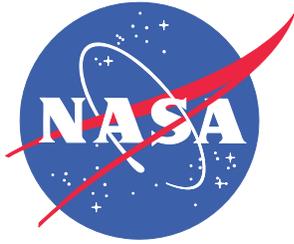


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NESC-RP-12-00824



Independent Assessment of Instrumentation for ISS On-Orbit NDE

Appendices

*Eric I Madaras/NESC
Langley Research Center, Hampton, Virginia*

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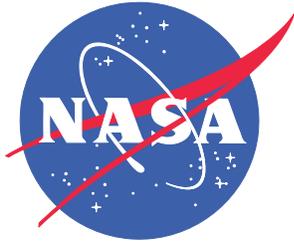
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Appendices

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National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23681-2199

July 2013

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Appendices

Independent Assessment of Instrumentation for International Space Station (ISS) On-orbit Nondestructive Evaluation (NDE)

May 16, 2013

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Appendix A. “MPLM Post-Proof Test Inspection Status,” Presented to the Space Station Program Control Board (SSPCB), February 14, 2005





MPLM Post-Proof Test Inspection Status

Last Updated 2/14/05

Chris Hansen
 Kornel Nagy
 Al Parrish
 NASA-JSC Engineering





Completed Work

- **Single-sided Eddy-Current inspections completed for FM2**
 - No flaws identified
- **Peaking and mismatch data verified and updated**
- **MPLM Finite Element Models verified**
 - NASA and Boeing experts worked with Alenia to evaluate existing MPLM models
 - Stress states for MPLM now well understood
 - Peaking and mismatch effects on weld stress well understood (peaking shown to have a large effect on stress levels)
- **MPLM Load spectrum development completed**
- **Fracture analysis for FM-2 is now complete**

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Analysis Results Summary



- **The minimum Critical Initial Flaw Size (CIFS) for the MPLM, using recent as-measured data was calculated to be 74mm (~3 in.)**
 - Full table of results is included in back-up charts
- **With an assumed flaw that is 90% through the thickness of the weld (the largest assumed flaw that we could have missed during inspections), the MPLM shows a capability of surviving a 5 mission profile**
 - 1 mission profile consists of 25 flights
 - This data is valid for both as-built measurements for peaking/mismatch, and spec values (up to 5° peaking)

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Conclusions for FM-2



- **Based on available data, the position of the JSC Fracture Control Board and JSC Engineering is that FM2 is currently certified for 1 more flight with no waiver rationale required**
 - The FCB would like to see the results of the Simulated Service testing before clearing FM2 for life, but positive results based on experience and already completed testing lead to a high level of confidence that FM2 will be cleared for life with no further testing, or waiver, required
- **MSFC Fracture Control Board has not completed their assessment for flight certification**

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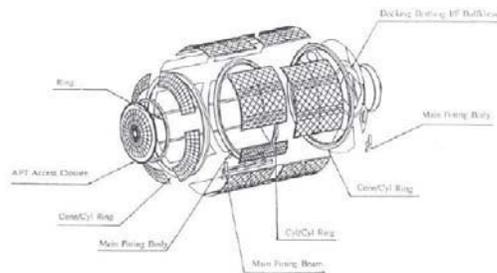
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Future Work – FM1



- **Actual peaking and mismatch measurements for FM1 is complete, therefore stress models and load spectrums from FM2 can be used since they envelope FM1**



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Future Work – FM1



- **Option 1: perform a single-sided eddy current inspection of FM1, equivalent to inspections performed on FM2**
 - Will certify FM1 for 1 flight, and probably for life based on final results from Simulated Service testing
 - No waiver required
 - Recommended option by JSC Eng. and JSC FCB
- **Option 2: Perform a single-sided eddy current inspection of FM1 radial welds only**
 - Will certify FM1 for 1 flight only, with a waiver required, but JSC Eng. and JSC FCB find this a technically acceptable option
 - Inspection of all welds missed during initial inspection will have to be completed before following FM1 flight
- **Option 3: No inspection**
 - Not supported by JSC Eng or JSC FCB
 - Effect of peaking on weld stresses very severe and not accounted for in original analysis, does not meet fracture control reqts.
- **Recommendations do not include MSFC FCB or NESC yet**

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Back-up charts



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Analysis Results



	No.	Peaking Angle (deg)	Mismatch (mm)	Stress Combination	Critical Initial Flaw Size (CIFS) (mm)
As-built Alenia data →	1	2.5 ⁽²⁾	0.5	Max Tension	76
				Max Bending	136
As measured peaking data →	2	3.15 ⁽³⁾	0.5	Max Tension	74
				Max Bending	136
Spec peaking value →	3	5.0 ⁽⁴⁾	0.0	Max Tension	66
				Max Bending	136

No.	Peaking Angle (deg)	Mismatch (mm)	Stress Combination	Proof Cycles	Ground Press Cycle	Flaw Size (depth/length) mm		Life
						Start	Failed	
1	2.5 ⁽²⁾	0.5	Max Tension	Yes	Yes	6.3 / 63	79	6
				No	Yes	6.3 / 63	NA	<1 ⁽⁵⁾
2	3.15 ⁽³⁾	0.5	Max Bending	Yes	Yes	6.3 / 63	6.417 / 65.2	50 +
				No	Yes	6.3 / 63	77	5
3	5.0 ⁽⁴⁾	0.0	Max Tension	No	No	6.3 / 63	69	7
				Yes	Yes	6.3 / 63	6.35 / 65.7	50+

(5) 1 life = 25 MPLM flights for this analysis

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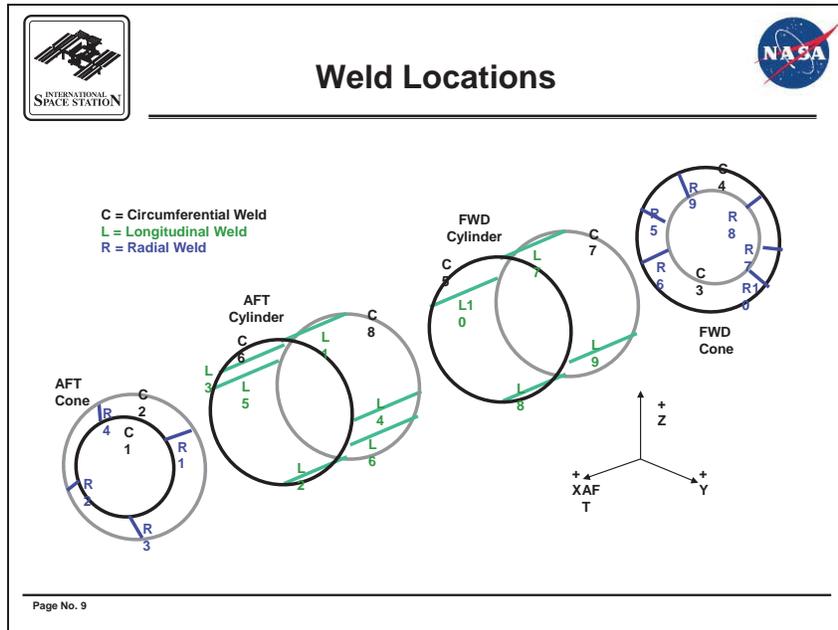
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Appendix B. Presentation to SRB: MMOD Excerpts




Systems Engineering and Integration Office

Presentation to SRB
4/26/2013
MMOD Excerpts

5/8/2013





MMOD Risk
10 Year Risk Assessment



ISS MMOD Risks				
10-year future time period, updated with latest NASA results documented in JSC-65837 and JSC-66198				
	Date	Penetration Risk	Loss-of-crew (LOC) Risk	Evacuation Risk due to MMOD
Requirement (Penetration Risk) Goal (LOC Risk)		≤ 24% (PNP=0.76)	≤ 5% (PNCf=0.95)	NA
Assessed ISS Risk In March 2012	March 2012	52% (PNP=0.48)	8.0% (PNCf=0.920)	16.1% (PNeVac=0.839)
With partial implementation of Progress enhancement beginning with 47P	April 2012	49.0% (PNP=0.510)	7.6% (PNCf=0.924)	14.4% (PNeVac=0.856)
Above and Soyuz enhancement beginning with 30S	May 2012	34.5% (PNP=0.655)	5.2% (PNCf=0.948)	14.3% (PNeVac=0.857)
Above and 5 SM debris panels installed on RS EVA 31	August 2012	33.9% (PNP=0.661)	5.1% (PNCf=0.949)	13.7% (PNeVac=0.863)
Above and full implementation of Progress enhancement beginning with 57P	October 2014	28.0% (PNP=0.720)	4.6% (PNCf=0.954)	11.0% (PNeVac=0.890)
Above and commercial crew vehicles beginning in 2017 (reduce Soyuz flights)	2017	26.5% (PNP=0.735)**	4.4% (PNCf=0.956)	11.0% (PNeVac=0.890)

Completed
↑
↓
Planned

** The future mix of visiting vehicles subject to change. As commercial crew and cargo vehicles replace Soyuz/Progress vehicles, ISS MMOD risks will improve.

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MMOD Risk

10 Year Risk Assessment



- **MMOD risk assessments will be updated after the new orbital debris model (ORDEM 3.0) is released, and as additional elements are added to ISS.**
 - Overall ISS MMOD Risks will likely increase with these changes, although risks for some modules will decrease while others (mainly Russian visiting vehicles) will increase
- **“Penetration” is a hole in pressure shell of crew modules, damage/hole in external pressure vessels, damage to CMG rotors (i.e., MMOD damage that endangers crew &/or ISS survivability)**
 - 90% of the MMOD penetration risk is due to RS elements, 10% of risk due to NASA/ESA/JAXA elements
- **Loss-of-crew (LOC) risk results from rapid depress due to MMOD penetration, internal fragments causing LOC injury, and other catastrophic failure modes.**
- **Evacuation from MMOD results if some or all crew are evacuated due to non-fatal injury to crew (requiring evac), rapid depress (uncontrolled depress) or loss of critical functions (SM or Node 3 depress). No loss of crew risk is included in the evac risk assessment.**

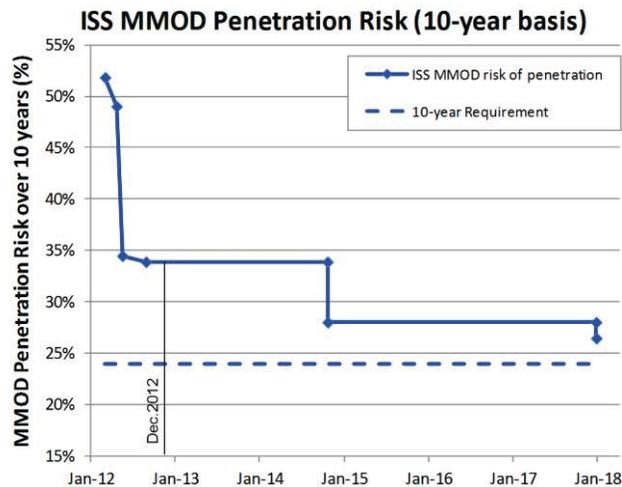
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MMOD Risk

Penetration Risk Over Time



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Appendix C. Manufactured Test Articles

NDE Flaw Detectability Feasibility Study Standards

September 12, 2012

Ajay Koshti

1

Summary of NDE Standards

Standard #	Description	Qty	Plate Thickness	Construction	Usage Notes	Fabricated By
1A	Iso-grid plate with notches and flat bottom holes, flaws on grid side	1	0.436"	Iso-grid flat	Simulates FGB pressure wall MMOD damage	LaRC
1B	Iso-grid plate with notches and flat bottom holes, flaws on flat side	1	0.436"	Iso-grid flat	Simulates FGB pressure wall MMOD damage	LaRC
2	Flat plate with notches and flat bottom holes along two lines	2	0.1875	Flat	Simulates US module MMOD damage, shear wave from a distance with and without patch	LaRC
3	Flat plate with flat bottom holes in circular pattern	1	0.1875	Flat	Simulates US module MMOD damage, JSC shear wave from a distance with and without patch	JSC
4	Flat plate with notches and flat bottom holes along two lines	2	0.0625	Flat	Simulates FGB pressure wall MMOD damage with and without patch	LaRC
5	Flat plate with flat bottom holes in circular pattern	1	0.0625	Flat	Simulates FGB pressure wall MMOD damage with and without patch	JSC
6A	Curved plate with notches and flat bottom holes along two lines, notches parallel to curved edge	1	0.1875	83" radius	Simulates US module MMOD damage, JSC shear wave from a distance with and without patch	JSC
6B	Curved plate with notches and flat bottom holes along two lines, notches parallel to straight edge	1	0.1875	83" radius	Simulates US module MMOD damage, JSC shear wave from a distance with and without patch	JSC
7A	Curved plate with notches and flat bottom holes along two lines, notches parallel to curved edge	1	0.1875	25" radius	Simulates US module MMOD damage, JSC shear wave from a distance with and without patch	JSC
7B	Curved plate with notches and flat bottom holes along two lines, notches parallel to straight edge	1	0.1875	25" radius	Simulates US module MMOD damage, JSC shear wave from a distance with and without patch	JSC

Note: Autocad files or pdf copies of individual drawings are available

2

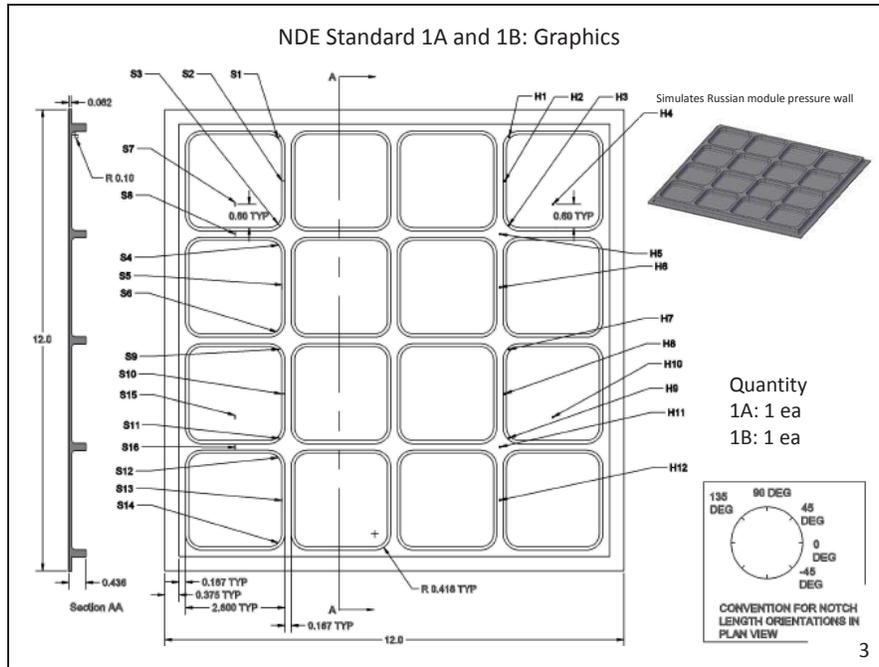


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NDE Standard 1: Notes

Part
Name: **NDE Standard 1A**
Part Description: Flat plate with drilled holes and EDM slots

Annotated Entity	Description	Other Description
S1	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.010 +/-0.003	Length along fillet radius, 45 deg
S2	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.010 +/-0.003	Length along fillet radius, 0 deg
S3	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.010 +/-0.003	Length along fillet radius, -45 deg
S4	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.010 +/-0.003	Length along the tangent of the fillet radius, 135 deg
S5	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.010 +/-0.003	Length along the tangent of the fillet radius, 90 deg
S6	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.010 +/-0.003	Length along the tangent of the fillet radius, 45 deg
S7	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.010 +/-0.003	Length along 90 deg
S8	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.010 +/-0.003	Length along 90 deg
S9	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.020 +/-0.003	Length along fillet radius, 45 deg
S10	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.020 +/-0.003	Length along fillet radius, 0 deg
S11	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.020 +/-0.003	Length along fillet radius, -45 deg
S12	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.020 +/-0.003	Length along the tangent of the fillet radius, 135 deg
S13	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.020 +/-0.003	Length along the tangent of the fillet radius, 90 deg
S14	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.020 +/-0.003	Length along the tangent of the fillet radius, 45 deg
S15	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.020 +/-0.003	Length along 90 deg
S16	EDM Slot Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.020 +/-0.003	Length along 90 deg
H1	Drilled Hole Diameter 3/64, Depth 0.010 +/-0.003	Length along 90 deg
H2	Drilled Hole Diameter 3/64, Depth 0.010 +/-0.003	
H3	Drilled Hole Diameter 3/64, Depth 0.010 +/-0.003	
H4	Drilled Hole Diameter 3/64, Depth 0.010 +/-0.003	
H5	Drilled Hole Diameter 3/64, Depth 0.010 +/-0.003	
H6	Drilled Hole Diameter 3/64, Depth 0.010 +/-0.003	
H7	Drilled Hole Diameter 3/64, Depth 0.020 +/-0.003	
H8	Drilled Hole Diameter 3/64, Depth 0.020 +/-0.003	
H9	Drilled Hole Diameter 3/64, Depth 0.020 +/-0.003	
H10	Drilled Hole Diameter 3/64, Depth 0.020 +/-0.003	
H11	Drilled Hole Diameter 3/64, Depth 0.020 +/-0.003	
H12	Drilled Hole Diameter 3/64, Depth 0.020 +/-0.003	

- General Notes**
- 1 Material: AL 6061 T6
 - 2 Dimensions in inches
 - 3 Locate slots and holes as indicated using a full scale template on flat side
 - 4 Tolerance: X.X = +/-0.1, X.XX = +/-0.01, X.XXX = 0.002 Unless Otherwise Specified.
 - 5 Surface finish 63 RHR or better. Break sharp edges and corners.
 - 6 Use flat tip drill for drilled holes
 - 7 Drilled holes and slots are machined normal to the local surface on the Flat side

Ajay Koshi, August 14, 2012

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NDE Standard 1B: Notes

Part Name: **NDE Standard 1B**
Part Description: Flat plate with drilled holes and EDM slots

Annotation

n	Annotated Entity	Description
S1	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.010 +/-0.003
S2	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.010 +/-0.003
S3	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.010 +/-0.003
S4	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.010 +/-0.003
S5	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.010 +/-0.003
S6	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.010 +/-0.003
S7	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.010 +/-0.003
S8	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.010 +/-0.003
S9	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.020 +/-0.003
S10	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.020 +/-0.003
S11	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.020 +/-0.003
S12	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.020 +/-0.003
S13	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.020 +/-0.003
S14	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.020 +/-0.003
S15	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.020 +/-0.003
S16	EDM Slot	Length 0.100 +/-0.005, Width 0.003 -0.006, Depth 0.020 +/-0.003
H1	Drilled Hole	Diameter 3/64, Depth 0.010 +/-0.003
H2	Drilled Hole	Diameter 3/64, Depth 0.010 +/-0.003
H3	Drilled Hole	Diameter 3/64, Depth 0.010 +/-0.003
H4	Drilled Hole	Diameter 3/64, Depth 0.010 +/-0.003
H5	Drilled Hole	Diameter 3/64, Depth 0.010 +/-0.003
H6	Drilled Hole	Diameter 3/64, Depth 0.010 +/-0.003
H7	Drilled Hole	Diameter 3/64, Depth 0.020 +/-0.003
H8	Drilled Hole	Diameter 3/64, Depth 0.020 +/-0.003
H9	Drilled Hole	Diameter 3/64, Depth 0.020 +/-0.003
H10	Drilled Hole	Diameter 3/64, Depth 0.020 +/-0.003
H11	Drilled Hole	Diameter 3/64, Depth 0.020 +/-0.003
H12	Drilled Hole	Diameter 3/64, Depth 0.020 +/-0.003

Other Description

Length along fillet radius, 45 deg
Length along fillet radius, 0 deg
Length along fillet radius, -45 deg
Length along the tangent of the fillet radius, 135 deg
Length along the tangent of the fillet radius, 90 deg
Length along the tangent of the fillet radius, 45 deg
Length along 90 deg
Length along 90 deg
Length along fillet radius, 45 deg
Length along fillet radius, 0 deg
Length along fillet radius, -45 deg
Length along the tangent of the fillet radius, 135 deg
Length along the tangent of the fillet radius, 90 deg
Length along the tangent of the fillet radius, 45 deg
Length along 90 deg
Length along 90 deg

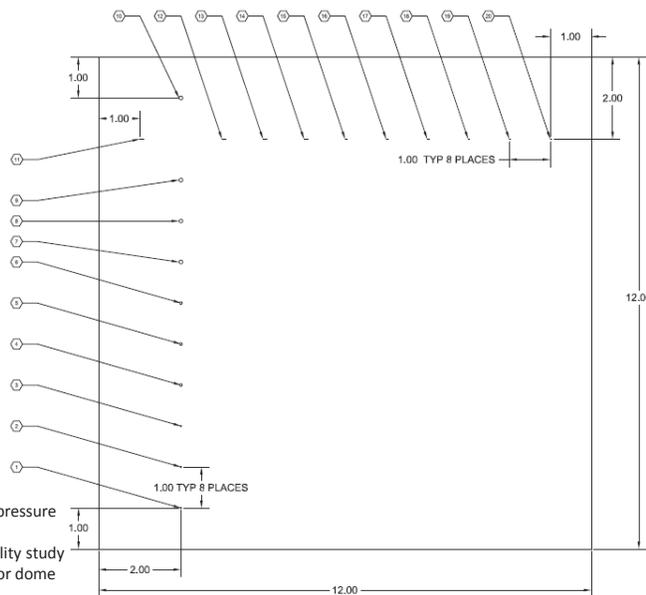
General Notes

- 1 Material: AL 6061 T6
- 2 Dimensions in inches.
- 3 Locate slots and holes visibly centered as indicated
- 4 Tolerance: XX = +/-0.1, XXX = +/-0.01, XXXX = 0.002 Unless Otherwise Specified.
- 5 Surface finish 63 RHR or better. Break sharp edges and corners.
- 6 Use flat tip drill for drilled holes
- 7 Drilled holes and slots are machined normal to the local surface on the iso-grid side

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NDE Standard 2

Quantity: 2 ea



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NDE Standard 2: Notes

Part Name: NDE Standard 2
Part Description: Flat plate with drilled holes and EDM slots

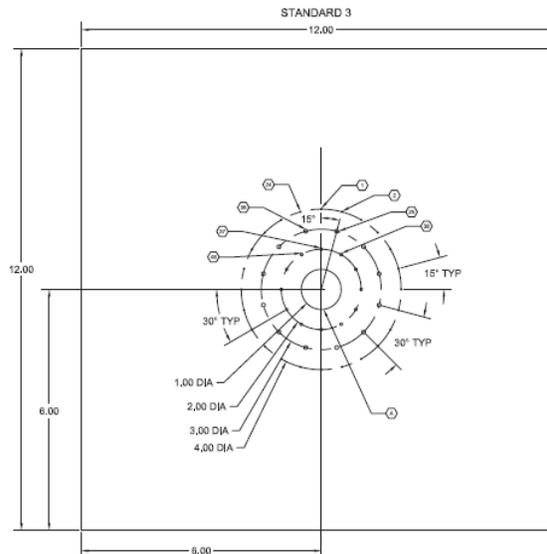
Hex Notes	Annotated Entity	Description
	0 Plate	AL 6061 T6, 0.1875 +/-0.002 Thick, 12.00 Long X 12.00 Wide
	1 Drilled Hole	Diameter 1/32, Depth 0.025 +/-0.003
	2 Drilled Hole	Diameter 1/32, Depth 0.050 +/-0.003
	3 Drilled Hole	Diameter 1/32, Depth 0.075 +/-0.003
	4 Drilled Hole	Diameter 1/16, Depth 0.025 +/-0.003
	5 Drilled Hole	Diameter 1/16, Depth 0.050 +/-0.003
	6 Drilled Hole	Diameter 1/16, Depth 0.075 +/-0.003
	7 Drilled Hole	Diameter 3/32, Depth 0.025 +/-0.003
	8 Drilled Hole	Diameter 3/32, Depth 0.050 +/-0.003
	9 Drilled Hole	Diameter 3/32, Depth 0.075 +/-0.003
	10 Drilled Hole	Diameter 3/32, Depth 0.100 +/-0.003
	11 EDM Slot	Length 0.032 +/-0.005, Width 0.003 -0.006, Depth 0.025 +/-0.003
	12 EDM Slot	Length 0.032 +/-0.005, Width 0.003 -0.006, Depth 0.050 +/-0.003
	13 EDM Slot	Length 0.032 +/-0.005, Width 0.003 -0.006, Depth 0.075 +/-0.003
	14 EDM Slot	Length 0.063 +/-0.005, Width 0.003 -0.006, Depth 0.100 +/-0.003
	15 EDM Slot	Length 0.063 +/-0.005, Width 0.003 -0.006, Depth 0.125 +/-0.003
	16 EDM Slot	Length 0.063 +/-0.005, Width 0.003 -0.006, Depth 0.025 +/-0.003
	17 EDM Slot	Length 0.094 +/-0.005, Width 0.003 -0.006, Depth 0.050 +/-0.003
	18 EDM Slot	Length 0.094 +/-0.005, Width 0.003 -0.006, Depth 0.075 +/-0.003
	19 EDM Slot	Length 0.094 +/-0.005, Width 0.003 -0.006, Depth 0.100 +/-0.003
	20 EDM Slot	Length 0.094 +/-0.005, Width 0.003 -0.006, Depth 0.125 +/-0.003

- General Notes**
- 1 Dimensions in inches.
 - 2 Location Tolerances for Holes and Slots: +/- 0.010.
 - 3 Tolerance: XX = +/-0.1, XXX = +/- 0.01, XXXX = 0.002 Unless Otherwise Specified.
 - 4 Surface finish 63 RHR or better. Break sharp edges and corners.
 - 5 Use 120 degree tipped drill for drilled holes.

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NDE Standard 3

Quantity: 1 ea



Simulates US module
pressure wall.
For NDE flaw detectability
study under patch or don
repair

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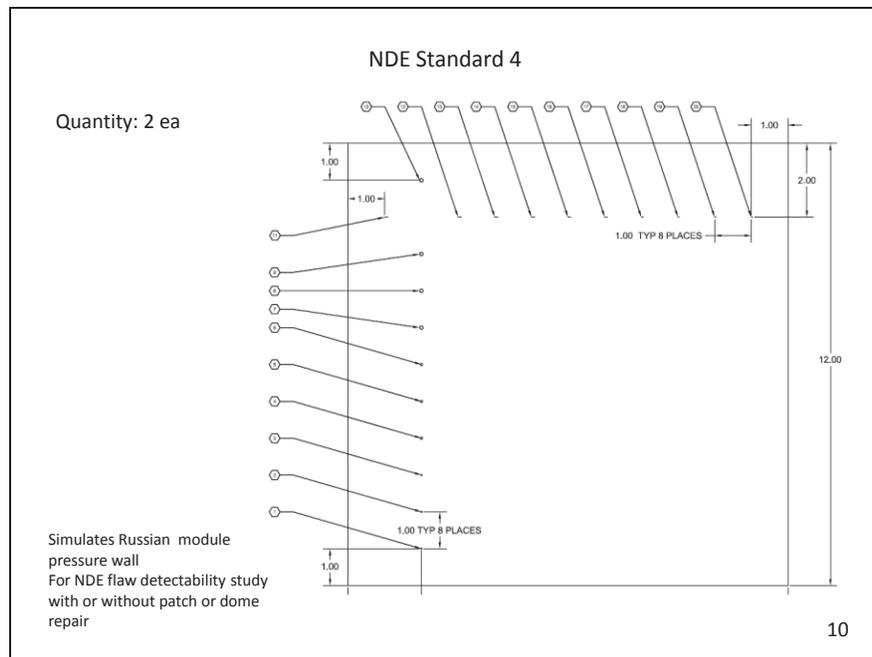
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NDE Standard 3: Notes					
Part Name	NDE Standard 3				
Part Description	Flat Plate with Drilled Holes				
Numbered Hex Notes	Diameter	Depth	Numbered Hex Notes	Diameter	Depth
1	0.031	0.025	25	0.063	0.125
2	0.031	0.050	26	0.063	0.100
3	0.031	0.075	27	0.063	0.075
4	0.031	0.100	28	0.063	0.050
5	0.031	0.125	29	0.063	0.025
6	0.031	0.025	30	0.063	0.125
7	0.031	0.050	31	0.063	0.100
8	0.031	0.075	32	0.063	0.075
9	0.031	0.100	33	0.063	0.050
10	0.031	0.125	34	0.063	0.025
11	0.031	0.025	35	0.063	0.050
12	0.031	0.050	36	0.063	0.025
13	0.031	0.075	37	0.094	0.125
14	0.031	0.100	38	0.094	0.100
15	0.031	0.125	39	0.094	0.075
16	0.031	0.025	40	0.094	0.050
17	0.031	0.050	41	0.094	0.025
18	0.031	0.075	42	0.094	0.125
19	0.031	0.100	43	0.094	0.100
20	0.031	0.125	44	0.094	0.075
21	0.031	0.050	45	0.094	0.050
22	0.031	0.075	46	0.094	0.025
23	0.031	0.100	47	0.094	0.125
24	0.031	0.125	48	0.094	0.100

Letter Hex Note
A Hole Diameter 1.000 +/- 0.005, Depth 0.100 +/- 0.005, Inner Fillet Radius 0.032 +/- 0.005

General Notes
1 AL 6061 T6, 0.1875 +/- 0.002 Thick, 12.00 Long X 12.00 Wide
2 Dimensions in Inches.
3 Hex note number is same as hole #. Drilled holes are arranged on three circles. Hole numbers are counted clockwise on each circle.
4 Hole # 1 through 48 are drilled with 120 deg. tip angle drills
5 Drilled Hole Tolerance: Diameter +/- 0.005, Depth +/- 0.002
6 Location Tolerance for Holes : +/- 0.010 and +/- 2 Deg
7 Dimensional Tolerance: XX = +/- 0.1, XXX = +/- 0.01, XXXX = 0.002 Unless Otherwise Specified.
8 Surface finish 63 RHR or better. Deburr holes. Break external sharp edges and corners.
9 Use 120 degree tipped drill for drilled holes.

9



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NDE Standard 4

Part Name NDE Standard 4
Part Description: Flat plate with drilled holes and EDM slots

Hex Notes	Annotated Entity	Description
0	Plate	AL 6061 T6, 0.063 +/-0.002 Thick, 12.00 Long X 12.00 Wide
1	Drilled Hole	Diameter 1/32, Depth 0.010 +/-0.003
2	Drilled Hole	Diameter 1/32, Depth 0.020 +/-0.003
3	Drilled Hole	Diameter 1/32, Depth 0.030 +/-0.003
4	Drilled Hole	Diameter 1/16, Depth 0.010 +/-0.003
5	Drilled Hole	Diameter 1/16, Depth 0.020 +/-0.003
6	Drilled Hole	Diameter 1/16, Depth 0.030 +/-0.003
7	Drilled Hole	Diameter 3/32, Depth 0.010 +/-0.003
8	Drilled Hole	Diameter 3/32, Depth 0.020 +/-0.003
9	Drilled Hole	Diameter 3/32, Depth 0.030 +/-0.003
10	Drilled Hole	Diameter 3/32, Depth 0.040 +/-0.003
11	EDM Slot	Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.005 +/-0.002
12	EDM Slot	Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.010 +/-0.003
13	EDM Slot	Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.020 +/-0.003
14	EDM Slot	Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.030 +/-0.003
15	EDM Slot	Length 0.100 +/-0.005, Width 0.003-0.006, Depth 0.040 +/-0.003
16	EDM Slot	Length 0.200 +/-0.005, Width 0.003-0.006, Depth 0.005 +/-0.003
17	EDM Slot	Length 0.200 +/-0.005, Width 0.003-0.006, Depth 0.010 +/-0.003
18	EDM Slot	Length 0.200 +/-0.005, Width 0.003-0.006, Depth 0.020 +/-0.003
19	EDM Slot	Length 0.200 +/-0.005, Width 0.003-0.006, Depth 0.030 +/-0.003
20	EDM Slot	Length 0.200 +/-0.005, Width 0.003-0.006, Depth 0.040 +/-0.003

General Notes

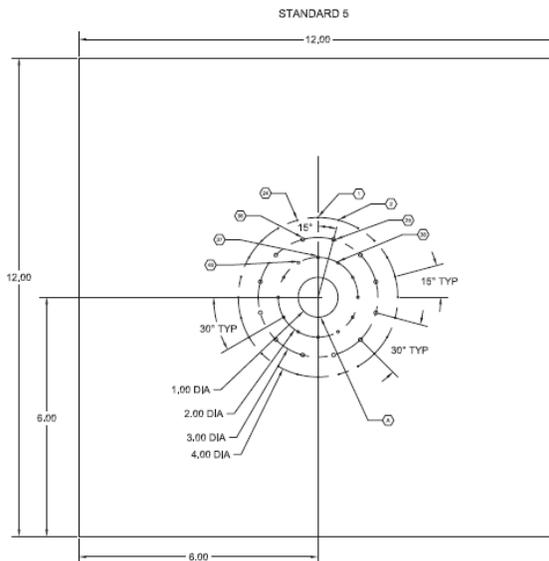
- Dimensions in inches.
- Location Tolerances for Holes and Slots: +/- 0.010.
- Tolerance: X.X = +/- 0.1, X.XX = +/- 0.01, X.XXX = 0.002 Unless Otherwise Specified.
- Surface finish 63 RHR or better. Break sharp edges and corners.
- Surface finish 63 RHR or better. Break sharp edges and corners.
- Use flat tip drill for drilled holes

Ajay Koshti, July 9, 2012

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NDE Standard 5

Quantity: 1 ea



Simulates Russian module press wall

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NDE Standard 5

Part Name		NDE Standard 5			
Part Description		Flat plate with drilled holes			
Numbered Hex Notes	Diameter	Depth	Numbered Hex Notes	Diameter	Depth
1	0.031	0.005	25	0.063	0.005
2	0.031	0.010	26	0.063	0.010
3	0.031	0.015	27	0.063	0.015
4	0.031	0.020	28	0.063	0.020
5	0.031	0.025	29	0.063	0.025
6	0.031	0.030	30	0.063	0.030
7	0.031	0.035	31	0.063	0.035
8	0.031	0.040	32	0.063	0.040
9	0.031	0.005	33	0.063	0.025
10	0.031	0.010	34	0.063	0.030
11	0.031	0.015	35	0.063	0.035
12	0.031	0.020	36	0.063	0.040
13	0.031	0.025	37	0.094	0.005
14	0.031	0.030	38	0.094	0.010
15	0.031	0.035	39	0.094	0.015
16	0.031	0.040	40	0.094	0.020
17	0.031	0.005	41	0.094	0.025
18	0.031	0.010	42	0.094	0.030
19	0.031	0.015	43	0.094	0.035
20	0.031	0.020	44	0.094	0.040
21	0.031	0.025	45	0.094	0.025
22	0.031	0.030	46	0.094	0.030
23	0.031	0.035	47	0.094	0.035
24	0.031	0.040	48	0.094	0.040

Letter Hex Note
A Hole Diameter 1.000+/- 0.005, Through Hole

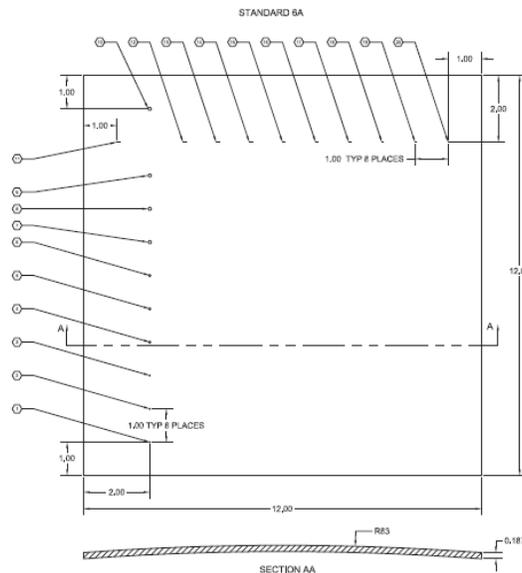
General Notes
1 AL 6061 T6, 0.063 +/-0.002 Thick, 12.00 Long X 12.00 Wide
2 Dimensions in inches.
3 Hex note number is same as hole #. Drilled holes are arranged on three circles. Hole numbers are counted clockwise on each circle
4 Hole # 1 through 48 are drilled with flat tip drills
5 Drilled Hole Tolerance: Diameter +/- 0.005, Depth +/- 0.002
6 Location tolerance for holes: +/- 0.010 and +/- 2 Deg
7 Dimensional tolerance: X.X = +/-0.1, X.XX = +/- 0.01, X.XXX = 0.002 Unless Otherwise Specified.
8 Surface finish 63 RHR or better. Deburr holes. Break external sharp edges and corners.

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NDE Standard 6A

Quantity:
6A: 1 ea

83" Radius



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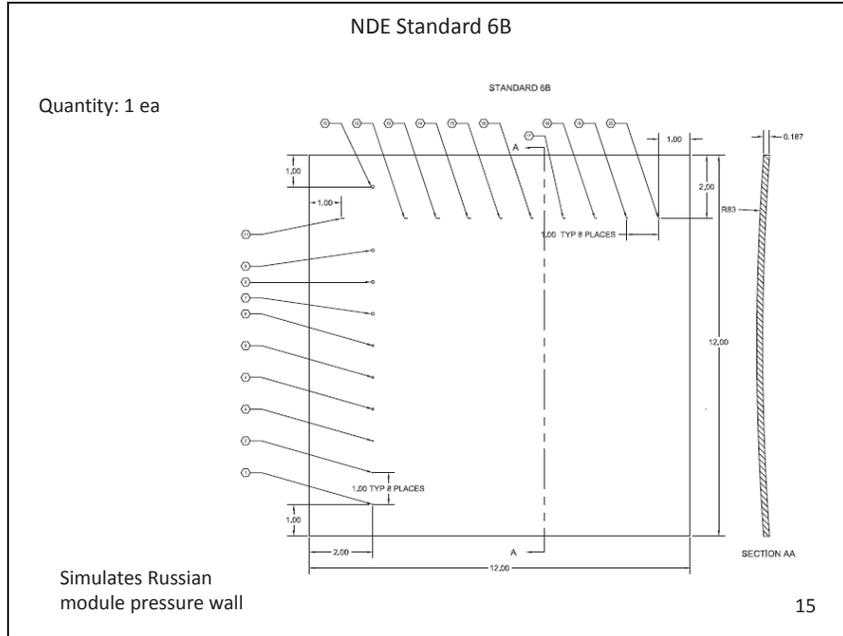
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NDE Standard 6A and 6B

Part Name: NDE Standard 6A and 6B
Part Description: Curved plate with drilled holes and EDM slots

Hex Notes	Annotated Entity	Description
0	Plate	AL 6061 T6, 0.1875 +/-0.002 Thick, 12.00 Long X 12.00 Wide
1	Drilled Hole	Diameter 1/32, Depth 0.025 +/-0.003
2	Drilled Hole	Diameter 1/32, Depth 0.050 +/-0.003
3	Drilled Hole	Diameter 1/32, Depth 0.075 +/-0.003
4	Drilled Hole	Diameter 1/16, Depth 0.025 +/-0.003
5	Drilled Hole	Diameter 1/16, Depth 0.050 +/-0.003
6	Drilled Hole	Diameter 1/16, Depth 0.075 +/-0.003
7	Drilled Hole	Diameter 3/32, Depth 0.025 +/-0.003
8	Drilled Hole	Diameter 3/32, Depth 0.050 +/-0.003
9	Drilled Hole	Diameter 3/32, Depth 0.075 +/-0.003
10	Drilled Hole	Diameter 3/32, Depth 0.100 +/-0.003
11	EDM Slot	Length 0.032 +/-0.005, Width 0.003 -0.006, Depth 0.025 +/-0.003
12	EDM Slot	Length 0.032 +/-0.005, Width 0.003 -0.006, Depth 0.050 +/-0.003
13	EDM Slot	Length 0.032 +/-0.005, Width 0.003 -0.006, Depth 0.075 +/-0.003
14	EDM Slot	Length 0.063 +/-0.005, Width 0.003 -0.006, Depth 0.100 +/-0.003
15	EDM Slot	Length 0.063 +/-0.005, Width 0.003 -0.006, Depth 0.125 +/-0.003
16	EDM Slot	Length 0.063 +/-0.005, Width 0.003 -0.006, Depth 0.025 +/-0.003
17	EDM Slot	Length 0.094 +/-0.005, Width 0.003 -0.006, Depth 0.050 +/-0.003
18	EDM Slot	Length 0.094 +/-0.005, Width 0.003 -0.006, Depth 0.075 +/-0.003
19	EDM Slot	Length 0.094 +/-0.005, Width 0.003 -0.006, Depth 0.100 +/-0.003
20	EDM Slot	Length 0.094 +/-0.005, Width 0.003 -0.006, Depth 0.125 +/-0.003

General Notes

- Dimensions in inches.
- Location Tolerances for Holes and Slots: +/- 0.010.
- Tolerance: X.X = +/-0.1, X.XX = +/-0.01, X.XXX = 0.002 Unless Otherwise Specified.
- Surface finish 63 RHR or better. Break sharp edges and corners.
- For standard 6A, notch lengths are parallel to curved edge of the part
- For standard 6B, notch lengths are parallel to straight edge of the part
- Curved plate inner radius: 83 +/- 5
- Holes and notches are machined perpendicular to machined surface from the convex side
- Use 120 degree tipped drill for drilled holes.

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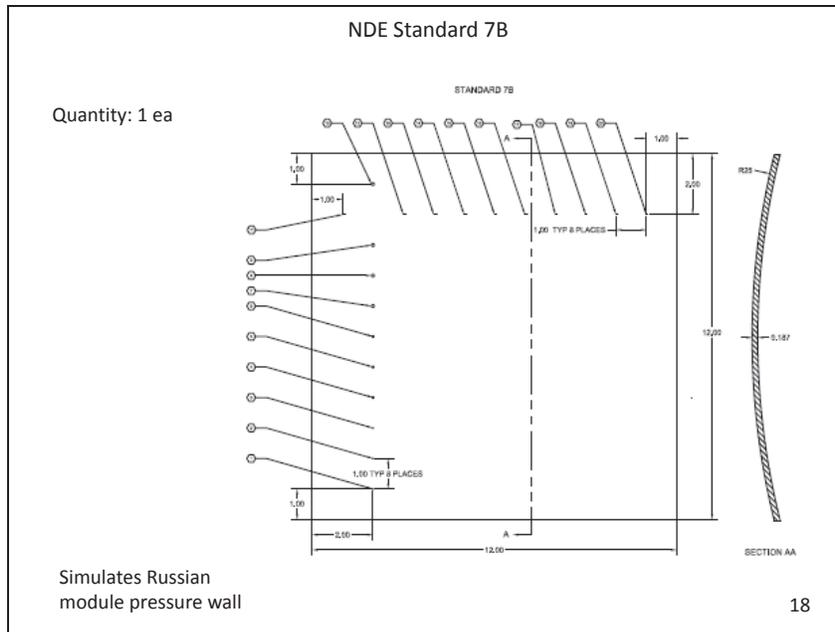
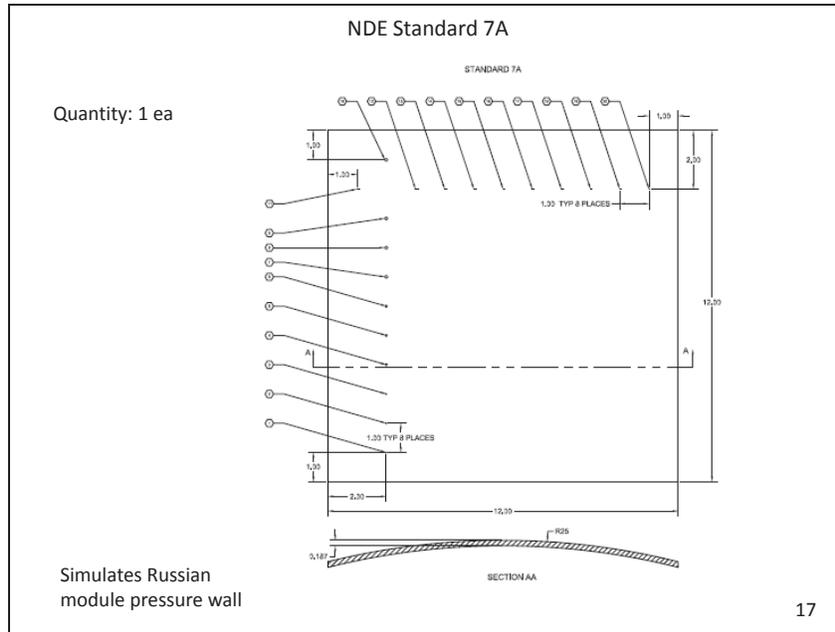


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NDE Standard 7A and 7B

Part Name: **NDE Standard 7A and 7B**

Part Description: Curved plate with drilled holes and EDM slots

Hex Notes	Annotated Entity	Description
0	Plate	AL 6061 T6, 0.1875 +/-0.002 Thick, 12.00 Long X 12.00 Wide
1	Drilled Hole	Diameter 1/32, Depth 0.025 +/-0.003
2	Drilled Hole	Diameter 1/32, Depth 0.050 +/-0.003
3	Drilled Hole	Diameter 1/32, Depth 0.075 +/-0.003
4	Drilled Hole	Diameter 1/16, Depth 0.025 +/-0.003
5	Drilled Hole	Diameter 1/16, Depth 0.050 +/-0.003
6	Drilled Hole	Diameter 1/16, Depth 0.075 +/-0.003
7	Drilled Hole	Diameter 3/32, Depth 0.025 +/-0.003
8	Drilled Hole	Diameter 3/32, Depth 0.050 +/-0.003
9	Drilled Hole	Diameter 3/32, Depth 0.075 +/-0.003
10	Drilled Hole	Diameter 3/32, Depth 0.100 +/-0.003
11	EDM Slot	Length 0.032 +/-0.005, Width 0.003 -0.006, Depth 0.025 +/-0.003
12	EDM Slot	Length 0.032 +/-0.005, Width 0.003 -0.006, Depth 0.050 +/-0.003
13	EDM Slot	Length 0.032 +/-0.005, Width 0.003 -0.006, Depth 0.075 +/-0.003
14	EDM Slot	Length 0.063 +/-0.005, Width 0.003 -0.006, Depth 0.100 +/-0.003
15	EDM Slot	Length 0.063 +/-0.005, Width 0.003 -0.006, Depth 0.125 +/-0.003
16	EDM Slot	Length 0.063 +/-0.005, Width 0.003 -0.006, Depth 0.025 +/-0.003
17	EDM Slot	Length 0.094 +/-0.005, Width 0.003 -0.006, Depth 0.050 +/-0.003
18	EDM Slot	Length 0.094 +/-0.005, Width 0.003 -0.006, Depth 0.075 +/-0.003
19	EDM Slot	Length 0.094 +/-0.005, Width 0.003 -0.006, Depth 0.100 +/-0.003
20	EDM Slot	Length 0.094 +/-0.005, Width 0.003 -0.006, Depth 0.125 +/-0.003

General Notes

- 1 Dimensions in inches.
- 2 Location Tolerances for Holes and Slots: +/- 0.010.
- 3 Tolerance: X.X +/-0.1, X.XX +/- 0.01, X.XXX - 0.002 Unless Otherwise Specified.
- 4 Surface finish 63 RHR or better. Break sharp edges and corners.
- 5 For standard 7A, notch lengths are parallel to curved edge of the part
- 6 For standard 7B, notch lengths are parallel to straight edge of the part
- 7 Curved plate inner radius: 25 +/- 1
- 8 Holes and notches are machined perpendicular to machined surface from the convex side
- 9 Use 120 degree tipped drill for drilled holes.

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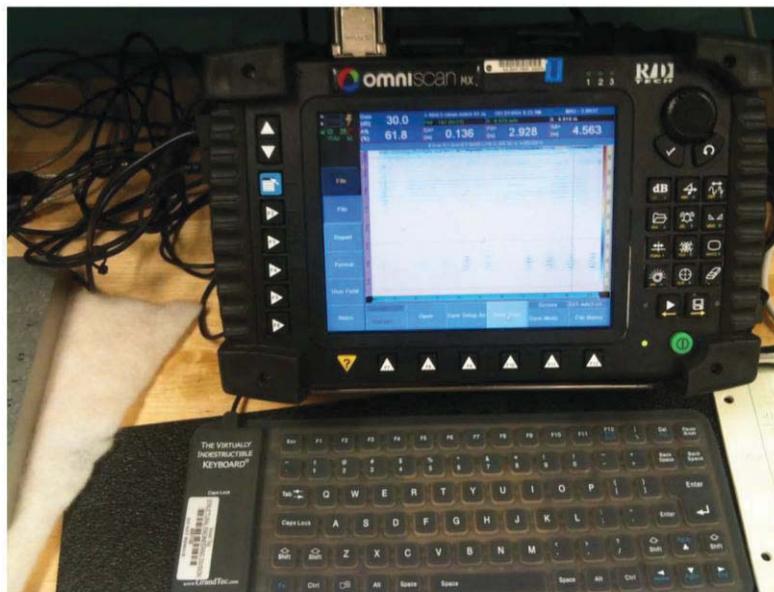
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Appendix D. Olympus Omniscan MX UT Results

Olympus Omniscan MX UT



Scans below using the OmniScan MX UT portable scanner.

The scans were performed using Phase Array.

Ratings:

0	Failure to identify important features
1	Features slightly detectable but not clearly defined
2	Undoubtable feature detection

Average RATING amongst all scans:	1.62
Average RATING amongst NDE Standard Scans:	1.60
Average RATING amongst impacted plate scans:	1.27
Average RATING amongst bond plate scans:	2.00

NDE Standard 1A:	0.00		Impacted Plate 186:	2.00	
NDE Standard 1B:	0.00		Impacted Plate 1900:	0.00	
NDE Standard 2:	2.00		Impacted Plate 1907:	1.33	
NDE Standard 3:	2.00		Impacted Plate T3:	2.00	
NDE Standard 4:	2.00		Impacted Plate 243:	1.00	
NDE Standard 5:	2.00				
NDE Standard 6A:	2.00	Eng. Est.	Bond Plate 123:	2.00	not saved
NDE Standard 6B:	2.00	Eng. Est.	Bond Plate 158:	2.00	not saved
NDE Standard 7A:	2.00	Eng. Est.	Bond Plate 028B:	2.00	not saved
NDE Standard 7B:	2.00	Eng. Est.	Bond Plate 132A:	2.00	not saved



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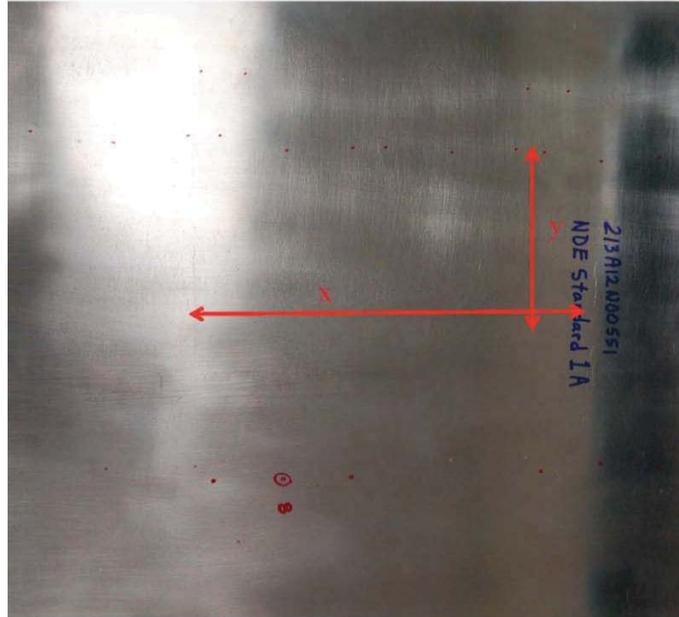
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NDE Standard IA Notches

Image of Samples



NDE Standard IA Notches

Clean/Un-Patched Samples

No images from the IVA side: Grid impedes scanning of the plate

RATING=

0



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NDE Standard IA Notches

Taped/Patched Samples

No images from the IVA side: Grid impedes scanning of the plate

RATING= 0

NDE Standard IA Notches

Plate/Patched Samples

No images from the IVA side: Grid impedes scanning of the plate

RATING= 0
RATING= 0



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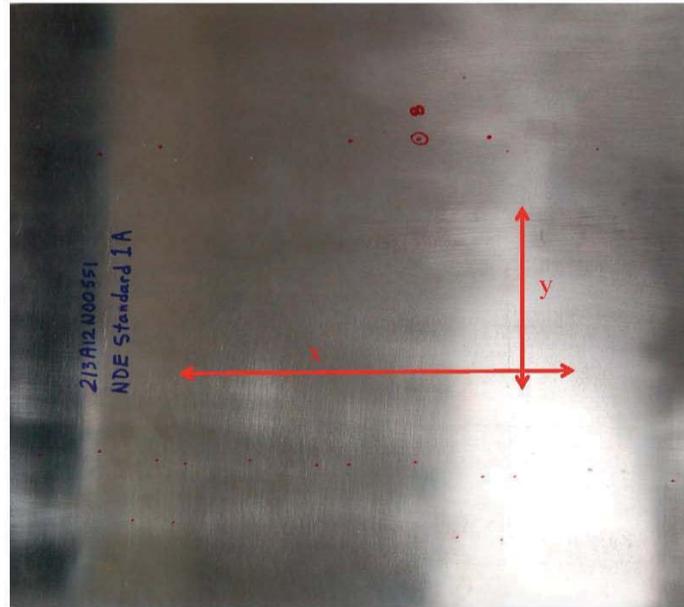
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NDE Standard 1A Holes

Image of Samples



NDE Standard 1A Holes

Clean/Un-Patched Samples

No images from the IVA side: Grid impedes scanning of the plate

RATING=

0



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NDE Standard 1A Holes

Taped/Patched Samples

No images from the IVA side: Grid impedes scanning of the plate

RATING=

0

NDE Standard 1A Holes

Plate/Patched Samples

No images from the IVA side: Grid impedes scanning of the plate

RATING=

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RATING=

0



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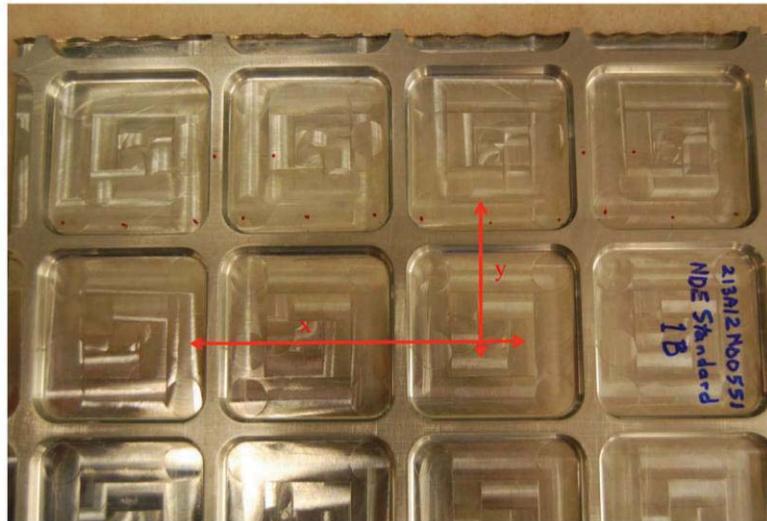
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NDE Standard IB Notches

Image of Samples



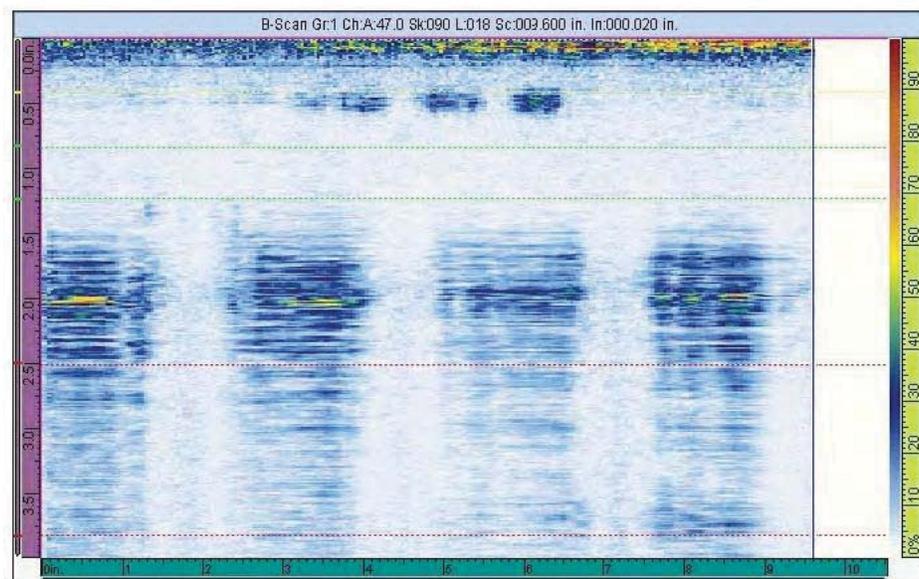
NDE Standard IB Notches

Clean/Un-Patched Samples

551-NDE1B-Clean-Notch-01-Bscan

RATING=

0





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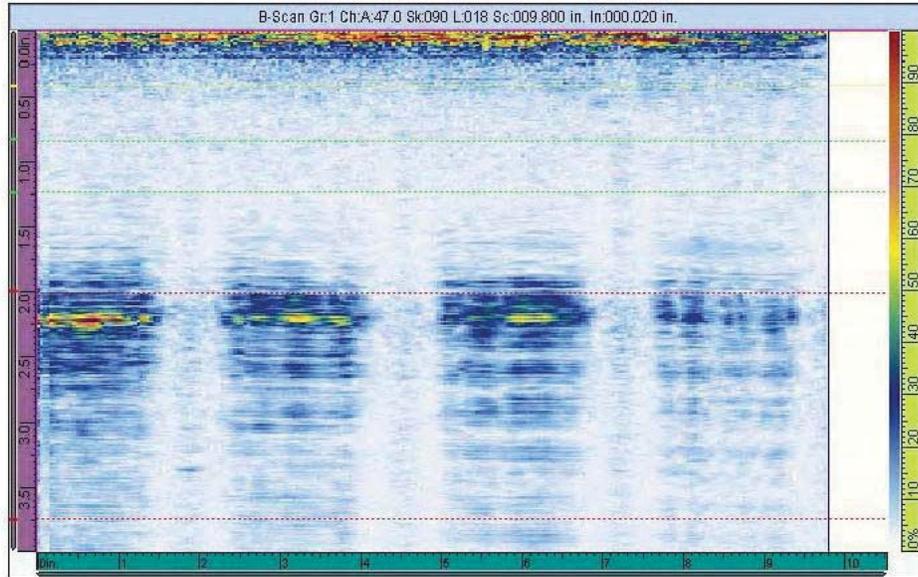
NDE Standard 1B Notches

551-NDE1B-Tape-Notch-02-Bscan

Tap ed/Patched Samples

RATING=

0



NDE Standard 1B Notches

Plate/Patched Samples

RATING=

0

RATING=

0

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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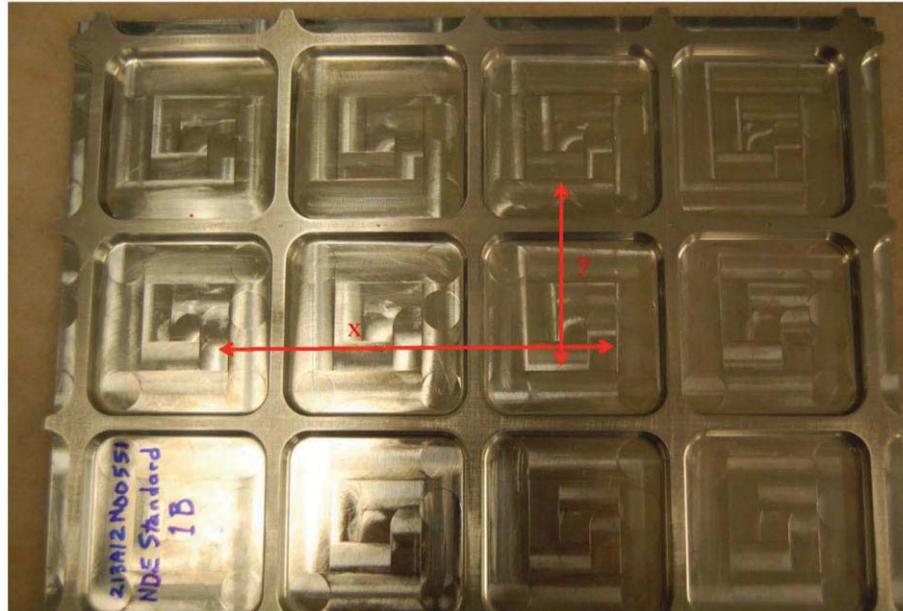
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NDE Standard 1B Holes

Image of Samples



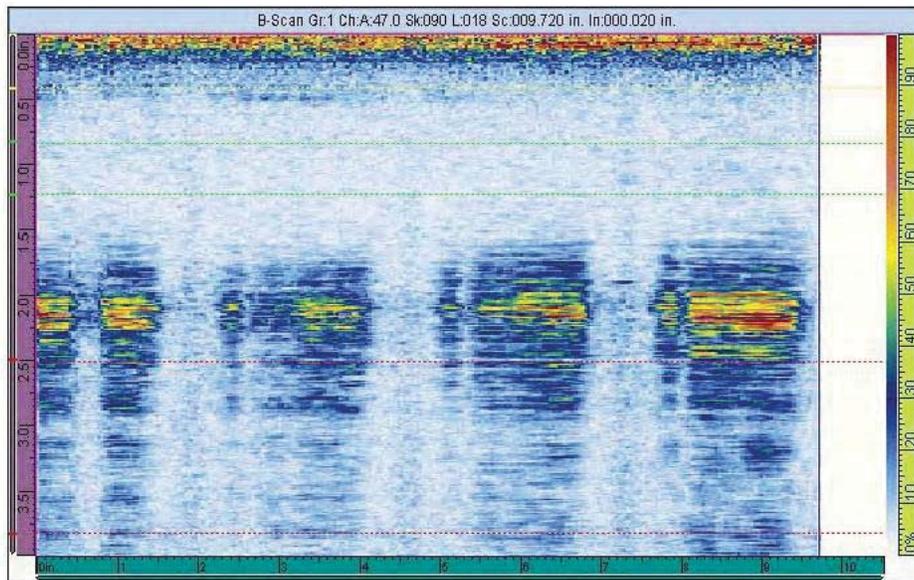
NDE Standard 1B Holes

Clean/Un-Patched Samples

551-NDE1B-Clean-Hole-01-Bscan

RATING=

0





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NDE Standard 1B Holes

551-NDE1B-Clean-Hole-01-Bscan

(image not created however file data exists)

Taped/Patched Samples

RATING=

0

NDE Standard 1B Holes

Plate/Patched Samples

RATING=

0

RATING=

0

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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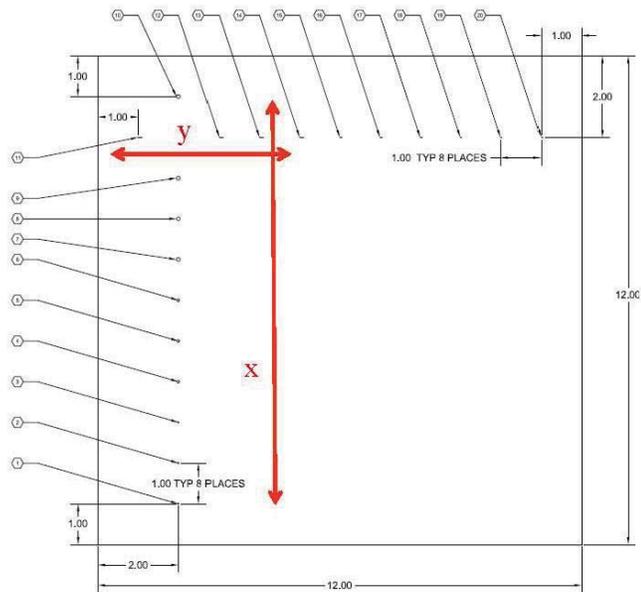
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NDE Standard 2 holes

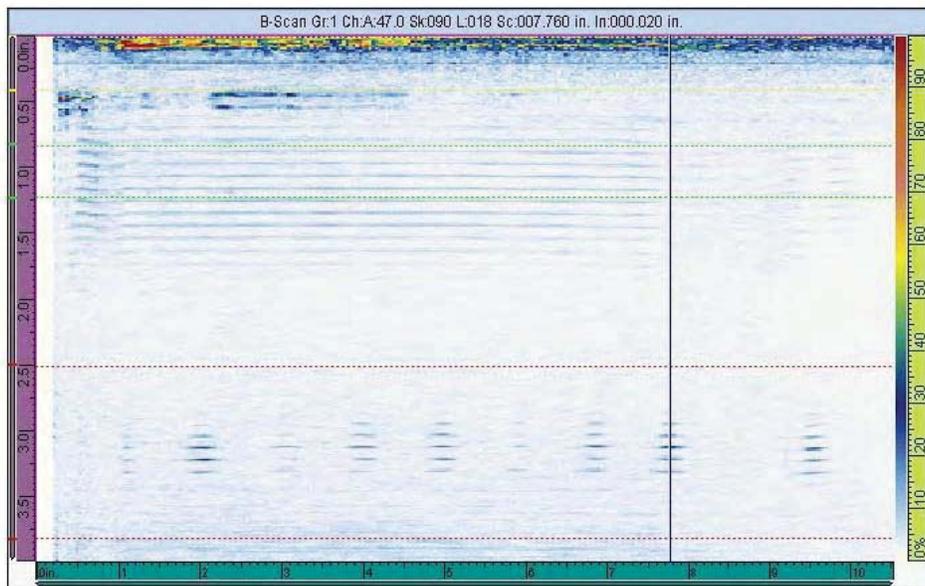
Image of Samples



NDE Standard 2 holes

Clean/Un-Patched Samples

551-NDE2-clean-hole-02





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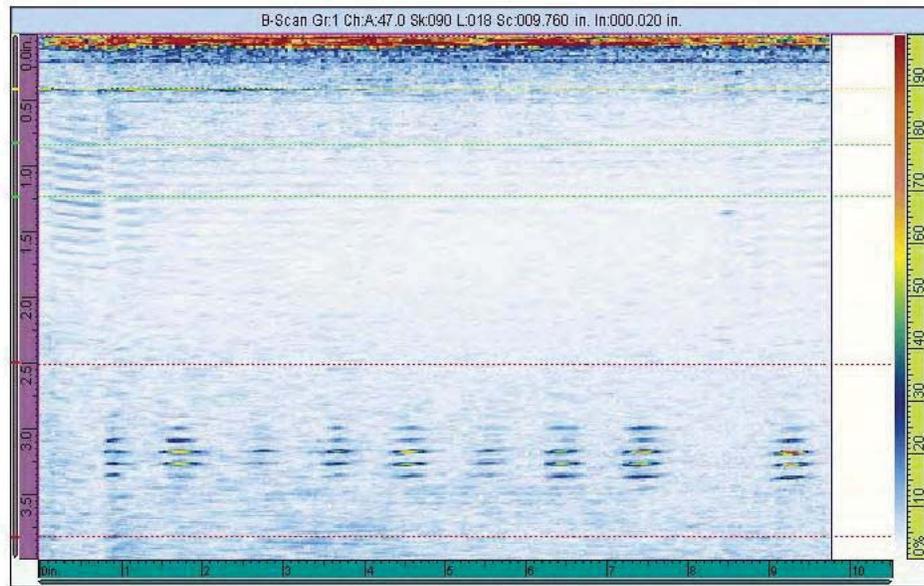
NDE Standard 2 holes

Taped/Patched Samples

551-NDE2-tape-hole-02

RATING=

2



NDE Standard 2 holes

Plate/Patched Samples

RATING=

2

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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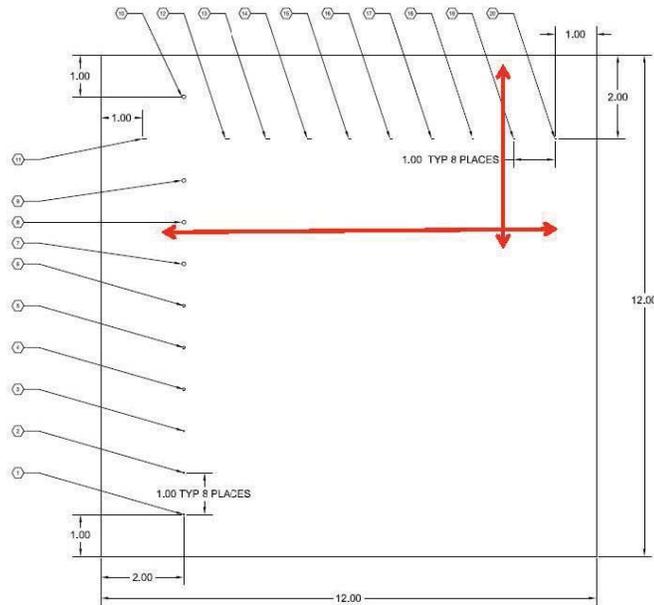
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NDE Standard 2 notches

Image of Samples



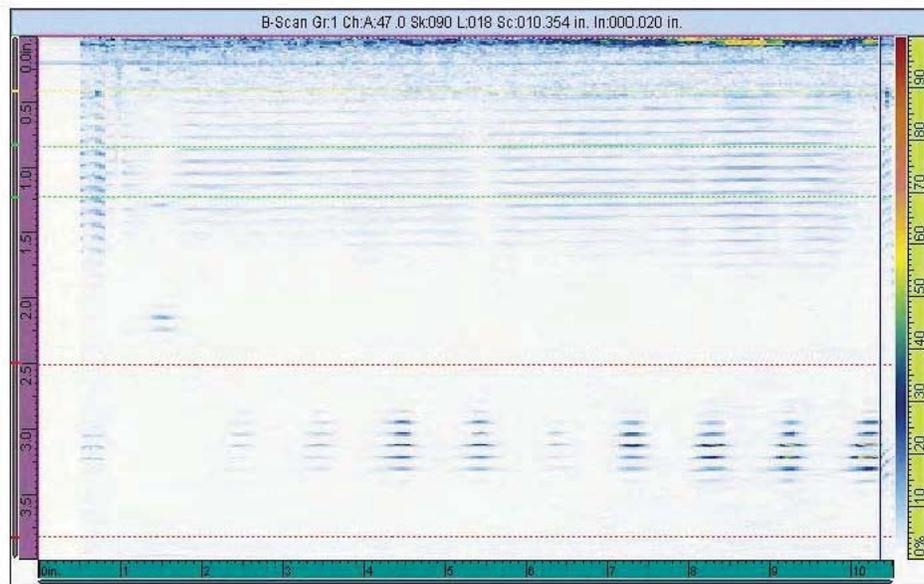
NDE Standard 2 notches

551-NDE2-clean-notch-02

Clean/Un-Patched Samples

RATING=

2





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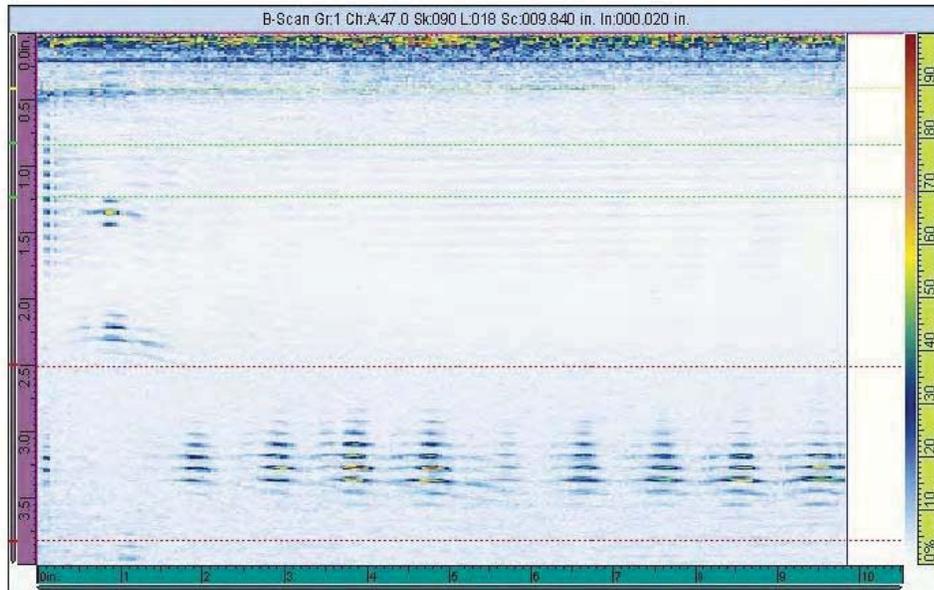
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NDE Standard 2 notches

551-NDE2-tape-notch-02

Taped/Patched Samples



NDE Standard 2 notches

Plate/Patched Samples

RATING= 2

RATING= 2

RATING= 2

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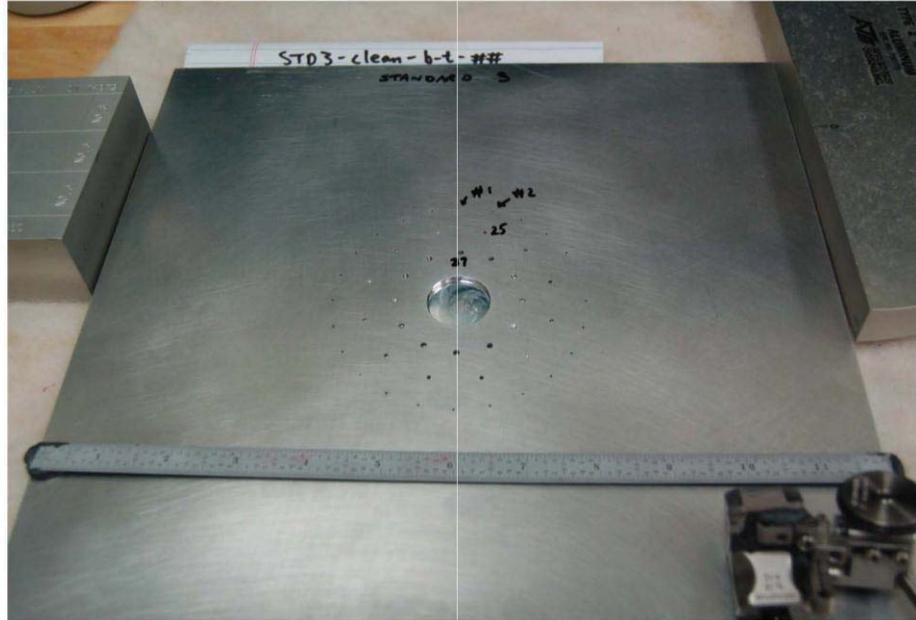
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NDE Standard 3

Image of Samples



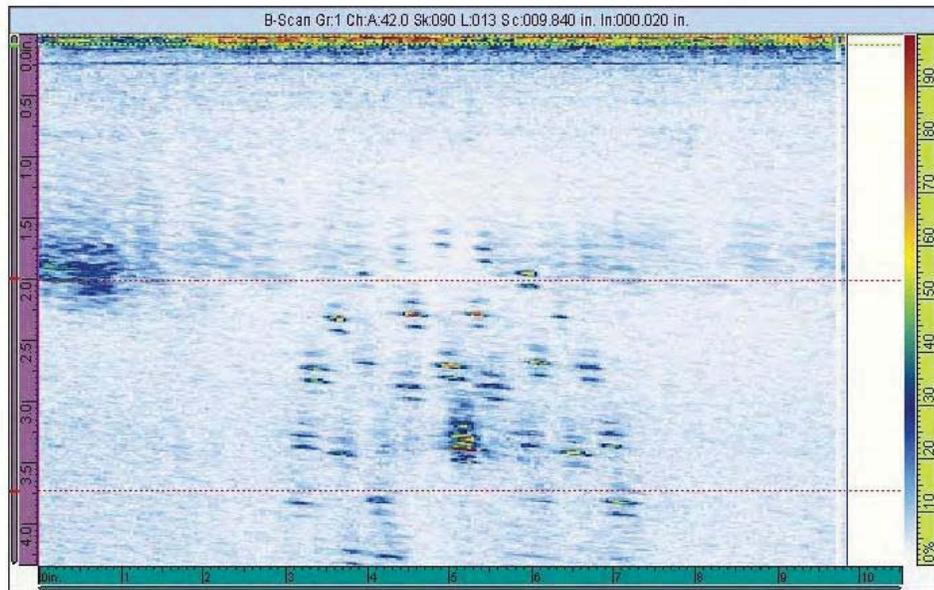
NDE Standard 3

std3-clean-b-t

Clean/Un-Patched Samples

RATING=

2





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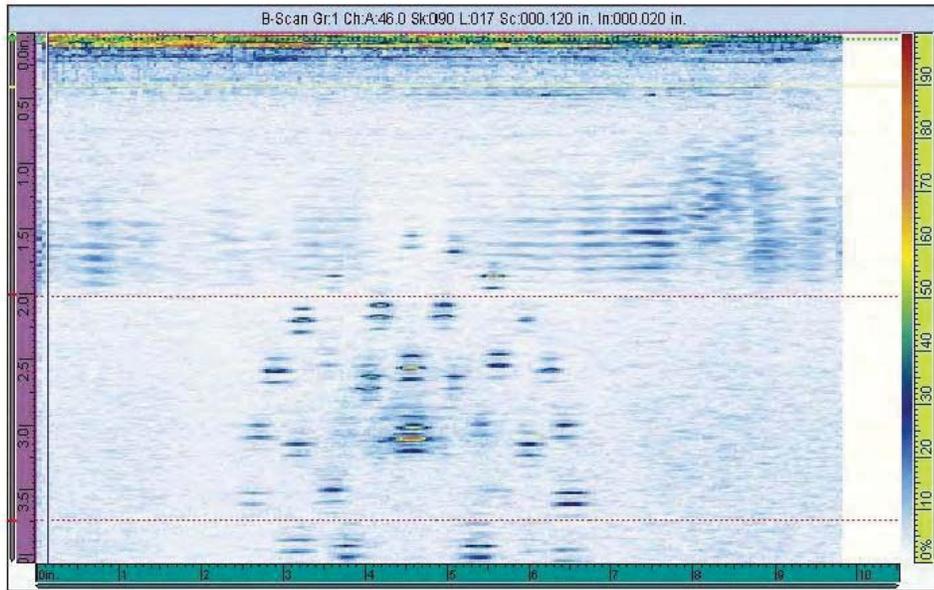
NDE Standard 3

Taped/Patched Samples

std3-tape-b-t

RATING=

2



NDE Standard 3

Plate/Patched Samples

RATING=

2

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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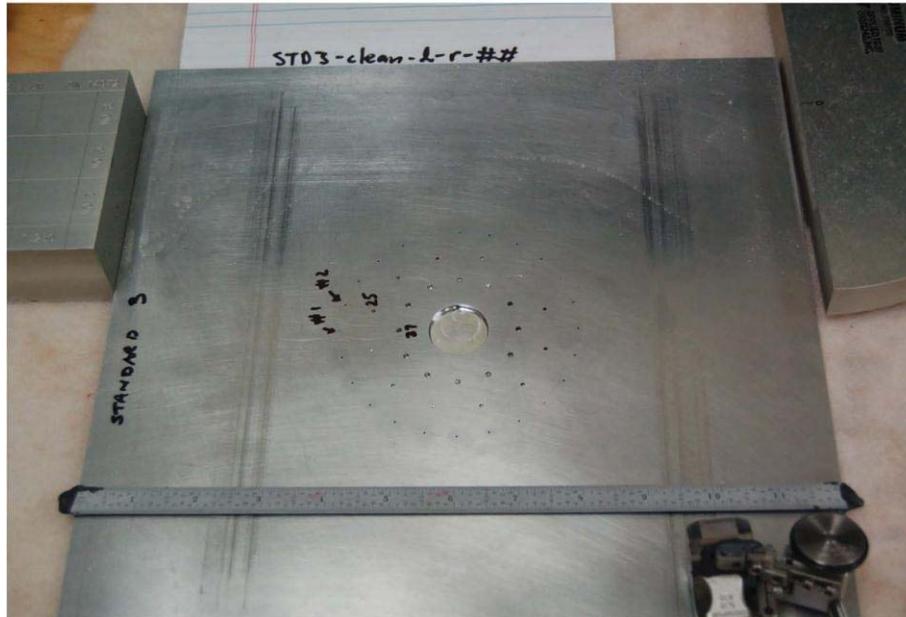
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NDE Standard 3

Image of Samples



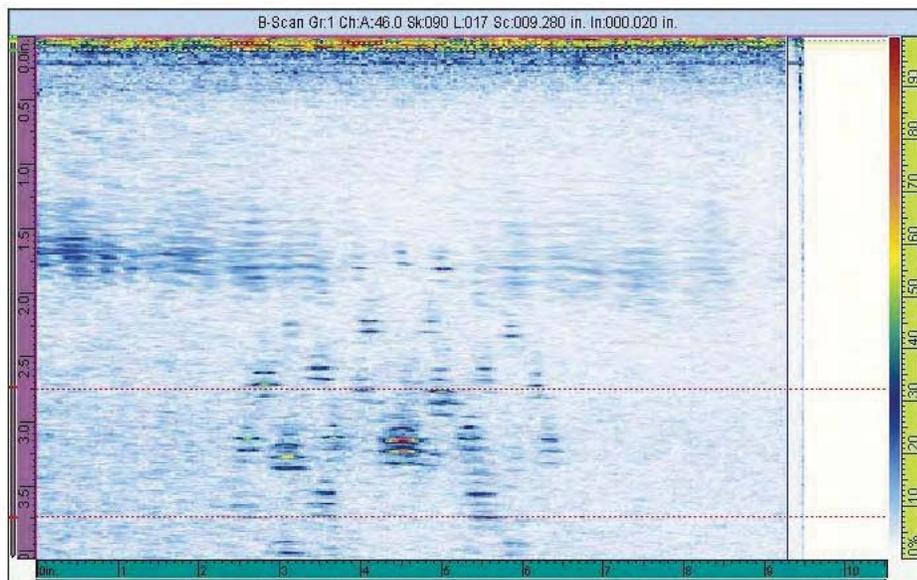
NDE Standard 3

Clean/Un-Patched Samples

std3-clean-l-r

RATING=

2





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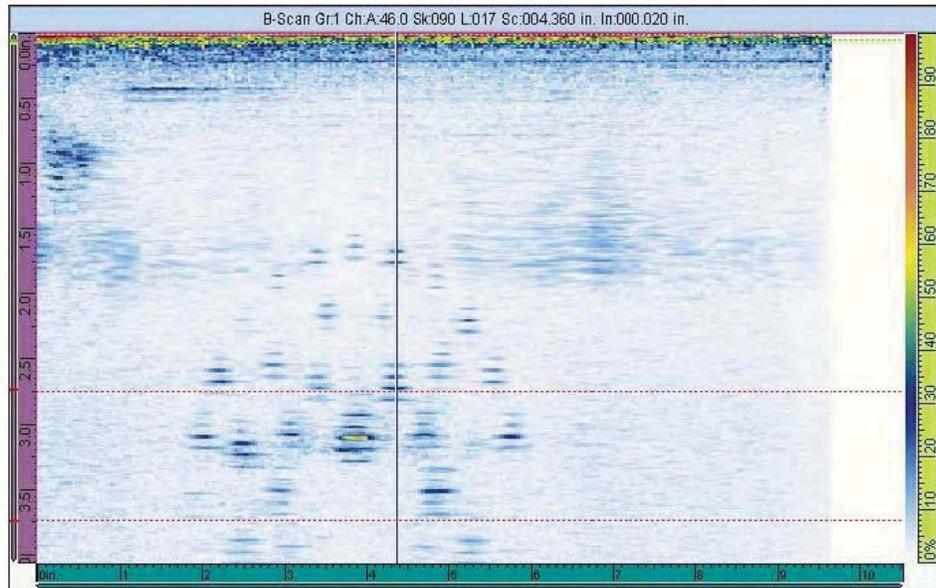
NDE Standard 3

std3-tape-1-r

Taped/Patched Samples

RATING=

2



NDE Standard 3

Plate/Patched Samples

RATING=

2

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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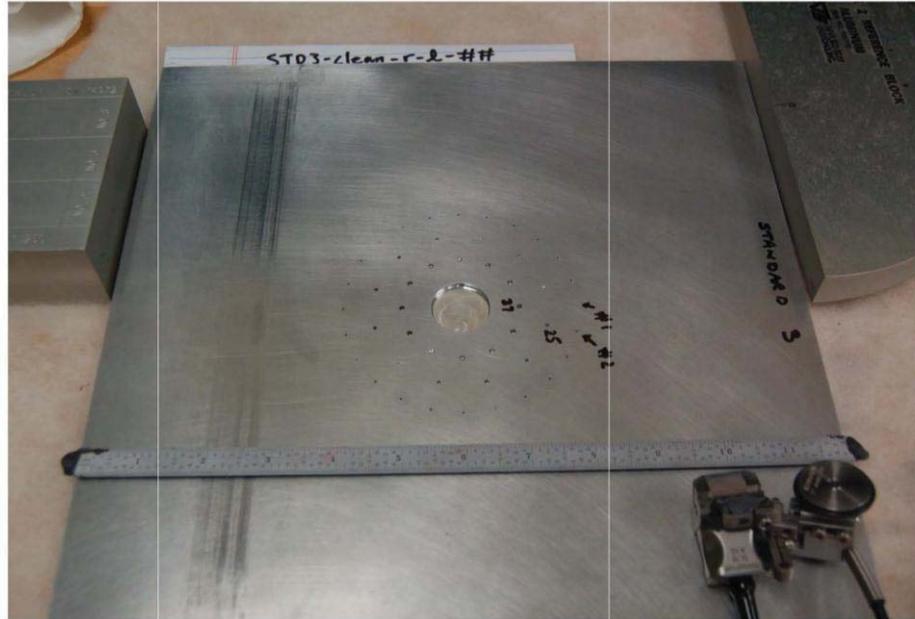
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NDE Standard 3

Image of Samples



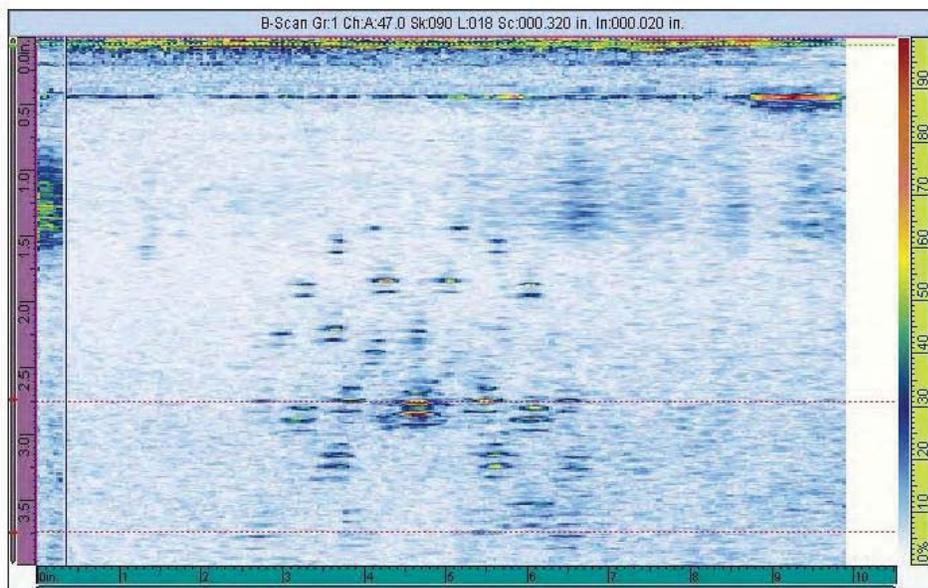
NDE Standard 3

Clean/Un-Patched Samples

std3-clean-r-1

RATING=

2





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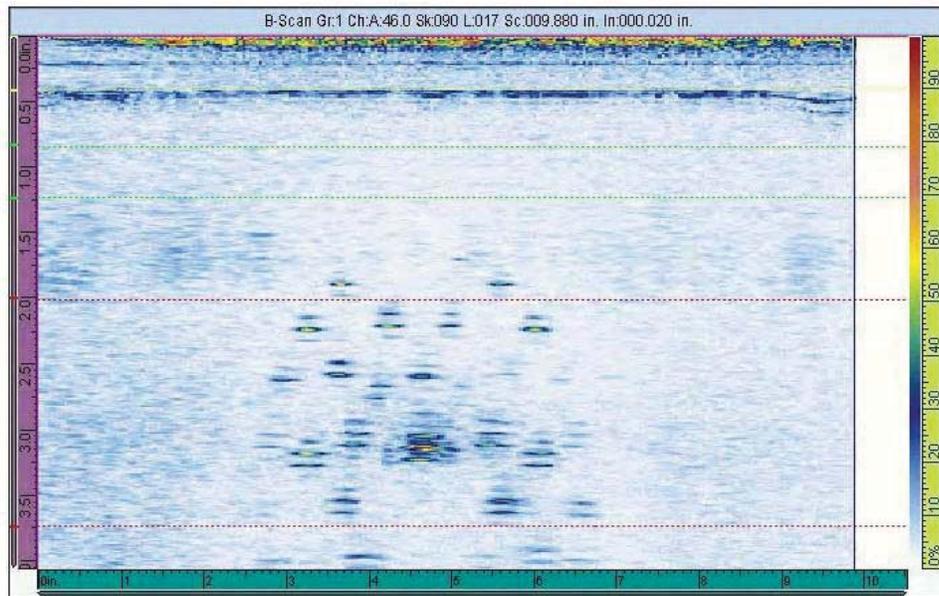
NDE Standard 3

Taped/Patched Samples

std3-tape-r1

RATING=

2



NDE Standard 3

Plate/Patched Samples

RATING=

2

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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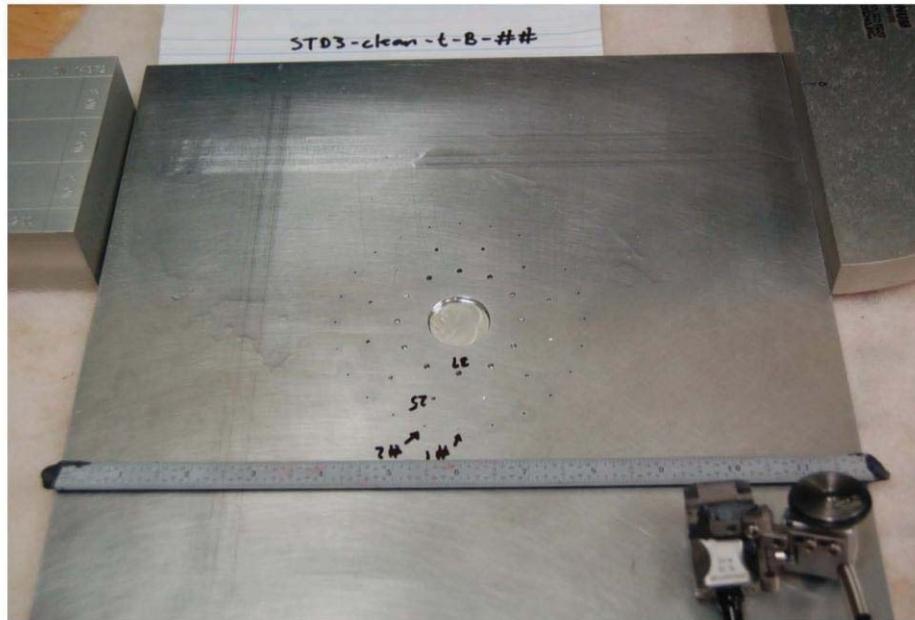
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NDE Standard 3

Image of Samples



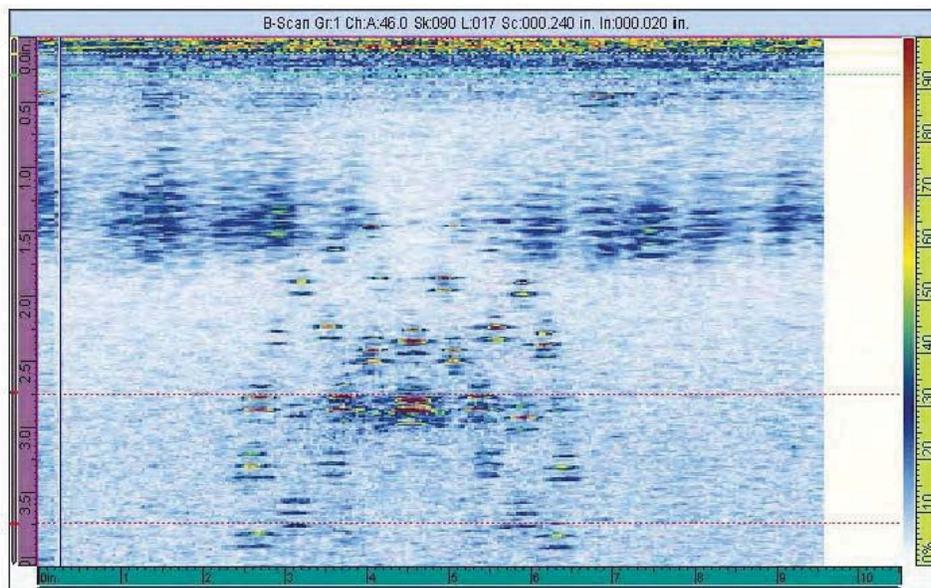
NDE Standard 3

std3-clean-t-b

Clean/Un-Patched Samples

RATING=

2





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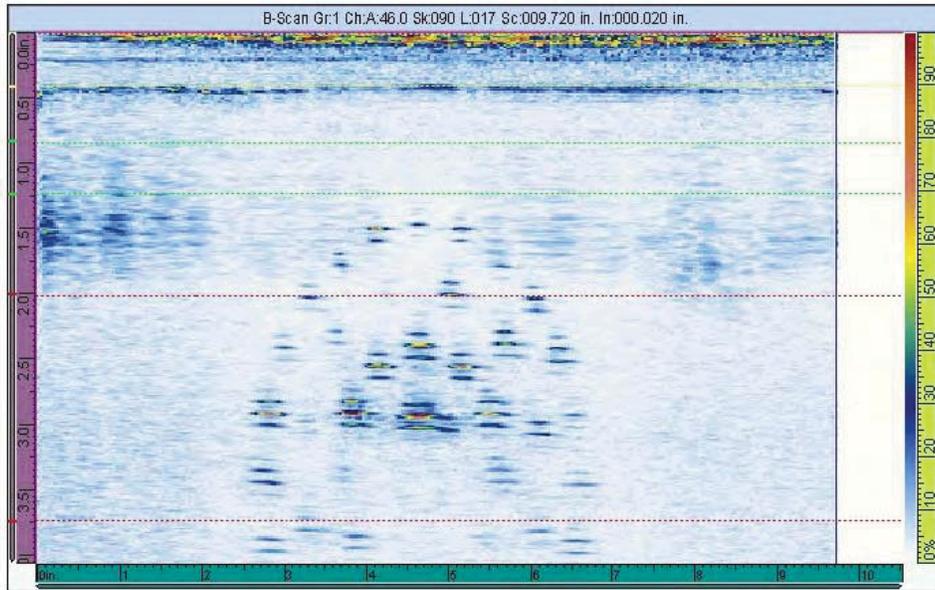
NDE Standard 3

Taped/Patched Samples

std3-tape-t-b

RATING=

2



NDE Standard 3

Plate/Patched Samples

RATING=

2

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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Plate 551 NDE Standard 4

Image of Samples

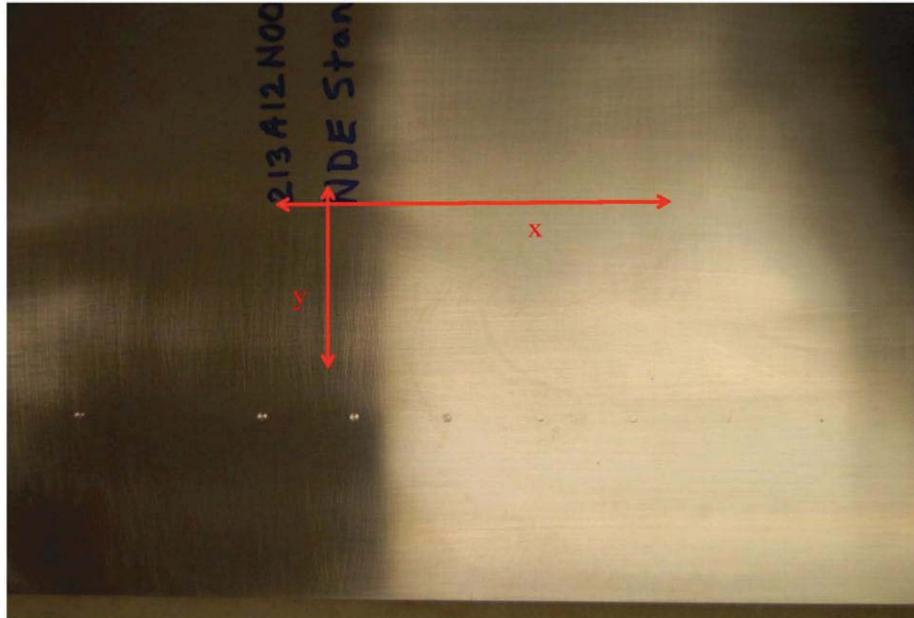


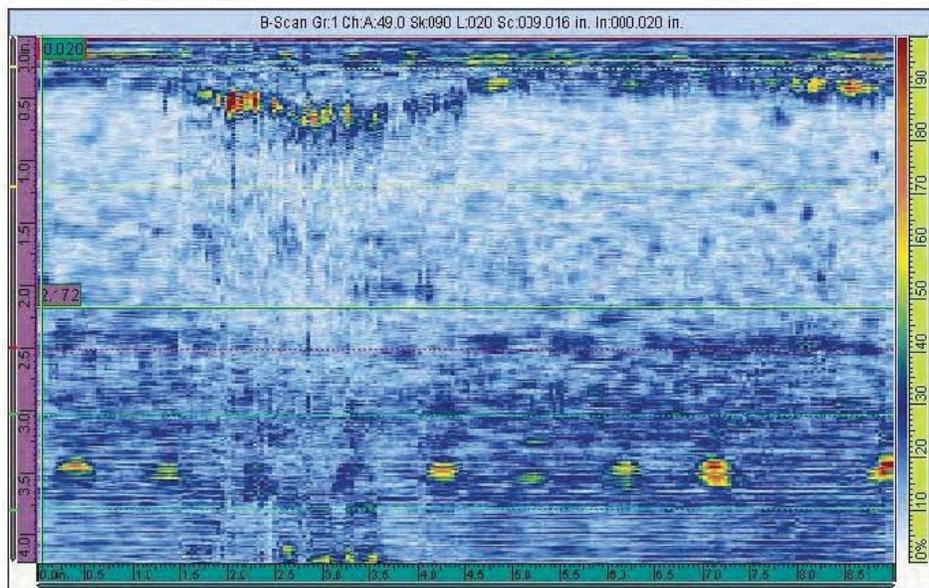
Plate 551 NDE Standard 4

551-clean-hole
(gain was set too high)

Clean/Un-Patched Samples

RATING=

2





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Plate 551 NDE Standard 4

551-tape-hole

Taped/Patched Samples

RATING=

2

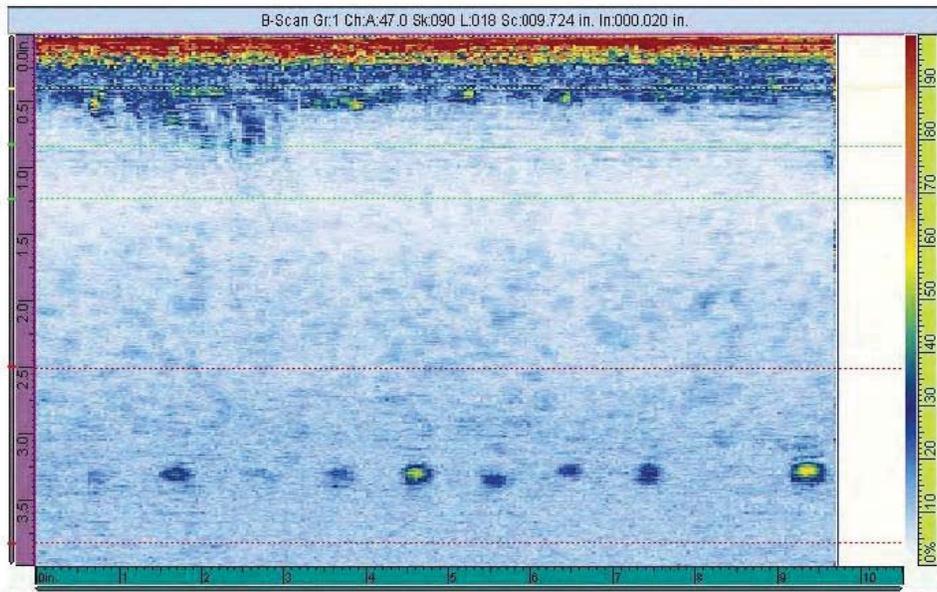


Plate 551 NDE Standard 4

Plate/Patched Samples

RATING=

2

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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Plate 551 NDE Standard 4

Image of Samples

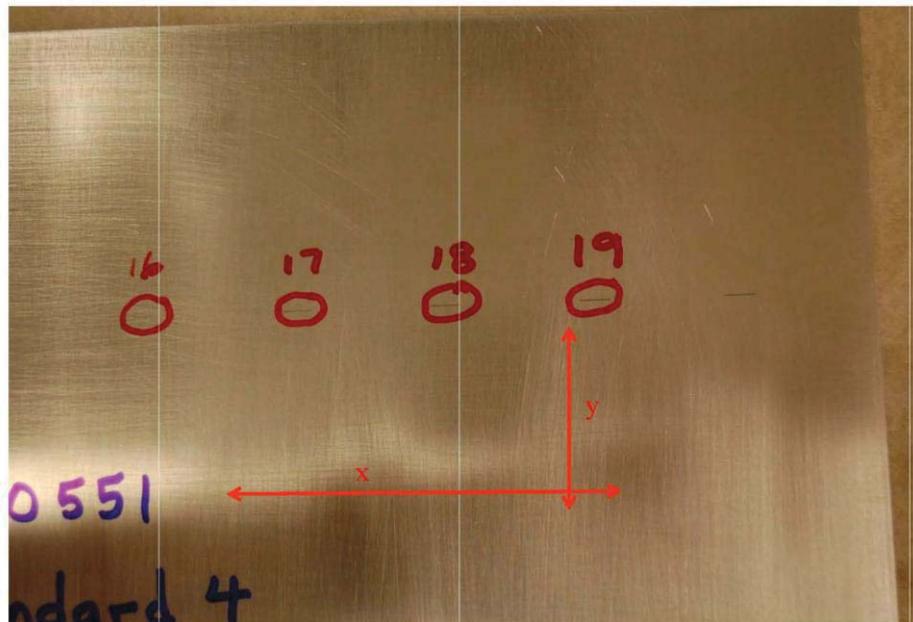


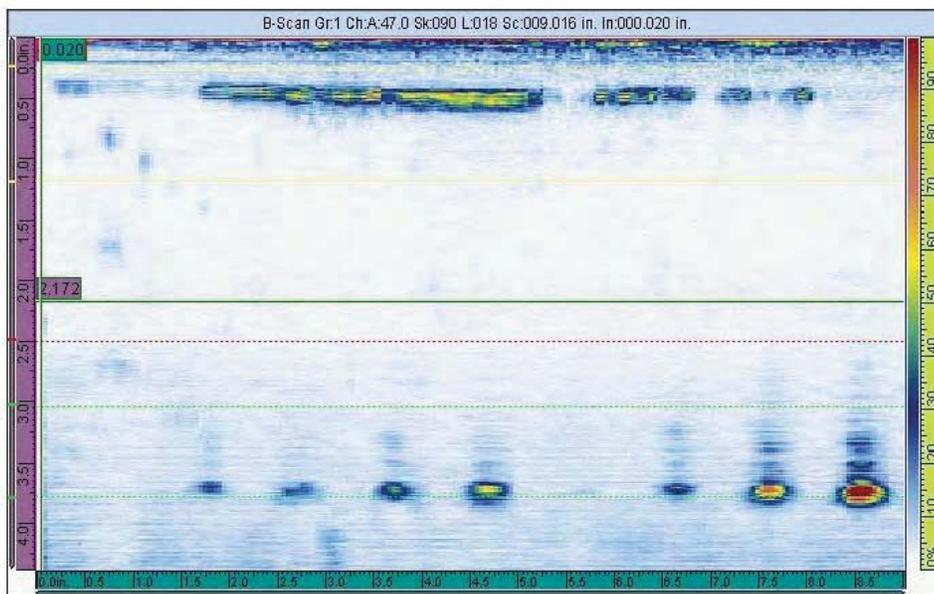
Plate 551 NDE Standard 4

551-clean-notch

Clean/Un-Patched Samples

RATING=

2





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Plate 551 NDE Standard 4

551-tape-notch

Taped/Patched Samples

RATING=

2

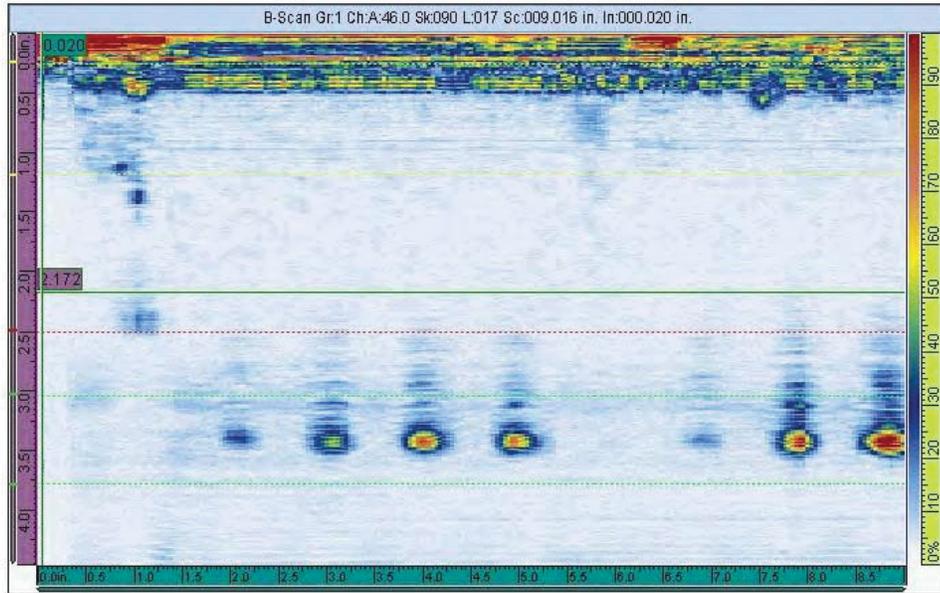


Plate 551 NDE Standard 4

Plate/Patched Samples

RATING=

2

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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NDE Standard 5

Image of Samples



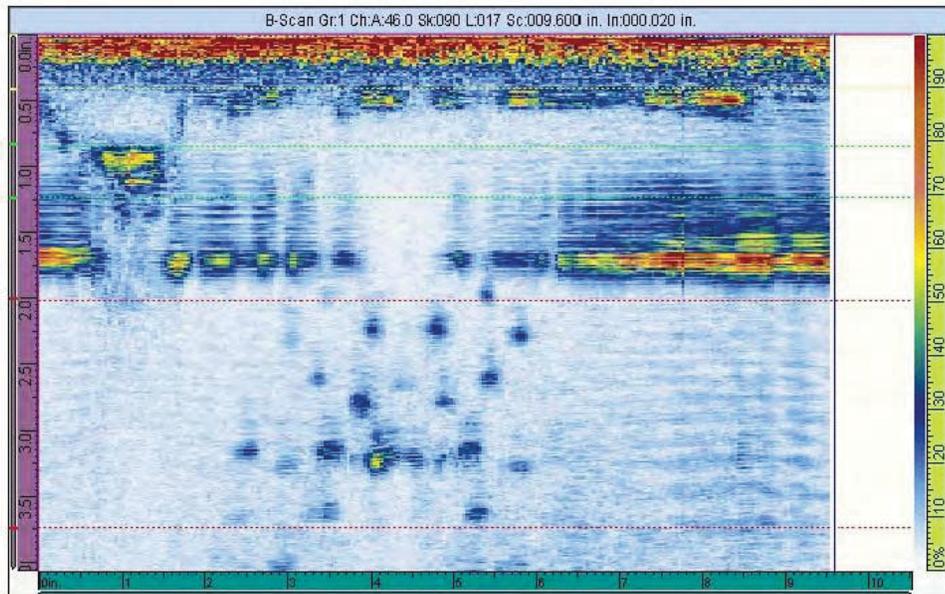
NDE Standard 5

std5-clean-b-t

Clean/Un-Patched Samples

RATING=

2





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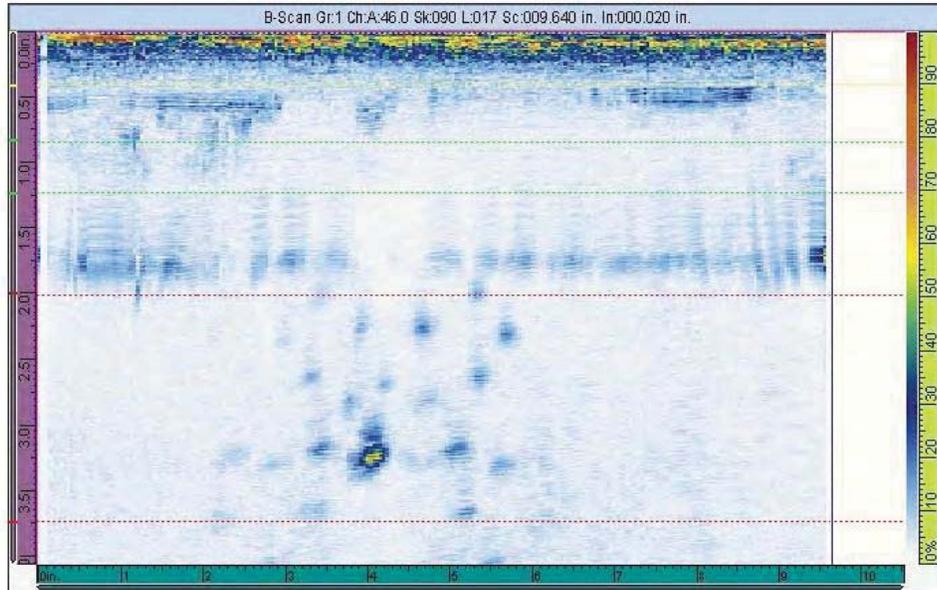
NDE Standard 5

Taped/Patched Samples

std5-tape-b-t

RATING=

2



NDE Standard 5

Plate/Patched Samples

RATING=

2

RATING=

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Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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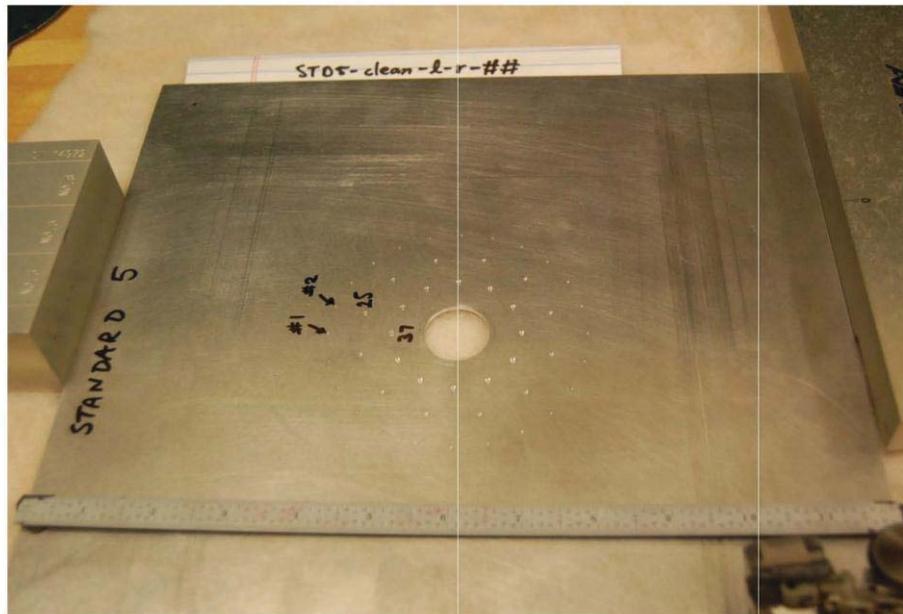
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NDE Standard 5

Image of Samples



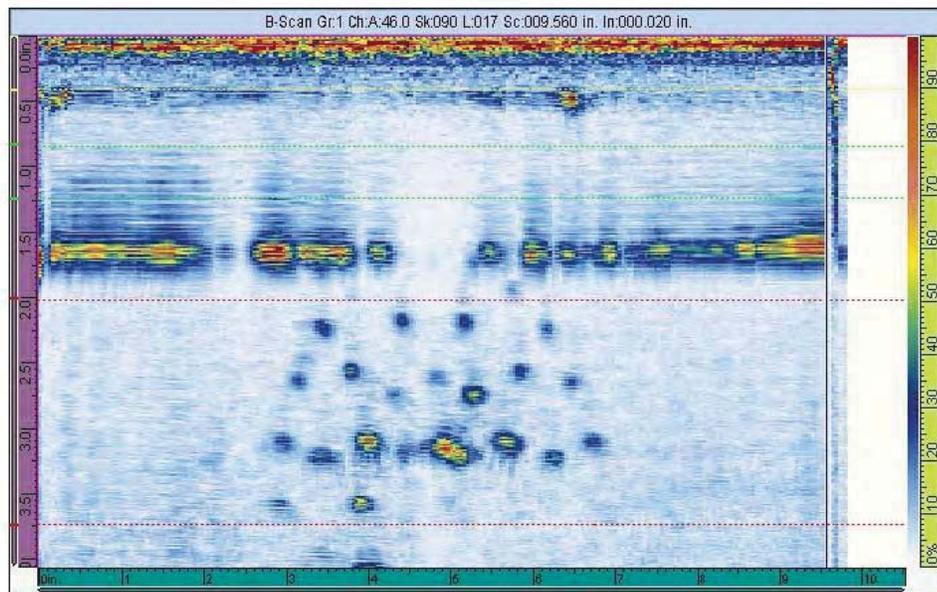
NDE Standard 5

Clean/Un-Patched Samples

std5-clean-l-r

RATING=

2





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NDE Standard 5

std5-tape-l-r

Taped/Patched Samples

RATING=

2

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NDE Standard 5

Plate/Patched Samples

RATING=

2

RATING=

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Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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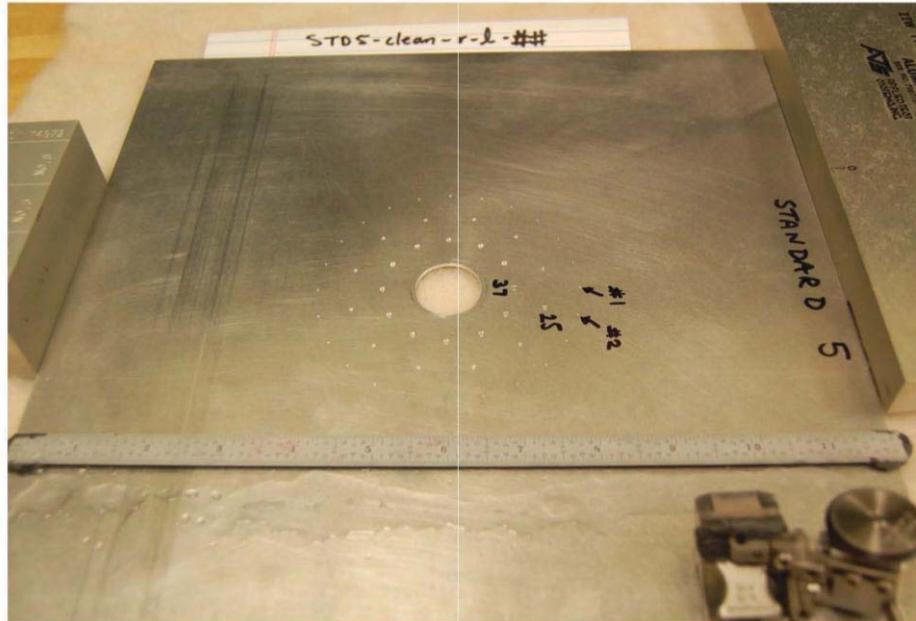
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NDE Standard 5

Image of Samples



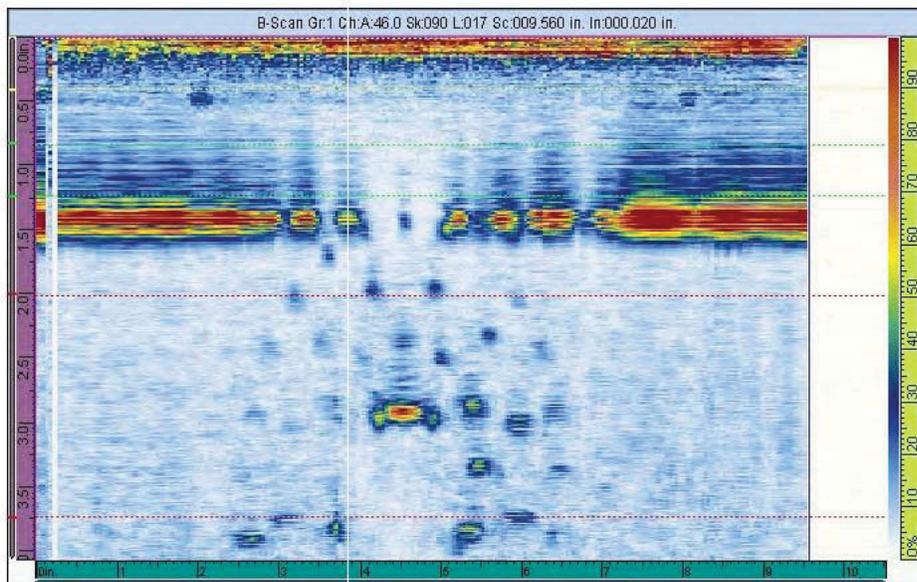
NDE Standard 5

std5-clean-r-l

Clean/Un-Patched Samples

RATING=

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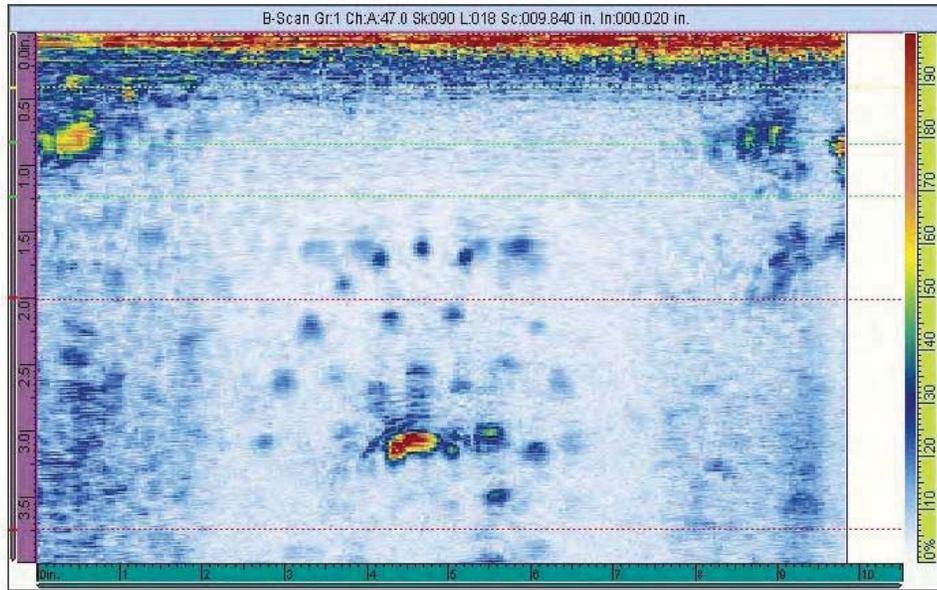
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std5-tape-r-1

Taped/Patched Samples

RATING=

2



NDE Standard 5

Plate/Patched Samples

RATING=

RATING=

2

2

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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NDE Standard 5

Image of Samples



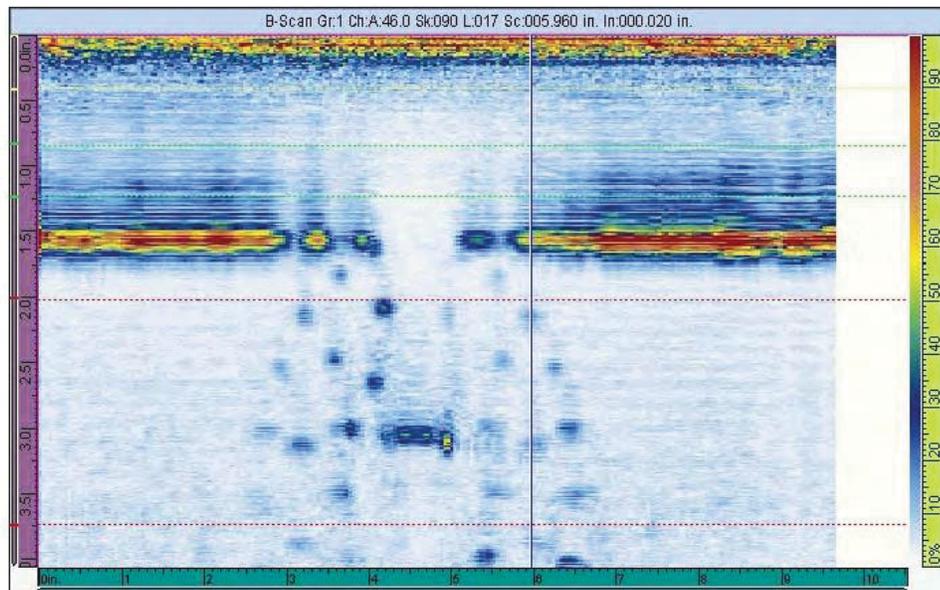
NDE Standard 5

std5-clean-t-b

Clean/Un-Patched Samples

RATING=

2





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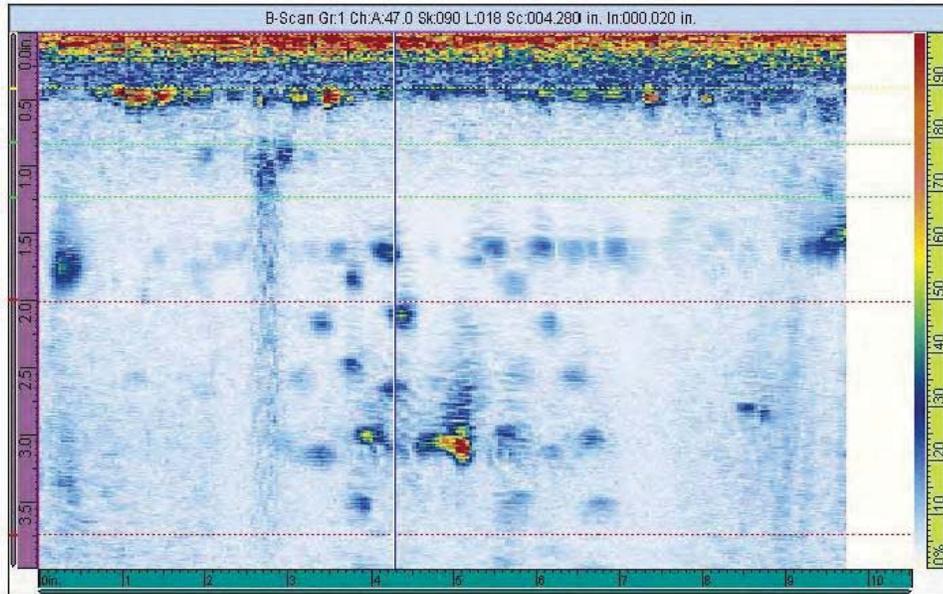
NDE Standard 5

Taped/Patched Samples

std5-tape-t-b

RATING=

2



NDE Standard 5

Plate/Patched Samples

RATING=

2

RATING=

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Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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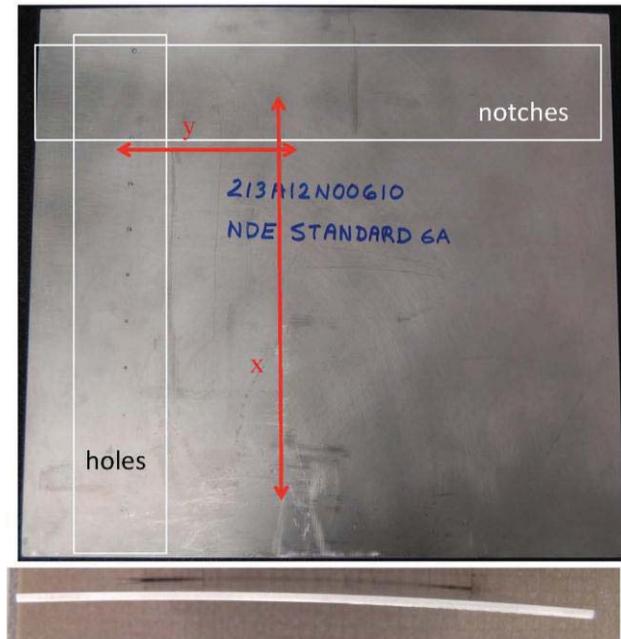
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NDE Standard 6A

Image of Samples



NDE Standard 6A

Clean/Un-Patched Samples

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.



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NDE Standard 6A

Taped/Patched Samples

RATING= 2

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NDE Standard 6A

Plate/Patched Samples

RATING= 2
RATING= 2

Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.



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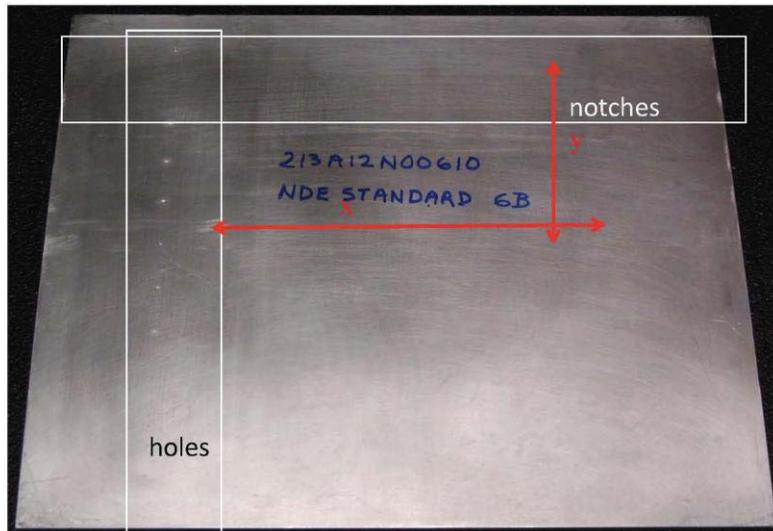
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Image of Samples

NDE Standard 6B



NDE Standard 6B

Clean/Un-Patched Samples

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.



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NDE Standard 6B

Taped/Patched Samples

RATING= 2

Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.

NDE Standard 6B

Plate/Patched Samples

RATING= 2
RATING= 2

Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.



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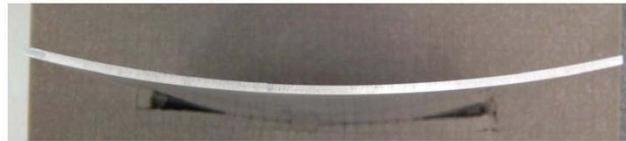
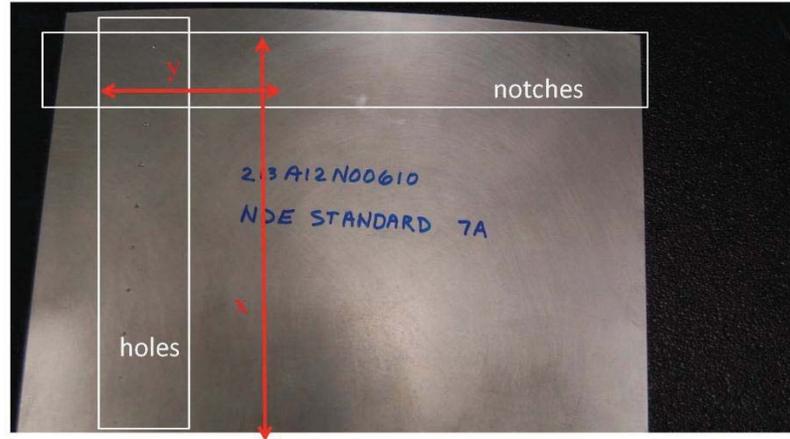
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NDE Standard 7A

Image of Samples



NDE Standard 7A

Clean/Un-Patched Samples

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.



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NDE Standard 7A

Taped/Patched Samples

RATING= 2

Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.

NDE Standard 7A

Plate/Patched Samples

RATING= 2
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Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.



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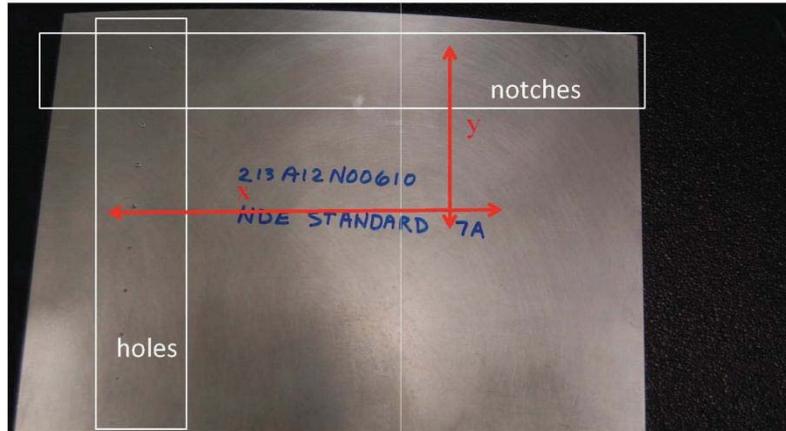
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NDE Standard 7A

Image of Samples



NDE Standard 7A

Clean/Un-Patched Samples

RATING=

2

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NDE Standard 7A

Taped/Patched Samples

RATING= 2

Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.

NDE Standard 7A

Plate/Patched Samples

RATING= 2
RATING= 2

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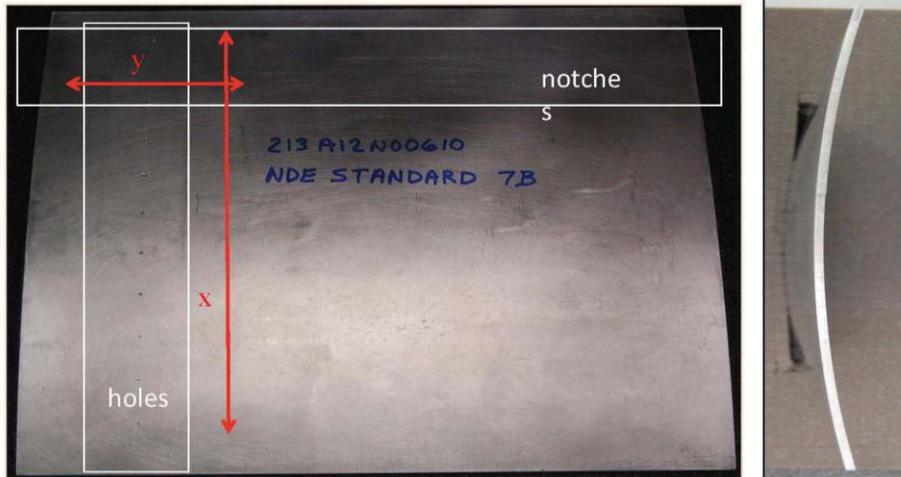
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NDE Standard 7B

Image of Samples



NDE Standard 7B

Clean/Un-Patched Samples

RATING=

2

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NDE Standard 7B

Taped/Patched Samples

RATING= 2

Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.

NDE Standard 7B

Plate/Patched Samples

RATING= 2
RATING= 2

Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.



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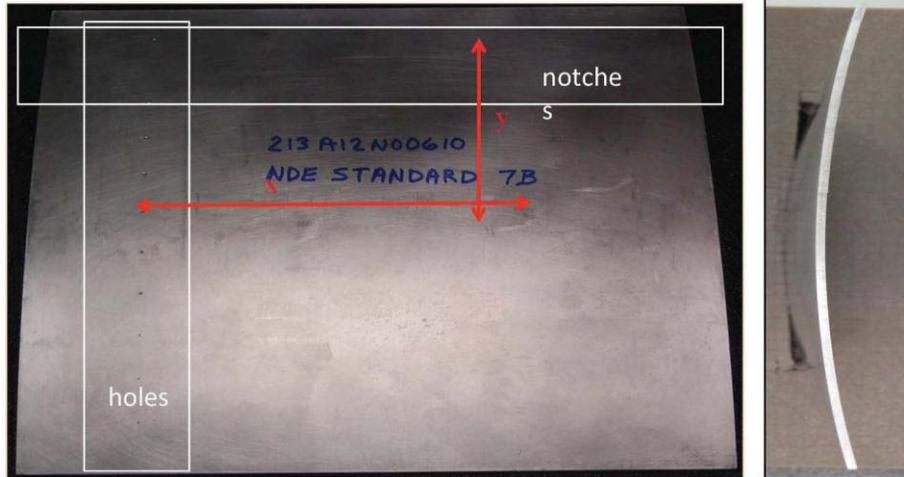
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NDE Standard 7B

Image of Samples



NDE Standard 7B

Clean/Un-Patched Samples

RATING=

2

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NDE Standard 7B

Taped/Patched Samples

RATING=

2

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NDE Standard 7B

Plate/Patched Samples

RATING=

2

RATING=

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Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.



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Plate 186

Image of Samples

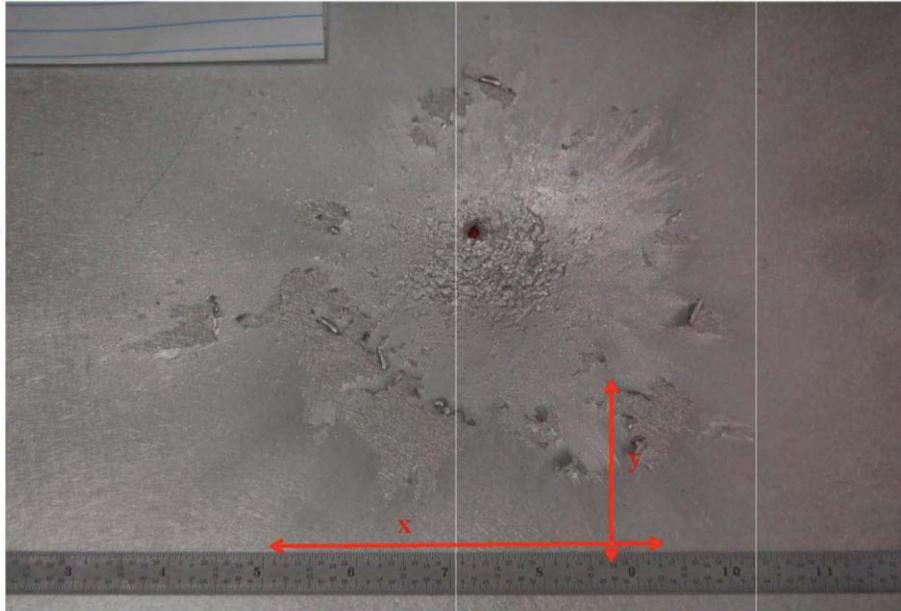


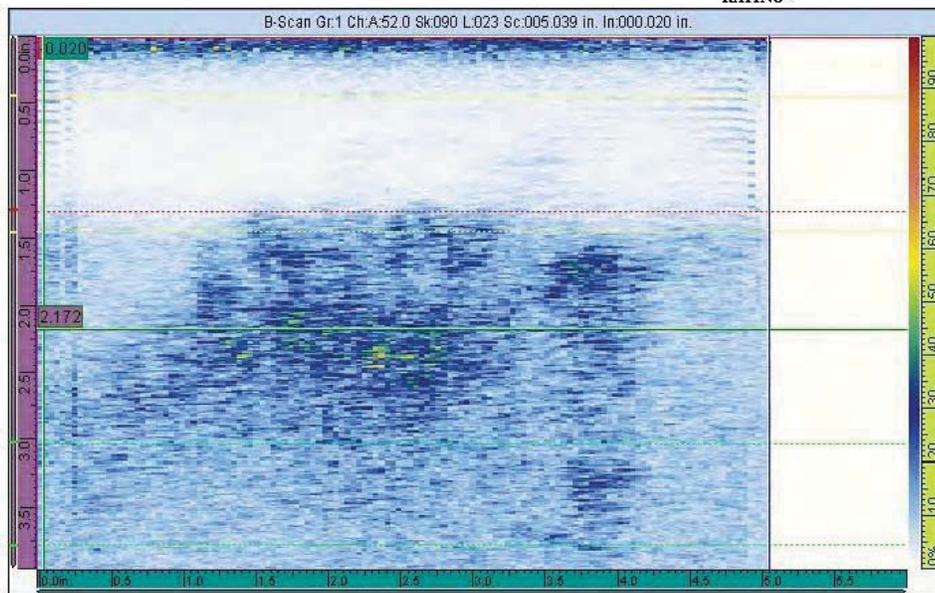
Plate 186

Clean/Un-Patched Samples

186-clean-b-t

RATING=

2





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Plate 186

Taped/Patched Samples

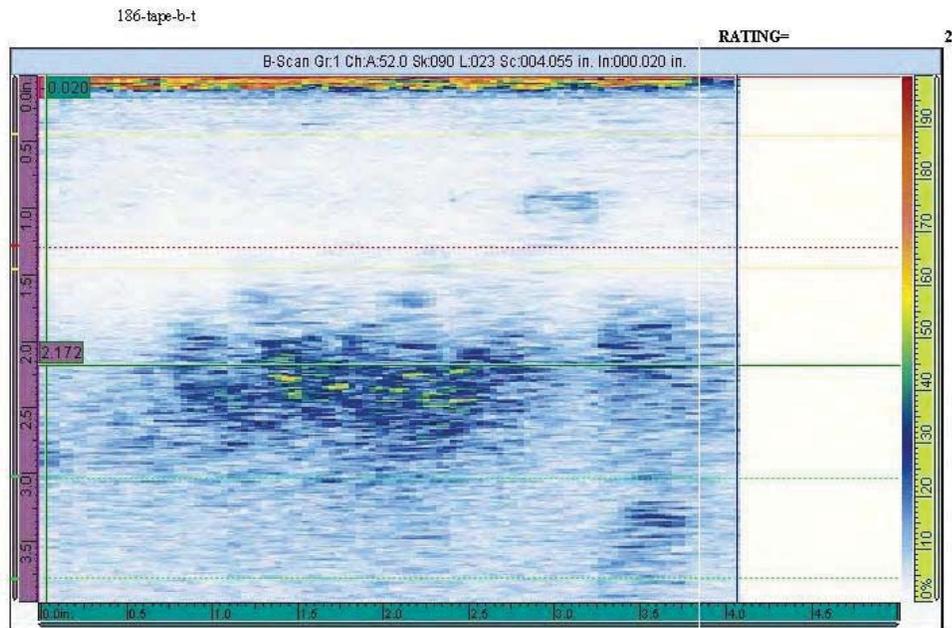


Plate 186

Plate/Patched Samples

RATING= 2

RATING= 2

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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Plate 186

Image of Samples

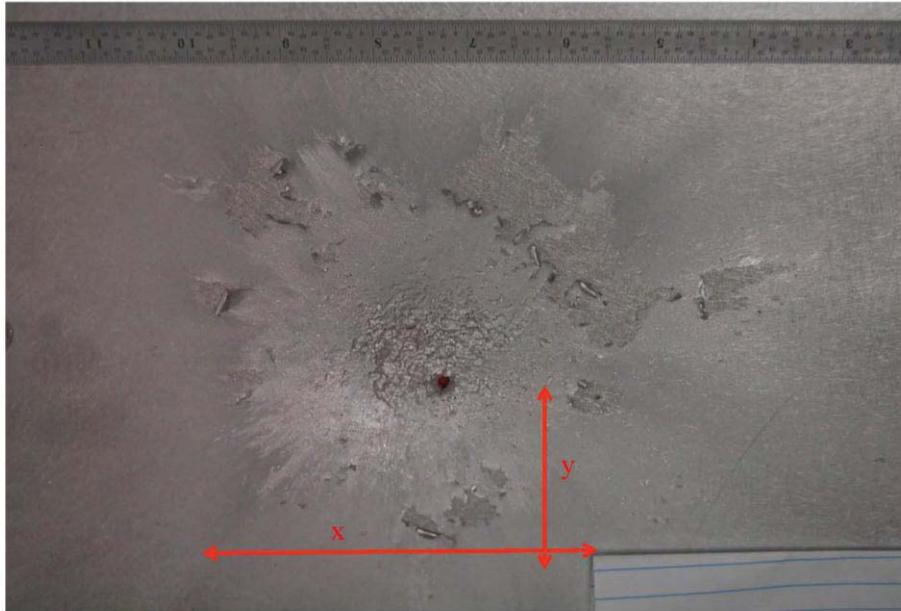


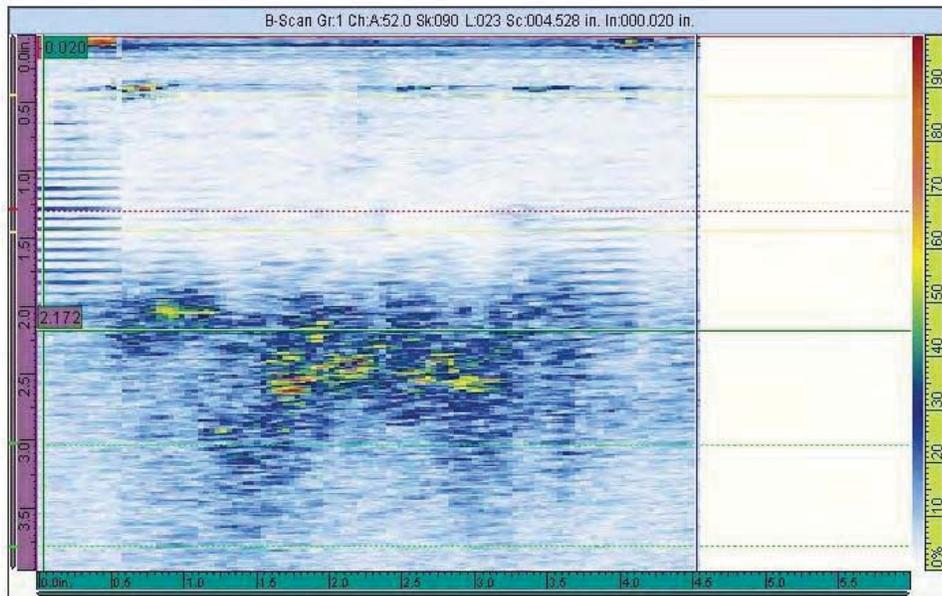
Plate 186

186-clean-t-b

Clean/Un-Paired Samples

RATING=

2





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Plate 186

186-tape-t-b

Taped/Patched Samples

RATING=

2

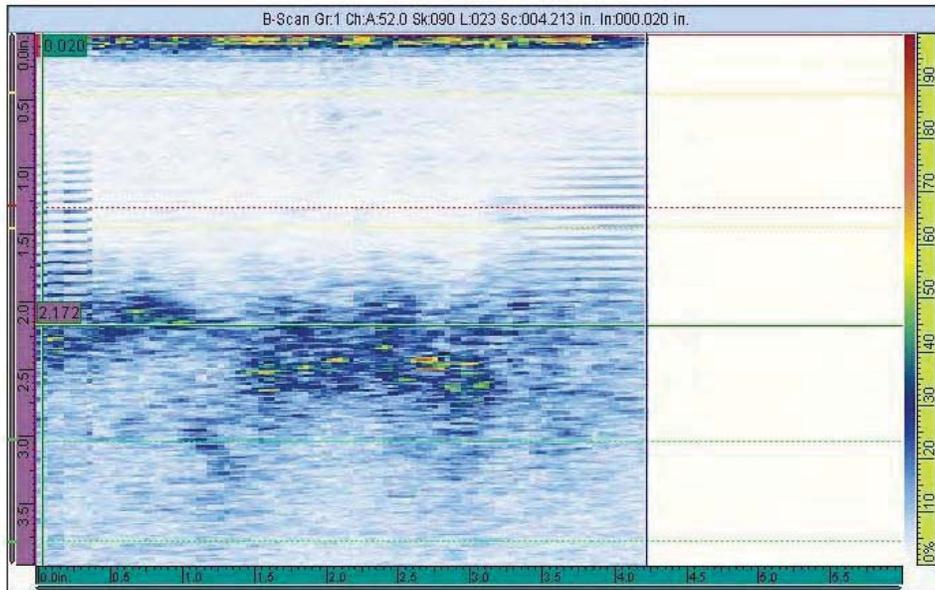


Plate 186

Plate/Patched Samples

RATING=

2

RATING=

2

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Plate 1900

Image of Samples

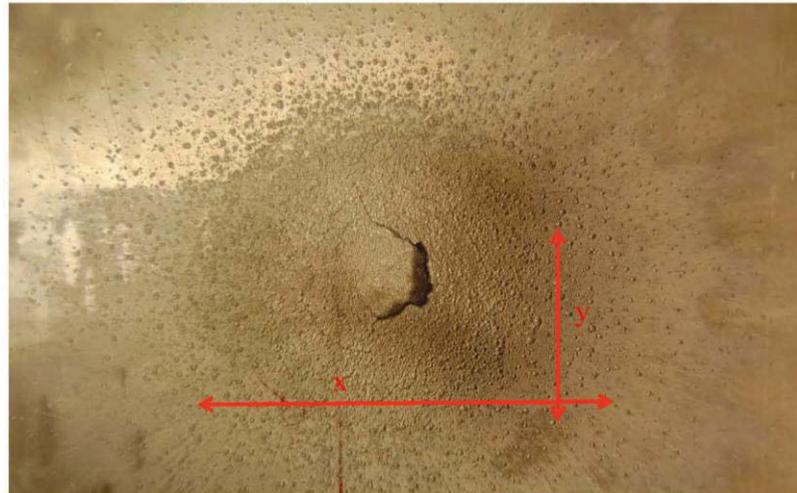


Plate 1900

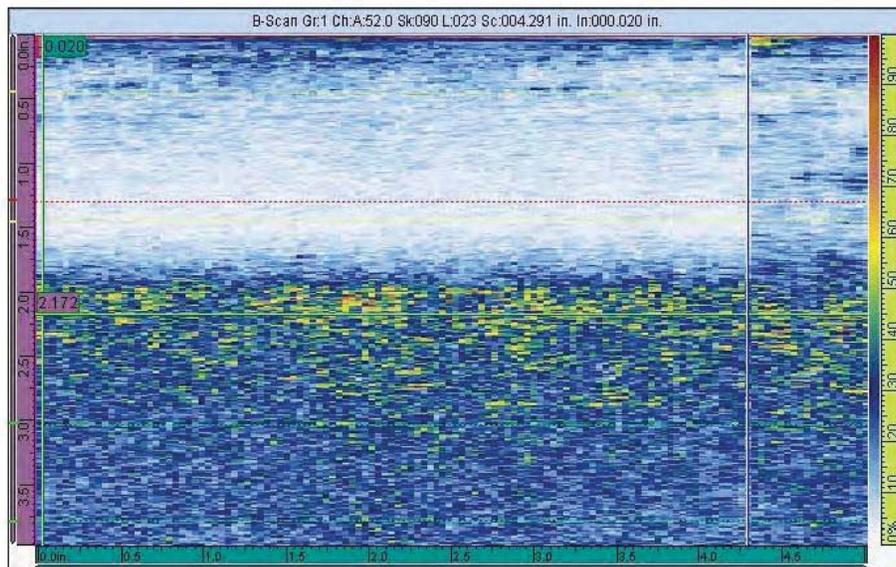
Clean/Un-Paired Samples

1900-clean-L-r

Uncovered plate can also be scanned with a 90 degree probe over parts with contour resolution

RATING=

0





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Plate 1900
1900-tape-1-r

Taped/Patched Samples

RATING= 0

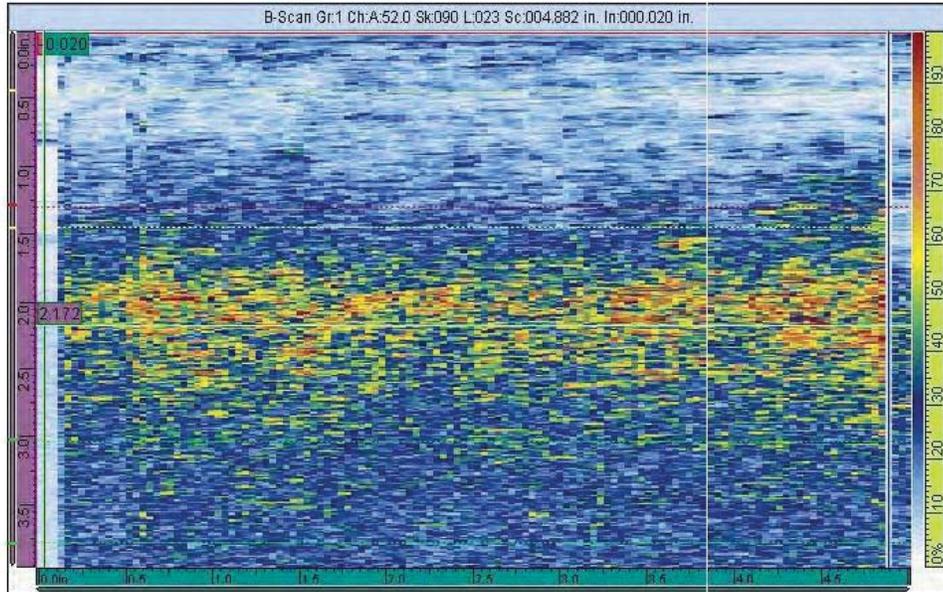


Plate 1900

Plate/Patched Samples

RATING= 0

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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Plate 1900

Image of Samples

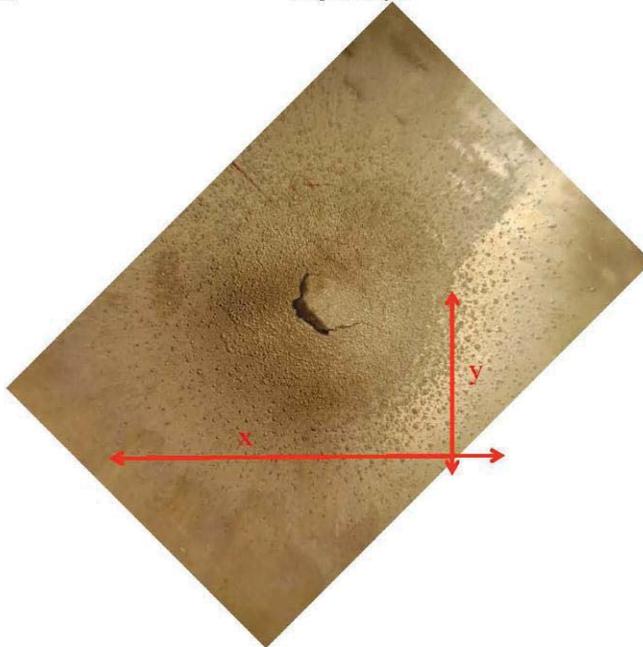


Plate 1900

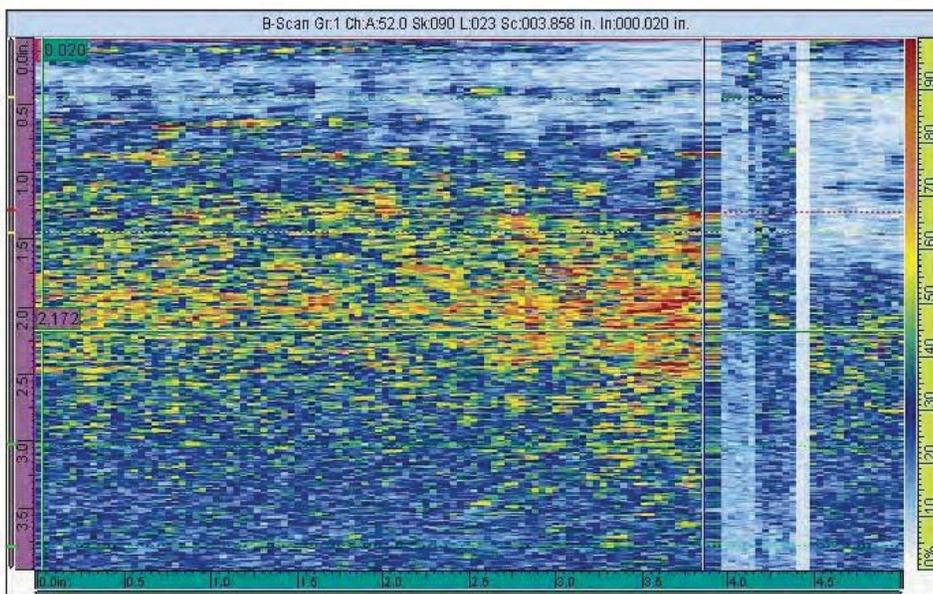
Clean/Un-Patched Samples

1900-clean-1-r45

Uncovered plate can also be scanned with a 90 degree probe over parts with contour resolution

RATING=

0





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Plate 1900

1900-tape-1-r45

Taped/Patched Samples

RATING=

0

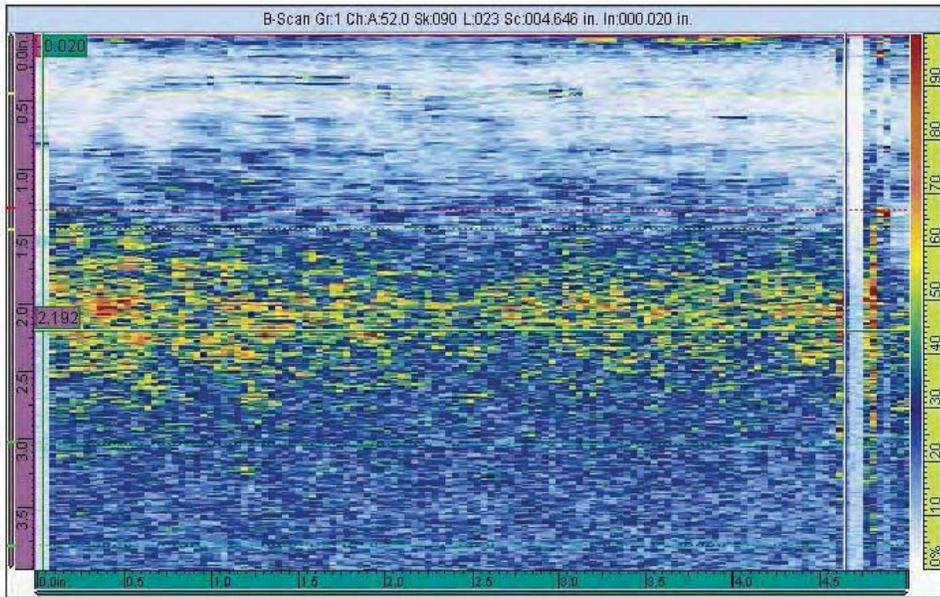


Plate 1900

RATING=

0

RATING=

0

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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Plate 1900

Image of Samples

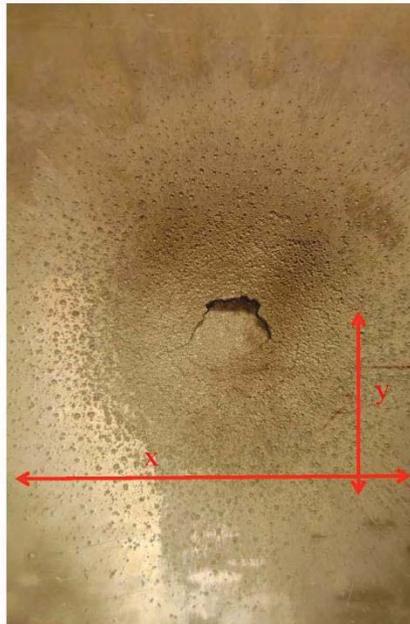


Plate 1900

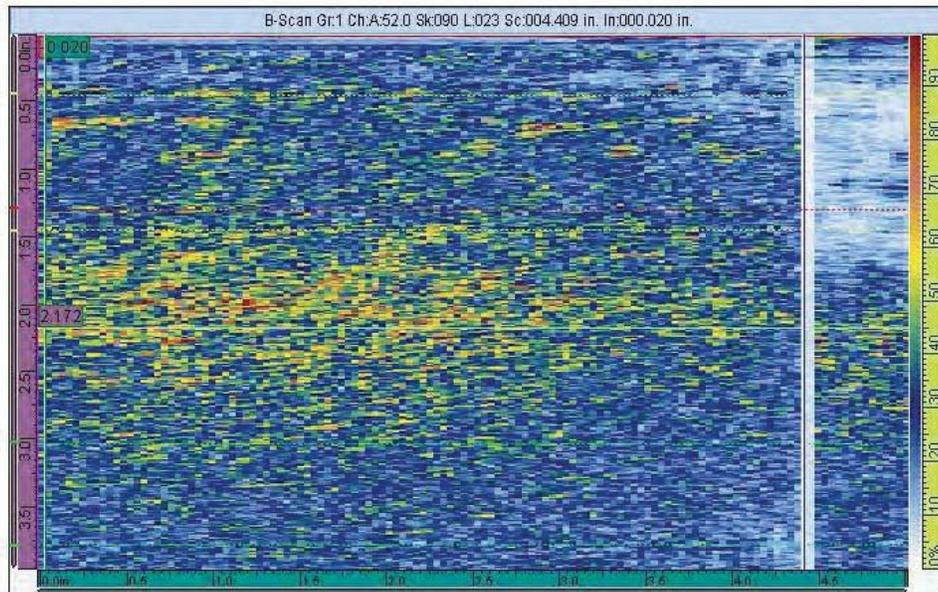
1900-clean-r1

Clean/Un-Patched Samples

Uncovered plate can also be scanned with a 90 degree probe over parts with contour resolution

RATING=

0





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Plate 1900
1900-tape-r-1

Taped/Patched Samples

RATING= 0

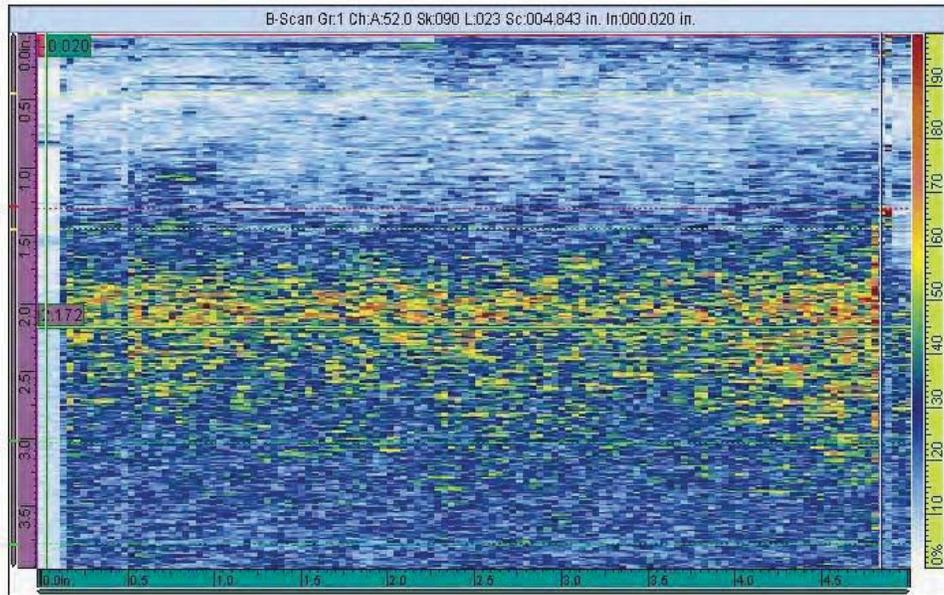


Plate 1900

Plate/Patched Samples

RATING= 0
RATING= 0

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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Plate 1900

Image of Samples

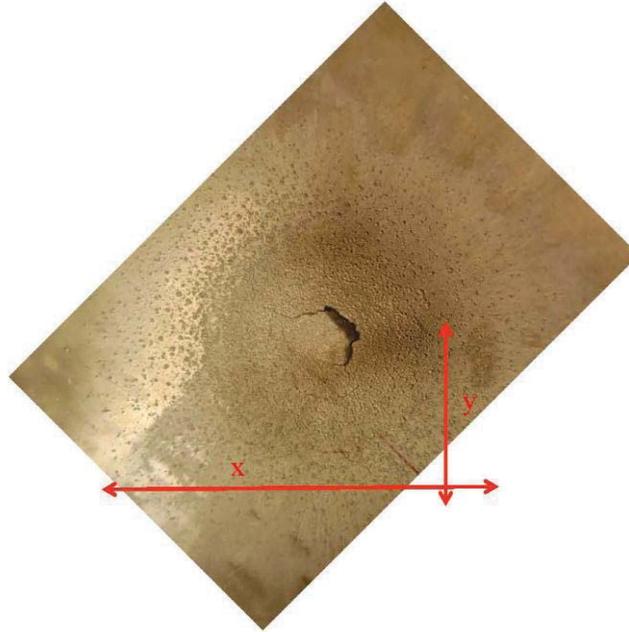


Plate 1900

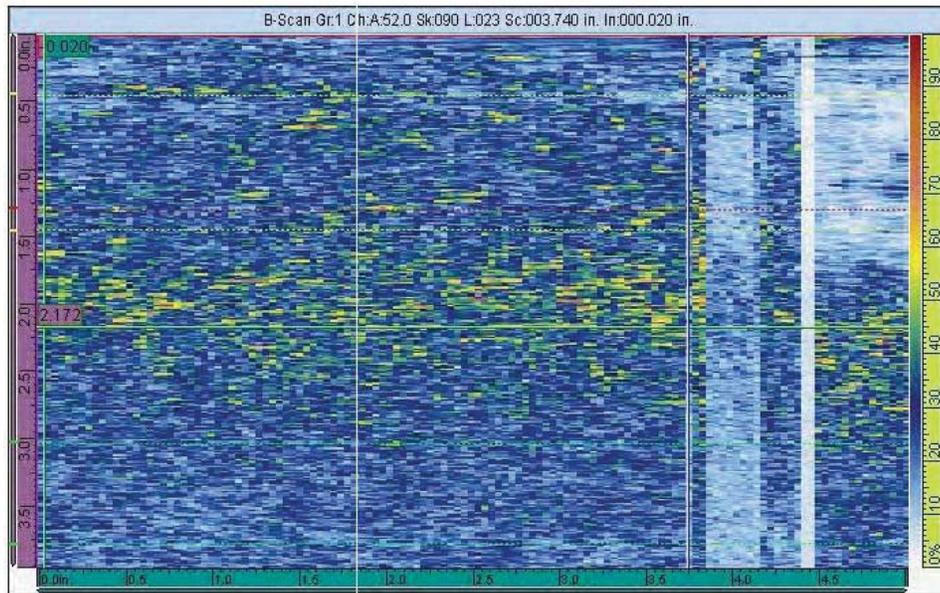
Clean/Un-Paired Samples

1900-clean-r145

Uncovered plate can also be scanned with a 90 degree probe over parts with contour resolution.

RATING=

0





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Plate 1900
1900-taps-r-145

Taped/Patched Samples

RATING= **0**

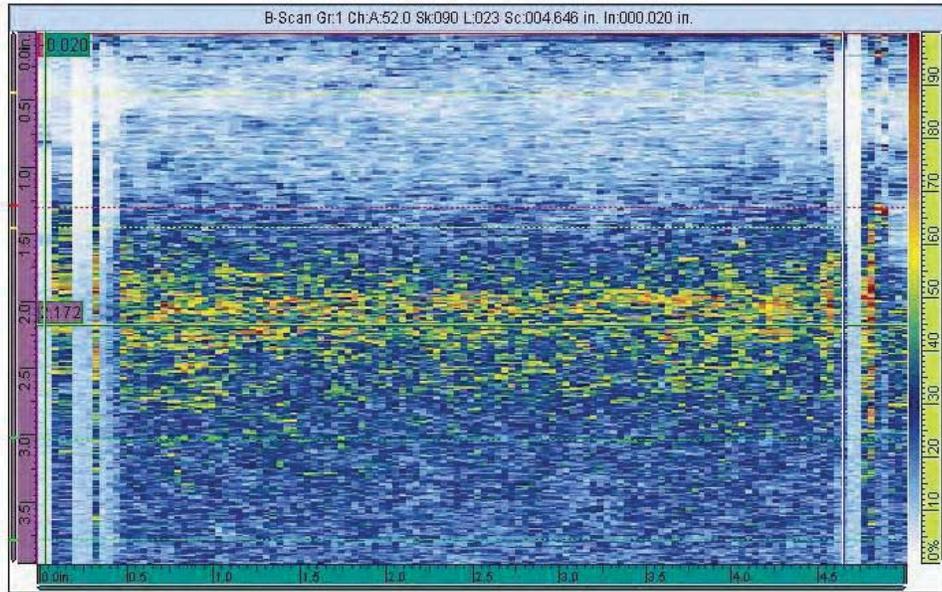


Plate 1900

Plate/Patched Samples

RATING= **0**
RATING= **0**

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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Plate 1907

Image of Samples

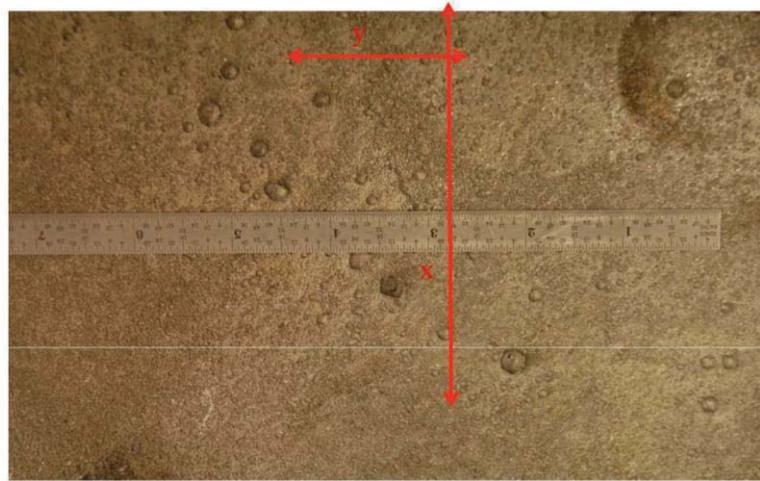


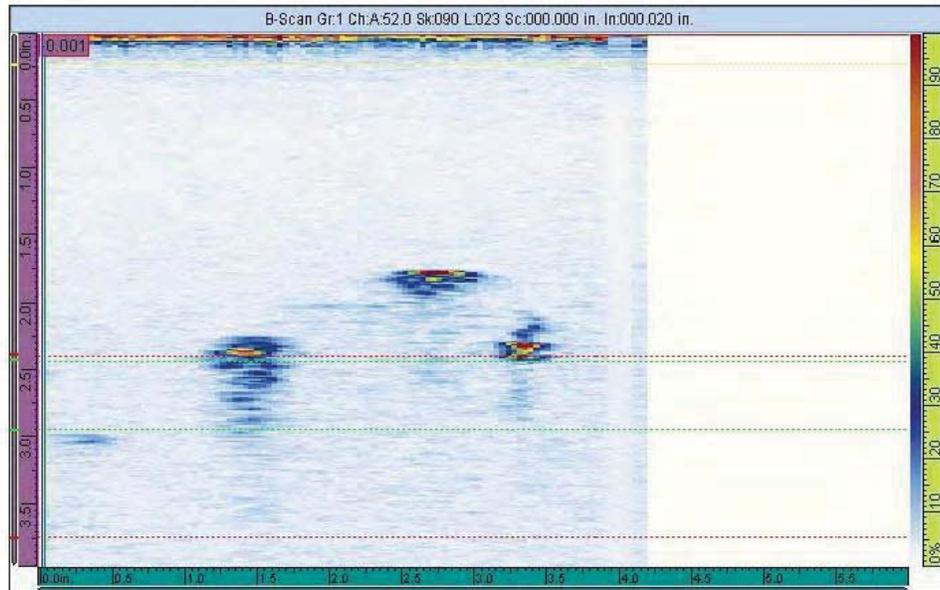
Plate 1907
1907-clean-1.r

Clean/Un-Patched Samples

RATING=

2

Uncovered plate can also be scanned with a 90 degree probe over parts with contour resolution





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Plate 1907
1907-tape-1-r

Taped/Patched Samples

RATING=

1

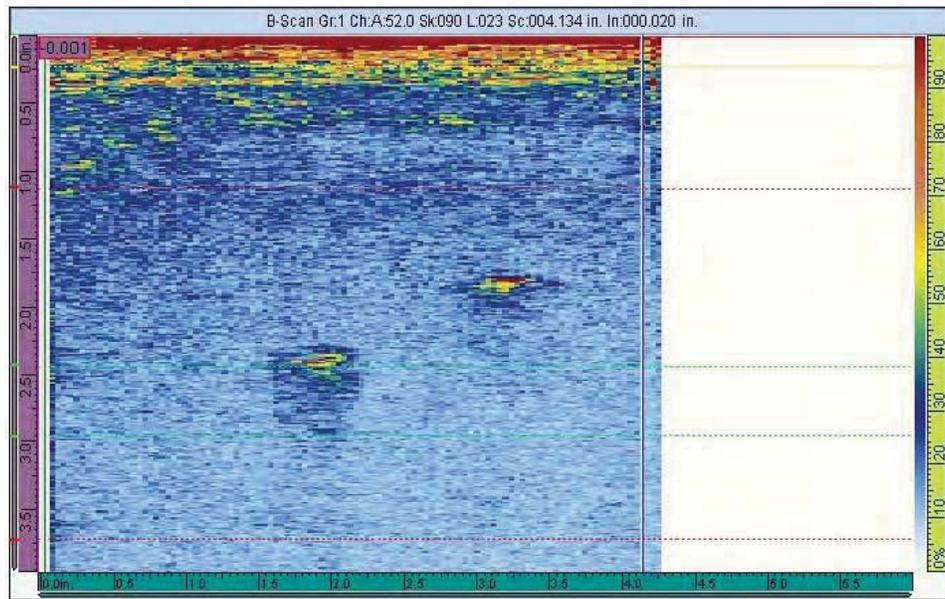


Plate 1907

Plate/Patched Samples

RATING=

1

RATING= 1.333333333

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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Plate 1907

Image of Samples

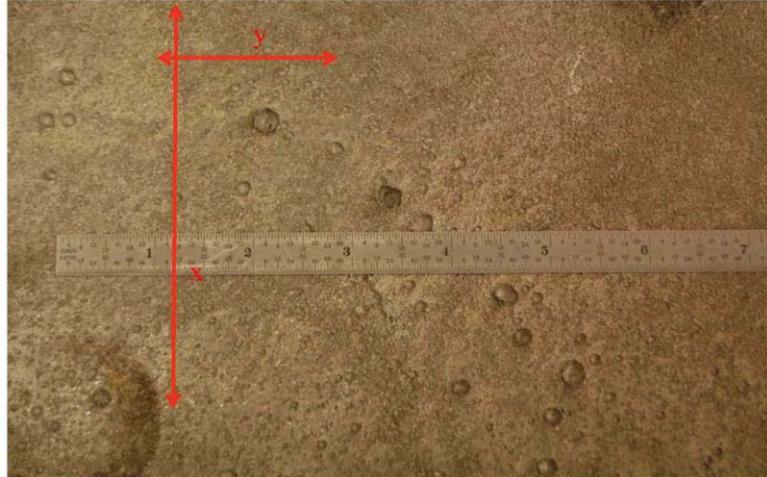


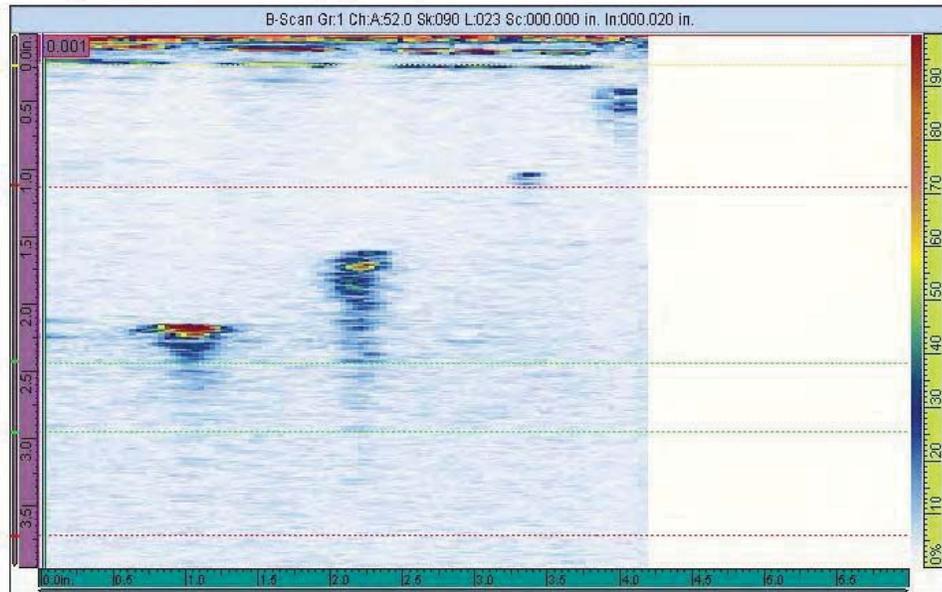
Plate 1907
1907-clean-r1

Clean/Un-Patched Samples

RATING=

2

Uncovered plate can also be scanned with a 90 degree probe over parts with contour resolution





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Plate 1907
1907-tape-r-1

Taped/Patched Samples

RATING=

1

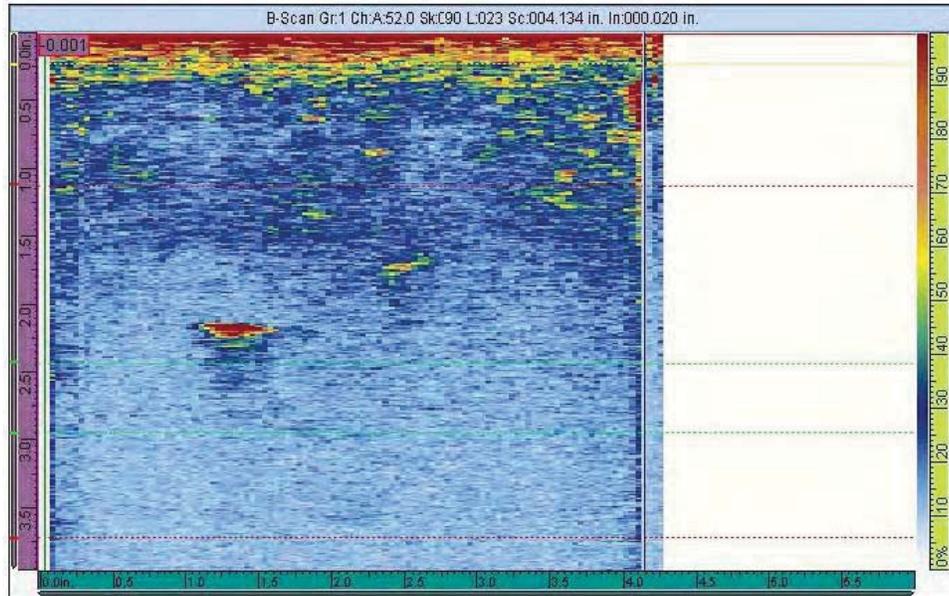


Plate 1907

Plate/Patched Samples

RATING=

1

RATING=

1.33333333

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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Plate T3

Image of Samples

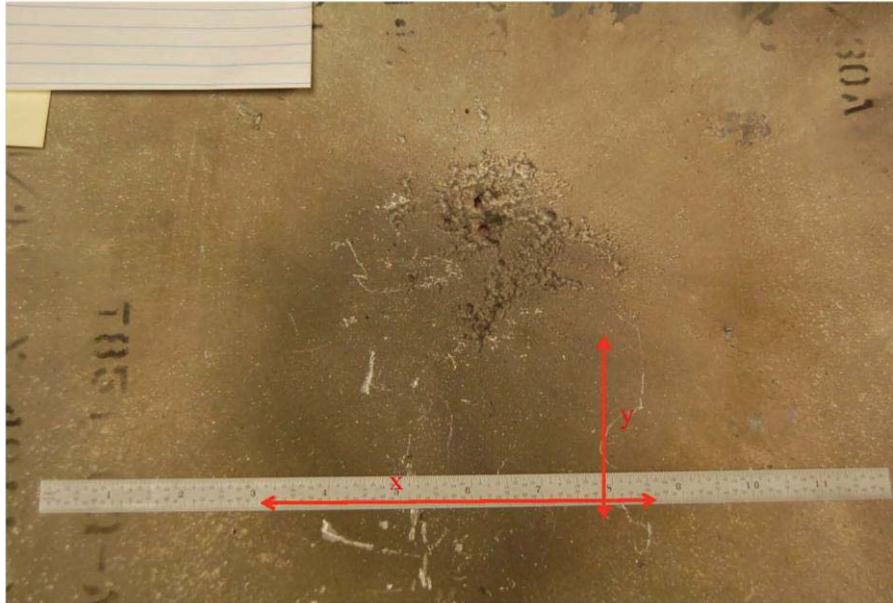
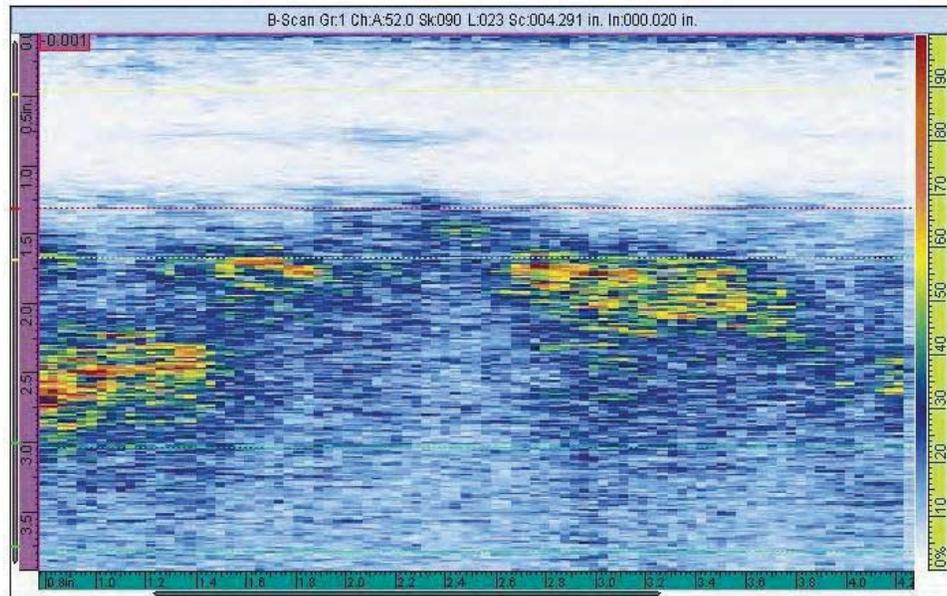


Plate T3
T3-clean-Lr

Clean/Un-Patched Samples

RATING=

2





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Plate T3
T3-tape-l-r

Taped/Patched Samples

RATING=

2

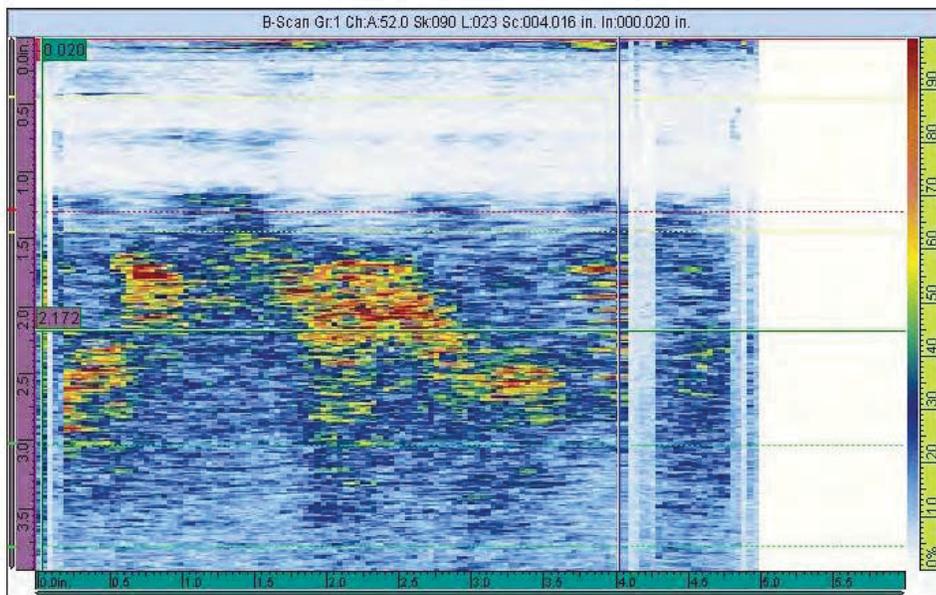


Plate T3

Plate/Patched Samples

RATING=

2

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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Plate T3

Image of Samples

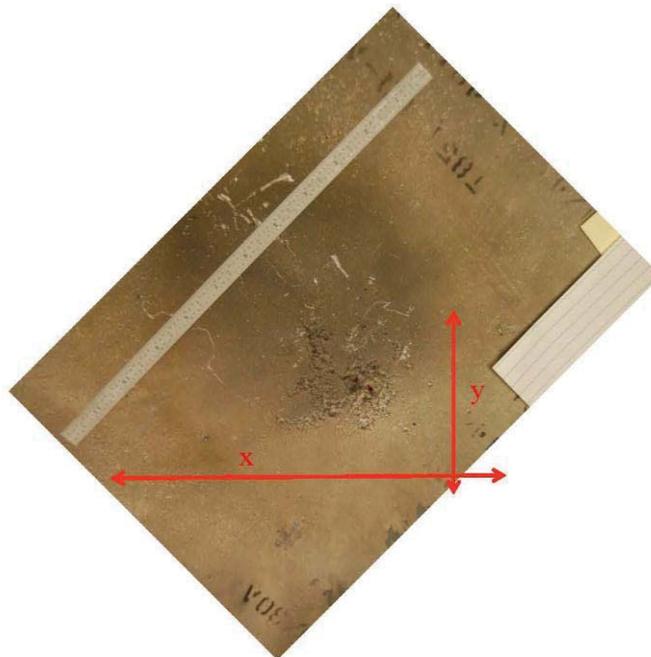


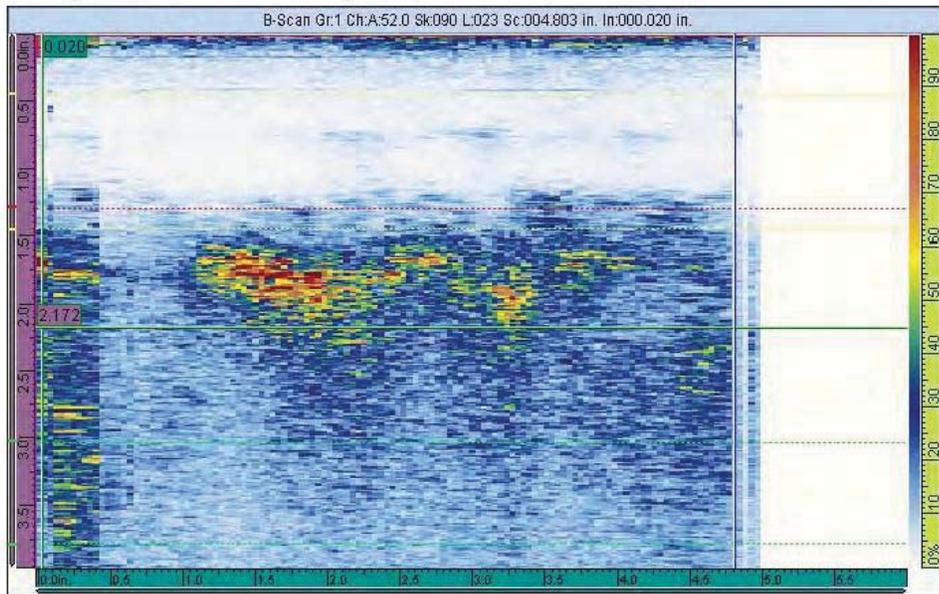
Plate T3
T3-clean-L-r45

Clean/Un-Patched Samples

RATING=

2

Uncovered plate can also be scanned with a 90 degree probe over parts with contour resolution





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Plate T3
T3-tape-1-r45

Taped/Patched Samples

RATING=

2

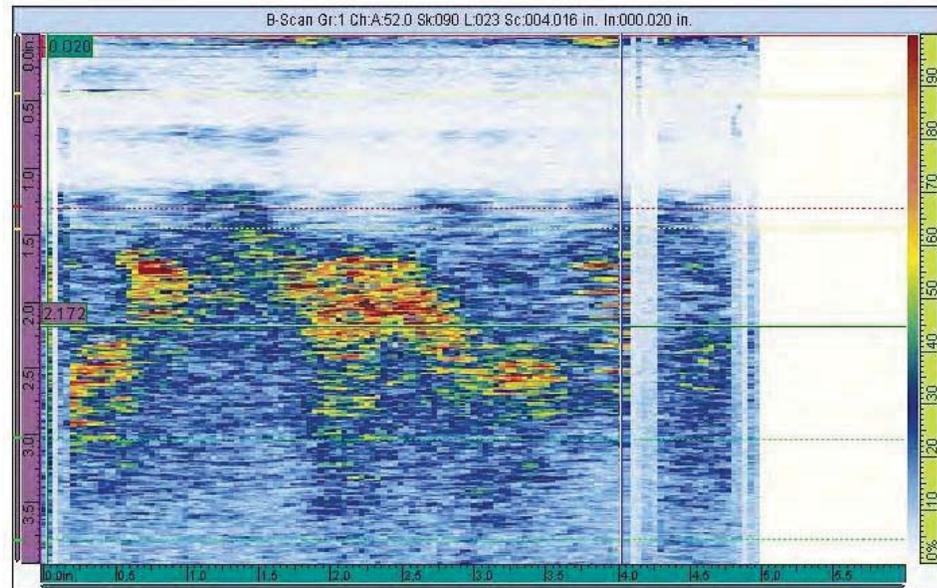


Plate T3

Plate/Patched Samples

RATING=

2

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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Plate T3

Image of Samples

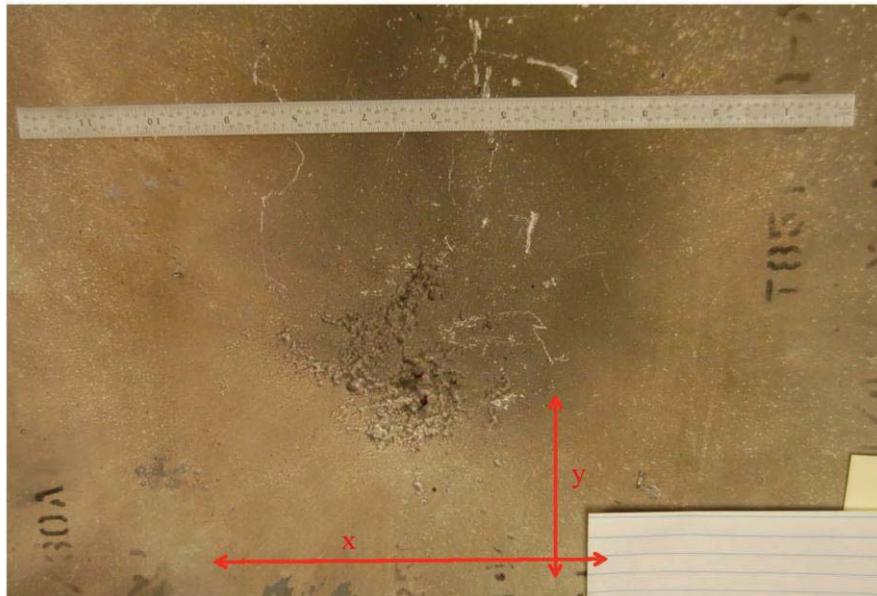


Plate T3

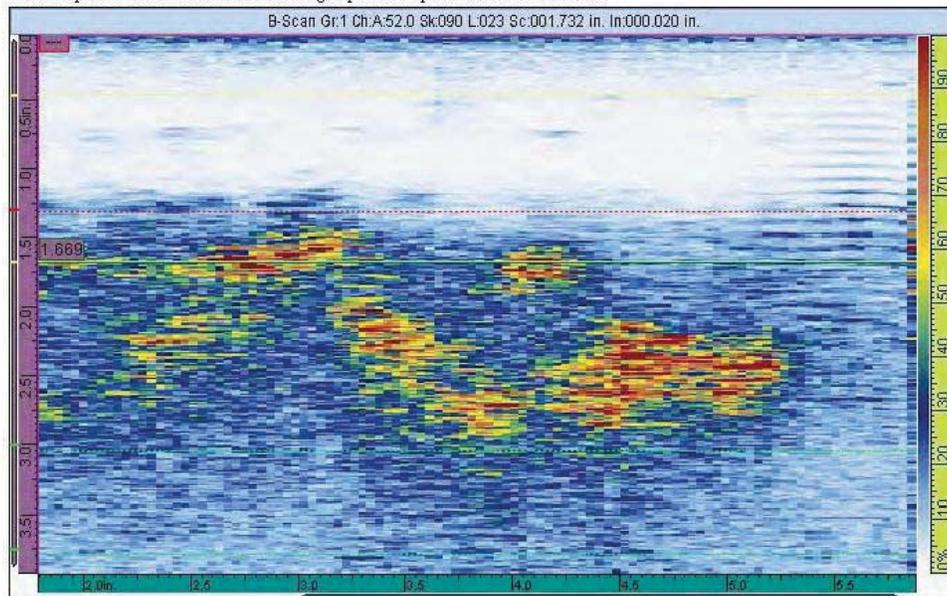
T3-clean-r-1

Clean/Un-Patched Samples

RATING=

2

Uncovered plate can also be scanned with a 90 degree probe over parts with contour resolution





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Plate T3
T3-tape-r-1

Taped/Patched Samples

RATING=

2

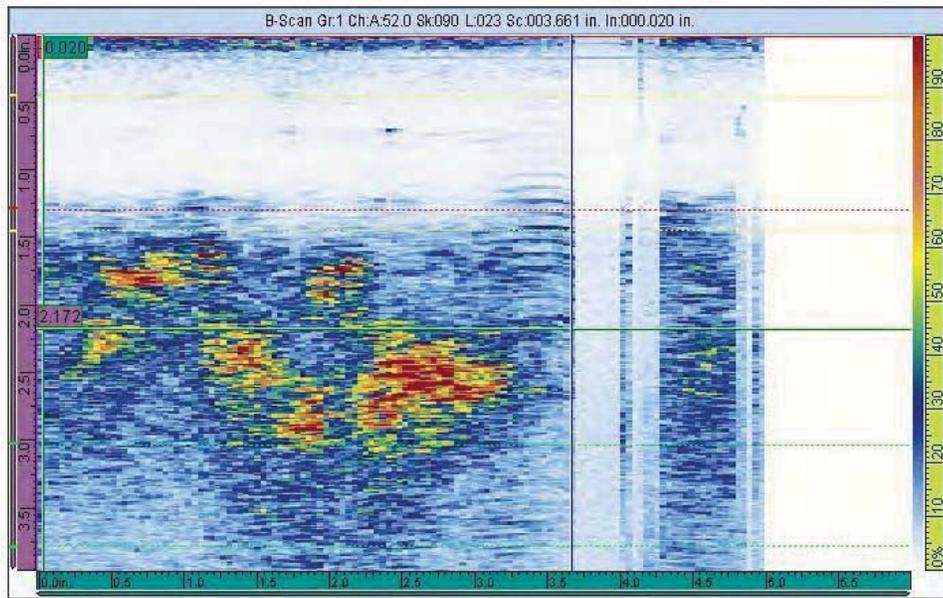


Plate T3

Plate/Patched Samples

RATING=

2

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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Plate T3

Image of Samples

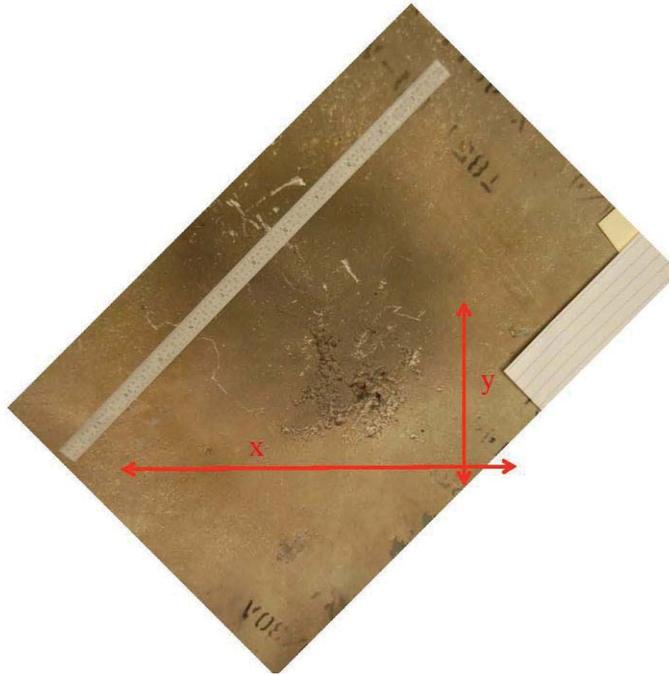


Plate T3

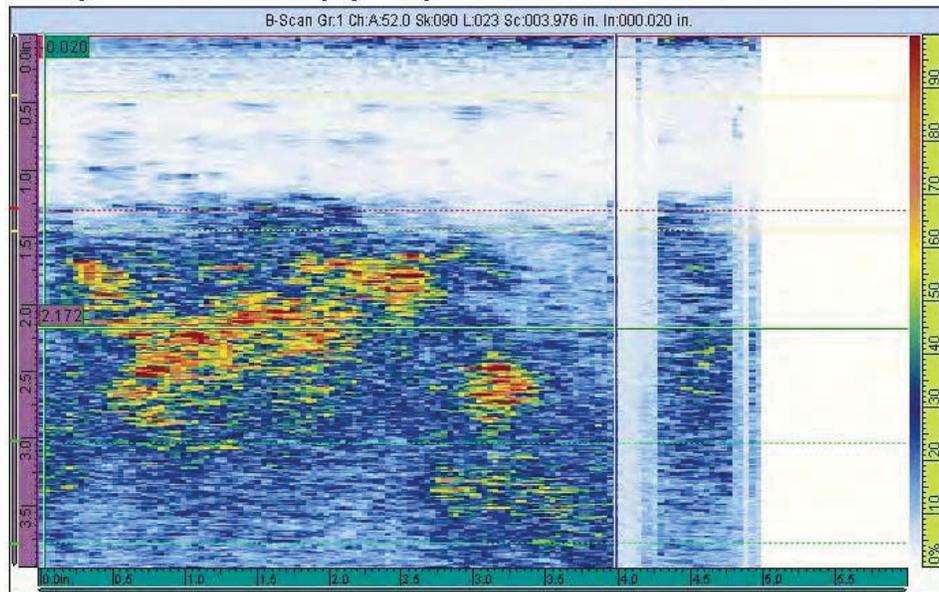
Clean/Un-Patched Samples

T3-clean-r-145

RATING=

2

Uncovered plate can also be scanned with a 90 degree probe over parts with contour resolution





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Plate T3
T3-tape-r-145

Taped/Patched Samples

RATING=

2

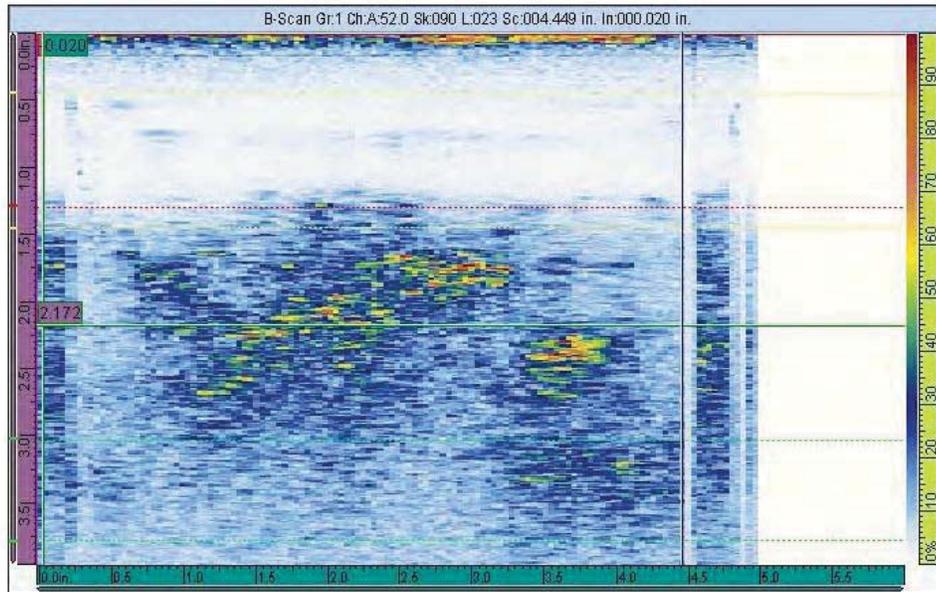


Plate T3

Plate/Patched Samples

RATING=

RATING=

2

2

Plates not scanned, however, engineering estimates can be made by comparison to tape patched plates



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Plate 12243 (FGB impact plate)

Image of Samples

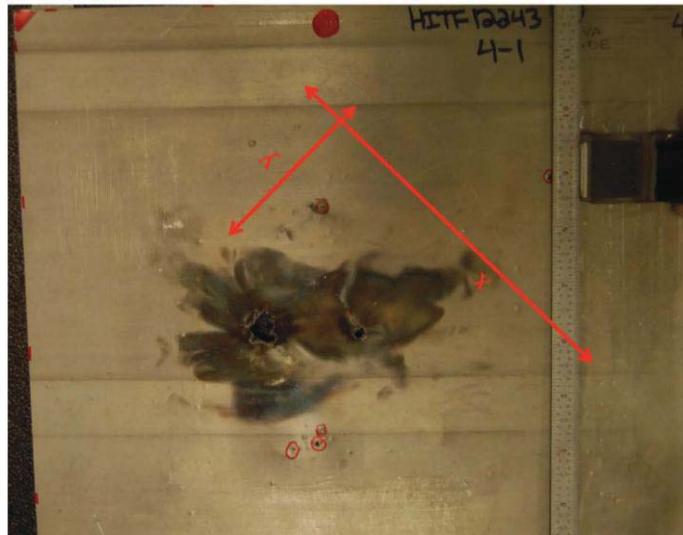


Plate 12243 (FGB impact plate)

Clean/Un-Patched Samples

RATING=

1

Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.



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Plate 12243 (FGB impact plate)

Taped/Patched Samples

RATING= 1

Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.

Plate 12243 (FGB impact plate)

Plate/Patched Samples

RATING= 1
RATING= 1

Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.



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Plate 123 (Bond Plate)

Image of Samples

c-scan image from water tank

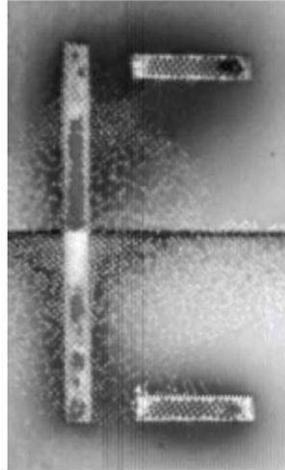


Plate 123 (Bond Plate)

Clean/Un-Patched Samples

Scans not saved

RATING=

2



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Plate 158 (Bond Plate)

Image of Samples

e-scan image from water tank

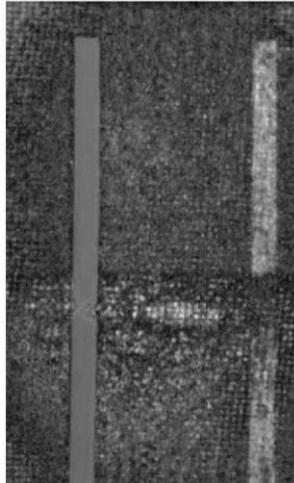


Plate 158 (Bond Plate)

Clean/Un-Patched Samples

Scans not saved

RATING=

2



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Plate 028B (Bond Plate)

Image of Samples

c-scan image from water tank

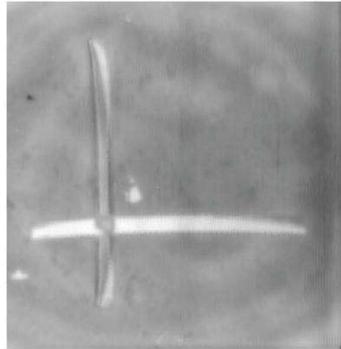


Plate 028B (Bond Plate)

Clean/Un-Patched Samples

Scans not saved

RATING=

2



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Plate 132A (Bond Plate)

Image of Samples

Plate 132A (Bond Plate)
Scans not saved

Clean/Un-Patched Samples

RATING=

2



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Appendix E. Sonatest Veo Results

Sonatest VEO



Scans below using the Sonatest VEO UT portable scanner.
The scans were performed using Phase Array.

Ratings:

0	Failure to identify important features
1	Features slightly detectable but not clearly defined
2	Undoubtable feature detection

Average RATING amongst all scans:	1.62
Average RATING amongst NDE Standard Scans:	1.60
Average RATING amongst impacted plate scans:	1.27
Average RATING amongst bond plate scans:	2.00

NDE Standard 1A:	0.00	Impacted Plate 186:	2.00
NDE Standard 1B:	0.00	Impacted Plate 1900:	0.00
NDE Standard 2:	2.00	Impacted Plate 1907:	1.33
NDE Standard 3:	2.00	Impacted Plate T3:	2.00
NDE Standard 4:	2.00	Impacted Plate 243:	1.00
NDE Standard 5:	2.00	not saved	
NDE Standard 6A:	2.00	Bond Plate 123:	2.00
NDE Standard 6B:	2.00	Bond Plate 158:	2.00
NDE Standard 7A:	2.00	Bond Plate 028B:	2.00
NDE Standard 7B:	2.00	Bond Plate 132A:	2.00



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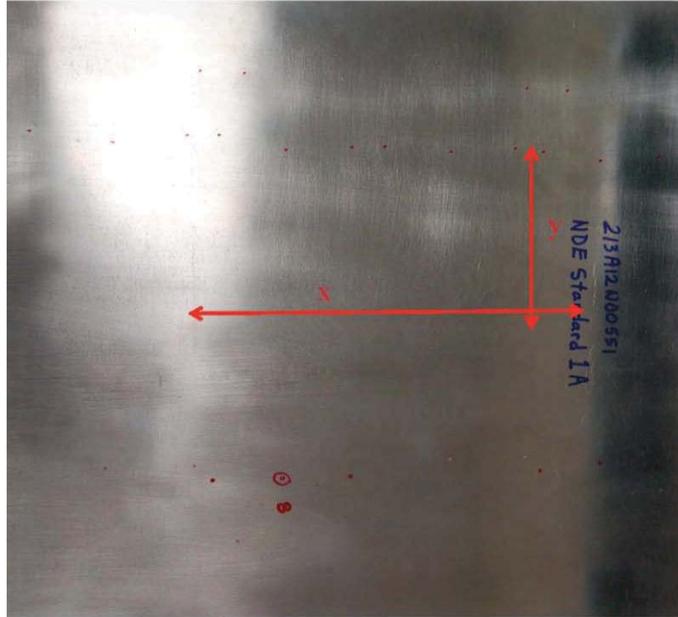
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NDE Standard IA Notches

Image of Samples



NDE Standard IA Notches

Clean/Un-Patched Samples

No images from the IVA side: Grid impedes scanning of the plate

RATING=

0



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NDE Standard 1A Notches

Taped/Patched Samples

No images from the IVA side. Grid impedes scanning of the plate

RATING= 0

NDE Standard 1A Notches

Plate/Patched Samples

No images from the IVA side. Grid impedes scanning of the plate

RATING= 0
RATING= 0



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1.0

Title:

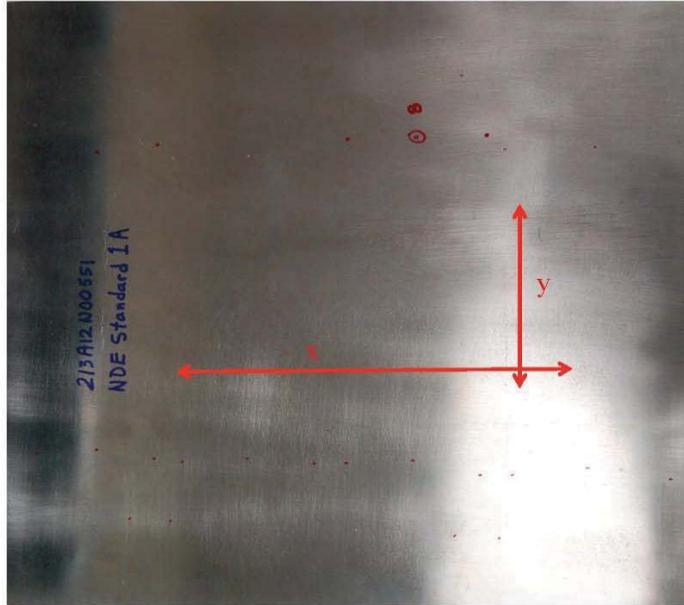
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NDE Standard 1A Holes

Image of Samples



NDE Standard 1A Holes

Clean/Un-Patched Samples

No images from the IVA side: Grid impedes scanning of the plate

RATING=

0



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NDE Standard 1A Holes

Taped/Patched Samples

No images from the IVA side: Grid impedes scanning of the plate

RATING= 0

NDE Standard 1A Holes

Plate/Patched Samples

No images from the IVA side: Grid impedes scanning of the plate

RATING= 0
RATING= 0



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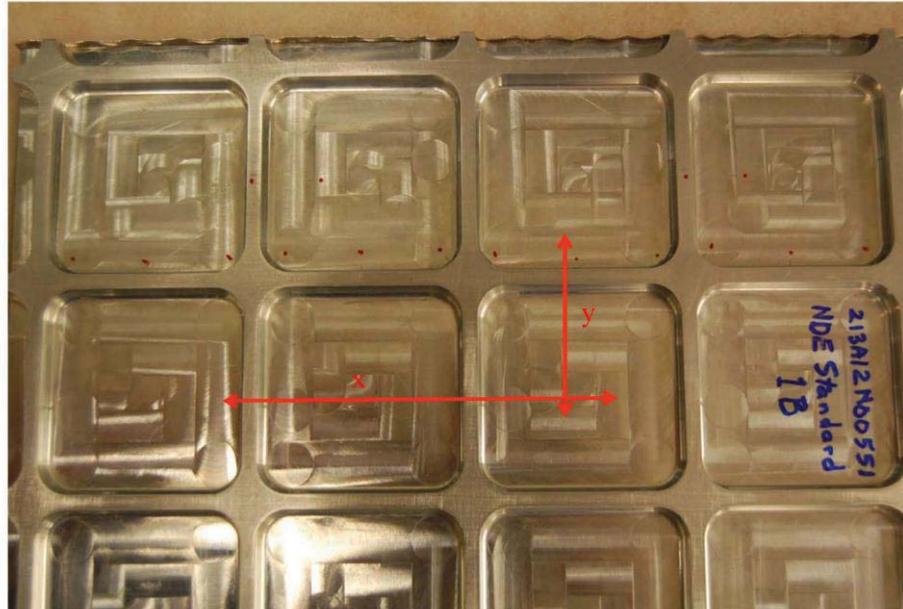
Title:

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NDE Standard 1B Notches

Image of Samples



NDE Standard 1B Notches

Clean/Un-Patched Samples

Note: no images were saved: results were similar to those for the Omniscan MX

RATING=

0



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NDE Standard 1B Notches

Taped/Patched Samples

Note: no images were saved: results were similar to those for the Omniscan MX

RATING= 0

NDE Standard 1B Notches

Plate/Patched Samples

Note: no images were saved: results were similar to those for the Omniscan MX

RATING= 0
RATING= 0



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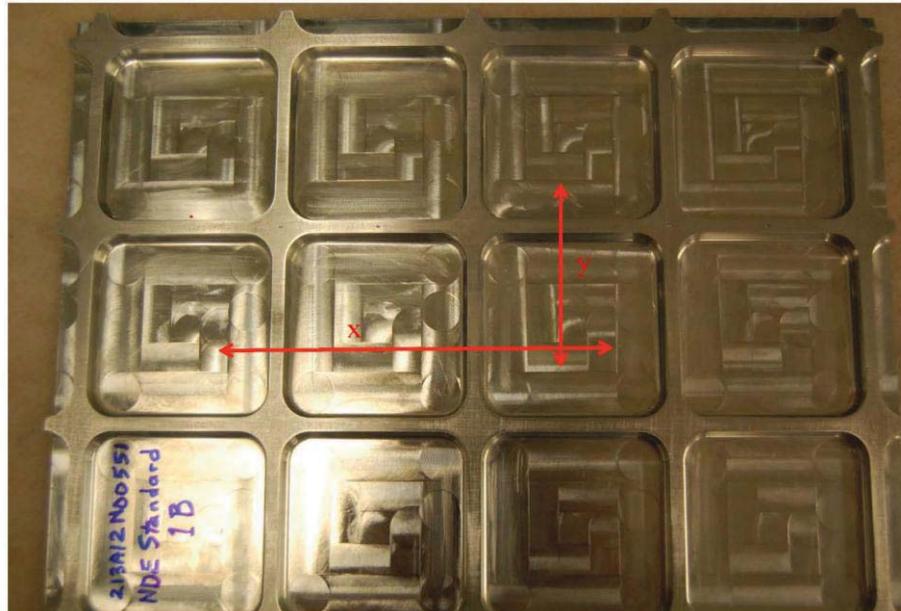
Title:

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NDE Standard 1B Holes

Image of Samples



NDE Standard 1B Holes

Clean/Un-Patched Samples

Note: no images were saved: results were similar to those for the Omniscan MX

RATING=

0



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NDE Standard 1B Holes

Taped/Patched Samples

Note: no images were saved: results were similar to those for the Omniscan MX

RATING=

0

NDE Standard 1B Holes

Plate/Patched Samples

Note: no images were saved: results were similar to those for the Omniscan MX

RATING=

0

RATING=

0



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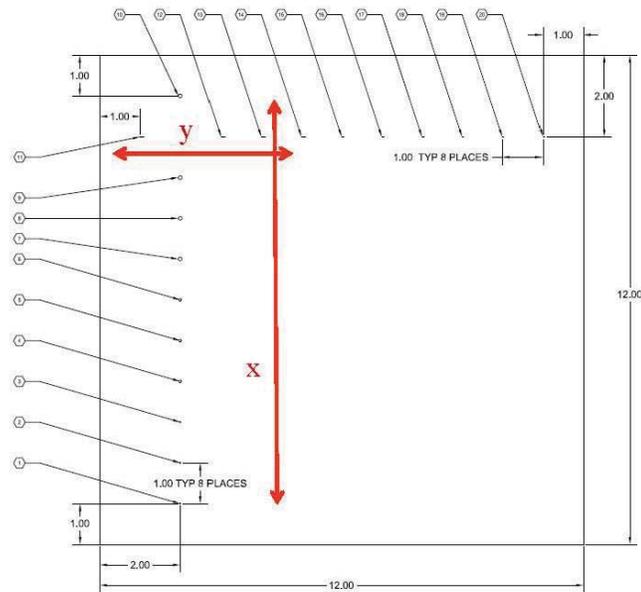
Title:

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NDE Standard 2 holes

Image of Samples



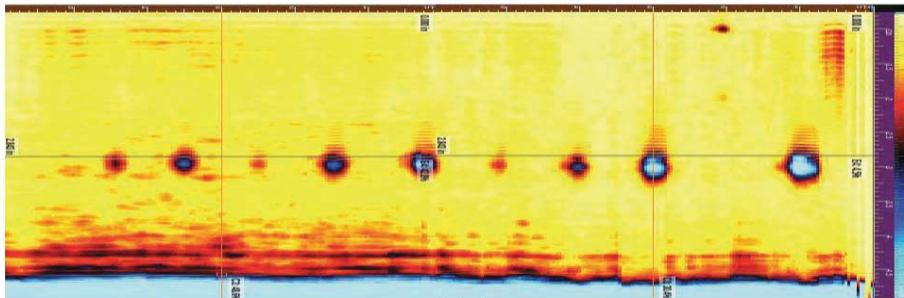
NDE Standard 2 holes

NASA_std2-clean-holes-2_0001
NASA_std2-clean-holes-1_0001

Clean/Un-Patched Samples

RATING=

2





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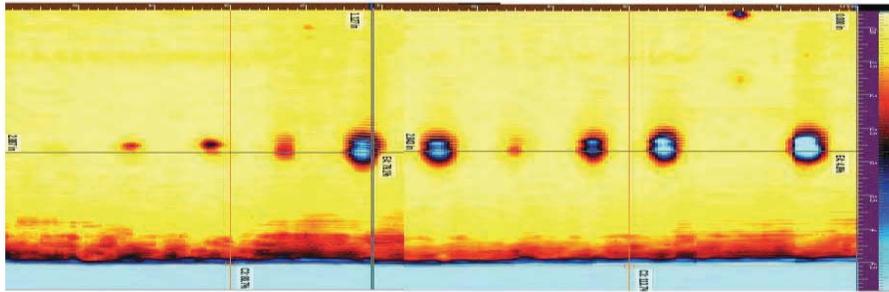
NDE Standard 2 holes

NASA_std2-tape-holes-2_0001
NASA_std2-tape-holes-1_0001

Taped/Patched Samples

RATING=

2



NDE Standard 2 holes

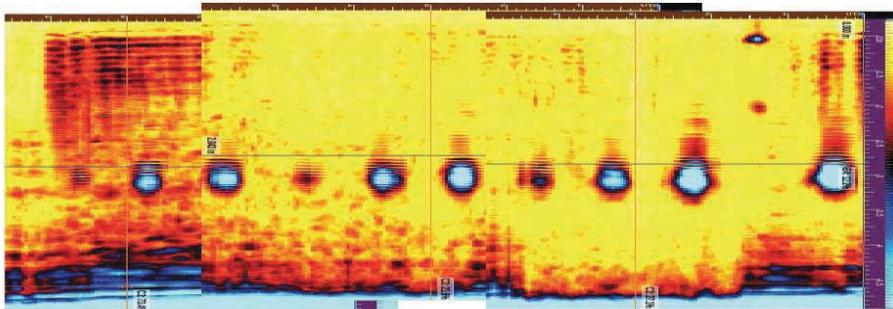
Plate/Patched Samples

RATING=

2

RATING=

2





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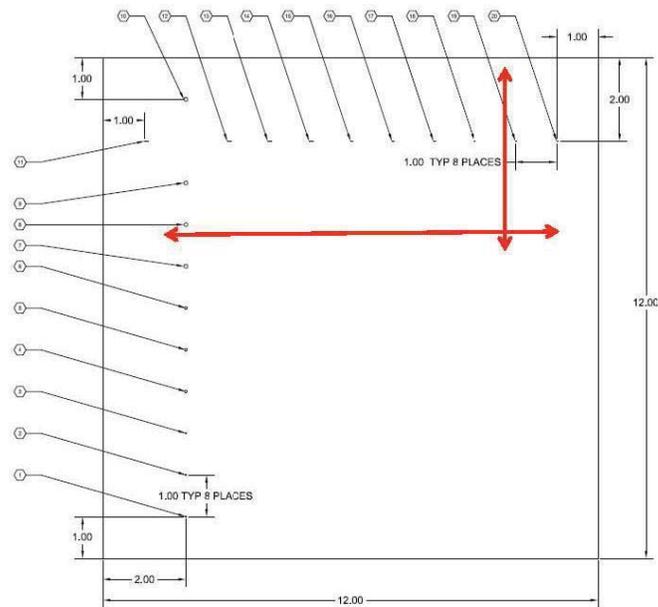
Title:

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NDE Standard 2 notches

Image of Samples

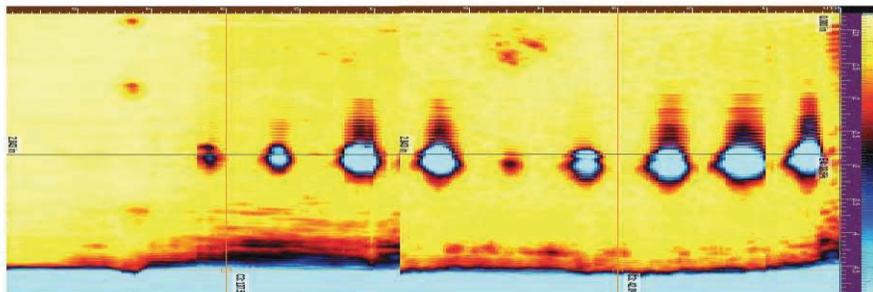


NDE Standard 2 notches

Clean/Un-Patched Samples

RATING=

2





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Title:

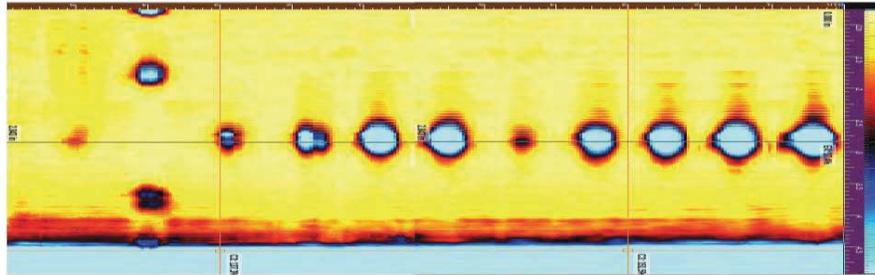
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NDE Standard 2 notches

Taped/Patched Samples

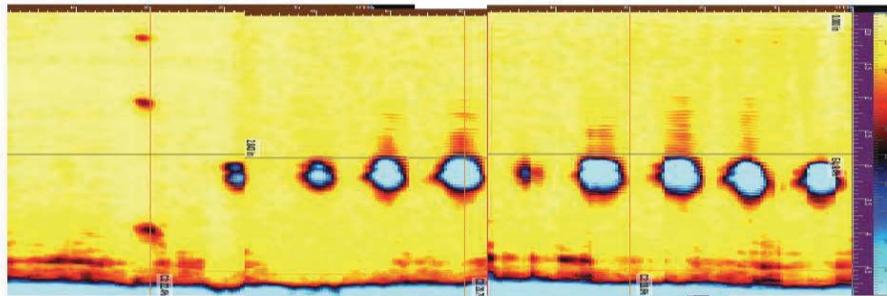
RATING= 2



NDE Standard 2 notches

Plate/Patched Samples

RATING= 2
RATING= 2





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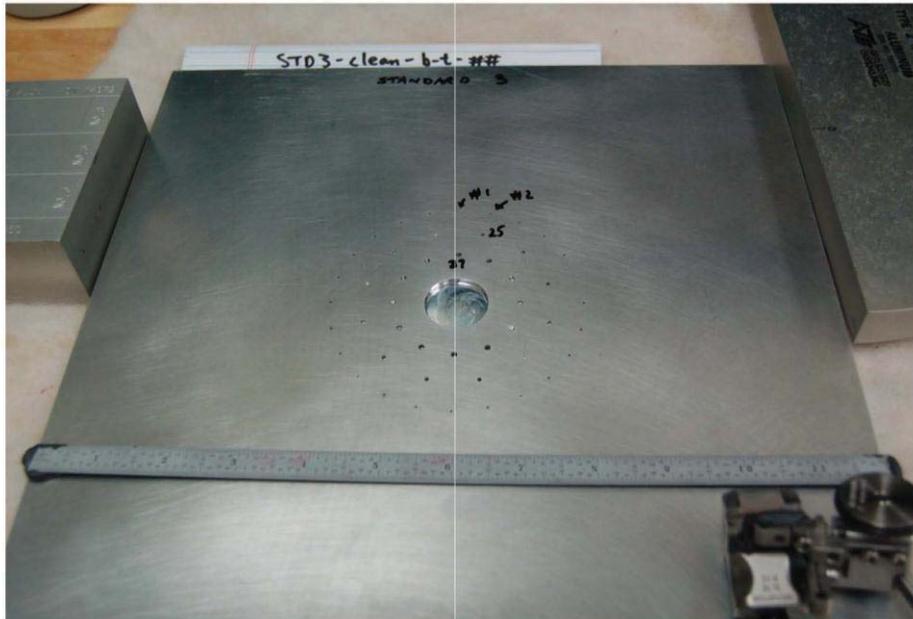
Title:

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NDE Standard 3

Image of Samples



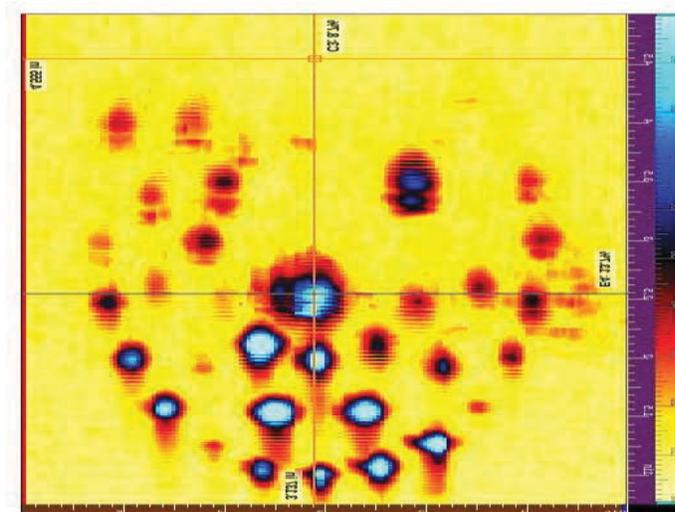
NDE Standard 3

NASA_STD3-CLEAN_B-T-1_0000

Clean/Un-Patched Samples

RATING=

2





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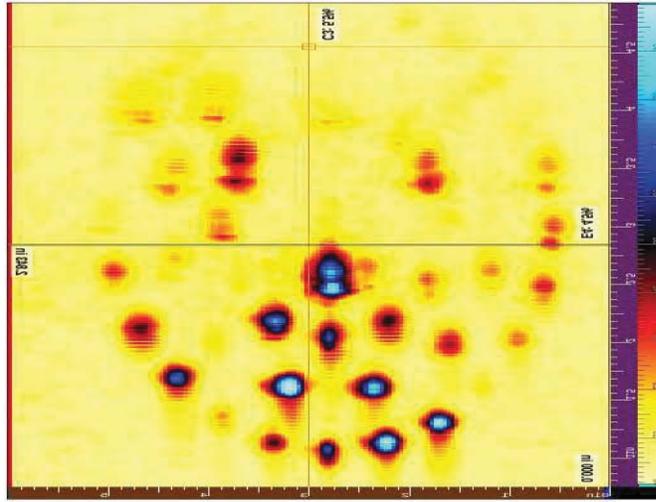
NDE Standard 3

NASA_STD3-TAPE_B-T-1_0000

Tap ed/Patched Samples

RATING=

2



NDE Standard 3

NASA_STD3-PLATE_B-T-1_0000

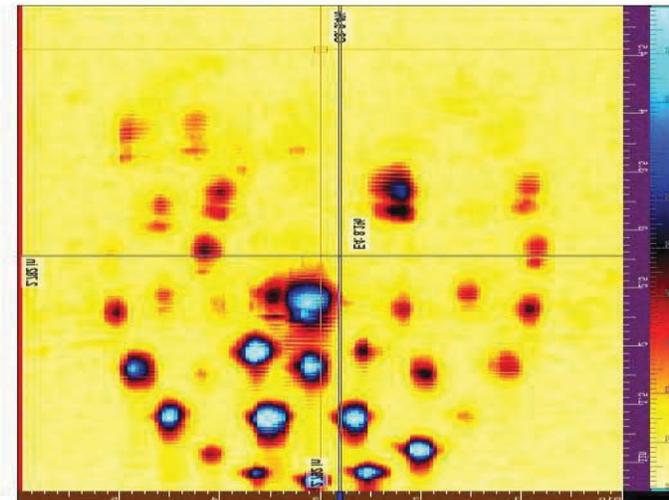
Plate/Patched Samples

RATING=

2

RATING=

2





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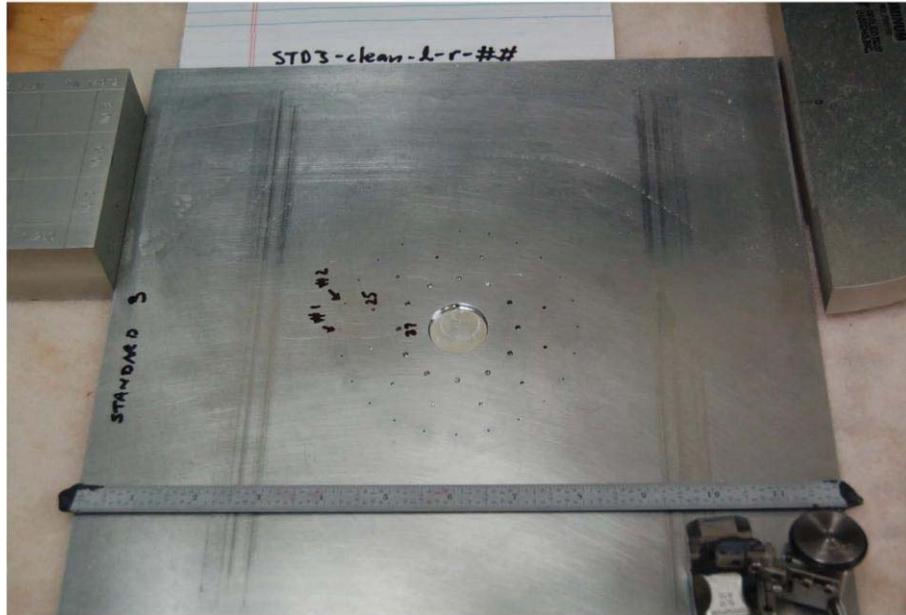
Title:

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NDE Standard 3

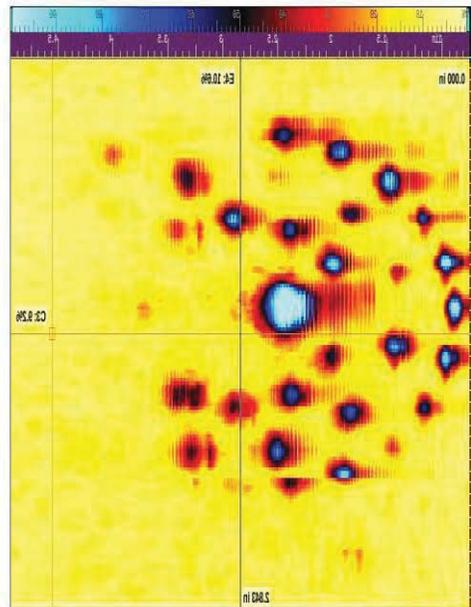
Image of Samples



NDE Standard 3

NASA_STD3-CLEAN_L-R-1_0000

Clean/Un-Patched Samples



RATING=

2



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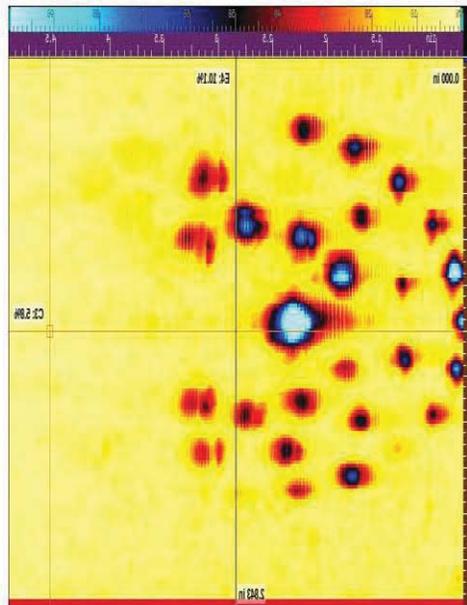
NDE Standard 3

NASA_STD3-TAPE_L-R-1_0000

Taped/Patched Samples

RATING=

2



NDE Standard 3

NASA_STD3-PLATE_R-L-1_0002

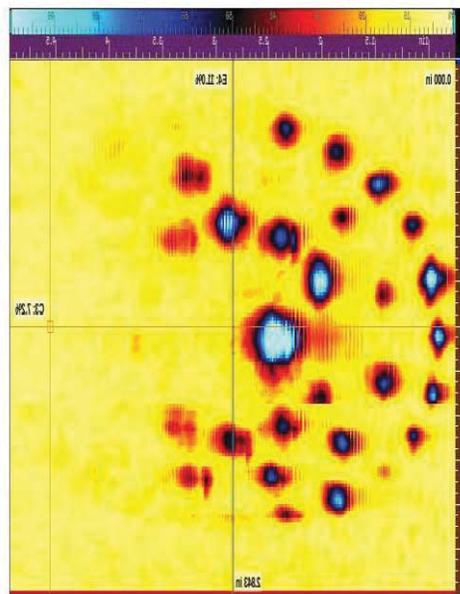
Plate/Patched Samples

RATING=

2

RATING=

2





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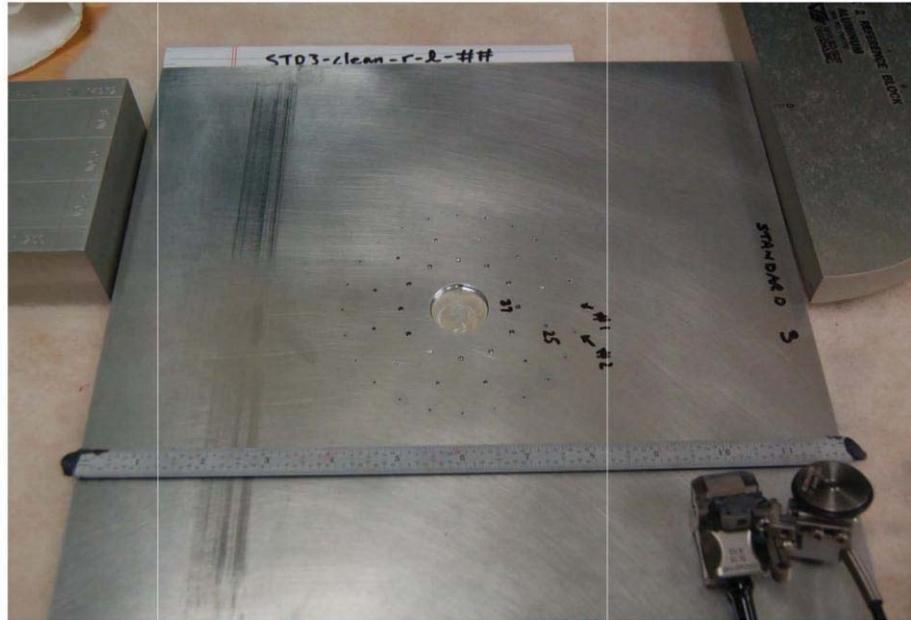
Title:

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NDE Standard 3

Image of Samples



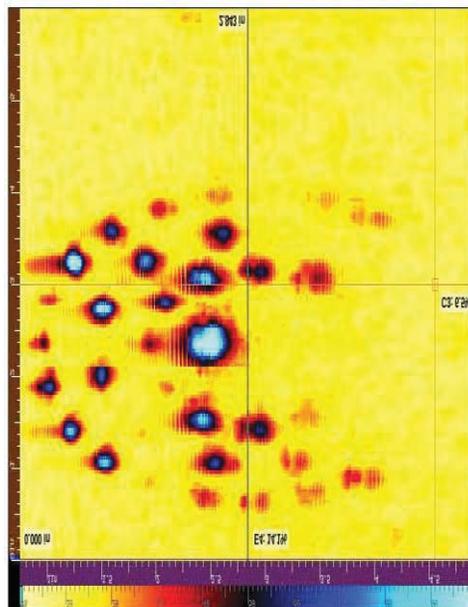
NDE Standard 3

NASA_STD3-CLEAN_R-L-2_0000

Clean/Un-Patched Samples

RATING=

2





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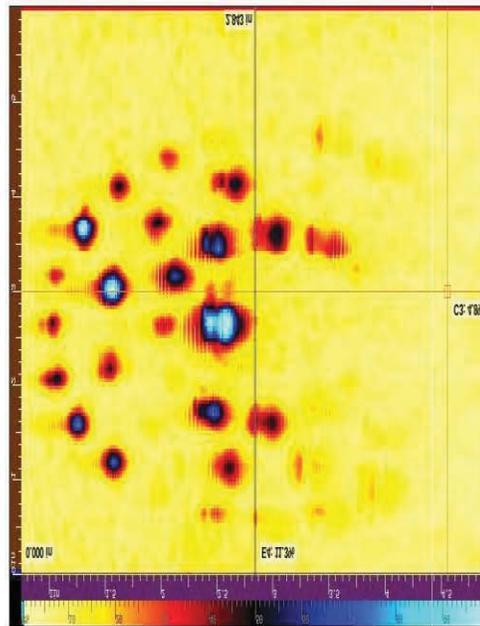
NDE Standard 3

NASA_STD3-TAPE_R-L-1_0000

Taped/Patched Samples

RATING=

2



NDE Standard 3

NASA_STD3-PLATE_R-L-1_0000

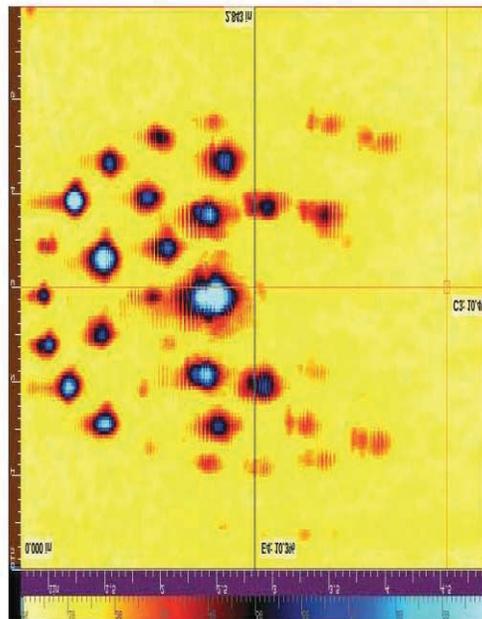
Plate/Patched Samples

RATING=

2

RATING=

2





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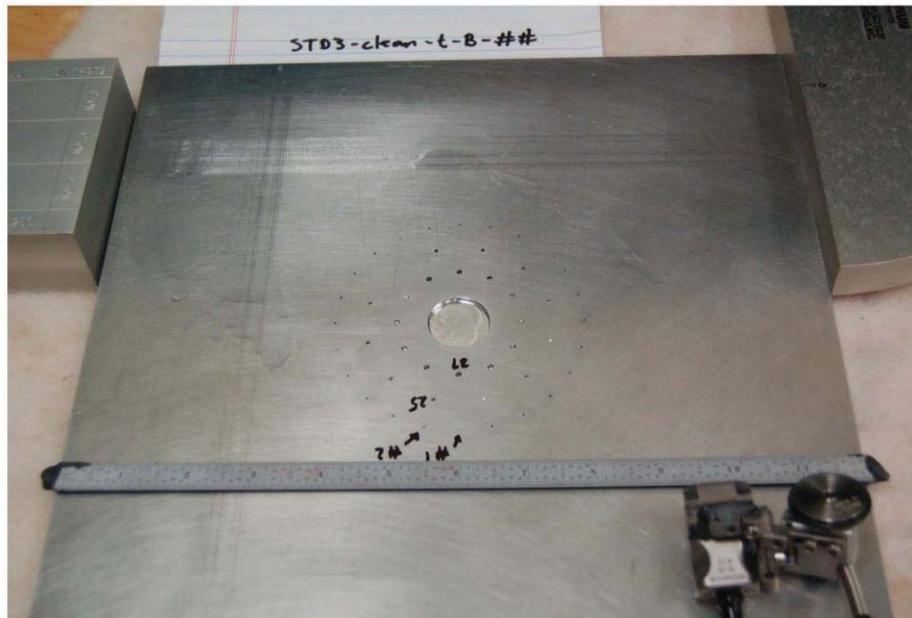
Title:

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NDE Standard 3

Image of Samples



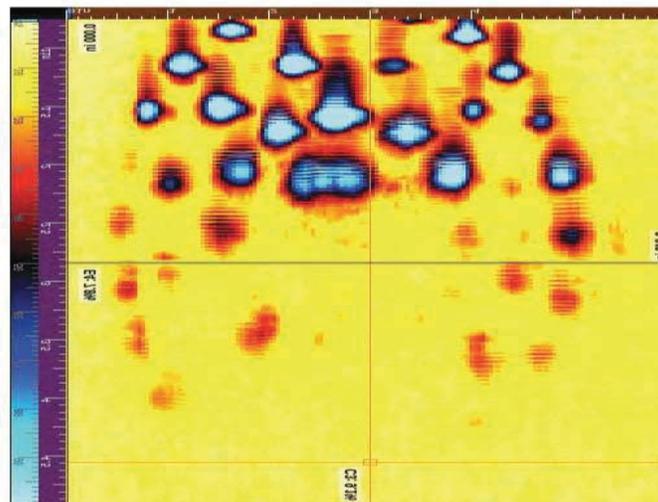
NDE Standard 3

NASA_STD3-CLEAN_T-B-1_0000

Clean/Un-Patched Samples

RATING=

2





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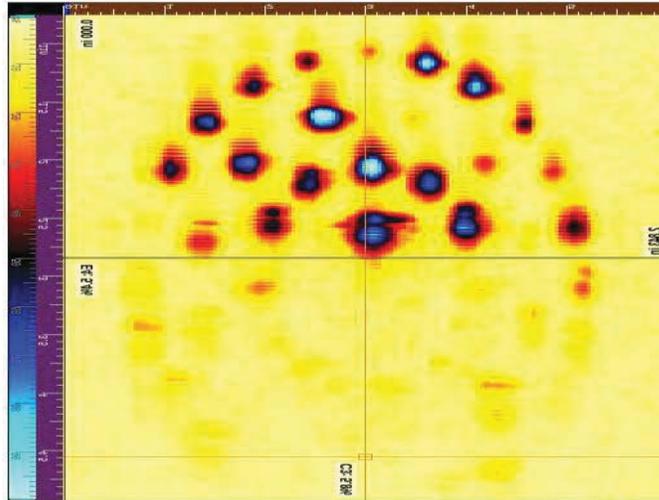
NDE Standard 3

NASA_STD3-TAPE_TB-1_0000

Tap ed/Patched Samples

RATING=

2



NDE Standard 3

NASA_STD3-PLATE_TB-1_0000

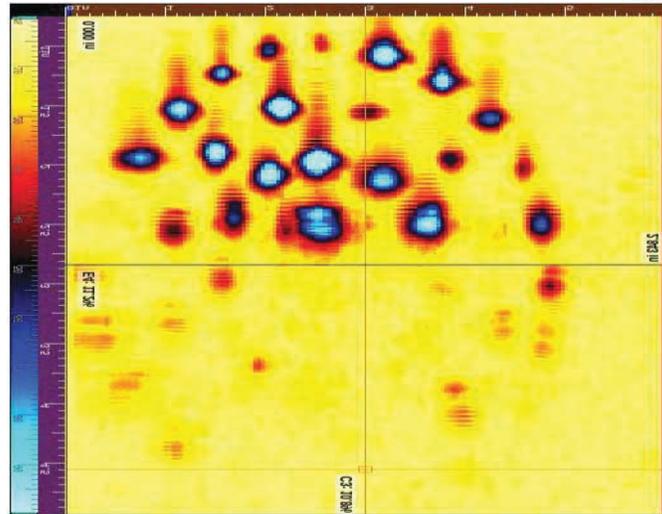
Plate/Patched Samples

RATING=

2

RATING=

2





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Plate 551 NDE Standard 4

Image of Samples

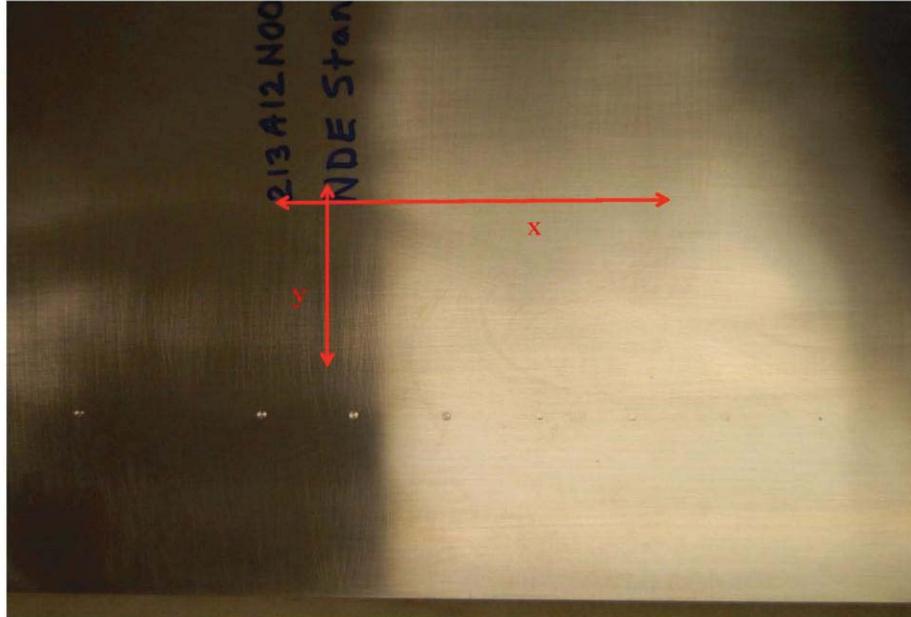


Plate 551 NDE Standard 4

551-clean-hole
(gain was set too high)

Clean/Un-Patched Samples

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to fact that the scans were successful with the tape attached which is a more difficult situation



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Plate 551 NDE Standard 4

NASA_std4-tape-holes-1_0000
NASA_std4-tape-holes-2_0000

Taped/Patched Samples

RATING=

2

Note: smallest holes were detected.
Deeper holes were easily detectable.
Larger diameter holes were also easily detected.

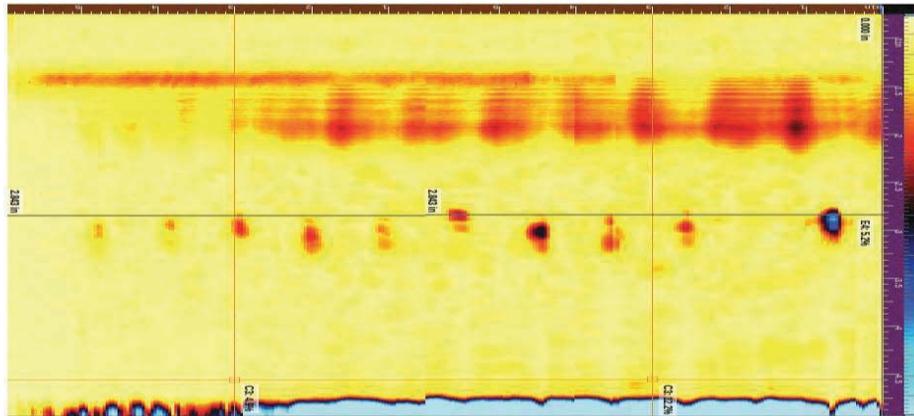


Plate 551 NDE Standard 4

NASA_std4-plate-holes-1_0000
NASA_std4-plate-holes-2_0000

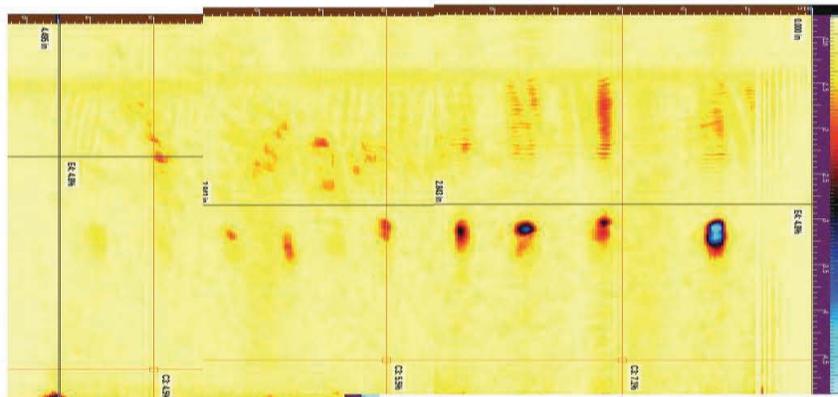
Plate/Patched Samples

RATING=

2

2

Note: two smallest holes were at the noise floor
Deeper holes were easily detectable.
Larger diameter holes were also easily detected.





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Plate 551 NDE Standard 4

Image of Samples

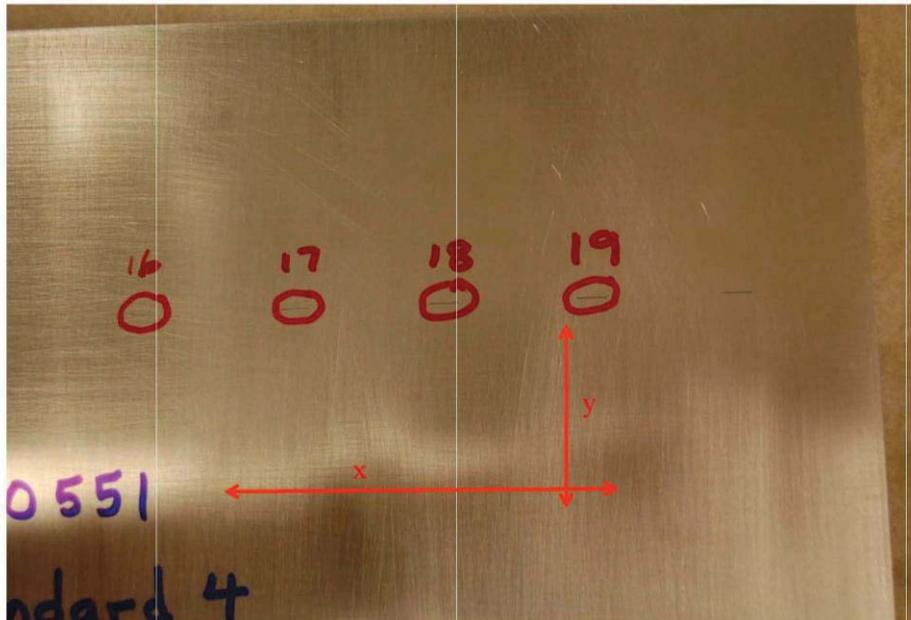


Plate 551 NDE Standard 4

551-clean-notch

Clean/Un-Patched Samples

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to fact that the scans were successful with the tape attached which is a more difficult situation.



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Plate 551 NDE Standard 4

NASA_std4-tape-EDM notches-1_0000
NASA_std4-tape-EDM notches-2_0000

Taped/Patched Samples

RATING=

2

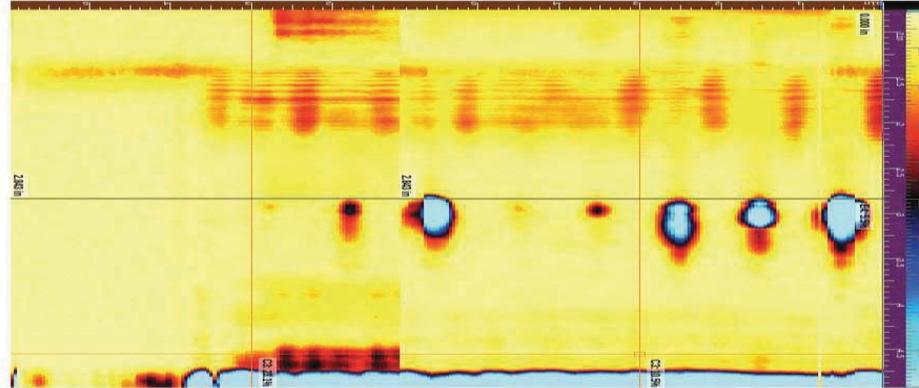


Plate 551 NDE Standard 4

NASA_std4-plate-EDM notches-1_0000
NASA_std4-plate-EDM notches-2_0000

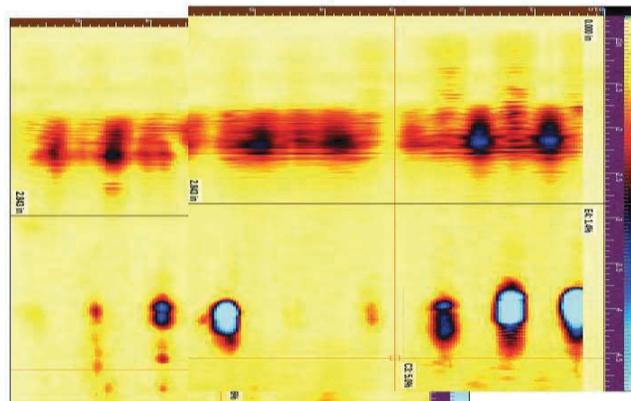
Plate/Patched Samples

RATING=

2

RATING=

2





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NDE Standard 5

Image of Samples



NDE Standard 5

Clean/Un-Patched Samples

RATING=

2

Images not saved.
data similar Omniscan MX UT phased array system.



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NDE Standard 5

Taped/Patched Samples

RATING= 2

Images not saved.
data similar Omniscan MX UT phased array system.

NDE Standard 5

Plate/Patched Samples

RATING= 2
RATING= 2

Images not saved.
data similar Omniscan MX UT phased array system.



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Title:

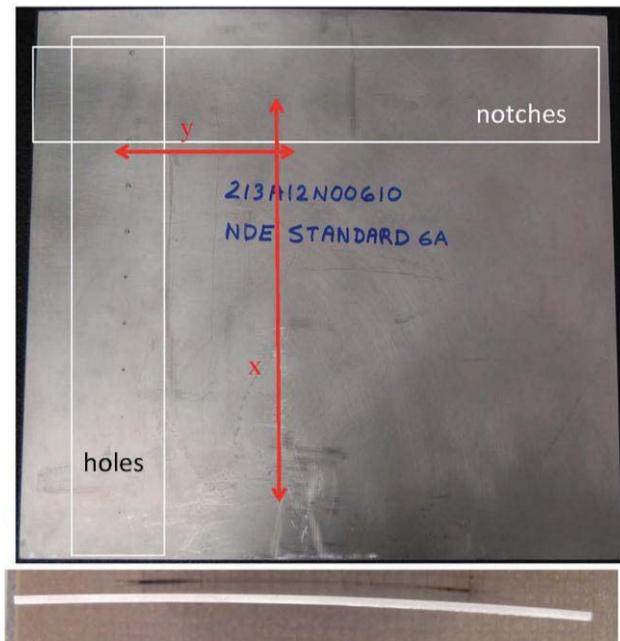
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NDE Standard 6A

Image of Samples



NDE Standard 6A

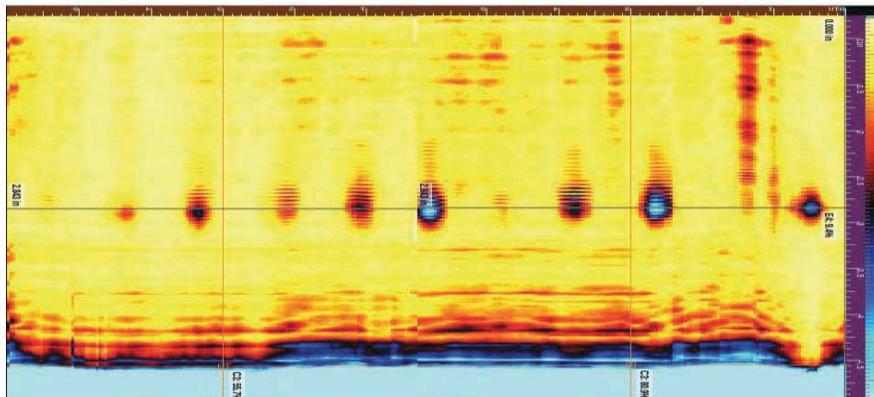
Clean/Un-Patched Samples

NASA_std6A-clean-holes-1_0000
NASA_std6A-clean-holes-2_0000

RATING=

2

Note: smallest holes were detected.
Deeper holes were easily detectable.
Larger diameter holes were also easily detected.





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NDE Standard 6A

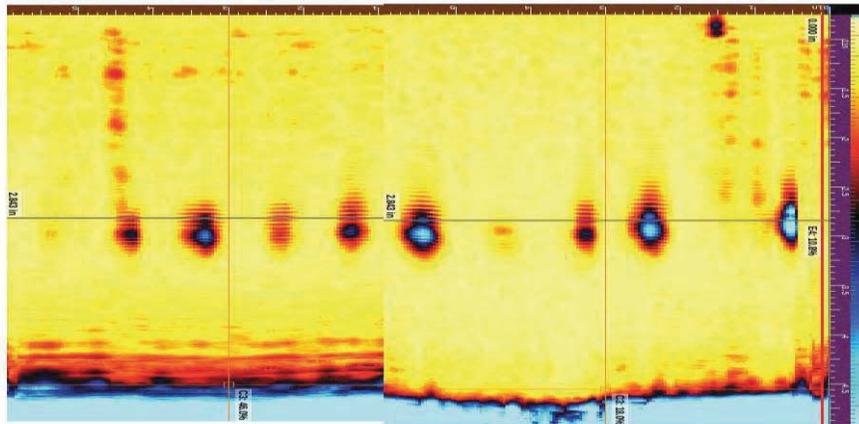
NASA_std6A-tape-holes-1_0000
NASA_std6A-tape-holes-2_0000

Taped/Patched Samples

RATING=

2

Note: smallest holes were detected.
Deeper holes were easily detectable.
Larger diameter holes were also easily detected.



NDE Standard 6A

Plate/Patched Samples

RATING=

2

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to fact that the scans were successful with the tape attached which is a more difficult situation



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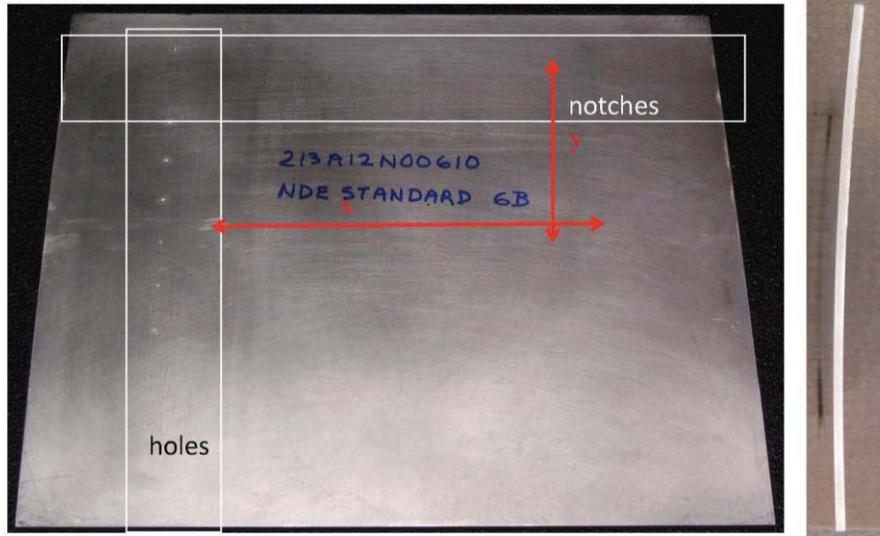
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NDE Standard 6B

Image of Samples



NDE Standard 6B

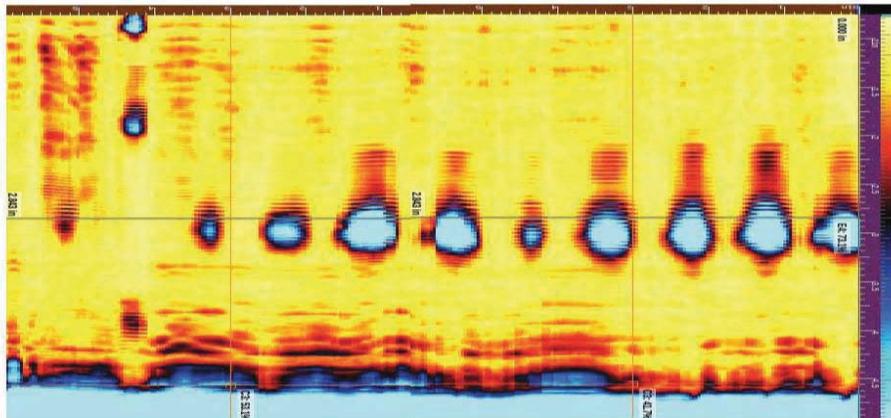
Clean/Un-Patched Samples

NASA_std6B-clean-EDM notches-1_0000
NASA_std6B-clean-EDM notches-2_0000

RATING=

2

Note: smallest EDM notches were detected.
Deeper notches were easily detectable.
Longer notches were also easily detected.





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NDE Standard 6B

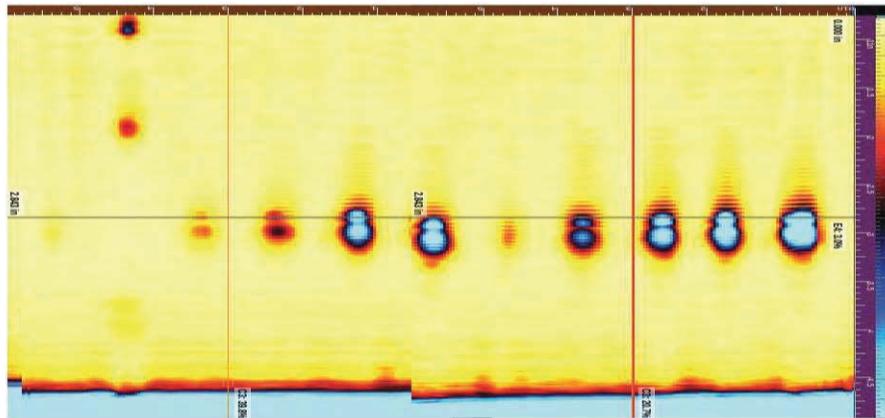
Taped/Patched Samples

NASA_std6B-tape-EDM notches-1_0000.png
NASA_std6B-tape-EDM notches-2_0000.png

RATING=

2

Note: smallest EDM notches were detected.
Deeper notches were easily detectable.
Longer notches were also easily detected.



NDE Standard 6B

Plate/Patched Samples

RATING=

2

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to fact that the scans were successful with the tape attached which is a more difficult situation



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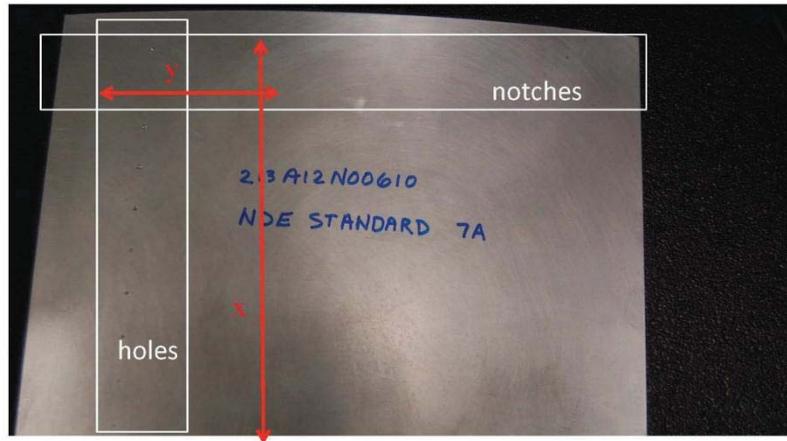
Title:

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NDE Standard 7A

Image of Samples



NDE Standard 7A

Clean/Un-Patched Samples

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to fact that the scans were successful with the plate patch attached which is a more difficult situation



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NDE Standard 7A

Taped/Patched Samples

RATING= 2

Plates not scanned, however, engineering estimates can be made by comparison to fact that the scans were successful with the plate patch attached which is a more difficult situation

NDE Standard 7A

Plate/Patched Samples

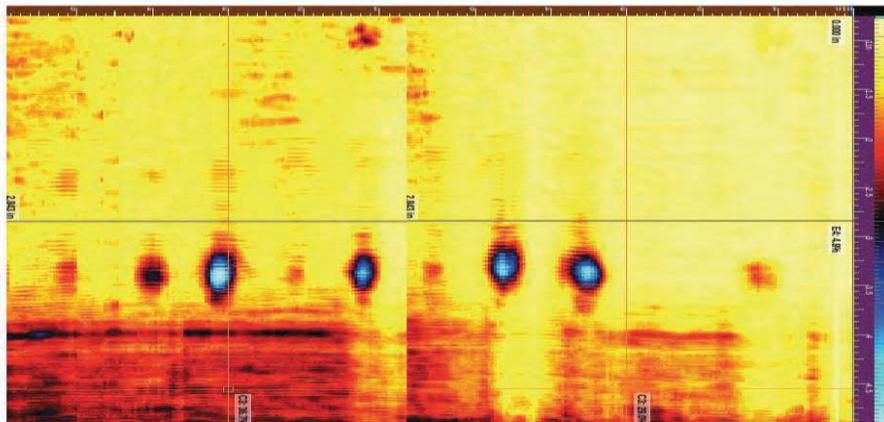
NASA_STD7A-plate-HOLES-3_0000

RATING= 2

RATING= 2

Note: smallest holes were detected.

Deeper holes were easily detectable.
Larger diameter holes were also easily detected.





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1.0

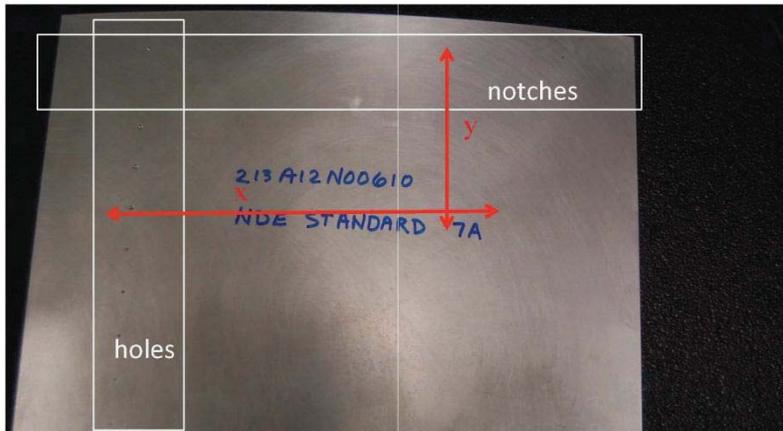
Title:

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NDE Standard 7A

Image of Samples



NDE Standard 7A

Clean/Un-Patched Samples

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to fact that the scans were successful with the plate patch attached which is a more difficult situation



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NDE Standard 7A

Taped/Patched Samples

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to fact that the scans were successful with the plate patch attached which is a more difficult situation

NDE Standard 7A

NASA_STD7A-plate-EDM-3_0000

Plate/Patched Samples

RATING=

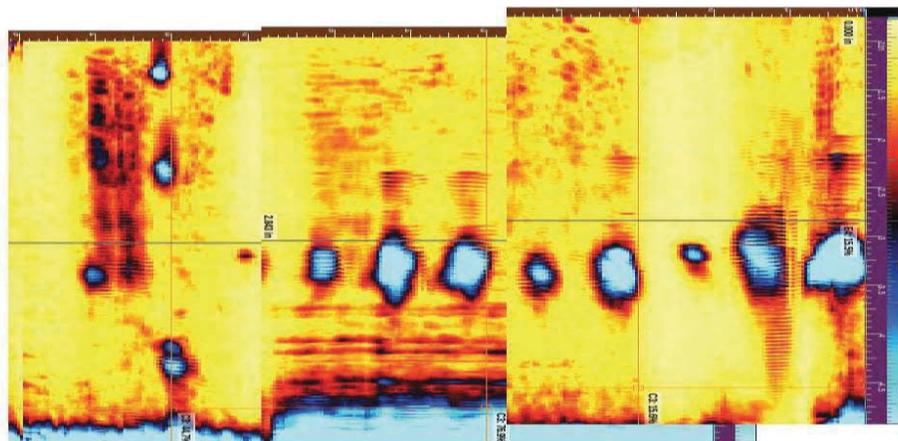
2

RATING=

2

Note: smallest holes were detected.

Deeper holes were easily detectable.
Larger diameter holes were also easily detected.





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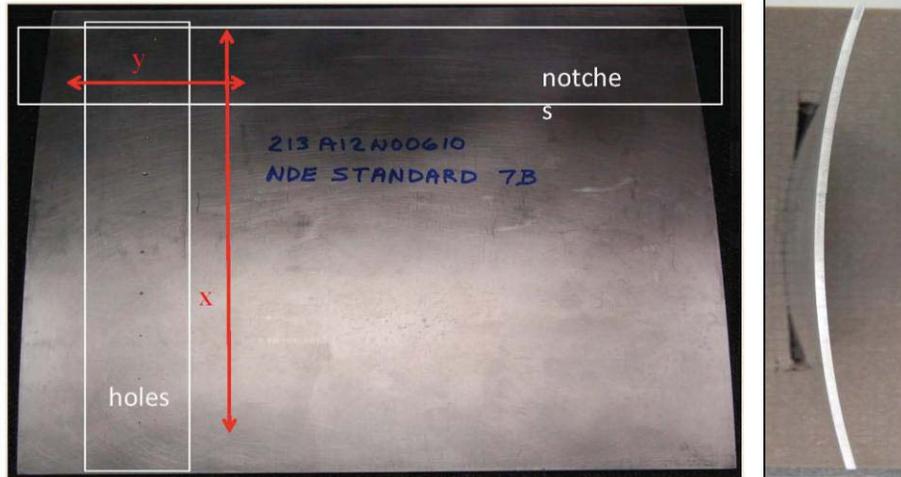
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NDE Standard 7B

Image of Samples



NDE Standard 7B

Clean/Un-Patched Samples

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to fact that the scans were successful with the tape attached which is a more difficult situation



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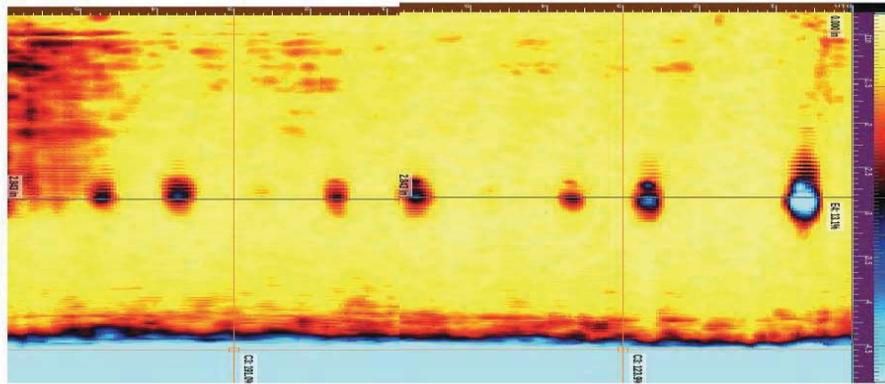
NDE Standard 7B

NASA_STD7B-tape-HOLES-1_0000
NASA_STD7B-tape-HOLES-2_0000

Taped/Patched Samples

RATING=

2



NDE Standard 7B

NASA_STD7B-plate-HOLES-1_0000
NASA_STD7B-plate-HOLES-2_0000

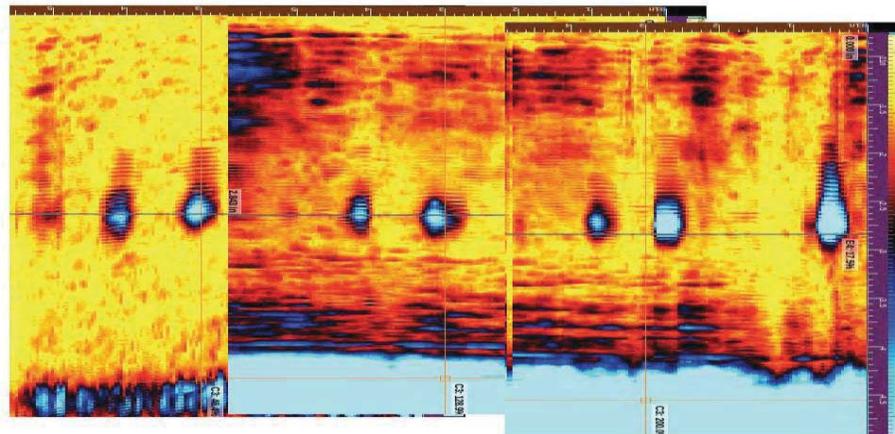
Plate/Patched Samples

RATING=

2

RATING=

2





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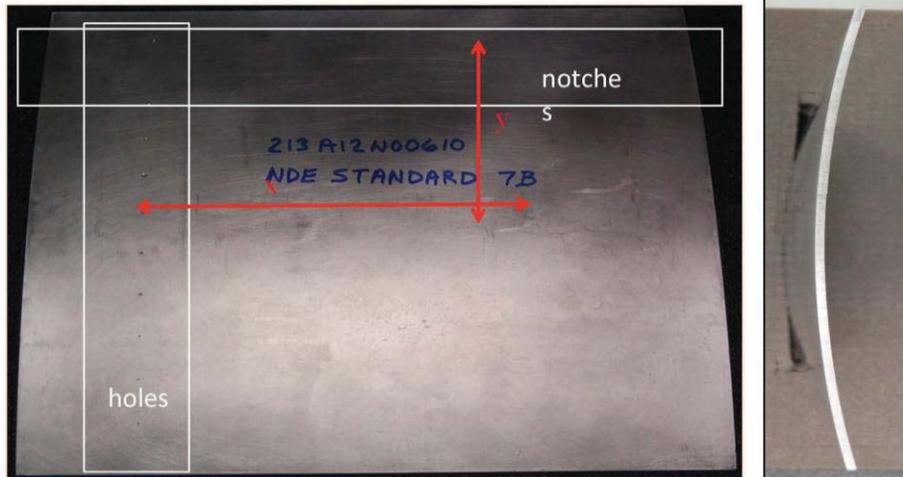
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NDE Standard 7B

Image of Samples



NDE Standard 7B

Clean/Un-Patched Samples

RATING=

2

Plates not scanned, however, engineering estimates can be made by comparison to fact that the scans were successful with the tape attached which is a more difficult situation



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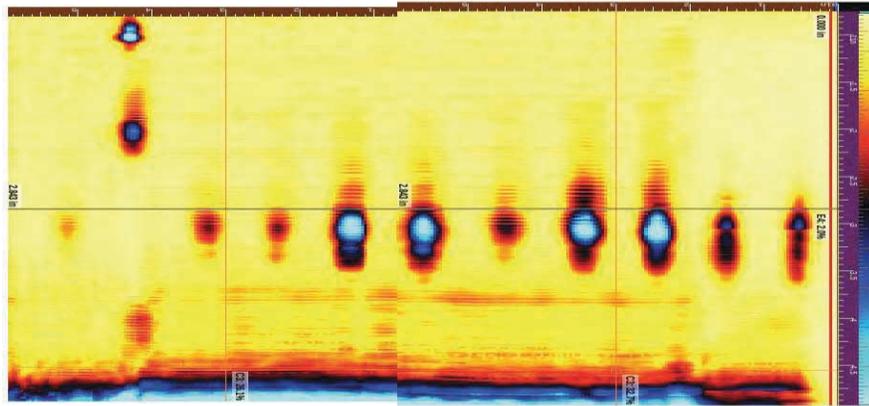
NDE Standard 7B

NASA_STD7B-tape-EDM-1_0000.png
NASA_STD7B-tape-EDM-2_0000.png

Taped/Patched Samples

RATING=

2



NDE Standard 7B

NASA_STD7B-plate-EDM-1_0000.png
NASA_STD7B-plate-EDM-2_0000.png

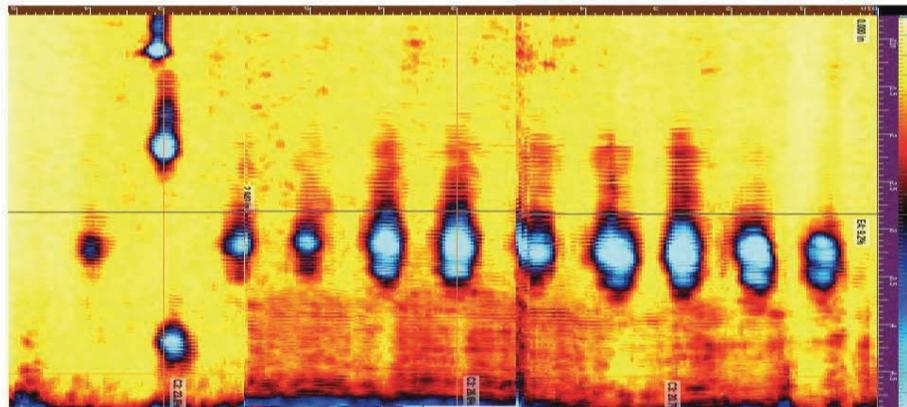
Plate/Patched Samples

RATING=

2

RATING=

2





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Plate 186

Image of Samples

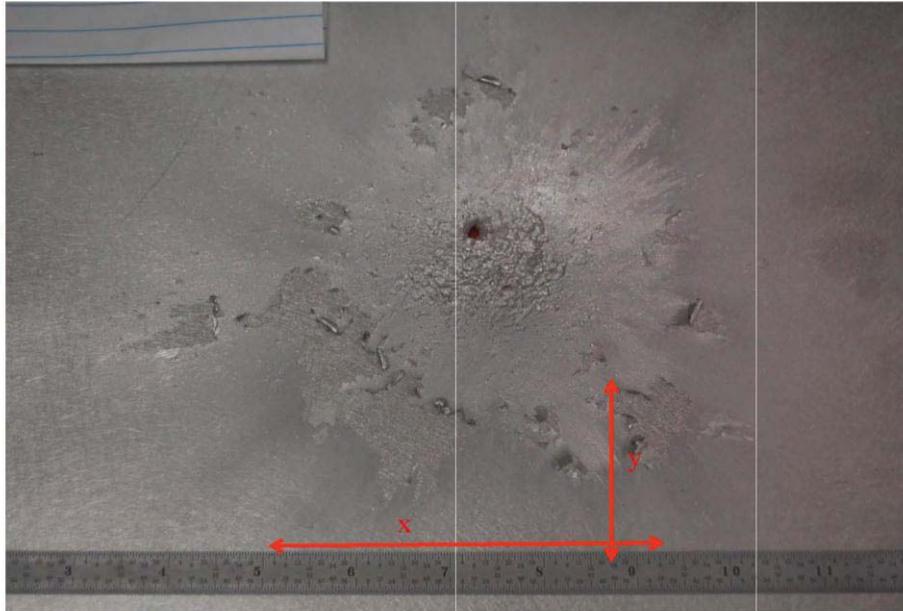


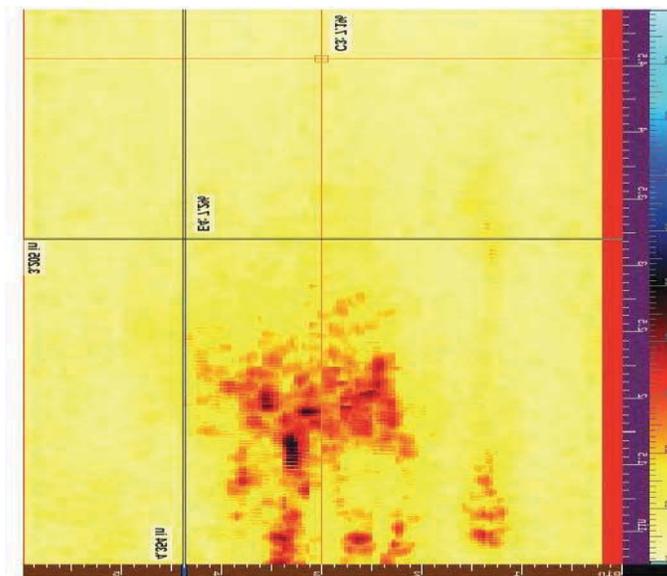
Plate 106

Clean/Un-Patched Samples

NASA_186-CLEAN-B-T-1_0000

RATING=

2





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Plate 186

Tap ed/Patched Samples

NASA_186-TAPE_B-T-01_0000

RATING=

2

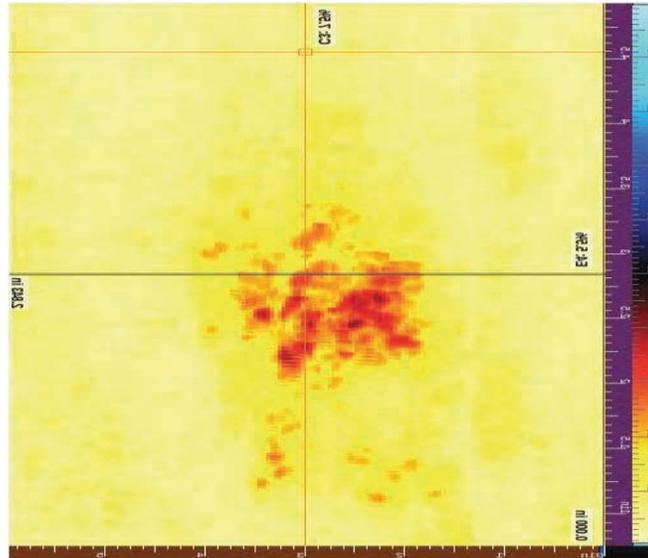


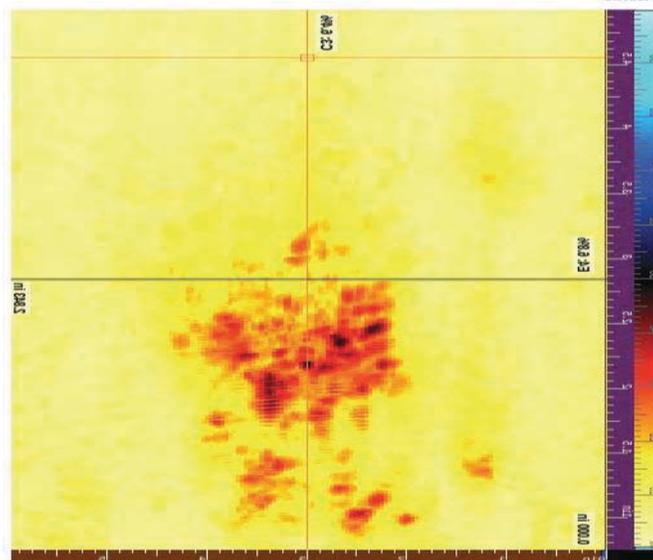
Plate 186

Plate/Patched Samples

RATING=

2

2





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Plate 186

Image of Samples

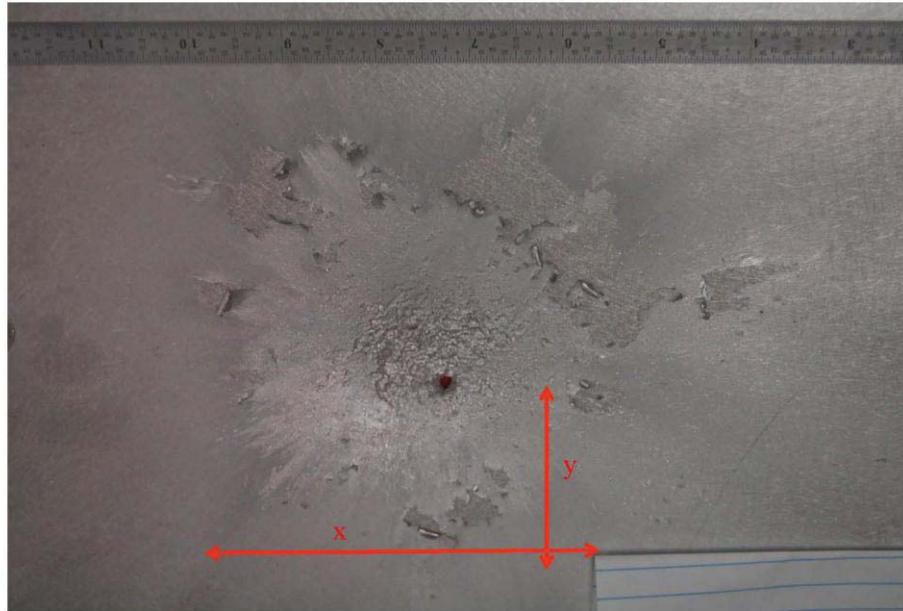


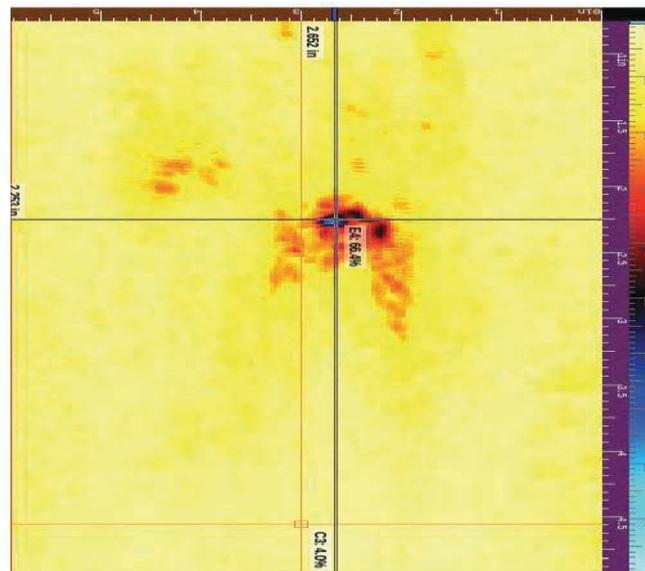
Plate 186

NASA_186-CLEAN-TB-1_0000

Clean/Un-Patched Samples

RATING=

2





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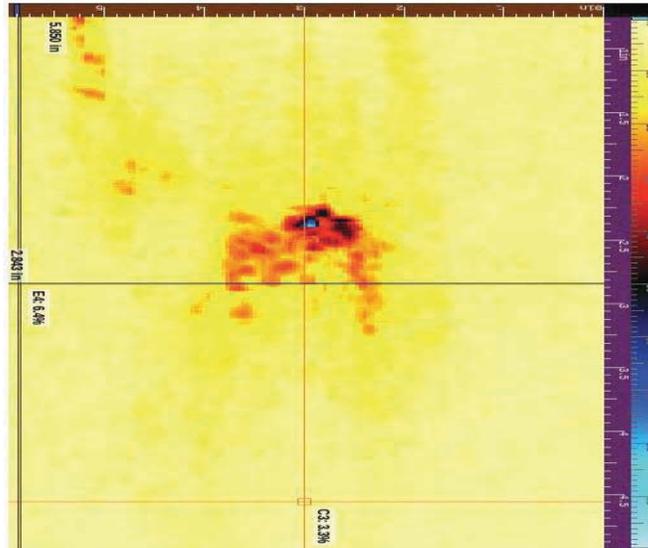
Plate 186

NASA_186-TAPE_TB-02_0000

Tap ed/Patched Samples

RATING=

2



NASA_186-PLATE_TB-02_0000

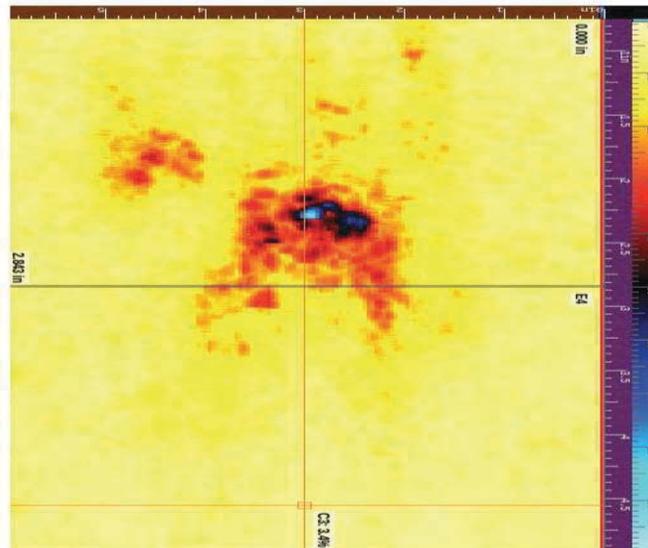
Plate/Patched Samples

RATING=

2

RATING=

2





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Plate 1900

Image of Samples

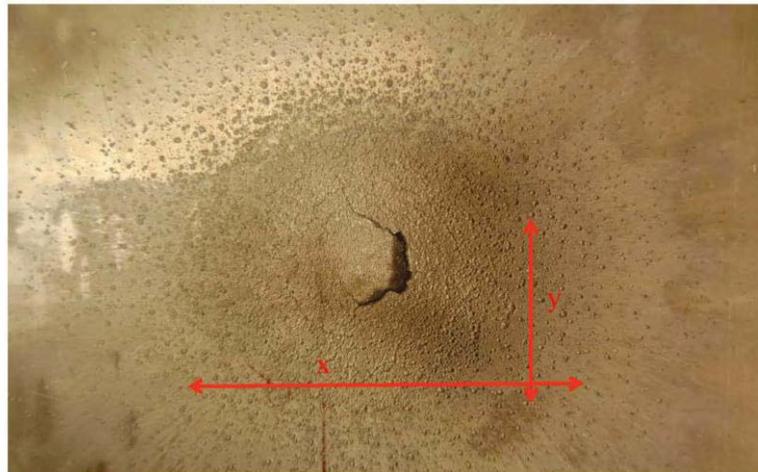


Plate 1900

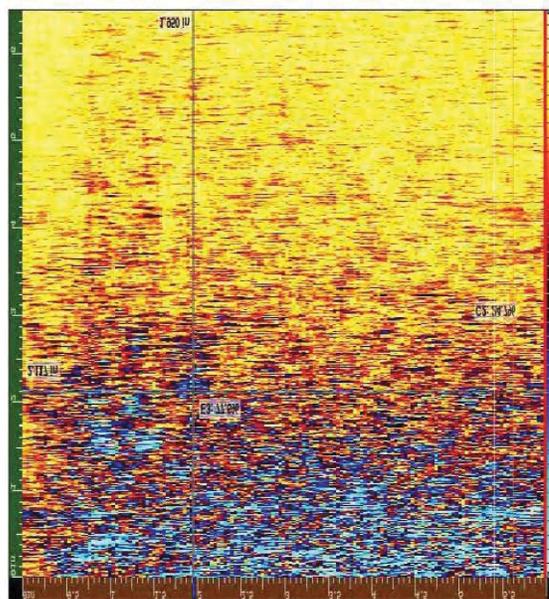
NASA_1900-CLEAN_B-T-1_0000
(B-Scan)

Clean/Un-Patched Samples

Uncovered plate can also be scanned with a 90 degree probe
over parts for contour resolution

RATING=

0



Not able to detect large
cracks from 4" away.



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Plate 1900

NASA_1900-TAPE_B-T-1_0000
(B-Scan)

Taped/Patched Samples

RATING= 0

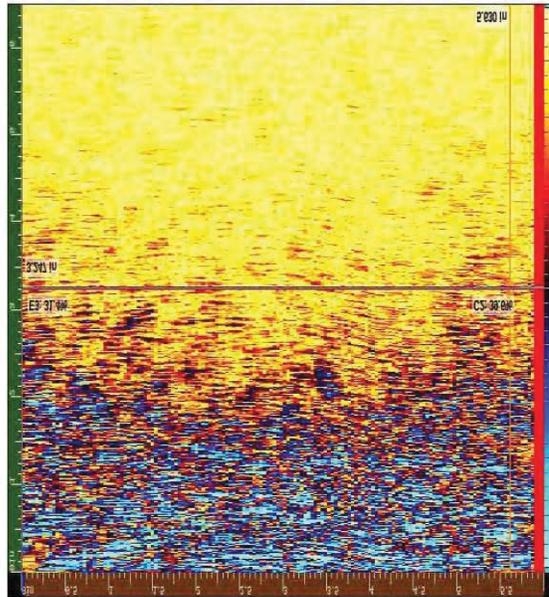
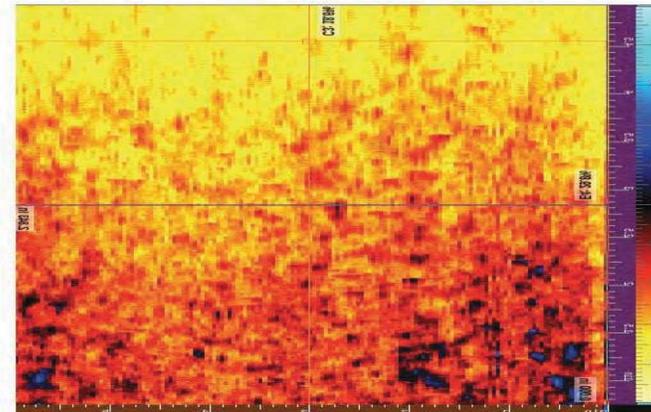


Plate 1900

NASA_1900-PLATE-B-T-1_0000

Plate/Patched Samples

RATING= 0
RATING= 0





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Plate 1900

Image of Samples

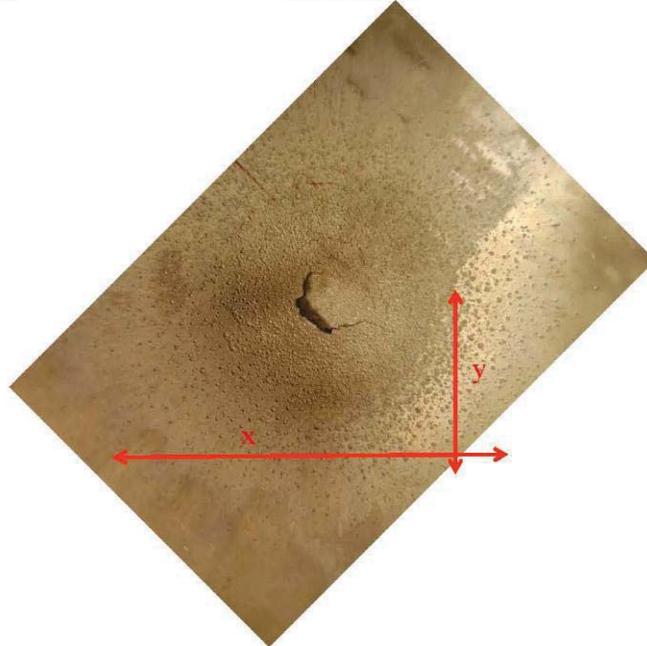
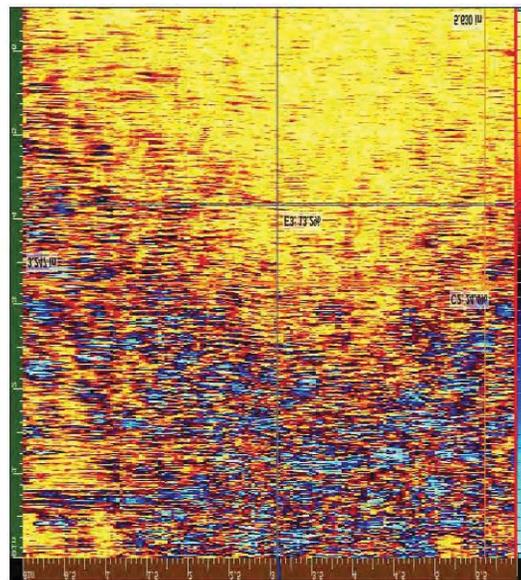


Plate 1900
NASA_1900-CLEAN_B-T45-1_0000
(B-Scan)

Clean/Un-Patched Samples
Uncovered plate can also be scanned with a 90 degree probe
over parts for contour resolution

RATING=

0



Not able to detect large
cracks from 4" away.



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Plate 1900

NASA_1900-TAPE_B-T45-3_0000
(B-Scan)

Taped/Patched Samples

RATING=

0

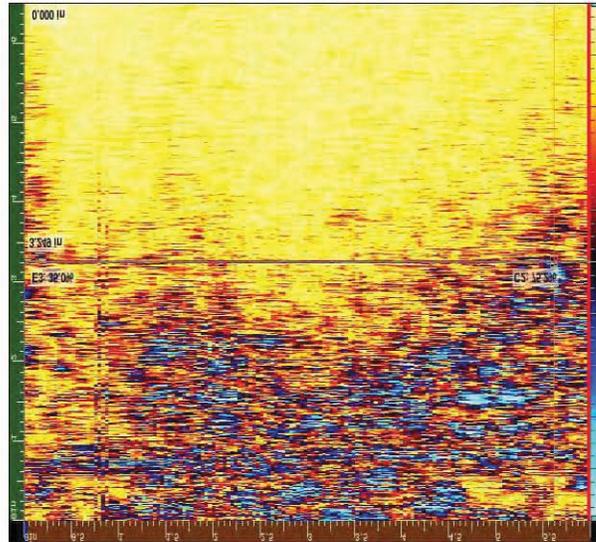


Plate 1900

Plate/Patched Samples

RATING=

0

RATING=

0

Plates not scanned, however, engineering estimates can be made by comparison to the scans made with and without the tape attached.



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Plate 1900

Image of Samples

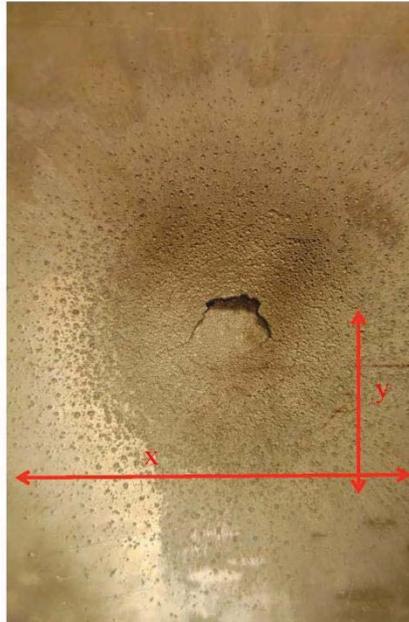


Plate 1900

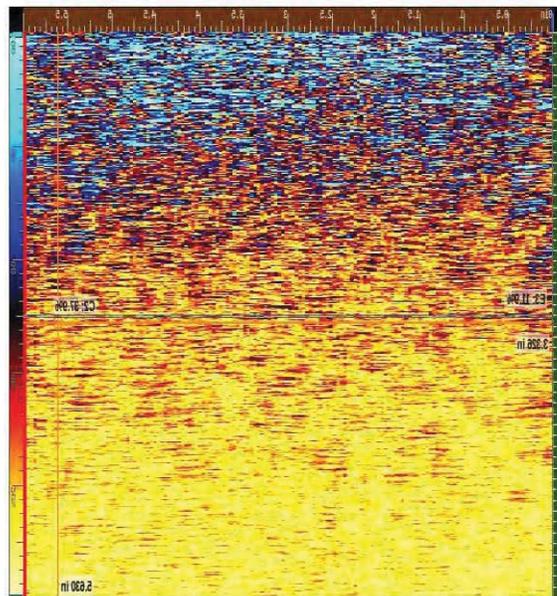
NASA_1900-CLEAN_T-B-1_0000
(B-Scan)

Clean/Un-Patched Samples

Uncovered plate can also be scanned with a 90 degree probe
over parts for contour resolution

RATING=

0



Not able to detect large
cracks from 4" away.



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NASA_1900-TAPE_T-B-3_0000
(B-Scan)

Taped/Patched Samples

RATING=

0

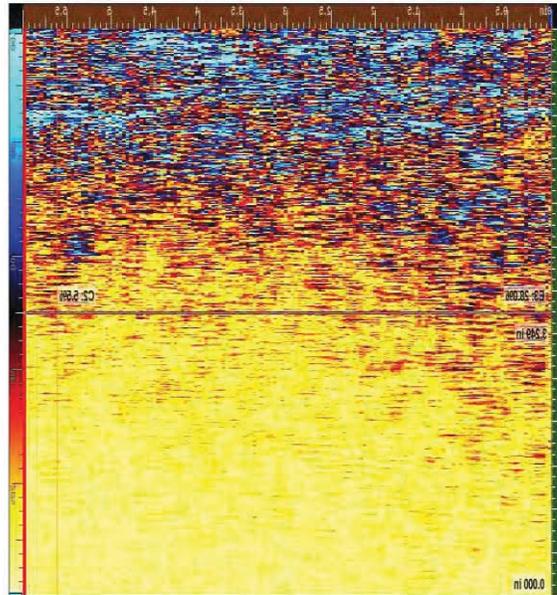


Plate 1900

NASA_1900-PLATE-T-B-1_0000

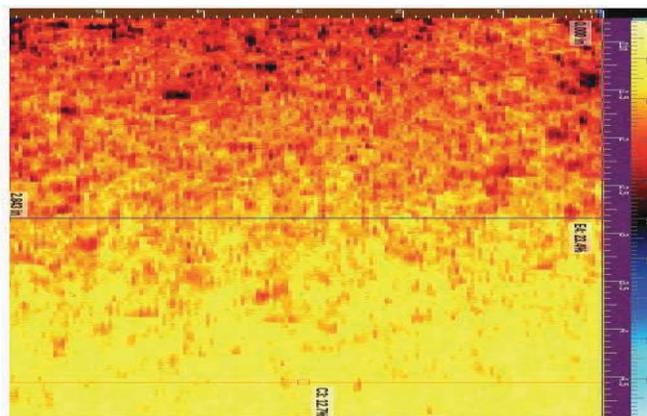
Plate/Patched Samples

RATING=

0

RATING=

0





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Plate 1900

Image of Samples

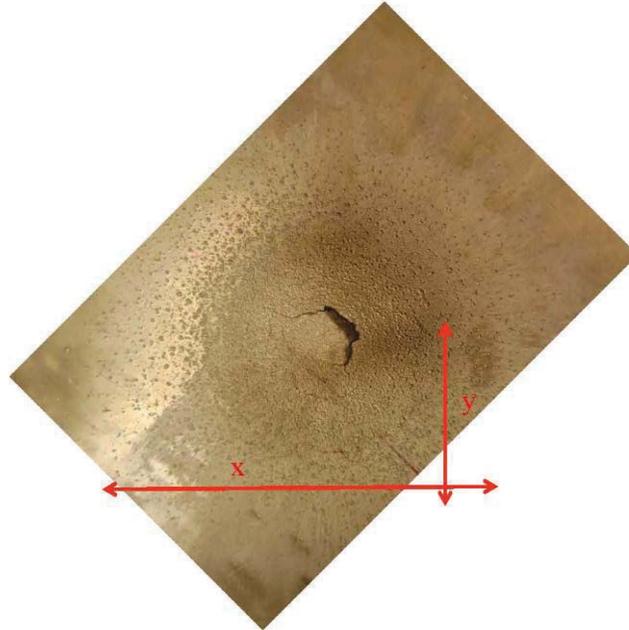
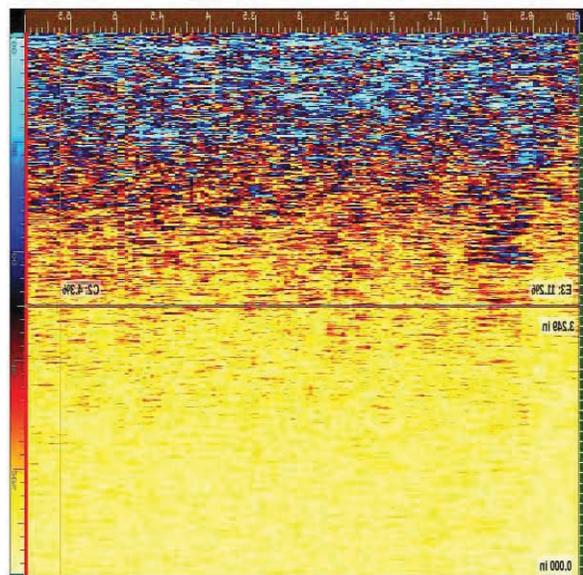


Plate 1900
NASA_1900-CLEAN_B-T45-1_0000
(B-Scan)

Clean/Un-Patched Samples
Uncovered plate can also be scanned with a 90 degree probe
over parts for contour resolution
RATING=

0



Not able to detect large cracks from 4" away.



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Plate 1900
NASA_1900-TAPE_T-B45-2_0000
(B-Scan)

Taped/Patched Samples

RATING= 0

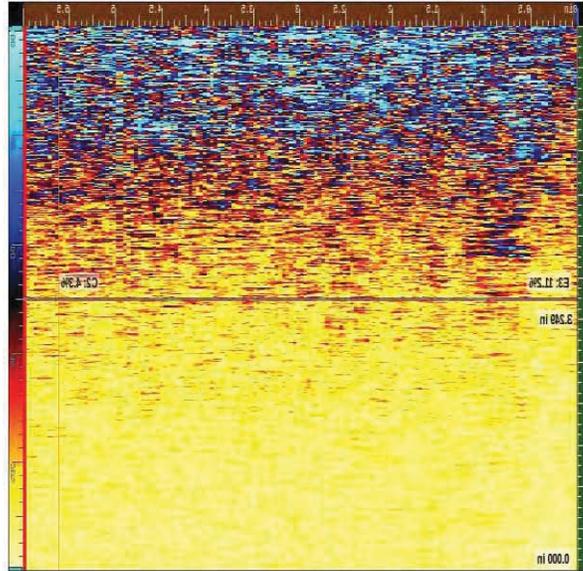


Plate 1900

Plate/Patched Samples

RATING= 0 RATING= 0

Plates not scanned, however, engineering estimates can be made by comparison to the scans made with and without the tape attached.



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Plate 1907

Image of Samples

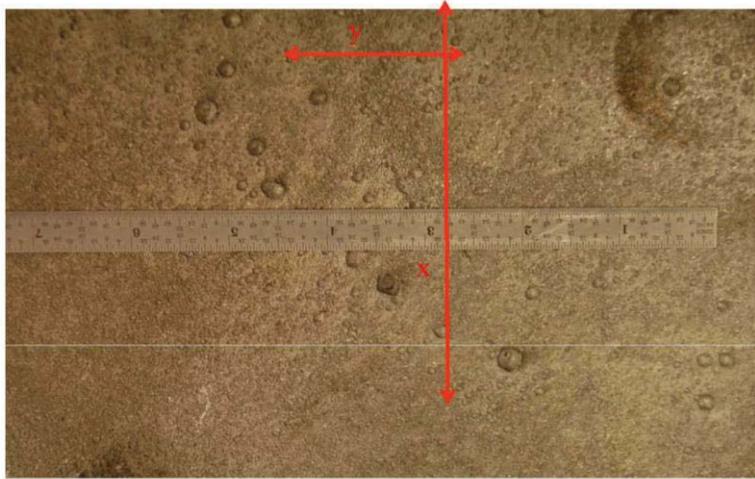


Plate 1907

Clean/Un-Patched Samples

Uncovered plate can also be scanned with a 90 degree probe
over parts for contour resolution **RATING=**

2

Engineering estimates can be made by comparison
to the scans made with the tape attached.



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Plate 1907

NASA_1907-TAPE_L-R-1_0000
(B-Scan)

Tap ed/Patched Samples

RATING=

1

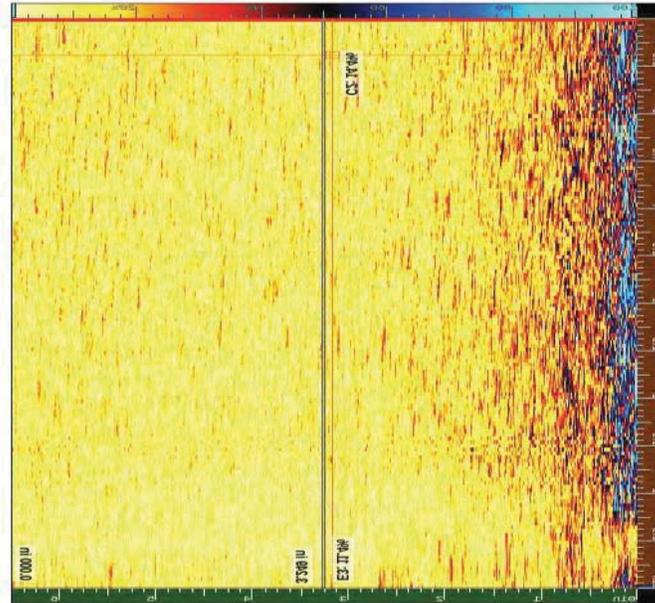


Plate 1907

NASA_1907-PLATE_L-R-1_0000
(Top-Scan)

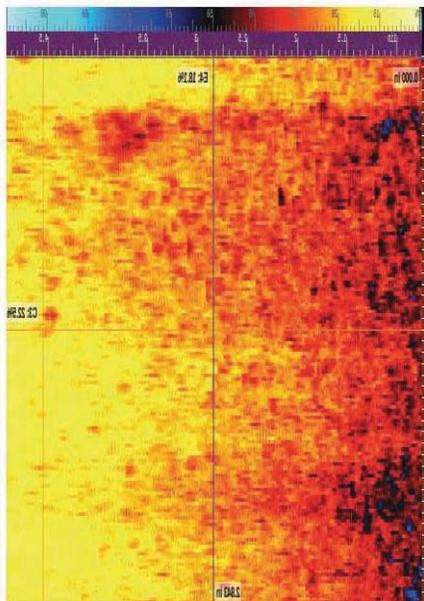
Plate/Patched Samples

RATING=

1

RATING=

1.333333333





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Plate 1907

Image of Samples

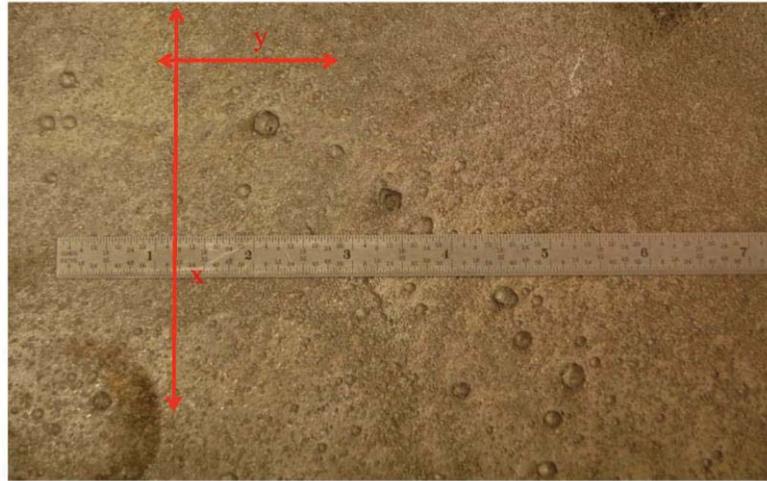


Plate 1907

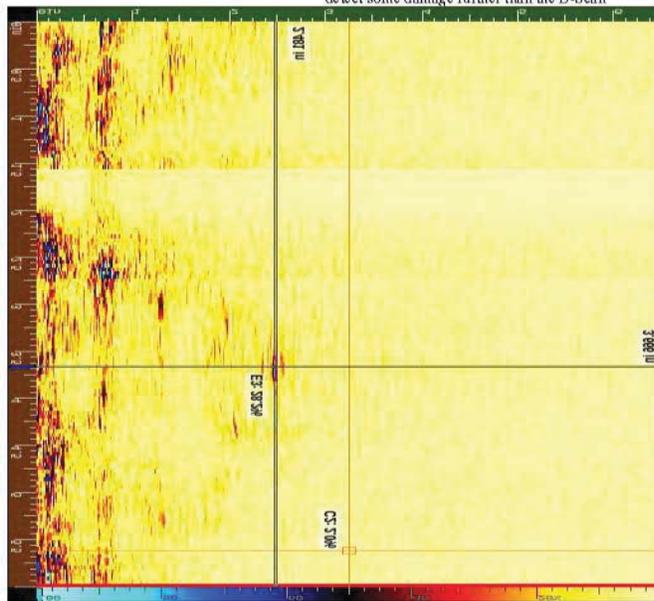
NASA_1907-CLEAN_R-L-1_0001
(B-Scan)

Clean/Un-Patched Samples

Noisy and susceptible to lift off due to surface dimples. Top Scan did seem to detect some damage further than the B-Scan

RATING=

2





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Plate 1907

NASA_1907-TAPE_R-L-1_0000
(B-Scan)

Tap ed/Patched Samples

RATING=

1

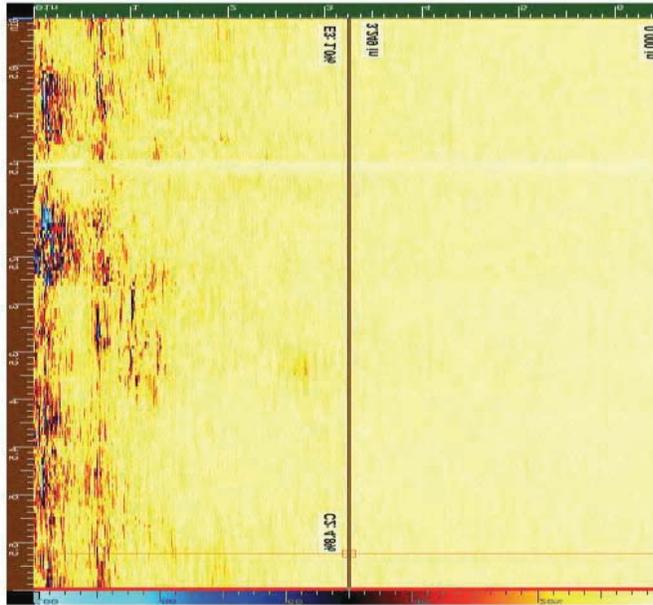


Plate 1907

NASA_1907-PLATE_R-L-1_0000
(Top-Scan)

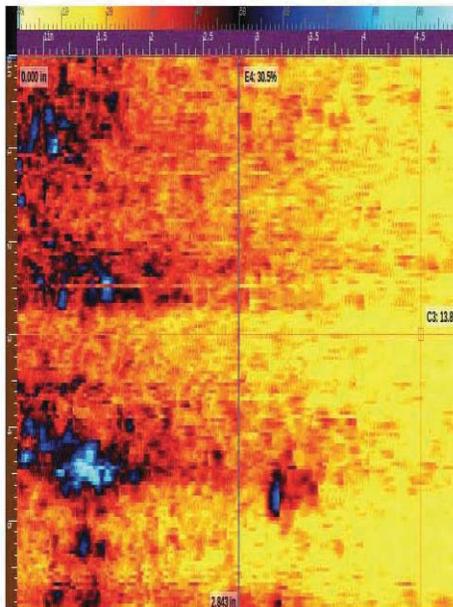
Plate/Patched Samples

RATING=

1

RATING=

1.333333333





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Plate T3

Image of Samples



Plate T3

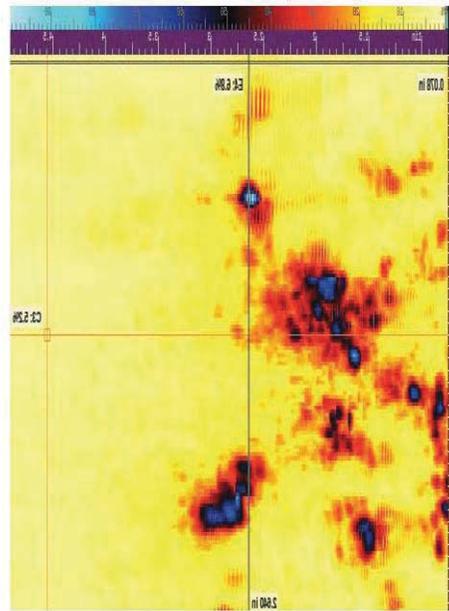
NASA_T3-CLEAN L-R-1_0000

Clean/Un-Patched Samples

Uncovered plate can also be scanned with a 90 degree probe
over parts for contour resolution

RATING=

2





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Plate T3
NASA_T3-TAPE L-R-1_0000

Taped/Patched Samples

RATING= 2

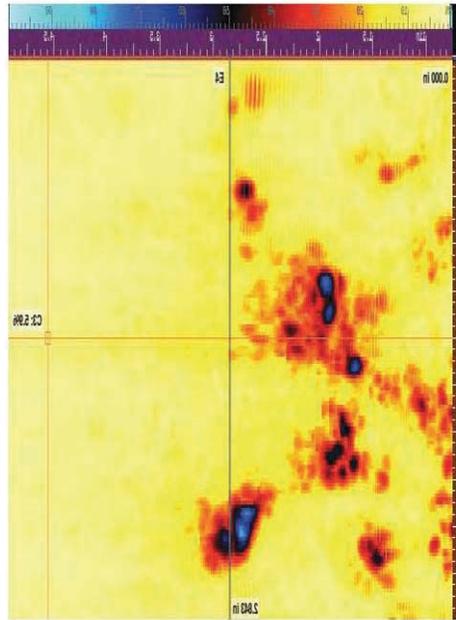
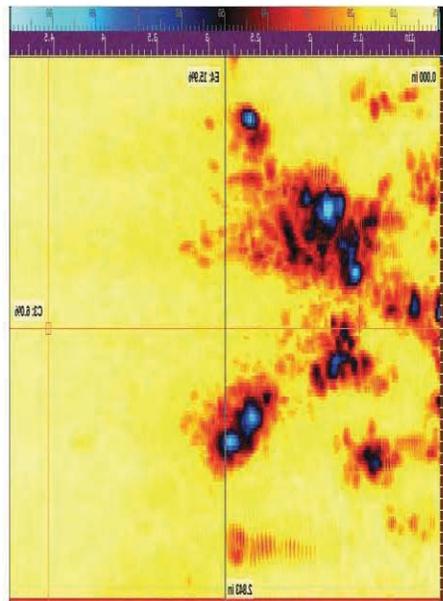


Plate T3
NASA_T3-PLATE-R-L-1_0000

Plate/Patched Samples

RATING= RATING= 2 2





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Plate T3

Image of Samples

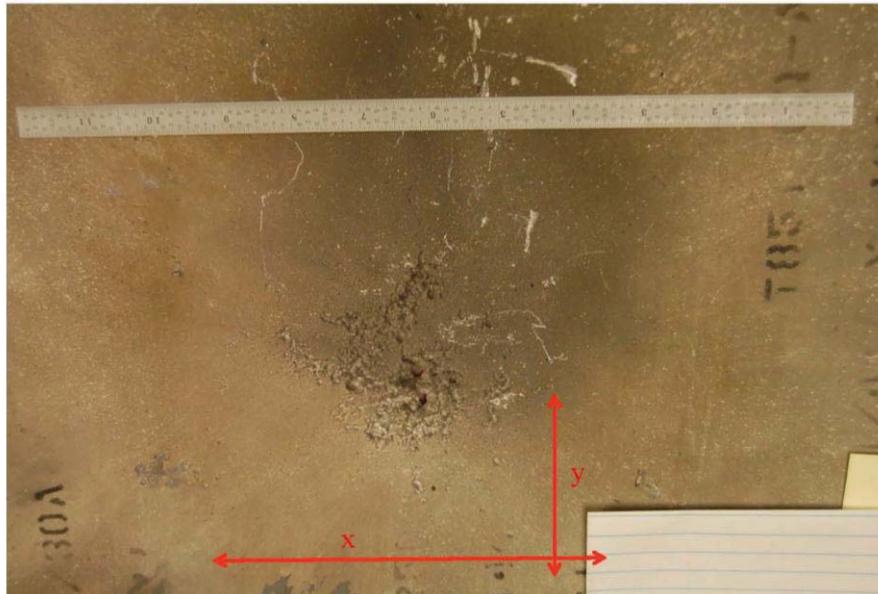


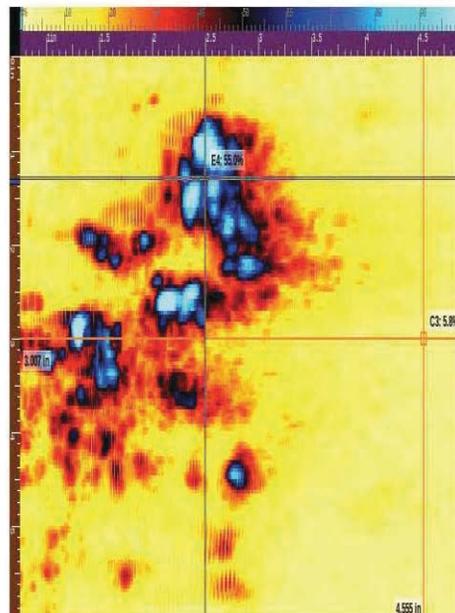
Plate T3
NASA_T3-CLEAN R-L-2_0000

Clean/Un-Patched Samples

Uncovered plate can also be scanned with a 90 degree probe
over parts for contour resolution

RATING=

2





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Plate T3
NASA_T3-TAPE L-R-1_0000

Taped/Patched Samples

RATING=

2

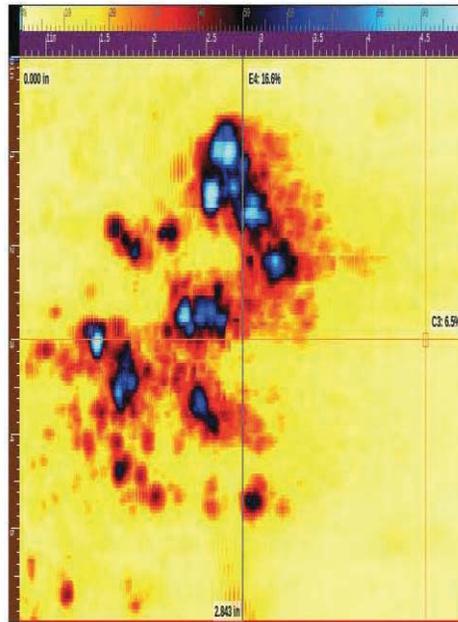


Plate T3
NASA_T3-PLATE-R-L-1_0000

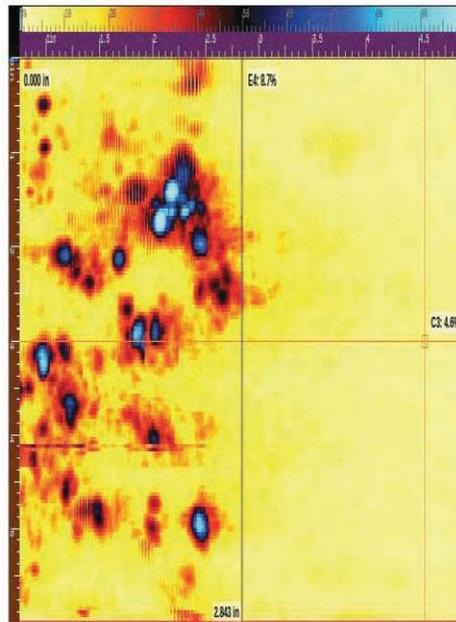
Plate/Patched Samples

RATING=

RATING=

2

2





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Plate 12243 (FGB impact plate)

Image of Samples

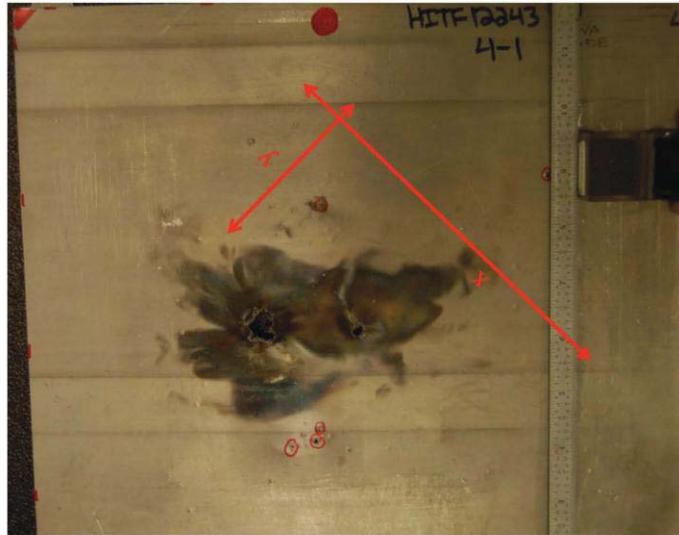


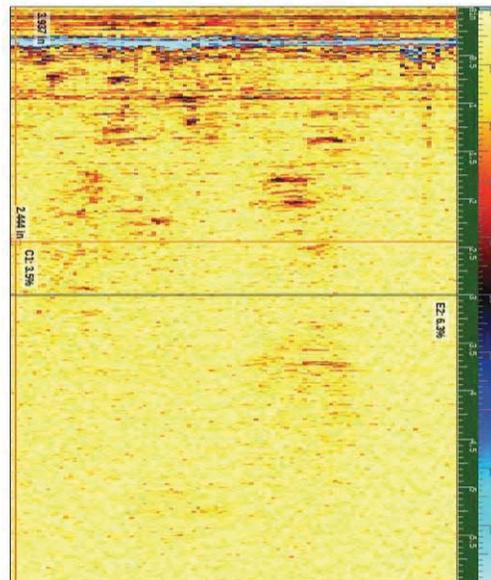
Plate 12243 (FGB impact plate)
NASA_243-PLATE-TT-RT45-1_0001

Clean/Un-Patched Samples

RATING=

1

Small hole



Multiple dents

Single element transducer
mapped out the damage
faintly.

Large hole



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Plate 12243 (FGB impact plate)

Taped/Patched Samples

RATING=

1

Plate 12243 (FGB impact plate)

Plate/Patched Samples

RATING=

1

RATING=

1



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Plate 123 (Bond Plate)

Image of Samples

c-scan image from water tank

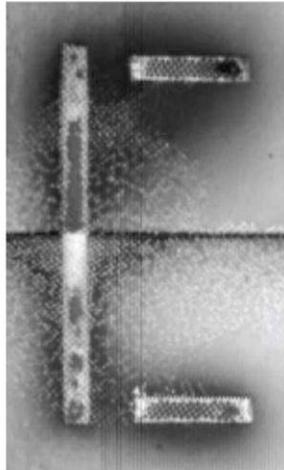
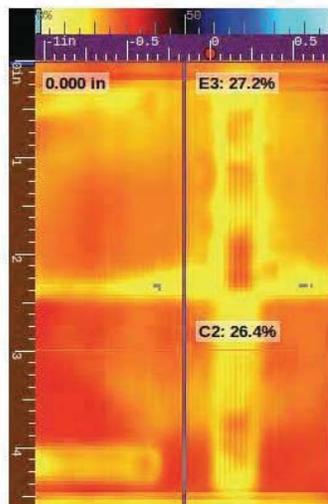


Plate 123 (Bond Plate)
NASA_USS123_0003

Clean/Un-Patched Samples

RATING=

2





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Plate 158 (Bond Plate)

Image of Samples

c-scan image from water tank

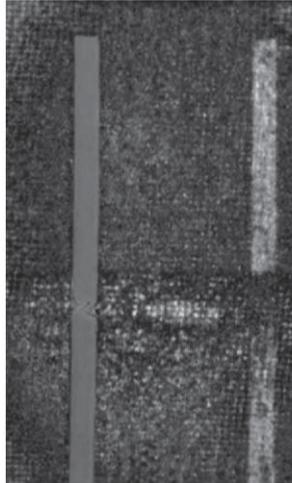
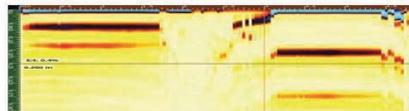


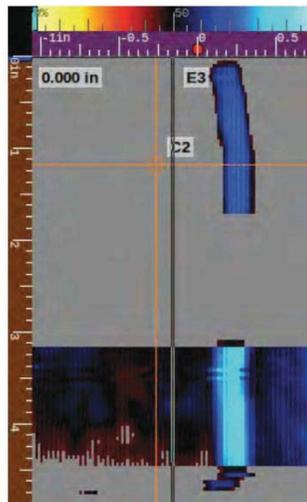
Plate 158 (Bond Plate)
NASA_USS158-2_0000

Clean/Un-Patched Samples



RATING=

2





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Plate 028B (Bond Plate)

Image of Samples

c-scan image from water tank

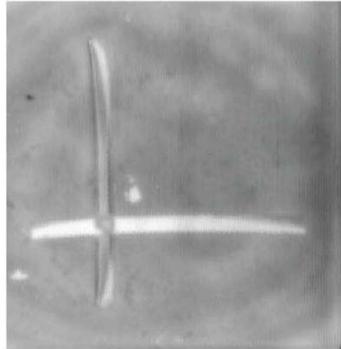
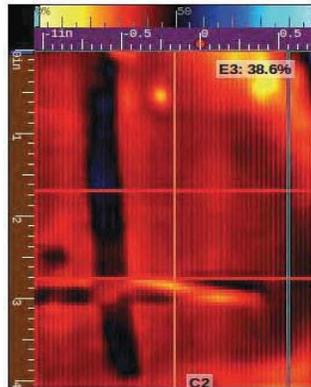


Plate 028B (Bond Plate)
NASA_USS028B-1_0009

Clean/Un-Patched Samples

RATING=

2





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Plate 132A (Bond Plate)

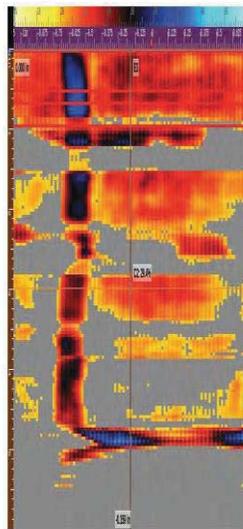
Image of Samples

Plate 132A (Bond Plate)
NASA_USS132A-1_0000

Clean/Un-Patched Samples

RATING=

2





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Appendix F. General Electric® Phasor™ Results

GE Phasor



Scans below used the GE Phasor scanner:

Ratings:

0	Failure to identify important features
1	Features slightly detectable but not clearly defined
2	Undoubtable feature detection

Average RATING amongst all scans:	1.07
Average RATING amongst NDE Standard Scans:	0.80
Average RATING amongst impacted plate scans:	0.40
Average RATING amongst bond plate scans:	2.00

NDE Standard 1A:	0.00	Eng. Est.	Impacted Plate 186:	1.00	Eng. Est.
NDE Standard 1B:	0.00	Eng. Est.	Impacted Plate 1900:	0.00	Eng. Est.
NDE Standard 2:	1.00		Impacted Plate 1907:	0.00	
NDE Standard 3:	1.00	Eng. Est.	Impacted Plate T3:	1.00	Eng. Est.
NDE Standard 4:	1.00	Eng. Est.	Impacted Plate 243:	0.00	Eng. Est.
NDE Standard 5:	1.00	Eng. Est.			
NDE Standard 6A:	1.00	Eng. Est.	Bond Plate 123:	2.00	Eng. Est.
NDE Standard 6B:	1.00	Eng. Est.	Bond Plate 158:	2.00	Eng. Est.
NDE Standard 7A:	1.00	Eng. Est.	Bond Plate 028B:	2.00	Eng. Est.
NDE Standard 7B:	1.00	Eng. Est.	Bond Plate 132A:	2.00	Eng. Est.



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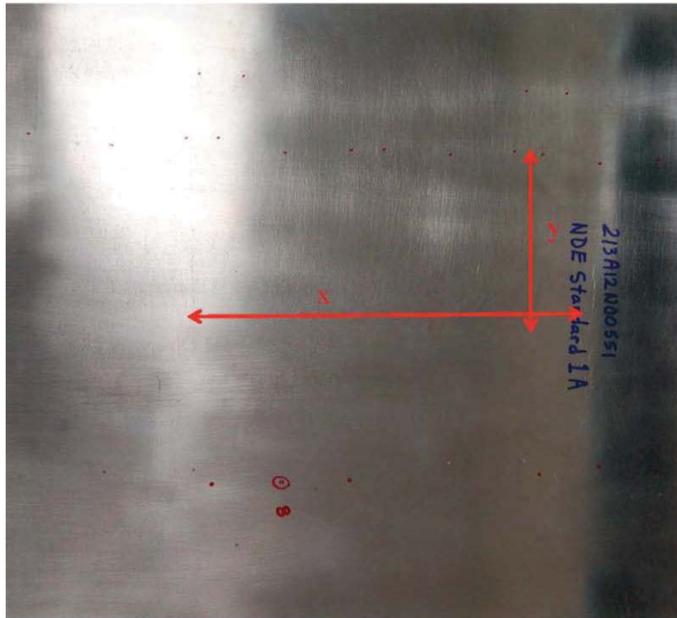
Title:

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NDE Standard IA Notches

Image of Samples



NDE Standard IA Notches

Clean/Un-Patched Samples

RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion



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NDE Standard 1A Notches

Taped/Patched Samples

RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion

NDE Standard 1A Notches

Plate/Patched Samples

RATING= 0
RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion



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Title:

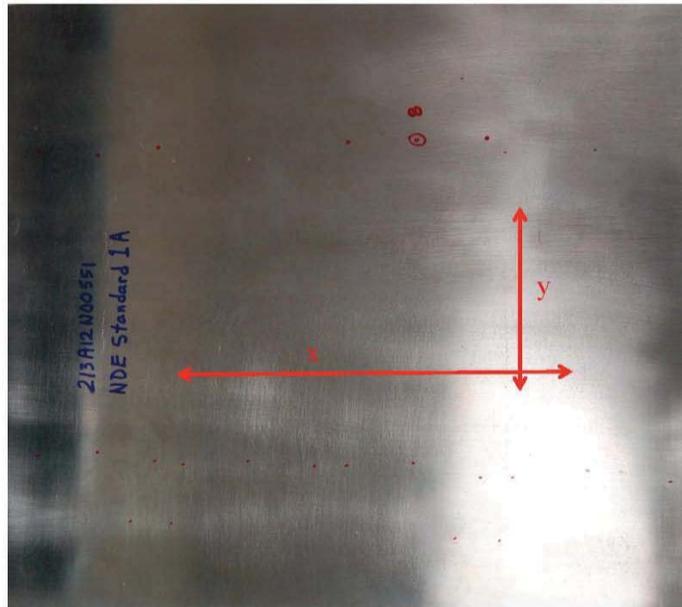
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NDE Standard 1A Holes

Image of Samples



NDE Standard 1A holes

Clean/Un-Patched Samples

RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion



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NDE Standard 1A holes

Taped/Patched Samples

RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion

NDE Standard 1A holes

Plate/Patched Samples

RATING= 0
RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion



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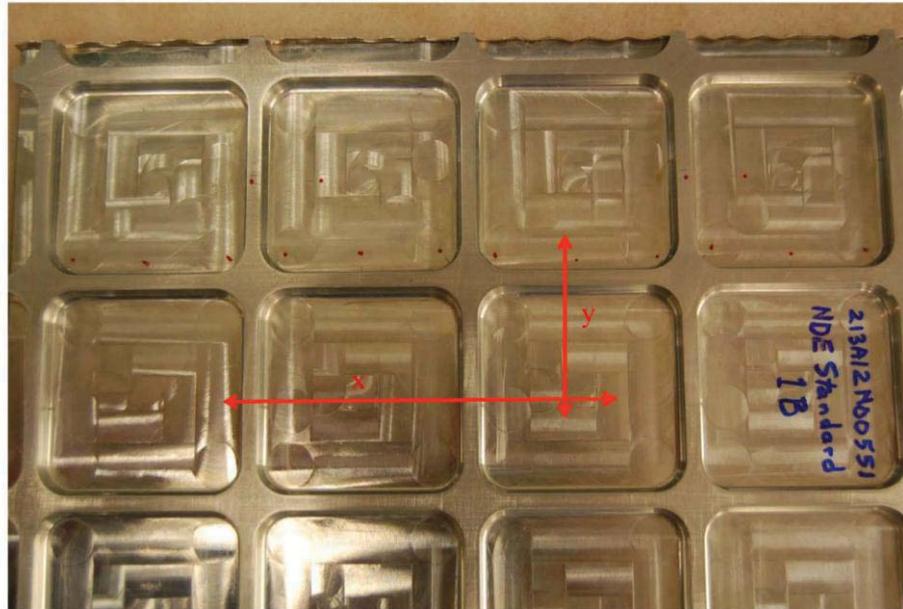
Title:

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NDE Standard 1B Notches

Image of Samples



NDE Standard 1B Notches

Clean/Un-Patched Samples

RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion



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NDE Standard 1B Notches

Taped/Patched Samples

RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion

NDE Standard 1B Notches

Plate/Patched Samples

RATING= 0
RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion



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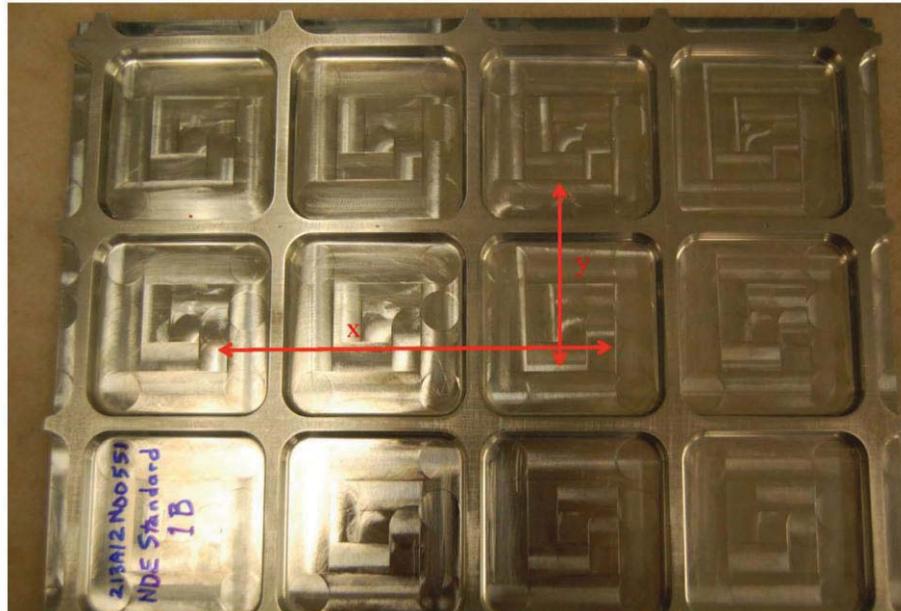
Title:

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NDE Standard 1B Holes

Image of Samples



NDE Standard 1B Holes

Clean/Un-Patched Samples

RATING=

0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion



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NDE Standard 1B Holes

Taped/Patched Samples

RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion

NDE Standard 1B Holes

Plate/Patched Samples

RATING= 0
RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion



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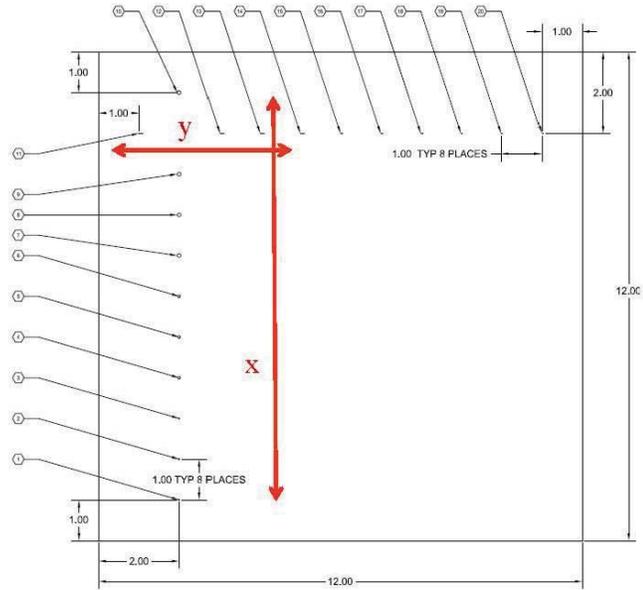
Title:

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NDE Standard 2 holes

Image of Samples



NDE Standard 2 holes

Clean/Un-Patched Samples

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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NDE Standard 2 holes

Taped/Patched Samples

RATING 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

NDE Standard 2 holes

Plate/Patched Samples

RATING= 1 RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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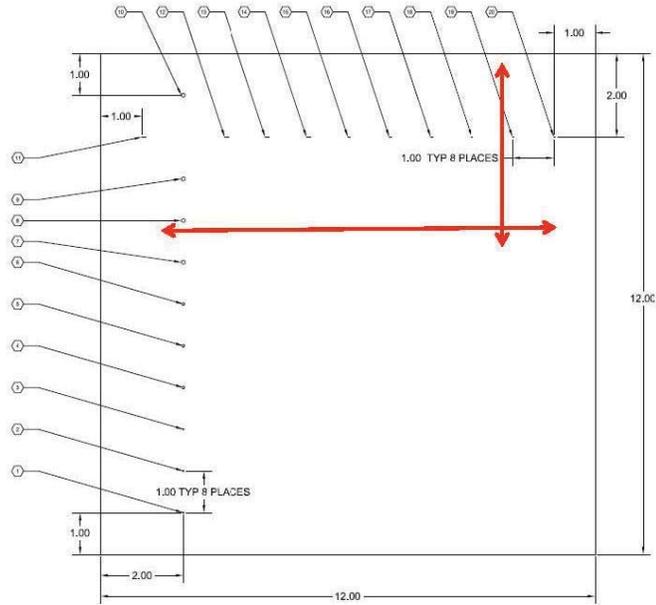
Title:

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NDE Standard 2 notches

Image of Samples



NDE Standard 2 notches

Clean/Un-Patched Samples

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion.
Rating estimated based on engineering estimate.



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NDE Standard 2 notches

Taped/Patched Samples

RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

NDE Standard 2 notches

Plate/Patched Samples

RATING= 1
RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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NDE Standard 3

Taped/Patched Samples

RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

NDE Standard 3

Plate/Patched Samples

RATING= 1 RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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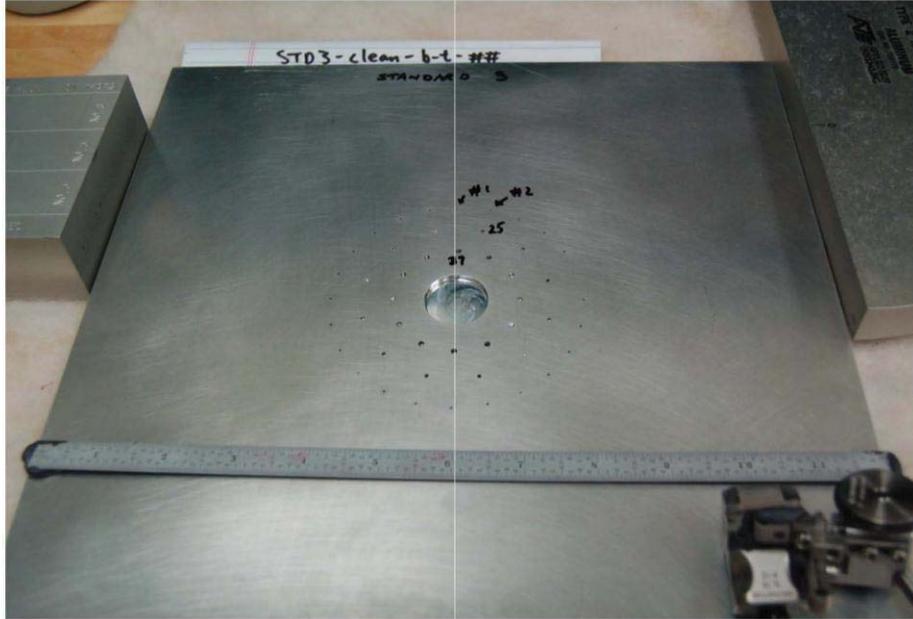
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NDE Standard 3

Image of Samples



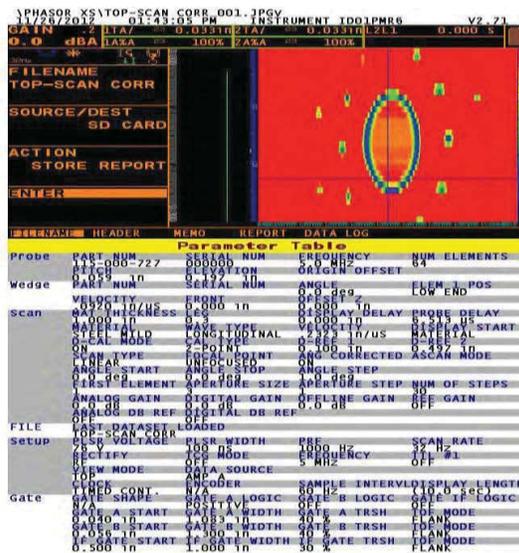
NDE Standard 3

Clean/Un-Patched Samples

RATING=

1

Scanned with a zero degree wedge





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NDE Standard 3

Taped/Patched Samples

RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

NDE Standard 3

Plate/Patched Samples

RATING= 0
RATING= 0.66666667

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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Plate 551 NDE Standard 4 holes

Image of Samples

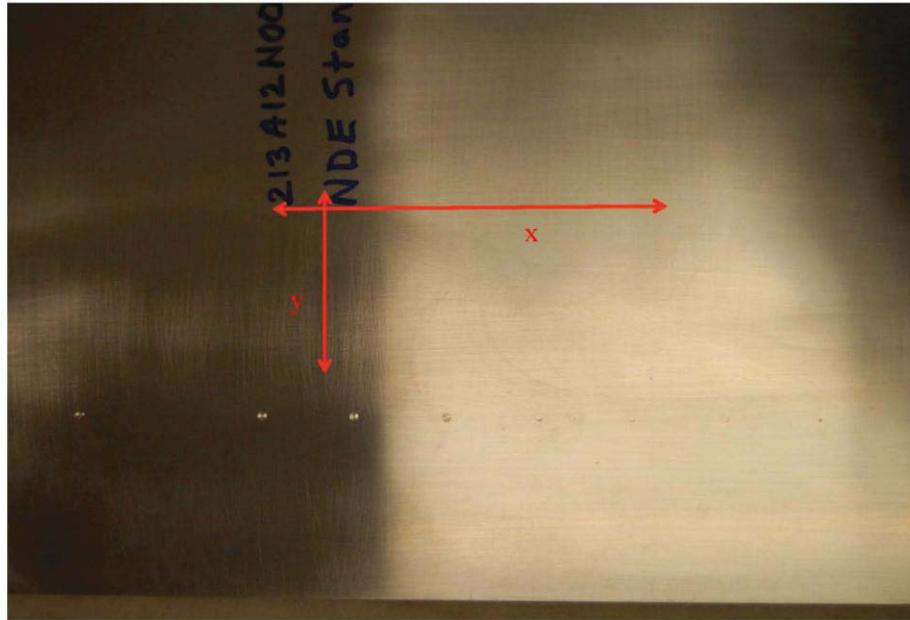


Plate 551 NDE Standard 4 holes

Clean/Un-Patched Samples

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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Plate 551 NDE Standard 4 holes

Taped/Patched Samples

RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample
as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

Plate 551 NDE Standard 4 holes

Plate/Patched Samples

RATING= 1
RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample
as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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Plate 551 NDE Standard 4 notches

Image of Samples

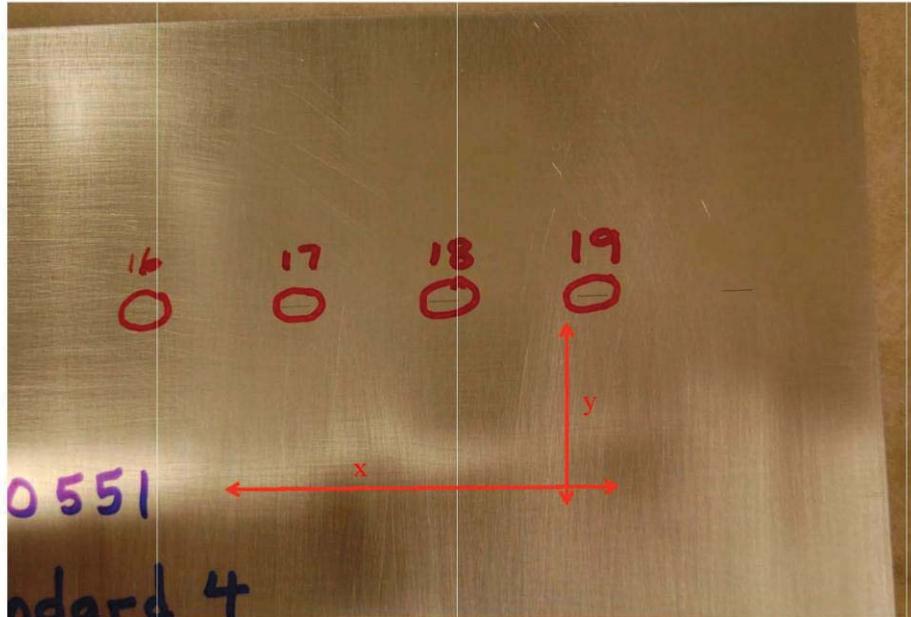


Plate 551 NDE Standard 4 notches

Clean/Un-Patched Samples

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample
as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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Plate 551 NDE Standard 4 notches

Taped/Patched Samples

RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

Plate 551 NDE Standard 4 notches

Plate/Patched Samples

RATING= 1
RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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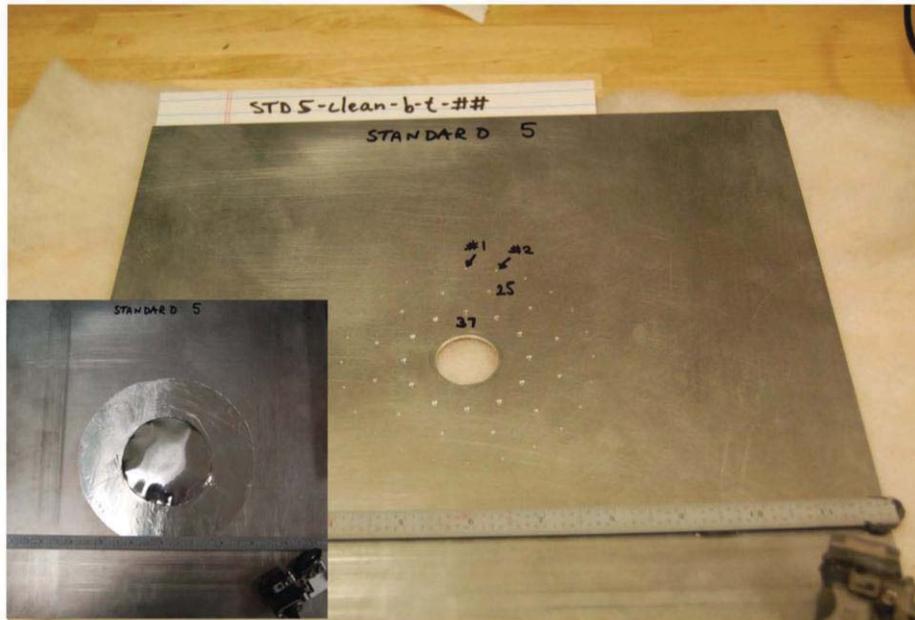
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NDE Standard 5

Image of Samples



NDE Standard 5

Clean/Un-Patched Samples

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion



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NDE Standard 5

Taped/Patched Samples

RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

NDE Standard 5

Plate/Patched Samples

RATING= 1
RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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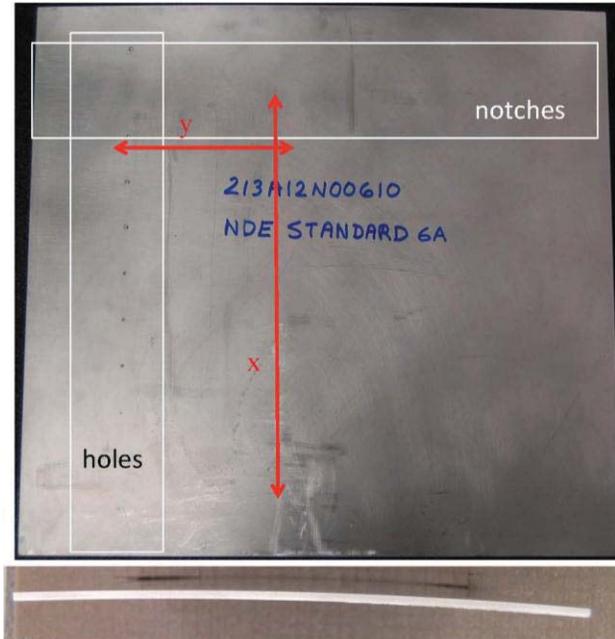
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NDE Standard 6A

Image of Samples



NDE Standard 6A

Clean/Un-Patched Samples

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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NDE Standard 6A

Taped/Patched Samples

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

RATING= 1

NDE Standard 6A

Plate/Patched Samples

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

RATING= 1 RATING= 1



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Title:

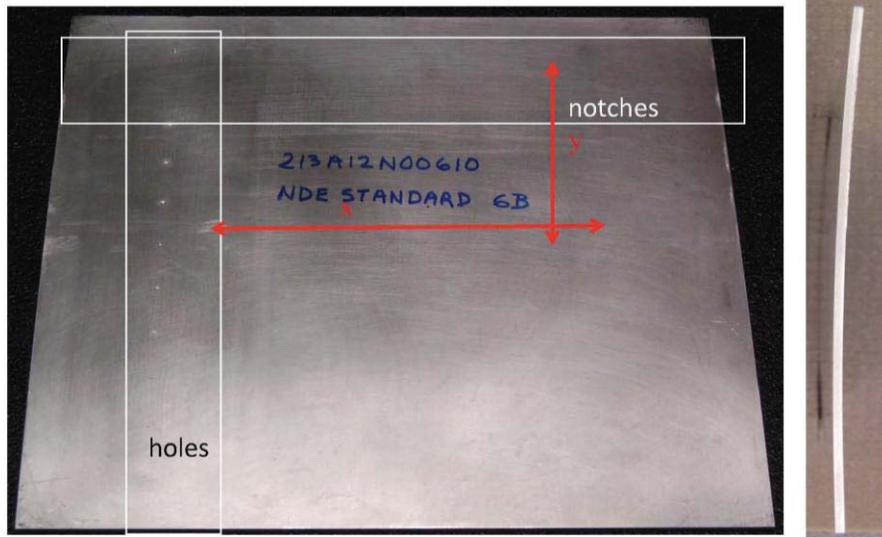
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NDE Standard 6B

Image of Samples



NDE Standard 6B

Clean/Un-Patched Samples

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample
as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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NDE Standard 6B

Taped/Patched Samples

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample
as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

NDE Standard 6B

Plate/Patched Samples

RATING=

1

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample
as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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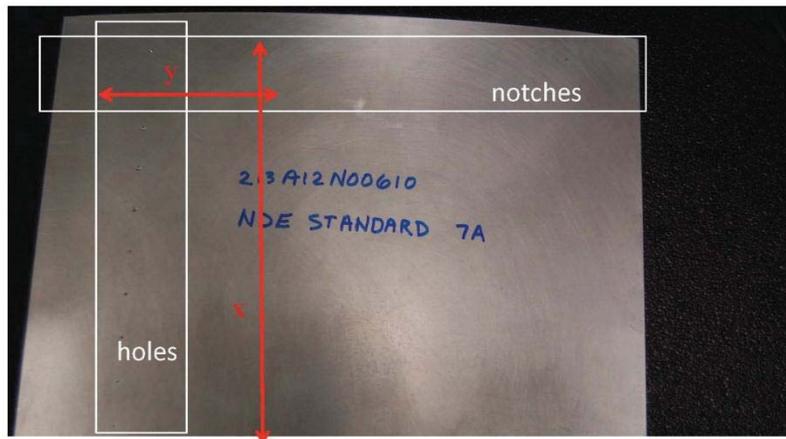
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NDE Standard 7A notches

Image of Samples



NDE Standard 7A notches

Clean/Un-Patched Samples

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample
as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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NDE Standard 7A notches

Taped/Patched Samples

RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

NDE Standard 7A notches

Plate/Patched Samples

RATING= 1
RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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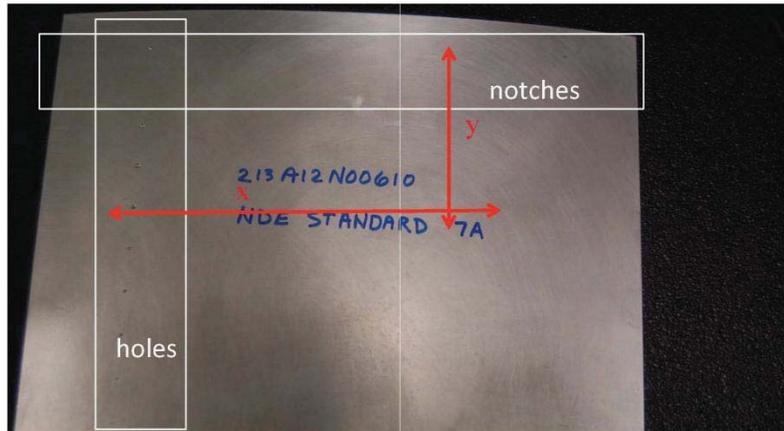
Title:

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NDE Standard 7A holes

Image of Samples



NDE Standard 7A holes

Clean/Un-Patched Samples

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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NDE Standard 7A holes

Taped/Patched Samples

RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

NDE Standard 7A holes

Plate/Patched Samples

RATING= 1
RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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Title:

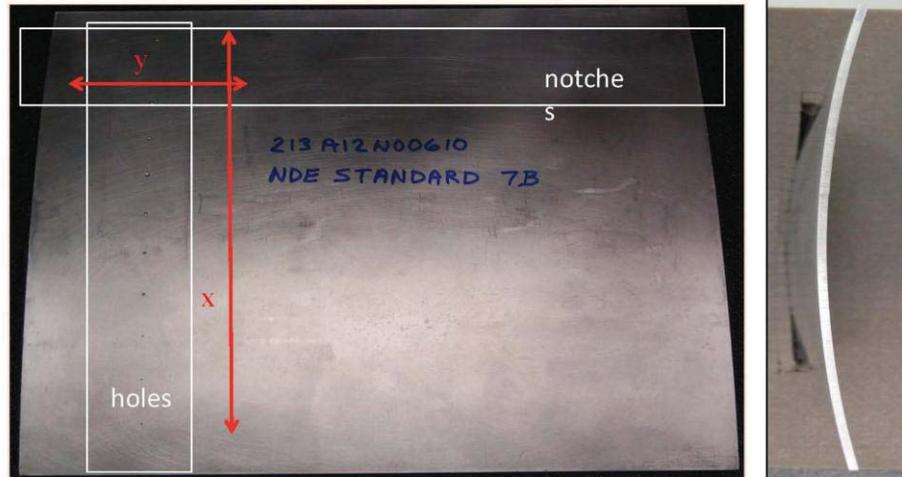
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NDE Standard 7B notches

Image of Samples



NDE Standard 7B notches

Clean/Un-Patched Samples

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

RATING=

1



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NDE Standard 7B notches

Taped/Patched Samples

RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

NDE Standard 7B notches

Plate/Patched Samples

RATING= 1 RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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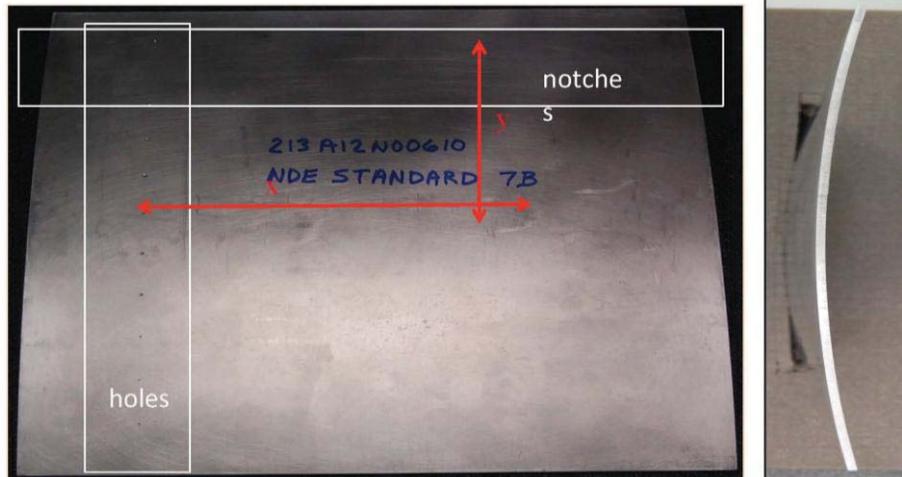
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NDE Standard 7B

Image of Samples



NDE Standard 7B

Clean/Un-Patched Samples

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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NDE Standard 7B

Taped/Patched Samples

RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

NDE Standard 7B

Plate/Patched Samples

RATING= 1
RATING= 1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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Plate 186

Image of Samples

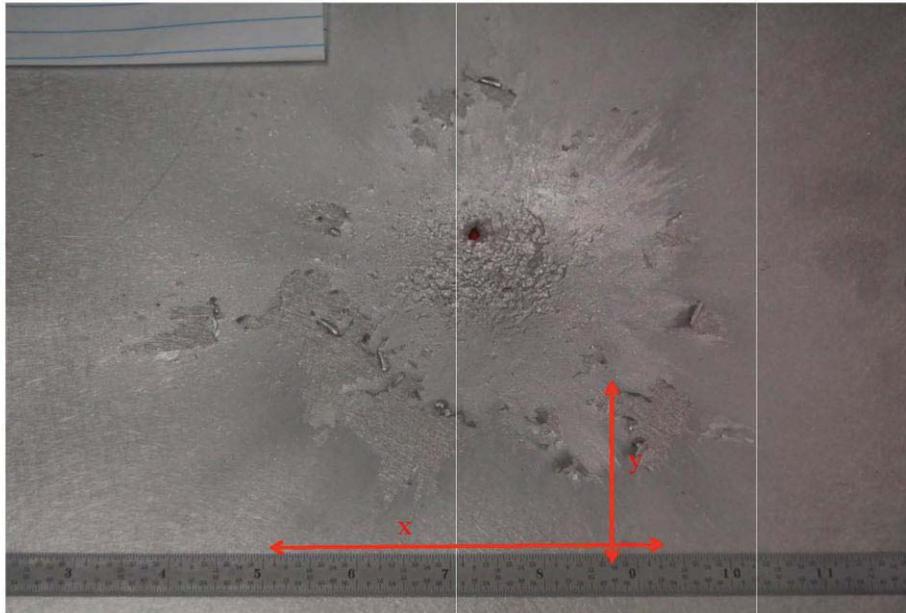


Plate 186

Clean/Un-Patched Samples

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion.
Rating estimated based on engineering estimate

RATING= 1



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Plate 186

Taped/Patched Samples

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

RATING= 1

Plate 186

Plate/Patched Samples

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

RATING= RATING= 1 1



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Plate 1900

Image of Samples



Plate 1900

Clean/Un-Patched Samples

RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 2" thick which causes extreme image distortion



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Plate 1900

Taped/Patched Samples

RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 2" thick which causes extreme image distortion

Plate 1900

Plate/Patched Samples

RATING= 0
RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 2" thick which causes extreme image distortion



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Plate 1907

Image of Samples

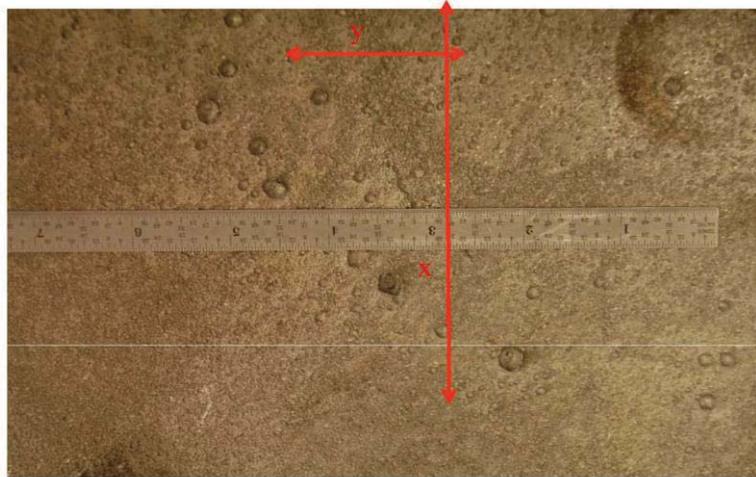


Plate 1907

Clean/Un-Patched Samples

RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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Plate 1907

Taped/Patched Samples

RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

Plate 1907

Plate/Patched Samples

RATING= 0
RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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Plate T3

Image of Samples



Plate T3

Clean/Un-Patched Samples

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample
as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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Plate T3

Taped/Patched Samples

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate

Plate T3

Plate/Patched Samples

RATING=

1

RATING=

1

The only way to see 4" with a shear wave wedge is to declare the sample as 1" thick which causes extreme image distortion
Rating estimated based on engineering estimate



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Plate 12243 (FGB impact plate)

Image of Samples

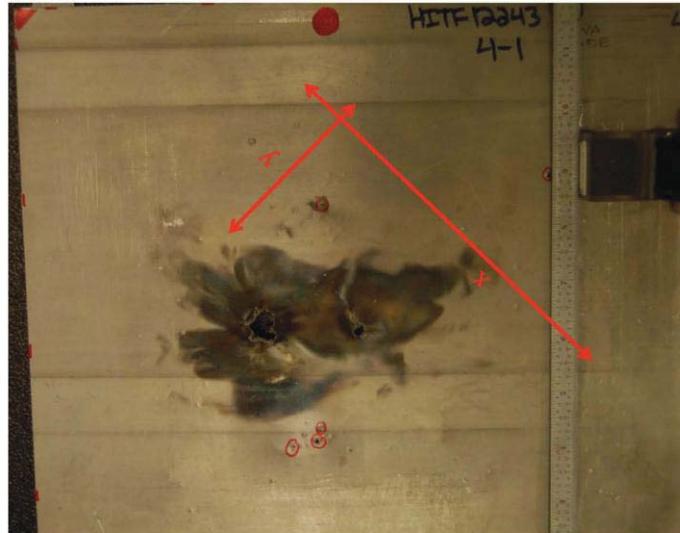


Plate 12243 (FGB impact plate)

Clean/Un-Patched Samples

RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 2" thick which causes extreme image distortion



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Plate 12243 (FGB impact plate)

Taped/Patched Samples

RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 2" thick which causes extreme image distortion

Plate 12243 (FGB impact plate)

Plate/Patched Samples

RATING= 0
RATING= 0

The only way to see 4" with a shear wave wedge is to declare the sample as 2" thick which causes extreme image distortion



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Plate 123 (Bond Plate)

Image of Samples

c-scan image from water tank

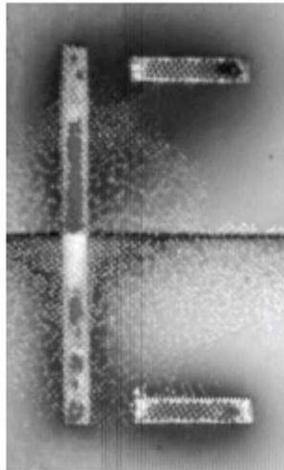


Plate 123 (Bond Plate)

Clean/Un-Patched Samples

RATING=

2

Based on zero angle scans on Std.3, and
Base on comparison with VEO and Omniscan MX systems, this scanner should
be able to image the bond flaws satisfactory



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Plate 158 (Bond Plate)

Image of Samples

e-scan image from water tank

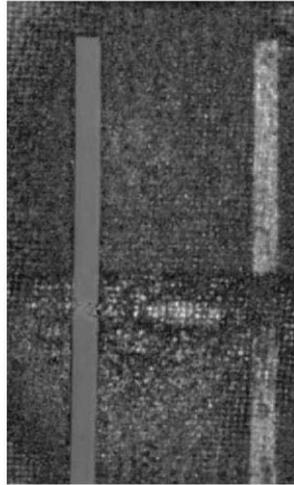


Plate 158 (Bond Plate)

Clean/Un-Patched Samples

Based on zero angle scans on Std.3, and
Base on comparison with VEO and Omniscan MX systems, this scanner should
be able to image the bond flaws satisfactory

RATING=

2



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Plate 028B (Bond Plate)

Image of Samples

c-scan image from water tank

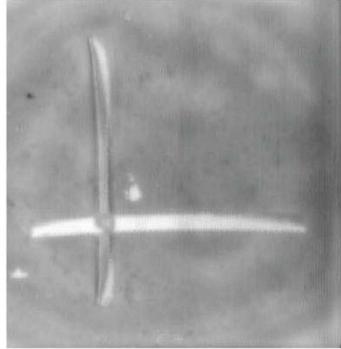


Plate 028B (Bond Plate)

Clean/Un-Patched Samples

Based on zero angle scans on Std.3, and
Base on comparison with VEO and Omniscan MX systems, this scanne should
be able to image the bond flaws satisfactory

RATING=

2



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Plate 132A (Bond Plate)

Image of Samples

Plate 132A (Bond Plate)

Clean/Un-Patched Samples

Based on zero angle scans on Std.3, and
Base on comparison with VEO and Omniscan MX systems, this scanne should
be able to image the bond flaws satisfactory

RATING=

2



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Appendix G. Olympus Omniscan MX EC Results

Olympus Omniscan MX EC Results



Scans below used the Omniscan EC Array scanner.

Ratings:

0	Failure to identify important features
1	Features slightly detectable but not clearly defined
2	Undoubtable feature detection

Average RATING amongst all scans:	0.20
Average RATING amongst NDE Standard Scans:	0.60
Average RATING amongst impacted plate scans:	0.00
Average RATING amongst bond plate scans:	0.00

NDE Standard 1A:	0.00	Eng. Est.	Impacted Plate 186:	0.00	Eng. Est.
NDE Standard 1B:	0.00	Eng. Est.	Impacted Plate 1900:	0.00	Eng. Est.
NDE Standard 2:	0.67	Eng. Est.	Impacted Plate 1907:	0.00	Eng. Est.
NDE Standard 3:	0.67		Impacted Plate T3:	0.00	Eng. Est.
NDE Standard 4:	1.00		Impacted Plate 243:	0.00	Eng. Est.
NDE Standard 5:	1.00	Eng. Est.			
NDE Standard 6A:	0.67	Eng. Est.	Bond Plate 123:	0.00	Eng. Est.
NDE Standard 6B:	0.67	Eng. Est.	Bond Plate 158:	0.00	Eng. Est.
NDE Standard 7A:	0.67	Eng. Est.	Bond Plate 028B:	0.00	Eng. Est.
NDE Standard 7B:	0.67	Eng. Est.	Bond Plate 132A:	0.00	Eng. Est.



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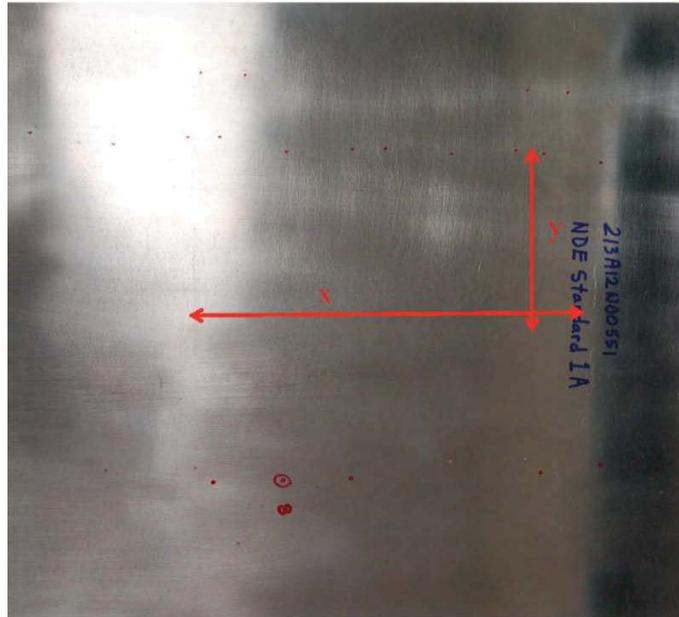
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NDE Standard 1A Notches

Image of Samples



NDE Standard 1A Notches

Clean/Un-Patched Samples

The ribs interfere with scanning

RATING=

0



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NDE Standard 1A Notches

Taped/Patched Samples

The ribs interfere with scanning

RATING= 0

NDE Standard 1A Notches

Plate/Patched Samples

The ribs interfere with scanning

RATING= 0
RATING= 0



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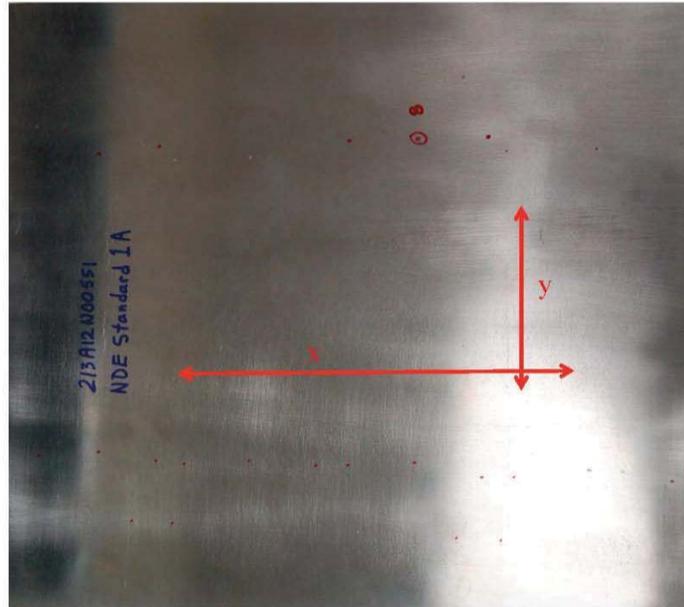
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NDE Standard 1A Holes

Image of Samples



NDE Standard 1A Holes

Clean/Un-Patched Samples

The ribs interfere with scanning

RATING=

0



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NDE Standard 1A Holes

Taped/Patched Samples

The ribs interfere with scanning

RATING=

0

NDE Standard 1A Holes

Plate/Patched Samples

The ribs interfere with scanning

RATING=

0

RATING=

0



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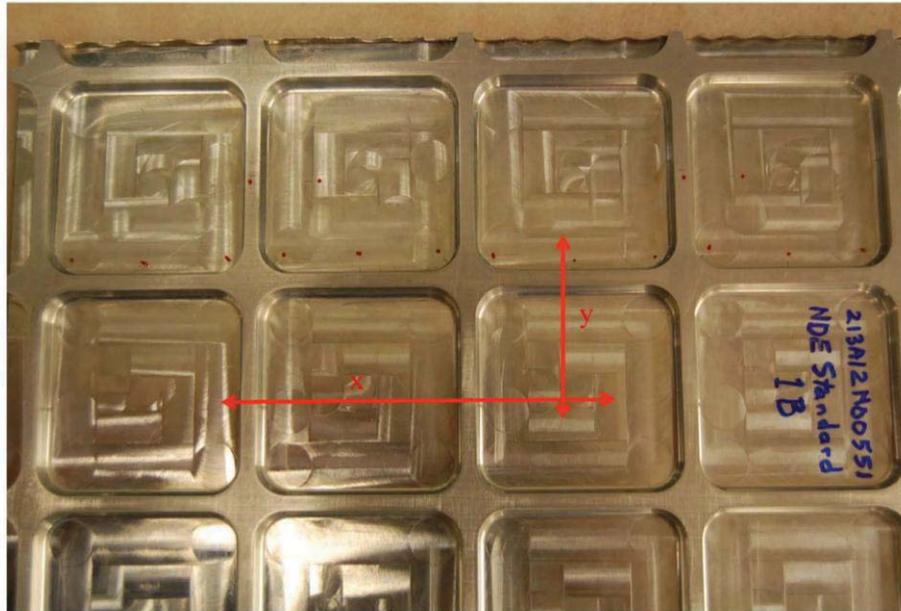
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NDE Standard 1B Notches

Image of Samples



NDE Standard 1B Notches

Clean/Un-Patched Samples

The ribs can be seen, but the ribs interfere with the flaw detection

RATING=

0



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NDE Standard 1B Notches

Taped/Patched Samples

The ribs can be seen, but the ribs interfere with the flaw detection

RATING= 0

NDE Standard 1B Notches

Plate/Patched Samples

Can't measure through the plate.

RATING= 0
RATING= 0



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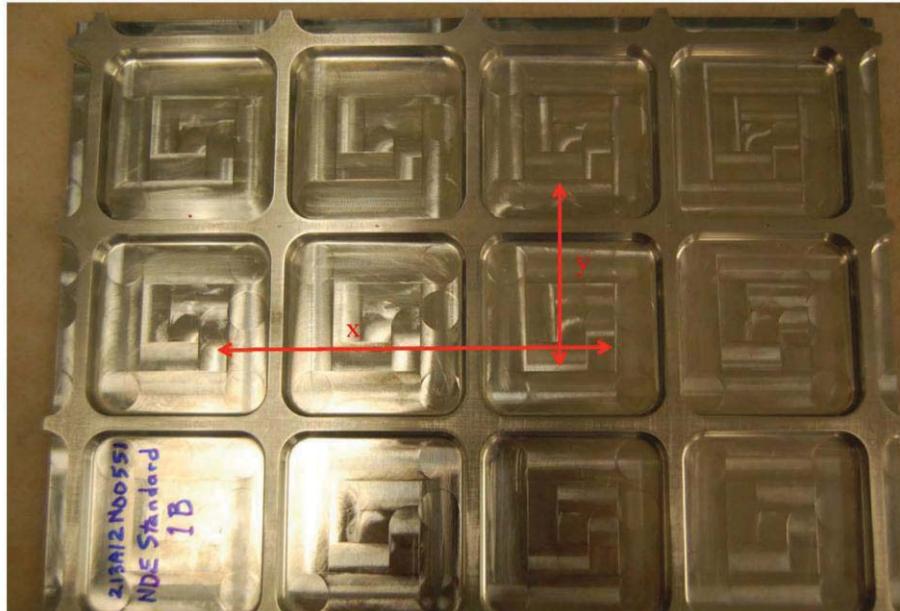
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NDE Standard 1B Holes

Image of Samples



NDE Standard 1B Holes

Clean/Un-Patched Samples

RATING= 0

The ribs can be seen, but the ribs interfere with the flaw detection



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NDE Standard 1B Holes

Taped/Patched Samples

RATING= 0

The ribs can be seen, but the ribs interfere with the flaw detection

NDE Standard 1B Holes

Plate/Patched Samples

RATING= 0
RATING= 0

Can't measure through the plate.



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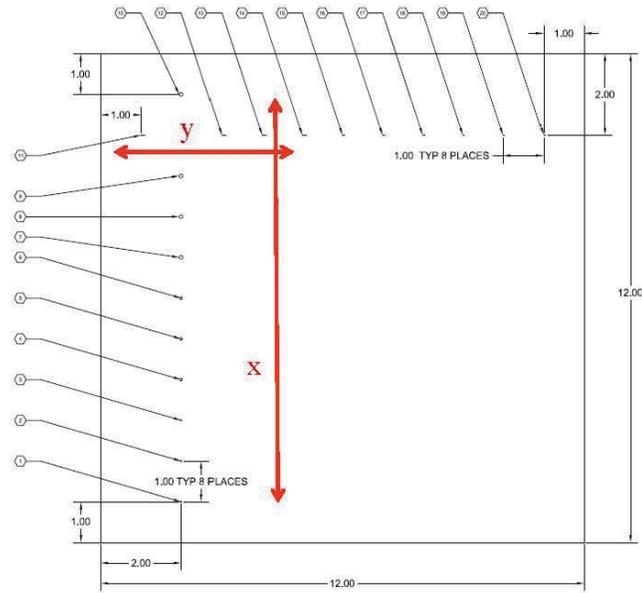
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NDE Standard 2 holes

Image of Samples



NDE Standard 2 holes

Clean/Un-Patched Samples

RATING=

1

Engineering evaluation is that it would measure the deepest holes. See std 4.



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NDE Standard 2 holes

Taped/Patched Samples

RATING 1

Engineering evaluation is that it would measure the deepest holes,
even through the tape, but with some degradation. See std 4.
This system will still have trouble with the tape patch at the repair's center

NDE Standard 2 holes

Plate/Patched Samples

RATING= 0
RATING= 0.66666667

Can't measure through the plate.



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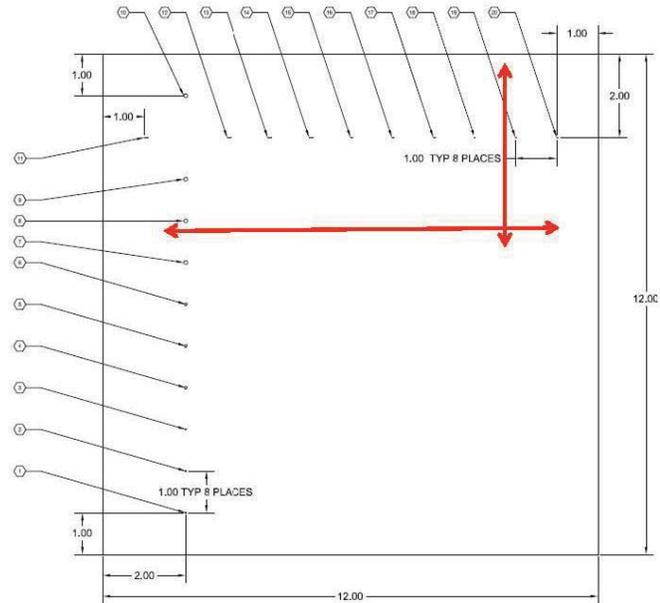
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NDE Standard 2 notches

Image of Samples



NDE Standard 2 notches

Clean/Un-Patched Samples

RATING=

1

Engineering evaluation is that it would measure the deepest notches. See std 4.



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NDE Standard 2 notches

Taped/Patched Samples

RATING= 1

Engineering evaluation is that it would measure the deepest notches, even through the tape, but with some degradation. See std 4. This system will still have trouble with the tape patch at the repair's center

NDE Standard 2 notches

Plate/Patched Samples

RATING= 0
RATING= 0.666666667

Can't measure through the plate.



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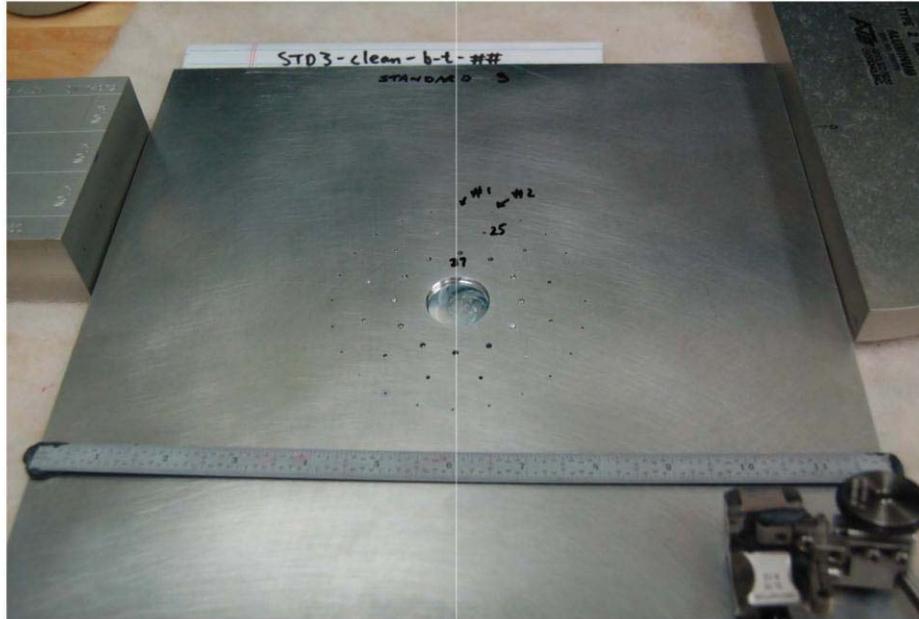
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NDE Standard 3

Image of Samples

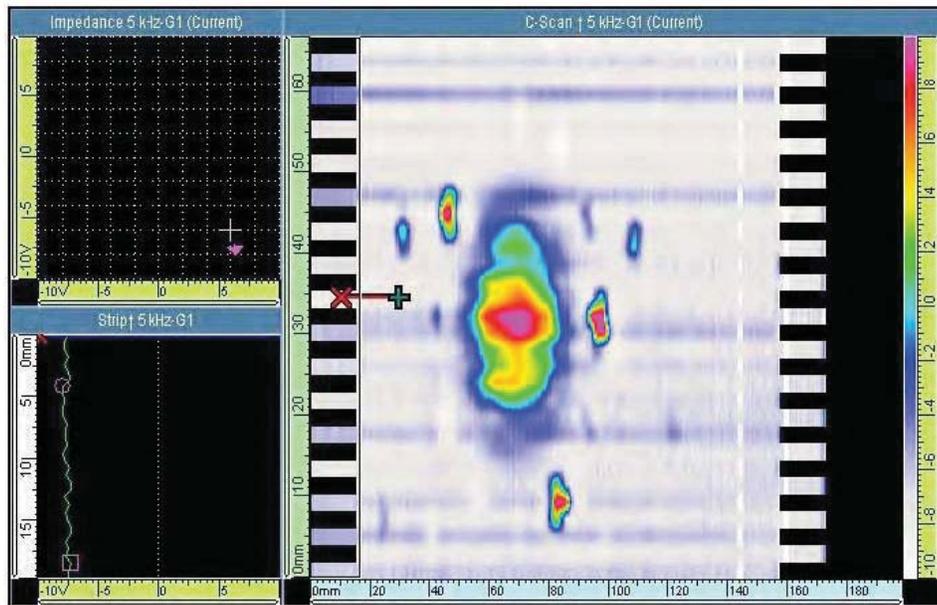


NDE Standard 3

Clean/Un-Patched Samples

RATING=

1





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NDE Standard 3

Taped/Patched Samples

RATING= 1

This system will still have trouble with the tape patch at the repair's center
Engineering evaluation is that it would measure through the tape with some degradation See Std 4.

NDE Standard 3

Plate/Patched Samples

RATING= 0
RATING= 0.666666667

Can't measure through the plate.



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Plate 551 NDE Standard 4 holes

Image of Samples

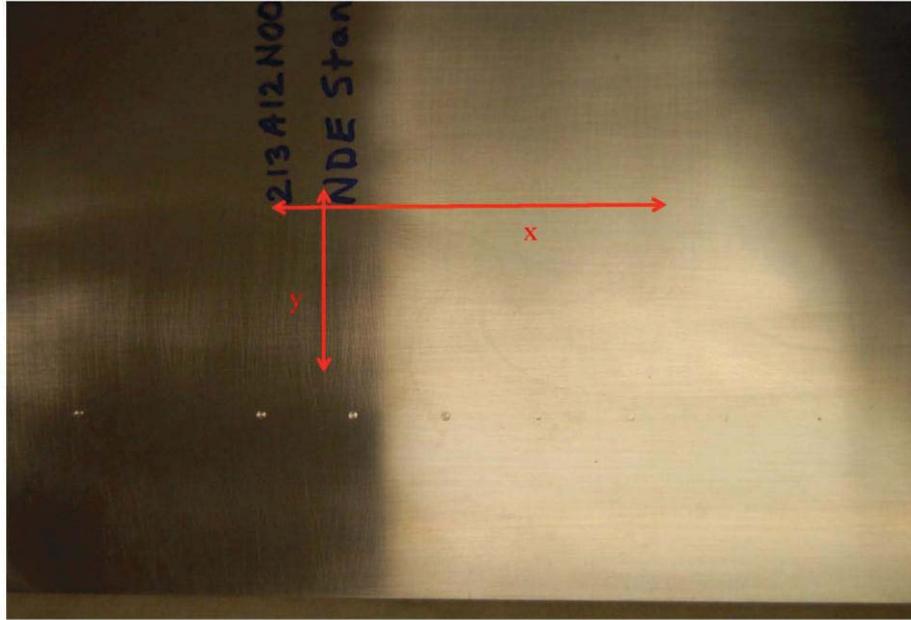
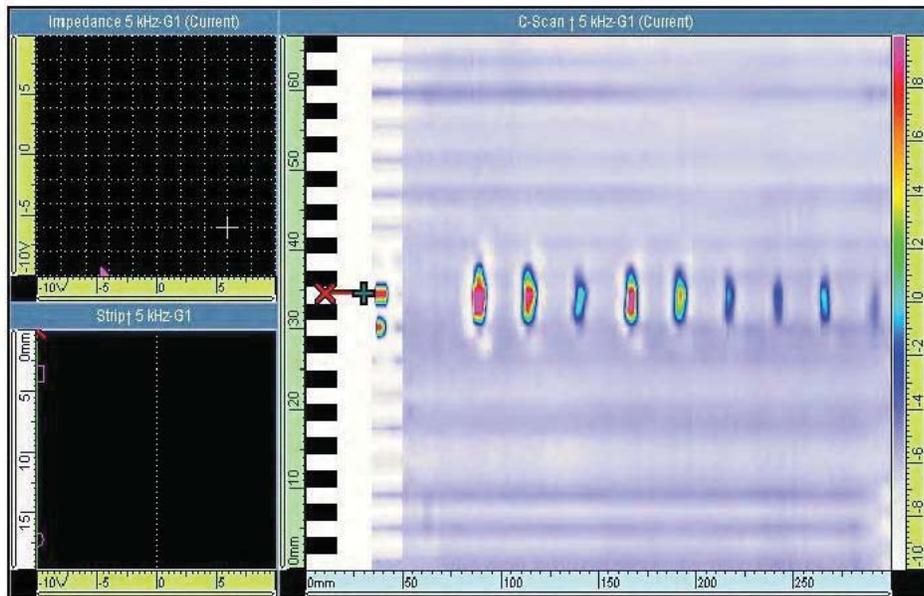


Plate 551 NDE Standard 4 holes

Clean/Un-Patched Samples

RATING=

2





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Plate 551 NDE Standard 4 holes

Taped/Patched Samples

This system will still have trouble with the tape patch at the repair's center

RATING=

1

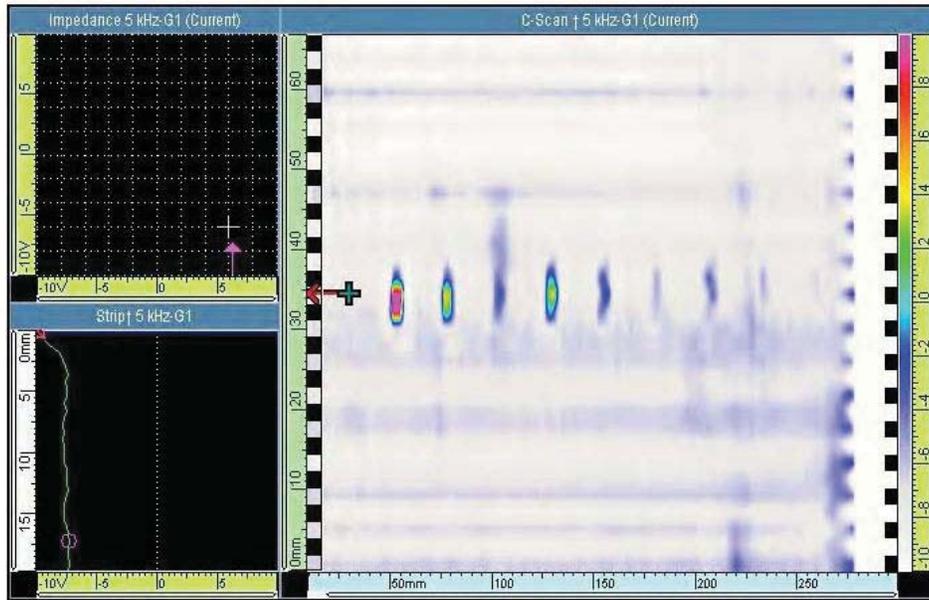


Plate 551 NDE Standard 4 holes

Plate/Patched Samples

RATING=

0

RATING=

1

Can't measure through the plate.



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Plate 551 NDE Standard 4 notches

Image of Samples

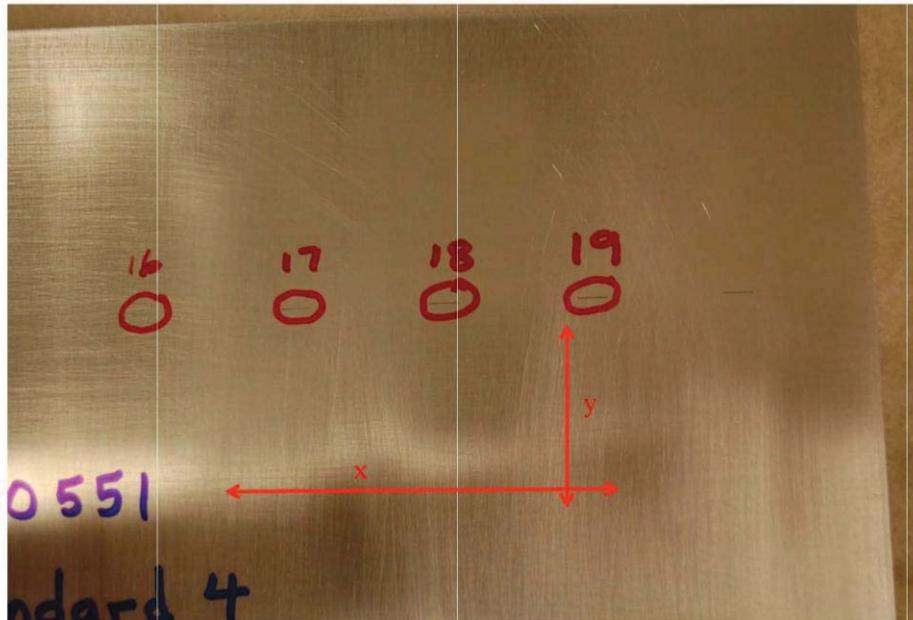
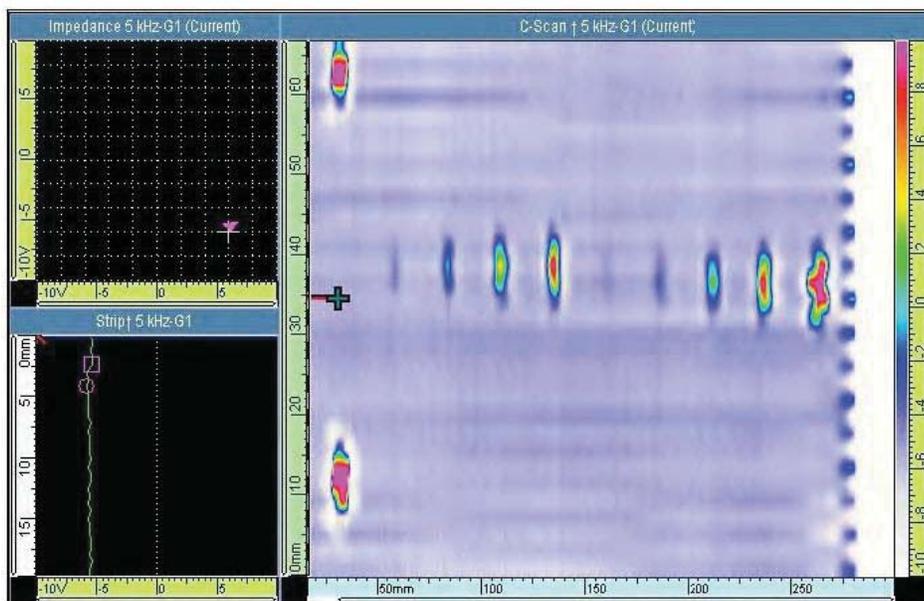


Plate 551 NDE Standard 4 notches

Clean/Un-Patched Samples

RATING=

2





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Plate 551 NDE Standard 4 notches

Taped/Patched Samples

RATING= 1

This system will still have trouble with the tape patch at the repair's center
Engineering evaluation is that it would measure through the tape with some degradation See Std 4.

Plate 551 NDE Standard 4 notches

Plate/Patched Samples

RATING= 0
RATING= 1

Can't measure through the plate.



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NDE Standard 5

Image of Samples



NDE Standard 5

Clean/Un-Patched Samples

RATING=

2

Engineering evaluation is that it would measure through this 1/16" thick sample. See Std 3 & 4.



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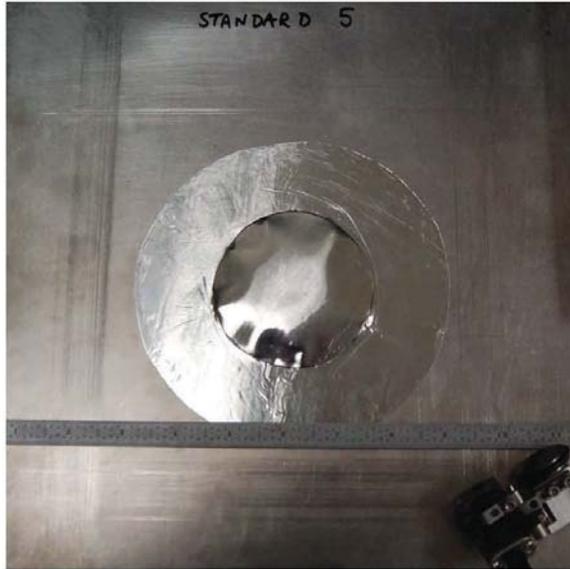
NDE Standard 5

Taped/Patched Samples

RATING=

1

This system will still have trouble with the tape patch at the repair's center
Engineering evaluation is that it would measure through the tape with some degradation See Std 4.



NDE Standard 5

Plate/Patched Samples

RATING=

0

RATING=

1

Can't measure through the plate.



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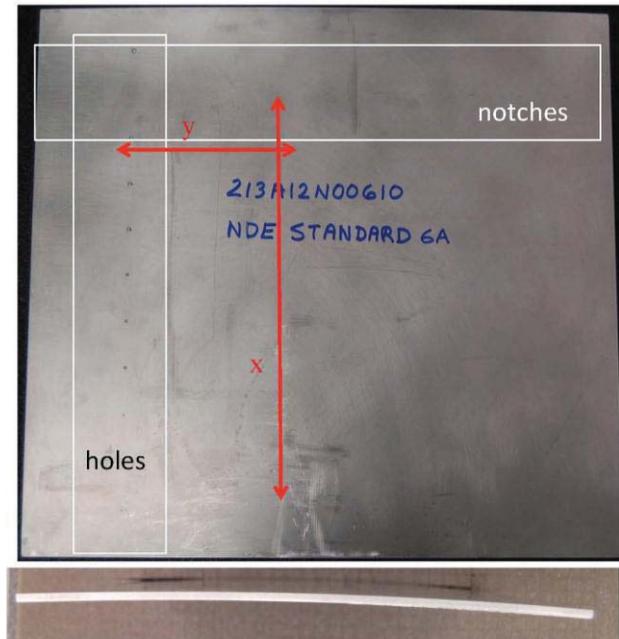
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NDE Standard 6A holes

Image of Samples



NDE Standard 6A holes

Clean/Un-Patched Samples

RATING=

1

Engineering evaluation is that it would measure the deepest holes. See std 4.



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NDE Standard 6A holes

Taped/Patched Samples

RATING= 1

Engineering evaluation is that it would measure the deepest holes,
even through the tape, but with some degradation. See std 4.
This system will still have trouble with the tape patch at the repair's center

NDE Standard 6A holes

Plate/Patched Samples

RATING= 0
RATING= 0.666666667

Can't measure through the plate.



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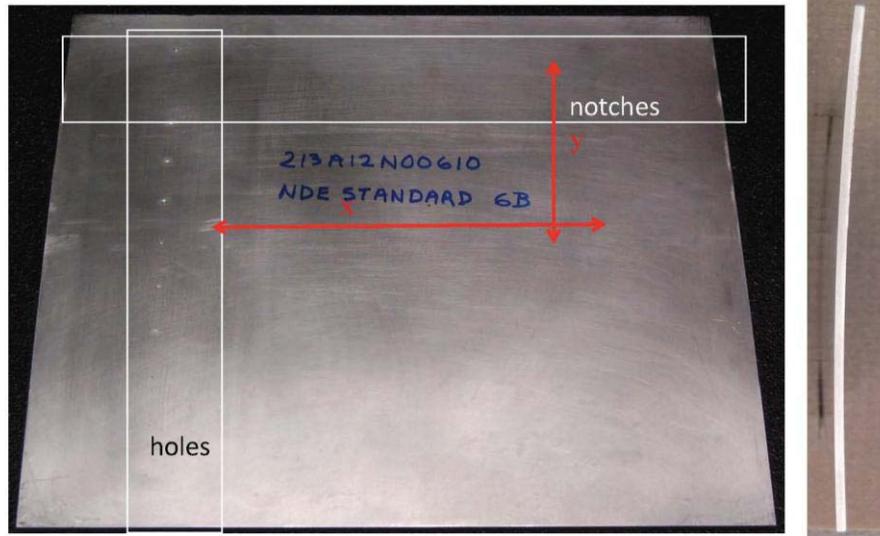
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NDE Standard 6B notches

Image of Samples



NDE Standard 6B notches

Clean/Un-Patched Samples

RATING=

1

Engineering evaluation is that it would measure the deepest notches. See std 4.



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NDE Standard 6B notches

Taped/Patched Samples

RATING=

1

Engineering evaluation is that it would measure the deepest notches, even through the tape, but with some degradation. See std 4. This system will still have trouble with the tape patch at the repair's center

NDE Standard 6B notches

Plate/Patched Samples

RATING=

0

RATING=

0.666666667

Can't measure through the plate.



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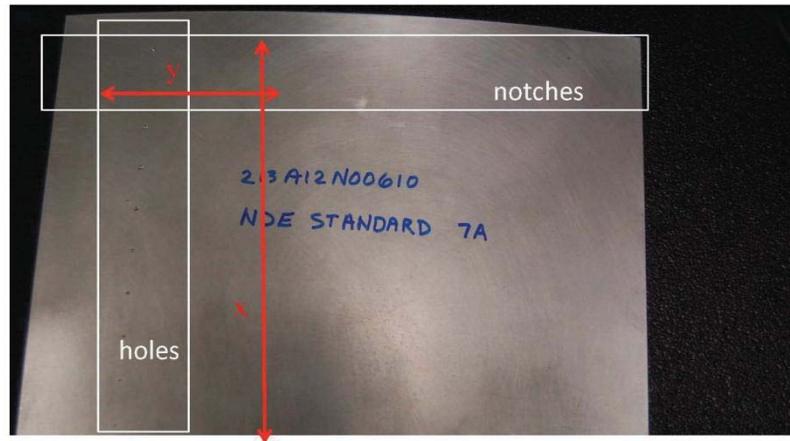
Title:

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NDE Standard 7A holes

Image of Samples



NDE Standard 7A holes

Clean/Un-Patched Samples

Engineering evaluation is that it would measure the deepest holes. See std 4.

RATING=

1



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NDE Standard 7A holes

Taped/Patched Samples

RATING= 1

Engineering evaluation is that it would measure the deepest holes, even through the tape, but with some degradation. See std 4. This system will still have trouble with the tape patch at the repair's center

NDE Standard 7A holes

Plate/Patched Samples

RATING= 0
RATING= 0.66666667

Can't measure through the plate.



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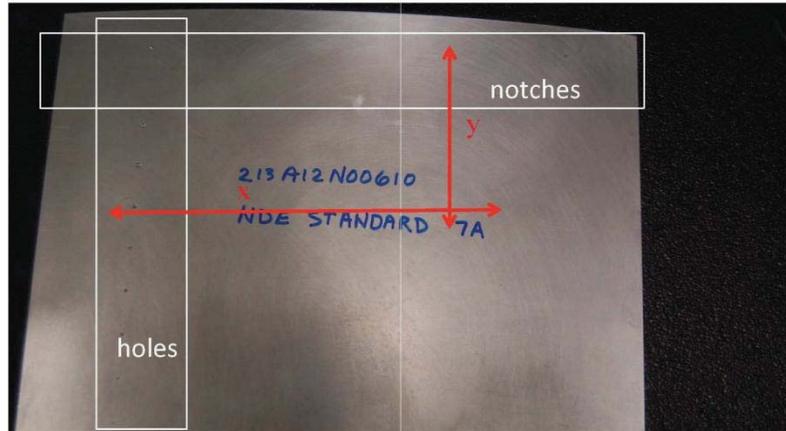
Title:

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NDE Standard 7A notches

Image of Samples



NDE Standard 7A notches

Clean/Un-Patched Samples

RATING=

1

Engineering evaluation is that it would measure the deepest notches. See std 4.



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NDE Standard 7A notches

Taped/Patched Samples

RATING= 1

Engineering evaluation is that it would measure the deepest notches,
even through the tape, but with some degradation. See std 4.
This system will still have trouble with the tape patch at the repair's center

NDE Standard 7A notches

Plate/Patched Samples

RATING= 0
RATING= 0.666666667

Can't measure through the plate.



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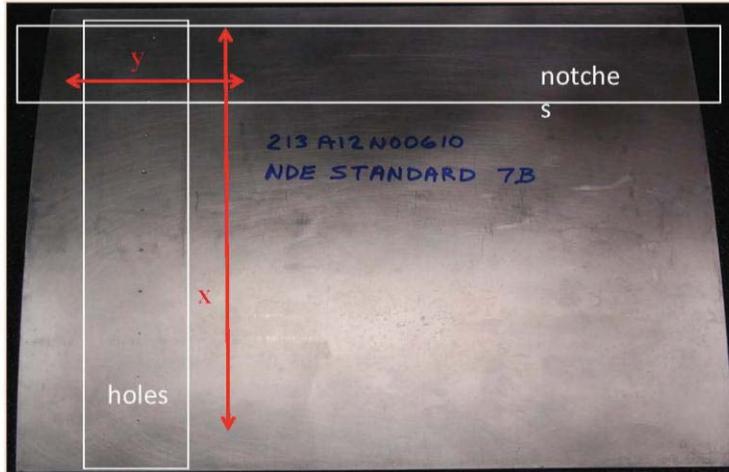
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NDE Standard 7B holes

Image of Samples



NDE Standard 7B holes

Clean/Un-Patched Samples

RATING=

1

Engineering evaluation is that it would measure the deepest holes. See std 4.



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NDE Standard 7B holes

Taped/Patched Samples

RATING= 1

Engineering evaluation is that it would measure the deepest holes,
even through the tape, but with some degradation. See std 4.
This system will still have trouble with the tape patch at the repair's center

NDE Standard 7B holes

Plate/Patched Samples

RATING= 0
RATING= 0.666666667

Can't measure through the plate.



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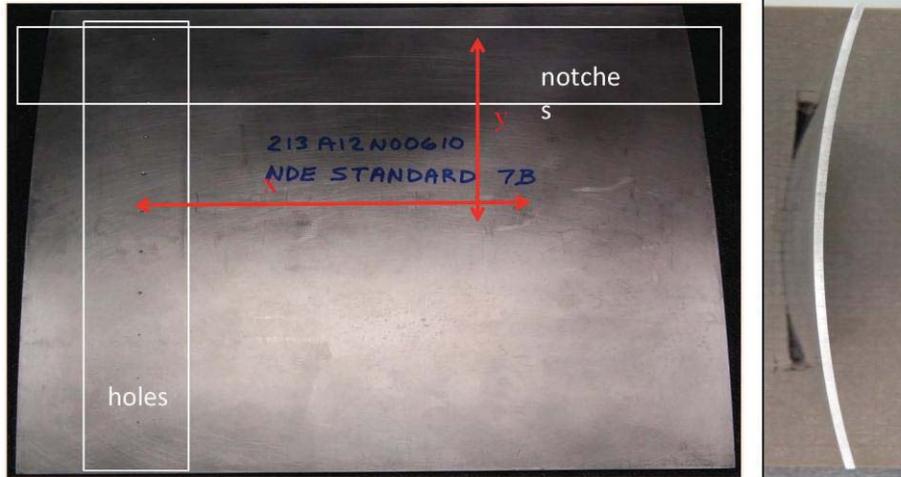
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NDE Standard 7B notches

Image of Samples



NDE Standard 7B notches

Clean/Un-Patched Samples

RATING=

1

Engineering evaluation is that it would measure the deepest notches. See std 4.



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NDE Standard 7B notches

Taped/Patched Samples

RATING= 1

Engineering evaluation is that it would measure the deepest notches, even through the tape, but with some degradation. See std 4. This system will still have trouble with the tape patch at the repair's center

NDE Standard 7B notches

Plate/Patched Samples

RATING= 0
RATING= 0.666666667

Can't measure through the plate.



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Plate 186

Image of Samples

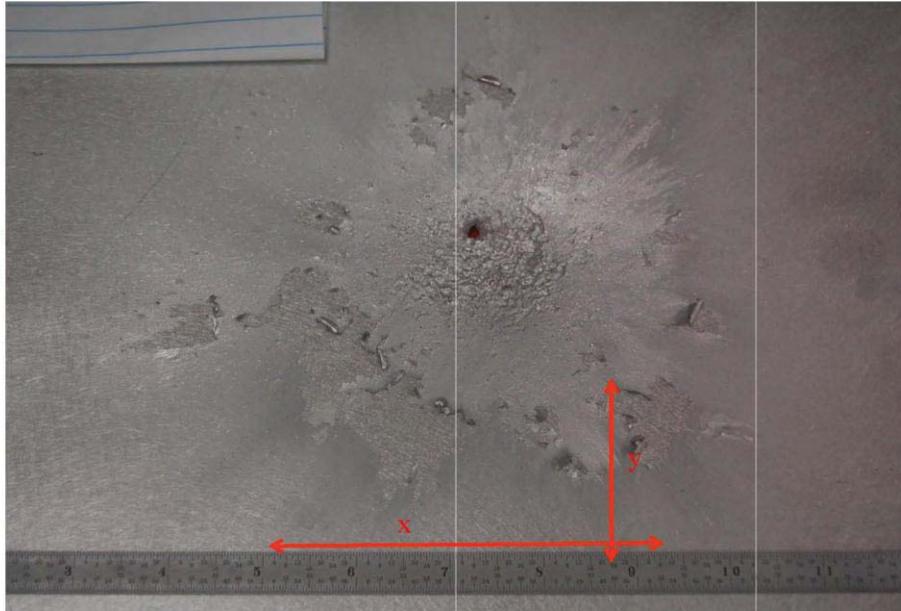


Plate 186

Clean/Un-Patched Samples

Sample's surface was too uneven to measure



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Plate 186

Taped/Patched Samples

Sample's surface was too uneven to measure

RATING= 0

Plate 186

Plate/Patched Samples

Can't measure through the plate.

RATING= 0
RATING= 0



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Plate 1900

Image of Samples



Plate 1900

Clean/Un-Patched Samples

Sample's surface was too uneven to measure

RATING=

0



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Plate 1900

Taped/Patched Samples

Sample's surface was too uneven to measure

RATING= 0

Plate 1900

Plate/Patched Samples

Can't measure through the plate.

RATING= 0
RATING= 0



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Plate 1907

Image of Samples

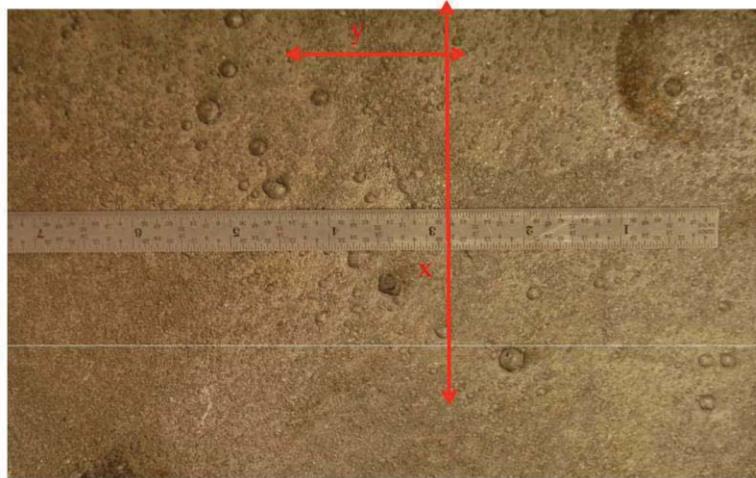


Plate 1907

Clean/Un-Patched Samples

RATING=

0

Sample's surface was too uneven to measure



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Plate 1907

Taped/Patched Samples

Sample's surface was too uneven to measure

RATING= 0

Plate 1907

Plate/Patched Samples

Can't measure through the plate.

RATING= 0
RATING= 0



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Plate T3

Image of Samples

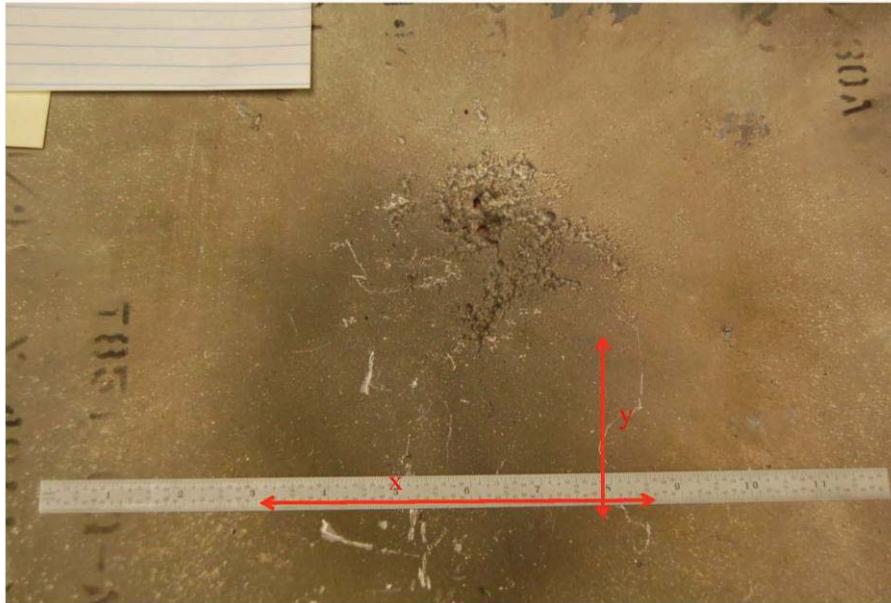


Plate T3

Clean/Un-Patched Samples

RATING= 0

Sample's surface was too uneven to measure



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Plate T3

Taped/Patched Samples

Sample's surface was too uneven to measure

RATING= 0

Plate T3

Plate/Patched Samples

Can't measure through the plate.

RATING= 0
RATING= 0



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Plate 12243 (FGB impact plate)

Image of Samples

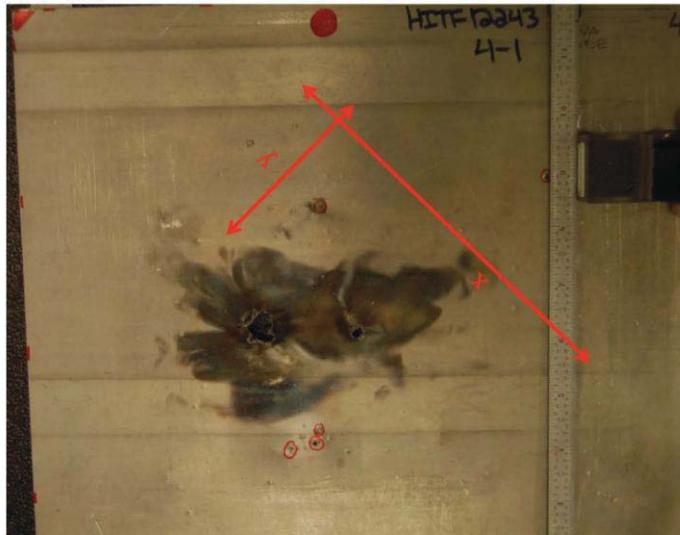


Plate 12243 (FGB impact plate)

Clean/Un-Patched Samples

RATING=

0

Sample's surface was too uneven to measure



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Plate 12243 (FGB impact plate)

Taped/Patched Samples

RATING= 0

Sample's surface was too uneven to measure

Plate 12243 (FGB impact plate)

Plate/Patched Samples

RATING= 0
RATING= 0

Can't measure through the plate.



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Plate 123 (Bond Plate)

Image of Samples

c-scan image from water tank

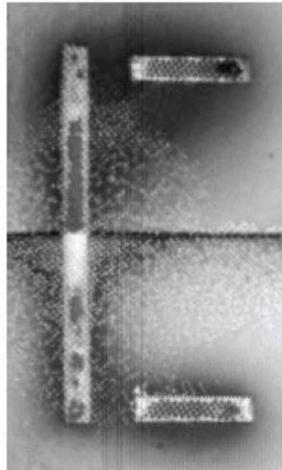


Plate 123 (Bond Plate)

Clean/Un-Patched Samples

Sample is too thick for probe to measure

RATING=

0



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Plate 158 (Bond Plate)

Image of Samples

c-scan image from water tank

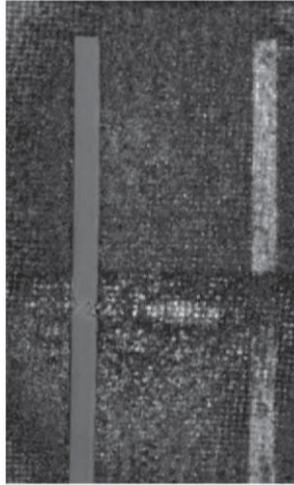


Plate 158 (Bond Plate)

Clean/Un-Patched Samples

Sample is too thick for probe to measure

RATING=

0



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Plate 028B (Bond Plate)

Image of Samples

c-scan image from water tank

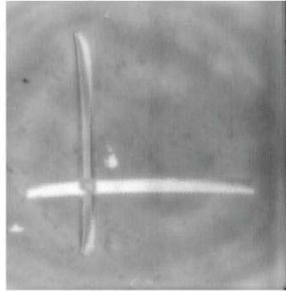


Plate 028B (Bond Plate)

Clean/Un-Patched Samples

Sample is too thick for probe to measure

RATING=

0



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Plate 132A (Bond Plate)

Image of Samples

Plate 132A (Bond Plate)

Clean/Un-Patched Samples

Sample is too thick for probe to measure

RATING=

0



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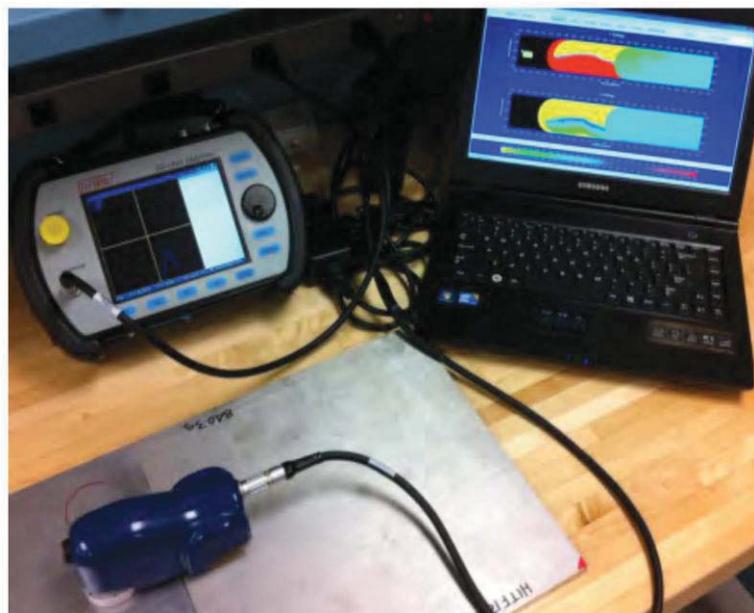
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Appendix H. UniWest[®] 454A/ECS3 Results

UniWest ECS3



Scans below used the UniWest 454A ECS3 scanner.

Ratings:

0	Failure to identify important features
1	Features slightly detectable but not clearly defined
2	Undoubtable feature detection

Average RATING amongst all scans:	0.07
Average RATING amongst NDE Standard Scans:	0.20
Average RATING amongst impacted plate scans:	0.00
Average RATING amongst bond plate scans:	0.00

NDE Standard 1A:	0.00	
NDE Standard 1B:	0.67	
NDE Standard 2:	0.00	
NDE Standard 3:	0.00	
NDE Standard 4:	0.67	Eng. Est.
NDE Standard 5:	0.67	Eng. Est.
NDE Standard 6A:	0.00	
NDE Standard 6B:	0.00	
NDE Standard 7A:	0.00	
NDE Standard 7B:	0.00	

Impacted Plate 186:	0.00
Impacted Plate 1900:	0.00
Impacted Plate 1907:	0.00
Impacted Plate T3:	0.00
Impacted Plate 243:	0.00
Bond Plate 123:	0.00
Bond Plate 158:	0.00
Bond Plate 028B:	0.00
Bond Plate 132A:	0.00



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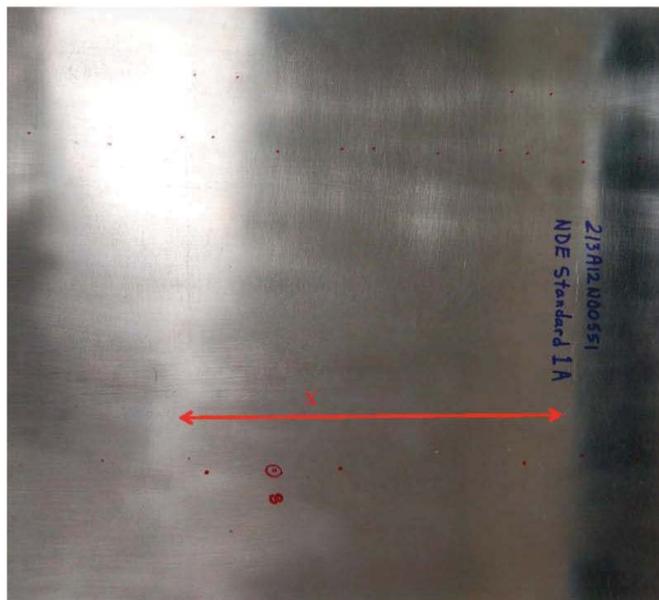
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NDE Standard 1A Notches

Image of Sample



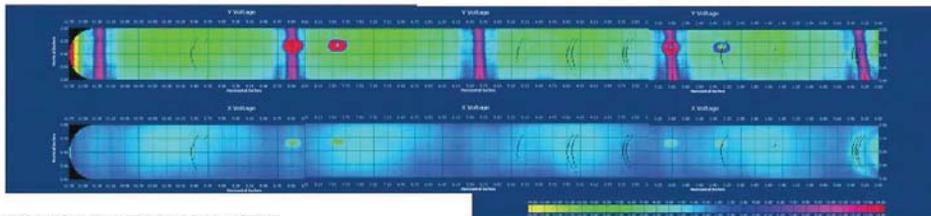
NDE Standard 1A Notches

Clean/Un-Patched Samples

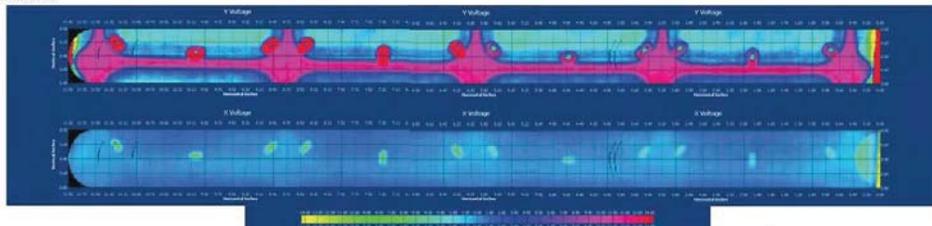
NASA std1A clean EDM notches2.csf.EMF
 NASA std1A clean EDM notches2-2.csf.EMF
 NASA std1A clean EDM notches2-3.csf.EMF

RATING= 0

No images from the IVA side: Grid impedes scanning of the standard
 EVA side No images from the IVA side: Grid impedes scanning of the plate
 From EVA side, 0.100 length x 0.010 deep EDM notches detected



NASA std1A clean EDM notches1.csf.EMF
 NASA std1A clean EDM notches1-2.csf.EMF
 NASA std1A EDM clean notches1-3.csf.EMF
 EVA side





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NDE Standard 1A Notches

Taped/Patched Samples

No images from the IVA side: Grid impedes scanning of the standard

RATING= 0

NDE Standard 1A Notches

Plate/Patched Samples

No images from the IVA side: Grid impedes scanning of the standard
Plate wouldn't work on this side.

RATING= 0
RATING= 0



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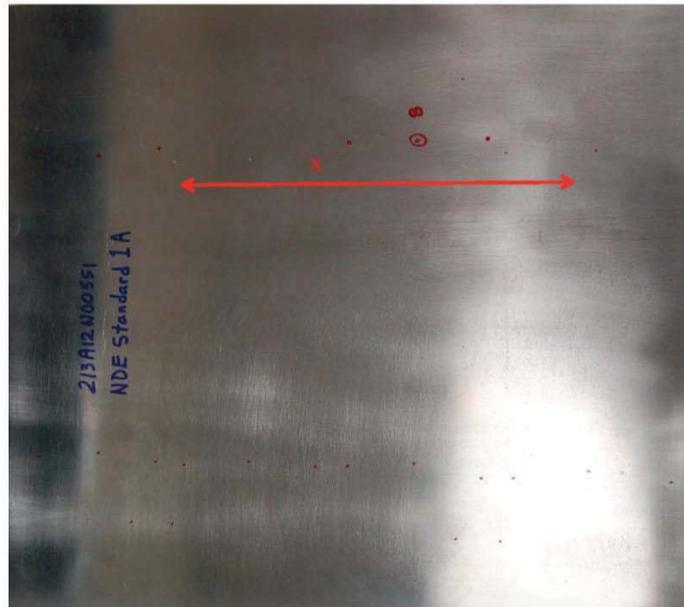
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NDE Standard 1A Holes

Image of Sample



NDE Standard 1A Holes

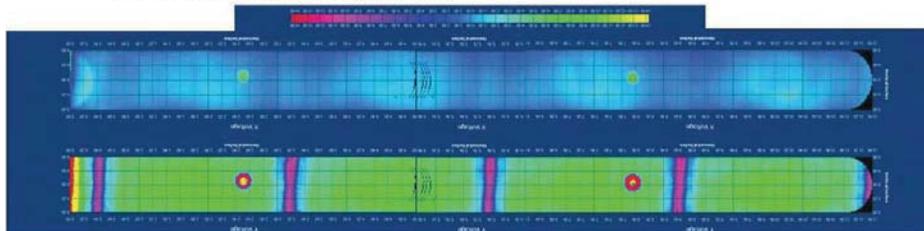
Clean/Un-Patched Samples

NASA std1A clean partial holes2.csf.EMF
 NASA std1A clean partial holes2-2.csf.EMF
 NASA std1A clean partial holes2-3.csf.EMF

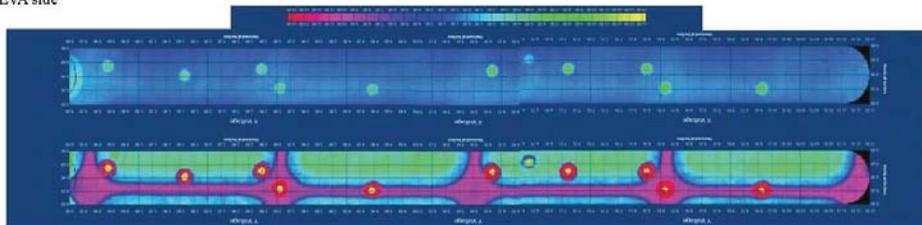
RATING=

0

EVA side No images from the IVA side: Grid impedes scanning of the standard
 From EVA side, 3/64" dia. x 0.010 deep holes detected



NASA std1A clean partial holes1.csf.EMF
 NASA std1A clean partial holes1-2.csf.EMF
 NASA std1A clean partial holes1-3.csf.EMF
 EVA side





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NDE Standard 1A Holes

Taped/Patched Samples

No images from the IVA side: Grid impedes scanning of the standard

RATING= 0

NDE Standard 1A Holes

Plate/Patched Samples

No images from the IVA side: Grid impedes scanning of the standard
Plate wouldn't work on this side

RATING= 0
RATING= 0



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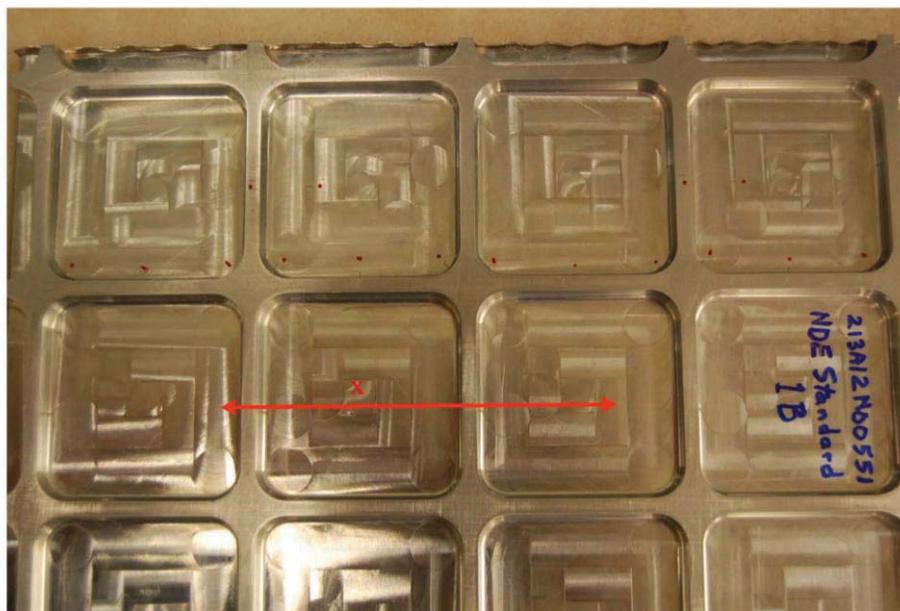
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NDE Standard 1B Notches

Image of Sample



NDE Standard 1B Notches

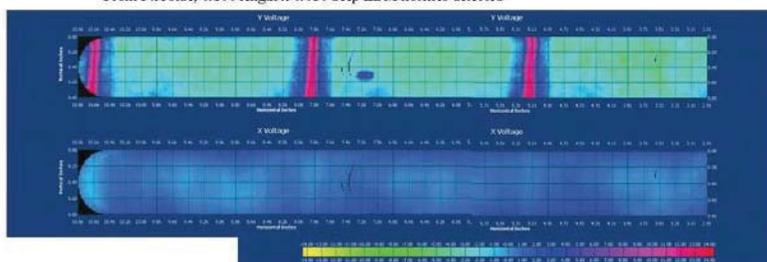
Clean/Un-Patched Samples

NASA std 1B clean EDM notches 2.csf.EMF
 NASA std 1B clean EDM notches 2-2.csf.EMF
 NASA std 1B clean EDM notches 2-3.csf.EMF

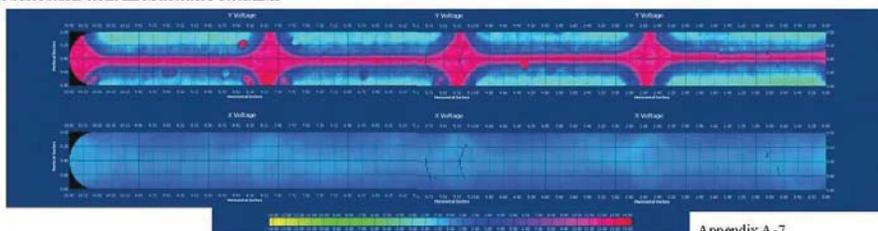
RATING=

2

IVA Side flaws are detectable through the wall
 From IVA side, 0.100 length x 0.010 deep EDM notches detected



NASA std 1B clean EDM notches 1.csf.EMF
 NASA std 1B clean EDM notches 1-2.csf.EMF
 NASA std 1B clean EDM notches 1-3.csf.EMF



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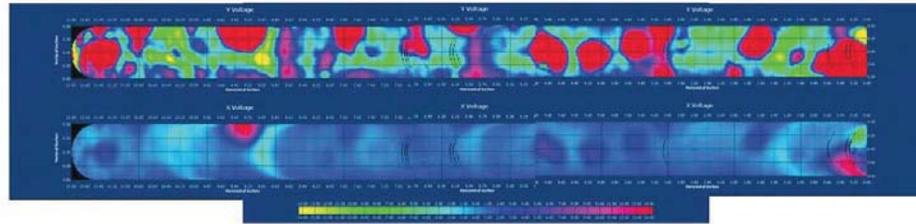
NDE Standard 1B Notches

NASA std1B tape EDM notches2.csf.EMF
NASA std1B tape EDM notches2-2.csf.EMF
NASA std1B tape EDM notches2-3.csf.EMF

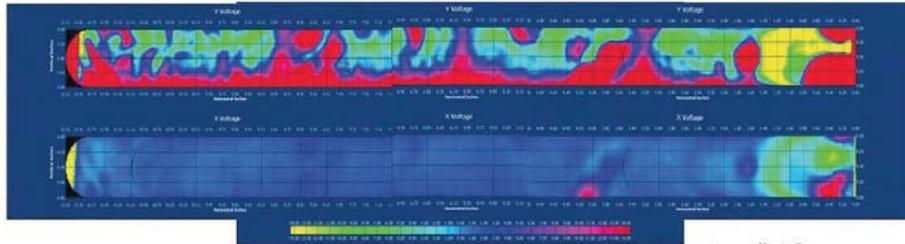
Taped/Patched Samples

RATING= 0

flaws are not detectable through the tape and wall



NASA std1B tape EDM notches1.csf.EMF
NASA std1B tape EDM notches1-2.csf.EMF
NASA std1B tape EDM notches1-3.csf.EMF



NDE Standard 1B Notches

Plate/Patched Samples

Note: no images were saved. System is unable to work through the plate
Plate wouldn't work on this side

RATING= 0
RATING= 0.66666667



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NDE Standard 1B Holes

Image of Sample



NDE Standard 1B Holes

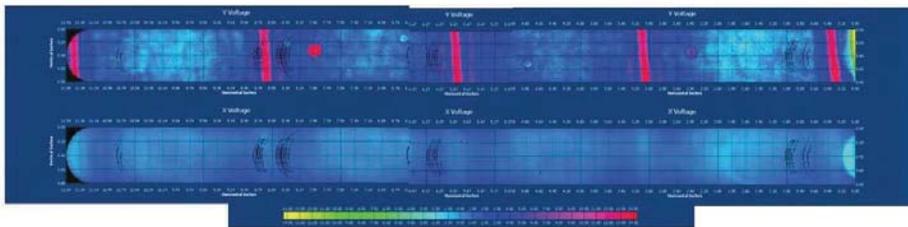
Clean/Un-Patched Samples

NASA std1B clean partial holes2.csf.EMF
 NASA std1B clean partial holes2-2.csf.EMF
 NASA std1B clean partial holes2-3.csf.EMF

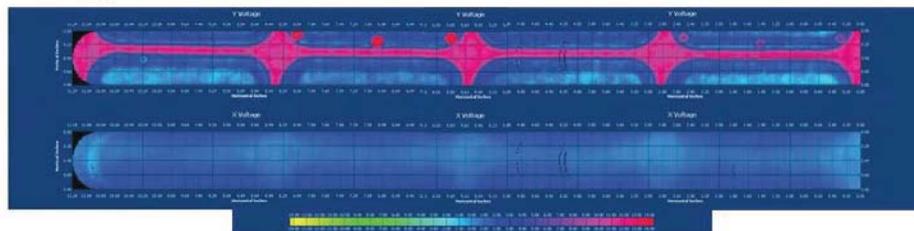
RATING=

2

From IVA side, 3/64" dia. x 0.010 deep holes detected



NASA std1B clean partial holes1.csf.EMF
 NASA std1B clean partial holes1-2.csf.EMF
 NASA std1B clean partial holes1-3.csf.EMF





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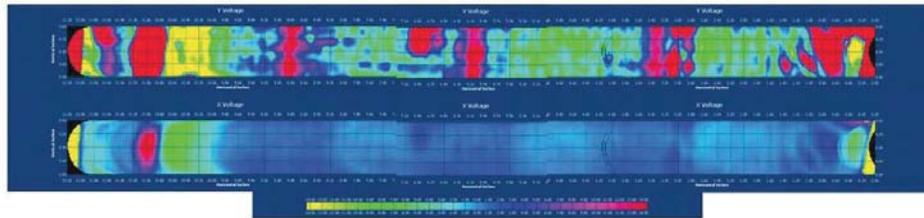
NDE Standard 1B Holes

NASA std1B tape partial holes2.csf.EMF
NASA std1B tape partial holes2-2.csf.EMF
NASA std1B tape partial holes2-3.csf.EMF

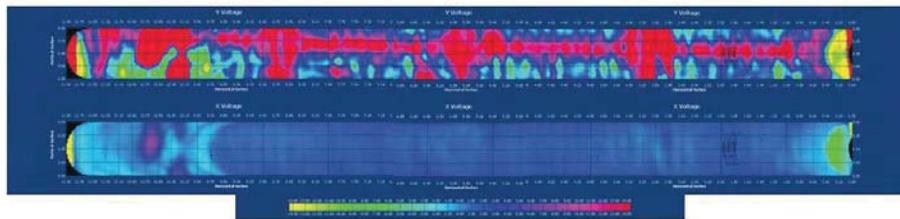
Taped/Patched Samples

RATING= 0

flaws are not detectable through the tape and wall



NASA std1B tape partial holes1.csf.EMF
NASA std1B tape partial holes1-2.csf.EMF
NASA std1B tape partial holes1-3.csf.EMF



NDE Standard 1B Holes

Plate/Patched Samples

Note: no images were saved. System is unable to work through the plate
Plate wouldn't work on this side

RATING= 0
RATING= 0.66666667



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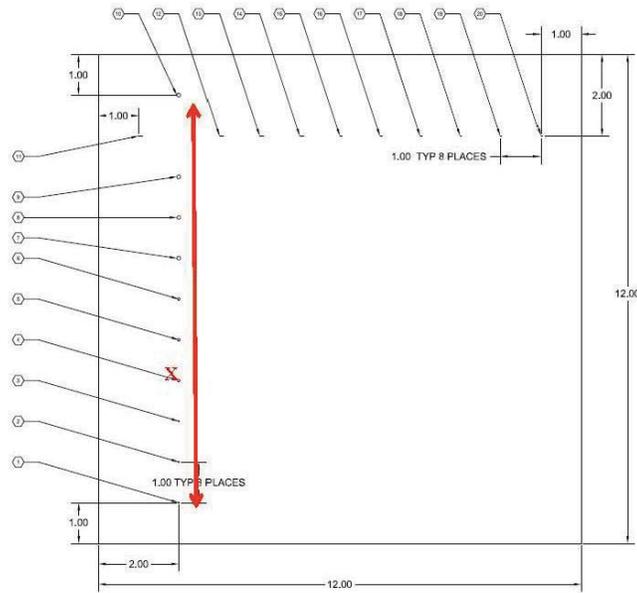
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NDE Standard 2 holes

Image of Sample



NDE Standard 2 holes

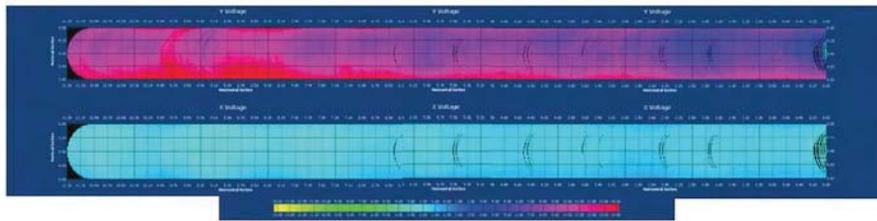
Clean/Un-Patched Samples

NASA std2 clean partial holes back.csf.EMF
 NASA std2 clean partial holes back-2.csf.EMF
 NASA std2 clean partial holes back-3.csf.EMF

RATING=

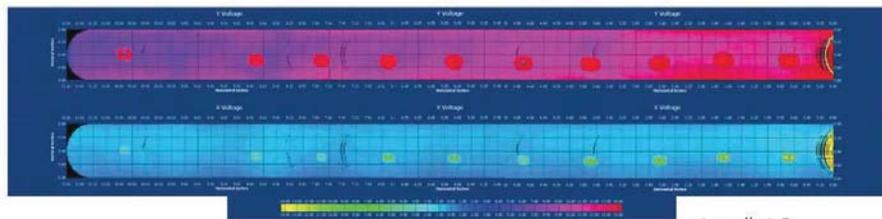
0

IVA side From IVA side, flaws are not detectable through the wall (too thick)



NASA std2 clean partial holes front.csf.EMF
 NASA std2 clean partial holes front-2.csf.EMF
 NASA std2 clean partial holes front-3.csf.EMF

EVA side





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NDE Standard 2 holes

Taped/Patched Samples

RATING 0

Based on std2 "clean" results not scanned

NDE Standard 2 holes

Plate/Patched Samples

RATING= 0 RATING= 0

Note: no images were saved. System is unable to work through the plate
Plate wouldn't work on this side



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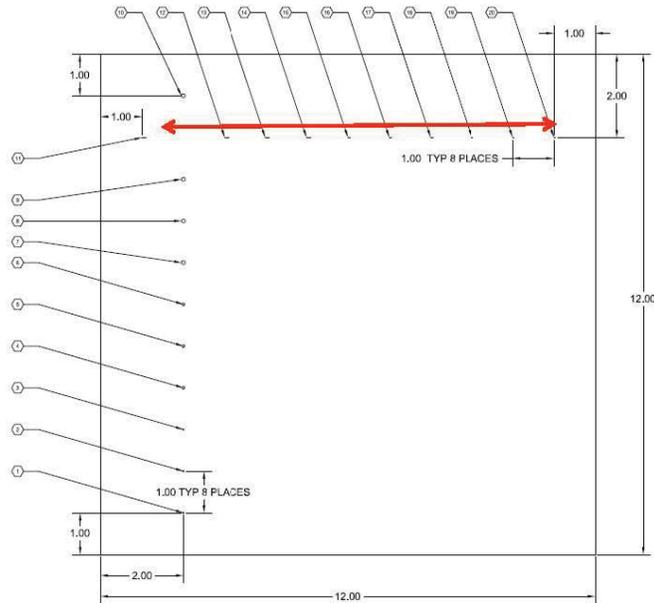
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NDE Standard 2 notches

Image of Sample



NDE Standard 2 notches

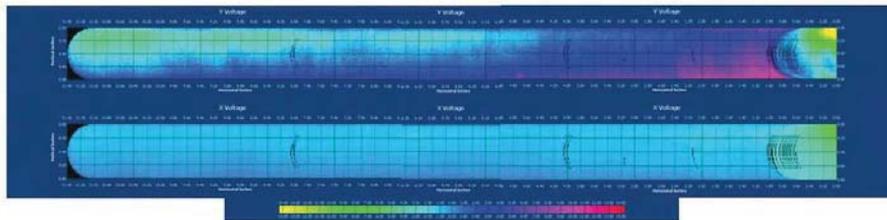
Clean/Un-Patched Samples

NASA std2 clean EDM notches back.csf.EMF
 NASA std2 clean EDM notches back-2.csf.EMF
 NASA std2 clean EDM notches back-3.csf.EMF

RATING=

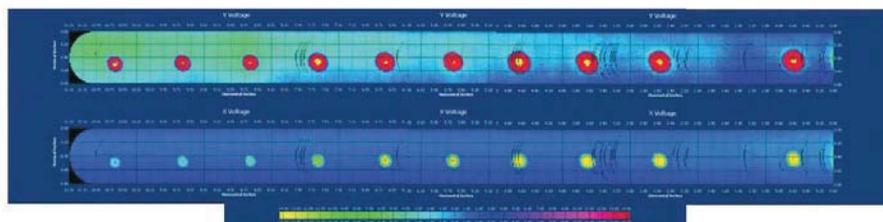
0

IVA side Scan from IVA side, flaws are not detectable through the wall (too thick)



NASA std2 clean EDM notches front.csf.EMF
 NASA std2 clean EDM notches front-2.csf.EMF
 NASA std2 clean EDM notches front-3.csf.EMF

EVA side





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NDE Standard 2 notches

Taped/Patched Samples

RATING= 0

Based on std2 "clean" results not scanned

NDE Standard 2 notches

Plate/Patched Samples

RATING= 0
RATING= 0

Based on std2 "clean" results not scanned



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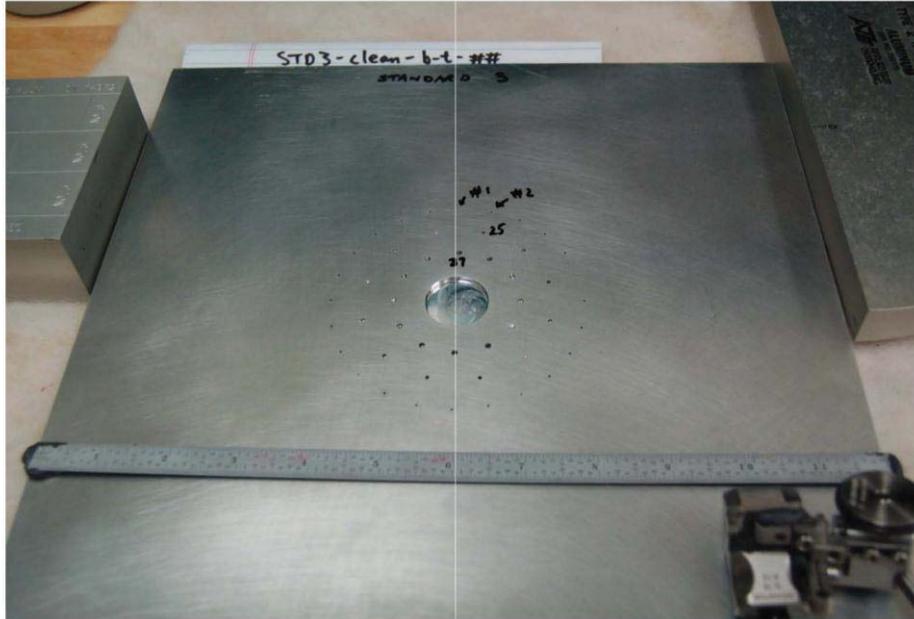
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NDE Standard 3

Image of Sample



NDE Standard 3

Clean/Un-Patched Samples

Based on Std. 2 results std3 was not scanned.

RATING=

0



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NDE Standard 3

Taped/Patched Samples

Based on Std. 2 results std3 was not scanned

RATING= 0

NDE Standard 3

Plate/Patched Samples

Based on Std. 2 results std3 was not scanned

RATING= 0
RATING= 0

Plates not scanned, however, engineering estimates can be made by comparison to similar plates and the VEO UT phased array system.



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Plate 551 NDE Standard 4 holes

Image of Sample

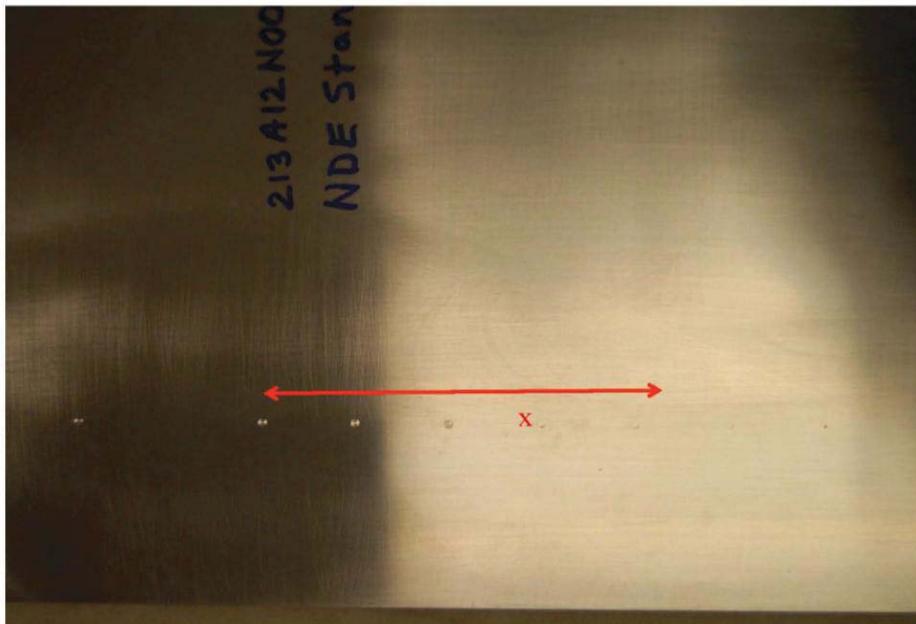


Plate 551 NDE Standard 4 holes

Clean/Un-Patched Samples

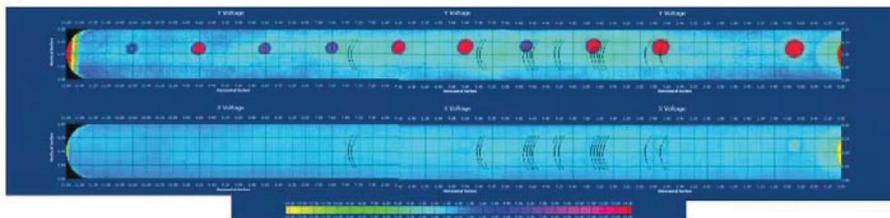
NASA std4 clean partial holes hidden.csf.EMF
NASA std4 clean partial holes hidden-2.csf.EMF
NASA std4 clean partial holes hidden-3.csf.EMF

RATING=

2

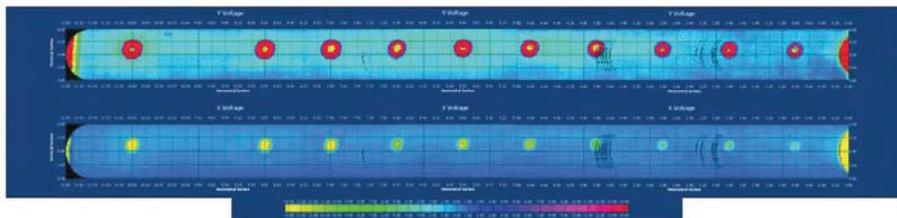
flaws are detectable through the wall

IVA side



NASA std4 clean partial holes front.csf.EMF
NASA std4 clean partial holes front-2.csf.EMF
NASA std4 clean partial holes front-3.csf.EMF

EVA side





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Plate 551 NDE Standard 4 holes

NASA std4 tape partial holes hidden.csf.EMF
NASA std4 tape partial holes hidden-2.csf.EMF
NASA std4 tape partial holes hidden-3.csf.EMF

Taped/Patched Samples

RATING= 0

No flaws were detected through the tape

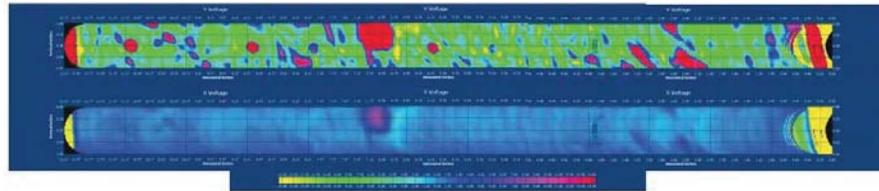


Plate 551 NDE Standard 4 holes

Didn't work through plate

Plate/Patched Samples

RATING= 0
RATING= 0.666666667



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Plate 551 NDE Standard 4 notches

Image of Sample

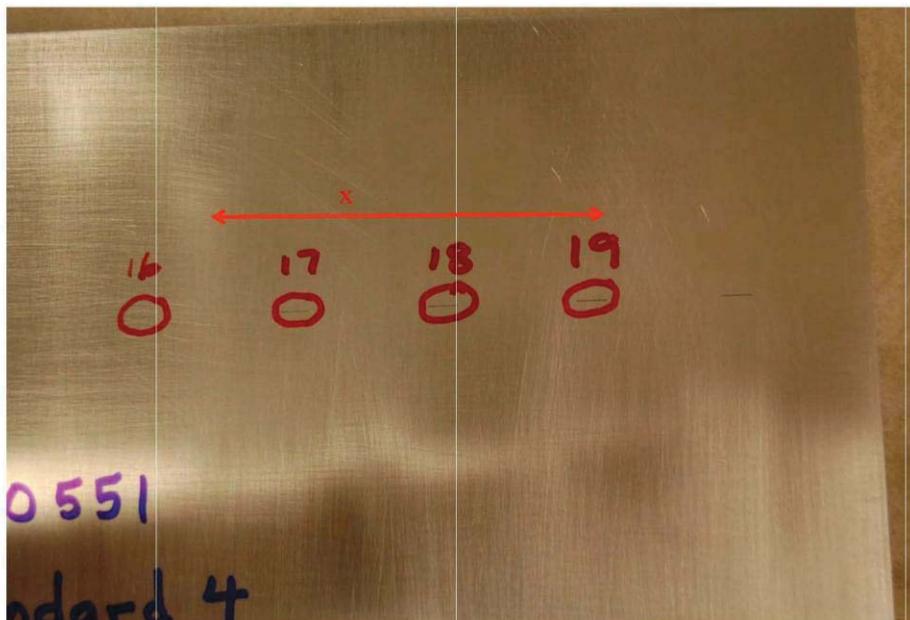


Plate 551 NDE Standard 4 notches

Clean/Un-Patched Samples

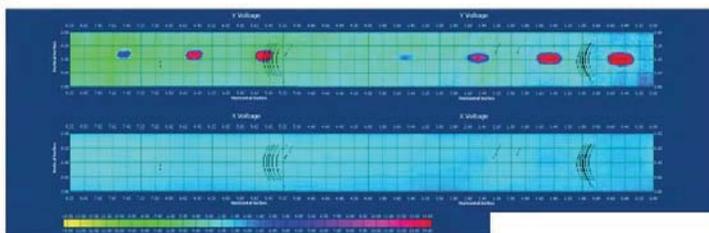
NASA std4 clean EDM notches hidden-2.csf.EMF
NASA std4 clean EDM notches hidden-3.csf.EMF

RATING=

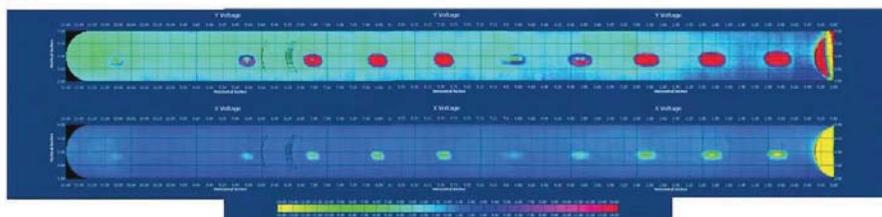
2

flaws are detectable through the wall

IVA side



NASA std4 clean EDM notches front.csf.EMF
NASA std4 clean EDM notches front-2.csf.EMF
NASA std4 clean EDM notches front-3.csf.EMF
EVA side





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Plate 551 NDE Standard 4 notches

NASA std4 tape EDM notches hidden.csf.EMF
NASA std4 tape EDM notches hidden-2.csf.EMF
NASA std4 tape EDM notches hidden-3.csf.EMF

Taped/Patched Samples

RATING=

0

No flaws were detected through the tape

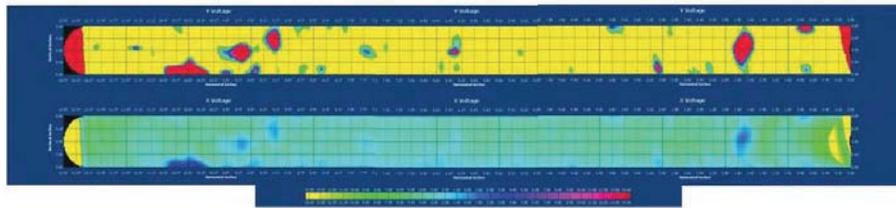


Plate 551 NDE Standard 4 notches

Didn't work through plate

Plate/Patched Samples

RATING=

RATING=

0.666666667



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NDE Standard 5

Image of Sample



NDE Standard 5

Clean/Un-Patched Samples

Engineering estimates based on panel 4 are that the flaws will be detectable through the wall

RATING=

2



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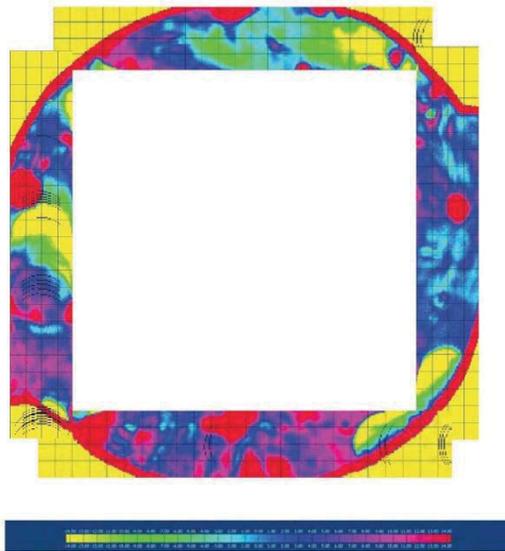
NDE Standard 5

NASA std5 tape partial holes hidden bottom r-l.csf
 NASA std5 tape partial holes hidden left b-t.csf.EMF
 NASA std5 tape partial holes hidden right b-t.csf.EMF
 NASA std5 tape partial holes hidden top r-l.csf.EMF

Taped/Patched Samples

RATING= 0

No flaws were detected through the tape



NDE Standard 5

Didn't work through plate

Plate/Patched Samples

RATING= 0
 RATING= 0.66666667



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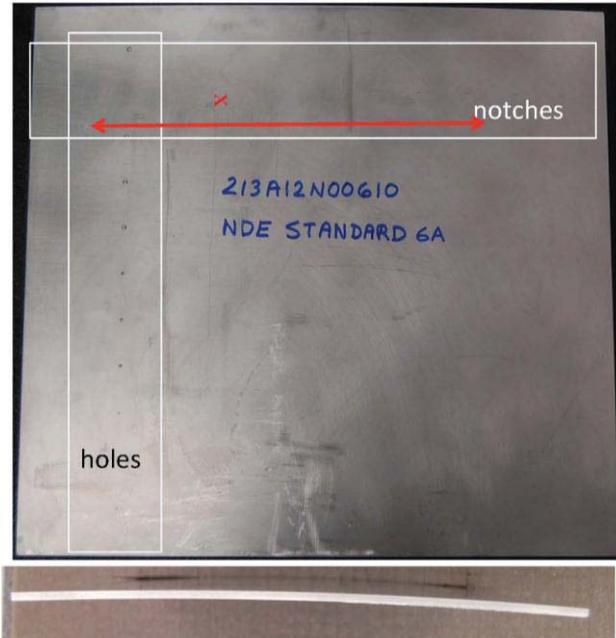
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NDE Standard 6A

Image of Sample



NDE Standard 6A

Clean/Un-Patched Samples

RATING=

0

Based on Std. 6B results Std. 6A was not scanned



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NDE Standard 6A

Taped/Patched Samples

RATING= 0

Based on Std. 6B results Std. 6A was not scanned

NDE Standard 6A

Plate/Patched Samples

RATING= 0
RATING= 0

Didn't work through plate



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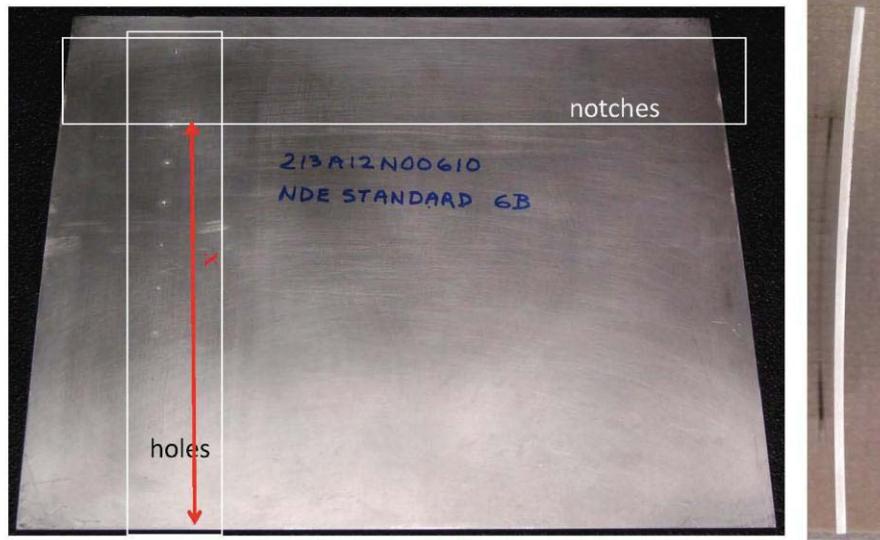
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NDE Standard 6B

Image of Sample



NDE Standard 6B

Clean/Un-Patched Samples

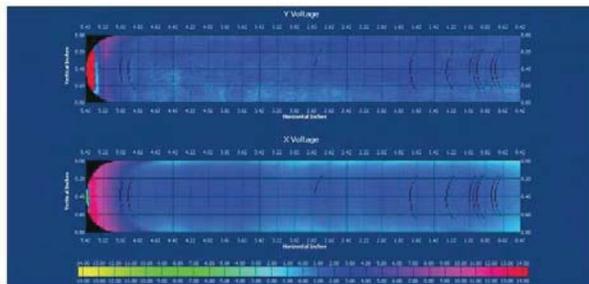
NASA std6B clean partial holes hidden.csf:EMF

RATING=

0

No flaws were detected through the wall. (too thick)

IVA side





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NDE Standard 6B

Taped/Patched Samples

RATING= 0

Not scanned based on std6B "clean" results

NDE Standard 6B

Plate/Patched Samples

RATING= 0
RATING= 0

Didn't work through plate



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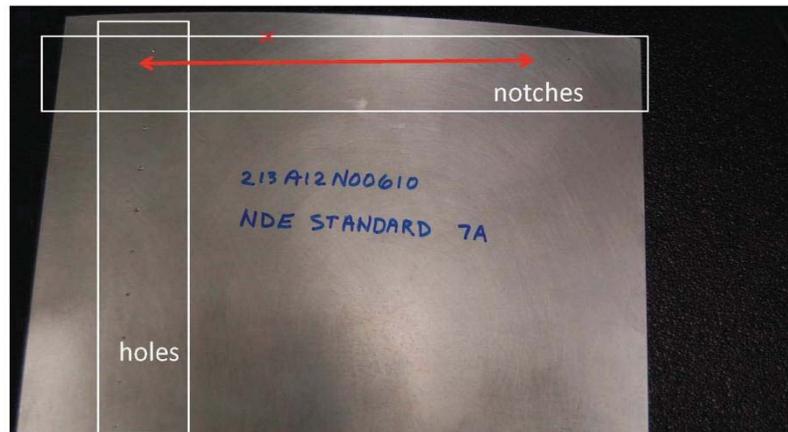
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NDE Standard 7A notches

Image of Sample



NDE Standard 7A notches

Clean/Un-Patched Samples

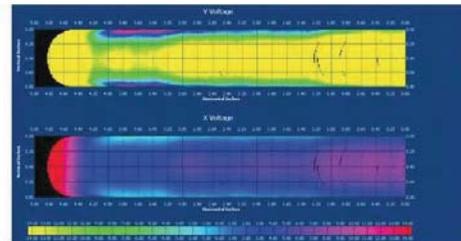
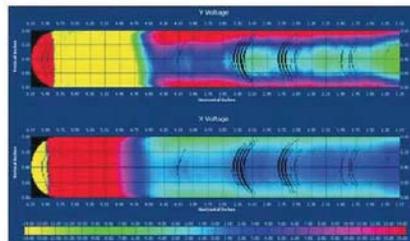
NASA std7 clean EDM notches hidden.csf:EMF

NASA std7 clean EDM notches hidden2.csf:EMF

RATING=

0

No flaws were detected through the wall. (too thick)





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NDE Standard 7A notches

Taped/Patched Samples

Not scanned based on std7A clean results

RATING= 0

NDE Standard 7A notches

Plate/Patched Samples

Didn't work through plate

RATING= 0
RATING= 0



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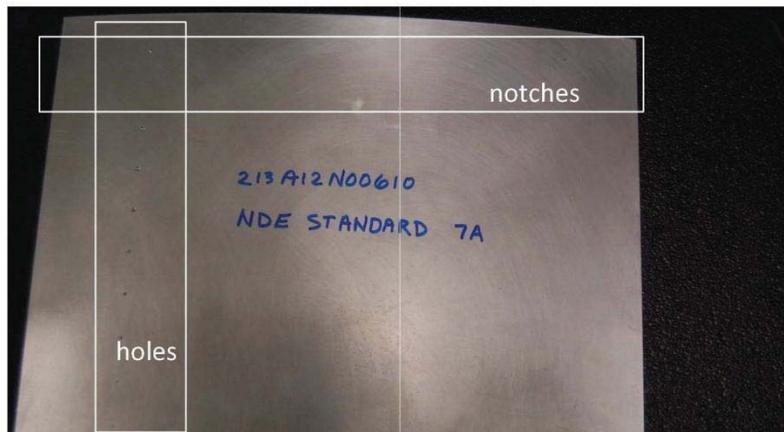
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NDE Standard 7A holes

Image of Sample



NDE Standard 7A holes

Clean/Un-Patched Samples

Based on Std. 7A notches results Std. 7A holes were not scanned

RATING=

0



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NDE Standard 7A holes

Taped/Patched Samples

Based on Std. 7A notches results Std. 7A holes were not scanned

RATING= 0

NDE Standard 7A holes

Plate/Patched Samples

Didn't work through plate

RATING= 0
RATING= 0



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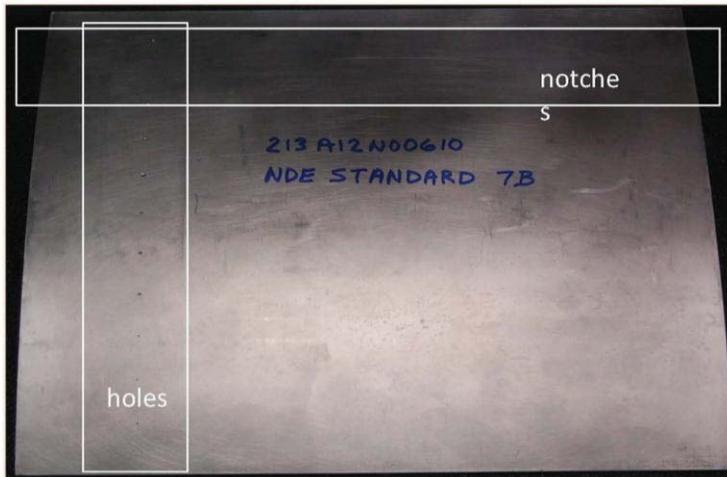
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NDE Standard 7B notches

Image of Sample



NDE Standard 7B notches

Clean/Un-Patched Samples

Based on Std. 7A notches results Std. 7B notches were not scanned

RATING=

0



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NDE Standard 7B notches

Taped/Patched Samples

Based on Std. 7A notches results Std. 7B notches were not scanned

RATING= 0

NDE Standard 7B notches

Plate/Patched Samples

Plate wouldn't work on this side

RATING= 0
RATING= 0



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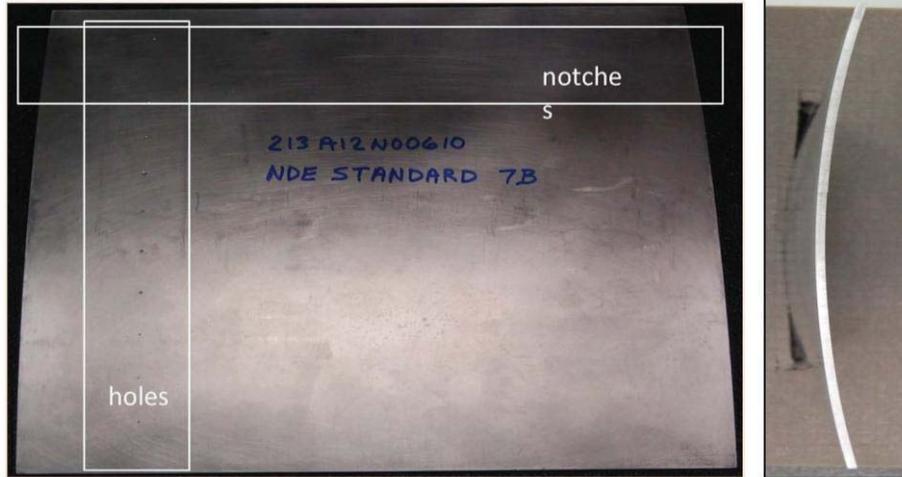
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NDE Standard 7B

Image of Sample



NDE Standard 7B

Clean/Un-Patched Samples

Based on Std. 7A notches results Std. 7B holes were not scanned

RATING=

0



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NDE Standard 7B

Taped/Patched Samples

Based on Std. 7A notches results Std. 7B holes were not scanned

RATING= 0

NDE Standard 7B

Plate/Patched Samples

Plate wouldn't work on this side

RATING= 0
RATING= 0



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Plate 186

Image of Sample



Plate 186

Clean/Un-Patched Samples

Based on Std. 7A results plate 186 was not scanned

RATING=

0



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Plate 186

Taped/Patched Samples

Based on Std. 7A results plate 186 was not scanned

RATING= 0

Plate 186

Plate/Patched Samples

Didn't work through plate

RATING= 0
RATING= 0



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Plate 1900

Image of Sample



Plate 1900

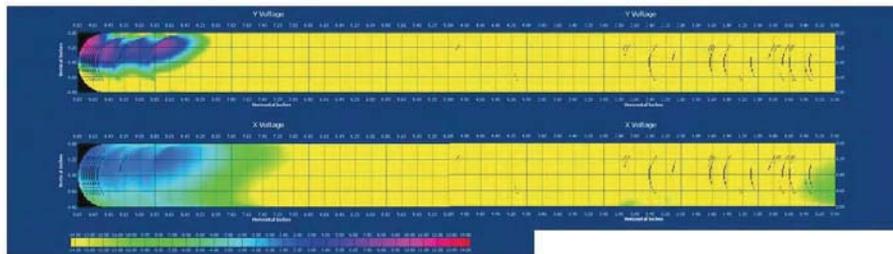
NASA STD1900 clean impact1.csf.EMF
NASA STD1900 clean impact1-2.csf.EMF

Clean/Un-Patched Samples

No flaws detected (too thick)

RATING=

0





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Plate 1900

Taped/Patched Samples

Not scanned based on Plate 1900 "clean" results

RATING=

0

Plate 1900

Plate/Patched Samples

Didn't work through plate

RATING=

0

RATING=

0



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Plate 1907

Image of Sample

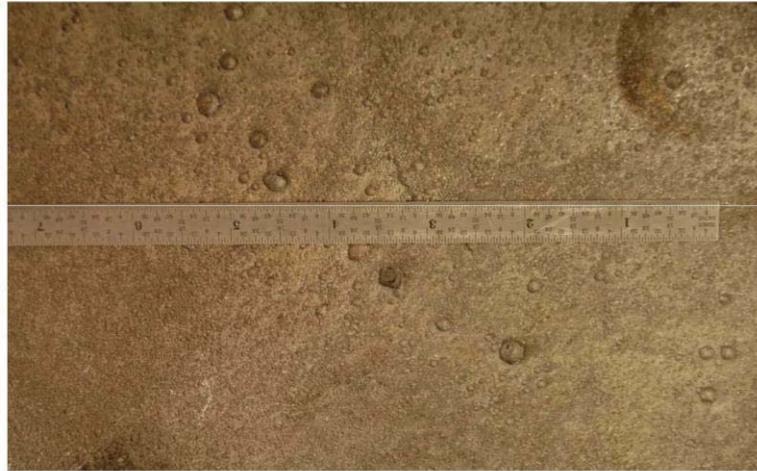


Plate 1907

Clean/Un-Patched Samples

Not scanned based on Std. 7A results

RATING=

0



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Plate 1907

Taped/Patched Samples

Not scanned based on Std. 7A results

RATING=

0

Plate 1907

Plate/Patched Samples

Didn't work through plate

RATING=

0

RATING=

0



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Plate T3

Image of Sample



Plate T3

Clean/Un-Patched Samples

Not scanned based on Std. 7A results

RATING= 0



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Plate T3

Taped/Patched Samples

Not scanned based on Std. 7A results

RATING=

0

Plate T3

Plate/Patched Samples

Plate wouldn't work on this side

RATING=

0

RATING=

0



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Plate 12243 (FGB impact plate)

Image of Sample

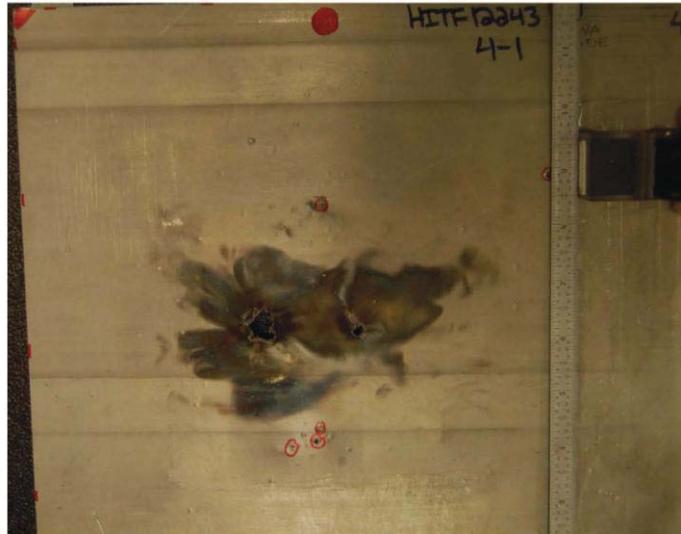


Plate 12243 (FGB impact plate)

Clean/Un-Patched Samples

Surface too uneven to scan
Rib structure was visible

RATING= 0



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Plate 12243 (FGB impact plate)

Taped/Patched Samples

Not scanned based on clean surface results.
Rib structure was partially visible

RATING= 0

Plate 12243 (FGB impact plate)

Plate/Patched Samples

Plate wouldn't work on this side

RATING= 0
RATING= 0



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Plate 123 (Bond Plate)

Image of Sample

c-scan image from water tank

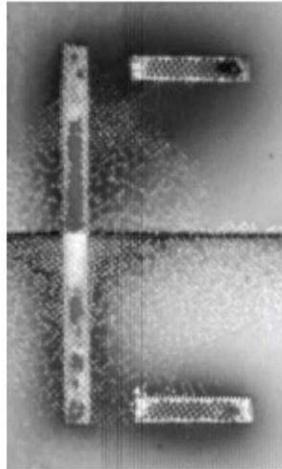


Plate 123 (Bond Plate)

Clean/Un-Patched Samples

Samples too thick to detect any flaws

RATING=

0



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Plate 158 (Bond Plate)

Image of Sample

c-scan image from water tank

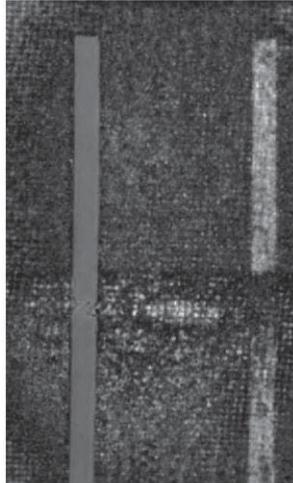


Plate 158 (Bond Plate)

Clean/Un-Patched Samples

Samples too thick to detect any flaws

RATING=

0



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Plate 028B (Bond Plate)

Image of Sample

c-scan image from water tank

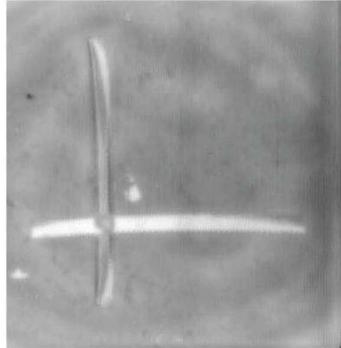


Plate 028B (Bond Plate)

Clean/Un-Patched Samples

Samples too thick to detect any flaws

RATING=

0



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Plate 132A (Bond Plate)

Image of Sample

Plate 132A (Bond Plate)

Clean/Un-Patched Samples

Samples too thick to detect any flaws

RATING=

0



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Appendix I. Jentek® GridStation® Results

Jentek GridStation



Scans below used the Jentek Grid Station scanner.

Ratings:

0	Failure to identify important features
1	Features slightly detectable but not clearly defined
2	Undoubtable feature detection

Average RATING amongst all scans:	0.07
Average RATING amongst NDE Standard Scans:	0.20
Average RATING amongst impacted plate scans:	0.00
Average RATING amongst bond plate scans:	0.00

NDE Standard 1A:	0.00	Eng. Est.
NDE Standard 1B:	0.17	
NDE Standard 2:	0.00	Eng. Est.
NDE Standard 3:	0.00	Eng. Est.
NDE Standard 4:	0.83	
NDE Standard 5:	1.00	
NDE Standard 6A:	0.00	Eng. Est.
NDE Standard 6B:	0.00	Eng. Est.
NDE Standard 7A:	0.00	Eng. Est.
NDE Standard 7B:	0.00	Eng. Est.

Impacted Plate 186:	0.00	Eng. Est.
Impacted Plate 1900:	0.00	Eng. Est.
Impacted Plate 1907:	0.00	Eng. Est.
Impacted Plate T3:	0.00	Eng. Est.
Impacted Plate 243:	0.00	Eng. Est.
Bond Plate 123:	0.00	Eng. Est.
Bond Plate 158:	0.00	Eng. Est.
Bond Plate 028B:	0.00	Eng. Est.
Bond Plate 132A:	0.00	Eng. Est.



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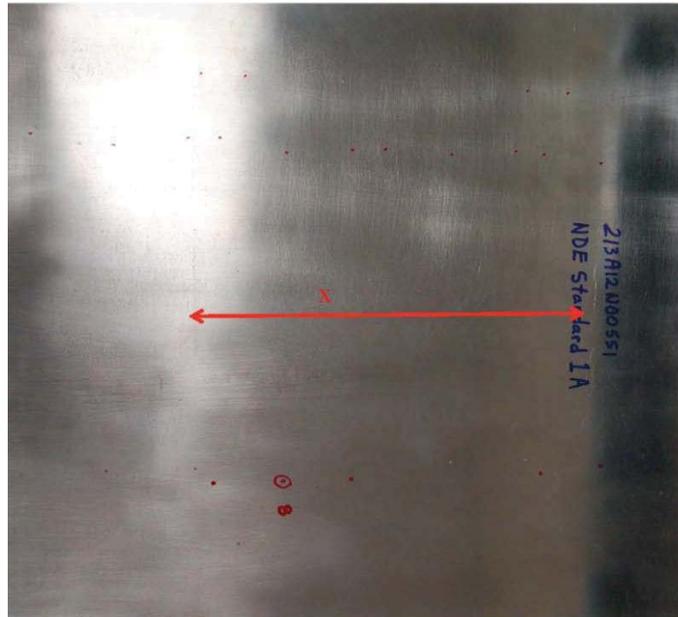
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NDE Standard IA Notches

Image of Samples



NDE Standard IA Notches

Clean/Un-Patched Samples

No images from the IVA side: Grid impedes scanning of the standard

RATING=

0



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NDE Standard 1A Notches

Taped/Patched Samples

No images from the IVA side: Grid impedes scanning of the standard

RATING= 0

NDE Standard 1A Notches

Plate/Patched Samples

Scanner can't work through plate repair.

RATING= 0
RATING= 0



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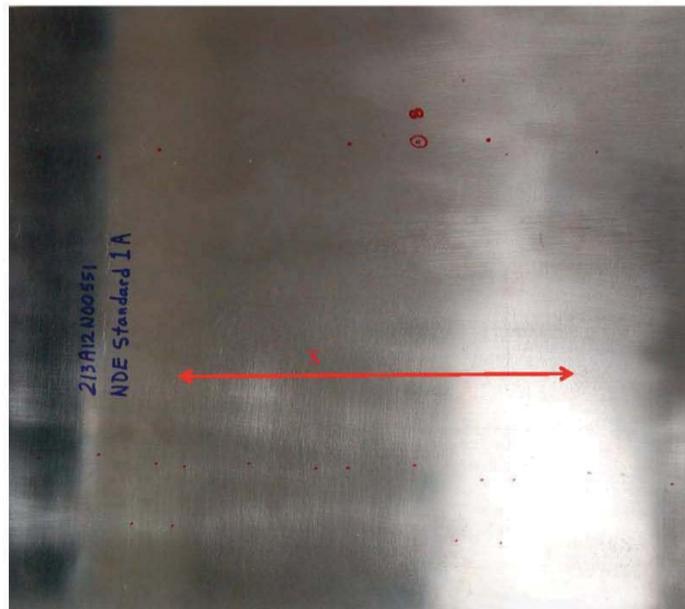
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NDE Standard 1A Holes

Image of Samples



NDE Standard 1A Holes

Clean/Un-Patched Samples

No images from the IVA side: Grid impedes scanning of the standard

RATING=

0



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NDE Standard 1A Holes

Taped/Patched Samples

RATING= 0

No images from the IVA side: Grid impedes scanning of the standard

NDE Standard 1A Holes

Plate/Patched Samples

RATING= 0
RATING= 0

Scanner can't work through plate repair.



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NDE Standard 1B Notches

Image of Samples



NDE Standard 1B Notches

Clean/Un-Patched Samples

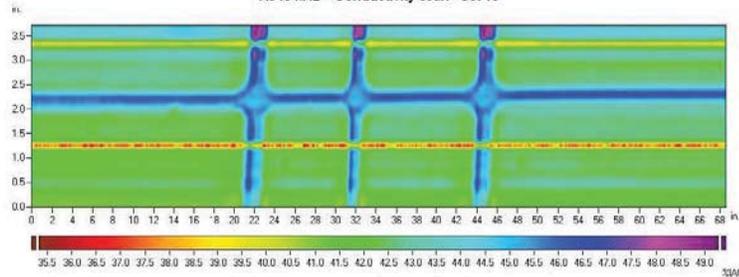
I/A Side

notch flaws were not detectable through the wall

RATING=

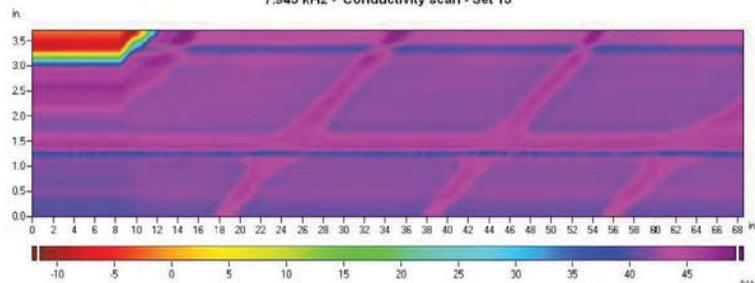
0

7.943 kHz - Conductivity scan - Set 10



0° Scan

7.943 kHz - Conductivity scan - Set 15



Angle Scan



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NDE Standard 1B Notches

Taped/Patched Samples

RATING= 0

Note: no images were saved. Syst System wasn't able to image through standard with tape.

NDE Standard 1B Notches

Plate/Patched Samples

RATING= 0
RATING= 0

Scanner can't work through repair plate.



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NDE Standard 1B Holes

Image of Samples



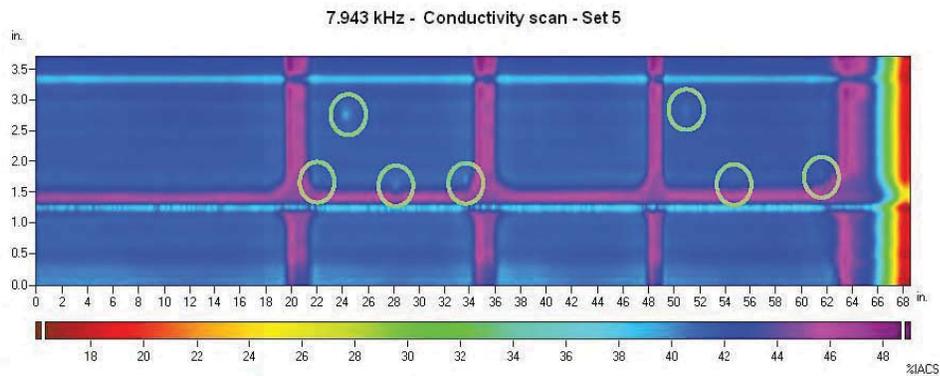
NDE Standard 1B Holes

Clean/Un-Patched Samples

RATING=

1

From IVA side, 3/64" dia. x 0.010 deep holes detected





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NDE Standard 1B Holes

Taped/Patched Samples

RATING= 0

Note: no images were saved. SystSystem wasn't able to image through standard with tape.

NDE Standard 1B Holes

Plate/Patched Samples

RATING= 0
RATING= 0.33333333

Scanner can't work through repair plate.



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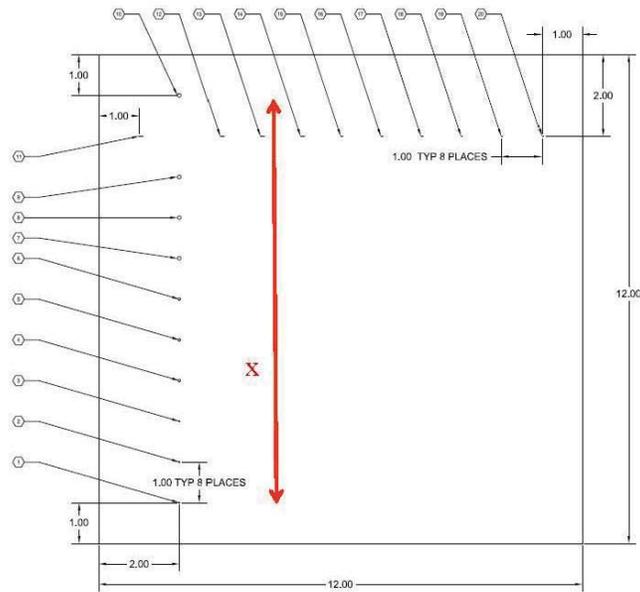
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NDE Standard 2 holes

Image of Samples



NDE Standard 2 holes

Clean/Un-Patched Samples

RATING=

0

Note: no images were saved. SystSystem wasn't able to image through standard.



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NDE Standard 2 holes

Taped/Patched Samples

RATING 0

Note: no images were saved. Syst System wasn't able to image through standard with tape.

NDE Standard 2 holes

Plate/Patched Samples

RATING= 0
RATING= 0

Scanner can't work through repair plate.



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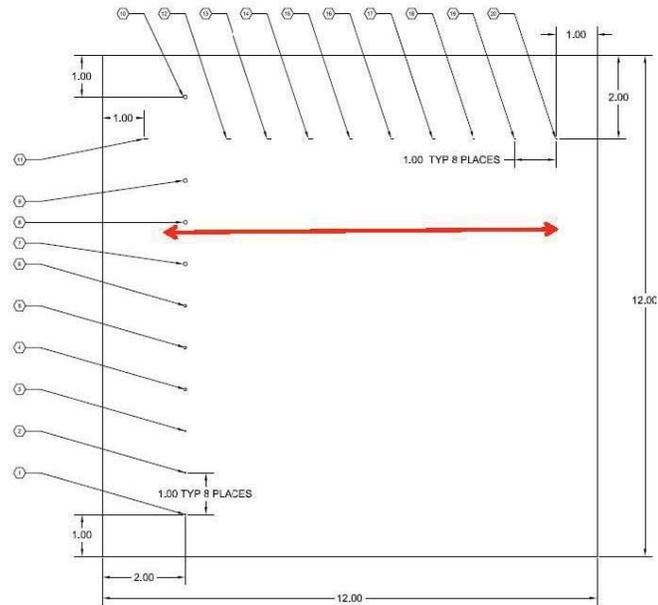
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NDE Standard 2 notches

Image of Samples



NDE Standard 2 notches

Clean/Un-Patched Samples

RATING=

0

Note: no images were saved. System is unable to image notches through the plate



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NDE Standard 2 notches

Taped/Patched Samples

RATING= 0

Note: no images were saved. System is unable to image notches through the plate

NDE Standard 2 notches

Plate/Patched Samples

RATING= 0
RATING= 0

Scanner can't work through repair plate.



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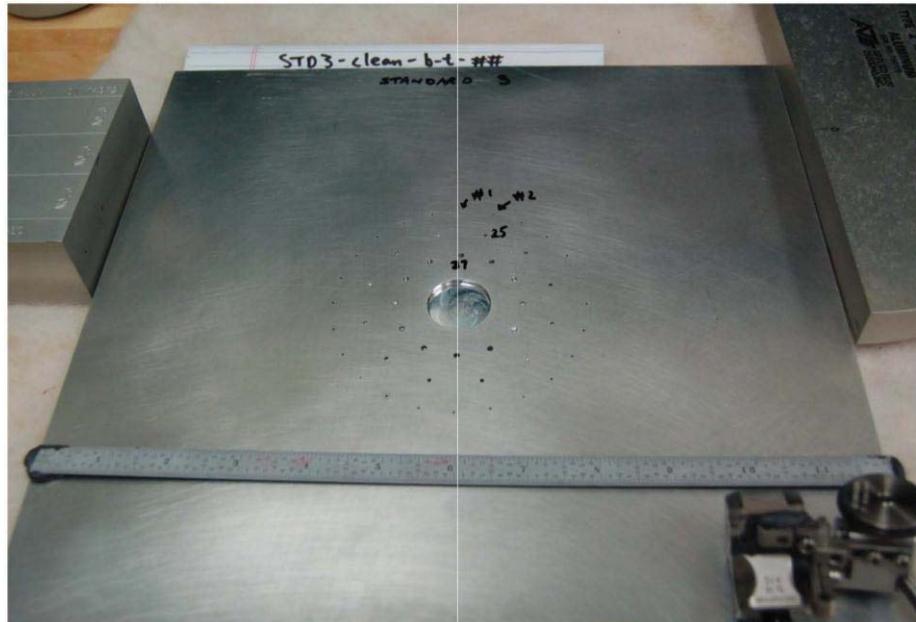
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NDE Standard 3

Image of Samples



NDE Standard 3

Clean/Un-Patched Samples

RATING=

0

Note: no images were saved. System is unable to image holes through the plate



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NDE Standard 3

Taped/Patched Samples

Note: no images were saved. System is unable to image holes through the plate.

RATING=

0

NDE Standard 3

Plate/Patched Samples

Scanner can't work through repair plate.

RATING=

0

RATING=

0



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Plate 551 NDE Standard 4 holes

Image of Samples

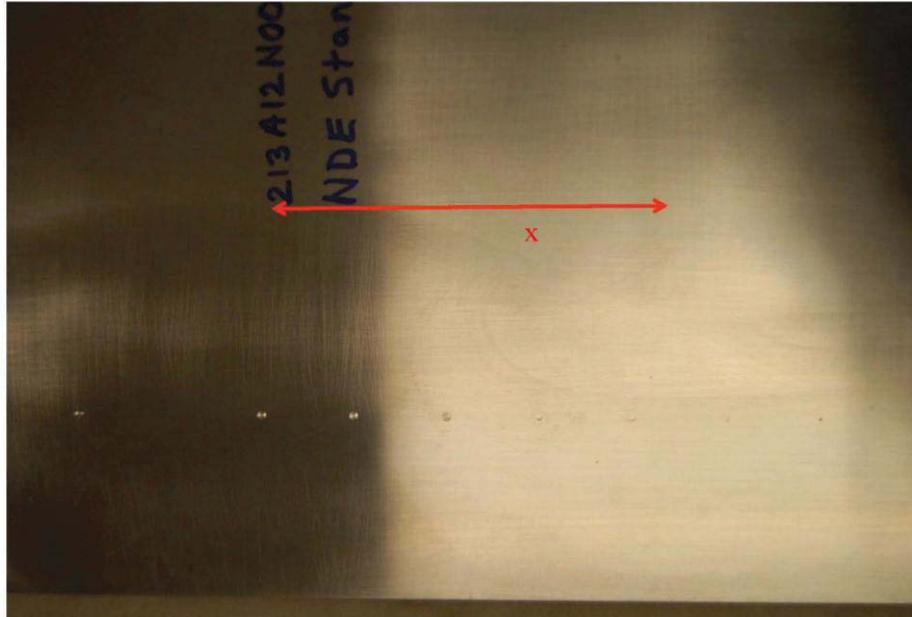


Plate 551 NDE Standard 4 holes

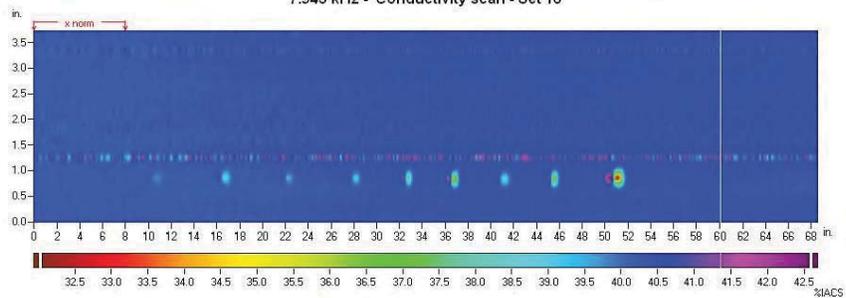
Clean/Un-Patched Samples

flaws are detectable through the wall

RATING=

2

7.943 kHz - Conductivity scan - Set 16





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Plate 551 NDE Standard 4 holes

Taped/Patched Samples

flaws are detectable through the wall and tape, but away from the center of the patch.

RATING=

1

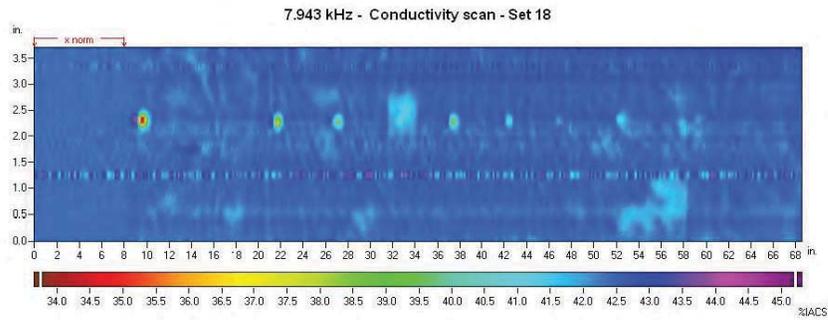


Plate 551 NDE Standard 4 holes

Plate/Patched Samples

Scanner can't work through repair plate.

RATING=

0

RATING=

1



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Plate 551 NDE Standard 4 notches

Image of Samples

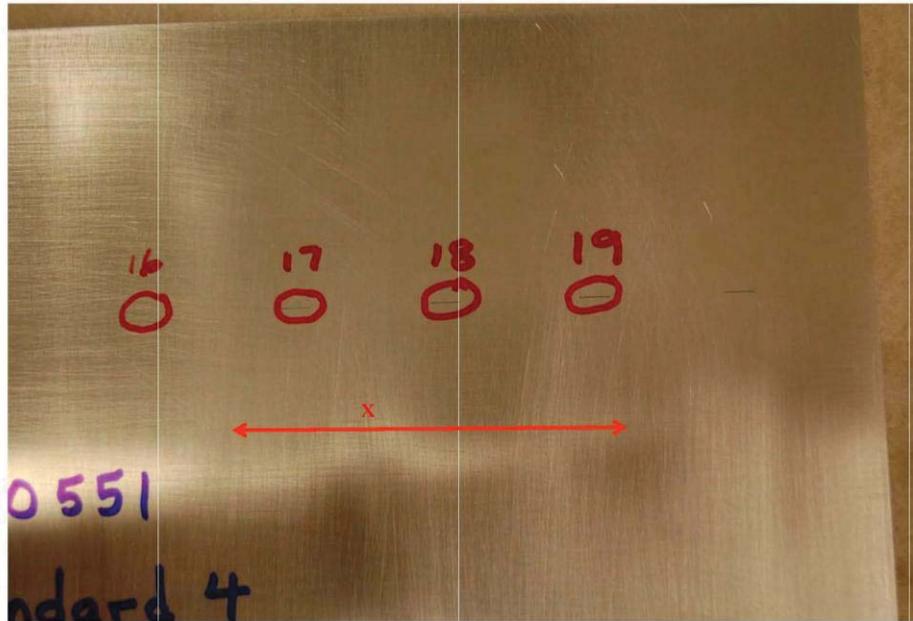


Plate 551 NDE Standard 4 notches

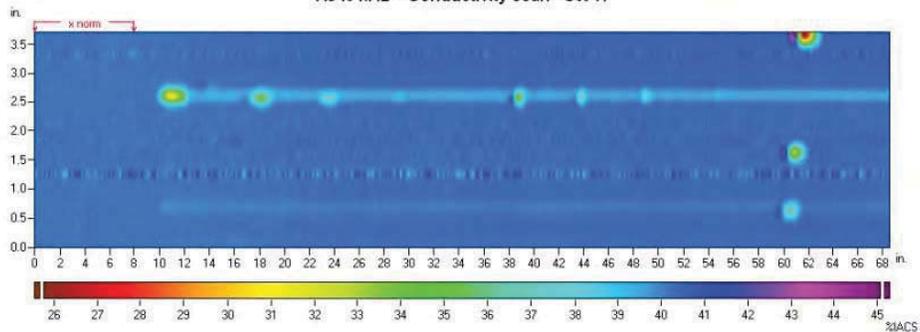
Clean/Un-Patched Samples

flaws are detectable through the wall

RATING=

1

7.943 kHz - Conductivity scan - Set 17





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Plate 551 NDE Standard 4 notches

Taped/Patched Samples

RATING=

1

Engineering estimates are that a few flaws would be detected through the tape, see Std 4 holes

Plate 551 NDE Standard 4 notches

Plate/Patched Samples

RATING=

RATING=

0.66666667

Scanner can't work through repair plate.



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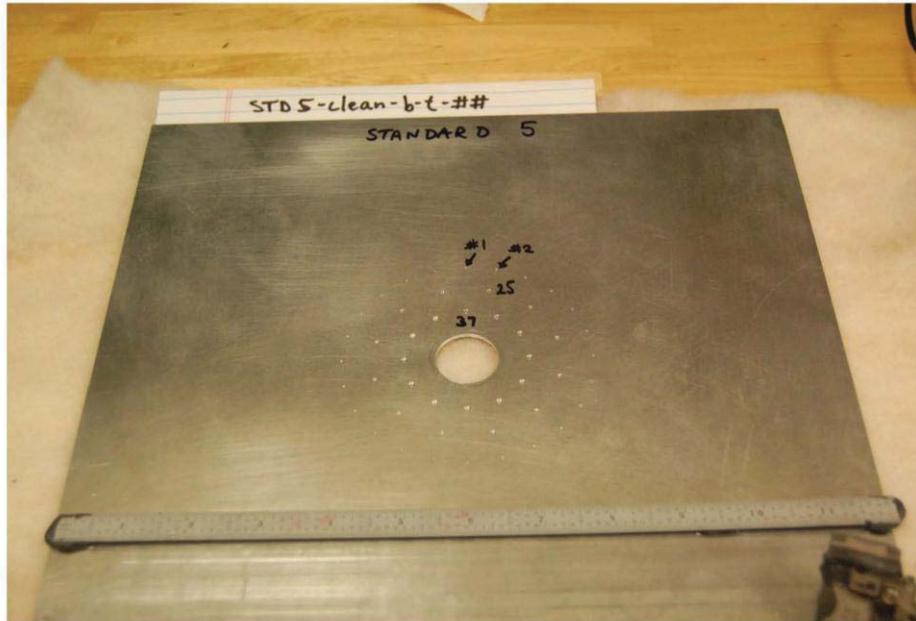
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NDE Standard 5

Image of Samples



NDE Standard 5

Clean/Un-Patched Samples

Note: no images were saved. Engineering estimates are that the system will be image the holes through the plate. (Sec Std 4)

RATING=

2



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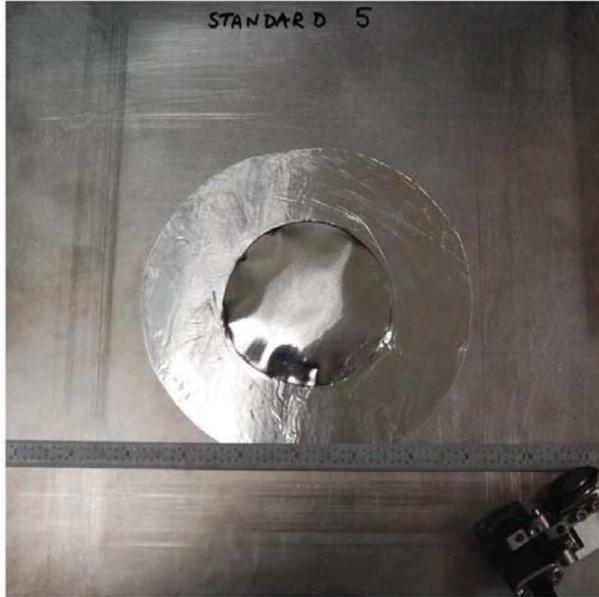
NDE Standard 5

Taped/Patched Samples

RATING=

1

Note: no images were saved. Engineering estimates are that the system might be able to image some of the holes through the tape and standar, but away from the center region. (See Std 4)



NDE Standard 5

Plate/Patched Samples

Scanner can't work through repair plate.

RATING=

RATING= 0

1



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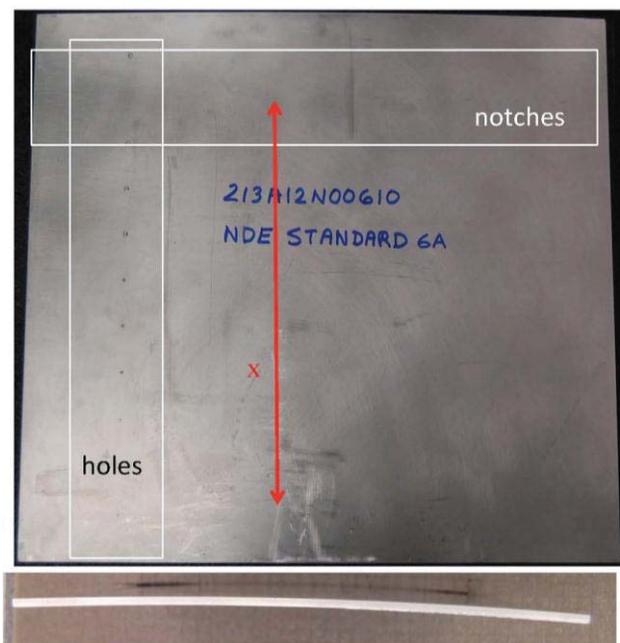
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NDE Standard 6A holes

Image of Samples



NDE Standard 6A holes

Clean/Un-Patched Samples

RATING=

0

Note: no images were saved. System is unable to image holes through the plate



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NDE Standard 6A holes

Taped/Patched Samples

RATING= 0

Note: no images were saved. System is unable to image holes through the plate

NDE Standard 6A holes

Plate/Patched Samples

RATING= 0
RATING= 0

Scanner can't work through repair plate.



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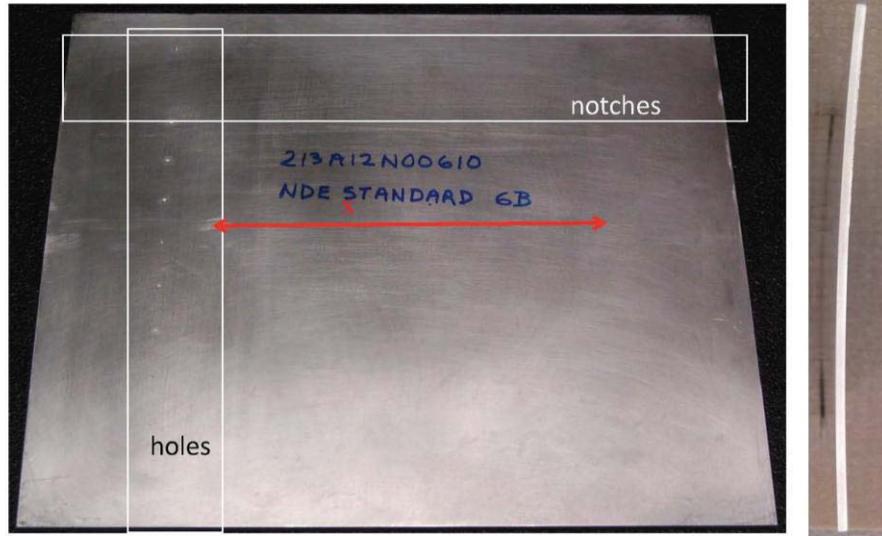
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NDE Standard 6B notches

Image of Samples



NDE Standard 6B notches

Clean/Un-Patched Samples

RATING=

0

Note: no images were saved. System is unable to image notches through the plate



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NDE Standard 6B notches

Taped/Patched Samples

RATING=

0

Note: no images were saved. System is unable to image notches through the plate

NDE Standard 6B notches

Plate/Patched Samples

RATING=

0

RATING=

0

Scanner can't work through repair plate.



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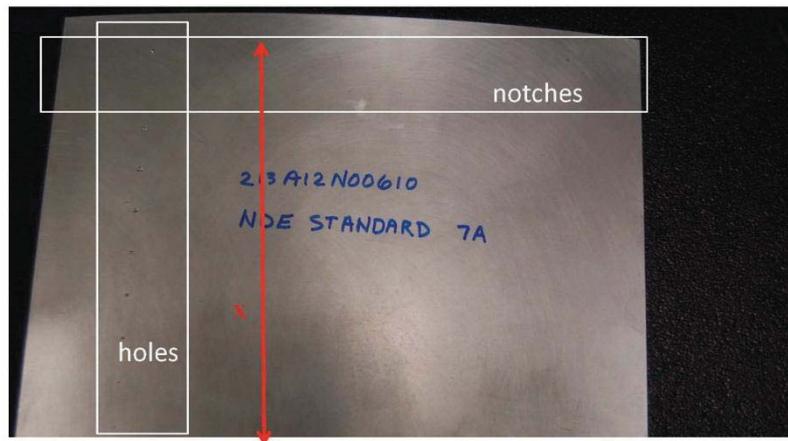
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NDE Standard 7A holes

Image of Samples



NDE Standard 7A holes

Clean/Un-Patched Samples

Note: no images were saved. System is unable to image holes through the plate.

RATING=

0



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NDE Standard 7A holes

Taped/Patched Samples

Note: no images were saved. System is unable to image holes through the plate.

RATING=

0

NDE Standard 7A holes

Plate/Patched Samples

Scanner can't work through repair plate.

RATING=

0

RATING=

0



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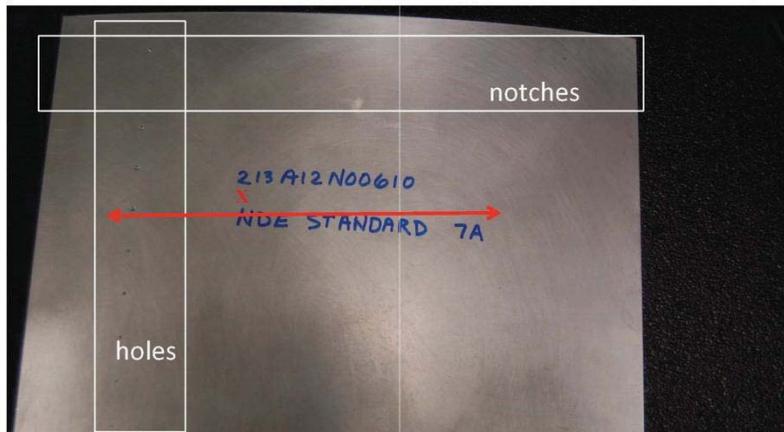
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NDE Standard 7A notches

Image of Samples



NDE Standard 7A notches

Clean/Un-Patched Samples

Note: no images were saved. System is unable to image notches through the plate

RATING=

0



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NDE Standard 7A notches

Taped/Patched Samples

Note: no images were saved. System is unable to image notches through the plate

RATING=

0

NDE Standard 7A notches

Plate/Patched Samples

Scanner can't work through repair plate.

RATING=

0

RATING=

0



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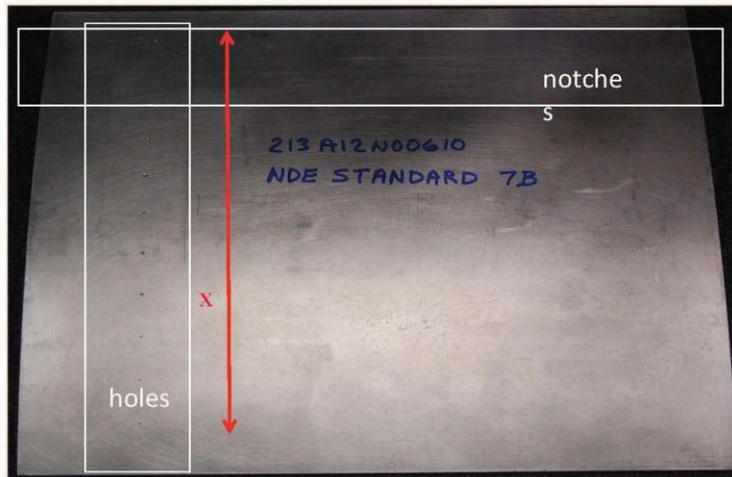
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NDE Standard 7B holes

Image of Samples



NDE Standard 7B holes

Clean/Un-Patched Samples

RATING=

0

Note: no images were saved. System is unable to image holes through the plate



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NDE Standard 7B holes

Taped/Patched Samples

RATING= 0

Note: no images were saved. System is unable to image holes through the plate

NDE Standard 7B holes

Plate/Patched Samples

RATING= 0 RATING= 0

Scanner can't work through repair plate.



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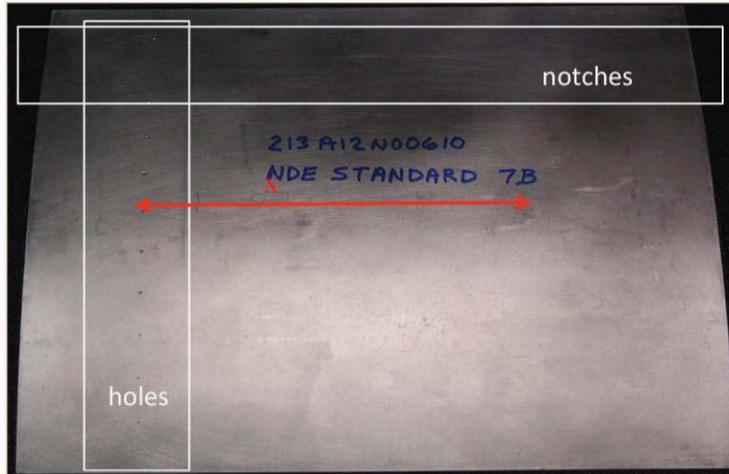
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NDE Standard 7B notches

Image of Samples



NDE Standard 7B notches

Clean/Un-Patched Samples

RATING=

0

Note: no images were saved. System is unable to image notches through the plate



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NDE Standard 7B notches

Taped/Patched Samples

RATING= 0

Note: no images were saved. System is unable to image notches through the plate

NDE Standard 7B notches

Plate/Patched Samples

RATING= 0 RATING= 0

Scanner can't work through repair plate.



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Plate 186

Image of Samples



Plate 186

Clean/Un-Patched Samples

Surface too thick and uneven to scan

RATING= 0



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Plate 186

Taped/Patched Samples

Surface too thick and uneven to scan

RATING= 0

Plate 186

Plate/Patched Samples

Scanner can't work through repair plate.

RATING= 0
RATING= 0



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Plate 1900

Image of Samples



Plate 1900

Clean/Un-Patched Samples

Surface too thick and uneven to scan

RATING=

0



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Plate 1900

Taped/Patched Samples

Surface too thick and uneven to see System wasn't able to image through standard with tape.

RATING=

0

Plate 1900

Plate/Patched Samples

Scanner can't work through repair plate.

RATING=

0

RATING=

0



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Plate 1907

Image of Samples



Plate 1907

Clean/Un-Patched Samples

Surface too thick and uneven to scan

RATING=

0



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Plate 1907

Taped/Patched Samples

Surface too thick and uneven to scan

RATING=

0

Plate 1907

Plate/Patched Samples

Scanner can't work through repair plate.

RATING=

0

RATING=

0



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Plate T3

Image of Samples



Plate T3

Clean/Un-Patched Samples

Surface toothick and uneven to scan

RATING=

0



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Plate T3

Taped/Patched Samples

Note: no images were saved. SystSystem wasn't able to image through standard with tape.

RATING= 0

Plate T3

Plate/Patched Samples

Scanner can't work through repair plate.

RATING= 0
RATING= 0



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Plate 12243 (FGB impact plate)

Image of Samples



Plate 12243 (FGB impact plate)

Clean/Un-Patched Samples

Surface too uneven to scan

RATING=

0



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Plate 12243 (FGB impact plate)

Taped/Patched Samples

Note: no images were saved. Syst System wasn't able to image through standard with tape.

RATING=

0

Plate 12243 (FGB impact plate)

Plate/Patched Samples

RATING=

0

Scanner can't work through repair plate.

RATING=

0



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Plate 123 (Bond Plate)

Image of Samples

c-scan image from water tank

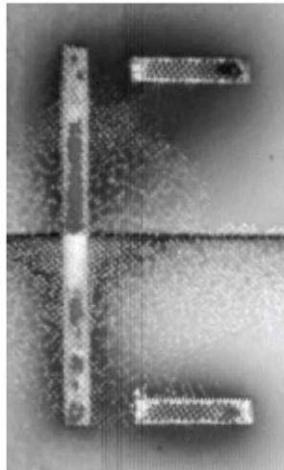


Plate 123 (Bond Plate)

Clean/Un-Patched Samples

Samples too detect thick to detect any flaws

RATING=

0



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Plate 158 (Bond Plate)

Image of Samples

c-scan image from water tank

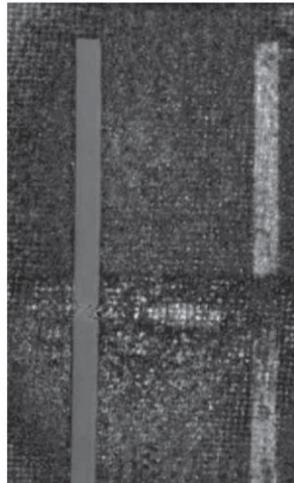


Plate 158 (Bond Plate)

Clean/Un-Patched Samples

Samples too thick to detect any flaws

RATING=

0



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Plate 028B (Bond Plate)

Image of Samples

c-scan image from water tank

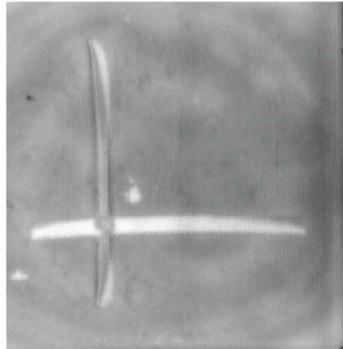


Plate 028B (Bond Plate)

Clean/Un-Patched Samples

Samples too thick to detect any flaws

RATING=

0



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Plate 132A (Bond Plate)

Image of Samples

Plate 132A (Bond Plate)

Clean/Un-Patched Samples

Samples too detect thick to detect any flaws

RATING=

0

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Appendix J. Astronaut Assessment Report

Nondestructive Evaluation (NDE) Commercial Off-the-shelf (COTS) Hardware Crew Review

Executive Summary

Over the life of the International Space Station (ISS) Program, there is a significant risk of module damage/penetration from micrometeoroid and orbital debris (MMOD) impact. Although there are leak repair kits on-orbit that address immediate pressure wall repair, there is currently no means to address long-term structural integrity after a repair (IRMA 4669). It has been proposed that COTS NDE equipment could be used to provide structural damage evaluation, as well as potential certification of the repair. In order to select the optimum COTS NDE instrument for on-orbit use, astronauts and engineers from NASA's Crew Office and Mission Operations Directorate (MOD) Operations Support Office (OSO) performed hands-on evaluations of several devices using predefined criteria.

Although each COTS NDE instrument had different graphical user interfaces (GUIs), menus, button layouts, and accessories, the overall astronaut feedback indicated that these instruments were all about the same with respect to device complexity and ease of use. In fact, all devices performed similarly in categories for operation, setup, teardown, crew time required, crew training required, and stowage volume. Ease of on-orbit operations will come down to having clear training videos and good procedures to operate any single instrument. However, device complexity and ease of use should be secondary to the device's overall function and performance (as evaluated by the NDE engineering community). But, if the Crew Office were to select a single COTS NDE instrument to fly to the ISS in the near future, the Sonatest Veo would be the preferred device. This instrument was a favorite of several astronauts due to the combination of device capability and good display imagery.

From a technological perspective, no show stoppers were identified, and any of the evaluated COTS NDE equipment could be flown to the ISS (pending typical certification requirements) and would provide NDE data. It is the opinion of the Crew Office that ultrasonic phased array (USPA) devices seemed to provide more capability over eddy current (EC) devices since USPA devices could scan across material where access might be blocked by the application of a pressure wall repair kit.

Test Description:

The goal of the NDE project is to certify a small, portable NDE diagnostic device that can detect and quantify flaws or cracks within ISS structures. This information could then be used to help understand the risks involved in continuing to allow crew to occupy these structures. NDE diagnostic equipment functions similar to a doctor's ultrasound machine and has a small LCD screen that highlights any defect in the scanned material.

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As stated before, the NDE team is seeking astronaut and MOD feedback on several different NDE devices in order to select a single device best suited for use on the ISS. Evaluation of the diagnostic equipment was based on factors such as power source, NDE experience required by crew, ease of setup/use, access requirements, crew time, number of crew required, calibration requirements, and overall device performance.

Test Dates and Location:

November 5–8, 2012, JSC Building 9, NDE Lab (room 1004)

Test Participants:

- Test Directors: Dr. Eric Madaras, Dr. Ajay Koshti
- Engineering Test Subjects: Bruce Blazine/United Space Alliance, Dan Perri/MOD, Bert Young/MOD, Chris Sinclair/MOD
- Astronaut Test Subjects: Pettit, Walker, Metcalf-Linenburger, Fincke, Yui, Aunon
- Test Report Preparation: Bruce Blazine

COTS NDE Diagnostic Equipment:

- Olympus MX UPAT
- Olympus MX EC Array
- GE Phasor UPAT
- Sonatest Veo UPAT
- UniWest ECS-3
- Jentek Grid Station EC Array

Summary Test Plan:

1. Introductions
2. COTS NDE description
 - a. Ultrasound
 - b. Eddy current
3. ISS operations scenarios
 - a. Hull penetrations
 - b. Light damage/suspect areas
4. COTS NDE diagnostic equipment evaluations
 - a. COTS diagnostic hardware
 - b. Test samples

Summary Test Procedure:

1. Set up and power on of COTS NDE instrument.
2. Load configuration file.
3. Scan test sample.
4. Save data file.
5. Repeat steps 3 and 4 for each test sample.

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6. Repeat all steps for each COTS NDE instrument.

Astronaut Observations:



Figure J-1. Astronaut Dr. Don Pettit Operating the Sonatest Veo System

Table J-1. Generic NDE Crew Comments

NDE Criteria	Crew-member Observations
NDE Operations & Scanning Techniques	<ul style="list-style-type: none"> • Using a guide/ruler helped with scanning. • Work with Human Research Facility (HRF) team and match their concept of operations, using real-time scanning feedback from ground support engineers. Match their training concept too (x2). • Will need excellent crew procedures (x3). • Avoid step-by-step screen shots of NDE GUI in crew procedures—it takes too long to read and follow. • Need water spray bottle/nozzle to create smaller water droplets. • Prefer water, avoid Braycote (too messy). • Using water okay, test probes with ~1-inch thick water. Probe does not need to be in contact with surface. • Equipment setup and teardown was easy (all devices performed about the same).
Overall Equipment Configuration	<ul style="list-style-type: none"> • Equipment should be robust. • Device complexity of use should be secondary to function/performance. • Need good crew restraints for crew and test equipment. • Smaller probe will be harder to use in microgravity versus larger probes. • Need small probe for behind racks. • Probe guide wheel was nice; easy to use with ruler as guide. • Avoid spring-loaded wheels or a mechanical encoder—wheel push-down is difficult in microgravity (x2).



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NDE Criteria	Crew-member Observations
	<ul style="list-style-type: none"> • If you have a wheel encoder, must have small spring-force, but this force is not a show stopper. Attempt the mechanical encoder first and then have a backup plan ready if it does not work (time series?). • Wheel encoder is a “definite no-go.” • A mouse optical encoder would work better than a mechanical encoder (x2). • Attempt a time-series scan instead of mechanical encoder. • Need arrows on probe to indicate beam scan direction and to indicate direction to move probe. • Suspect we would need a variety of probes. • If possible, consolidate one device to perform both USPA and EC scans. • Probe cumbersome with several wires—need integrated probe of encoder and transducer. • Avoid device with laptop and/or lots of extra parts. • The smaller the probe head the better.
Crew Training: Ground	<ul style="list-style-type: none"> • Minimal hands-on, quick familiarity (x2). • 30 minutes ground training sufficient. • Train device menu/GUI; scanning is easy. • Show crew the device and parts. • All devices require about the same crew training.
Crew Training: On-Orbit	<ul style="list-style-type: none"> • On-orbit video training will be essential and effective for this operation (x4). • Have test samples on-orbit for crew to practice on prior to scanning damaged/suspect areas (x3). • Need reference points to get repeatable scans. • When the time comes to use this device, bite the bullet and do on-orbit training.
ISS Interfaces	<ul style="list-style-type: none"> • Like flexibility of all power options: batteries, hard-line power (alternating current (AC)/direct current (DC)) (x2). • Use standard laptop power bricks with a simple connector adapter. • Will need battery power for easier access to tight spaces without power cables. • Avoid flying a new power brick (x2). • Avoid AC/DC conversion. • Need video out (video graphics array) for real-time downlink of imagery.
Crew Required	<ul style="list-style-type: none"> • Recommend two crew members to be scheduled for NDE operations, similar to how reliability, maintainability, and supportability operations are scheduled today.



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NDE Criteria	Crew-member Observations
	<ul style="list-style-type: none"> • One crew member should be sufficient for most applications, but might need a second crewmember to assist, depending on location, distance, and setup (laptop?) (x3). • Scanning must be a single-handed operation (x2). • Cannot scan using two hands—one hand required to allow crew to brace themselves. • Number of crew will depend on surface location and criticality.
Overall Equipment Size	<ul style="list-style-type: none"> • Device, scanners, and accessories should be as small as practical to save stowage volume. • All devices seemed to consume the same amount of stowage (x2).
USPA versus EC	<ul style="list-style-type: none"> • EC does not appear to help on ISS. • USPA gave an answer easier versus EC. • EC limited since cannot penetrate tape/leak repair patch. • Prefer U.S.—more capability.
Other Comments	<ul style="list-style-type: none"> • Does ground really have a plan for using the NDE-generated data? The information sent back to ground seems marginal for its intended purpose. How do you plan to use this information? Evacuate module? Evacuate ISS? Install a better patch? How engineers use this data needs to be answered. • It would be appropriate to test the NDS hardware on a microgravity flight. • Technology seems sound; no show stoppers for use on ISS (x2). • We should have this technology on ISS.



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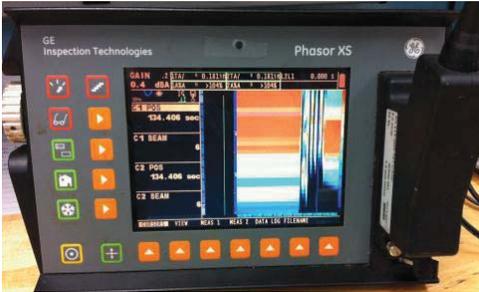
Version:
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Title:

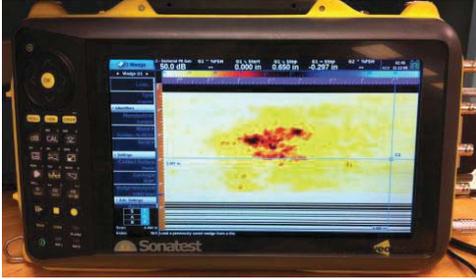
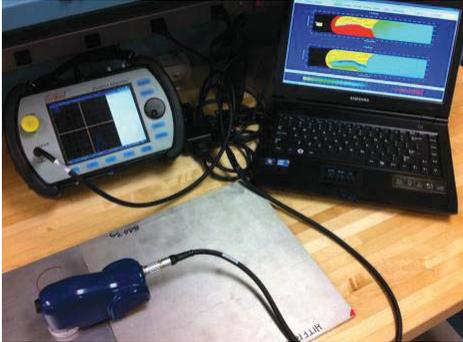
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Table J-2. Device-specific Crew Comments

NDE Criteria	Crewmember Observations
<p>Omniscan MX USPA</p> 	<ul style="list-style-type: none"> • Easy setup and teardown. • Two “Start” buttons are confusing. • The default probe was too delicate and complex. • This device would benefit from an “easy menu” option. • Avoid compact flash cards (like universal serial bus (USB)).
<p>Omniscan MX EC</p> 	<ul style="list-style-type: none"> • Same as Omniscan MX USPA.
<p>GE Phasor XS</p> 	<ul style="list-style-type: none"> • Display seems small. • Has fewer buttons. • GUI menus a little cumbersome w/roller controls. • This device would benefit from an “easy menu” option. • Would be hard to put Velcro on back due to large screws protruding from back. • Clunky box not really rugged for ISS use. • Similar in use to Omniscan.

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NDE Criteria	Crewmember Observations
Sonatest Veo 	<ul style="list-style-type: none"> • Nice imagery, like pictorial image of damage; easy to understand. • Adapt probe for use on-orbit. • Seems easier to use but still has a troublesome encoder. • Spring on encoder okay. • Power cable sticks out from the back—will interfere with setting the device on its back. • Easy to handle. • Good file and menu system, GUI easy. • Like lots of features, such as Ethernet capability, USB, and VGA out. • Preferred model (x2).
UniWest ECS-3 	<ul style="list-style-type: none"> • Laptop would allow more direct remote control from ground (black box). • Avoid using a laptop. • Current probe design too big and cumbersome (x3). • Cable out the back of probe will limit access on ISS. • Great imagery, “neat.” • Would prefer two-dimensional imagery. • Too bulky, not really space/ISS ready (x2).

Specific Findings and Recommendations:

The majority of astronaut feedback centered on the operation of the NDE hand-held scanner/encoder. Several different techniques and encoder configurations were evaluated with mixed results. In all cases, a method to identify specifically where on a panel one was scanning needs to be developed. The use of rulers, tape, sharpie marks, and cameras are all potential solutions to help with reference points. This is especially needed if one hopes to get repeatable scan results. Most crew members felt that using a guide or ruler helped to increase scanning accuracy (see Figure J-2 below).

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Figure J-2. Scanning using a Metal Ruler as a Guide

A variety of probes will be needed on the ISS. A large probe is easier to operate but will not fit in confined areas of the ISS, such as behind racks and other secondary structures. Therefore, a small probe will be required for these areas. Also, an integrated probe that includes a combination of encoder and transducer would be beneficial to develop—along with fewer wires—to minimize how cumbersome the probe is to operate in microgravity. The use of a wheel encoder was met with mixed reviews—some crew liked the wheel, while others said this was a “definite no-go.” The apprehension with a wheel encoder was due to the spring-force required to hold the wheel down onto the pressure shell—this would require a two-handed operation—a difficult task in microgravity since one hand is required to allow the crew to brace themselves while performing a scan.

Most crew felt that an optical scanner would work better than the wheel/mechanical encoder. Alternatively, one could also use a time-series scan as a backup method, in case a mechanical encoder did not work in microgravity. See Figures J-3 through J-5 below for example probes and encoders used during the evaluation.



Figure J-3. Ultrasound Array with Mechanical Wheel Encoder

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Figure J-4. Large EC Probe with Mechanical Wheel Encoder



Figure J-5. Large EC Probe

Several crew members recommended that the NDE operations concept should mimic the HRF. The HRF system also uses crew-operated ultrasound scanners, but in addition, the output is sent to the ground and HRF engineers are able to provide feedback to the crew in real time. This would provide the crew with an immediate response from NDE experts as to the quality of the data the scans are providing.

Training should be kept to a minimum during preflight training since there is only a minimal chance that crew will even need to operate this contingency-type equipment during their stay on the ISS. Once an event occurs that warrants the use of the NDE equipment (and all vehicle safing is complete), the crew can then train on the NDE equipment using on-orbit resources. The on-orbit resources should include video and computer-based training, clear procedures, and a few reference samples for crew to practice scanning.

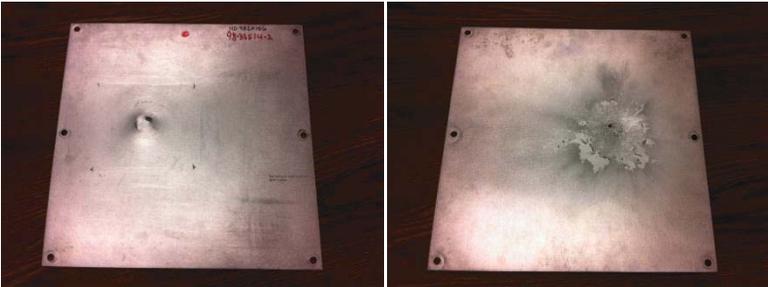
The majority of crew members felt that USPA devices seemed to provide more capability over EC devices, since USPA devices could scan sideways across material where access might be blocked by application of a pressure wall repair kit. A device with the ability to perform both types of scans might provide the most benefit to ISS. But, if the Crew Office were to select a single COTS NDE instrument to fly to ISS in the near future, it would be the Sonatest Veo. This instrument was a favorite of several astronauts due to the combination of device capability and good display imagery.

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Specifically how this NDE-generated data will be used by ground engineers and management is an area that still needs significant work. The information provided by these instruments seems marginal for its intended purpose (but is still better than no information). What decisions can management be expected to make based on this data? How do you quantify this data?

Finally, the Crew Office agrees that the NDE instruments examined during this evaluation have the potential to assist in understanding the type of damage sustained to ISS primary structures after an MMOD impact. The ISS Program should continue to develop this capability for use on the ISS.

Table J-1. Test Samples

Standard 3 	<ul style="list-style-type: none"> • 12 in. × 12 in. × 3/16 in. (flat). • Approximates primary United States on-orbit structure (USOS). • Circular pattern of machined partial through-holes covered with flexible patch. • Intravehicular activity (IVA), extravehicular activity (EVA) sides tested. • IVA side shown in photo.
HD9820186 	<ul style="list-style-type: none"> • 16 in. × 16 in. × 3/16 in. (flat). • Approximates primary USOS. • MMOD penetration covered with dome rigid patch. • IVA side tested only. • IVA, EVA sides shown in photo.



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NDE Standard 7B



- 12 in. × 12 in. × 3/16 in. (curved).
- Approximates primary USOS.
- Machined hole pattern on one side, AL tape on other side.
- IVA/tape side tested only.
- EVA side shown in photo.

NDE Standard 1B



- 12 in. × 12 in. × 1/16 in. (flat with ribs).
- Approximates Service Module/Functional and Cargo Module primary structure.
- Ribs and calibration standard notches and holes.
- IVA (smooth) side tested only.
- EVA side shown in photo.

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Appendix K. Operations Assessment Report

ISS Operations Support Office (OSO) Evaluation of On-orbit Intravehicular Activity (IVA) Nondestructive Evaluation (NDE) Instrumentation

NESC Assessment of NDE Equipment
 On-orbit Operations Assessment
 Mission Operations Directorate (MOD)
 Operations Support Officer Group – DX4
 Dan Perri, Bert Young, Chris Sinclair

The first part of the operations assessment was to identify several generic qualities that OSO determines are important in the selection of tools to be used on-orbit. These criteria are then weighted according to importance. Each candidate NDE device was then evaluated by both OSO personnel and Astronaut Office representatives, using the evaluation criteria to grade each device against the others. The final results of this evaluation will serve as the MOD recommendation.

These criteria are evaluated and graded, with the hope of narrowing down the selection to a single device that serves both the engineering and operations requirements and can be flown to the International Space Station (ISS).

Testing Plan

See the details of the evaluation methodology in Appendix J of this report.

Operations Evaluation Criteria

Crew time for measurements: How much crew time is required to take measurements? The least amount of crew interaction is ideal. A score of 1 would be for something that required constant user attention and interaction to produce a measurement. A score of 5 would be something that crew could set and forget.

Setup/tear down time: How much prep is required for the area to be scanned? Ideally, this equipment would require no setup and no surface prep activities before being ready to scan. Lots of preparation activities and assembly are not ideal but are in some cases unavoidable.

NDE expertise/training required by crew: How much training does a user need in order to take a useable scan? Can a crew member operate the equipment, and collect engineering-usable data without any prior training? The user interface ease of use also falls into this category. Most likely, the crew will not receive ground training on the device, and at most will take a computer-based training (CBT) module on-orbit right before using the device for the first time. The less training needed to obtain a useable scan, the better.

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Preventive/calibration/upkeep actions required: Does the tool require calibration before each run? Yearly calibration? No calibration at all? The less we have to fuss with the equipment during its lifetime, the better.

Access requirements: Can this device make useful scans around an already installed pressure wall repair patch (rigid patch or flexible patch)? If it can't create an image with a patch in place, it may not be viable for on-orbit use. Can it be used in limited access areas to make useful scans?

ISS interfaces: How will the device interface with ISS? How does it send and receive data? What are the power requirements, and are those compatible with current ISS capabilities? It seems like most devices can be used on board with little to no modification.

Number of crew required: Can this device be set up and operated by a single crew member?

Size (storage and access impacts): From an operations perspective, the volume a piece of equipment takes up can be a large factor. This piece of equipment should move between all modules on the ISS with ease. It also must not take up too much space in stowage.

Findings

After testing, each device was assigned a score in each category using a five-point scale. The points were weighted and added to produce a final score for each device, which could be used as a quantitative measurement to make an operations recommendation. The operations recommendation should be used in conjunction with the engineering recommendation when deciding which specific device to fly to the ISS.

Most of the devices require a similar amount of crew interaction to take measurements. They all require 100-percent crew attention to take measurements, so none of them were simple in that regard. Setup and teardown time for each device was also similar, but none were extremely difficult to set up. A couple of simple plug-in connections are all that each device requires, and usually each system requires a simple water spray as a coupling medium. The Uniwest system requires a second, dedicated laptop to make measurements, so it received a lower score than the others in this category.

Expertise required by crew is the category where we started to see some differences between devices. Some devices had easy-to-navigate user interfaces, fewer buttons, and were easy to load configuration files; these received the highest scores in this category. Other devices had user interface menus that were difficult to navigate or didn't have a good way to load configuration files. All of the devices could probably be trained using video/CBT along with some practice runs to get the onboard crew used to the operations. A common recommendation from the Crew Office was to mimic the Human Research Facility (HRF) group's model for doing body ultrasound imaging, where the HRF scientists on the ground talk the astronaut through each activity in real time using live video and audio, and we believe each device tested

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has the capability to be operated in this manner. Adopting this operations model could mean that crew members could get away with much less training to effectively take measurements.

Each device uses a small, handheld sensor array attached to a mechanical wheel encoder. Only the ultrasonic phased array (USPA) devices were successful in generating images around the leak repair patches. USPA sensors can send a shear wave through the module wall, whereas the eddy current (EC) devices can only image straight down. The straight-down image is, therefore, ruined by the presence of both the dome rigid patch and the aluminum tape flexible patches. While EC imaging serves an important purpose in NDE assessment, from an ISS operations perspective, if the device can't measure underneath a patch it should not be considered for this purpose.

All devices have similar power requirements that can be accommodated on the ISS, just about all of them have the ability to export video using VGA connections, and most have an Ethernet connection or USB compatibility.

In terms of number of crew required and overall device size, all devices were nearly identical. The Omniscan models have a slight edge since they are capable of doing USPA and EC scans by simply swapping a control module out of the back of the main unit, although this would require additional equipment.

Recommendations

The crew representatives had some useful comments and recommendations in regard to the coupling medium, sensor arrays, encoders, and operations/training concepts. For coupling medium, all crew said water would work great on-orbit, no need for ultrasound gel. The crew suggested that sensor arrays should be small but easy enough to hold with one hand. The encoders, which are used to record lateral motion of the sensor array as it slides across the surface and makes the scan, would ideally ditch the mechanical wheel encoder that most of the devices currently use. It was suggested that, prior to flying a device, engineers should look into providing a different type of encoder, either optical or laser, and attempt to integrate it into the sensor array so there are not quite as many separate moving parts for a zero-G crew to handle. As previously mentioned, crew also suggested mimicking the HRF operations model for conducting body ultrasound. OSO and the engineering team already invited some HRF representatives to come take a look at what was being done, and all agreed that it is a viable candidate for their operational philosophy. Some of the equipment they use to downlink video and data may also be compatible with the NDE equipment. This idea will need to be researched further.

Grading each device based on the operations criteria yielded a numerical score for each candidate. The Sonotest Veo was the winner. It was also the initial favorite based on gut reactions from all crew members and OSO teammates. The Omniscan was a close second, due to its potential versatility (although new models will be unable to conduct ultrasonic and EC

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measurements from a single unit), as well as its relative ease of use compared with the other units.

There appeared to be no holdups from an operations perspective, as any of these NDE devices can probably be operated by crew members on-orbit for their intended purpose. The ISS simply needs a device that can take measurements underneath the dome rigid patch and flexible patch; the USPA sensors can do this, while the EC arrays cannot. Of the devices tested, the Sonotest Veo best met the criteria.

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Appendix L. Engineering Assessment Report

Work was performed under NASA Contract NNJ05I05C



ESCG-4270-13-AS&T-DOC-0001
Revision: Baseline

Intravehicular Activity Non-Destructive Evaluation Tool Evaluation Test Report

Engineering and Science Contract Group
2224 Bay Area Boulevard, Houston, Texas 77058

February 2013

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Revision: Baseline

Intravehicular Activity Non-Destructive Evaluation Tool Evaluation Test Report

Prepared by

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Avionics Systems and Test Section
Science, Engineering, and Analysis Services Department

Approved by

Issa Zaid, Project Lead
Avionics Systems and Test Section
Science, Engineering, and Analysis Services Department

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2224 Bay Area Boulevard, Houston, Texas 77058

February 2013



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REVISION LOG

Revision	Date	Description
Baseline	February 2013	Initial release.



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ACRONYMS AND ABBREVIATIONS

°F	Degrees Fahrenheit
A	Ampere(s)
AC	Alternating Current
ARISS	Amateur Radio on ISS
AS&T	Avionics Systems and Test
BTU	British Thermal Unit
COTS	Commercial Off-the-Shelf
CUCU	COTS UHF Communication Unit
dB	Decibel(s)
EC	Eddy Current
EMI	Electromagnetic Interference
ESCG	Engineering and Science Contract Group
EUT	Equipment Under Test
FCB	Functional Cargo Block
GHz	Gigahertz
GLADIS	Global Awareness Data-exfiltration International Satellite
GPS	Global Positioning System
GTS	Global Timing System
IF	Intermediate Frequency
IR	Infrared
ISS	International Space Station
IVA	Intravehicular Activity
JSC	Johnson Space Center
kHz	Kilohertz
lb	Pound(s)
lbm	Pound-Mass
LCD	Liquid Crystal Display
MHz	Megahertz
NDE	Non-Destructive Evaluation



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NSD	Noise Spectral Density
PSD	Power Spectral Density
RE02	United States Radiated Emissions
RF	Radio Frequency
RS03	Radiated Susceptibility
Russian RE	Russian Radiated Emissions
SM	Service Module
SSCS	Space-to-Space Communication System
UHF	Ultrahigh Frequency
USPA	Ultrasonic Phased Array
V	Volt(s)
V2	Version 2
W	Watt(s)
WVS	Wireless Video System

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1. INTRODUCTION

The objective of this engineering evaluation was to compare the leading contenders for an Intravehicular Activity Non-Destructive Evaluation (IVA NDE) tool. Multiple environmental tests were performed on the units to obtain preliminary data and to assess the potential cost of certifying each unit.

The leading contenders were two Ultrasonic Phased-Array (USPA) devices—the OmniScan MX and the Sonatest VEO—which send ultrasonic waves into a sheet of metal to map out damage and flaws. The units would be used to analyze damage to the International Space Station (ISS) hull that has been patched or repaired. The analysis would provide insight into how long the ISS can be reasonably sustained.

The UniWest ECS-3 also was sent for Electromagnetic Interference (EMI) testing since the unit was available, and the data was requested for future reference. The UniWest ECS-3 is an Eddy-Current (EC) device, which uses alternating currents to induce an eddy current in the part being inspected. Flaws are found when the eddy-current flow in the part changes. This type of device is not currently being pursued, since it is unable to scan through the patches used to repair the ISS.

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2. EMI TEST RESULTS

Each unit was tested for United States Radiated Emissions (RE02), Russian Radiated Emissions (Russian RE), and Radiated Susceptibility (RS03). The hardware layout for each unit remained the same throughout all three tests.

The radiated emissions tests identify frequency bands between 14 kHz and 15.5 GHz within which the units introduce excessive noise that may interfere with other systems. The radiated susceptibility test identifies any frequency bands between 121 MHz and 15.6 GHz in which existing hardware may interfere with a unit's operation.

2.1 OmniScan MX

2.1.1 Hardware Setup

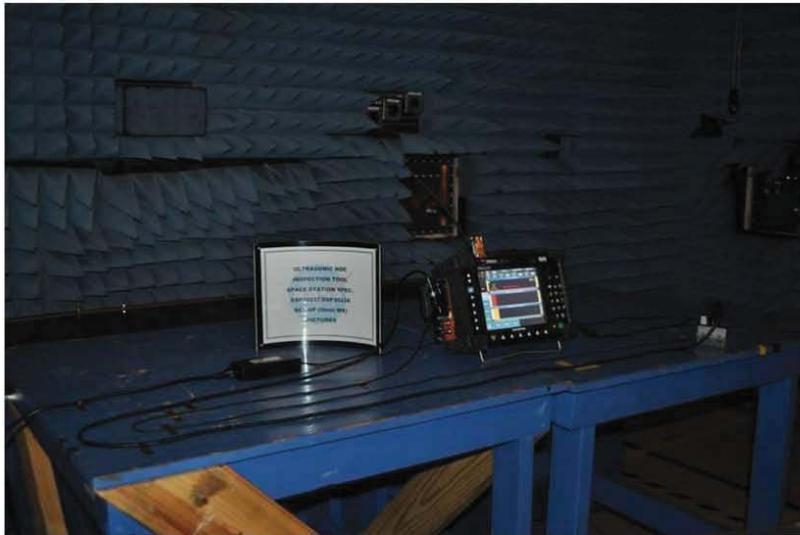


Figure 1: OmniScan MX EMI Hardware Setup

2.1.2 RE02

There were 10 failures in the horizontal polarization of RE02 in the frequency range of 280 to 600 MHz. The failures occurred while the unit was powered on and running. The largest margin was 8.385 dB at 440.200 MHz. (See Figure 2.)

To provide a baseline, a configuration with Alternating Current (AC) power unplugged was tested and showed no failures. (See Figure 3.)

The final configuration tested was with AC powered on and the Equipment Under Test (EUT) off, also resulting in no failures. This test showed that the AC power supply is not a major contributor to the failures seen during the RE02 test. (See Figure 4.)



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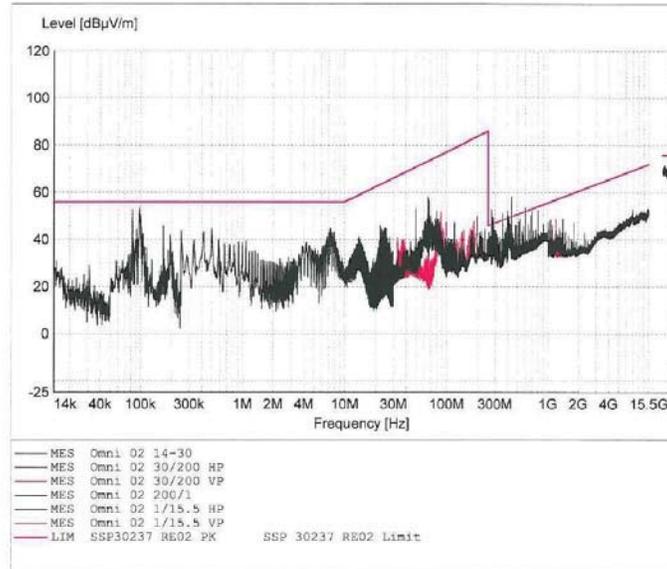


Figure 2: RE02 – OmniScan MX, Hardware Powered On

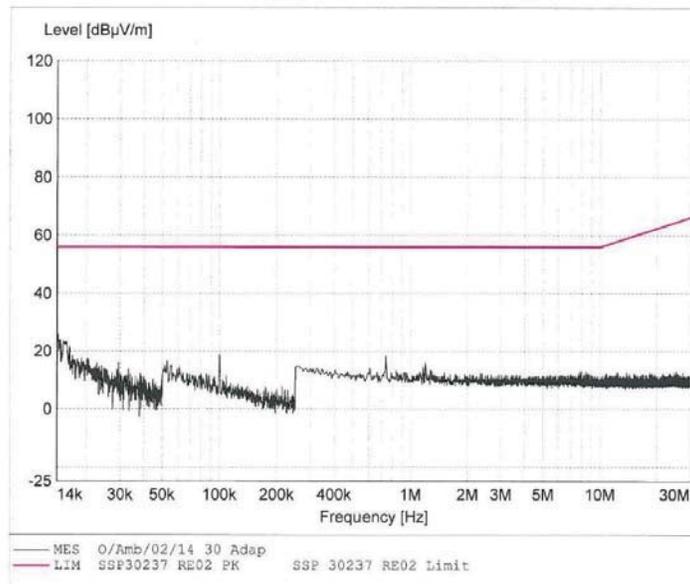


Figure 3: RE02 – OmniScan MX, AC Power Unplugged



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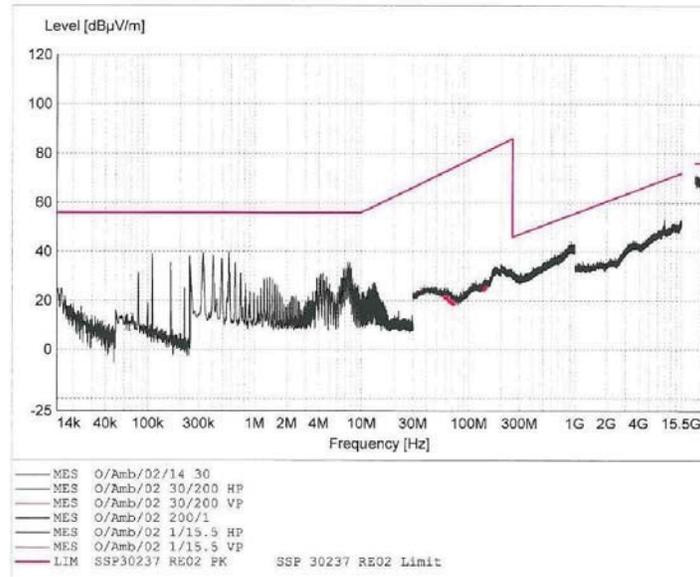


Figure 4: RE02 – OmniScan MX, AC Power On, EUT Off

2.1.3 Russian RE

There were numerous failures in the horizontal polarization of Russian RE in the frequency range of 33 to 440 MHz and in the vertical polarization in the frequency range of 0.0835 to 188 MHz. The largest margins were 14.01 dB at 49.98 MHz (vertical) and 15.53 dB at 65.7 MHz (horizontal). (See Figure 5.)

The AC power unplugged configuration was tested to provide a baseline and resulted in no failures. (See Figure 6.)

The configuration with AC powered on and EUT off had six failures between 0.1095 and 0.5775 MHz in the vertical polarization. The largest margin was 4.060 dB at 0.33 MHz. This indicated that the AC power supply by itself fails Russian RE. (See Figure 7.)



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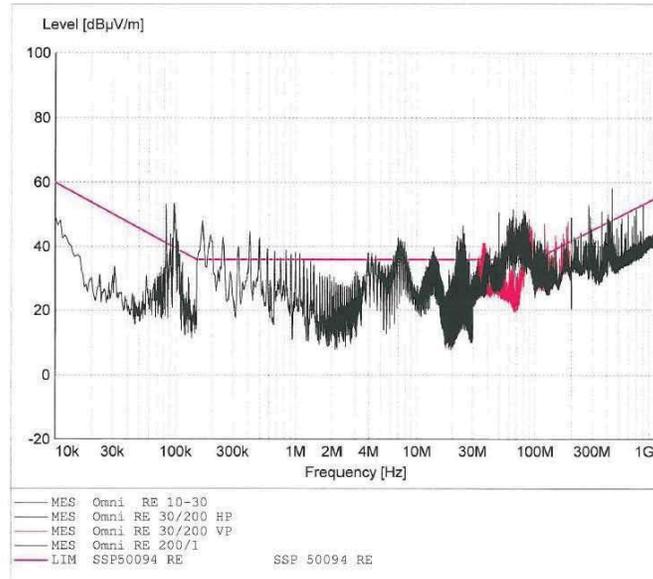


Figure 5: Russian RE – OmniScan MX, Hardware Powered On

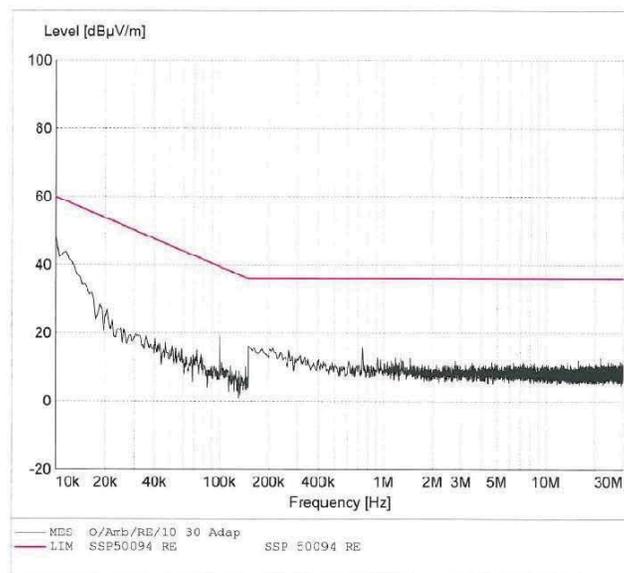


Figure 6: Russian RE – OmniScan MX, AC Power Unplugged



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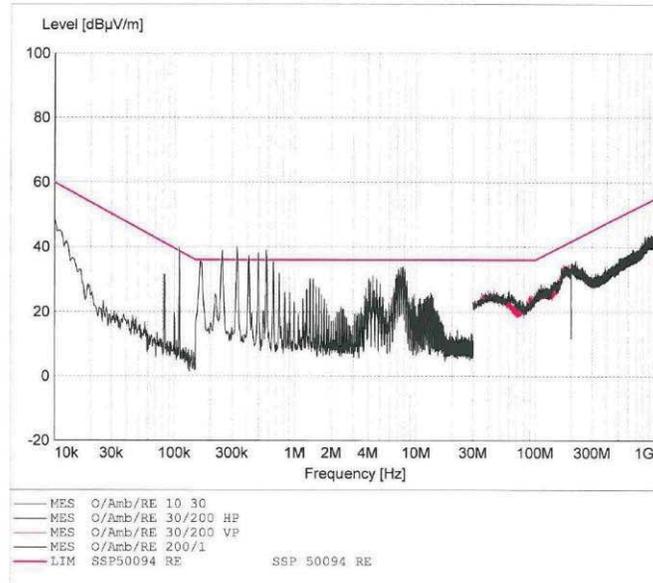


Figure 7: Russian RE – OmniScan MX, AC Powered On, EUT Off

2.1.4 RS03

The unit passed RS03, showing no signs of being susceptible at any frequency range.



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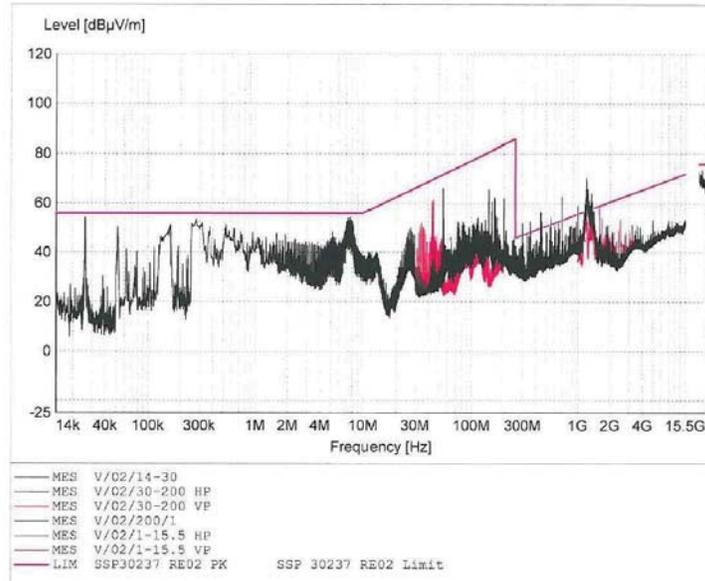


Figure 9: RE02 – Sonatest VEO, Hardware Powered On

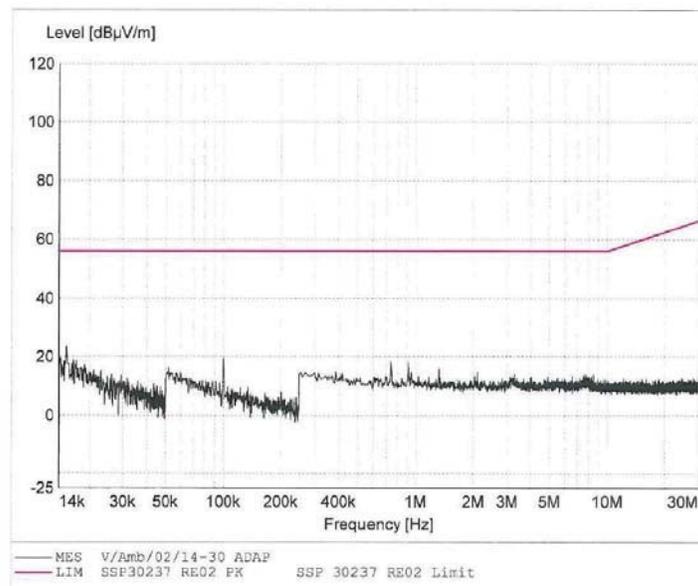


Figure 10: RE02 – Sonatest VEO, AC Power Unplugged



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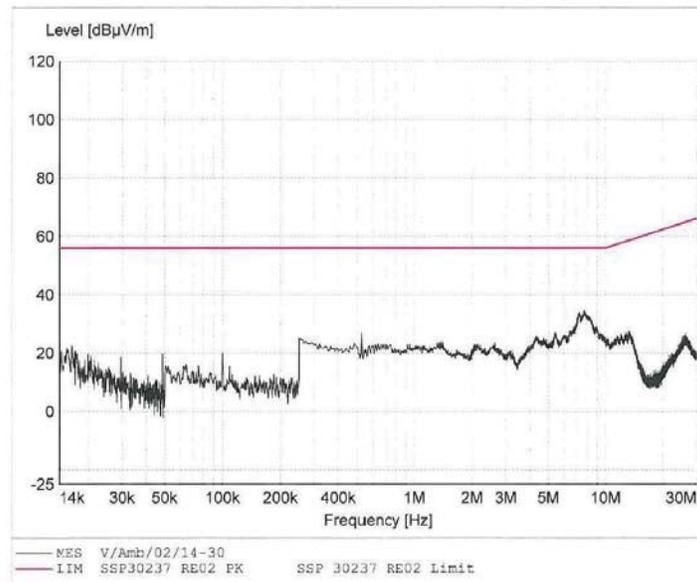


Figure 11: RE02 – Sonatest VEO, AC Power On, EUT Off

2.2.3 Russian RE

There were numerous failures in the horizontal polarization of Russian RE in the frequency range of 31 to 800 MHz and in the vertical polarization in the frequency range of 0.026 to 200 MHz. The largest margins were 30.44 dB at 54.6 MHz (horizontal) and 20.47 dB at 0.1545 MHz (vertical). (See Figure 12.)

The AC power unplugged configuration was tested to provide a baseline and resulted in no failures. (See Figure 13.)

The configuration with AC powered on and EUT off was also tested and had no failures, indicating that the AC power supply was not a major contributor to the failures seen during Russian RE. (See Figure 14.)



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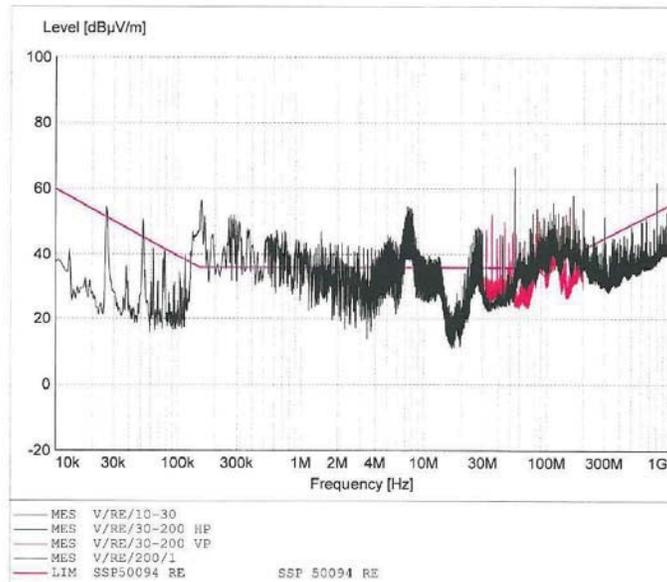


Figure 12: Russian RE – Sonatest VEO, Hardware Powered On

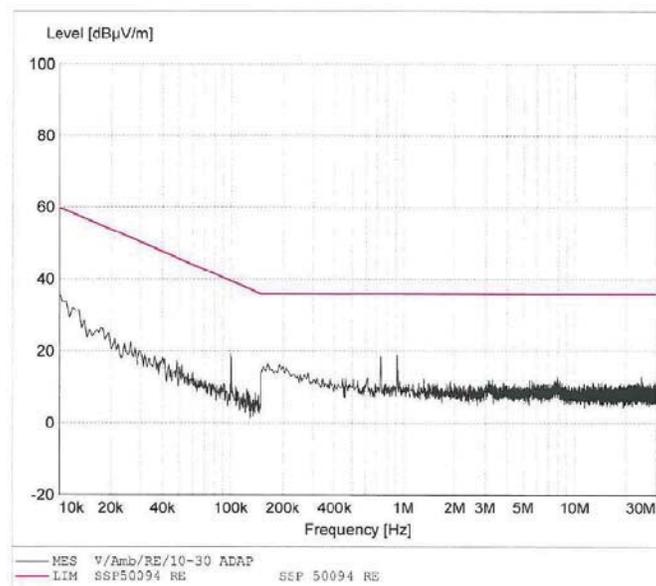


Figure 13: Russian RE – Sonatest VEO, AC Power Unplugged



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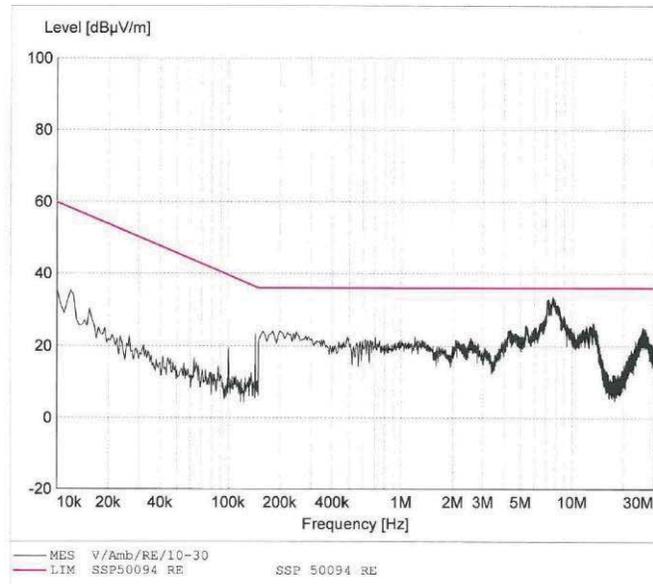


Figure 14: Russian RE – Sonatest VEO, AC Powered On, EUT Off

2.2.4 RS03

The unit passed RS03, showing no signs of being susceptible at any frequency range.

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2.3 UniWest

The UniWest is an EC device that requires a laptop for capturing data. The laptop was kept outside the test area, but the Ethernet cable provided additional EMI, as shown in Figure 17.

2.3.1 Hardware Setup



Figure 15: UniWest ECS-3 EMI Hardware Setup

2.3.2 RE02

There were five failures in the horizontal polarization of RE02 in the frequency range of 450 to 700 MHz. There were also 21 failures in the vertical polarization of RE02 in the frequency range of 0.0185 to 21 MHz. The failures occurred while the unit was powered on and running. The largest margins were 2.273 dB at 451.6 MHz (horizontal) and 13.38 dB at 0.06 MHz (vertical). (See Figure 16.)

The AC power unplugged configuration was tested to provide a baseline and resulted in no failures. (See Figures 17 and 18.)

The configuration with AC powered on and EUT off was also tested. This configuration had five failures in the vertical polarization of RE02 in the frequency range of 0.42 to 0.66 MHz. The largest margin was 5.29 dB at 0.66 MHz. (See Figures 19 and 20.)



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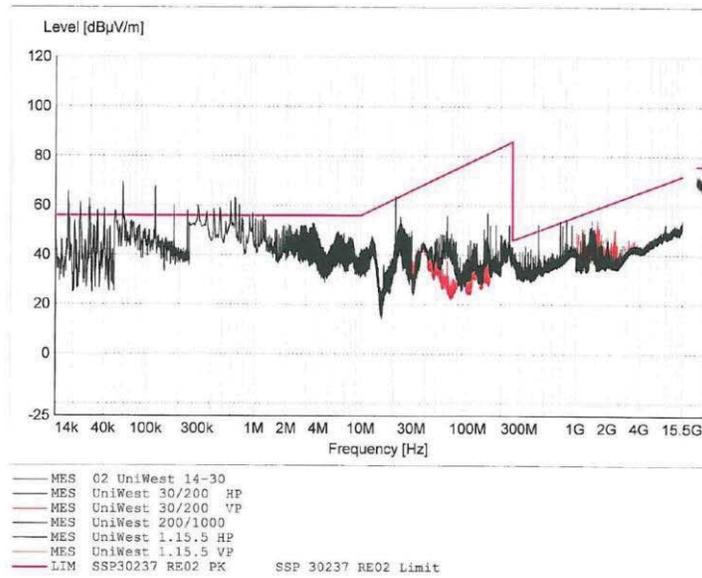


Figure 16: RE02 – UniWest, Hardware Powered On

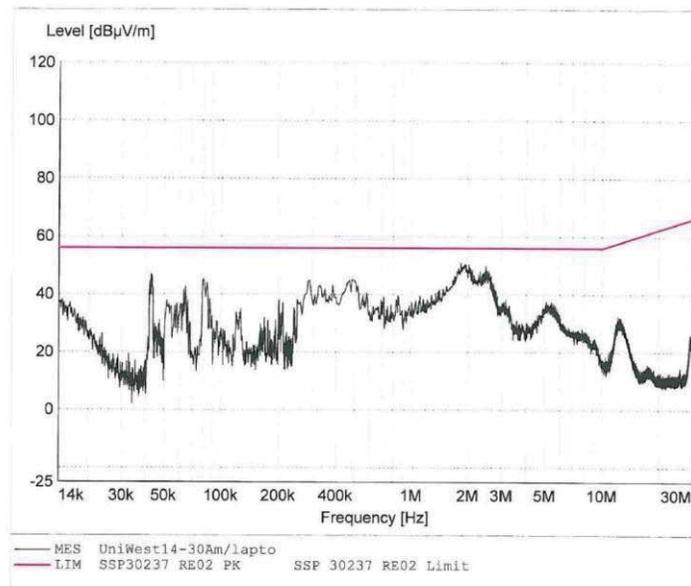


Figure 17: RE02 – UniWest, AC Power Unplugged, Laptop On



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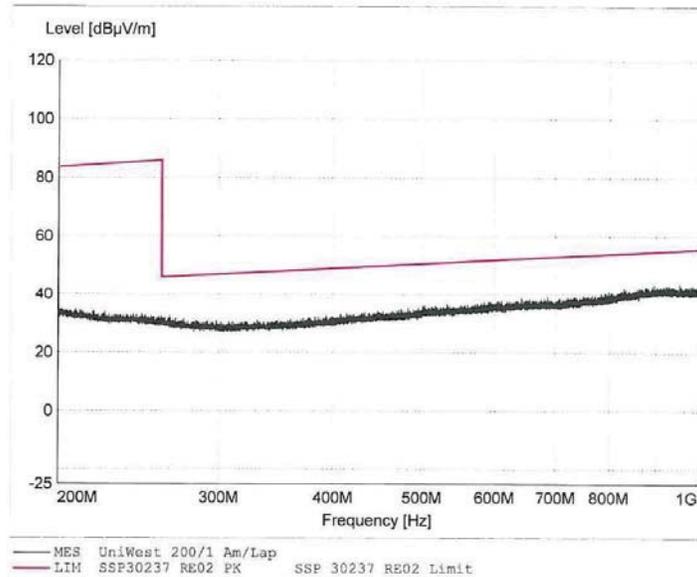


Figure 18: RE02 – UniWest, AC Power Unplugged, Laptop On 2

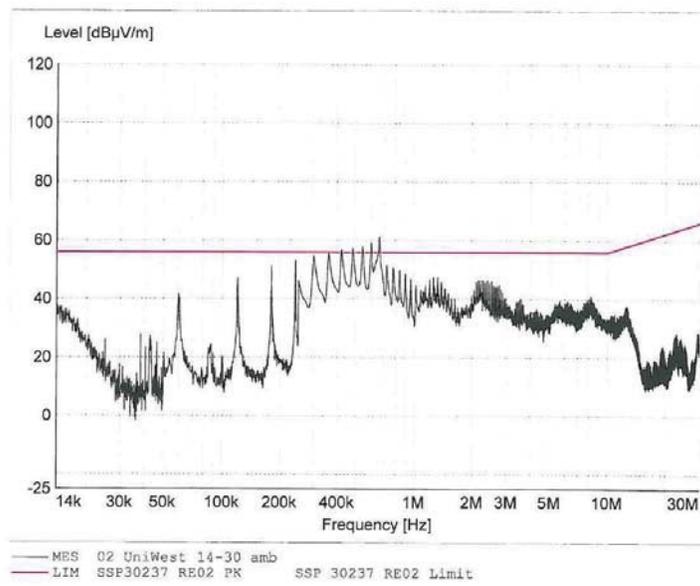


Figure 19: RE02 – UniWest, AC Power On, EUT Off



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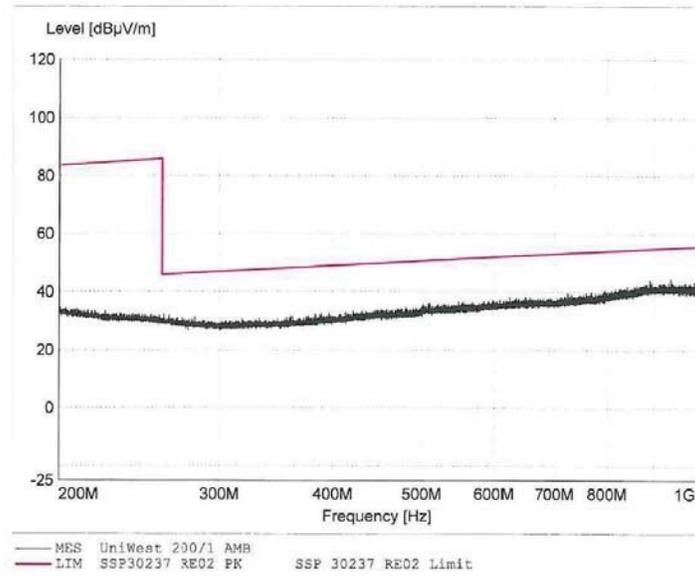


Figure 20: RE02 – UniWest, AC Power On, EUT Off 2

2.4 Potential Impacts

2.4.1 Expected Interference

The spurious emission at 400 MHz is close to several ISS Radio Frequency (RF) systems:

- 0.5 MHz from the Commercial Off-the-Shelf (COTS) Ultrahigh Frequency (UHF) Communication Unit (CUCU) (400.5 MHz)

Because the receiver's Noise Spectral Density (NSD) is degraded more than 9 dB by the interferer's Power Spectral Density (PSD), interference is expected for this system. Coordination may be required.

- 0.575 MHz from CUCU Version 2 (V2) (400.575 MHz)

Because the receiver's NSD is degraded more than 11 dB by the interferer's PSD, interference is expected for this system. Coordination may be required.

- 0.6 MHz from the Wireless Video System (WVS) UHF command link (400.575 MHz)

The emission is in the bandwidth of the WVS command link. The interferer's PSD is much greater than the WVS NSD; therefore, interference is possible.

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The spurious emission at 1226 MHz is close to the following ISS RF system:

1.6 MHz from the Global Positioning System (GPS) L2 (1227.6 MHz)

Because the received interferer's PSD is close to 20 dB higher than the effective receiver's NSD, interference is possible.

2.4.2 Other Services Analyzed

The spurious emission at 400 MHz is close to several ISS RF systems:

- a. 0.1 MHz from the Service Module (SM) Global Timing System (GTS) (400.1 MHz)

The receiver for GTS at this frequency is on the ground, so no interference is expected.

- b. 14.2 MHz from the Space-to-Space Communication System (SSCS) (414.2 MHz)

The emission is outside the Intermediate Frequency (IF) bandpass filter, so no interference is expected.

- c. 0.18 MHz from the Global Awareness Data-exfiltration International Satellite (GLADIS) (400.18 MHz)

The receiver's beam is very narrow, so no interference is expected.

The spurious emission at 407.7 MHz is close to the following ISS RF system:

9.4 MHz from SSCS (417.1 MHz)

The emission is outside the SSCS IF bandpass filter, so no interference is expected.

The spurious emission at 440.2 MHz is close to several ISS RF systems:

- a. 3.7 MHz from the Functional Cargo Block (FCB) Sirius Radio (436.5 MHz)

The receiver's bandwidth is 1.2 MHz, so no interference is expected.

- b. 9.8 MHz from SM GTS (449.9875 MHz)

The receiver on the ISS has a very narrow band, so no interference is expected.

- c. 3.7 MHz from the SM Amateur Radio on ISS (ARISS) (436.5 MHz)

The ARISS is a voice system, which has a very narrow bandwidth, so no interference is expected.

Note: A few of the systems had multiple spurious emissions associated with them. Only the closest emission was used.

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2.5 EMI Summary

The UniWest instrument had no failures that would interfere with current ISS systems.

The OmniScan MX had failures in the 400 MHz range that are expected to interfere with the CUCU and the CUCU V2. Interference with the WWS UHF command link is also possible. Workarounds are available for these frequency ranges.

The Sonatest VEO had failures in the 400 MHz range that are expected to interfere with the CUCU and the CUCU V2. Interference with the WWS UHF command link is possible, as well as interference with the GPS L2 in the 1226 MHz range. Workarounds are available for the 400 MHz frequency range, but the 1226 MHz signal interfering with the GPS would need to be mitigated.

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3. POWER INVERTER COMPATIBILITY

The power inverter compatibility test was performed to evaluate in-rush current and steady-state power draw. The test also verified that the COTS power cord was compatible with the ISS power inverter.

The values recorded below were taken during the power inverter compatibility test performed in the Power Quality Laboratory with a 120 V power inverter.

3.1 OmniScan MX

- a. Steady-state power = 22 W
- b. Maximum in-rush current = -17.34 A

The OmniScan MX was also informally tested with a 28 V inverter, which is the desired power supply for the Russian section. An A31p 28 V Emerald Brick was tested as a backup option. The unit functioned normally with both power supplies.

3.2 Sonatest VEO

- a. Steady-state power = 22 W
- b. Maximum in-rush current = 35 A

The Sonatest VEO was not tested with the 28 V inverter due to scheduling conflicts, but no issues are expected.

The Sonatest VEO was tested with an A31p 28 V Emerald Brick, but it failed to power up. It is suspected that the laboratory power supplies used with the Emerald Brick were unable to provide the required in-rush current. It is possible that the brick may still work on-orbit.

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4. THERMAL VACUUM ANALYSIS

A thermal vacuum analysis was performed to evaluate how well the units might operate in a scenario where a module had decompressed.

The thermal analysis used the steady-state power draw obtained from the power inverter test and the sink temperature range of either 40 °F or 140 °F obtained from the Active Thermal Controls group to determine how much heat was generated by the units themselves in a vacuum.

4.1 Assumptions

Little is known about the specific layout or contents of either unit; therefore, the following assumptions had to be made to get a basic analysis of a unit's thermal behavior in a vacuum:

- a. The Infrared (IR) emissivity of the outer surface of each unit was assumed to be 0.8. This number is characteristic of non-metallic paints, most anodized aluminum, beta cloth, plastic, and dull non-metallic surfaces.
- b. The specific heat of each unit's materials was assumed to be 0.2 BTU/lb-°F.
- c. The initial temperature of each unit was assumed to be 75 °F.
- d. The heat is transferred out of each unit strictly by thermal radiation (since it is in a vacuum) to a constant sink temperature of either 40 °F or 140 °F.
- e. The surface area of each unit is based on the dimensions shown in the respective user's manual specifications: Omniscan 12.6" x 8.2" x 5.0" and Sonatest 8.66" x 13.19" x 4.52".
- f. The mass of each box was taken from the respective user's manual specifications: Omniscan 10.1 lbm and Sonatest with one battery 11.6 lbm.
- g. The 22 W heat load is evenly distributed over the outer dimensions of each unit.

4.2 Results

Both units generated about the same amount of heat, as shown in Figure 21; however, the OmniScan MX does not use a fan for cooling, while the Sonatest VEO does. So in a vacuum environment, the OmniScan may perform a bit better. Both units will work during a cold cycle, when the ISS is out of the sun for an extended time. Neither unit will operate for long in a hot cycle, when the ISS is in the sun for an extended time. During a hot cycle, the units will exceed touch temperature within 30 minutes.



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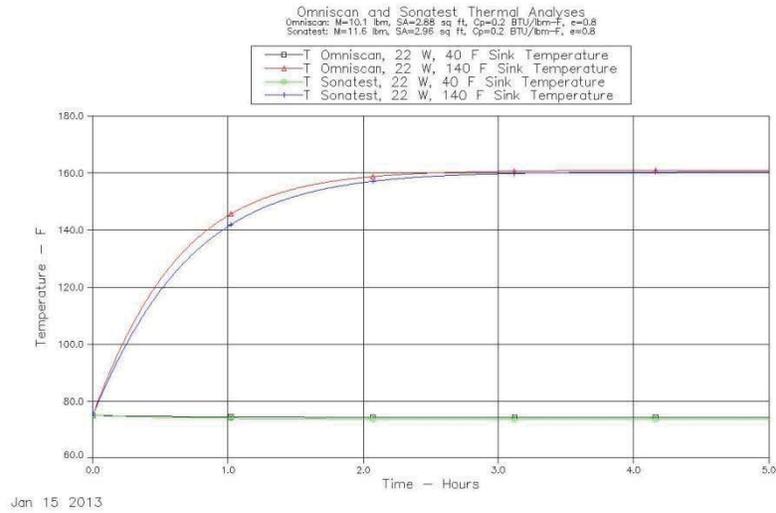


Figure 21: Thermal Analysis Results

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5. MATERIALS ANALYSIS

A materials analysis was requested to ensure that nothing off-gasses from the units that could be deemed harmful to people or equipment.

Minimal materials information is available from the vendor. Units are not available for testing.

5.1 OmniScan MX

Minimal materials information is available from the vendor. Units are not available for testing.

5.2 Sonatest VEO

Minimal materials information is available from the vendor. Units are not available for testing.

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6. SAFETY ANALYSIS

Basic hazards were examined prior to and during each test. No sharp edges or pinch points were found. The units are durable and designed to withstand falls and other impacts, so there are no concerns about parts of the units shattering. The UniWest appeared to emit dangerous frequencies from one side of the box; therefore, the EMI probe had to be located in a different spot to avoid interference. More testing would be required to verify the emissions and their severity.

A full safety analysis will be performed for certification.

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7. Certification Impacts

The cost per unit includes the base unit cost, modification, and testing; such as radiation, off-gassing, and safety only certification. There are several factors that could impact the safety only certification in terms of cost and schedule. These items include but are not limited to: thermal touch temperature, materials/offgassing, EMI/EMC, power quality, etc. One of the issues in certifying the Omniscan MX, for example; the project personnel would need to remove or redesign all rubber components for off-gassing reasons. The large rubber bumpers on the corners would not pose an issue, but the entire front panel interface uses rubber buttons. On the other hand, to certify the Sonatest VEO, the ISS Spectrum Analysis team needs to assess the impact of the exceedances of this device with the ISS Global Positioning System (GPS) at the frequency of 1.2GHz during Radiated Emission (RE02). If ISS Spectrum Analyst finds out that an interference is possible, an operational work around may be possible such as limiting the operation of the tool during critical periods which would be a minimal impact to the certification of this product. Other methods more invasive methods could involve coating the interior of the enclosure with an EMI spray, adding another clear panel over the Liquid Crystal Display (LCD) screen, replacing a component, adding shielding around a specific section of the box, or designing an entirely new enclosure.

Both units would need at least four Johnson Space Center (JSC) drawings; materials off-gas testing or analysis; a safety review; and official memorandums from the EMI, Structures, Thermal, and Human Factors Groups.

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8. CONCLUSIONS

Table 1: Figure of Merits

Criteria	Weight	Option 1 OmniScan MX (USPA)		Option 2 Sonatest VEO (USPA)		Option 3 UniWest ECS-3 (EC)	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
EMI	25	4	1	3	0.75	4	1
Power Inverter Compatibility	15	5	0.75	5	0.75		0
Thermal Vacuum Analysis	10	2	0.2	2	0.2		0
Materials Off-Gassing	25	3	0.75	4	1		0
Safety	25	5	1.25	5	1.25	4	1
	100	19	3.95	19	3.95	8	2.0

Overall, the Omniscan MX performed a bit better than the Sonatest VEO in environmental testing performed so far. The Omniscan MX has an abundance of rubber, which would heavily impact materials off-gassing results. While some of the rubber could be easily removed, other portions would be more difficult to modify.

The largest challenge for the Sonatest would be mitigating EMI. It will need to be modified to some extent, since the GPS is always running, and the Sonatest emits frequencies that would interfere with it. The type of mitigation required, however, depends on exactly what is emitting in the 1200 MHz range.

REPORT DOCUMENTATION PAGE

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14. ABSTRACT International Space Station (ISS) Structural and Mechanical Systems Manager, requested that the NASA Engineering and Safety Center (NESC) provide a quantitative assessment of commercially available nondestructive evaluation (NDE) instruments for potential application to the ISS. This work supports risk mitigation as outlined in the ISS Integrated Risk Management Application (IRMA) Watch Item #4669, which addresses the requirement for structural integrity after an ISS pressure wall leak in the event of a penetration due to micrometeoroid or debris (MMOD) impact. This document contains the appendices the final report.					
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