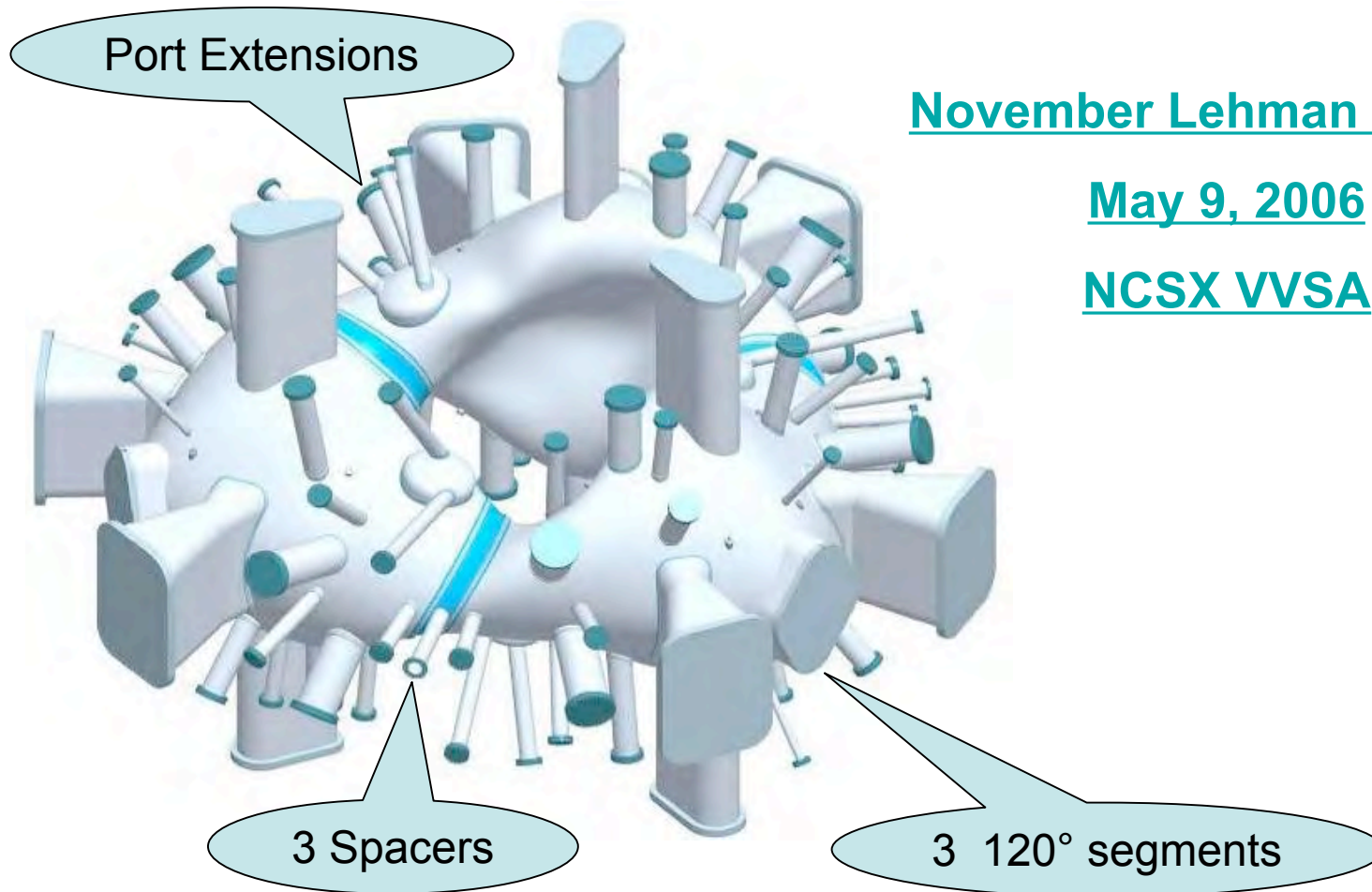


NCSX Vacuum Vessel Fabrication



Major Tool and Machine – S005243-F



November Lehman Review

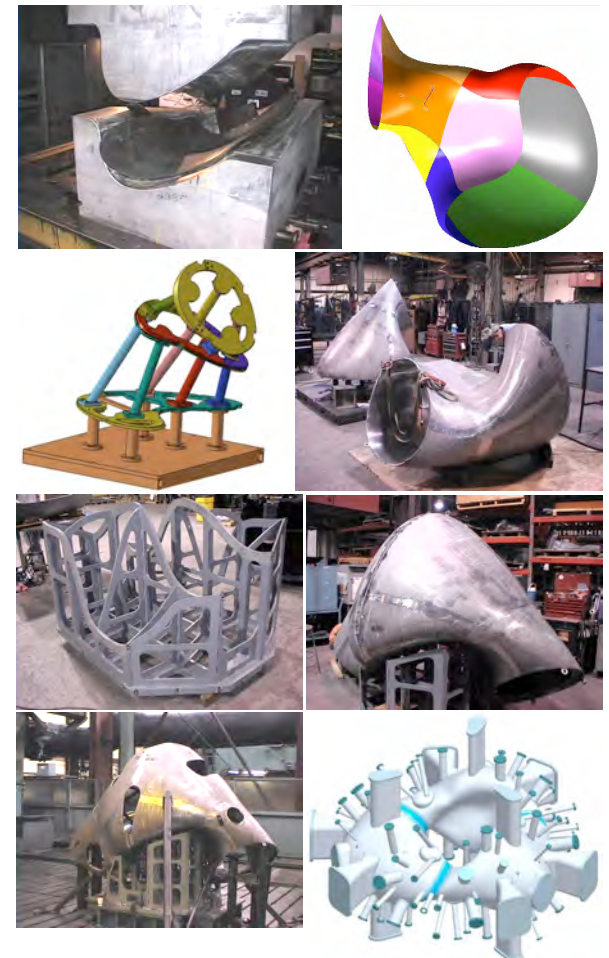
May 9, 2006

NCSX VVSA

Process



- Ten Kirksite die sets (20 total – upper and lower) cast and machined
- Ten Panels form each 60° segment
 - Press – anneal – press – local rework
- Upper and Lower 5 panel sets joined on a fixture to form ½ of a 60° segment
- Upper and lower ½ segments welded together over a collapsible welding fixture to form a 60° segment.
- 60° segments welded together on a fixture to form a 120° segment.
- Port holes bored and ports installed
- Leak checked and thermal cycled
- Ports cut off, aligned and weld prepped
- Shipped.
- Reassembled at PPPL after Modular Coils installed.



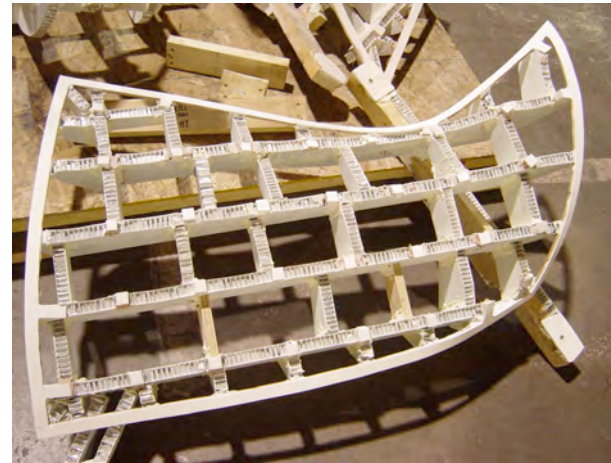
Metrology all the way



Gages for Individual panels (.090" tolerance)

Laser tracker using Verisurf® steps:

- **5 panels for 30° (.125" tolerance) 60° fixture used for reference**
- **10 panels for 60° (.188" tolerance) 60° fixture used for reference**
- **2 60° form 120° shell**
- **First best fit performed**
- **Part inverted for first full scan (including belly) reference fiducials placed on skin to transfer fiducials onto 120° fixture**
- **Install onto 120° fixture and rescan (70% surface – not including belly) using newly established 120° fiducials**
- **Install bracing and bore holes**
 - **Perform best fit of shell using 120° fiducials to lock into for leapfrogging tracker**
- **Weld ports – partial scan since ports block line of sight**
- **Vacuum test**
- **Cut off ports**
- **Disassemble and invert establish new fiducials for machining end flanges**
- **Back on 120° fixture for port verification and alignment for weld prep**
- **Final scan inverted and placed in 120° fixture for shipping**



5/9/2006

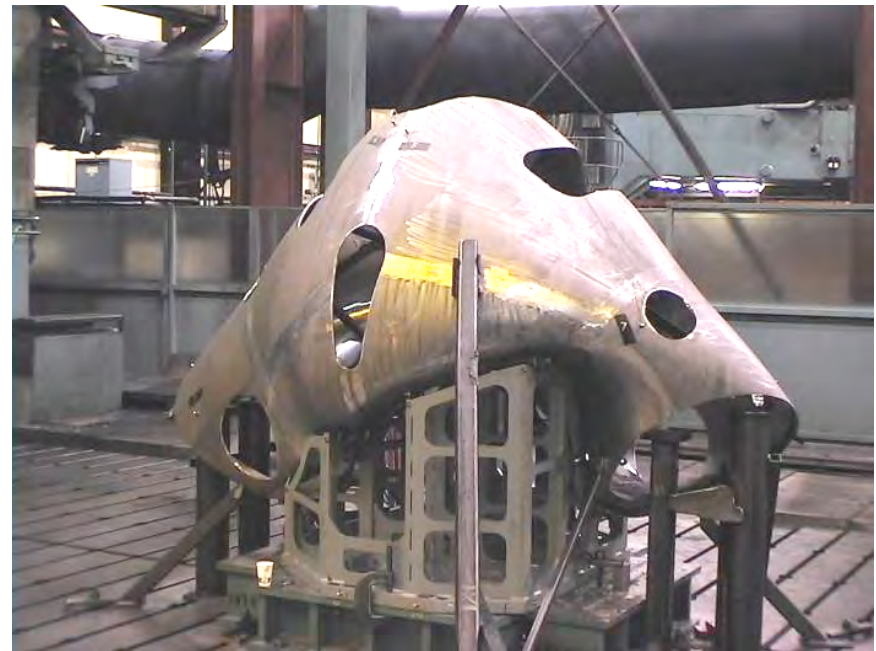
Mike Viola

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November 2005 Status

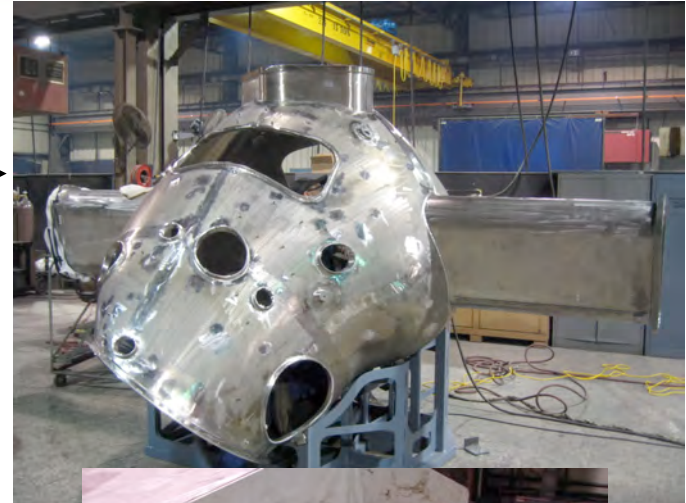


- ✓ 10 Die sets complete
- ✓ All 60 Panels complete
- ✓ 4 of 6 60° segments complete
- ✓ 2 of 3 120° segment shells complete
- ✓ Many challenges surmounted
- Port installation just beginning.



Current Status

- ✓ VVSA #1 – Nearly Complete! →
 - Passed QC examination
 - Final scan in progress
 - Data package being collated for review



- VVSA #2 →
 - Ports welded on
 - Leak check imminent
 - Ports to be cut off and weld prepped
 - Learned from VVSA #1 extra time needed to properly trim & weld prep



- VVSA #3 →
 - Ports being welded on.



Technical Challenges Have Been Overcome



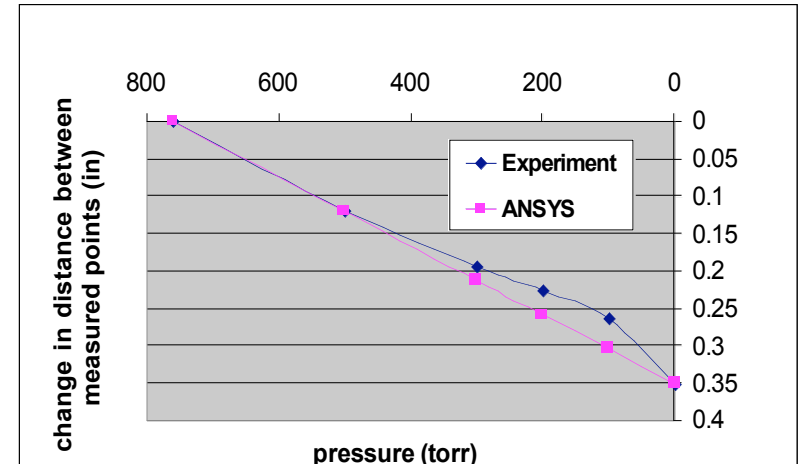
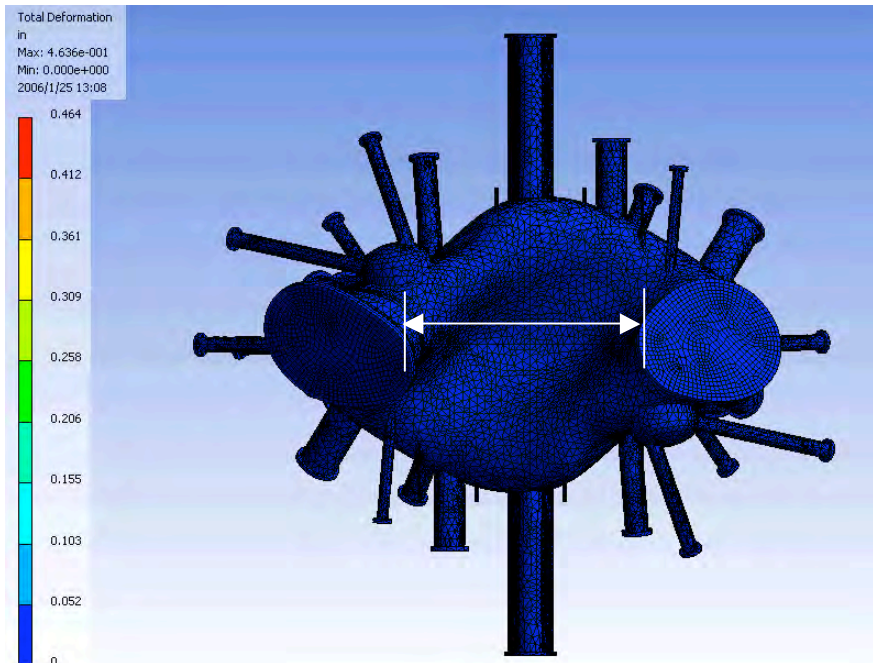
Vendor issues have delayed delivery but not impacted project schedule.

- Technical issues were carefully analyzed – extra time was needed to learn, interpret, and understand metrology results.
 - Shared in process results with NCSX team for risk determination
- The DSI was overscheduled which added several weeks of delay to the schedule.
- Every cutting and welding step requires metrology scans.
 - Cross-trained 4 additional laser operators for metrology
 - measure twice cut once
- VP of Production and Engineering agreed to apply 40-60% more manpower
 - An additional welding team has been assigned.
 - With the completion of the first VVSA, this will sufficiently augment the VVSA production to meet project schedule.
- VVSA is 9 months off of critical path.
- Level II milestone in September will be met.

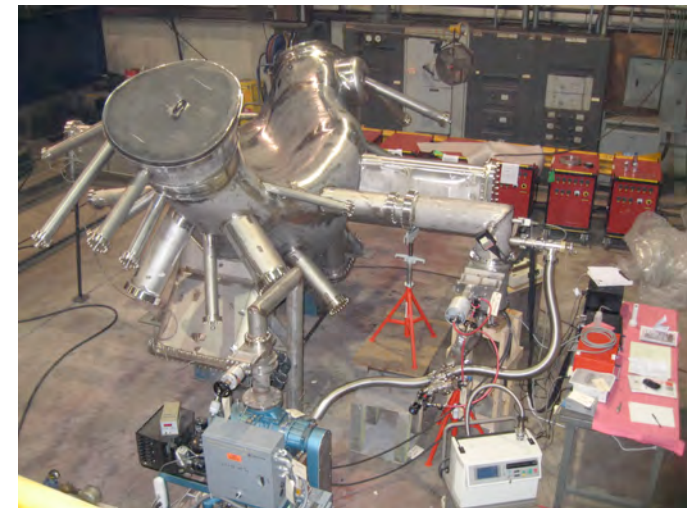
Leak check successful, deflect. confirms analysis



- No leaks detected, $P < 1e-7$ torr
- Distance between points on end flanges measured during leak test
- Deflection matches calculation (points move closer together by .35 inches)



Deflection vs pressure

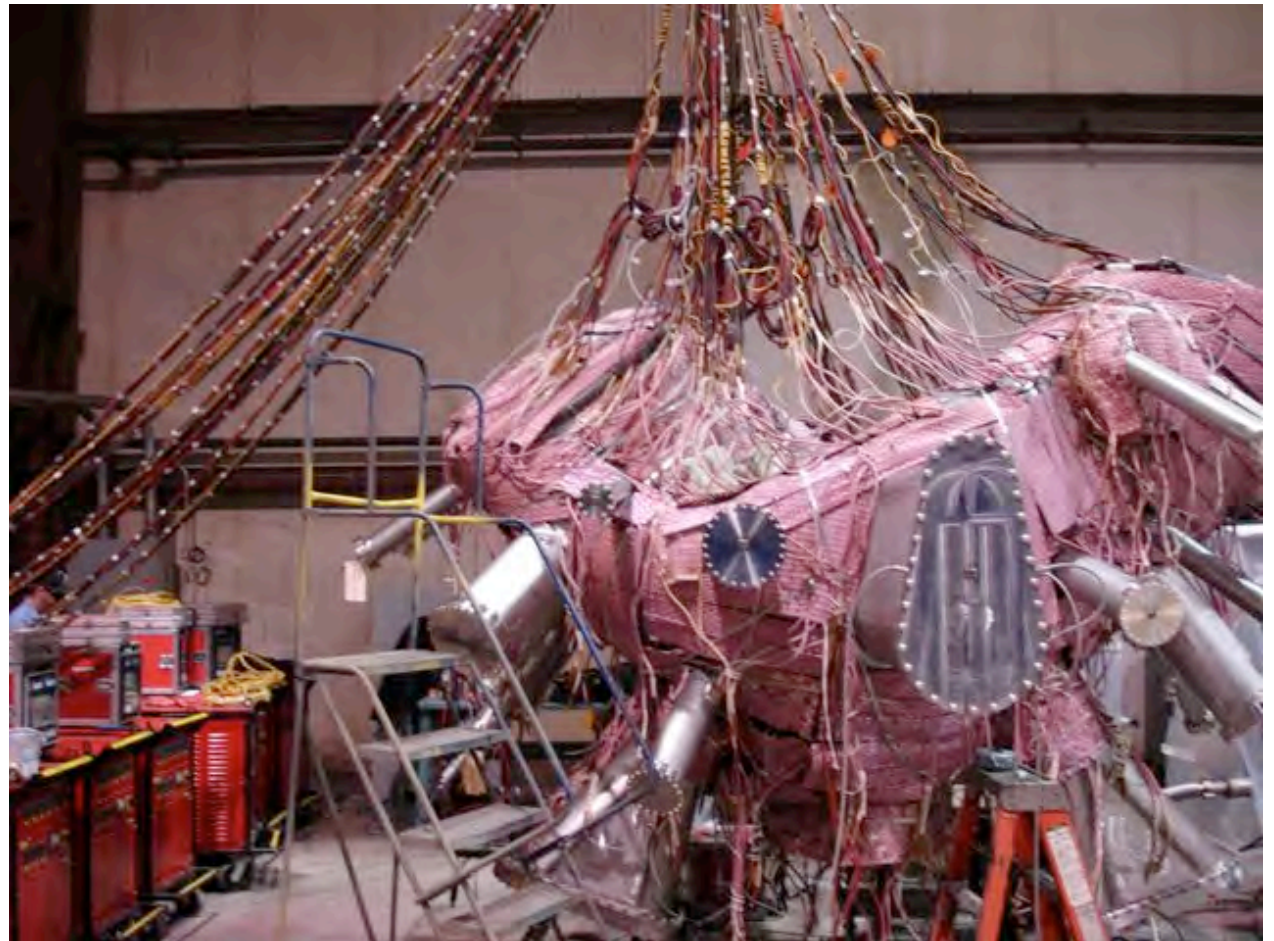


VVSA #1 during leak check

Thermal cycle qualified first VVSA



- **Thermal cycle completed successfully**
- **Further thermal cycling determined to be unwarranted**



VVSA #1 Nearly Complete!



- 8% Out of Tolerance (OOT) after shell welded

- 19% OOT after ports attached

JOB NUMBER 65678-1
 PART NUMBER VESSEL WITH PORT 12'S AND NB
 PART NAME
 INSPECTOR ED ROOT
 Probe Radius: 0.750
 Upper Tol: 0.188
 Lower Tol: -0.188

DATE: 3/16/2006

STAMP:

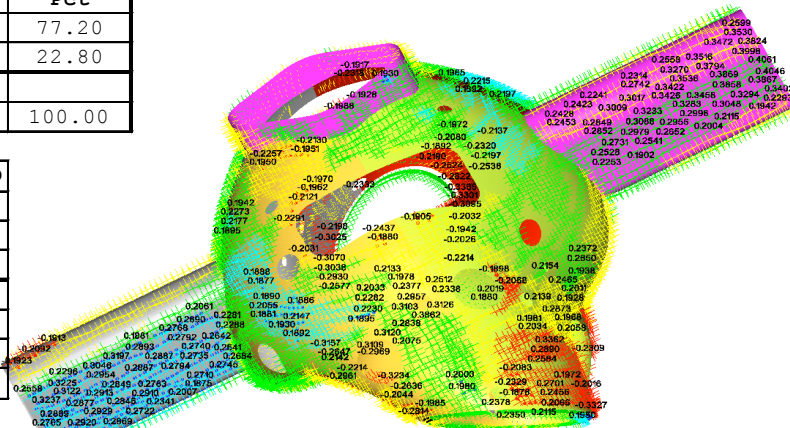
Total Points: 10998
 Number of OOT: 2508
 Average Deviation: 0.02861
 Maximum Deviation: 0.48600
 Minimum Deviation: -0.39600
 Deviation Range: 0.88200

Report Output: Actual Points

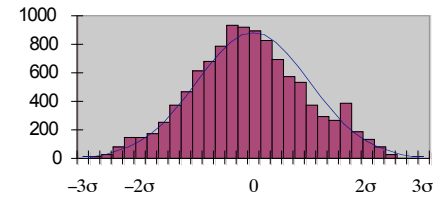
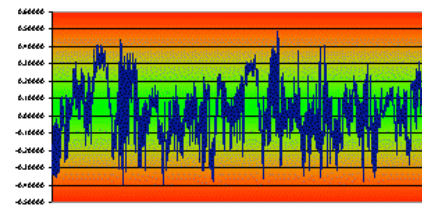
FULL SCAN - 3-14-06

	Neg	Nom	Pos	Total	Pct
In Tolerance:	3956	3	4531	8490	77.20
Out of Tolerance:	844		1664	2508	22.80
Failed Points:					
Total Points:	4800	3	6195	10998	100.00

	DX	DY	DZ	3D
Maximum Deviation:	0.3102	0.4085	0.3104	0.4860
Minimum Deviation:	-0.2723	-0.2723	-0.2723	-0.3960
Deviation Range:	0.5825	0.8084	0.6896	0.8820
Average Deviation:	-0.0076	-0.0044	-0.0006	0.0286
RMS Deviation:	0.0761	0.1069	0.0829	0.1552
Standard Deviation:	0.0757	0.1068	0.0829	0.1526



- 23% OOT after ports cut off – no encroachment on internal first wall envelope or external modular coil assembly.
- Conditions acceptable.



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VVSA #2



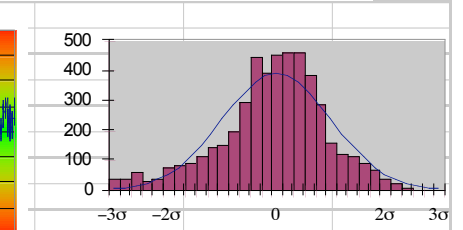
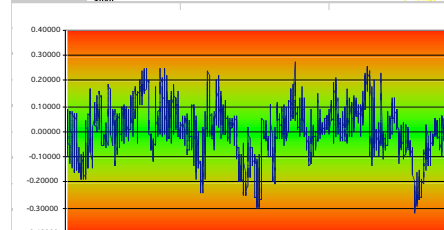
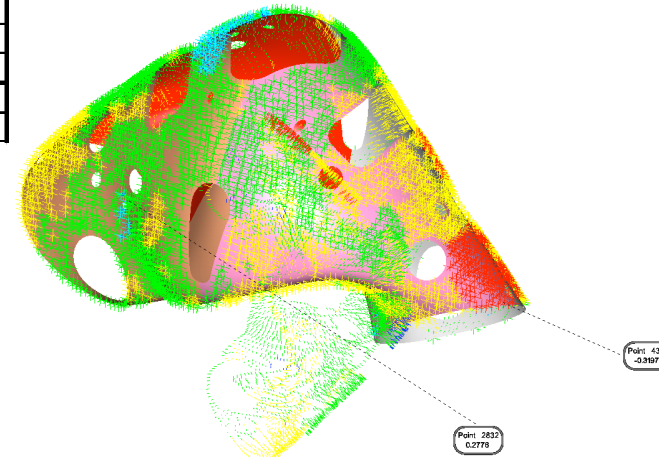
- 5.7% Out of Tolerance after shell welded.
- 8% Out of Tolerance after holes machined.

JOB NUMBER	65678/2 sub 5 OP 241	DATE:	1/16/2006
PART NUMBER	VESSEL AFTER REMOVING BRA		
PART NAME		STAMP:	
INSPECTOR	ROB DURHAM		
Probe Radius:	0.750	Total Points:	4865
Upper Tol:	0.188	Number of OOT:	380
Lower Tol:	-0.188	Average Deviation:	0.00342
		Maximum Deviation:	0.27760
		Minimum Deviation:	-0.31970
Report Output:	Actual Points	Deviation Range:	0.59730

VESSEL HALF B SKIN

	Neg	Nom	Pos	Total	Pct
In Tolerance:	1891	2	2592	4485	92.19
Out of Tolerance:	254		126	380	7.81
Failed Points:					
Total Points:	2145	2	2718	4865	100.00

	DX	DY	DZ	3D
Maximum Deviation:	0.2079	0.1319	0.2449	0.2776
Minimum Deviation:	-0.1889	-0.1889	-0.1889	-0.3197
Deviation Range:	0.3968	0.4040	0.4622	0.5973
Average Deviation:	0.0017	-0.0220	-0.0041	0.0034
RMS Deviation:	0.0573	0.0613	0.0562	0.1010
Standard Deviation:	0.0573	0.0572	0.0561	0.1009



- Tolerance conditions are improved over VVSA #1.
- Conditions acceptable.

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VVSA #3



• <1% Out of Tolerance after shell welded.

• 7% Out of Tolerance after holes machined.

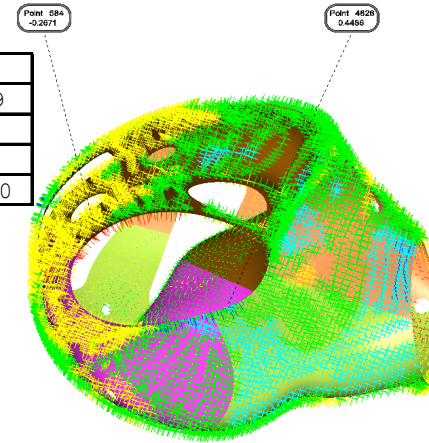
JOB NUMBER 65678/3 SUB 5 OP 241
 PART NUMBER EL SCAN AFTER PORT OPENING M2
 PART NAME
 INSPECTOR ROB DURHAM
 Probe Radius: 0.750
 Upper Tol: 0.188
 Lower Tol: -0.188
 Report Output: Actual Points

DATE: 5/2/2006

STAMP:

Total Points: 7310
 Number of OOT: 527
 Average Deviation: 0.02315
 Maximum Deviation: 0.44860
 Minimum Deviation: -0.26710
 Deviation Range: 0.71570

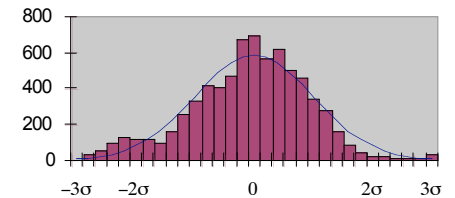
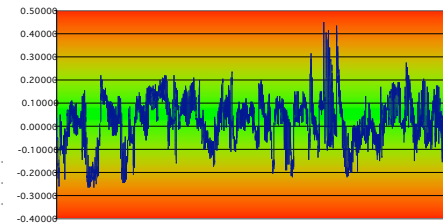
PROFILE OF VESSEL



	Neg	Nom	Pos	Total	Pct
In Tolerance:	2375	3	4405	6783	92.79
Out of Tolerance:	284		243	527	7.21
Failed Points:					
Total Points:	2659	3	4648	7310	100.00

	DX	DY	DZ	3D
Maximum Deviation:	0.1930	0.2099	0.1834	0.4486
Minimum Deviation:	-0.1731	-0.1731	-0.1731	-0.2671
Deviation Range:	0.3661	0.5611	0.4876	0.7157
Average Deviation:	0.0059	-0.0195	-0.0065	0.0232
RMS Deviation:	0.0564	0.0578	0.0675	0.1053
Standard Deviation:	0.0561	0.0544	0.0672	0.1027

• Conditions acceptable.



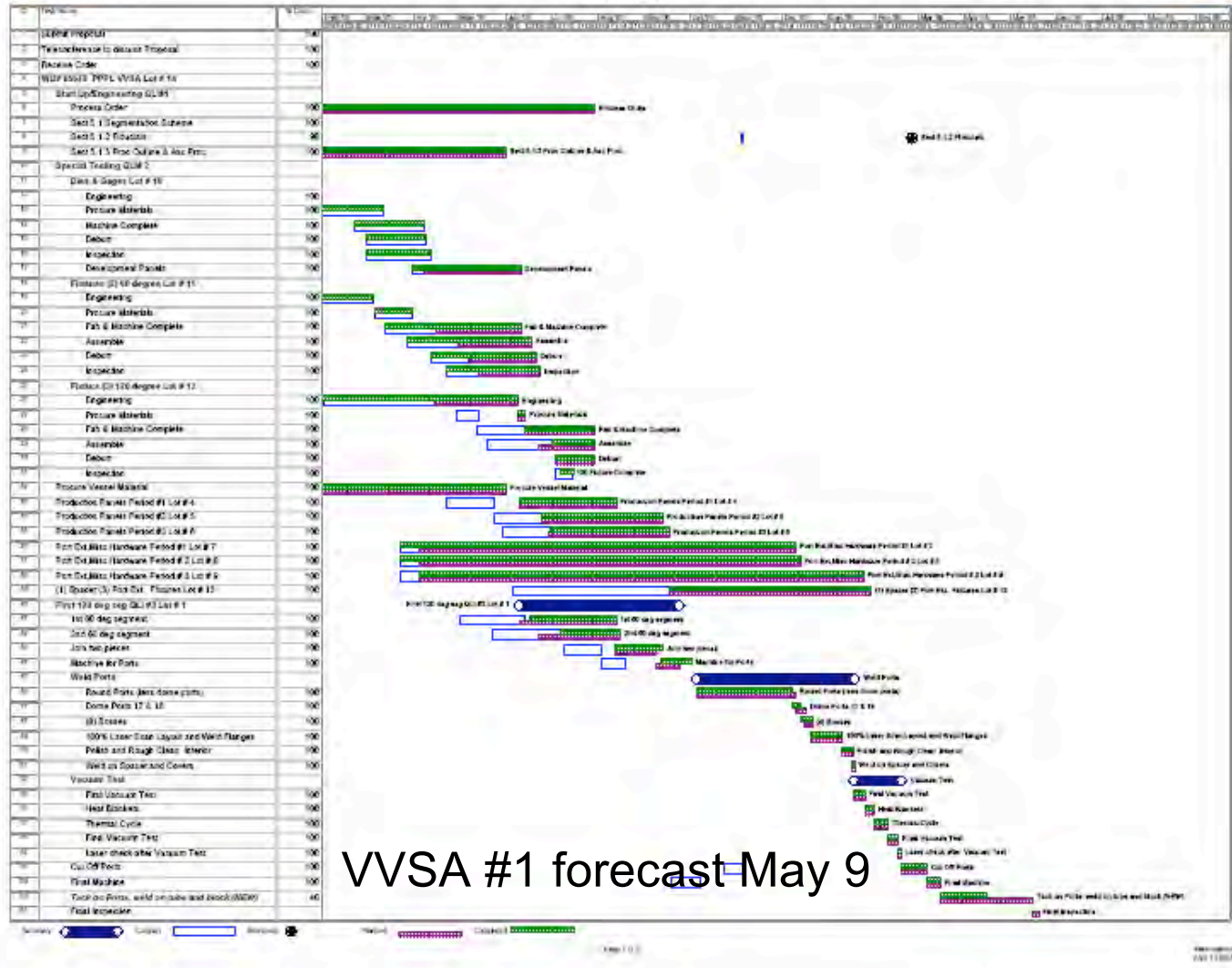
Current Status



NCSX VVSA for PPPL
Subcontract 3009043-F
HTM YV0456575



- ✓ A tremendous amount of work accomplished
- ✓ Learning curves mastered
- ✓ Contract is 77% complete
- ✓ VVSA #1 delivery Imminent!

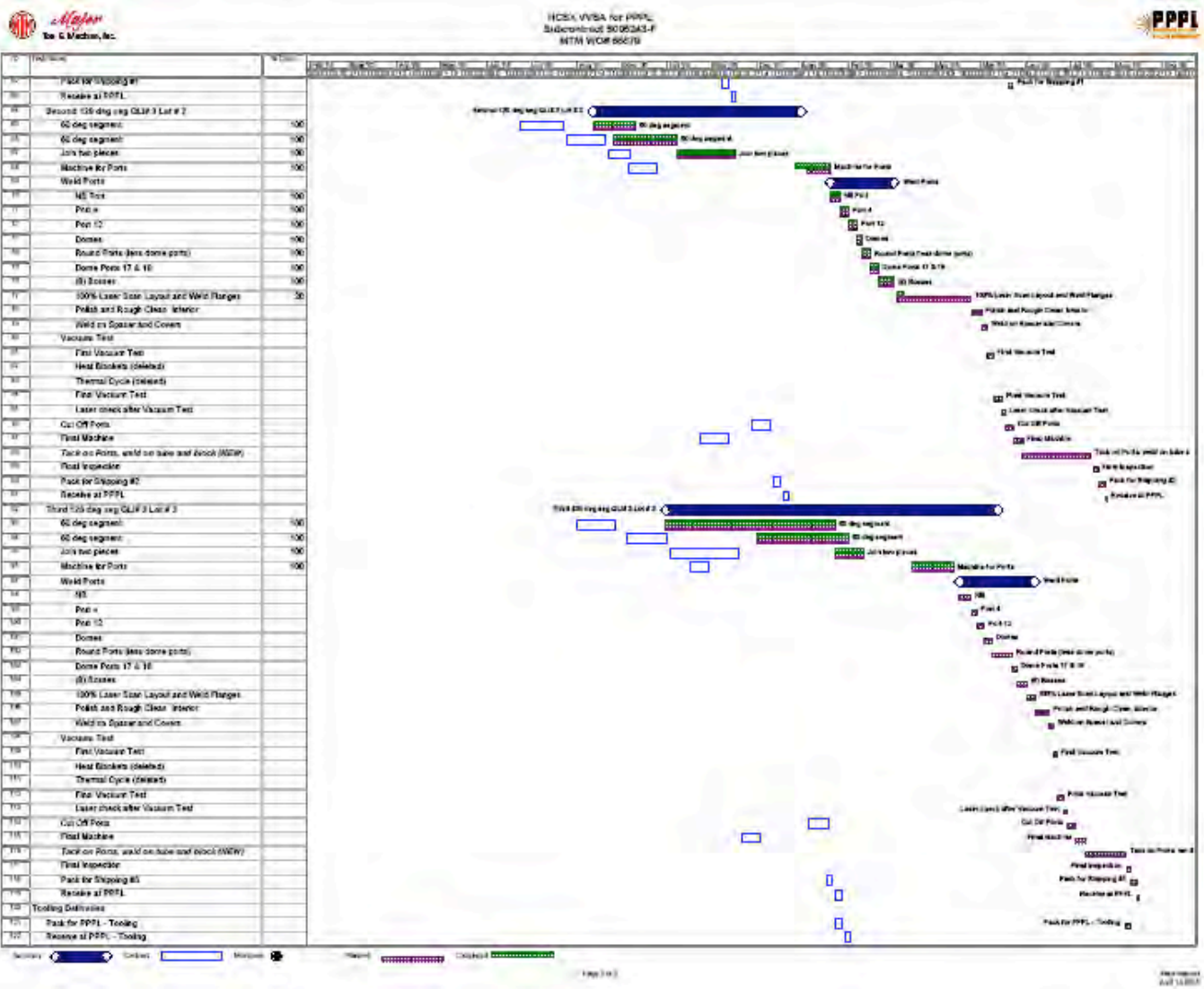


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Current Status



✓ VVSA #2 is on the home stretch – expected July 25.

✓ VVSA #3 right behind – to arrive by FY end.

Cost and Schedule



- As mentioned, Major Tool has placed additional resources on the VVSA contract to meet delivery schedule.
- November '05 Subcontract price was \$5,006,228. The current price is \$5,024,728 which was increased by \$18,500 to purchase new end covers
 - SS covers substituted for Inconel covers at contract signing for cost savings.
 - SS end covers had too large a difference in thermal expansion coefficient.

SUMMARY



- VVSA will meet project milestones.
- An additional welding team has been assigned and 4 more laser operators qualified for the VVSA contract to bring schedule back into acceptable delivery.
- Major Tool has mastered the techniques for fabricating the VVSAs. No further challenges are anticipated. The first VVSA fabrication is complete!
- We have purchased a Verisurf license to read and interpret the data directly.
- Risks continue to be actively managed – communication and feedback is excellent.