Section A: Materials to be used:

All connection plates are to be made of ASTM A572 Grade 50. A screenshot of the material properties is pictured below:

ASTM A572 Steel, grade 50

Categories: Metal; Ferrous Metal; ASTM Steel; Carbon Steel; Low Carbon Steel

Material Notes: High-strength low-alloy steel, structural quality

Vendors: No vendors are listed for this material. Please click here if you are a supplier and would like information on how to add your listing to this material.

Printer friendly version Download as PDF Download to Excel (requires Excel and Windows)
Export data to your CAD/FEA program

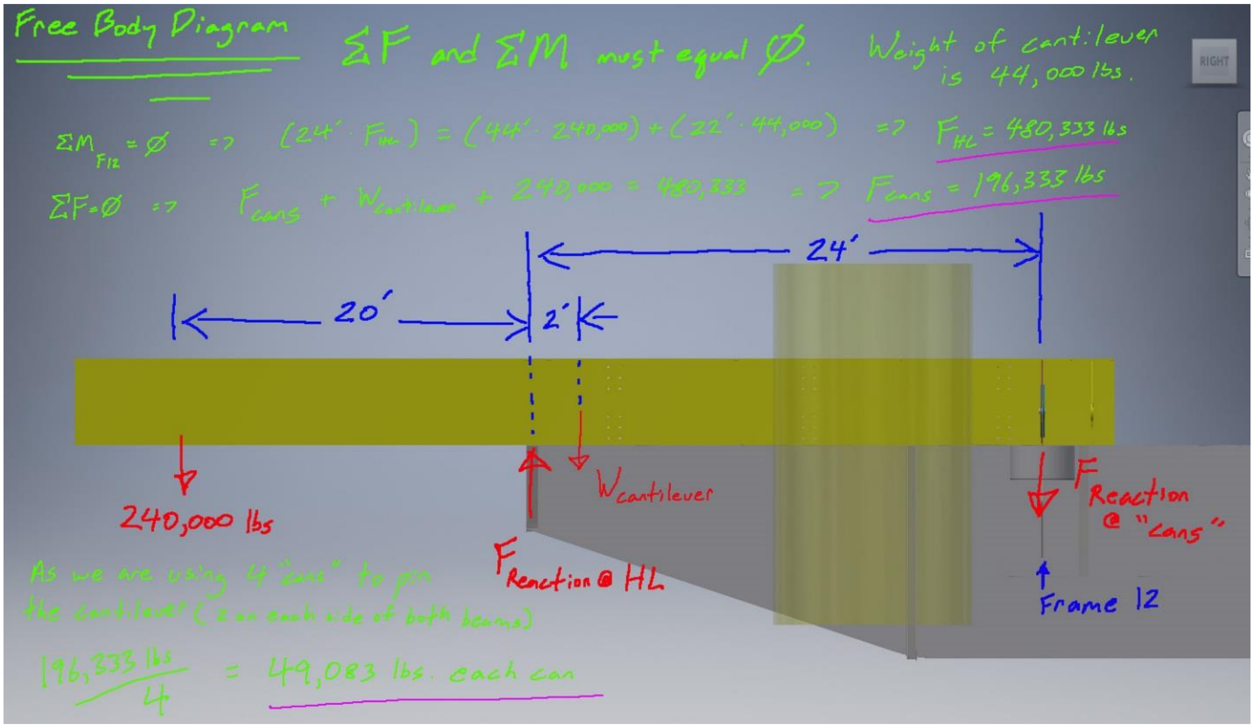
Physical Properties	Metric	English
Density	7.85 g/cc	0.284 lb/in³

Mechanical Properties	Metric	English
Hardness, Brinell	135	135
Hardness, Rockwell B	74	74
Tensile Strength, Ultimate	450 MPa	65300 psi
Tensile Strength, Yield	345 MPa	50000 psi
Elongation at Break	18 %	18 %
	21 %	21 %
Bulk Modulus	160 GPa	23200 ksi
Shear Modulus	80.0 GPa	11600 ksi

Component Elements Properties	Metric	English
Carbon, C	<= 0.23 %	<= 0.23 %
Iron, Fe	98 %	98 %
Manganese, Mn	1.35 %	1.35 %
Phosphorous, P	<= 0.040 %	<= 0.040 %
Silicon, Si	<= 0.40 %	<= 0.40 %
Sulfur, S	<= 0.050 %	<= 0.050 %

Section B: Free Body Diagram of forces:

Please see our FBD for the calculation of forces below. When loading the cantilever to its maximum rated load (240,000 lbs or 120 Short Tons at 20' from headlog), the resulting up-force at each of the 4 cans is calculated to be 49,083 lbs.



Section C: DNV Pad eye stress checks:

The Pad eye components are required to meet DNV 2.7-1 Appendix D (page 60) requirements for Tear-out and Contact stresses (screenshot of page 60 below)

More refined methods can of course be used if an optimised pad eye design is required. In such cases the calculations should be submitted with the approval documentation.

The two following criteria should be fulfilled:

1. Tear-out stress

$$Re \geq \frac{3 \times RSL}{2 \times H \times t - D_H \times t}$$

2. Contact stress

$$Re \geq 23.7 \times \sqrt{\frac{RSL}{D_H \times t}}$$

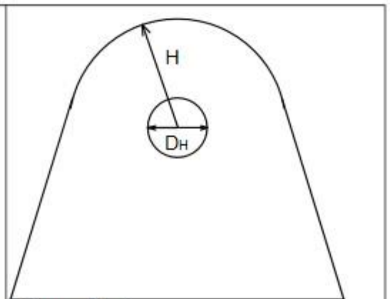


Figure D-1
Pad eye

where:

R_e = minimum specified yield strength of the pad eye material in N/mm^2
RSL = resulting sling load in N
H = the shortest distance from centre of bolt hole to edge of pad eye in mm
D_H = bolt hole diameter in mm
t = pad eye thickness in mm

Equation 1 is verifying that the stress level at the edge of the bolt hole is acceptable, assuming a stress concentration factor of 3.

Equation 2 is the formula for peak compressive stresses at the contact line between two concentric cylinders of steel, with a difference in diameter of 6%.

If fillet welded cheek plates are used to obtain the pad eye thickness required in [4.4.1] (clearance between pad eye and inside of shackle) these should not be taken into account in equation 1. The contact stress criterion may be calculated using the total thickness of pad eye and cheek plates.

Our variables are identified as follows:

Re = 345 MPa

RSL = 218603 N

t = 22.225 mm

H = 81.2 mm

Dh = 76.2 mm

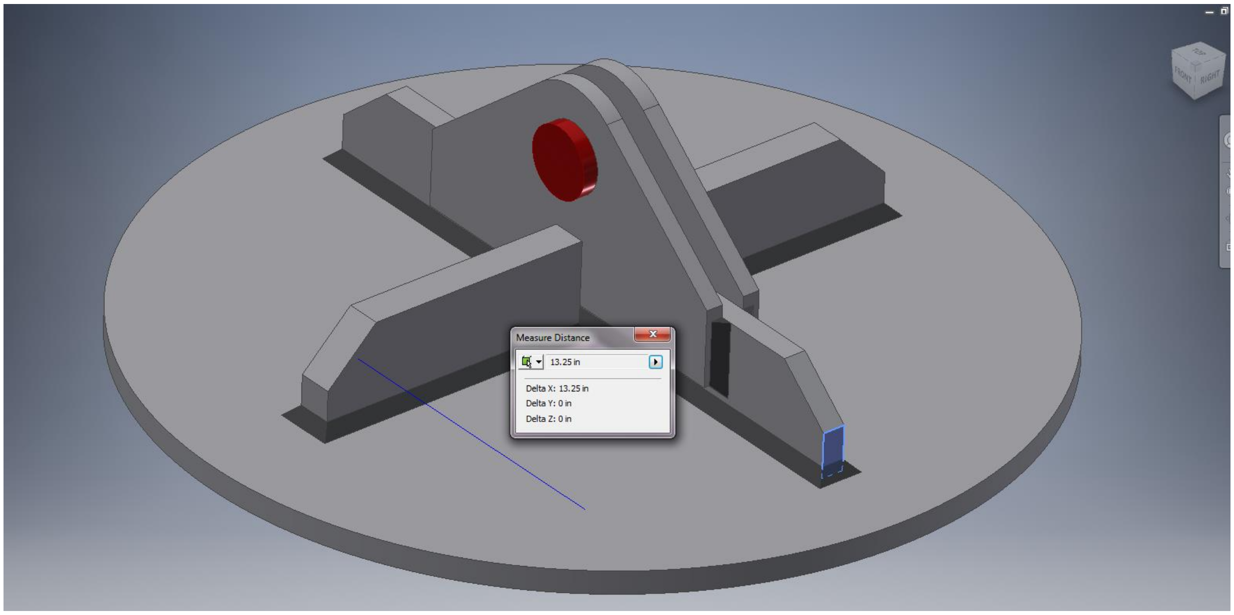
Results:

Both the Tear-out stress and the Contact stress checks are good. The Tear-out stress is calculated as 342.32 MPa, and the Contact stress is calculated as 269.26 MPa (both below the 345 MPa limit.)

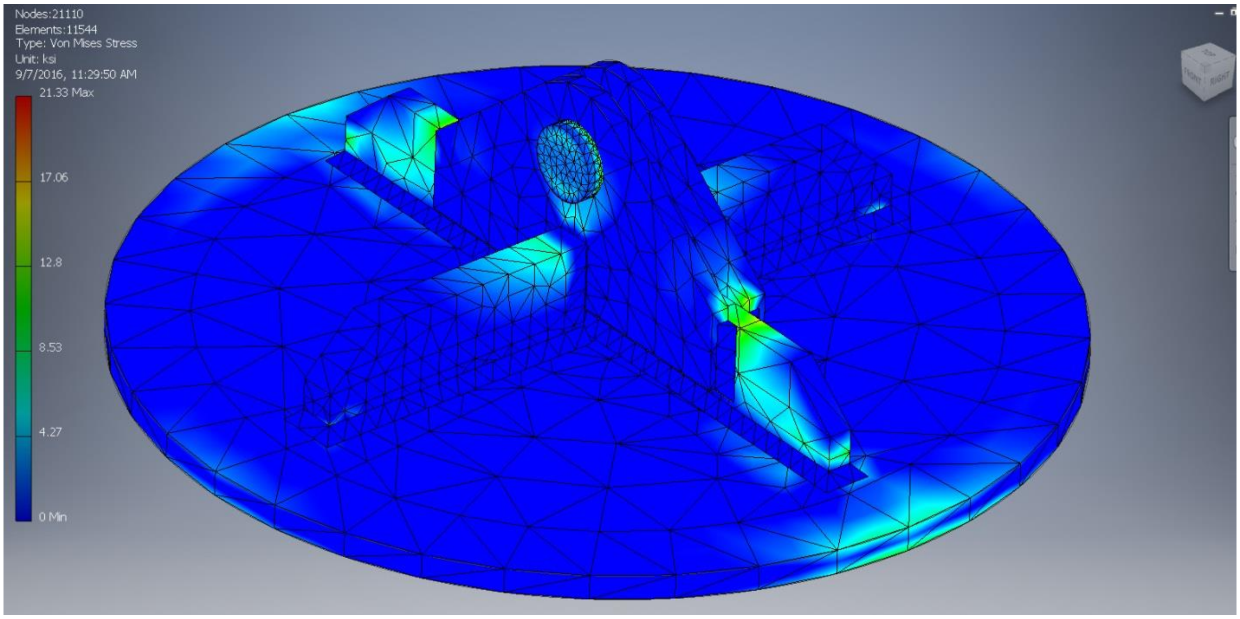
<u>Section D:</u> Analysis of welded placement of components on "can" baseplate (to see if any shifting of the welded components from nominal will affect stress results):

Our fab shop had provided a Certification (attached) that welded placement accuracy will be within 1/4" (6.35mm). Below is the analysis of components, first with no shifting (perfect placement), followed by components with shifting:

Pic1: No shift, showing reference 13.25" dimension

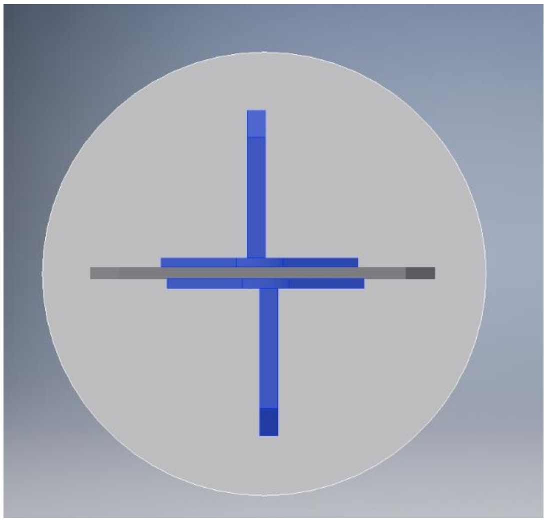


Pic2: No Shift FEA, 49,083 lbs of up-force applied to pin. Stresses well below 50ksi material yield strength, Factor of Safety greater than 2.3

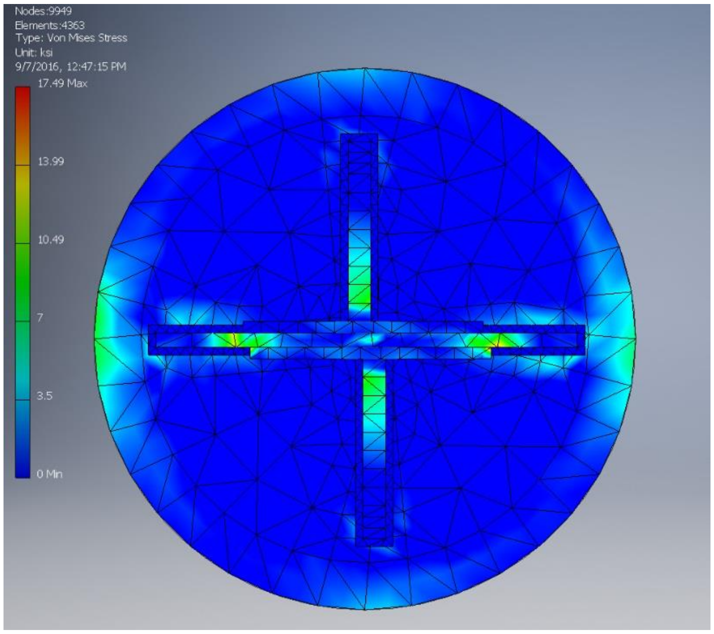


Pictures below show the worst-case possible of shifting. I shifted all plates in opposing directions about the main plate by ¼”. With stack-up of this error, we see a full 1” of movement in opposing directions. I’ve also raised one pad eye by ¼”, and lowered the other by ¼”.

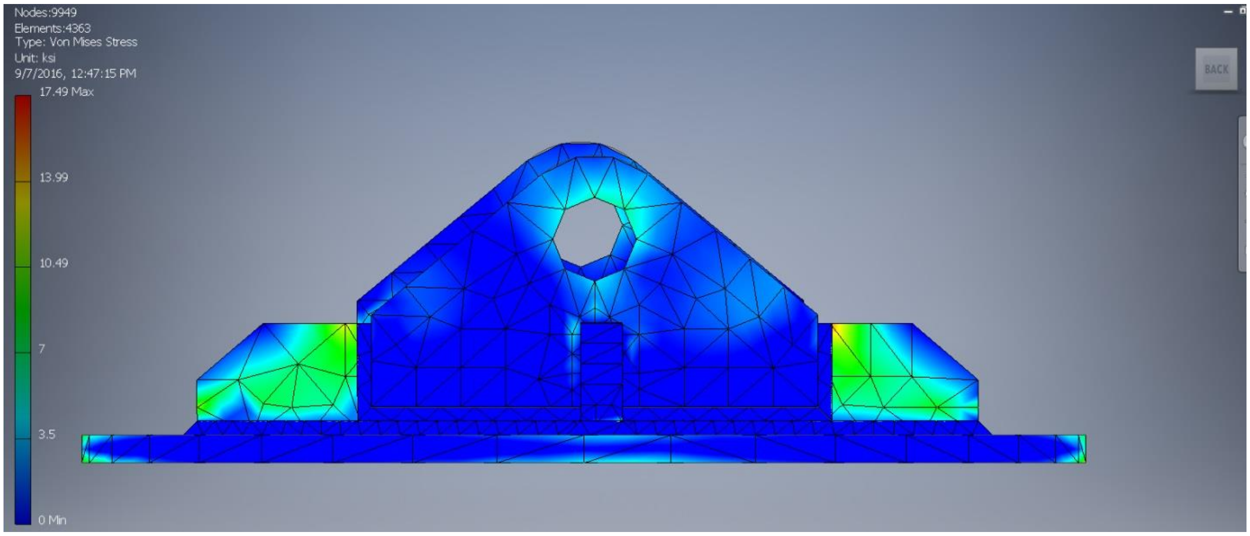
Pic3: Top view showing the worst-case shifting:



Pic4: Top view FEA with worst-case shifting.



Pic5: Side view with worst-case shifting

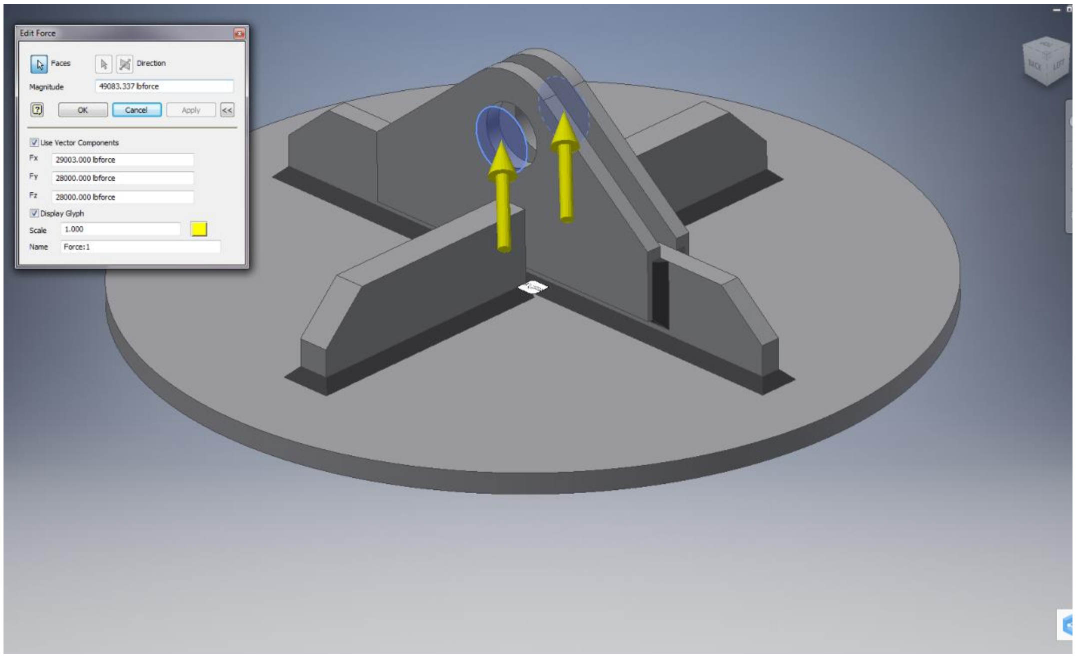


Results: Our analysis shows that even the worst-case shifting will not negatively impact the strength of our Pad eye connection. Both stresses and Factors of Safety look very good.

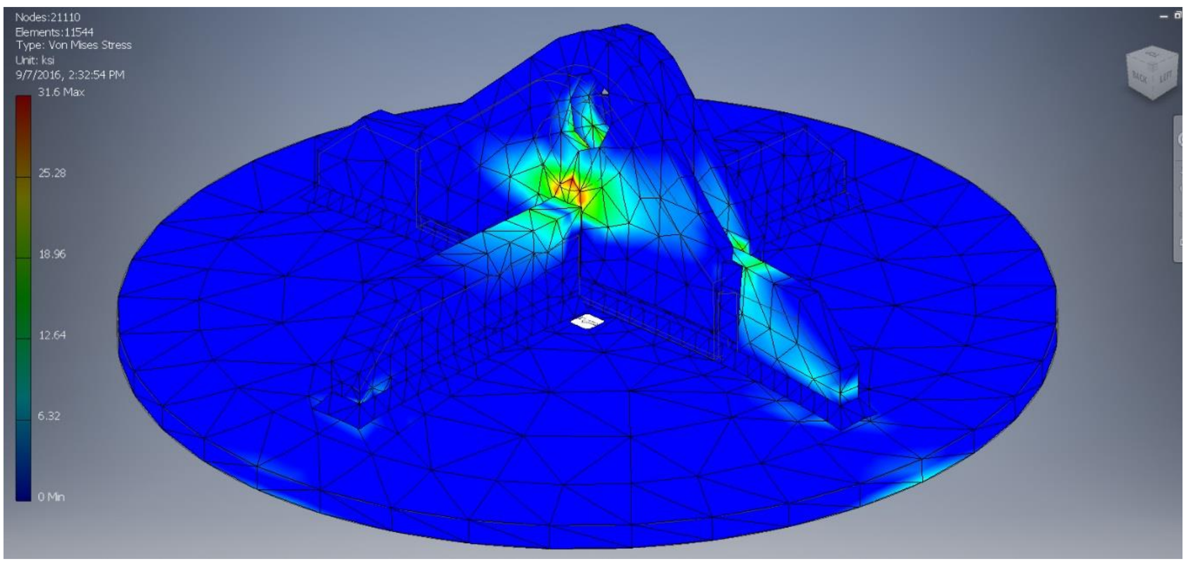
Section E: Out-of-plane loading (to ensure Pad eye components can tolerate loading at an extreme out-of-plane angle.)

Using vector components, I was able to apply load to the pad eye out-of-plane. The resulting vector is a worst-possible case scenario (out-of-plane force in two axis, extreme angle.)

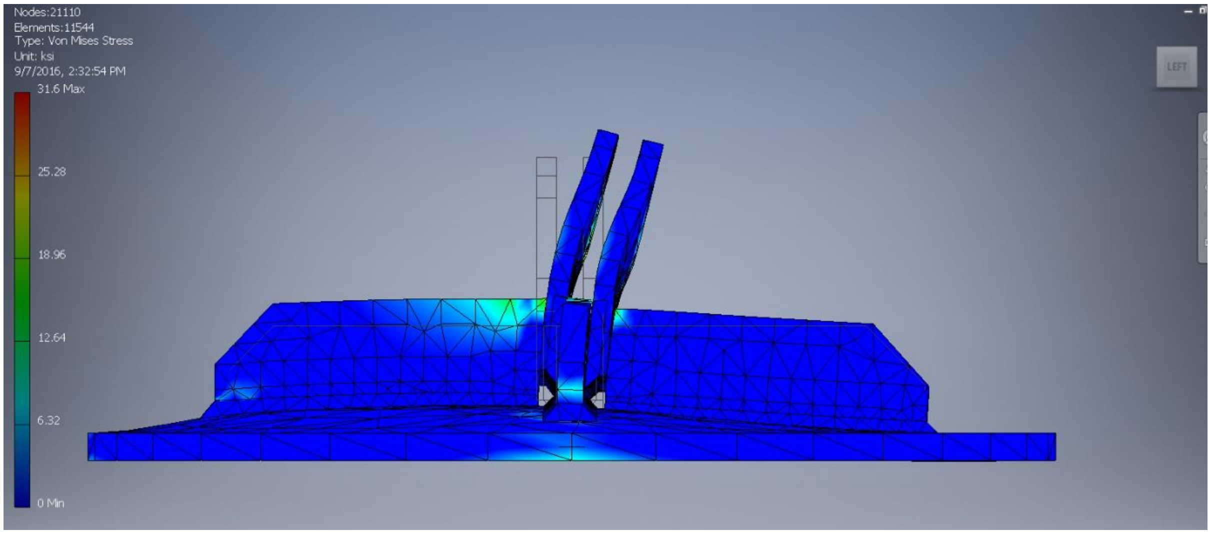
Pic1: Setup. Total x,y,z force magnitude = 49083 lbs.



Pic2: Isometric view. FEA results look good, with max stress of 31.6 ksi, Factor of Safety greater than 1.5



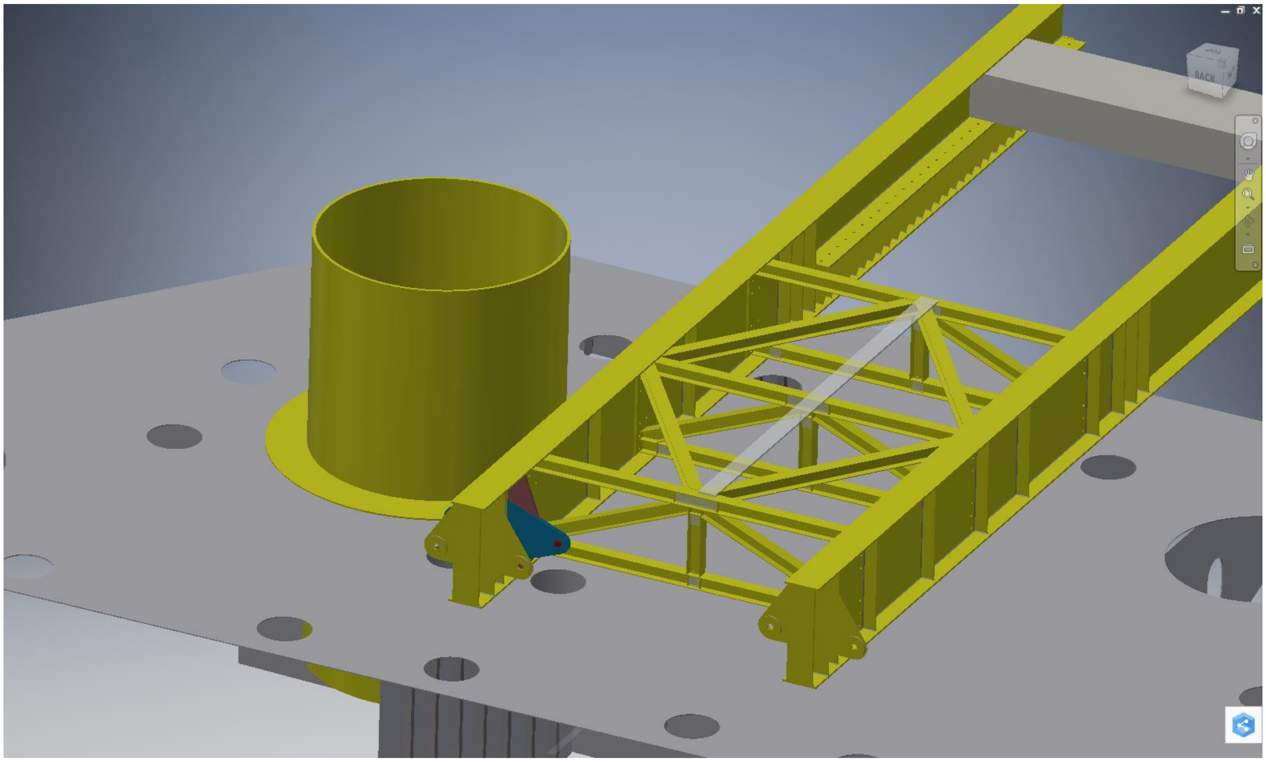
Pic3: Side view showing same



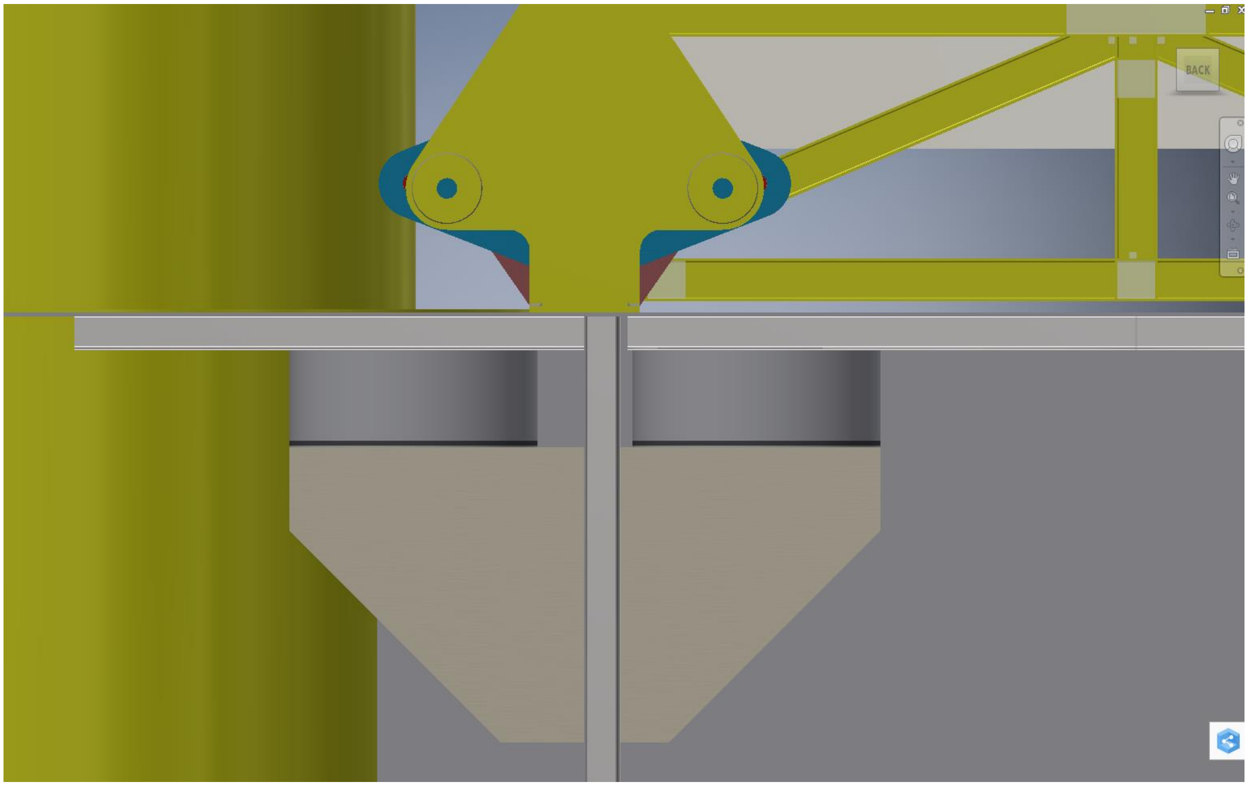
<u>Section F:</u> Sub-deck bracket analysis:

To create the needed load paths, several brackets must be installed below the main deck to connect the "cans" to the structural bulkheads.

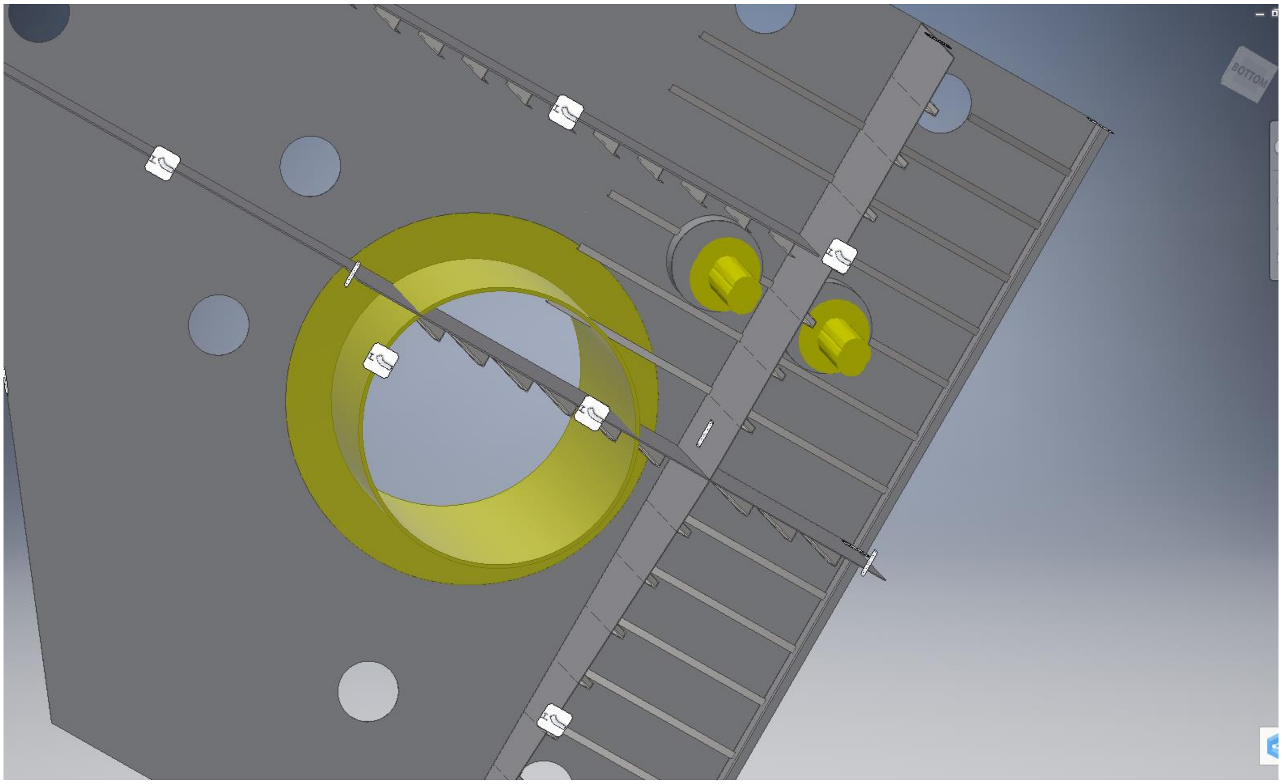
Pic1: Placement of cantilever on main deck. Iso view looking from rear-stbd. Note I've turned "visibility" off on several layers and bulkheads.



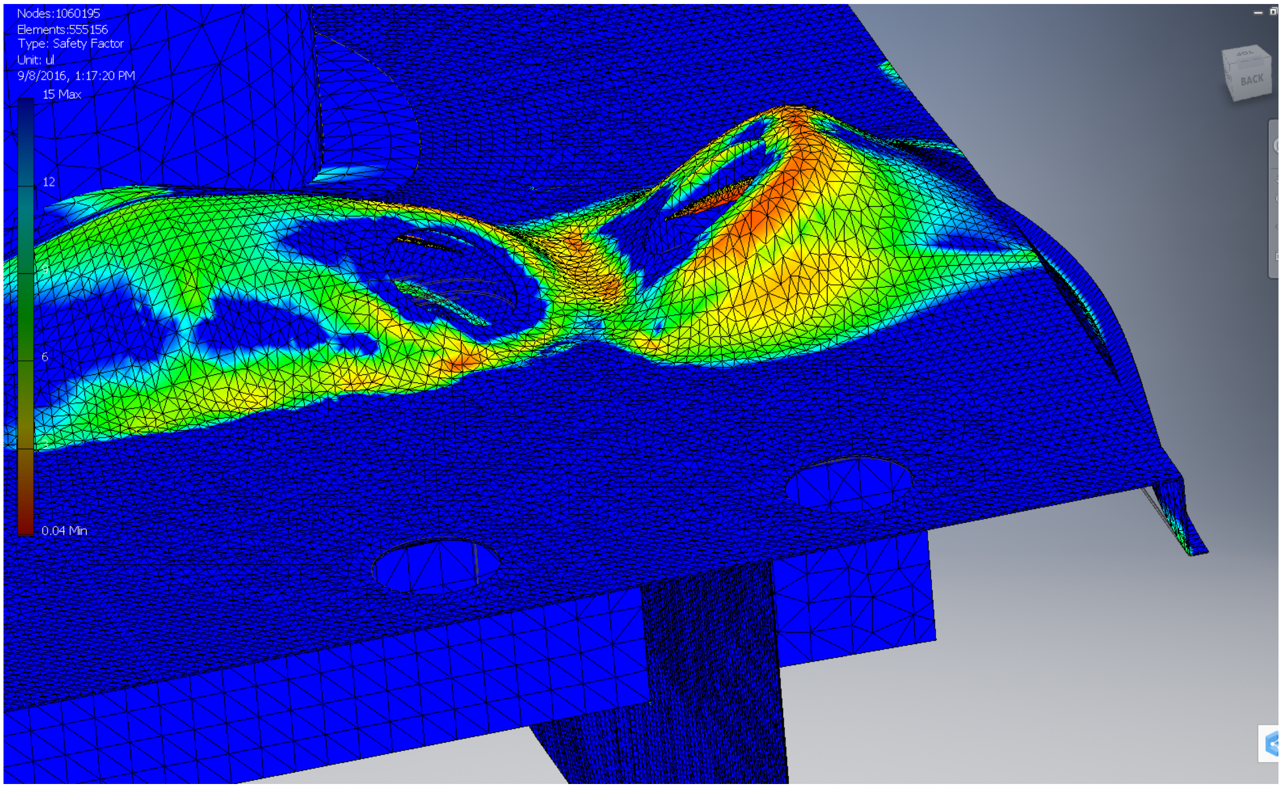
Pic2: Aft looking forward. The main deck is ½” thick A36, reinforced with 5”x3”x5/16” stiffeners every 2 feet. The longitudinal bulkhead is 6’-8” off of CL, running from Frame 9 to Frame 17. It’s made of 5/16” thick A36, reinforced with 5”x3”x5/16” stiffeners every 2 feet. Our brackets will weld directly to the bulkhead and to the bottom of the “can”.



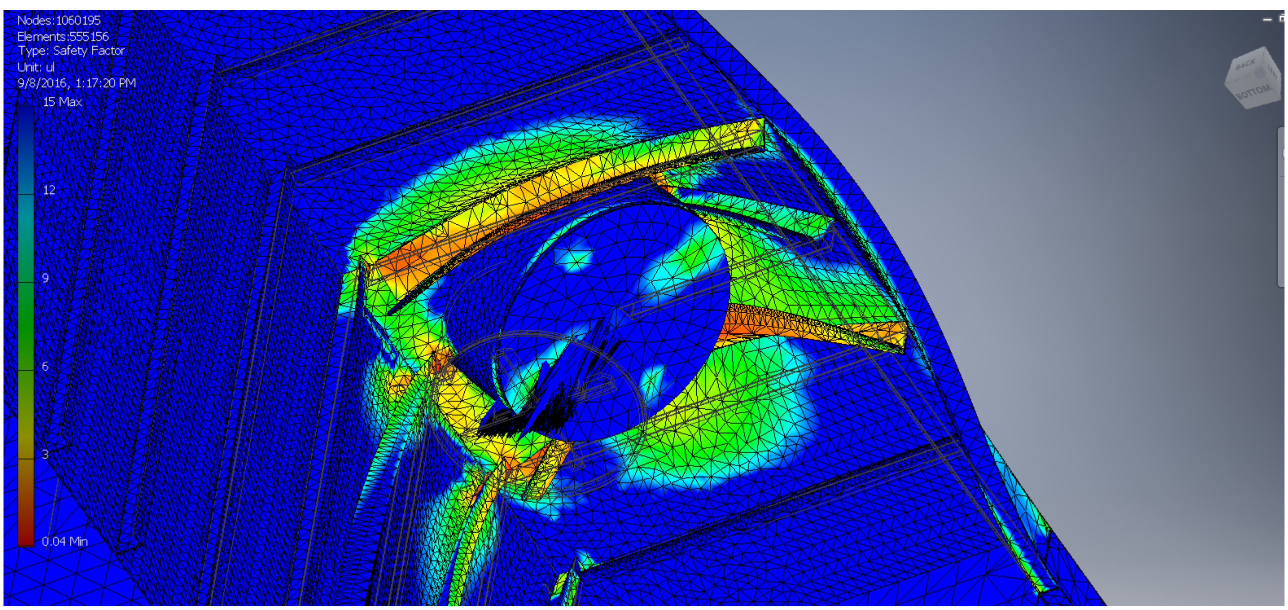
Pic3: Here's an iso view looking from bottom up. 49,083 lbs applied to each "can", total of 98,166 lbs up force. Note, I've removed the sub deck brackets… I want to show you results first without the brackets.



Pic4: Iso view looking from top-rear. **Without** the sub-deck brackets, only a small fraction of the load is transferred into the 6’-8” OC bulkhead, leaving the main deck to handle the remainder. As the FEA shows, we would have multiple areas of deformation and failure.

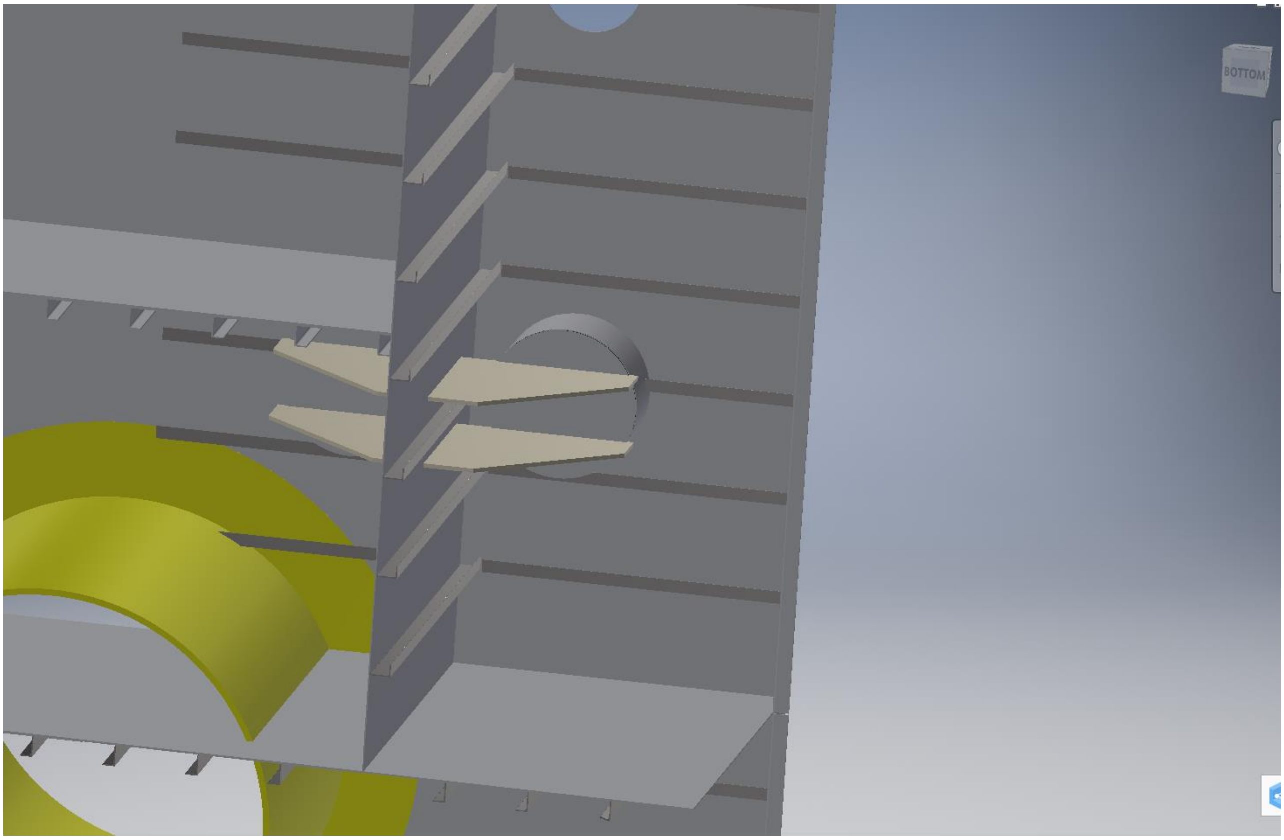


Pic5: Iso view looking from bottom-back. **Without** sub-deck brackets, failure is highly likely.

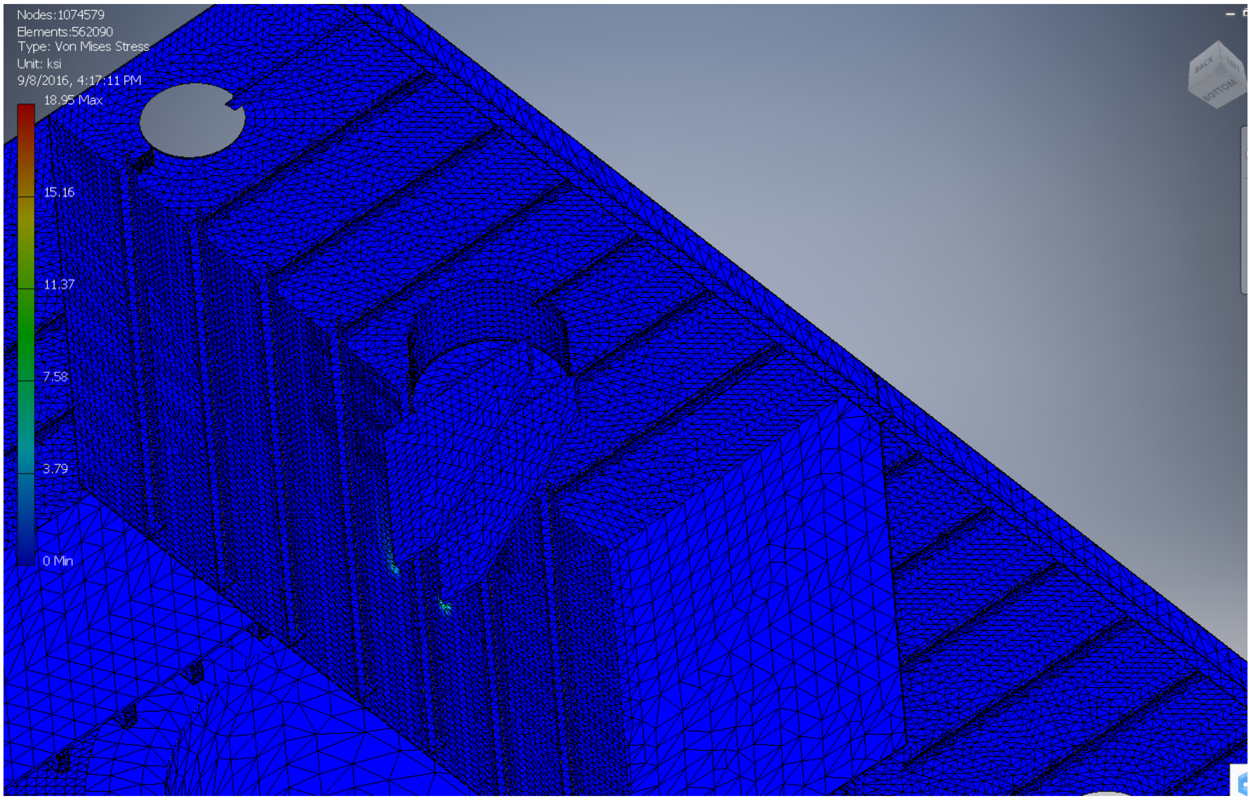


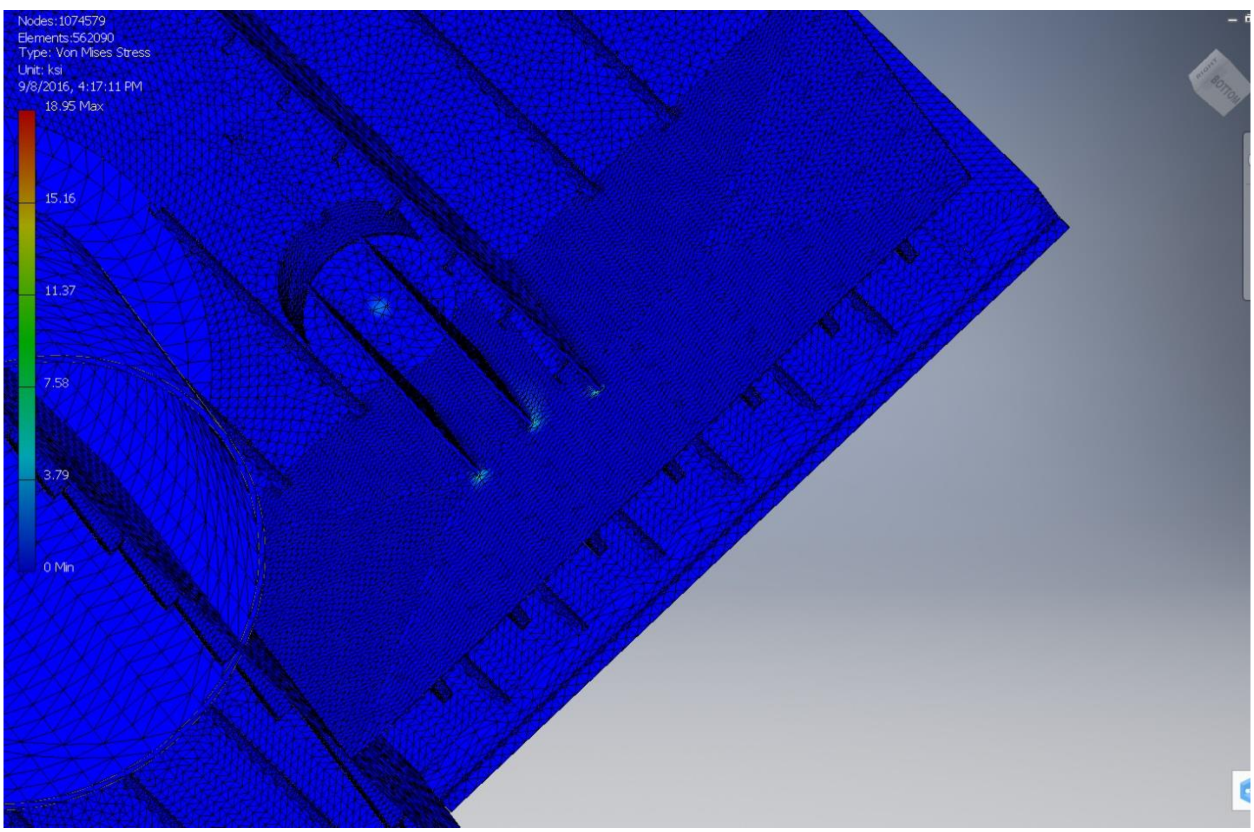
** Adding structural brackets to create desired load paths**

Pic6: Iso view, bottom looking up. Here, I've added the sub-deck brackets. Note that each "can" has 2 brackets, equaling 4 per side, or 8 total.

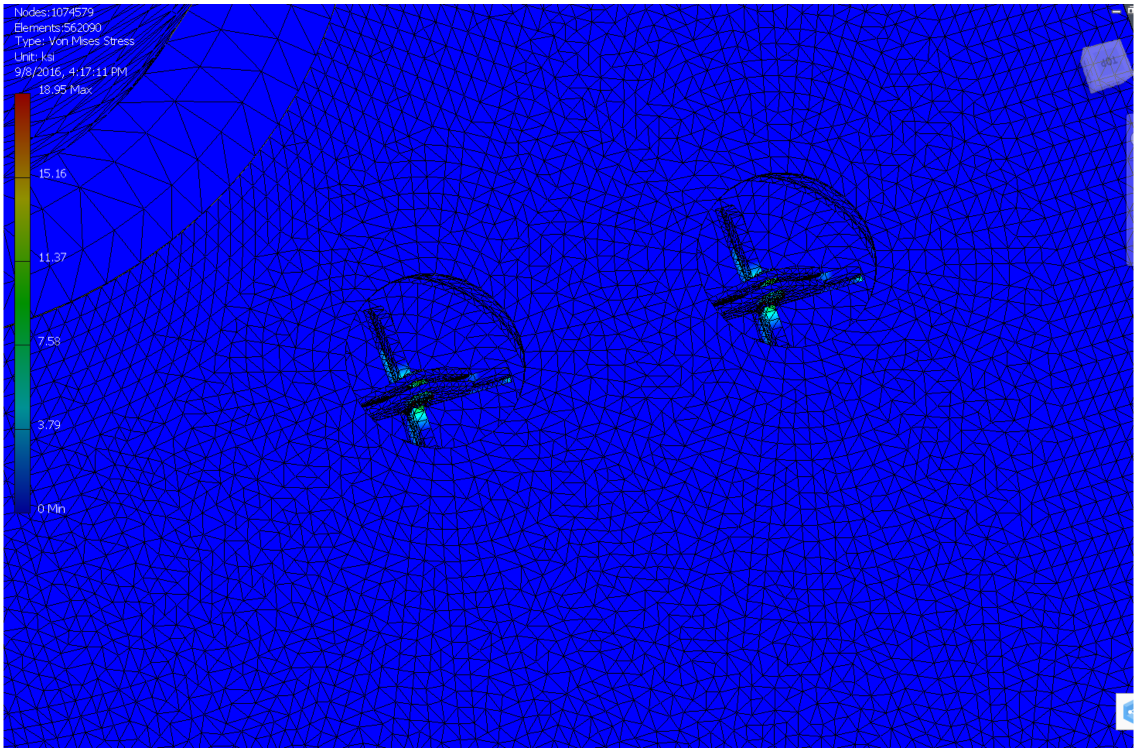


Pic7 and Pic8: Iso view from bottom-back. FEA results look outstanding, excellent Factors of Safety.





Pic9: Iso view from top. Looks great.



Pic10: Excellent FoS