

Analysis of the NCSX VV Turning Fixture Supports

An FEA analysis of the NCSX Vacuum Vessel assembly fixture support was performed to verify the adequacy of the design. Figure 1 shows the support and vessel shell model used in the analysis. The support structure weldment is comprised of 4" x 4" x 1/4" thick wall and 4" x 6" x 1/4" thick box beams of A36 steel. The base plates, mounting plates, and axel cradles and ribs are also fabricated from 1/2" thick A36 steel. The base plates are anchored to the floor with (6) 1/2" dia. steel bolts into Hilti concrete anchors in 4000 lb concrete. The supports were modeled with standard 8 & 6-node brick elements (CHEXA & CPENTA) in Nastran. The density of the vessel was increased by 30% to account for the additional weight of the heating and cooling tubes and closure end plates, producing a total assembly weight of 5079 lbs. The boundary conditions applied translation fixity in the three principle orthogonal directions at the 6 anchor bolt locations on the lower surface of each the base plate. A 1-G gravity acceleration (386.4 in/sec²) was applied in the negative X direction.

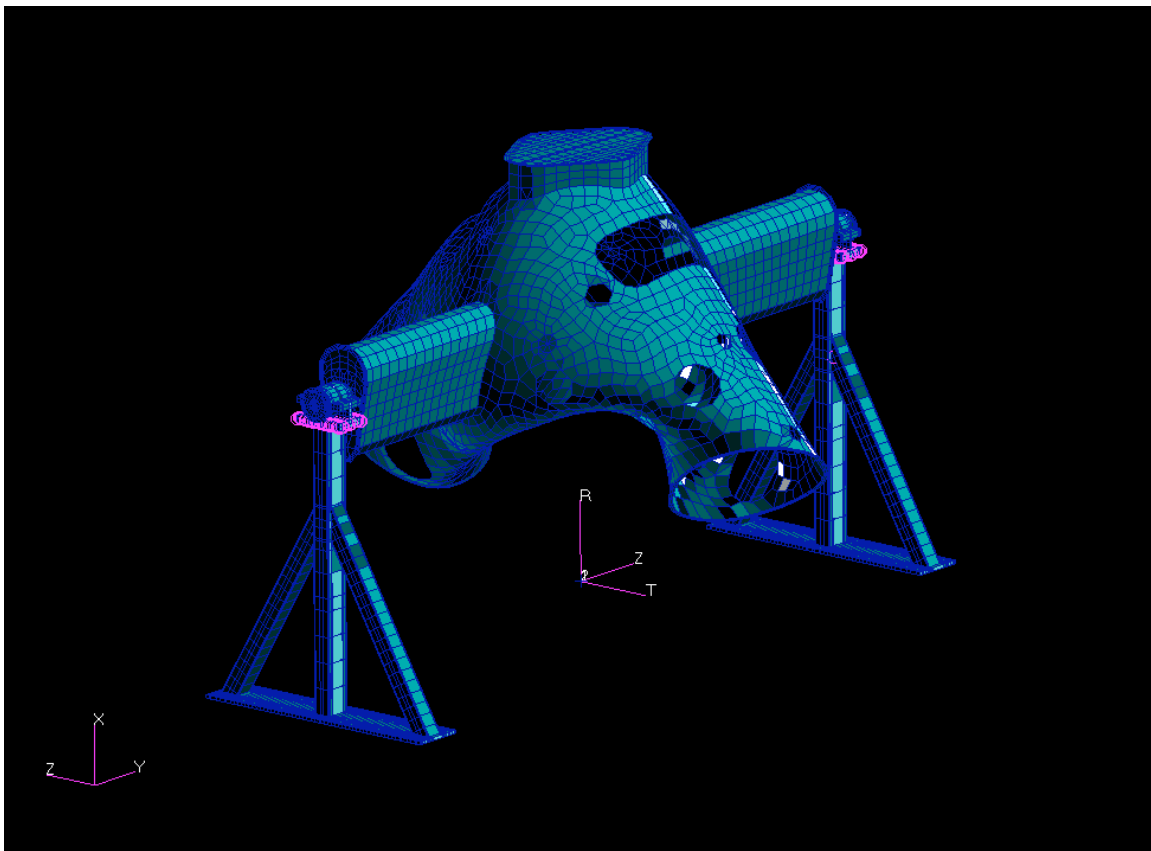


Figure 1. FEA Model of the V.V. Assembly Support Fixture

The displacement contours of the linear analysis are shown in figures 2 & 3. Figure 2 is the SRSS displacement contour plot and shows a maximum displacement of 0.067" at the vessel shell end perimeters. This result would be somewhat less if the stiffness of the closure end plates were included in the model.

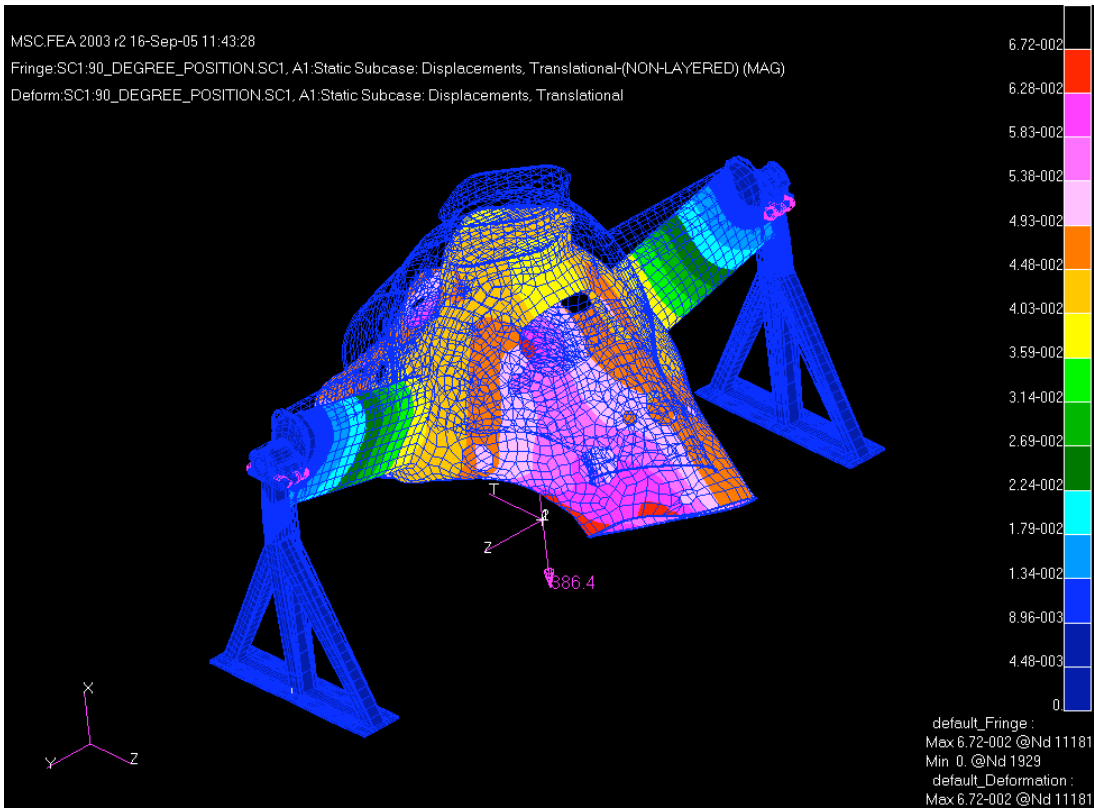


Figure 2. Displacement magnitude (SRSS) of the assembly due to a 1-G gravity loading.

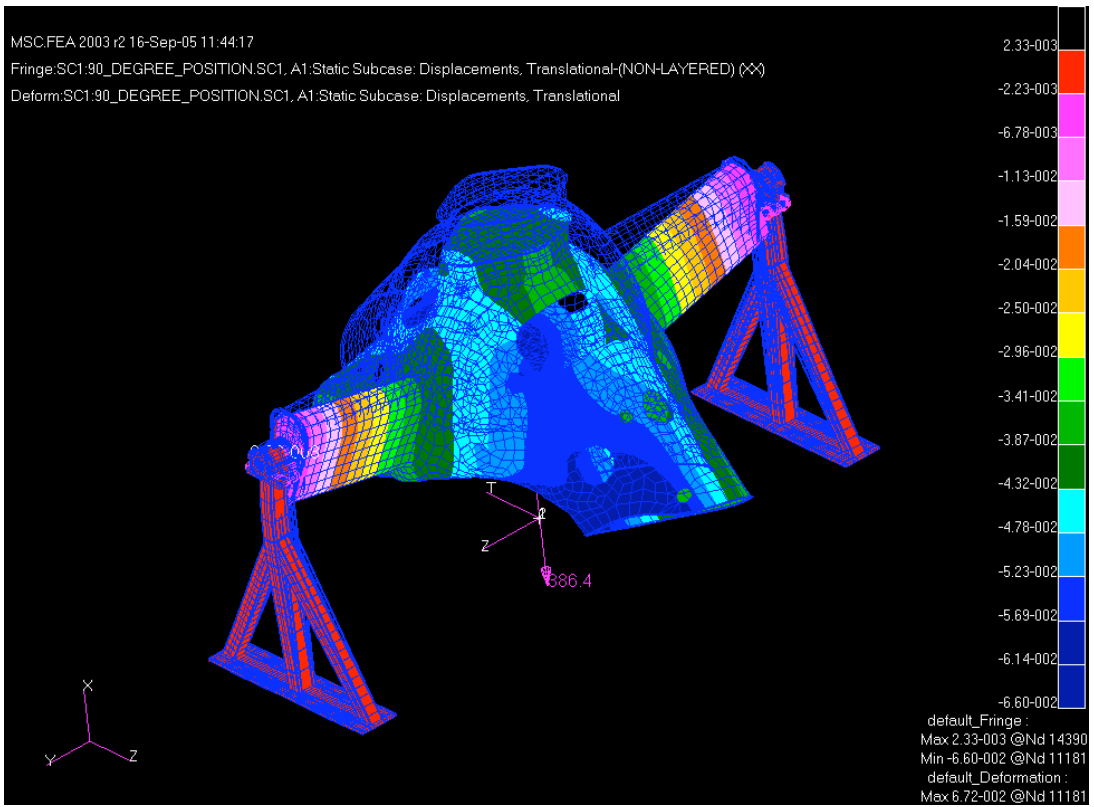


Figure 3. Vertical Displacements Due to a 1-G gravity loading

Figure 3 shows the vertical (X-direction) displacement contours with the maximum of 0.066" again at the outer end portions of the vessel shell. Figure 4 below is a contour plot of the Tresca stresses in the assembly. The peak stress of 5.1 ksi occurs at the trunion/cradle location as seen in detail in figure 5.

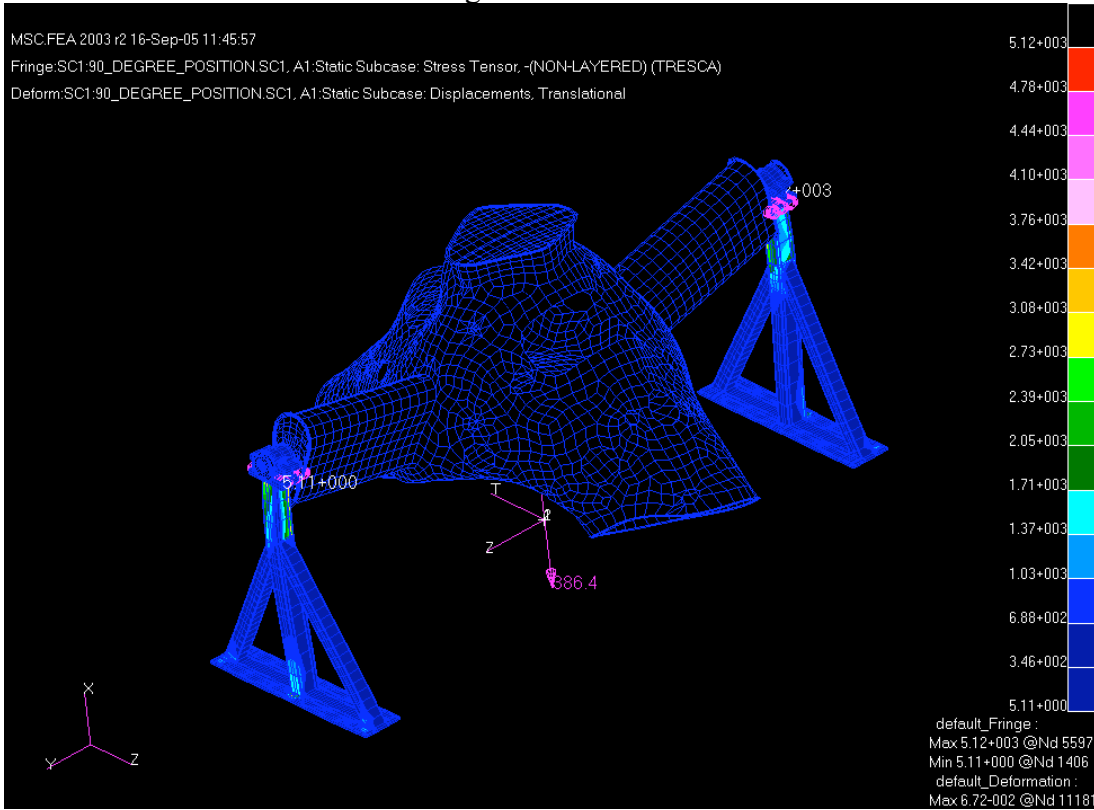


Figure 4. Tresca stress contours due to a 1-G gravity loading

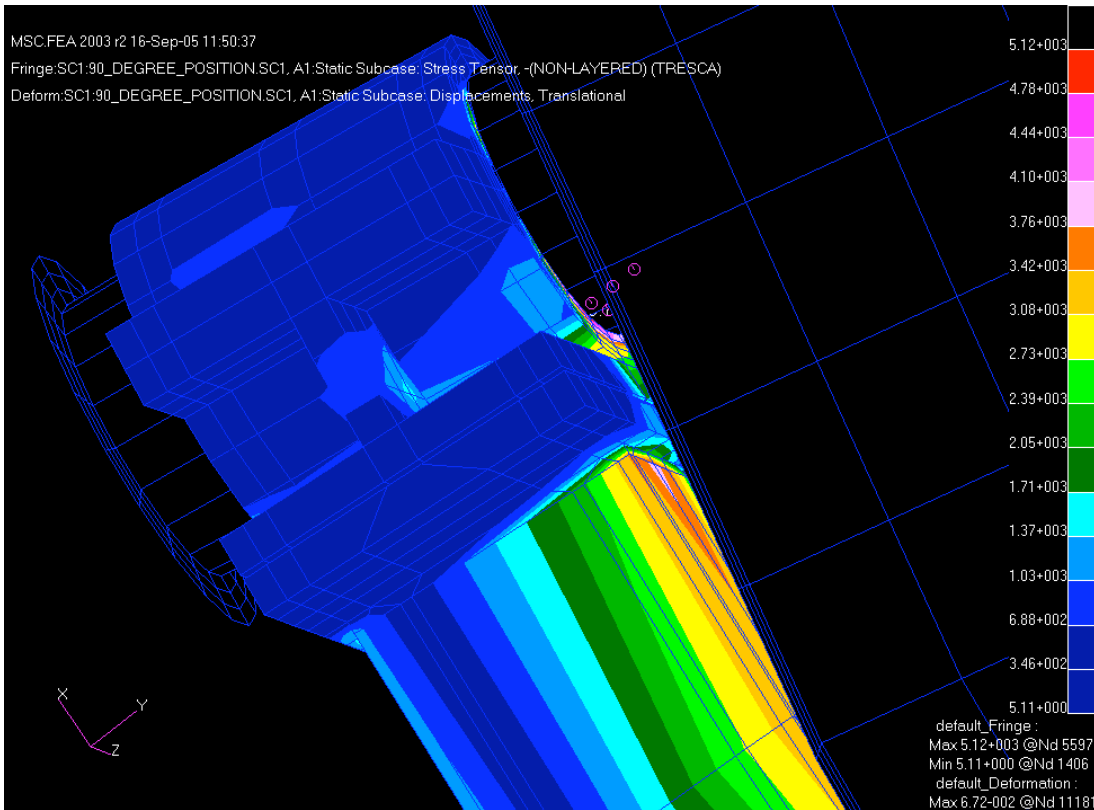


Figure 5. Location of the peak Tresca stress in the area of the cradle- trunion interface

Figure 6. shows a contour plot of the Major Principle Stress in the support assembly. The maximum principle stress is seen to be 3.3 ksi at the cradle/mounting plate weld.

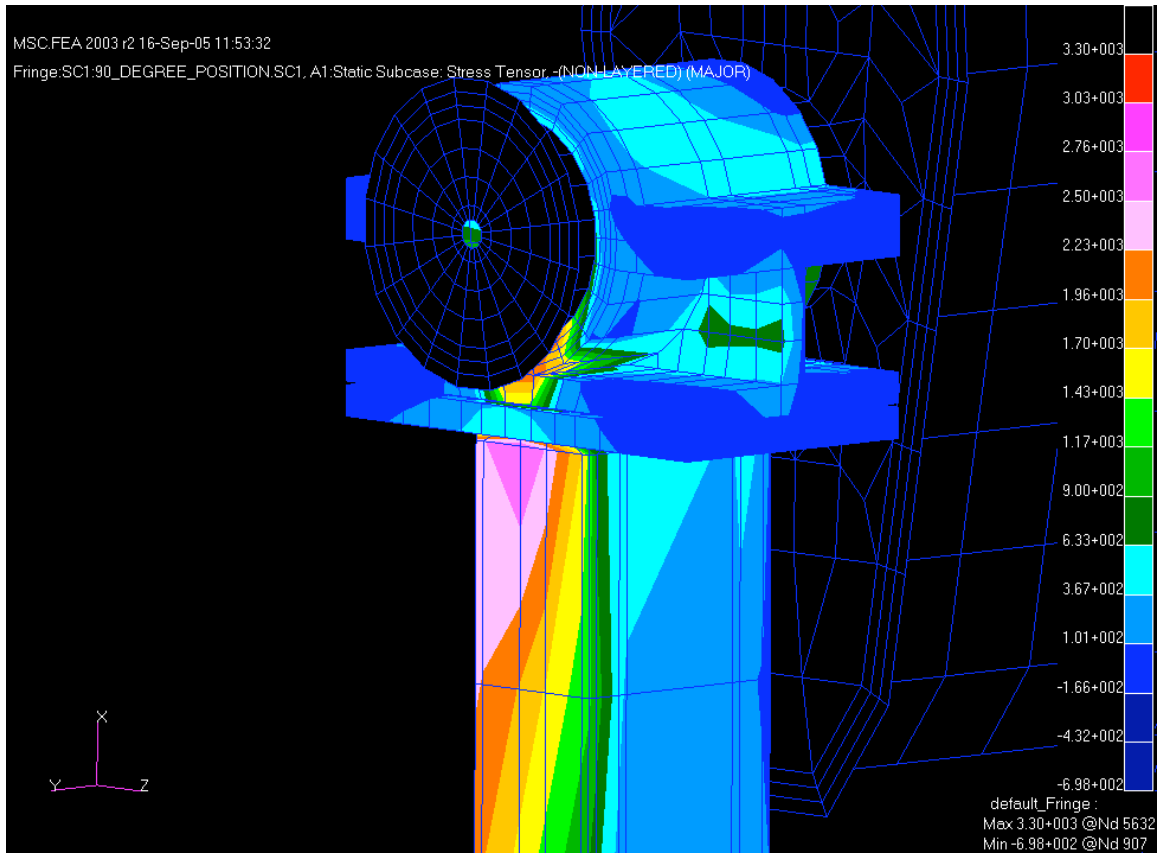


Figure 6. Contours of the Major Principle Stress in the supports

Discussion & Conclusions:

The vessel assembly fixture support weldment exhibits relatively small deflections and the calculated stress levels are well below AISC allowables for mild structural steels. The margins are greater than 4x in all portions of the structure and are adequate for the purpose intended. ASTM minimum values for A36 structural shapes are 36 ksi yield and 58-80 ksi tensile. The ASIC minimum allowable for bending and tension for A36 structural box shapes is $0.55 S_y = 19.8$ ksi in tension or 16.6 ksi in bending.