Powertech
REPORT

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Finite Element Analysis
Hydrogen Trailer Frame for Quantum Cylinders
DOT Permit DOT-SP 13173

Prepared for: Sandia National Laboratories **Project Number:** PL-00742
Project: Hydrogen Station Equipment Performance Device (HyStEP)
Report Number: TR00742-01-R01

OBJECTIVES

To determine if the cylinder rack attached to the trailer can withstand the designed impact loads stipulated by the standard DOT-SP 13173 (7th Rev.)

COMPUTER MODELS

- Software package SolidWorks – Simulation 2015 was used.
- The rack frame was modeled as a 3-dimensional frame using 3-D beam elements as shown in Figure 1 as per the design drawing. The joints were modeled as fixed connection (6 DOF are fixed). The welds are not modeled in detail assuming the welds are solid steel.
- The cylinders (3 in total) were not modeled but their weights were considered for calculation of the impact loads.
- The explosion proof box was not modeled but its weight was considered for calculation of the impact loads
- Each cylinder is weighted 51 kg.
- ASTM A500 Steel was applied to the steel members
- Based on the actual mounting arrangement the translation boundary conditions were used to model the connections between the rack and trailer. Figure 2 shows the details of the boundary conditions.

LOAD CASES

As per the standard the following four load cases were considered:

1) Eight times the weight of the assembly (rack and cylinders) applied in vertical direction
2) Eight times the weight of the assembly (rack and cylinders) applied in transverse direction
3) Eight times the weight of the assembly (rack and cylinders) applied in longitudinal direction
4) A static force of seven times longitudinally, three times laterally and three times vertically, the weight of the assembly applied simultaneously

ANALYSIS RESULTS

Finite element analysis was performed for each of the load cases. The maximum stresses and displacements are summarized in Table 1. It can be seen that for all the load cases none of the steel members are over stressed against the steel yield strength of 315 MPa. Figures 3 to 10 illustrate under the design impact loads how the rack would deform schematically (scaled factors vary from 50 to 100) and the corresponding distribution of axial and bending stress. Based on the results it can be concluded that under the design impact loads stipulated by the standard the cylinder rack is structurally sound in terms of strength and stiffness.

Prepared By:	Approved By:
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Date: 2015/12/14	

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TABLE 1 - Summary of the results

Load case	Max. Stress (bending + axial) (MPa)	Maximum displacement (mm)		
		Longitudinal (Z)	Transverse (X)	Vertical (Y)
Longitudinal	95	2.83		
Transverse	130		3.76	
Vertical	39			0.37
Combined	101	2.76		

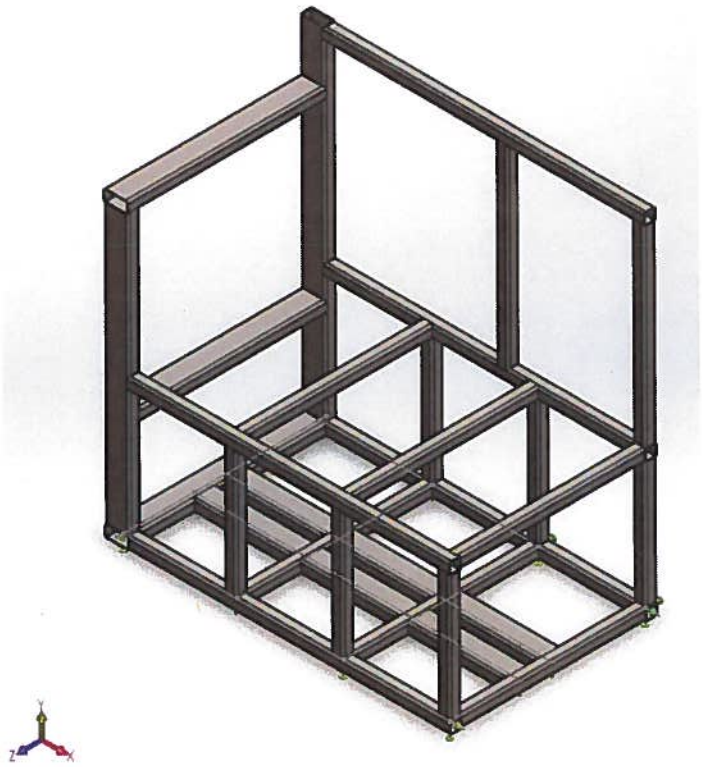

Figure 1: Finite Element Model of the Cylinder Rack

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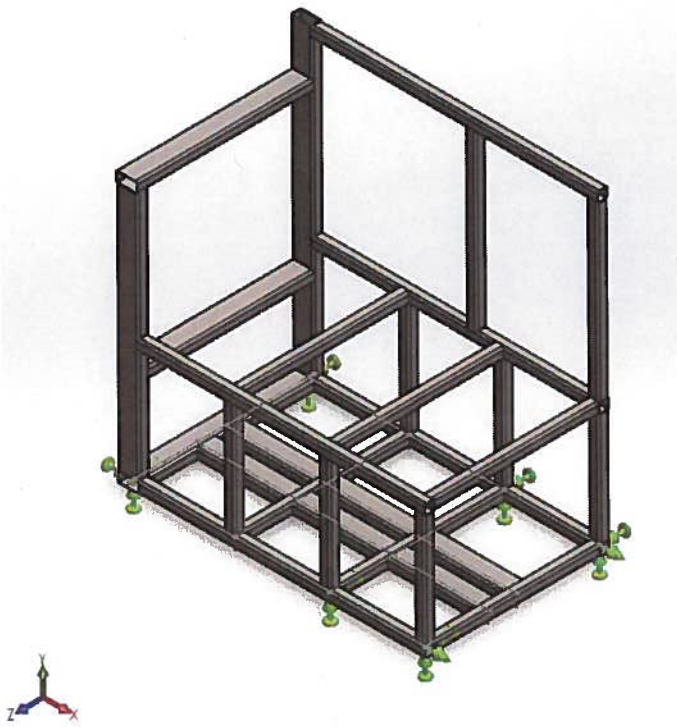

Figure 2: Illustration of boundary conditions

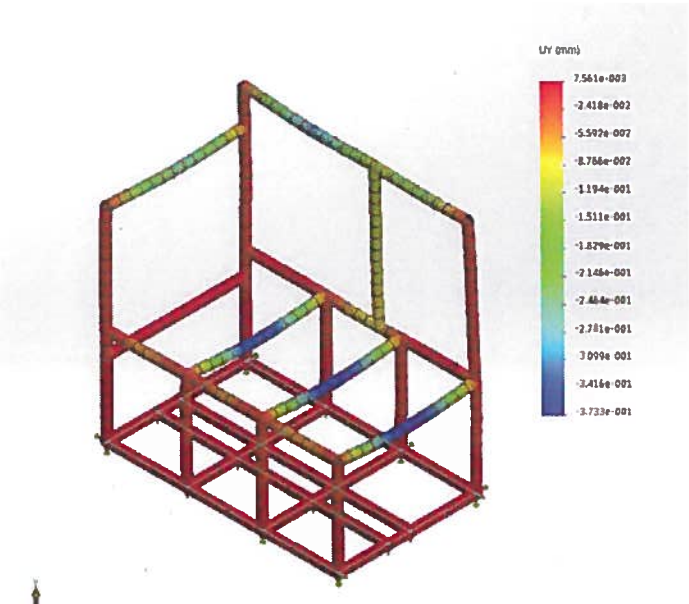

Figure 3: Deformation under load case 1 - vertical load (scaled 100 times)

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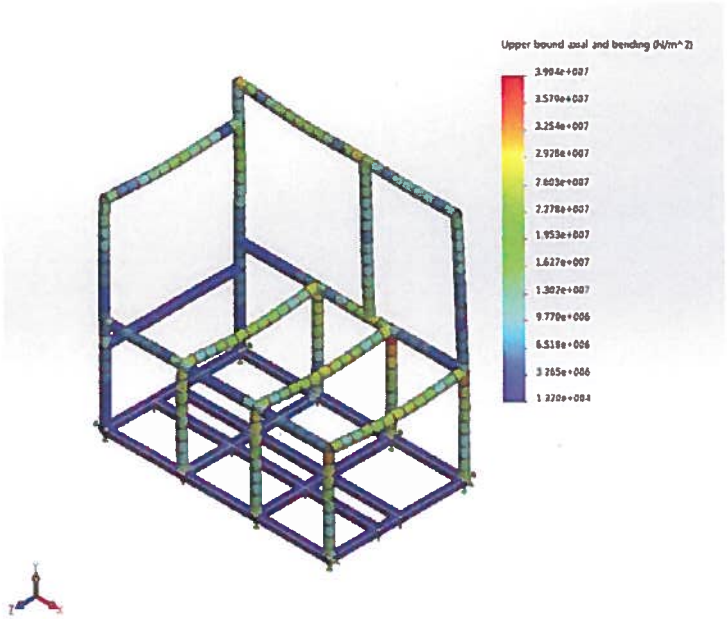

Figure 4: Axial and Bending Stress (N/m2) under load case 1 – Vertical load

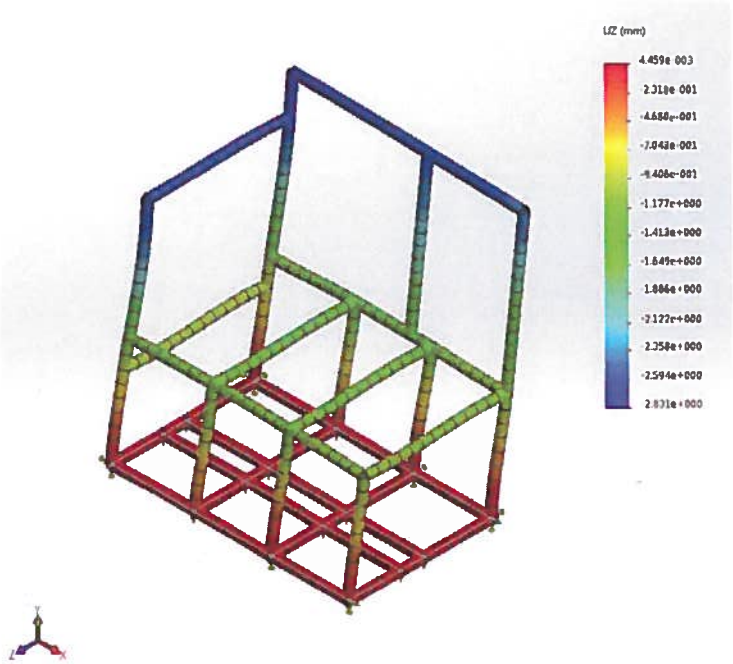

Figure 5: Deformation under load case 2 - longitudinal load (scaled 100 times)

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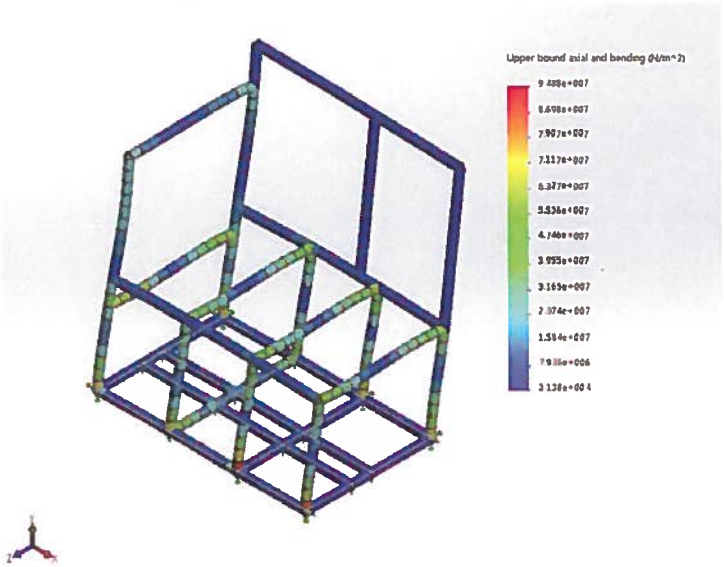

Figure 6: Axial and Bending Stress (N/m2) under load case 2 – Longitudinal load

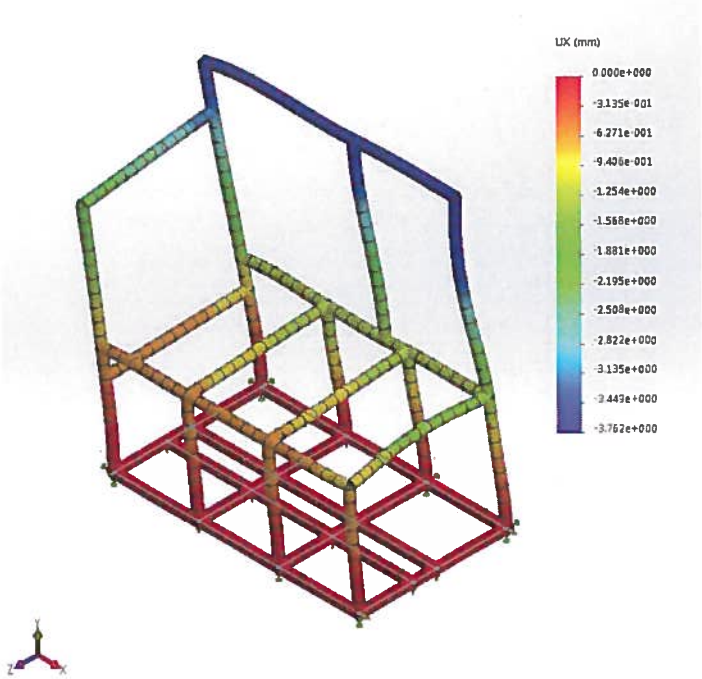

Figure 7: Deformation under load case 3 – Transverse load (scaled 100 times)

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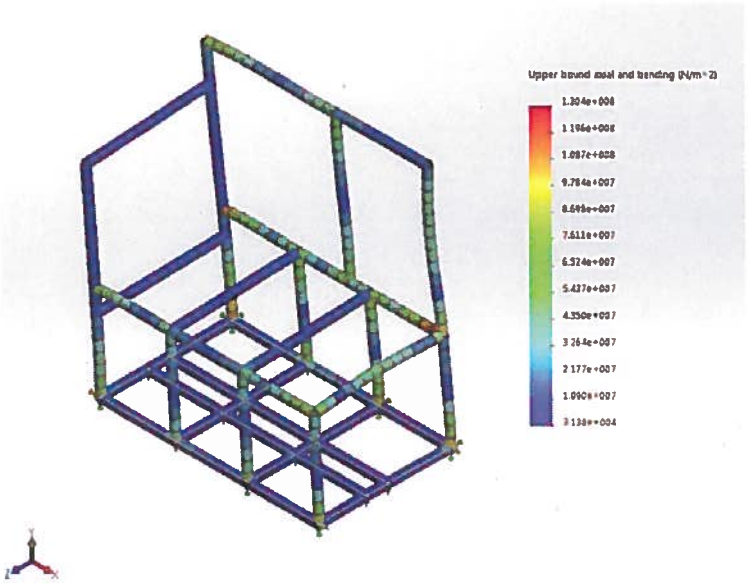

Figure 8: Axial and Bending Stress (N/m2) under load case 3 – Transverse load

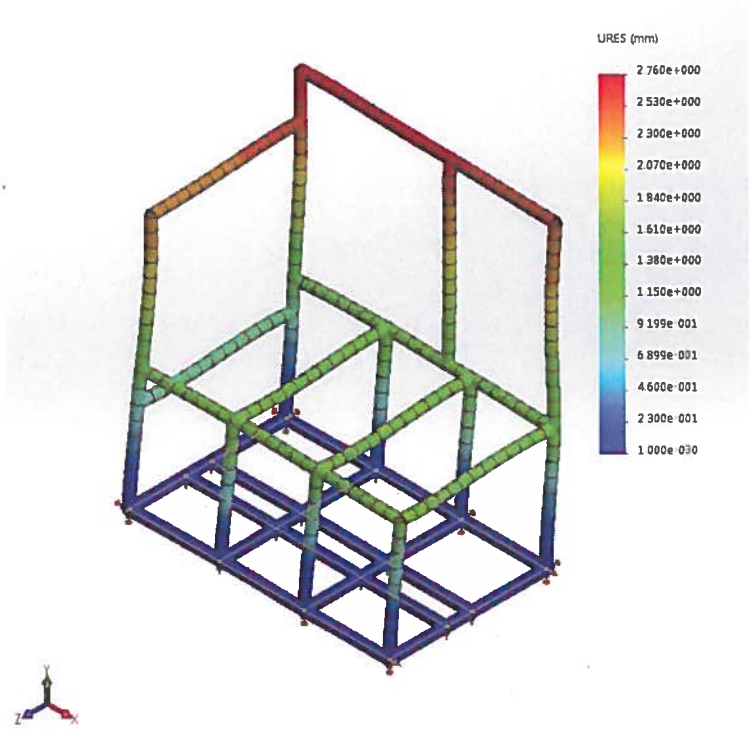

Figure 9: Resultant deformation under load case 4 - combined load (scaled 48 times)

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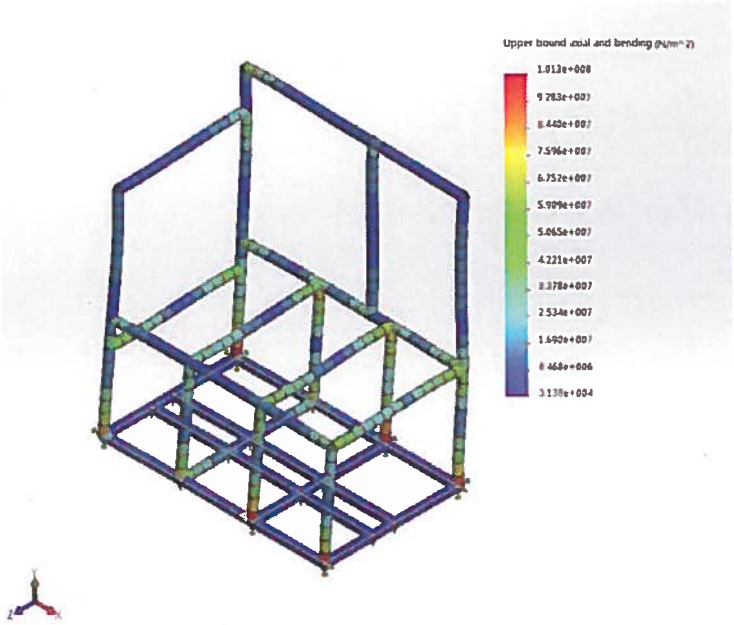

Figure 10: Axial and bending stress under load case 4 - combined load