APPLIED ENGINEERING CONCEPTS
Larry O'Keefe • Consulting Engineer

June 3, 2004

Mr. JR Cantrell
Design Engineer
Optima EPS Corp.
2166 Mountain Industrial Blvd.
Tucker, GA 30084

Dear Mr. Cantrell:

Applied Engineering Concepts has completed a finite element structural anlysis on Optima's Raytheon shelter mounted cabinets per Raytheon spec 13552673 in accordance with Optima purchase order T90316.

The two bay cabinet shown in Optima drawing SK-MA-0764 meets the requirements of paragraphs 2.9 through 2.12 of specification 13552673.

Sincerely,

Lawrence P. O'Keefe, PE

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Structural Analysis Of Optima's Raytheon Shelter Mounted Cabinets

Prepared For

Optima Electronics Packaging Systems
2166 Mountain Industrial Boulevard
Tucker, GA 30084-5008
Purchase Order T90316

May 28, 2004

Applied Engineering Concepts
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Introduction
In response to a proposal dated 3/17/04 by Applied Engineering Concepts (AEC) Optima Electronic Packaging Systems (Optima) issued purchase order T90316 to perform a finite element analysis on Optima's Raytheon shelter mounted cabinets per Raytheon environmental specification 13552673.

Scope Of Work
AEC initially developed a finite element analysis model of the MA-(44.86)19(22.85) cabinet bolted to the MA- (11.62)19(17.60) base; 430 pounds of evenly distributed load were added to simulate installed electronic equipment. This cabinet configuration was chosen because it represented worst case loading. It was also the smallest model with simpler building, debugging and testing.
In accordance with Raytheon specification 13552673 the cabinet was subjected to Random Vibration, Transportation Shock, Handling Shock and Acceleration loads. When the single cabinet failed Random Vibration in two axes, AEC added a model of the MA- (44.86)19(17.85) cabinet and Ma-(11.62)19(17.60) front bezel with 430 pounds of evenly distributed load to the original model to form a two bay cabinet configuration.
The two bay cabinet was subjected to Random Vibration in the transverse (X), longitudinal (Y) and vertical (Z) axes.
The single bay cabinet was subjected to Rail Shock in the X, Y and Z axes, and Acceleration loads in the X, Y and Z axes.
The single bay cabinet without base was subjected to Handling Shock in the Z axis.

Performance requirements
Failure is defined as permanent deformation of any cabinet structural member under the specified loads. This means that combined (Von Mises) stresses in any part of the cabinet assembly cannot exceed the material yield stress with a 1.5 factor of safety when test loads are applied. The principal cabinet structural materials and yield strengths with a 1.5 factor of safety are:

Aluminum 6061	23,400 PSI
Aluminum 5053	10,700 PSI
Cold rolled steel	40,000 PSI
Steel fasteners	50,000 PSI

Results Summary
The single bay cabinet configuration had acceptable stresses and deflections when it was subjected to Transportation Shock and Acceleration in all three axes.
The single bay cabinet without base had acceptable stresses and deflections when it was subjected to the simulated rotational edge drops specified for Handling Shock.
The initial Random Vibration analysis was performed on a single bay cabinet. When this analysis failed in the X and Y axes, AEC developed a two bay cabinet model, which more closely reflected the actual installation. The two bay cabinet configuration is much stronger, and had negligible stress and deflection in all three axes.
The two bay cabinet configuration meets all the requirements of paragraphs 2.9 through 2.12 of Raytheon specification 13552673.

Individual Analysis Results

Random Vibration - Non Operating

Loading

Frequency - Hertz	PSD – g^2/Hertz
10	.04
70	.04
500	.004

Results

As figures 1 through 3 show, stresses are negligible in all 3 axes.

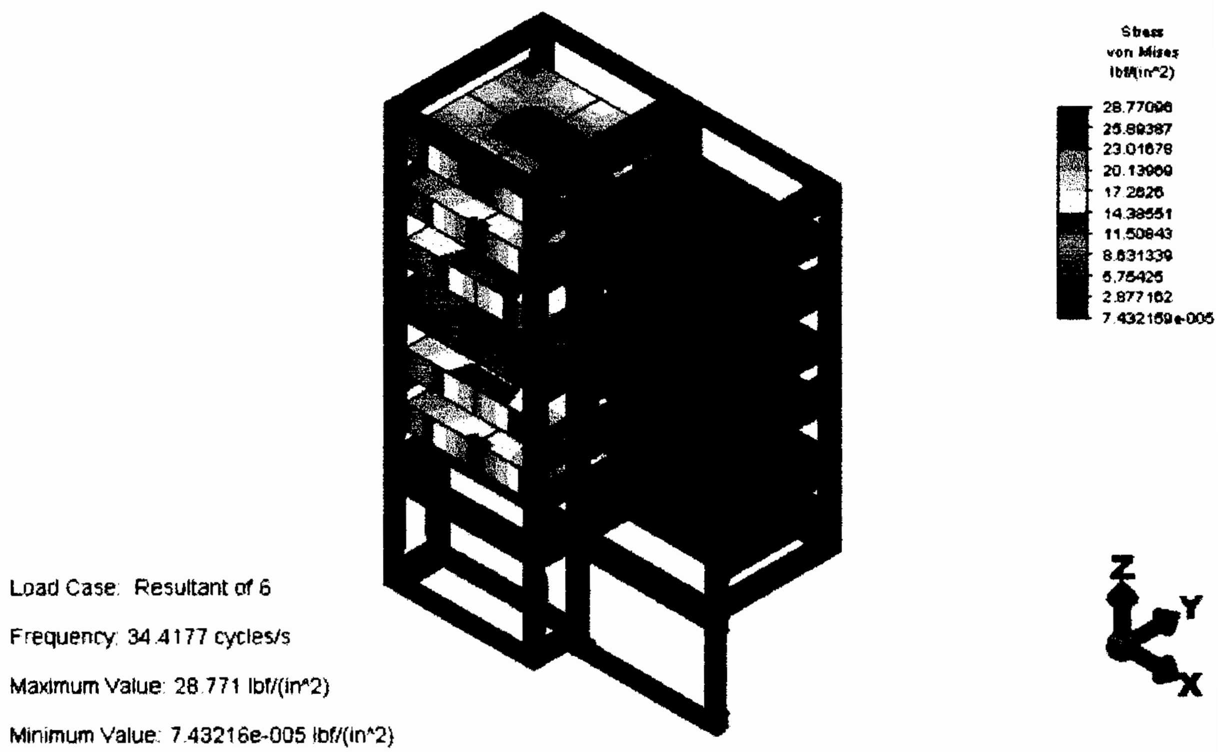

Figure 1 - Lateral Random Vibration

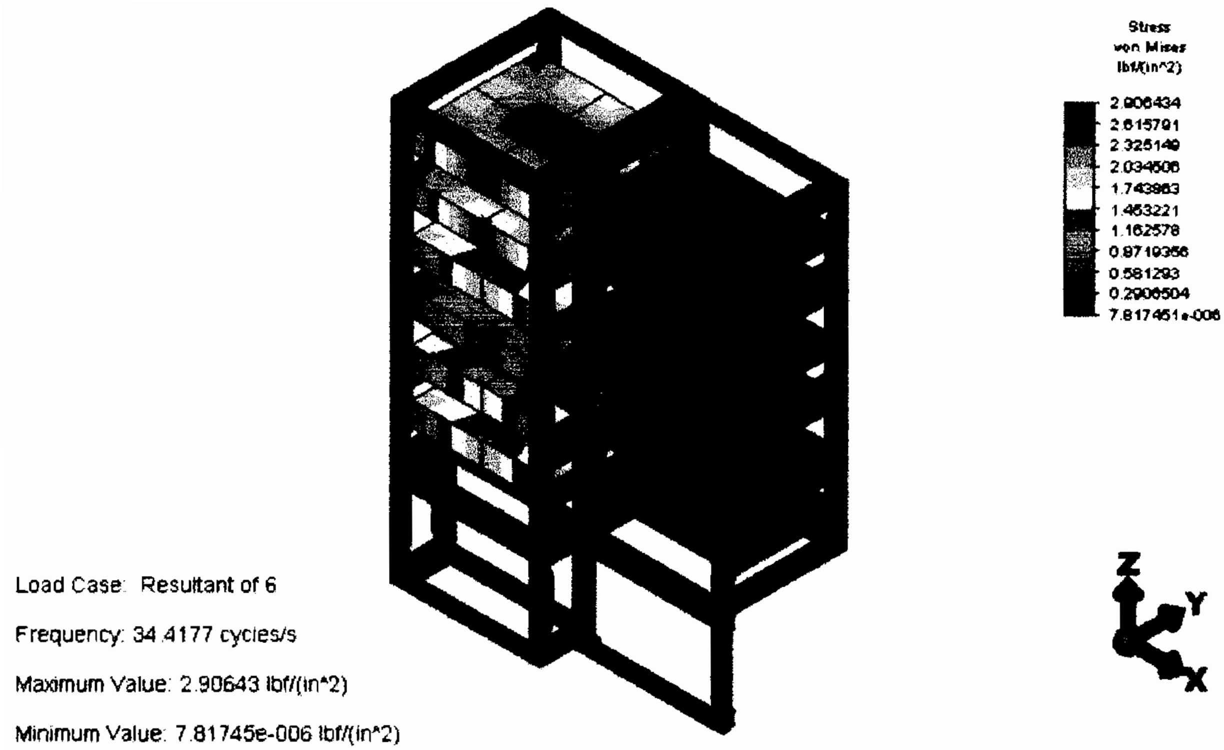

Figure 2 - Longitudinal Random Vibration

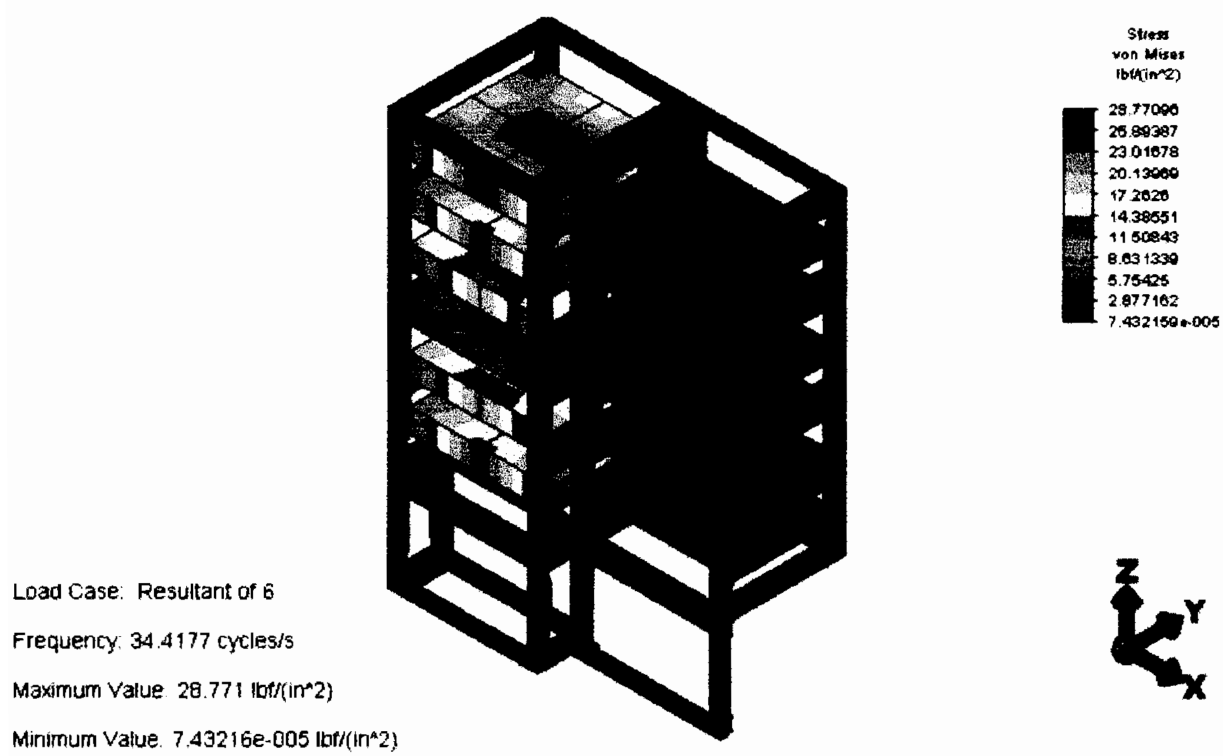

Figure 3 - Vertical Random Vibration

Transportation Shock

Loading

Axis	Magnitude	Duration
Lateral (X)	3g	30 msec. 1/2 sine
Longitudinal (Y)	6g	100 msec square wave
Vertical (Z)	4.5g	30 msec. 1/2 sine

Results

Maximum stresses occur in the cabinet mounting bolts in all 3 axes. (See figures 4, 5 and 6.) These stresses are below the allowable stress for fasteners. Stresses in all other structural members are lower than the allowables.

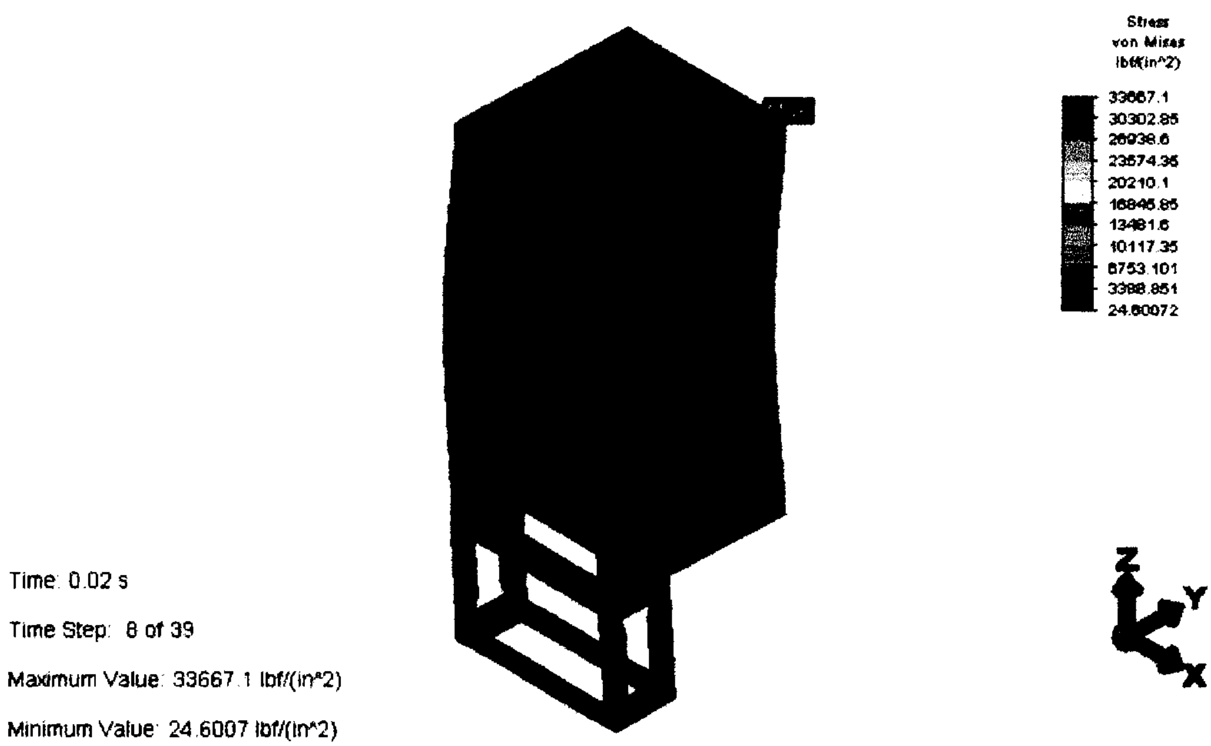

Figure 4 - Lateral Rail Impact Shock

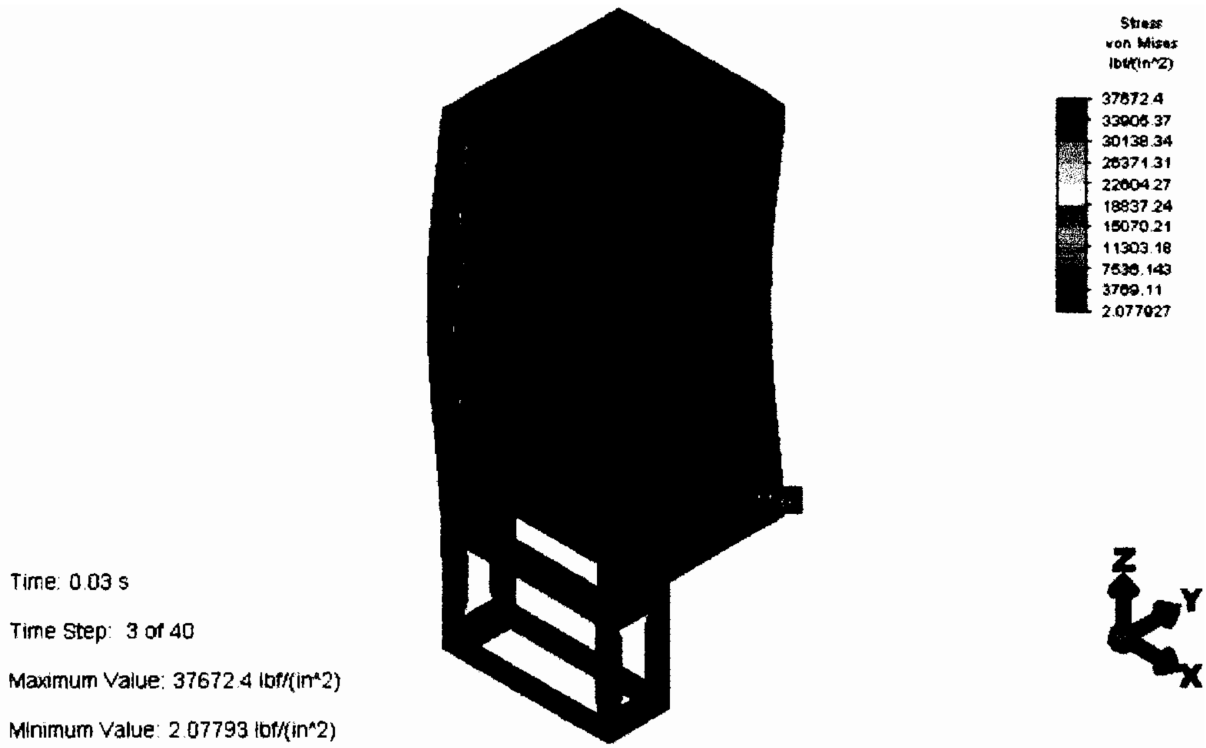

Figure 5 - Longitudinal Rail Impact Shock

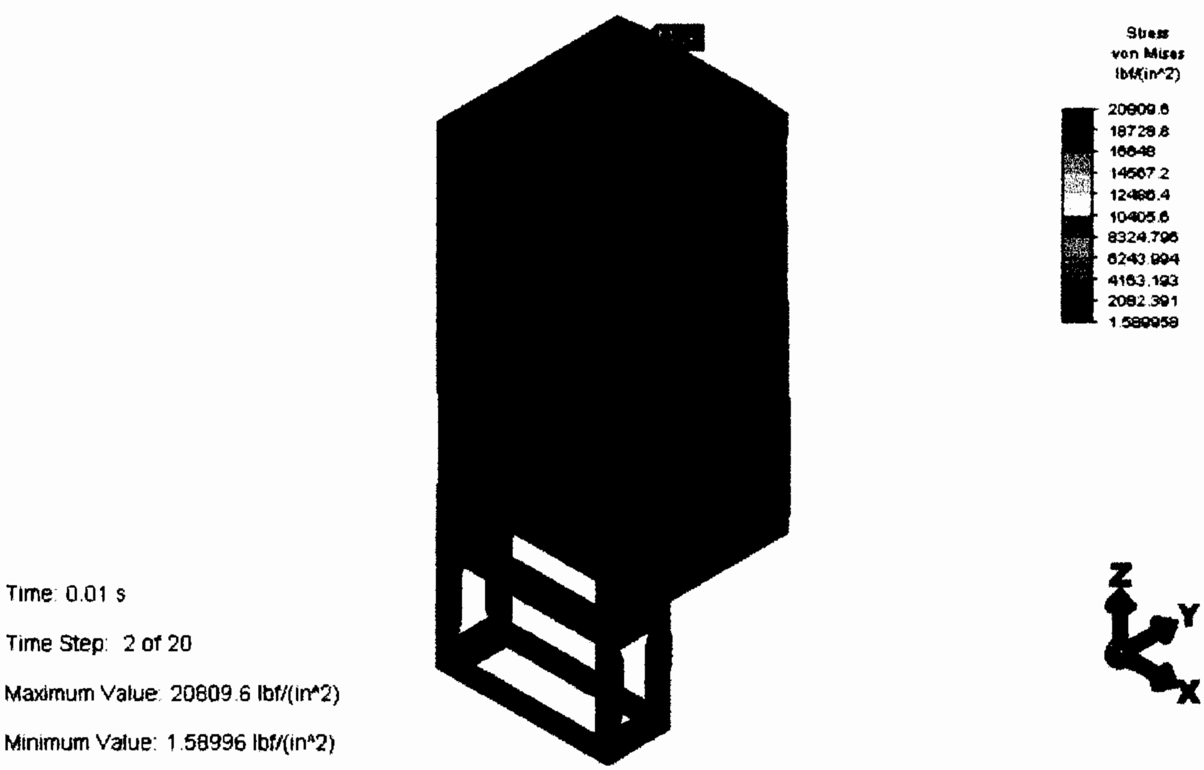

Figure 6 - Vertical Rail Impact Shock

Handling Shock
For this analysis, it was assumed that the cabinet would be shipped fully loaded with electronics and that the base would be shipped separately. It was also assumed that the cabinet would start rotating when its center of gravity reached the edge of the support surface and would hit the ground 6 inches below the support surface with the center of gravity directly over the impacting cabinet edge.
Two simulated drops were performed. For the front drop, the front edge of the cabinet has rotated about 34 degrees when the lower front edge impacts. For the right side drop, the cabinet has rotated about 25 degrees when the lower right edge impacts. Since the cabinet is symmetrical only two-drop tests are required. At impact, a 10g 25 msec half sine wave pulse is applied to the cabinet edge.

Results
For both drops, the maximum stresses occur in the cold rolled steel equipment support rackets. (See figures 7 and 8) The stresses for the right side drop are substantially higher than the front drop, but are well below the allowable stress for cold rolled steel. Stresses for all other structural members are below allowable levels.

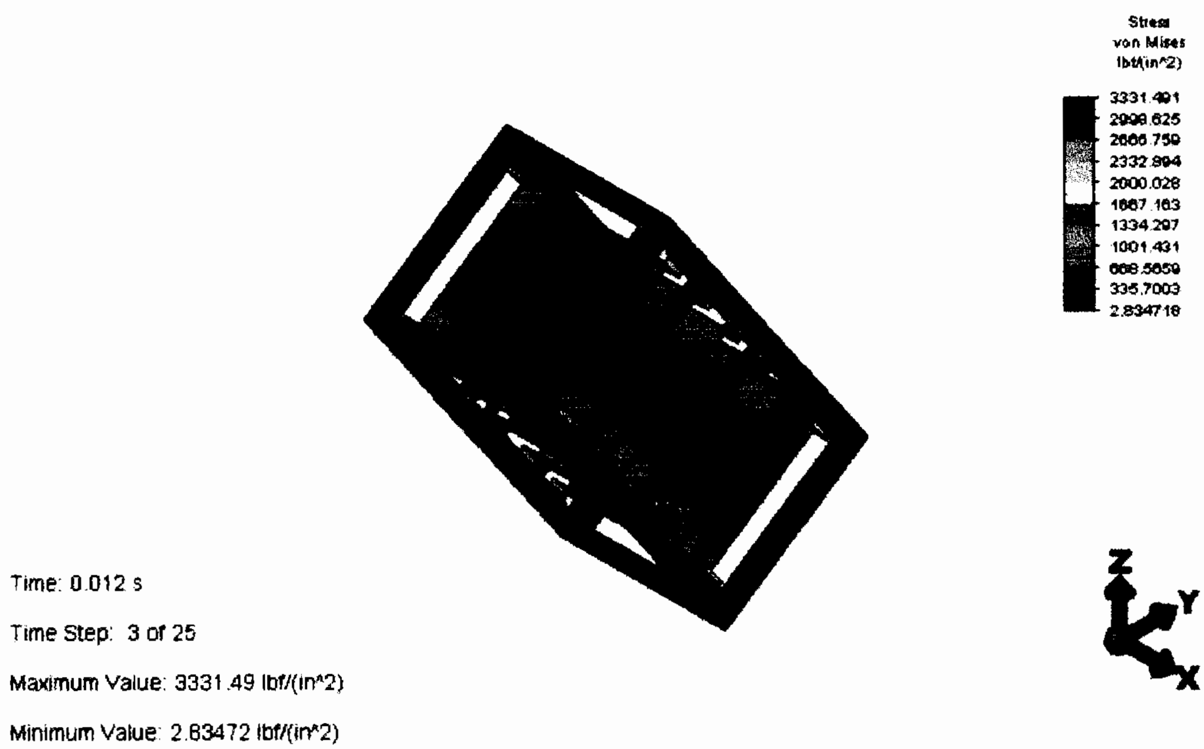

Figure 7 - Front Edge Rotational Drop

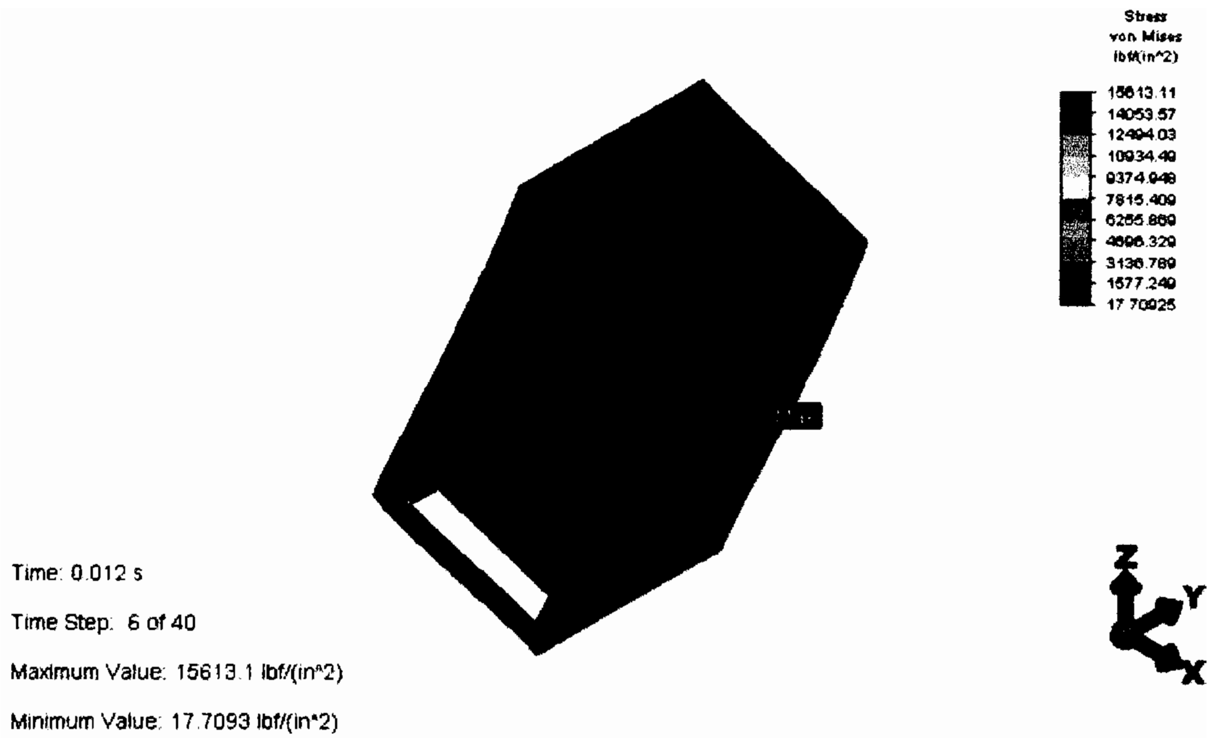

Figure 8 - Right Edge Rotational Drop

Acceleration

Loading

Axis	Magnitude
Lateral (X)	+/- 3g.0
Longitudinal (Y)	+/-1.5g
Vertical (Z)	2.0 g up/4.5 g down

Results

Maximum stresses for each axis occur in the mounting bolts. Stresses are within the 50,00 PSI allowable stress for fasteners. Stresses for all other structural members are within their allowable ranges. Deformations for positive and negative X and Y axis loadings are slightly different, but maximum stresses are identical.

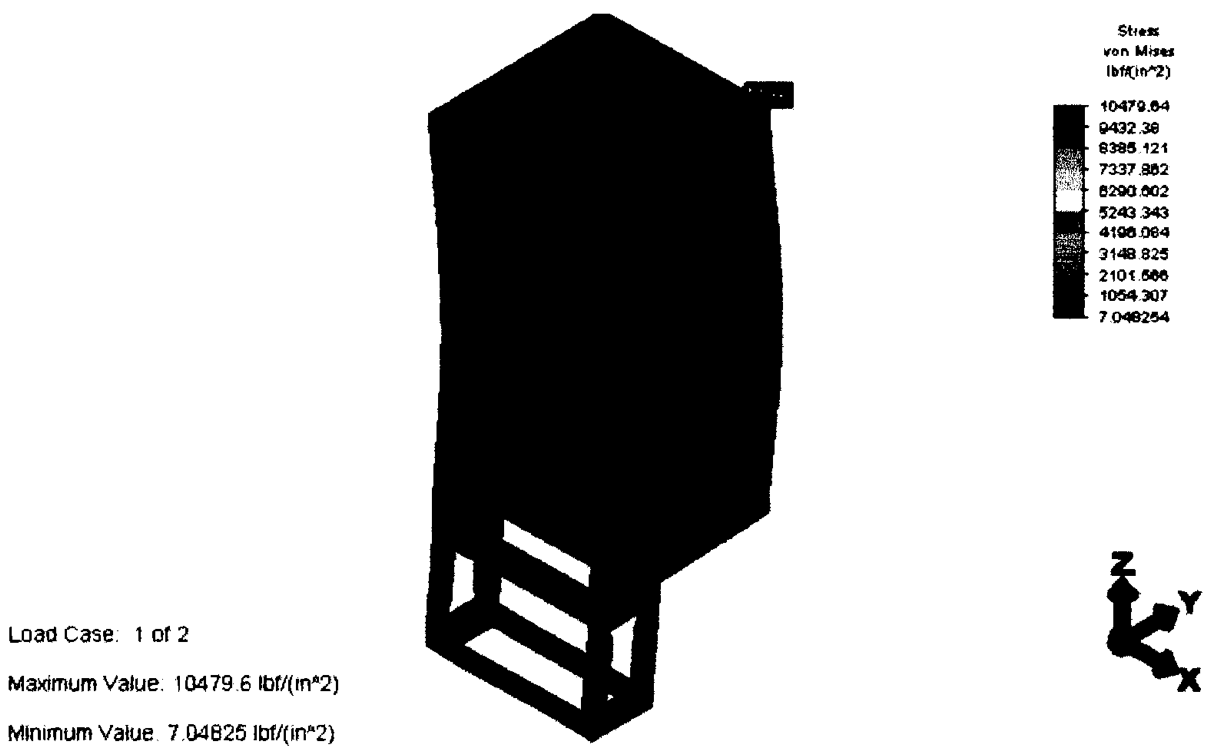

Figure 9 - Transverse Acceleration

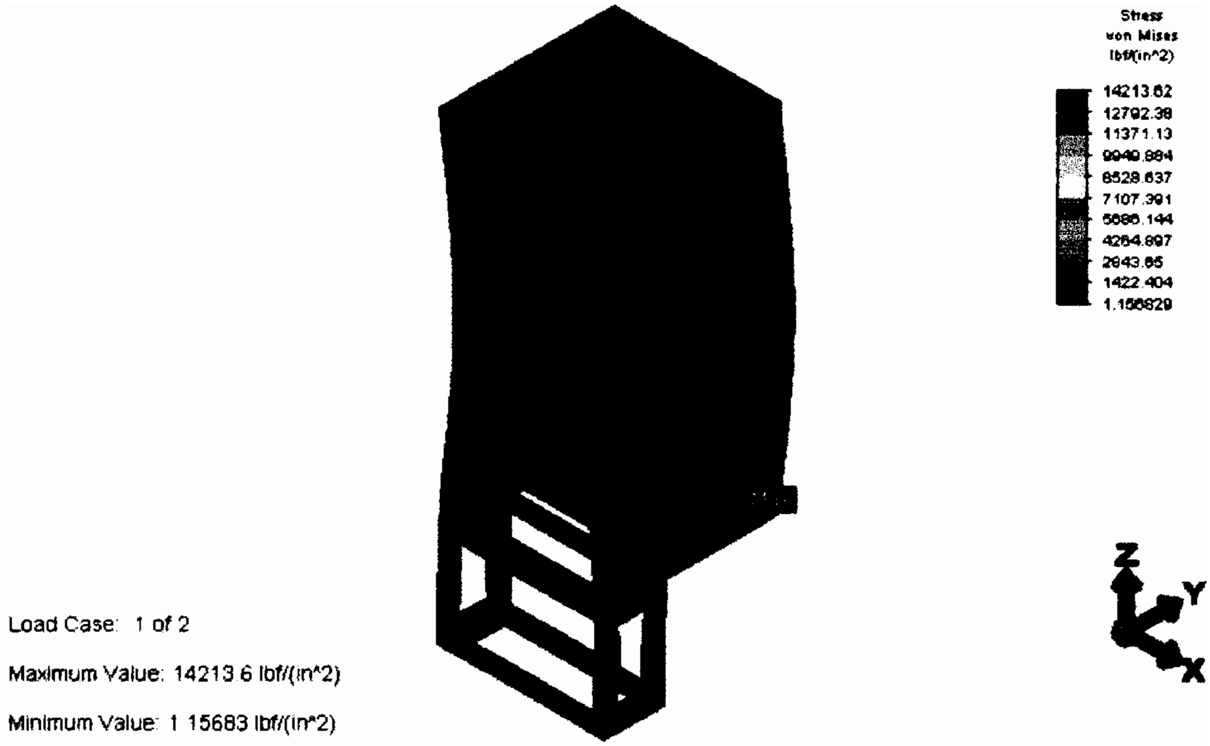

Figure 10 - Longitudinal Acceleration

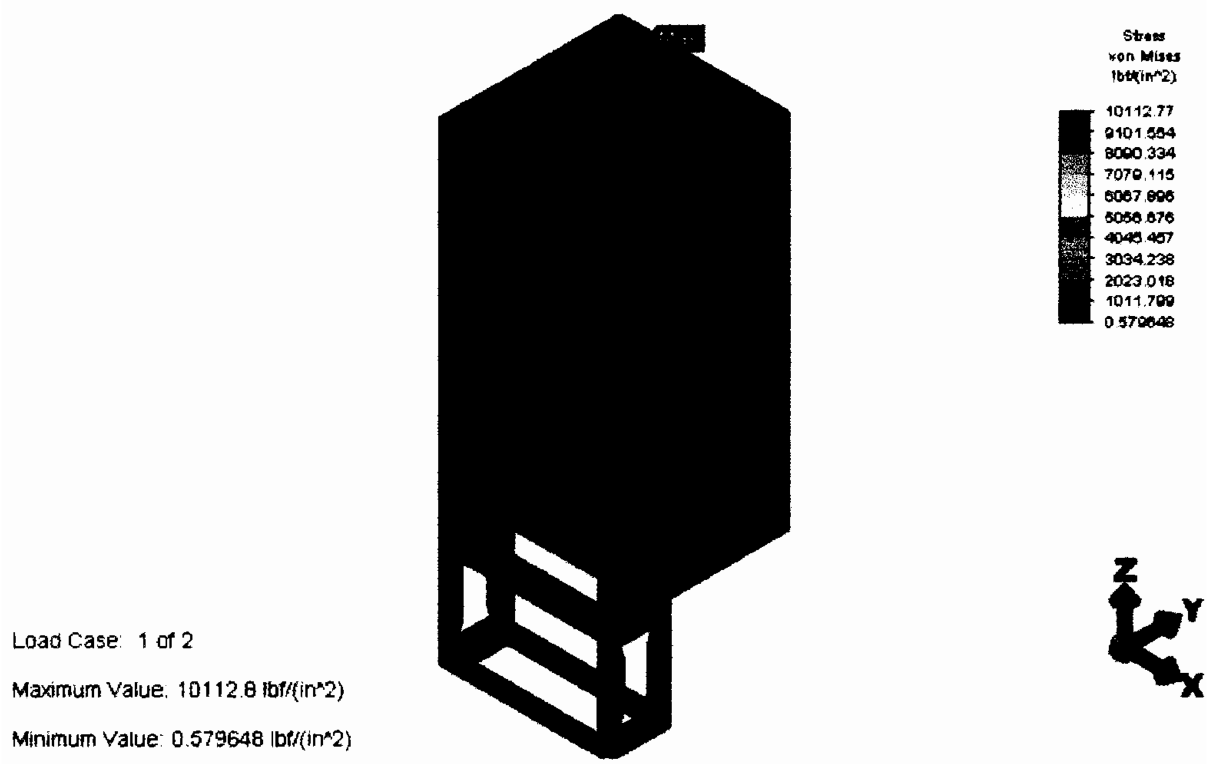

Figure 11 - Up Vertical Acceleration

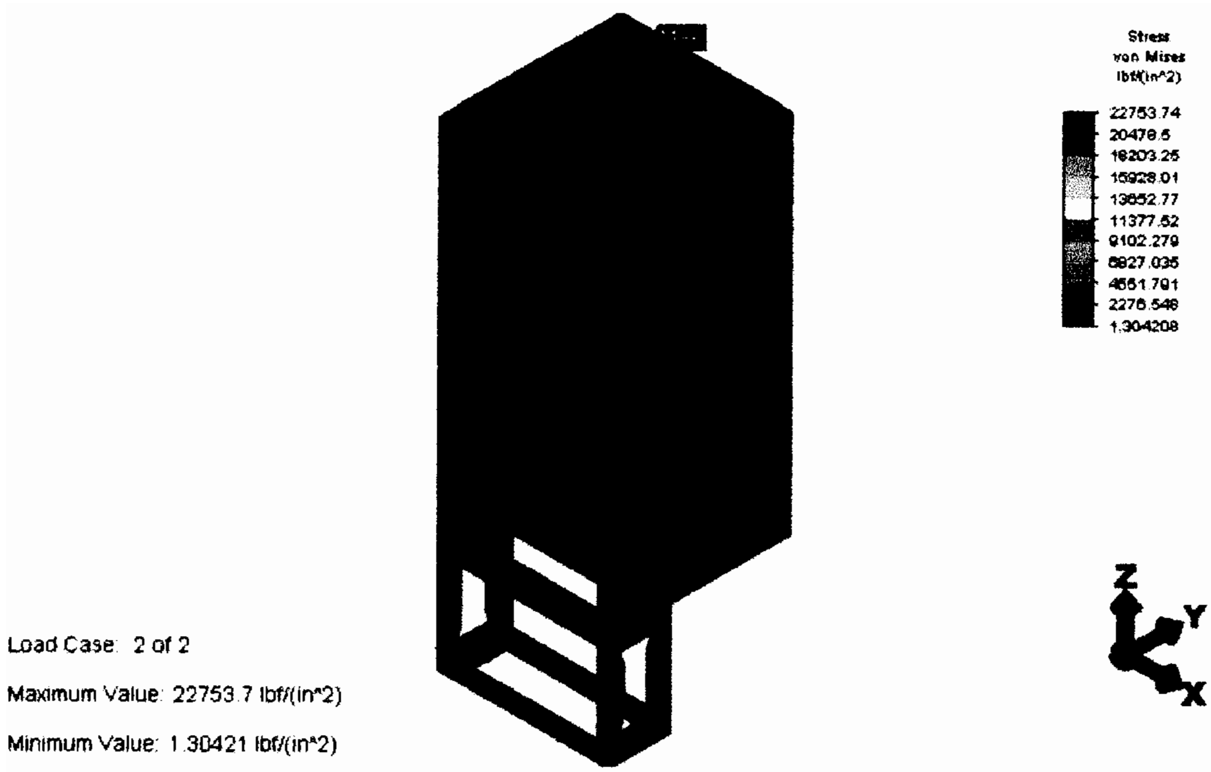

Figure 12- Down Vertical Acceleration