circumference

slice

Fluor TOFD on Pipe 125, Quad 4



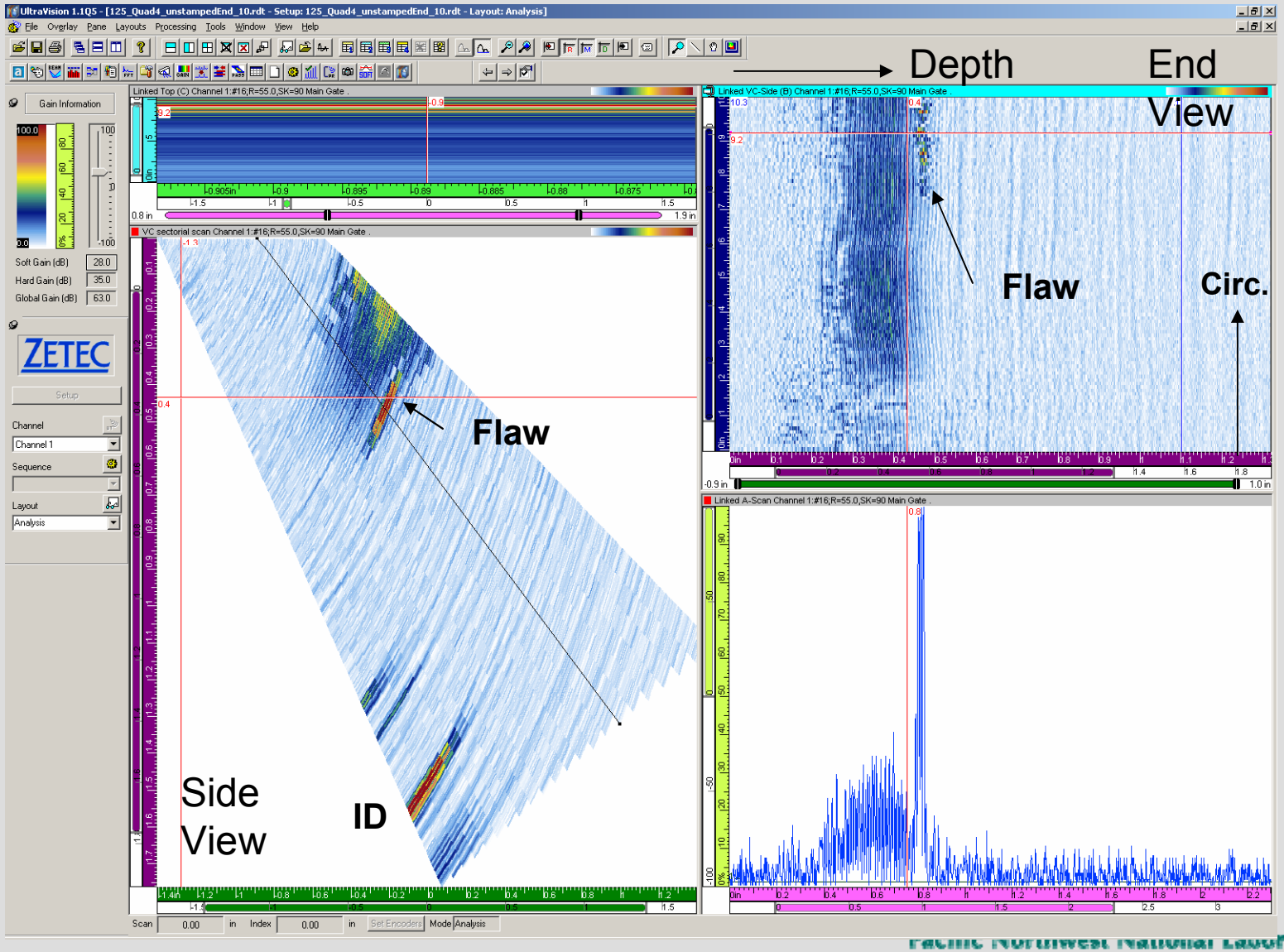
PNNL Phase Array on Pipe 125, Quad 4



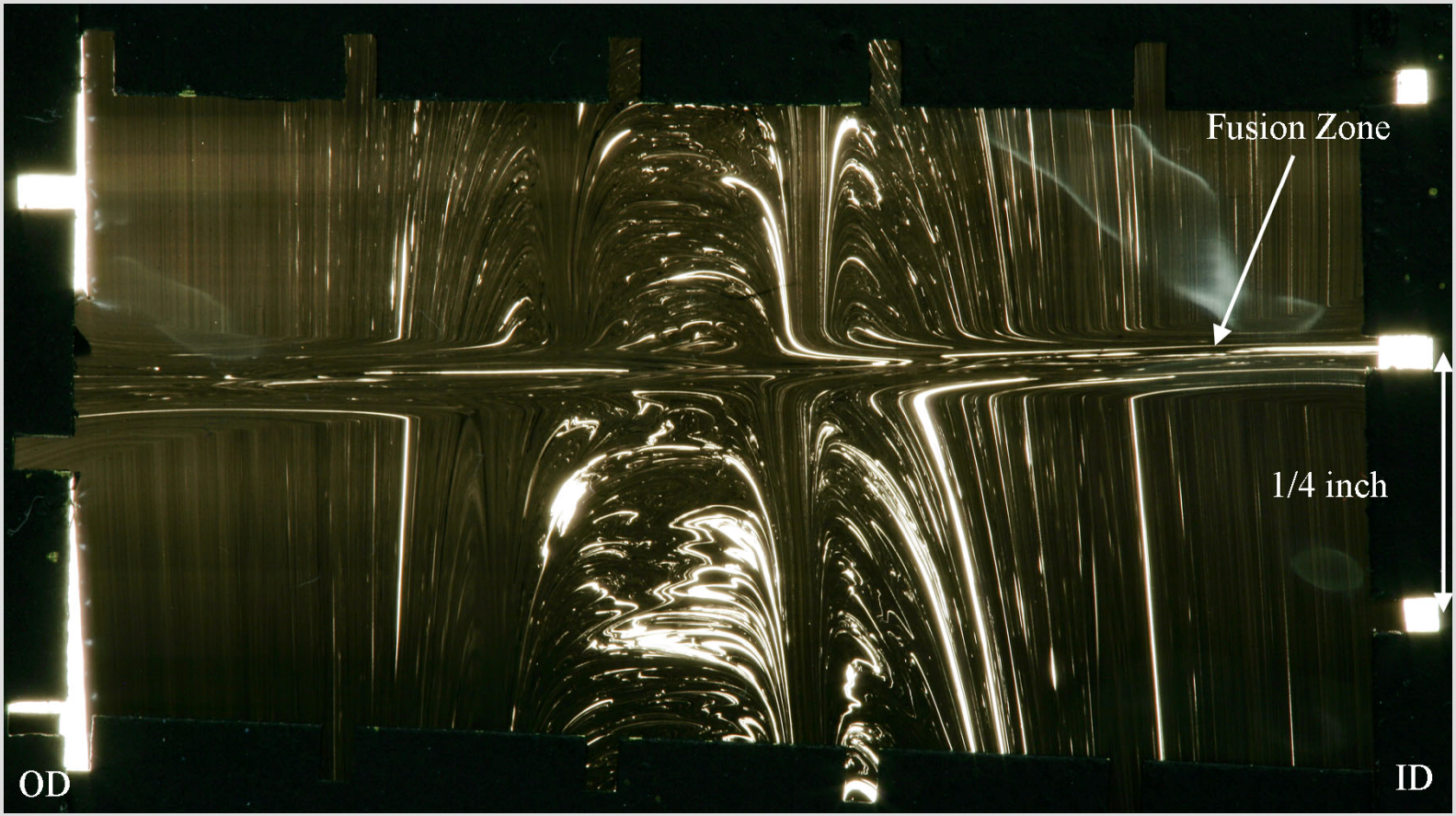
Depth

125, Quad 4

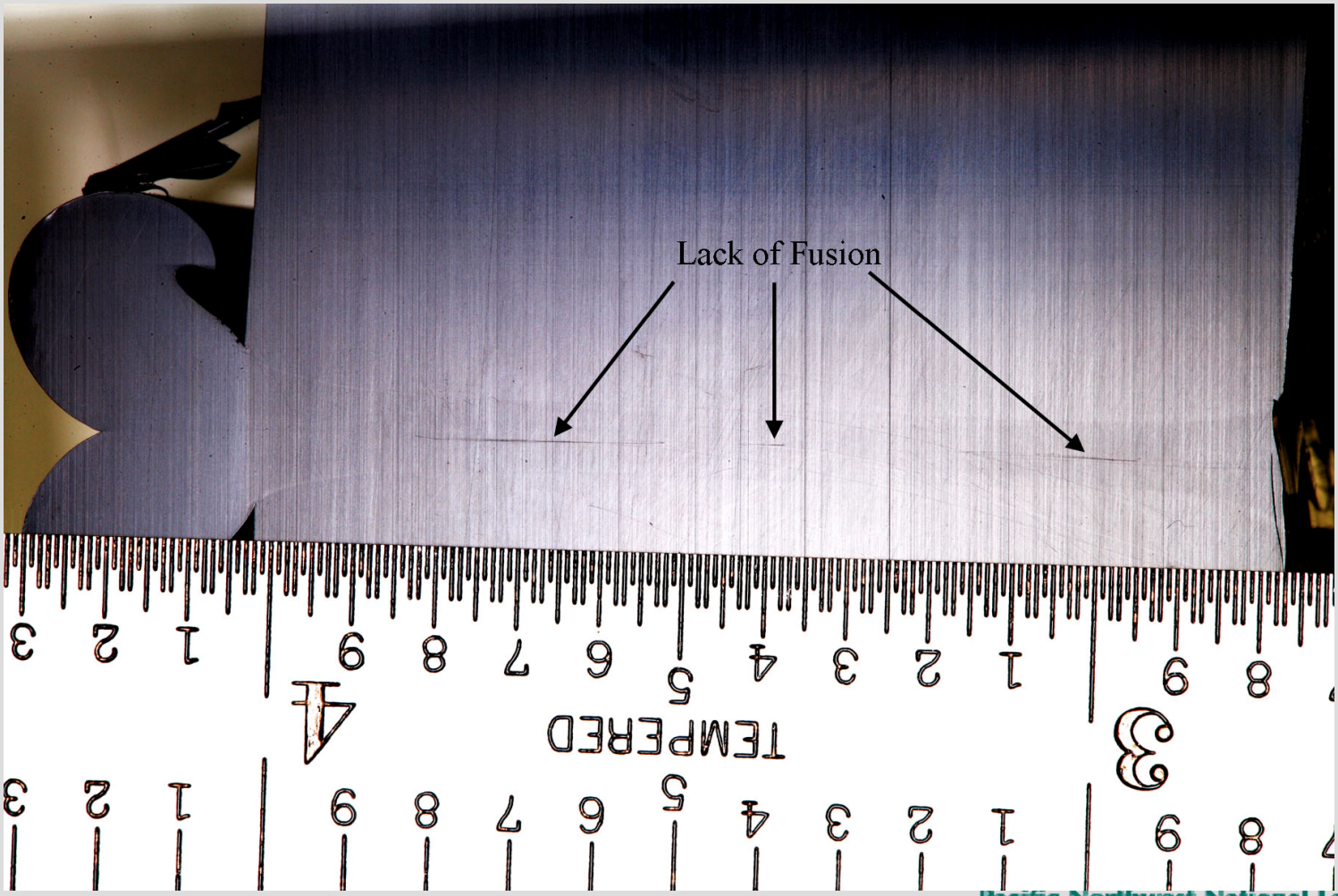
(data acquired at 40 – 60 deg)



Pipe 125 Quad 4 at 8.6 inch with LOF



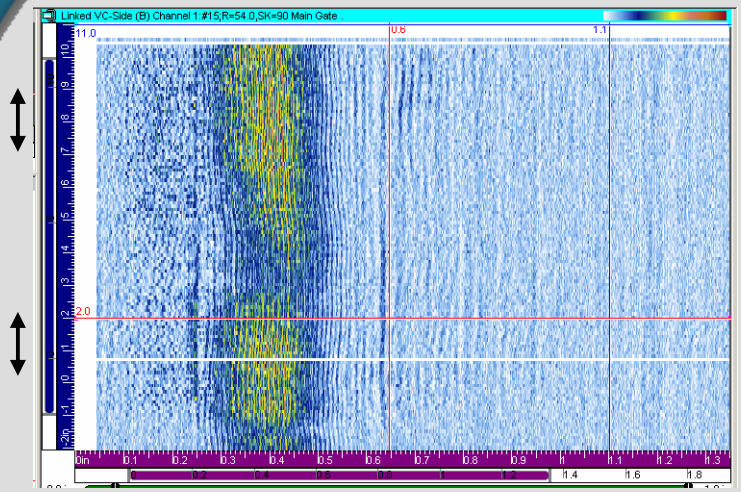
Pipe 125 Quad 4 at 8.6 inch with LOF

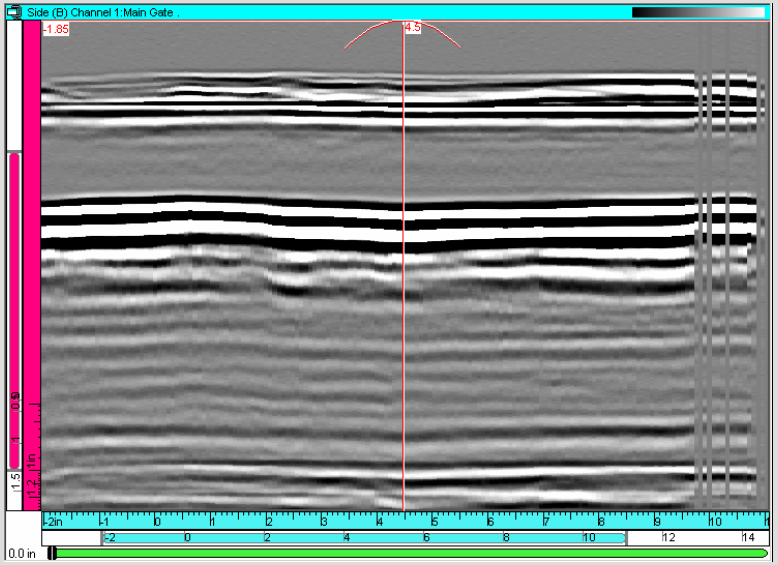


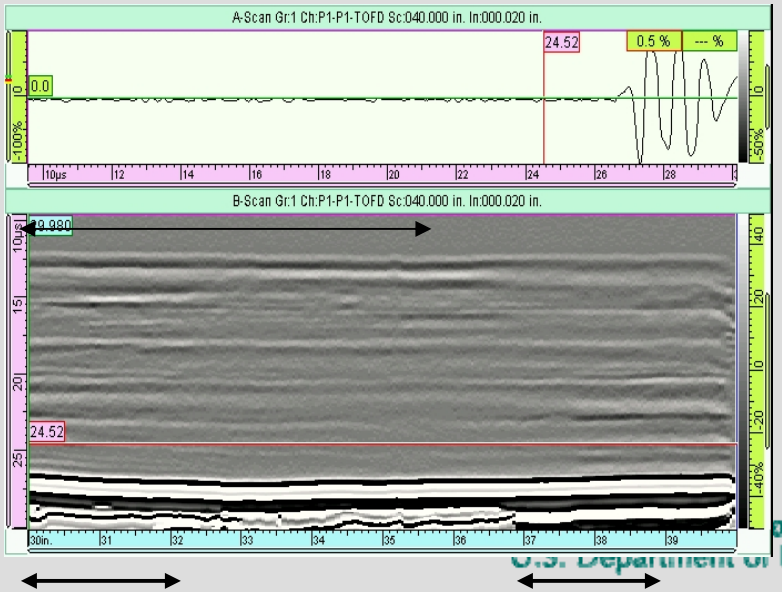
Material Selected and Sent to Jim Craig for Tensile Testing

- 1215 quad 4, 0 – 2 inch: LOF
- 7 – 9 inch: good
- 126 quad 4, 1 – 3 inch : LOF
- 7 – 9 inch: good
- 1224 quad 2, 2 – 4 inch: good
- NDE results for each of these regions follow

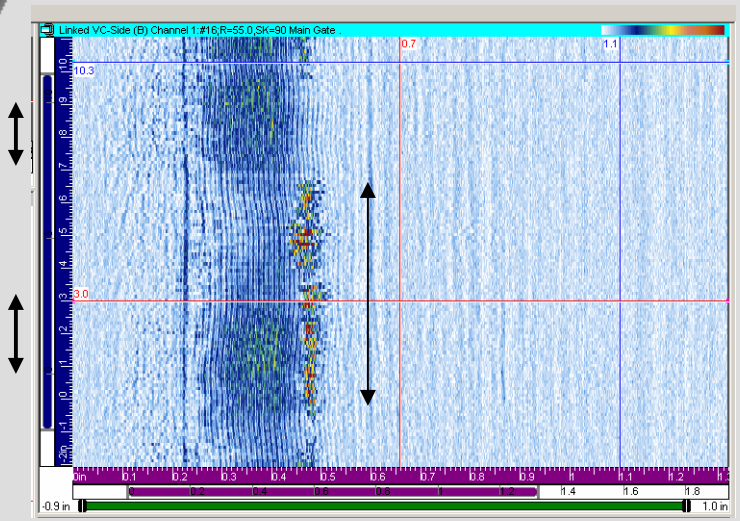
1215 Quad 4, showing areas for tensile test

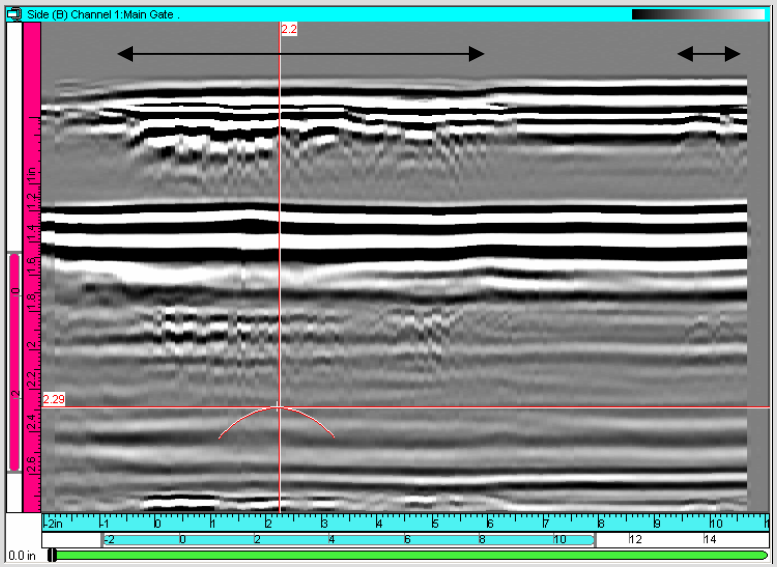


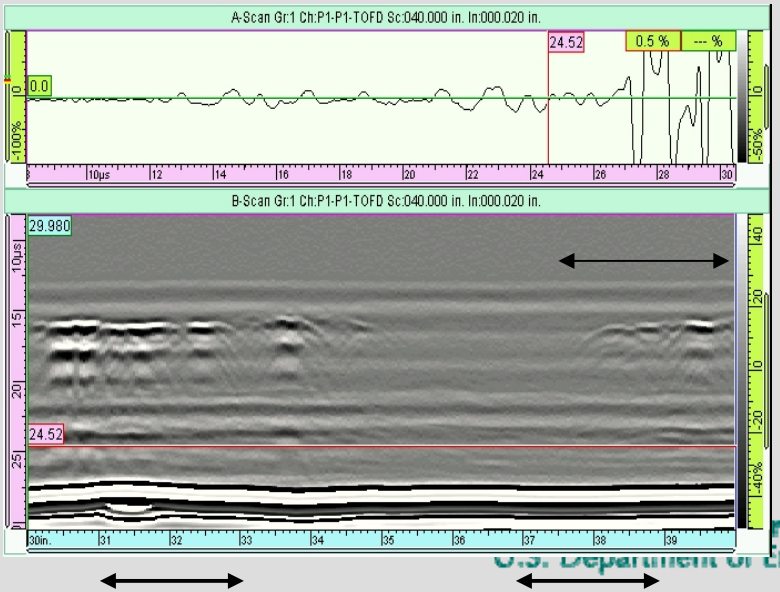




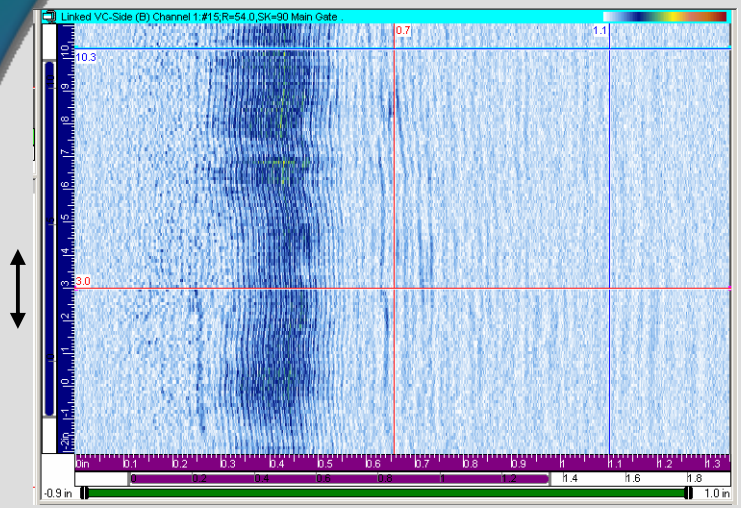
126, Quad 4, showing areas for tensile test

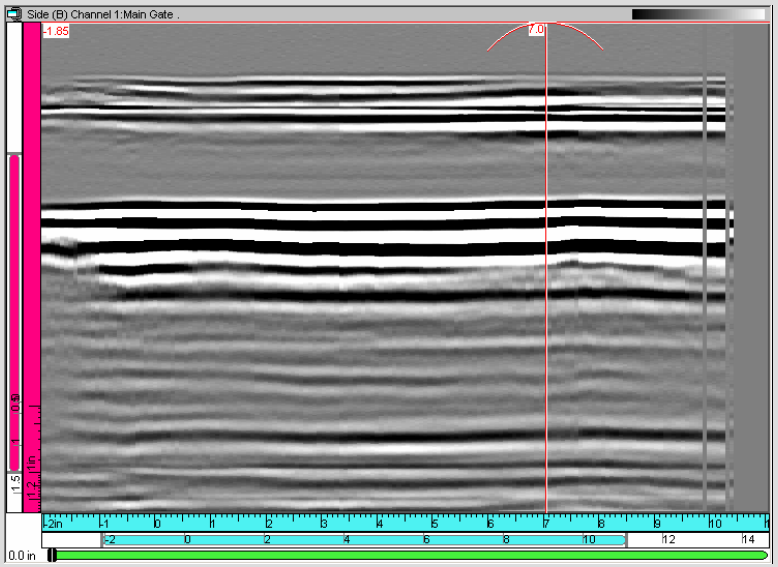


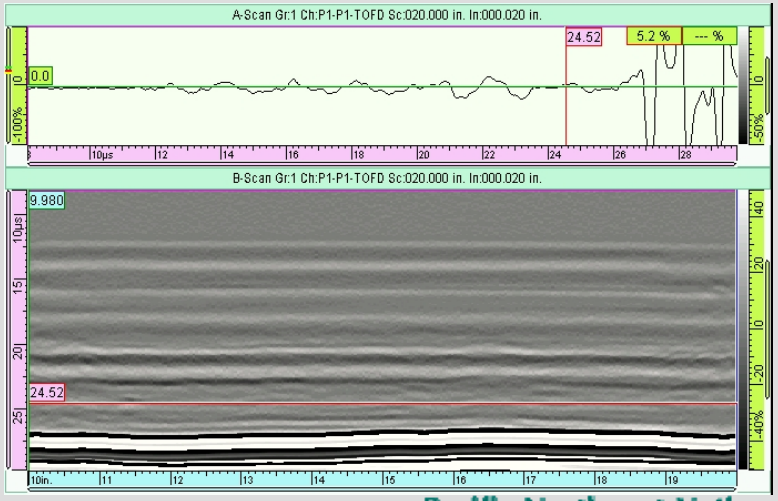




1224 Quad 2, showing area for tensile test



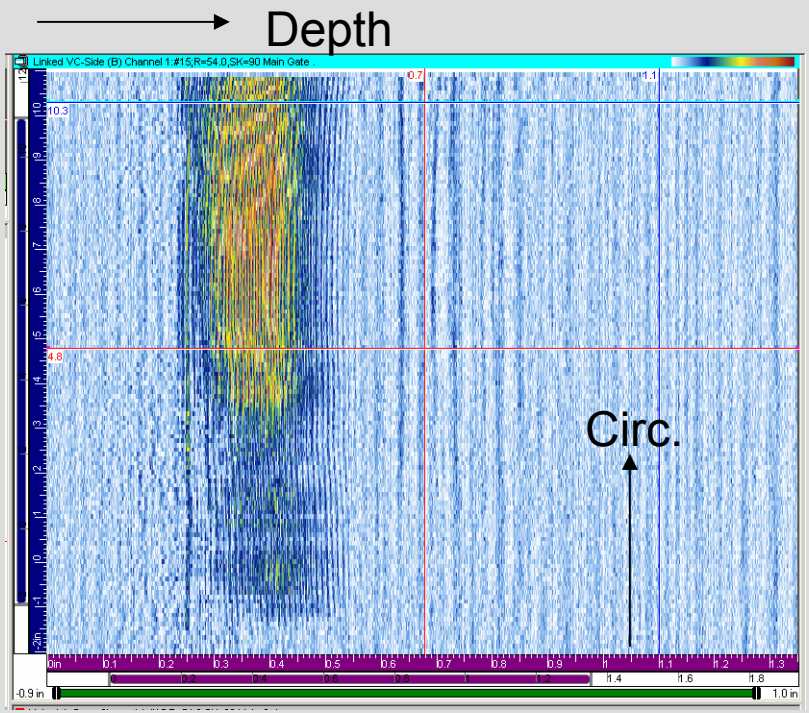


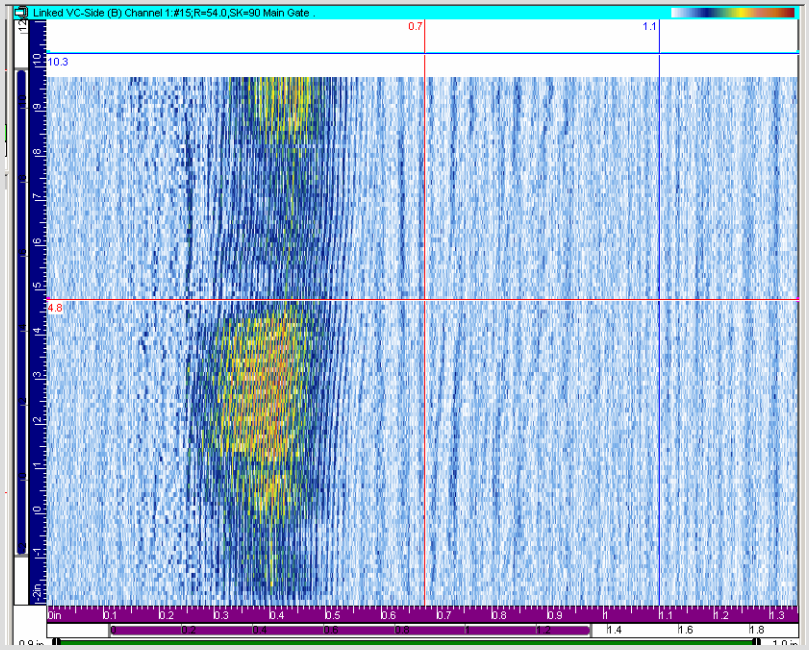


Comparison with 4710

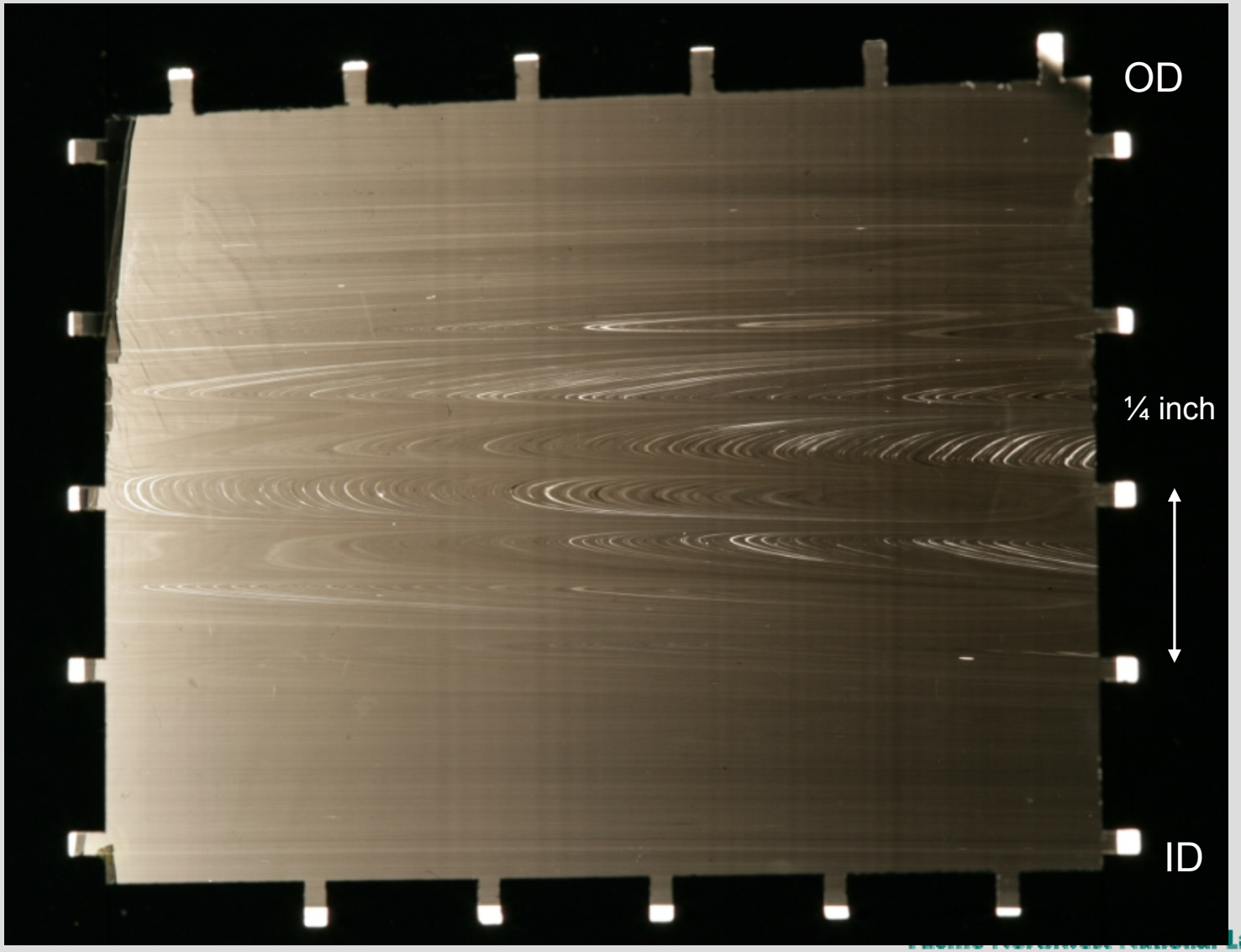
- Have only base material – no fusion joints of 4710 material
- Response of base material
- Thin slice of base material

4710 Base Material (PA)





4710 Base Material



Mechanical Testing of Selected Material

- Jim Craig conducted the testing of the selected materials using high speed tensile impact testing
- The testing was conducted to ASTM F2620 and meets the requirements in CC N-755
- This covers things like the pull rate of 6 inches/sec
- The only thing that was not done is that normally 4 samples are prepared at approximately 90 degrees and tested
- Only selected areas were tested to provide feedback on the success or failure of the NDE to detect LOF conditions

High Speed Impact Tensile Testing Results and UT Calls by PNNL and Fluor

Coupon	Wall	Width	Area	Max Force	Yield Stress	Yield Energy	Failure Energy	Yield Energy Density	Failure Energy Density	Failure Mode	Failure Location	Pipe[1]	Circ. Loc. Of Coupon	Fluor Call	PNNL Call
	(in)	(in)	(in^2)	(lb)	(PSI)	(in-lb)	(in-lb)	(in-lb/in^2)	(in-lb/in^2)				(in)		
1	1.22	0.41	0.49	1879	3803	463	1884	937	3814	Ductile	O/S	1215	7-9	good	good
2	1.22	0.41	0.49	1869	3798	422	1441	858	2929	Ductile	O/S	1215	0-2	bad	good
3	1.23	0.41	0.50	955	1909	43	47	86	94	Brittle	HAZ	126	1-3	bad	bad
4	1.21	0.41	0.49	1839	3752	371	399	757	814	Brittle	HAZ	126	7-9	good	good
5	1.22	0.41	0.50	1899	3813	476	609	956	1223	Brittle	HAZ	1224	2-4	good	good
6	1.19	0.40	0.48	1788	3734	409	1685	854	3518	Ductile	GAGE	Base			
7	1.23	0.41	0.50	1909	3826	497	1773	996	3553	Ductile	GAGE	Base			
8	1.23	0.40	0.49	1879	3803	428	1771	866	3585	Ductile	GAGE	Base			
[1] Note:	1215 q4: long open/close time only 20 sec														
	126 q4: fusion pressure during the heat cycle plus a 20 sec open/close time														
	1224 q2: fused as a good joint														

Summary

- Trying to validate what is in the LOF joint butt fusion samples has turned out to be more challenging than thought because of the non uniformity of the HDPE – better in 4710 but it may still be an issue
- Optical image of cross section provides identification of LOF but unknown if it will work for all cases of LOF in series of samples created under variety of fabrication conditions
- NDE responses were obtained with TOFD and phased array – qualitative correlation based on limited validation to date indicates that volumetric inspection is possible but its effectiveness is not quantified
- Mechanical testing results showed UT could detect some LOF conditions and not able at this time to detect others

Planned Activities

- Use mechanical test results of both good and NDE identified defective regions to refine NDE results
- Conduct additional NDE testing on some of the samples (more optimized PA) and determine what should be destructively characterized and what needs to be assessed via mechanical testing and/or slow crack growth rate testing
- Document work to date and discuss with NRC sponsor what future work should be conducted
- Present results to ASME SWG on HDPE