NCSX

Follow-up Analysis performed on the FPA Station 3 following its FDR

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Prepared By: Tom Brown Digitally signed by Tom Brown DN: cn=Tom Brown, c=US, o=PPPL Reason: I am the author of this document Date: 2007.08.03 17:46:13 -04'00' ______________________ T. Brown (Tooling Design WBS Manager)

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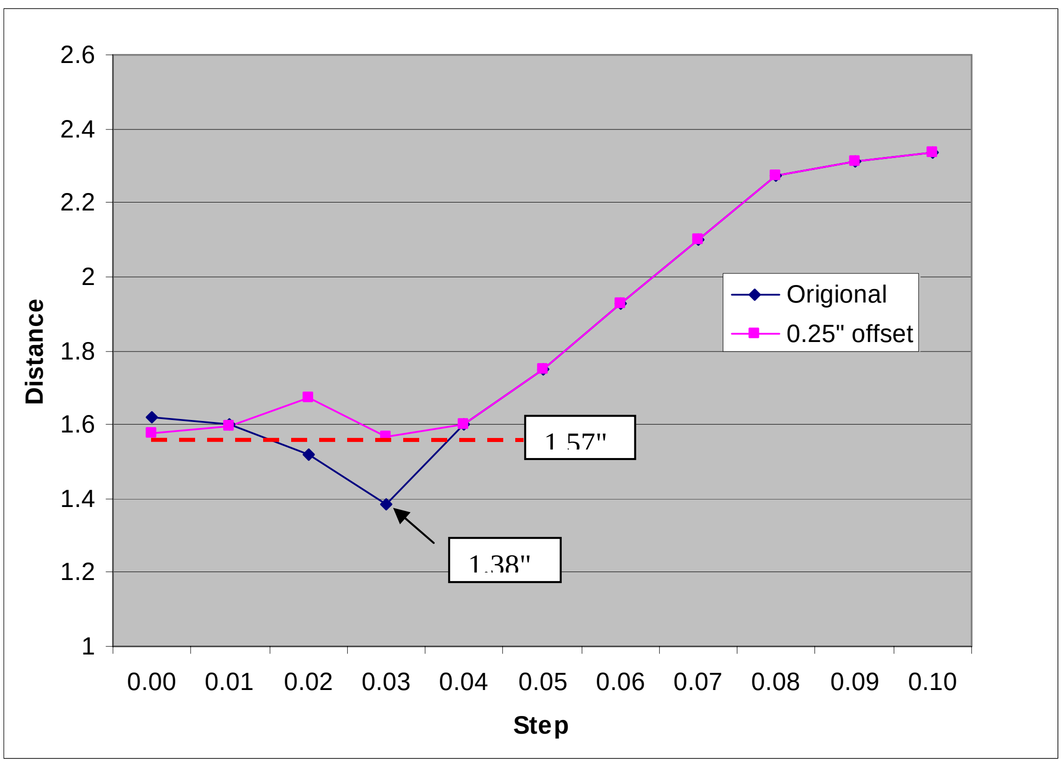
Executive Summary:

A number of issues were raised at the Station 3 FDR. Results of a MCHP / VV assembly simulation and structural analysis used to resolve these issues will be document in this report. Revising the MCHP path in the last four assembly steps has increased the VV / MCHP clearance from .34” to .57”. FEA analysis of the Station 3 vacuum vessel assembly fixture support was performed to verify the adequacy of the design in supporting a vessel against an external lateral load of 1000 lbs. A peak stress of 14 ksi was found at the vacuum base support bolts, resulting from a combined bending and compression load.

Increasing MC / VV Assembly Space

The VV assembly path was revised for the last four steps of the installation path, shifting the vessel outward 0.25”. The interference simulation run looking at the clearance between the VV and MC winding surfaces is show below. The minimum clearance space between the CAD defined clamp surfaces and the vessel components was increased from 0.38” to 0.57”. The graph below shows the clearance to the VV CAD surface. One inch of VV component space has been allocated as the maximum distance a component can be off the vessel surface. In practice the maximum component surface offset measured is 7/8”. This increases the minimum clearance to .695”; however, actual as-built clamps need to be measure at all close interfacing areas to obtain a final as-built clearance space. The clamp measurement activity is planned. Additional simulation runs could not increase the clearances.



VV Impact Load Calculation

Art Brooks made a (hopefully conservative) estimate of the collision between the MCWF (25000#) and the VV (? 6000#). Using a 1 in/s velocity of the MCWF (based on the Crane max speed) the velocity of the lighter vessel would be ~1.6 in/s after colliding elastically. He calculated a lateral spring constant of ~30 Kips/in for just the port 12 leg (which should be more representative) from the ANSYS model based on 1000# force and .032" deflection. Together this leads to an estimated collision force of 1090 lbs, not far from a 1000 lb earlier estimate that was assumed.

Elastic Collision between two bodies
(Assumes Head on or Central Collision between two bodieds A & B)

		Before	After	
Mass	ma	25000	25000	lbm
	mb	6000	6000	lbm
Velocity	va	1	0.612903	in/s
	vb	0	1.612903	in/s
	va-bv	1	-1	Check

Spring-Mass Energy Transfer

K	29411.76	lbf/in			
M	15.52795	ft-s^2/in	6000	lbm	(using m=f/a)
V	1.612903	in/s			
F	1089.999	lbf			

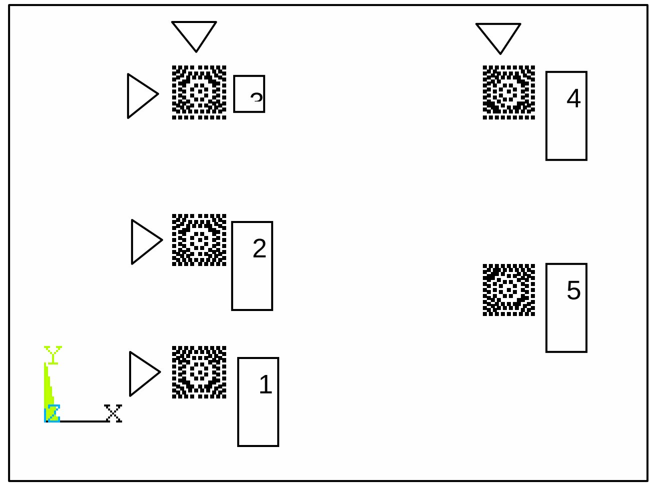
A follow-up calculation was made using revised numbers for the weight of the VV and MCHP's. An assumed VV weight (4431 lbs) based on CAD model data was used. This weight includes no ports except for the NB and vertical ports. It has all the services on the vessel plus a 5% weight contingency factor. Rerunning Art's analysis changes the impact load to 987 lbs from 1090 lbs....not that much of a change. Also the MCHP weight based on the same CAD analysis as was used in defining the 4431 lb VV weight is 22800 lbs. If the 22800 lb MCHP weight is used in conjunction with the 4431 lb VV weight the resultant impact load is 972 lbs.

Reaction Loads at MCHP Supports

The spreadsheet below shows the reaction loads at the Hilman rollers for the Modular Coil HP Support with gravity loads (25,000 lbs). The largest value is just under 10,000 lbs. Each of the five Hilman rollers are 8 ton units.

Stage 3 Modular Coil Supports
Reaction Loads at Base (Hilman Rollers)
Gravity Loads Only

	Reaction Load, lbs		
	Fx	Fy	Fz (Vertical)
1	-75.4	0.0	120.6
2	-181.2	0.0	9786.9
3	256.6	-166.9	1044.9
4	0.0	166.9	1086.3
5	0.0	0.0	8723.6
Total	**0.0**	**0.0**	**20762.3**



From ANSYS Model support-half2.db

Review of VV Lateral Support Response

The analysis of the vacuum vessel with lateral load acting on it was made using a FEA model (see Figure 4.1) that included the vertical and horizontal ports along with a simplified representation of the VV shell, mimicking the vessel weight and CG location. For the condition of the vessel gravity load plus 1000 lb lateral load resulted in a high stress of 14 ksi occurring in one of the three threaded studs that are used to anchor the base support to the floor.   The studs are 1-3/4” grade B7 alloy steel with 125 ksi ultimate and 105 ksi yield stress, providing a 41.7 ksi allowable (1/3 Sult).

Stage 3 VV Support Stress Analysis
Gravity + 1000# Lateral Load - Mechanica

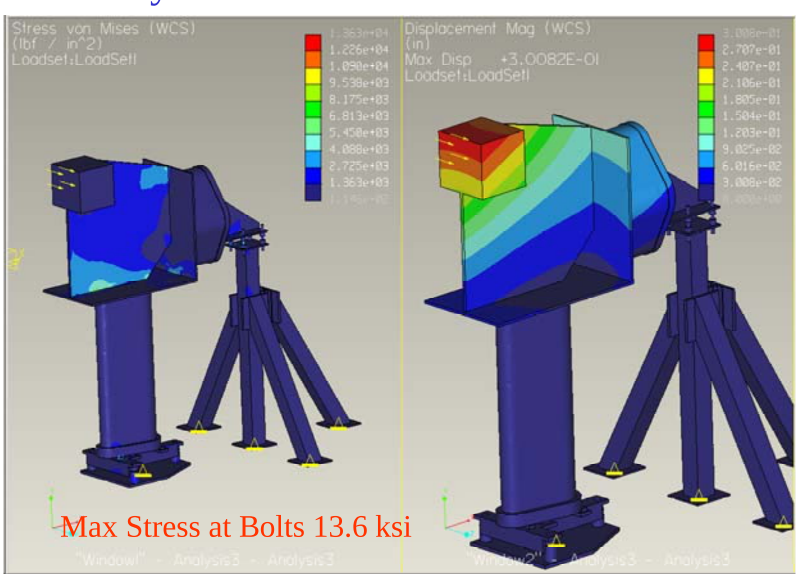


Figure 4.1   Mechanica FEA analysis of VV support

A confirmatory analysis was made on the same model using ANSYS and the same maximum bolt stress was determined (see Figure 4.2 below). The local peak stress is shown in figure 4.3.

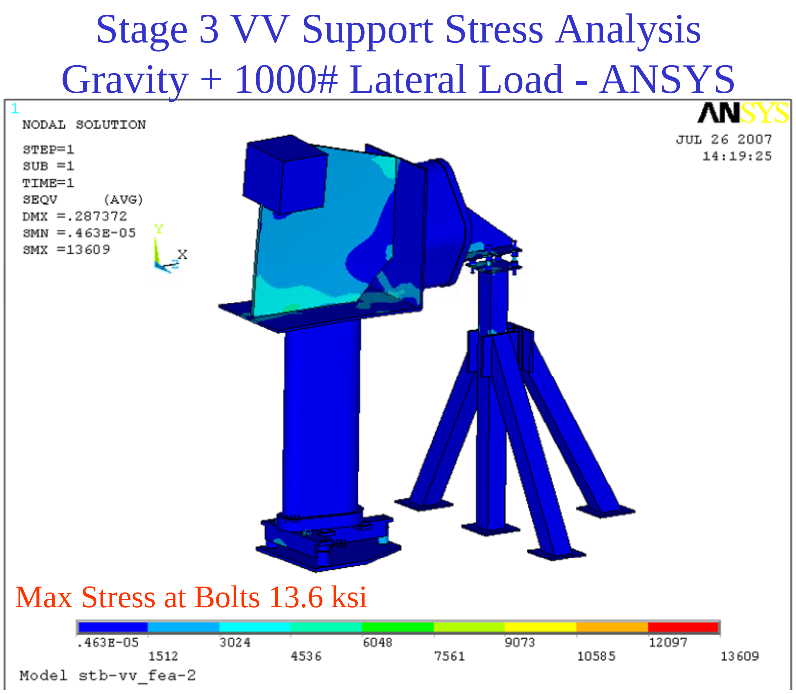


Figure 4.2 ANSYS FEA analysis of VV support

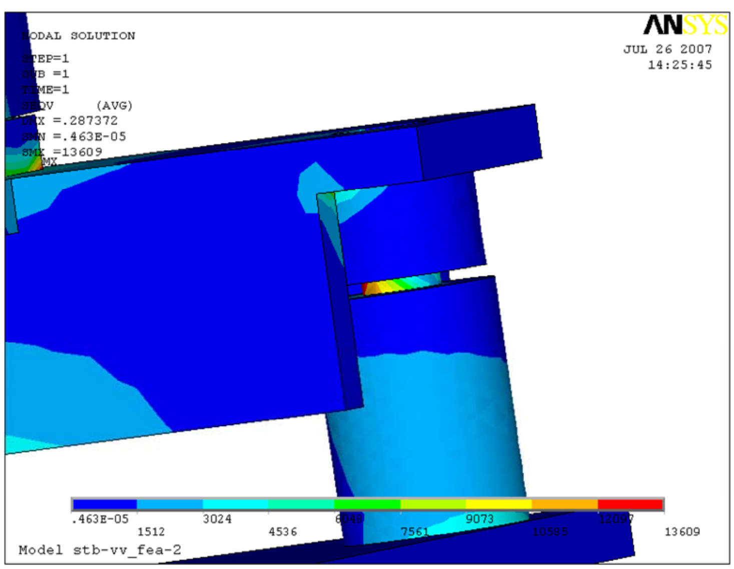


Figure 4.3 ANSYS FEA analyses showing the local peak stress