



ELECTRIC POWER
RESEARCH INSTITUTE

Inspection & Mitigation of Alloy 82/182 Butt Welds

PDI/NRC Meeting
May, 2007
Knoxville, TN

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Program Manager
Appendix VIII Performance Demonstration



Inspection & Mitigation of Alloy 82/182 Butt Welds

Summary

- **This project will build on the previously funded (MRP) work allowing the application of economically feasible pre-emptive weld overlays to large (greater than 27 inch diameter) Alloy 600 components which meets MRP-139 commitments**
- **Additionally, it will close several inspection gaps present on smaller diameter complex Alloy 600 welds , including pressurizer nozzles and drain lines**
- **This project will also evaluate techniques required to examine overlays that are applied over Alloy 600 welds that contain cast materials**

Inspection & Mitigation of Alloy 82/182 Butt Welds

Mapped to IMT Gaps:

Gap number	Gap title	Gap priority (H, M, L)
MT-01	Development of Alternative Mitigation Technologies	H
I & E - 05	NDE Capability: Appendix VIII Compliance	H
I & E - 01	NDE Technology: Dissimilar Metal (DM) Butt Welds	H
MT - 03	PWSCC Mitigation: Stress Improvement (SI) of Butt Welds	H

Sponsor Priority Input:

Sponsor – Mike Briley and Artie Smith

Priority - High

Inspection & Mitigation of Alloy 82/182 Butt Welds

Project Description

- Purpose of this project is to
 - **Fabricate samples to support the following tasks**
 - **Develop procedures and techniques to examine cast base material under weld overlays**
 - **Develop procedures and techniques examine beyond the outer 25% of the original base material will be required in order to reduce the size of the overlay for large diameter thick components**
 - **Develop code criteria in order to qualify the techniques developed**
 - **Obtain mitigation data to support the application of PWOL on large diameter components**

Inspection & Mitigation of Alloy 82/182 Butt Welds

Tasks & Deliverables

- MRP Funded Portion
 - Smaller Diameter Configurations
 - All have cast safe-ends
 - Surge Line Mock-ups have flaws at 50% and 75% of the original weld and base material thickness
 - In the cast and in weld
 - Delivered in January of 07.
 - Additional search units on order

Inspection & Mitigation of Alloy 82/182 Butt Welds

• Tasks & Deliverables

– MEOG/NDEC Funded Portion

- Design and fabricate large diameter thick test samples (RCS)
 - *November 2007 (Funded by MEOG)*
- *Document Mitigation Design Data*
 - *April 2008 (Funded by NDEC)*
- *Complete Relief Request Template*
 - *November 2008 (Funded by NDEC)*
- Characterize samples and evaluate techniques
 - *December 2008 (Funded by NDEC)*
- *If successful, qualify techniques*
 - *December 2008 (Funded by NDEC)*

Inspection & Mitigation of Alloy 82/182 Butt Welds

Benefits

- If successful this project will;
 - Allow the application of economically feasible pre-emptive weld overlays to large (greater than 27 inch diameter) Alloy 600 components
 - Close several inspection gaps present on smaller diameter complex Alloy 600 welds , including pressurizer nozzles and drain lines
 - Develop and qualify techniques required to examine overlays that are applied over Alloy 600 welds that contain cast materials

Inspection & Mitigation of Alloy 82/182 Butt Welds

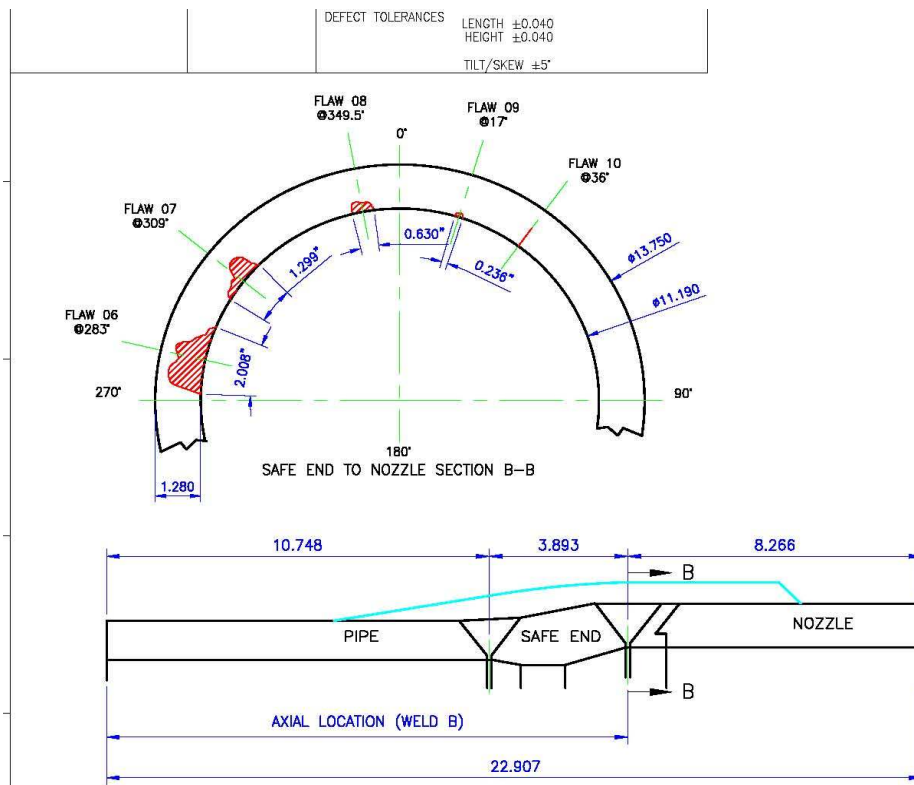
- **Other Related Projects**

- *“Indication Evaluation & Disposition for Weld Overlays”*
 - Funded by EPRI NDE
 - Addresses sizing of embedded planar flaws and laminar flaws
- All projects include development of code cases and relief requests in order to get criteria accepted by NRC and Code

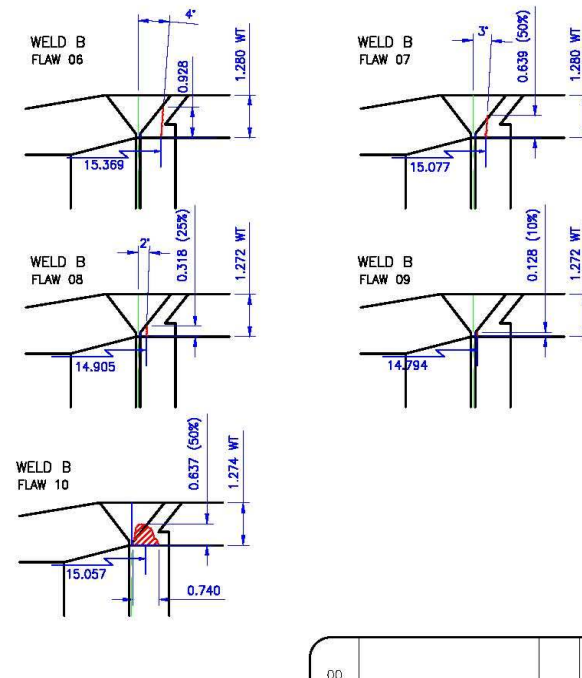
Status of Projects

- Expansion of examination volume beyond upper 25%
 - First sample fabricated (Pressurizer Surge)
 - Flaws implanted at various depths
 - 10 to 25 percent
 - 43 to 73 percent
 - Axial and Circumferential flaws included
 - Implanted in the following areas
 - Weld and base material of nozzle to safe end weld (dissimilar metal weld)
 - Base material heat affected zone of safe-end to pipe weld (Similar metal weld)

Status of Projects



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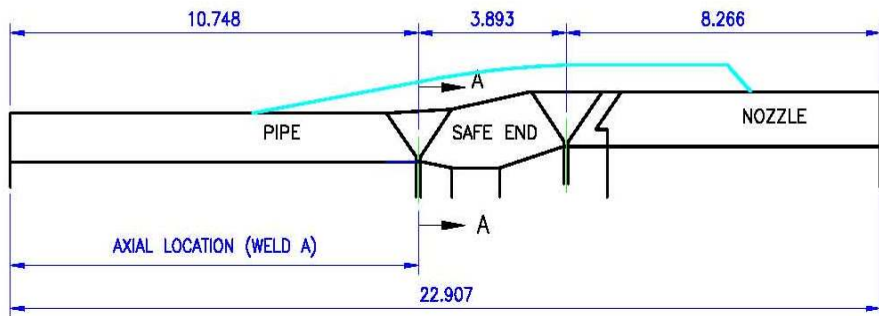
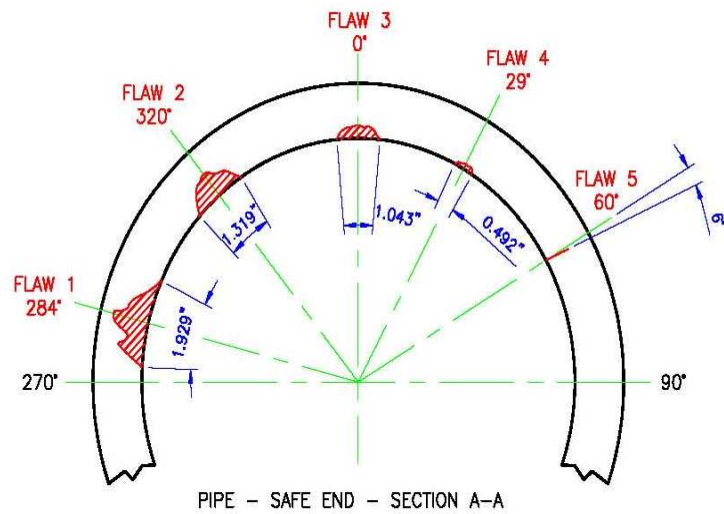


Status of Projects

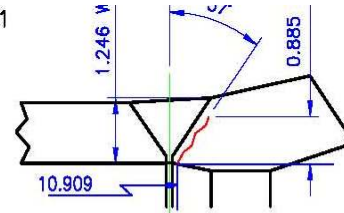
Range of flaw sizes in dissimilar metal weld

FLAW REF.	FLAW TYPE	POSITION	ORIENTATION	LENGTH	BEFORE OVERLAY			FLAW CENTER		AXIAL LOCATION	TILT	SKEW	GEOMETRY
				IN	HEIGHT (IN)	W.T.	%	IN	DEG.				
06	CRACK	NOZZLE	CIRC.	2.008	0.928	1.280	73	27.634	283	15.369	4°	90°	FLUSH CAP
07	CRACK	NOZZLE	CIRC.	1.299	0.639	1.280	50	30.168	309	15.077	3°	90°	
08	CRACK	NOZZLE	CIRC.	0.630	0.318	1.272	25	34.126	349.5	14.905	2°	90°	
09	CRACK	NOZZLE	CIRC.	0.236	0.128	1.272	10	1.674	17	14.794	0°	90°	
10	CRACK	NOZZLE	AXIAL	0.740	0.637	1.274	50	3.504	36	15.057	0°	0°	

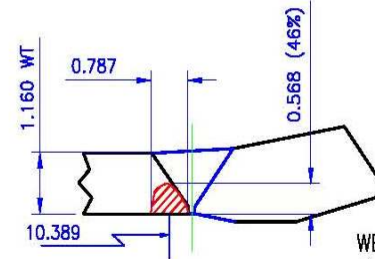
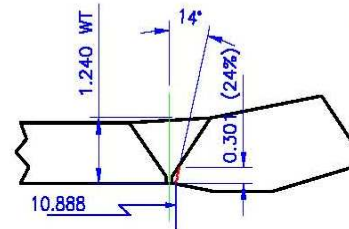
Status of Projects



FLAW 1

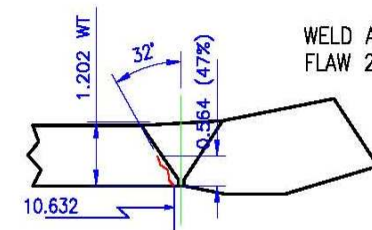


WELD A
FLAW 3

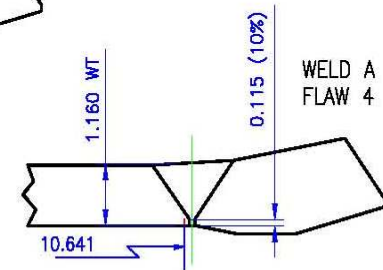


WELD A
FLAW 5

WELD A
FLAW 2



WELD A
FLAW 4



Status of Projects

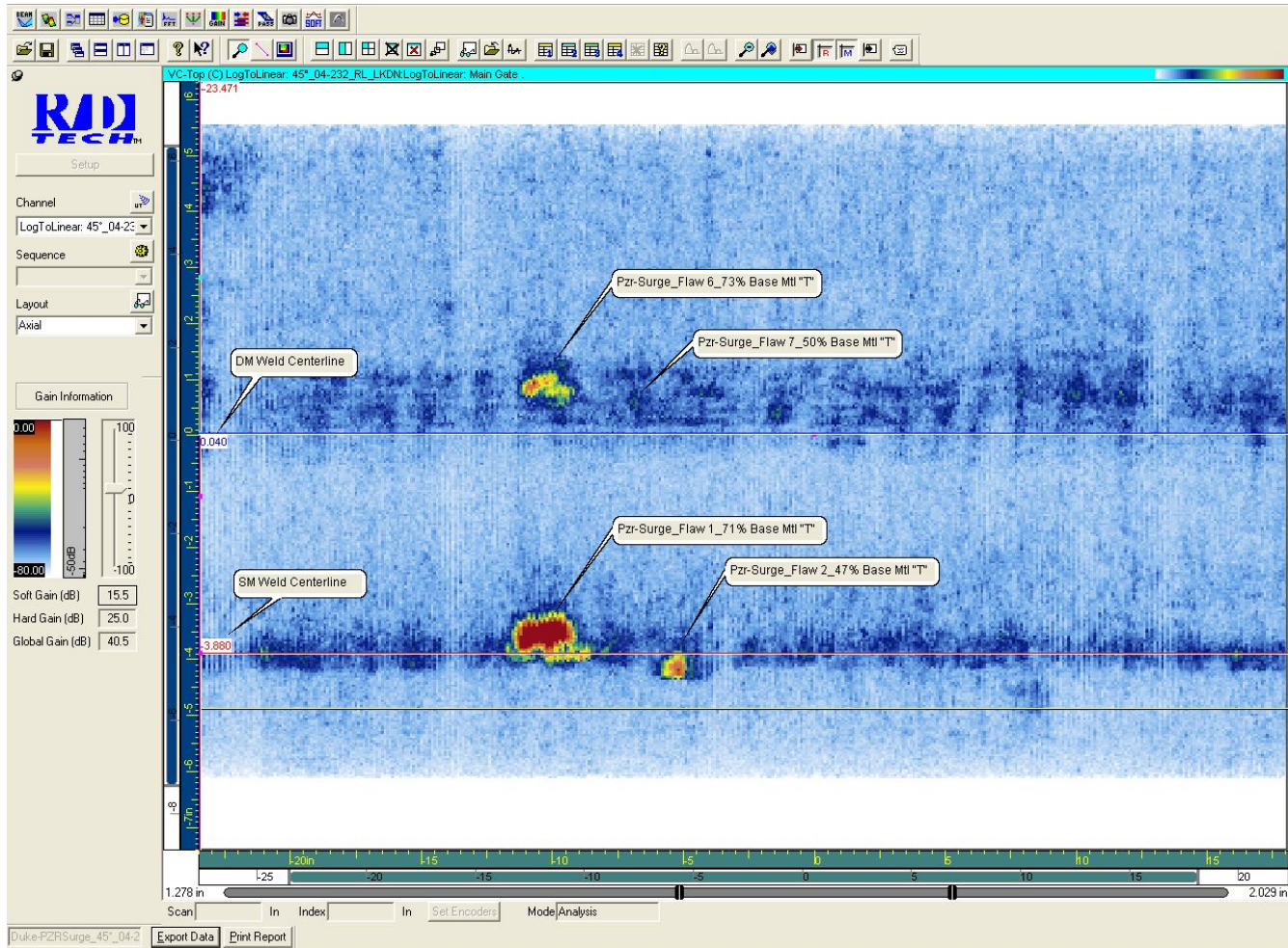
Range of flaw sizes in similar metal weld

FLAW REF.	FLAW TYPE	POSITION	ORIENTATION	LENGTH	BEFORE OVERLAY			FLAW CENTER		AXIAL LOCATION	TILT	SKEW	GEOMETRY
				IN	HEIGHT (IN)	W.T.	%	IN	DEG.				
01	CRACK	SAFE END	CIRC.	1.929	0.885	1.246	71	25.957	284	10.909	37°	90°	FLUSH CAP
02	CRACK	PIPE	CIRC.	1.319	0.564	1.202	47	29.252	320	10.632	32°	90°	
03	CRACK	SAFE END	CIRC.	1.043	0.301	1.240	24	0	0	10.888	14°	90°	
04	CRACK	PIPE	CIRC.	0.492	0.115	1.160	10	2.677	29	10.648	0°	90°	
05	CRACK	PIPE	AXIAL	0.787	0.568	1.225	46	5.492	60	10.389	6°	0°	

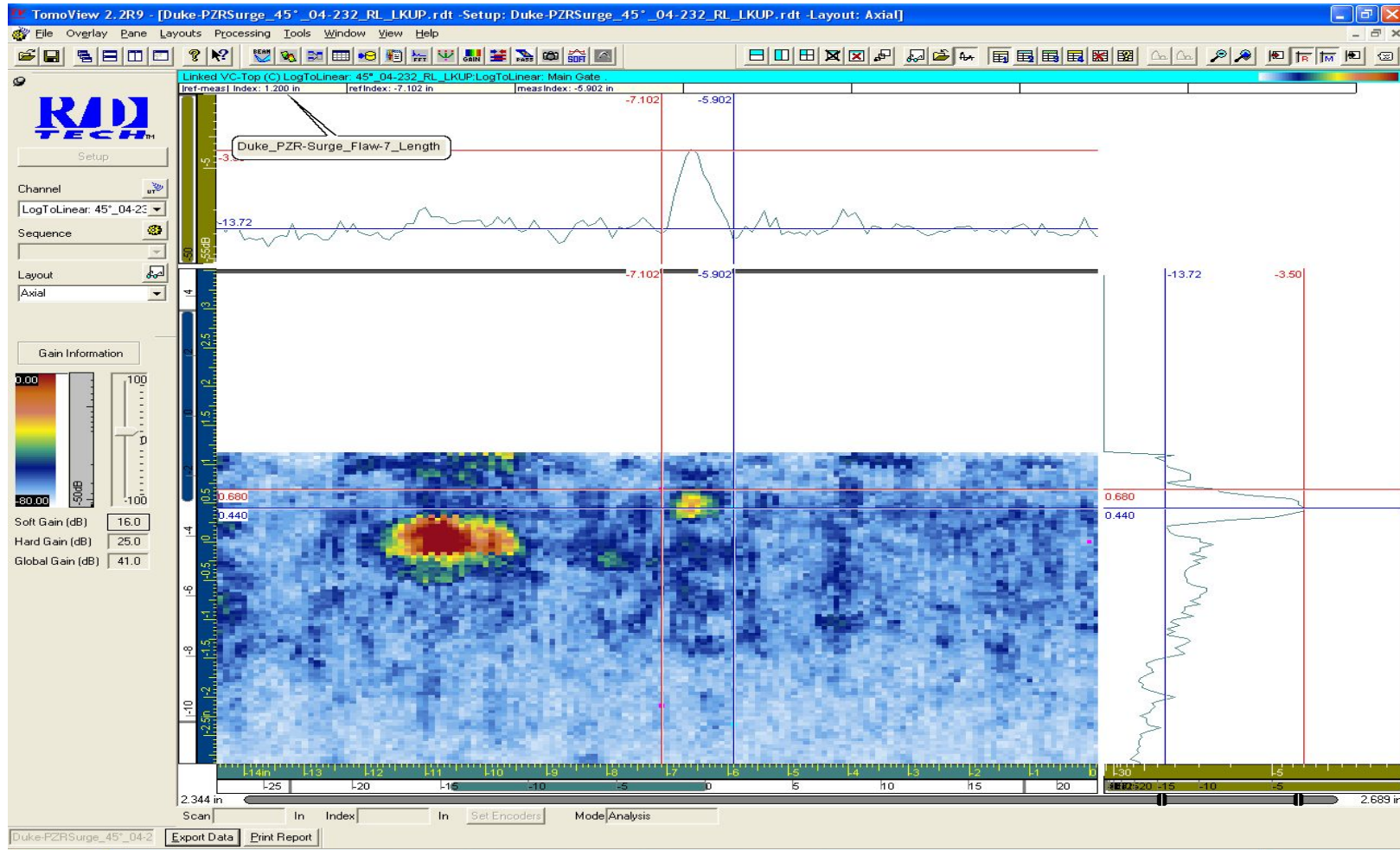
Status of Projects

- Expansion of examination volume beyond upper 25% (Conti.)
 - Conventional Techniques Applied
 - Promising results achieved for flaws in the 43% to 71% range
 - Depth sizing outside of RMS for some flaws in the 43% to 50% range
 - Flaws in the 10% to 35% range not detectable
 - Additional work underway to improve on results

Status of Projects



Status of Projects

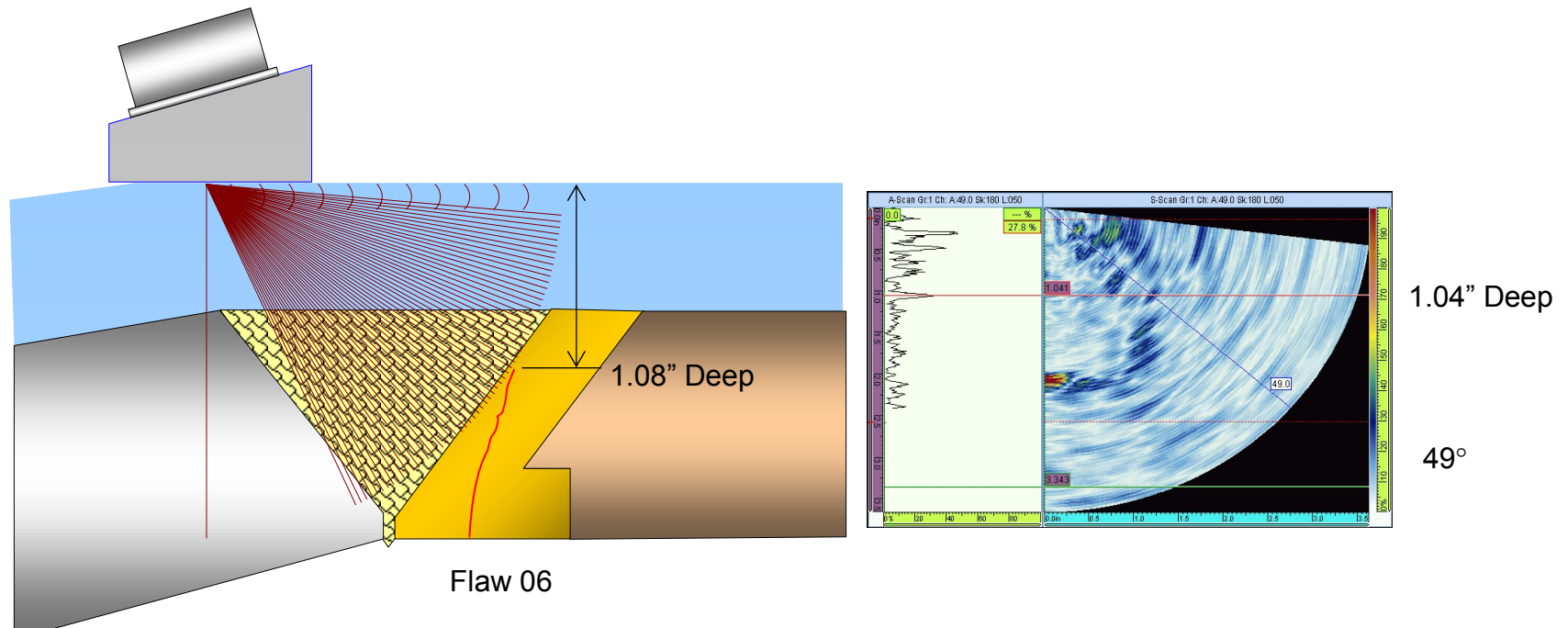


Status of Projects

- Phased Array techniques
 - Structural Integrity qualified phased array procedure for examination of weld overlays was also utilized
 - Linear Phased Array Technique
 - Wide range of angles applied

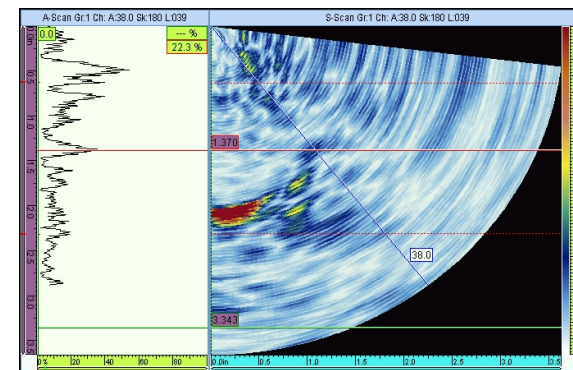
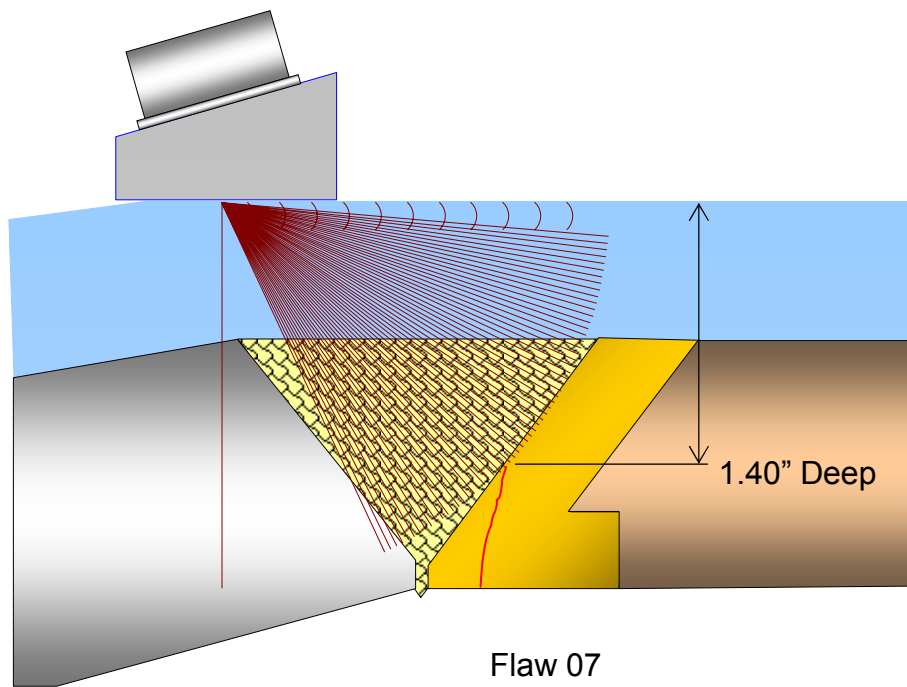
Status of Projects

- Structural Integrity Phased Array Technique



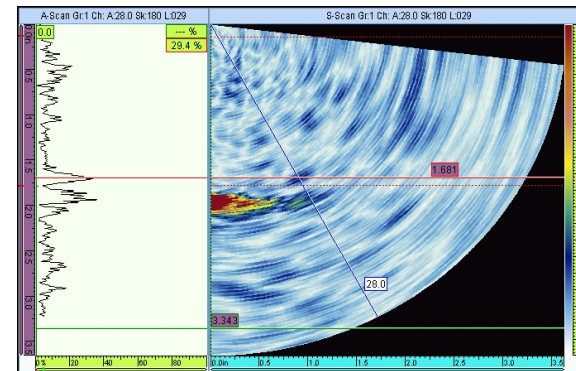
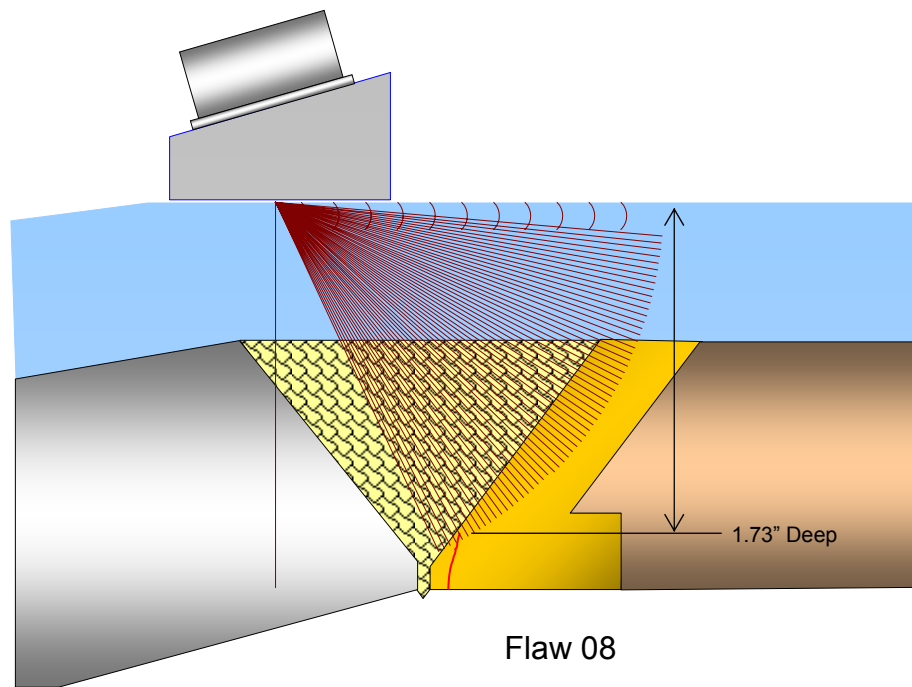
Status of Projects

- SI Phased Array Technique



Status of Projects

- SI Phased Array Technique



1.68" Deep

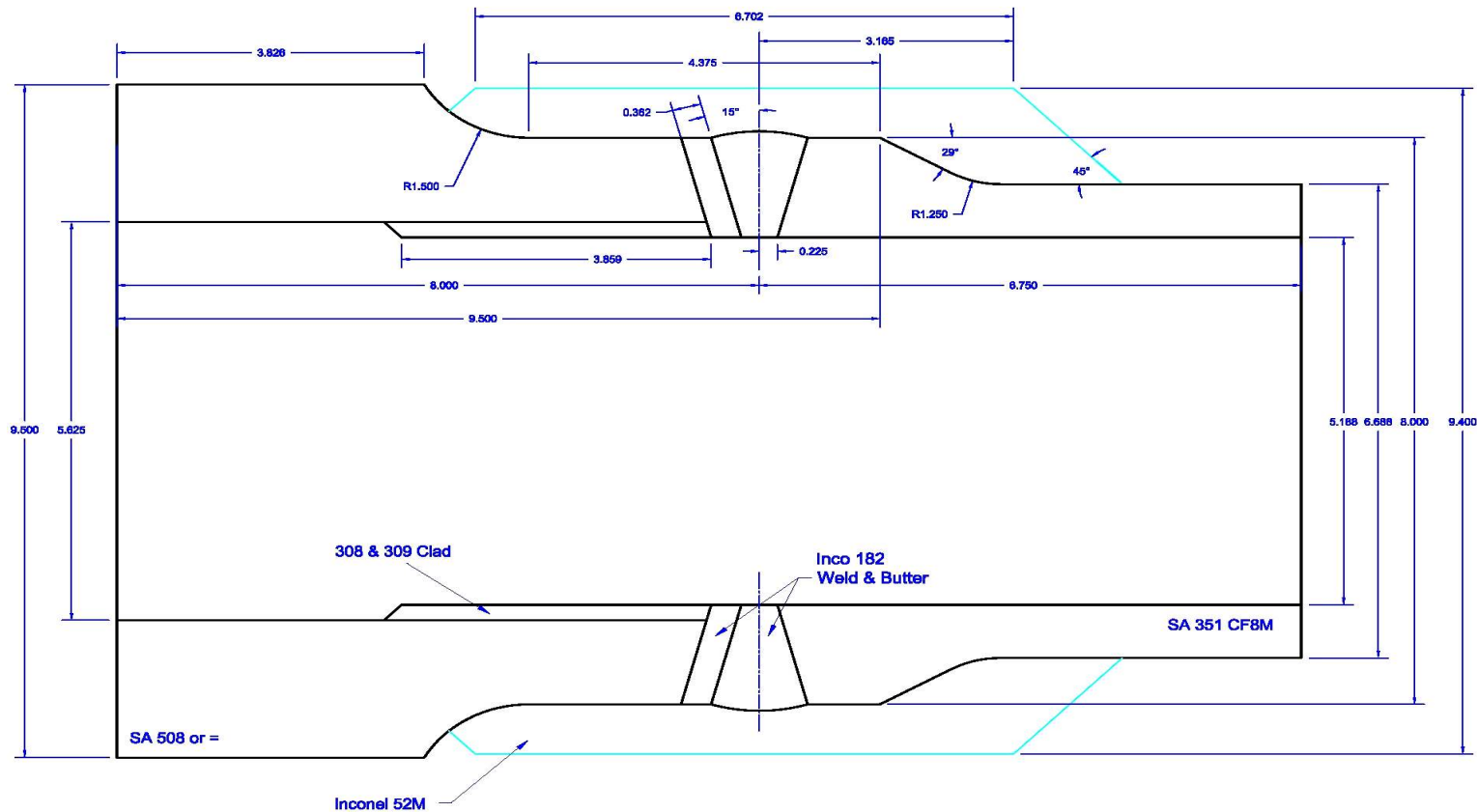
28°

Status of Projects

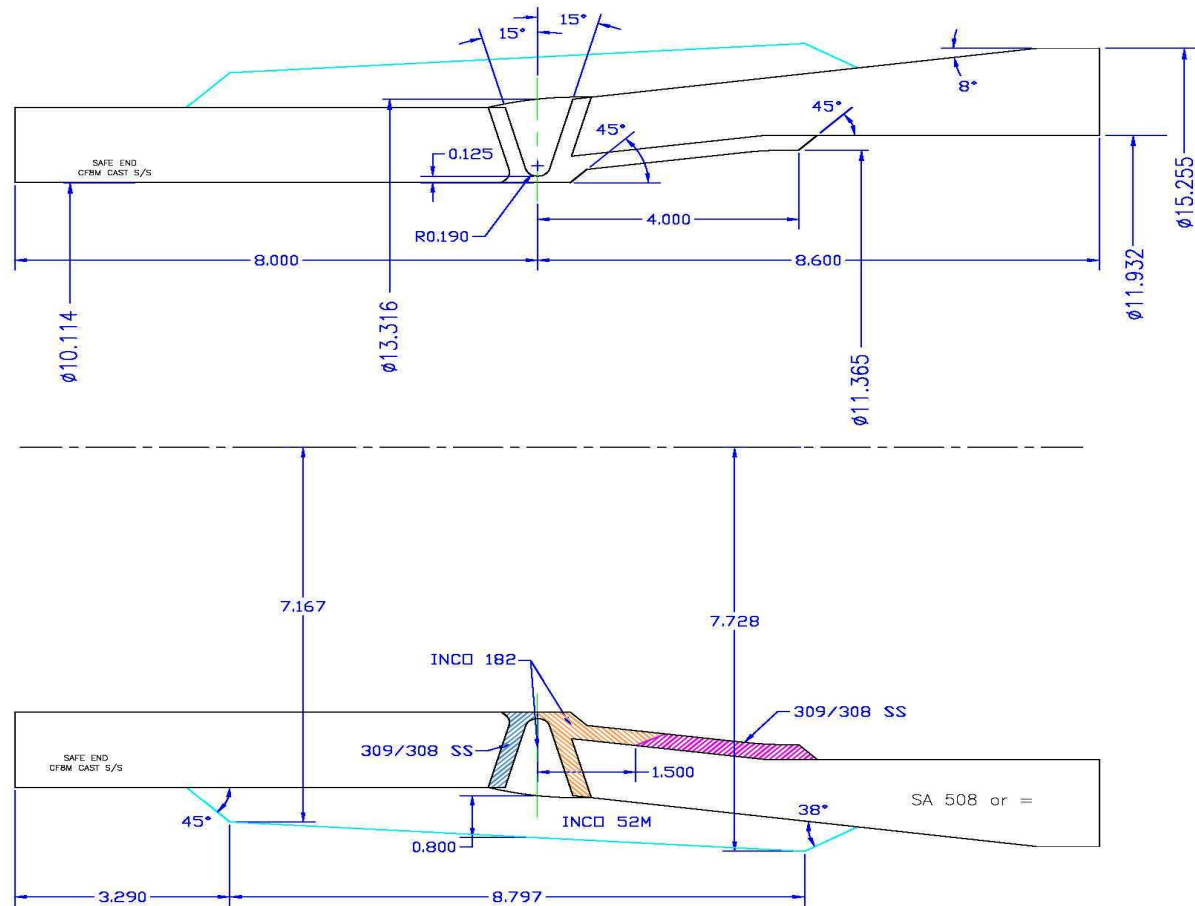
- Examination Overlays Over Cast Base Material
 - 3 samples delivered
 - (2) Pressurizer Safety Relief
 - (1) Pressurizer Surge
 - Flaws implanted in cast and weld material using HIP process
 - Axial and circumferential flaws
 - All flaws implanted with no tilt so they are equally challenging from both directions
 - No favorable side
 - Some flaws in cast material propagate into overlay material

Status of Projects

Safety/Relief WOL #1



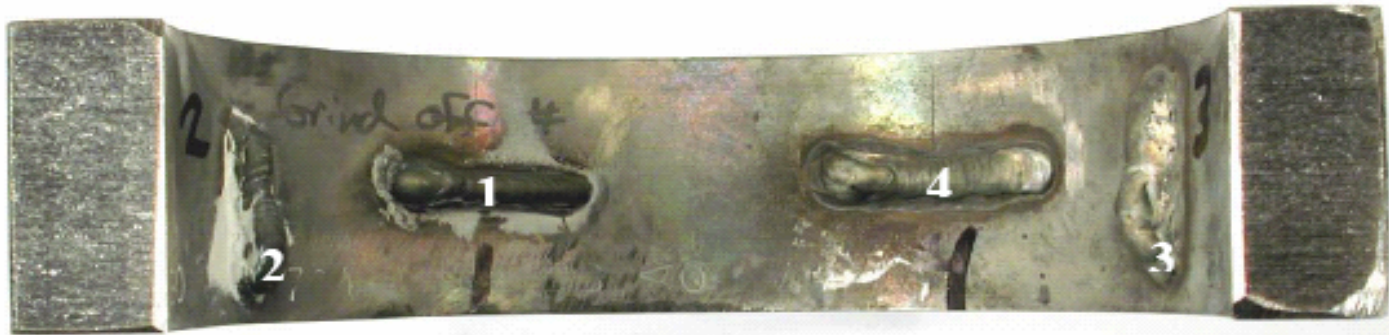
Status of Projects



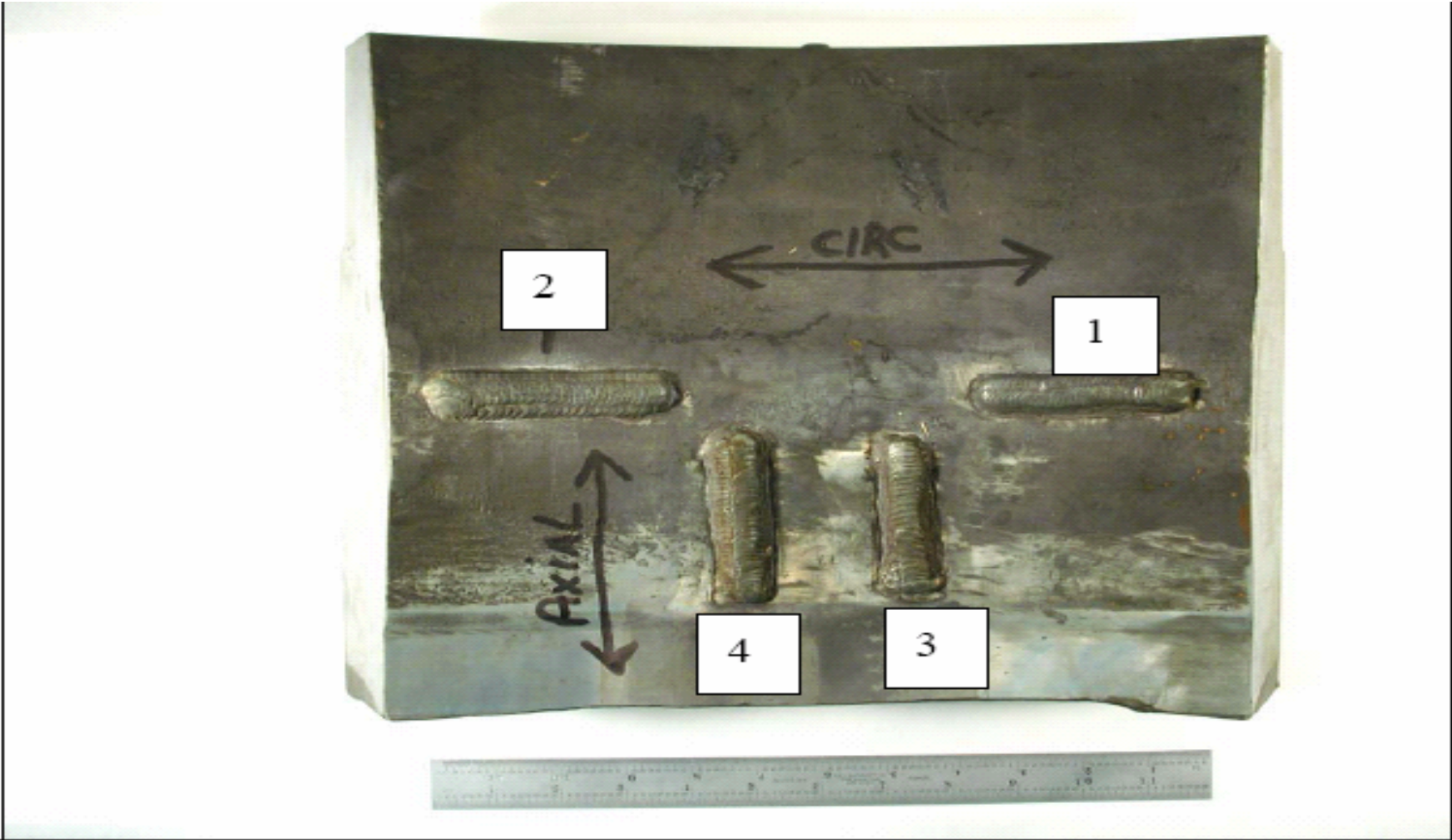
Status of Projects

- Examination Overlays Over Cast Base Material (Cont.)
 - Flaw Implantation Trials
 - Flaws appeared to compress to desired widths
 - No cast material disturbed during process

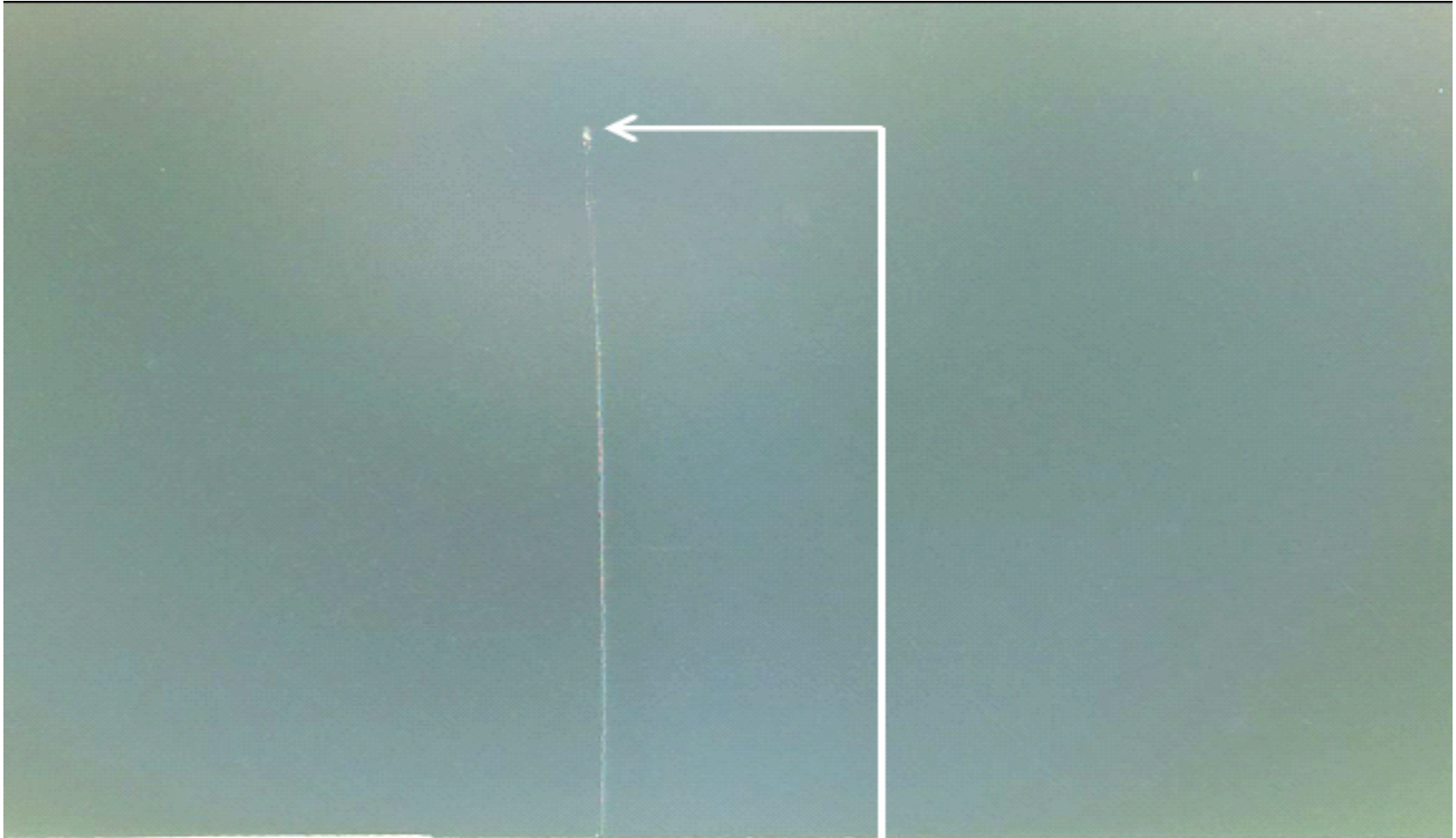
Status of Projects



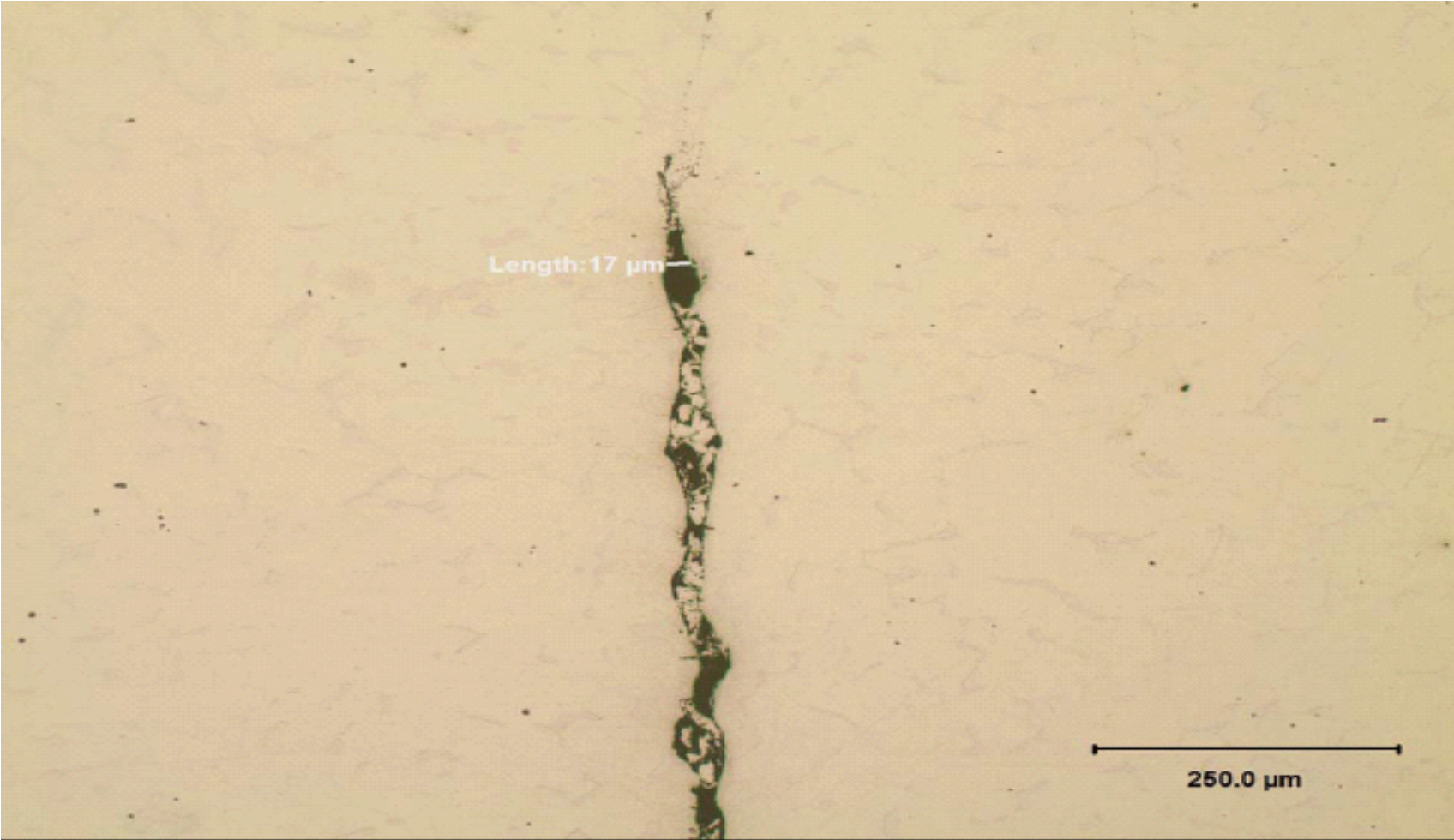
Status of Projects



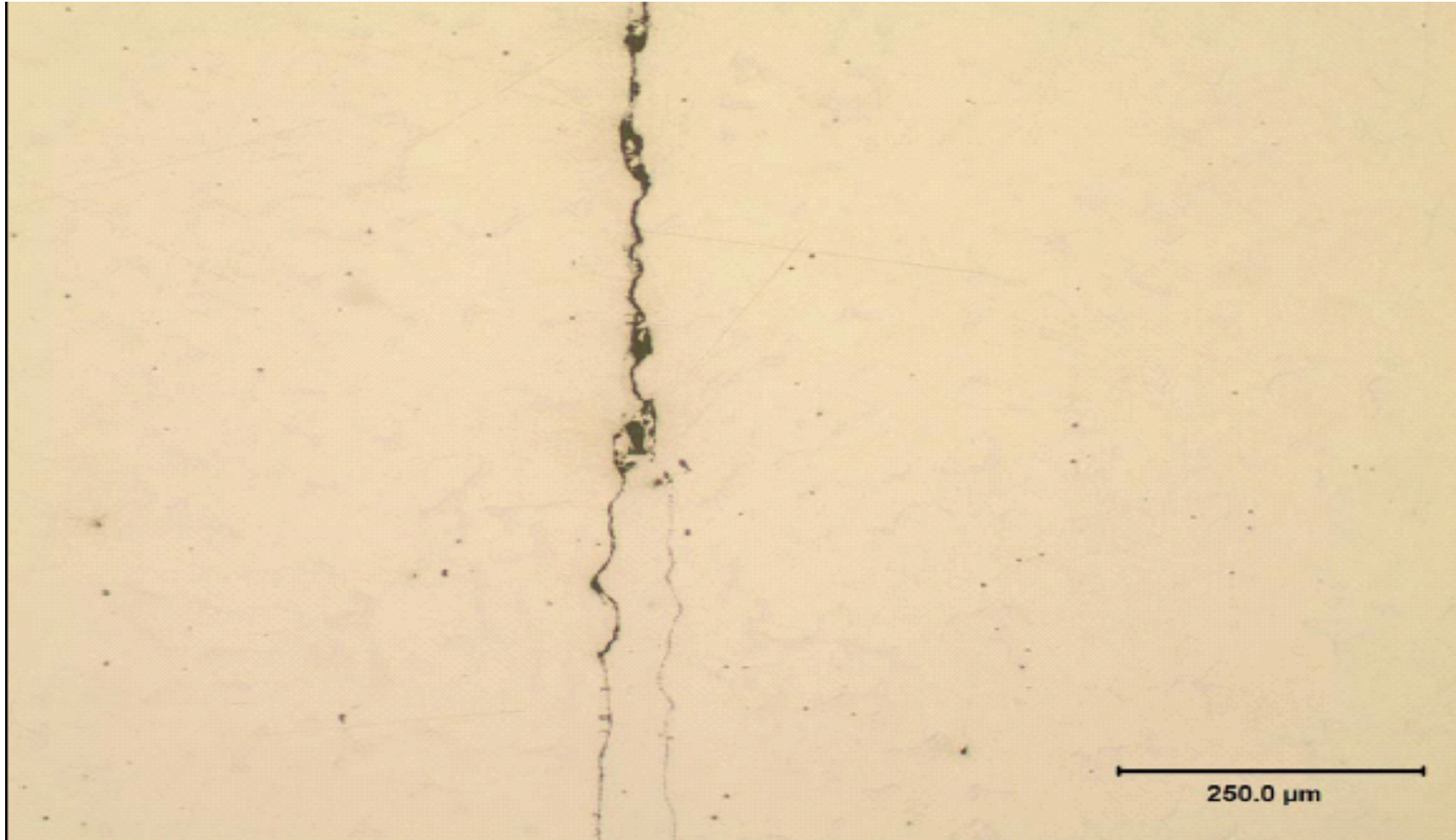
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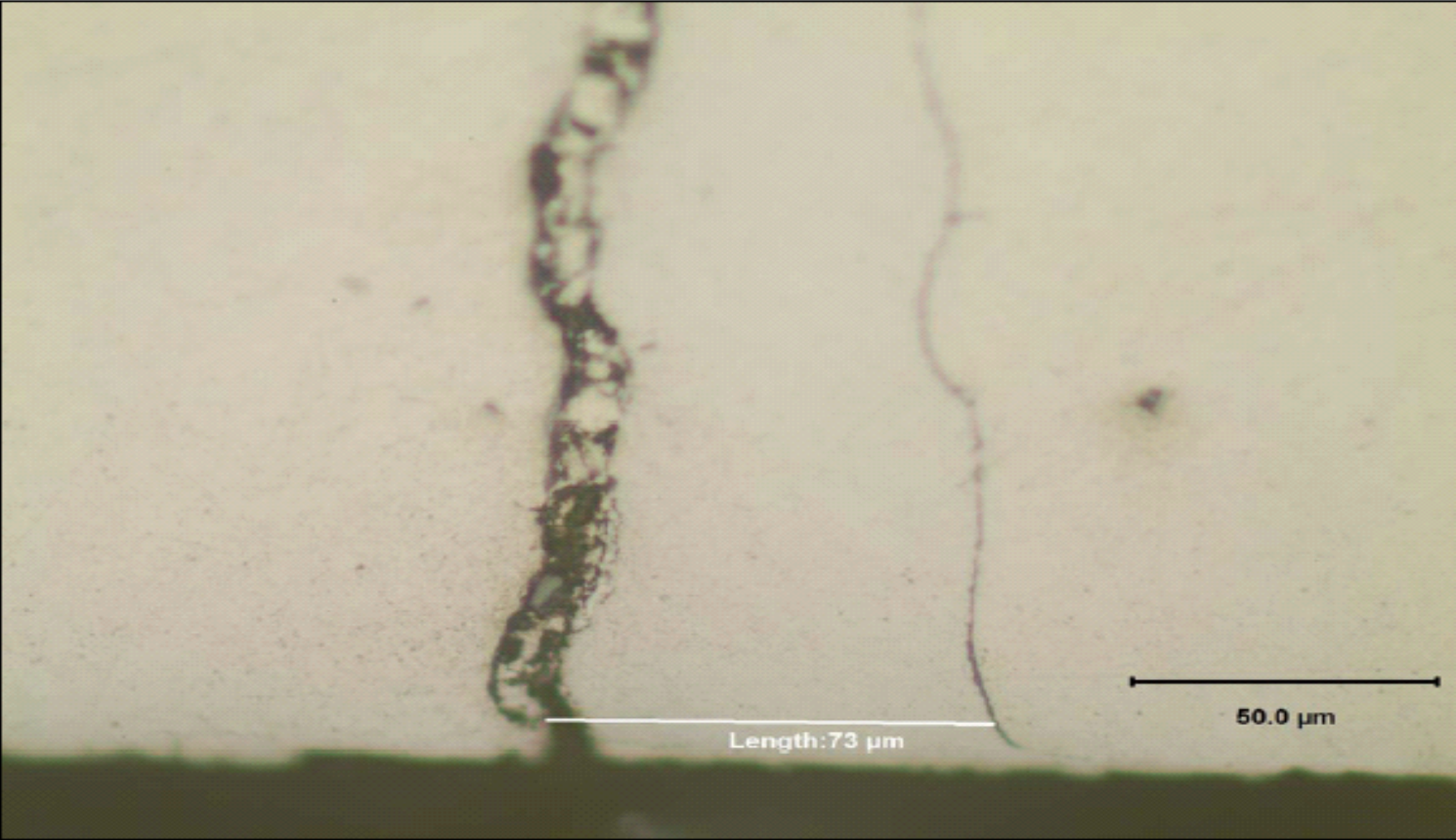
Status of Projects



Status of Projects



Status of Projects



Status of Projects

EDM Notch Measurements (inches)

Pipe Wall	Position	Nominal Tip	Thinnest	Typical 1	Typical 2	Opening	<u>Average</u>
Small	1 Circumferential	0.0032	0.0014	0.0028	0.0023	0.0052	0.0030
Small	4 Circumferential	0.0057	0.0019	0.0031	0.0023	0.0023	0.0031
Small	2 Axial	0.0007	0.00004 ⁽¹⁾	0.0019	0.0023	0.0029	0.0016
Small	3 Axial	0.0095	0.0017	0.0020	0.0026	0.0024	0.0036
Heavy	1 Circumferential	0.0068	0.0017	0.0106	0.0098	0.0024	0.0063
Heavy	3 Axial	0.0124	0.0014	0.0177	0.0071	0.0054	0.0088
Heavy	4 Axial	0.0084	0.0016	0.0028	0.0105	0.0052	0.0057

Note 1: Closed notch beyond extent of shim resulted in narrow measurement (also affects average).

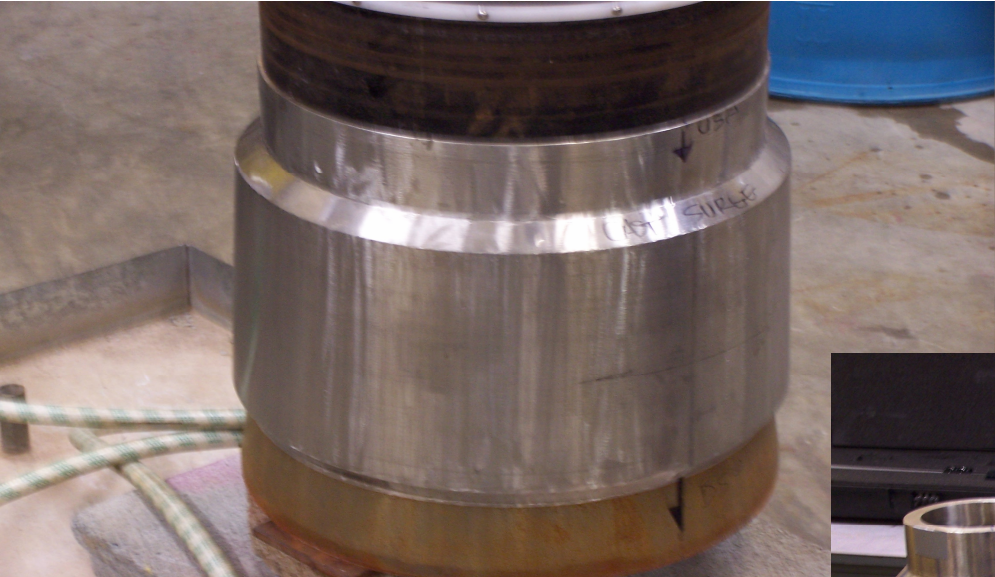
Status of Projects

- Examination Overlays Over Cast Base Material (Cont.)
 - Initial Results
 - All flaws in weld and ferritic base material readily detected and sized
 - Portion of flaws in cast material that have propagated into overlay material are readily detected
 - No flaws in cast base material have been detected to date with currently qualified conventional and phased array techniques

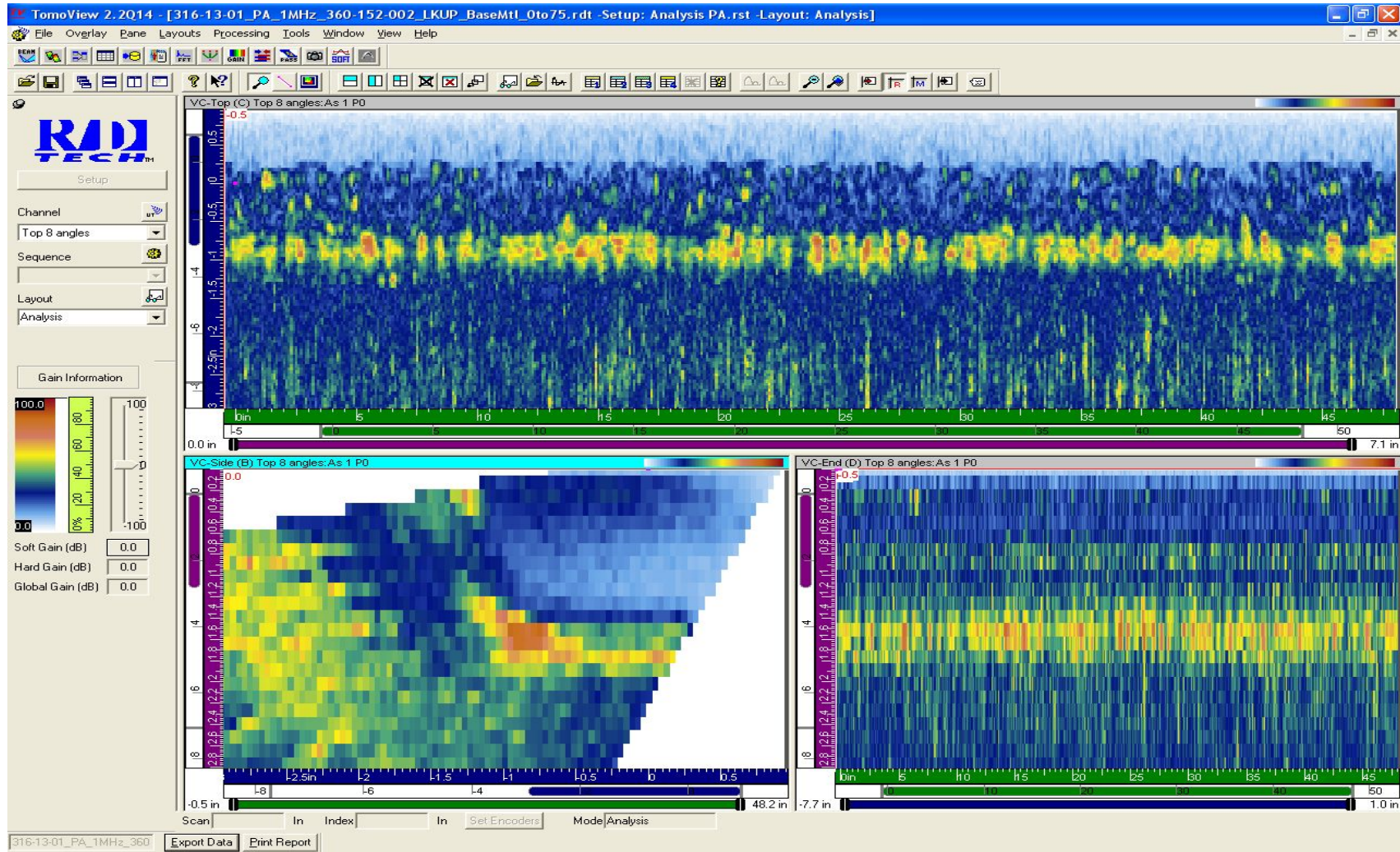
Status of Projects

- Examination Overlays Over Cast Base Material (Cont.)
 - Ongoing work
 - Scans performed on non-overlaid base material in an effort to evaluate material
 - Scanned corner of block with angle beam search units
 - Defined corner trap signal noted for entire circumference (No significant deviations in response noted for entire scan)
 - No non-spectral reflections or tip diffracted signals noted from face of flaws
 - Performed zero degree scan of entire base material through overlay and on base material only
 - Consistent back reflection noted with no significant deviations in responses

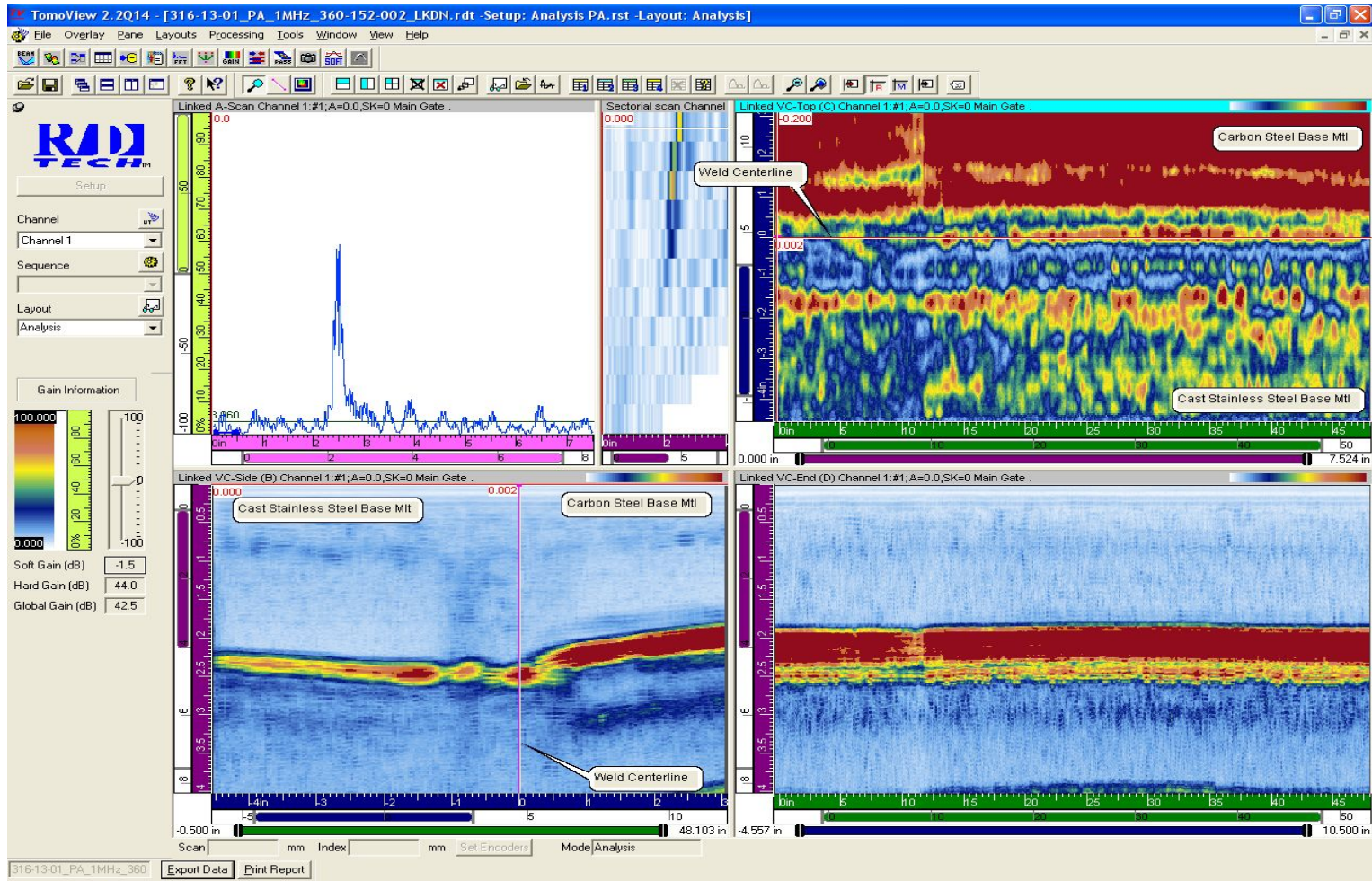
Status of Projects



Status of Projects



Status of Projects



Status of Projects

- Examination Overlays Over Cast Base Material (Cont.)
 - Ongoing work
 - Designing and purchasing conventional 500Khz search units
 - Borrowing modified instrument capable of collecting 500Khz data
 - Through transmission techniques
 - Delta techniques
 - Evaluating responses from rougher surfaces
 - Preliminary conclusions
 - Non-Spectral reflections from face of flaws reduced or eliminated in cast material
 - Flaws may be too smooth
 - Do not know what target flaws characteristics should be (Rough, smooth, branched)
 - No corner trap signal from flaws
 - Alternative flaw making processes may have to be evaluated
 - No good alternatives available that will provide accurate flaw size information
 - May need additional research
 - Modifications to HIP process to make rougher flaws

Status of Projects

- Examination Overlays Over Cast Base Material (Cont.)
 - Main Loop RCS overlay samples being designed
 - Uncertainty of flaw type may delay project
 - Engineering solution being evaluated at this time

Conclusion

- Several projects funded that are focused on mitigation of Alloy 600 components
- Major focus on improving examination techniques and expanding qualified procedures
- Significant Code activity underway