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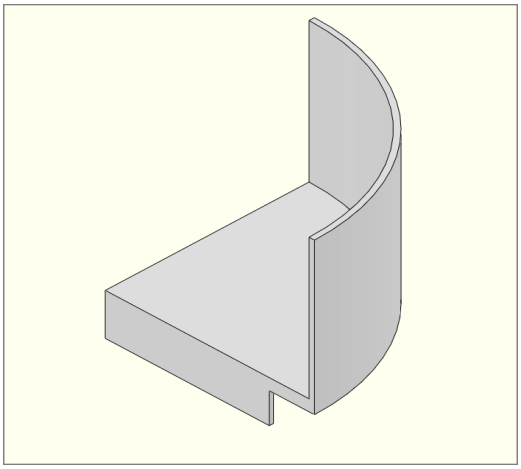
Finite Element Analysis (FEA) Report

XYZ Vessel Corp.

Inner Vessel Bottom Head Section

PVE-3259 Rev.0

January 14, 2009



PVE-3259 Rev.0

Ben Vanderloo

Laurence Brundrett P. Eng.

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Revision(s)			
Rev	Description	Date	By
0	Release	01/12/09	BV
1			
2			

Executive Summary ver 4.00

Project Information:

XYZ Vessel Corp.	Customer
Inner Vessel Bottom Head Section	Vessel / Component(s)
PVE-3259 Rev.0	Part Number
PVE-3259 Rev.0	Job
SolidWorks CosmosWorks 2008	FEA Program Used
14-Jan-2009	Date

Max Pressure (psi) 60	@Temperature (F) 200	Maximum Allowed Working Pressure
Max Operating Temp (F) 200	@ Pressure (psi) 60	Maximum Design Metal Temperature

Goal:

The inner vessel bottom head PVE-3259 will be used under ASME VIII-1 service. This head cannot be calculated to ASME VIII-1 code rules due to the complexity of its geometry. The rules of VIII-2 are used with VIII-1 allowed stresses to determine the acceptability of the bottom head.

Summary Conclusions:

Materials

Material strength properties used in this report are obtained from ASME IID, Table 1A. Stress classification limits are calculated to VIII-2 rules using ASME IID allowables for VIII-1. Properties are shown for SA-516 70. This is the primary material of construction.

Model Information

The model used in this report represents a quarter of the inner vessel bottom head. The mesh size has been refined to 0.125" for all components. A 2nd order, tetrahedral solid mesh is used for this model. The mesh size reduces the reported error to less than 5% for general areas.

Restraints & Loads

The support area has been fixed and all cut plane edges have been restrained using symmetry restraints. These restraints prevent rigid body motion in all directions while allowing the model to deform as expected. All reaction forces are as expected and the model is in balance.

Results

Through the FEA we found a 0.0104" maximum displacement to be acceptable. All general membrane stresses are below the 20,000 psi general allowable. All local membrane stresses are within the 30,000 psi local allowable. The inner vessel bottom head design is acceptable.

Analysis Conclusion:

The bottom head PVE-3259 meets ASME VIII-2 design rules using VIII-1 allowed stresses. The inner vessel bottom head design is acceptable.

Material Stress Limits ver 4.00 ASME VIII-2 Fig 4-130.1

Material:

SA-516 70	**Material**
Inner Vessel Bottom Head	**Application**

Strength Properties:

ASME VIII-IID, 2007	**Source** of strength properties
200	**T** [ºF] temperature
20,000	**Sm** [psi] basic allowable stress at temperature T
	Sy [psi] yield stress at temperature T (optional)
1.0	**k** [] - stress intensity k factor
1.00	**E1** [] - weld efficiency factor
1.00	**E2** [] - casting efficiency factor

FEA Properties:

ASME VIII-IID, 2007	**Source** of FEA properties
28,800,000	**E** [psi] - modulus of elasticity (at temperature)
0.26	**v** [] - Poison's ratio

Stress Limits:

Pm = k*E1*E2*Sm general primary membrane stress intensity limit

1*1*1*20000 = **20,000**

Pl = 1.5*k*E1*E2*Sm local membrane stress intensity limit

1.5*1*1*1*20000 = **30,000**

Pl+Pb = 1.5*k*E1*E2*Sm primary membrane + primary bending stress intensity limit

1.5*1*1*1*20000 = **30,000**

Pl+Pb+Q = Max(3*E1*E2*Sm,2*E1*E2*Sy) primary + secondary stress intensity

MAX(3*1*1*20000,2*1*1*0) = **60,000**

Pl+Pb+Q+F = Use fatigue curves peak stress intensity limit

Comments:

(1) Sy material property is not required, more conservative Pl+Pb+Q limits might be computed without it.
(2) Refer to VIII-2 Table AD-150.1 for k values
(3) The thermal expansion coeficient is only required for studies including thermal stresses
(4) Refer to VIII-2 App 4-130 and following for the Pm, Pl, Q and F stress limits
(5) Refer to VIII-2 App 4-130 Table 4-120.1 for the correct application of the calculated stress limits
(6) Use IID tables 2A and 2B for Sm for VIII-2 studies
(7) Use IID tables 1A and 2A for Sm values (S) for VIII-1 studies
(8) Use B31.1 Table A for Sm values for B31.1 studies
(9) Use B31.3 Table A for Sm values for B31.3 studies

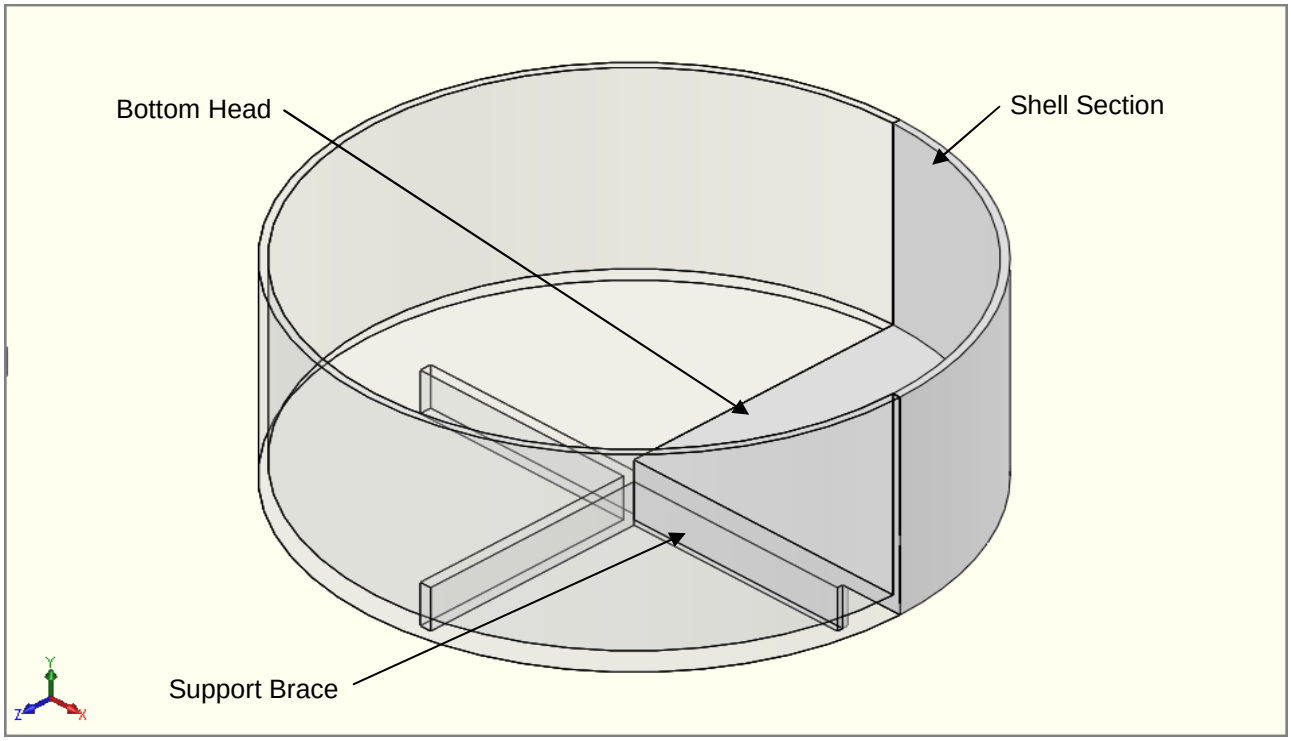


Fig-A A view of the inner vessel bottom head. A quarter solid model was used to simplify the analysis. Note that the scope of this report is limited to the head component. A section of shell has been added to provide realistic results. Refer to drawing PVE-3259 for more details.

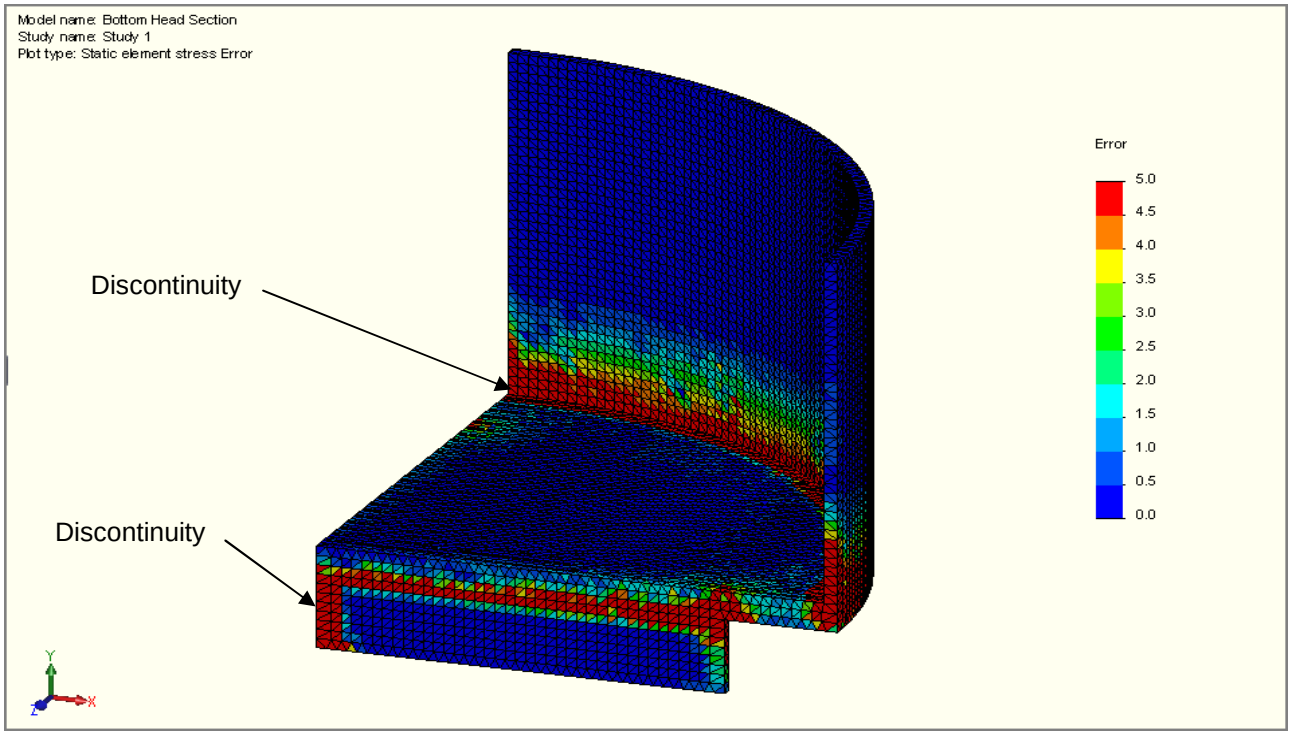


Fig-B A view of the error plot capped at 5% with the mesh overlaid. A global mesh size of 1/8" was used for the entire model. Error exceeding the 5% are located at areas of discontinuity. The error is acceptable and the model may be used for results.

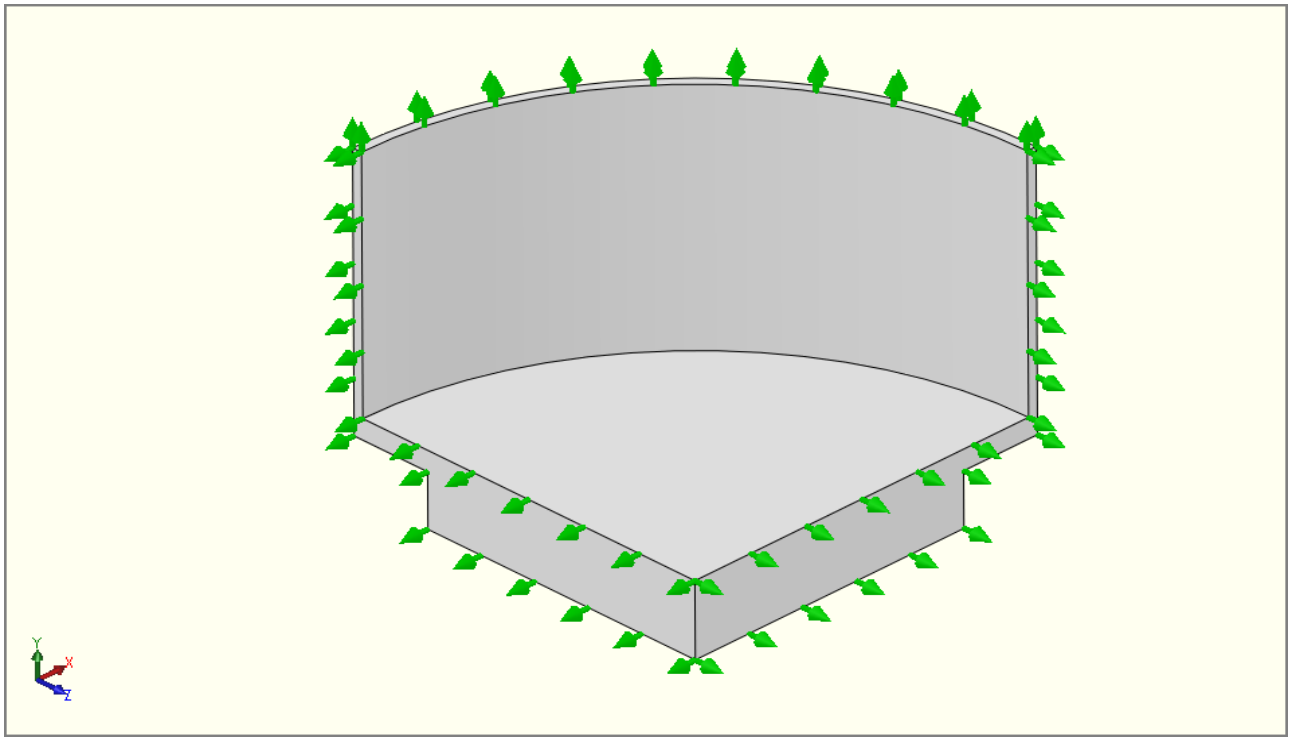


Fig-A A view of the symmetry restraints applied to the model. Symmetry restraints are applied to all of the cut plane edges to provide realistic results and simulate the complete model.

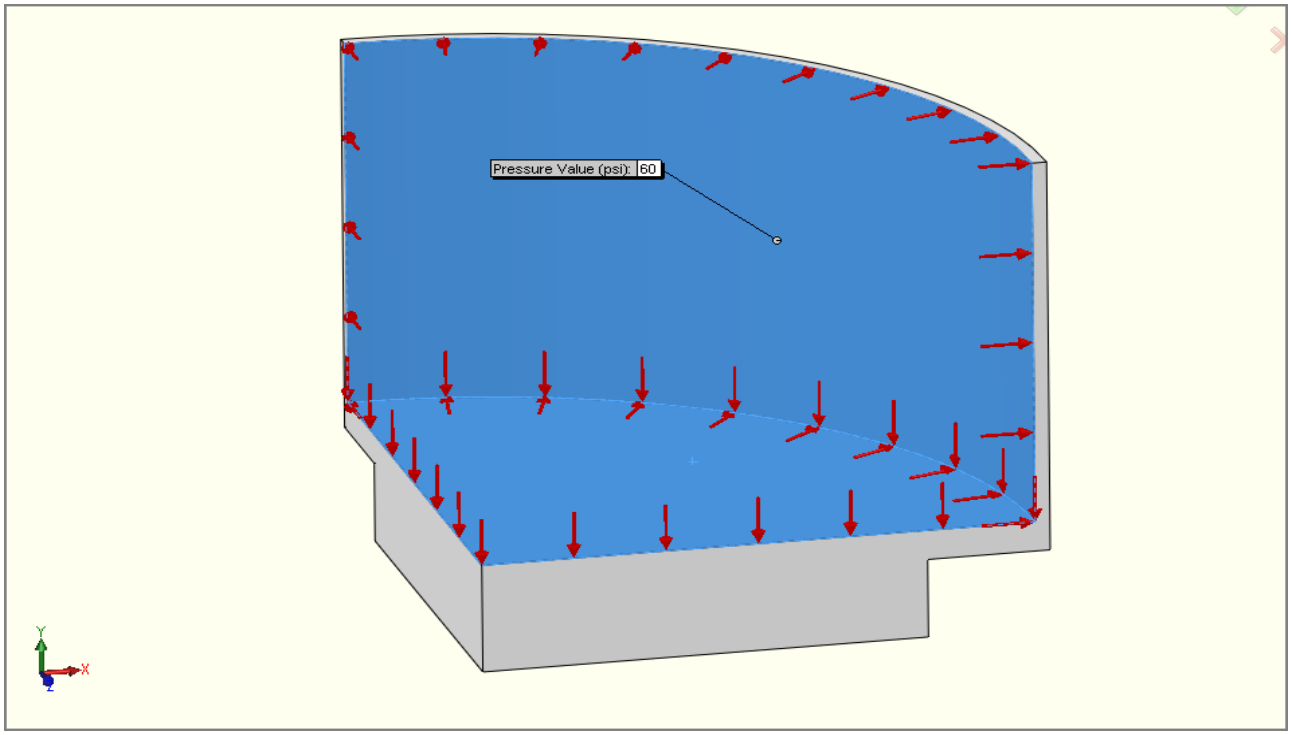
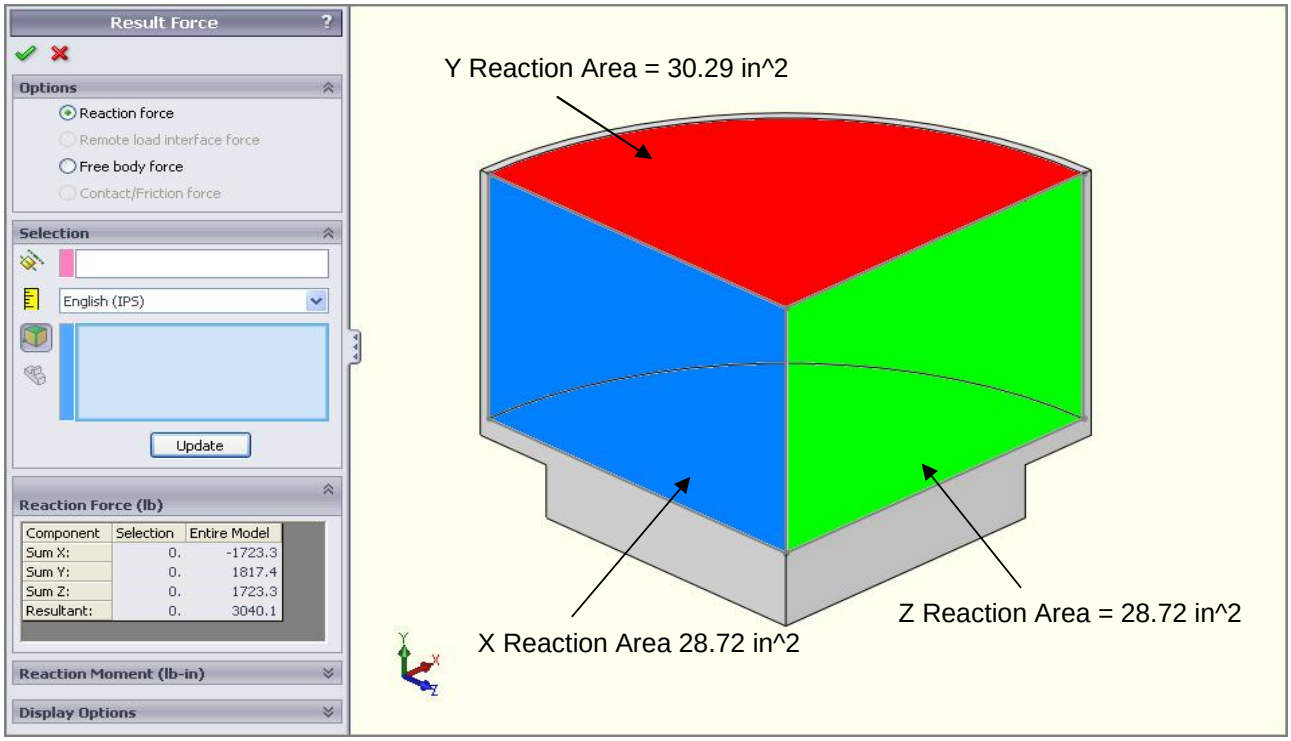


Fig-B A view of the 60 psi internal pressure applied to the head.

Reaction Forces ver 4.08



View showing global reaction forces from analysis "X" = -1723.3 lb, "Y" = 1817.4 lb, "Z" = 1723.3 lb
Calculated Reaction Forces = Analysis Reaction Forces within 0.0%
Model is balanced, results are valid.

X Axis: reaction forces on the YZ plane caused by loads in the X direction

28.72	**XArea** [in2] - Pressurized area on YZ plane	
60	**P** [psi] - Pressure	
0	**XForce** [lbs] - Added force in the X direction	
-1,723.300	**XReaction** [lbs] - Reaction force in X direction reported by FEA program	
TReactionX [lbs] = XArea*P+XForce	Theoretical X reaction force	29*60+0 = **1,723**

Y Axis: reaction forces on the XZ plane caused by loads in the Y direction

30.29	**YArea** [in2] - Pressurized area on XZ plane	
0	**YForce** [lbs] - Added force in the Y direction	
1,817.40	**YReaction** [lbs] - Reaction force in Y direction reported by FEA program	
TReactionY [lbs] = YArea*P+YForce	Theoretical Y reaction force	30*60+0 = **1,817**

Z Axis: reaction forces on the XY plane caused by loads in the Z direction

28.72	**ZArea** [in2] - Pressurized area on XY plane	
0	**ZForce** [lbs] - Added force in the Z direction	
1,723.30	**ZReaction** [lbs] - Reaction force in Z direction reported by FEA program	
TReactionZ [lbs] = ZArea*P+ZForce	Theoretical Z reaction force	29*60+0 = **1,723**

Resultant of reaction forces in X, Y and Z:

TResultant [lbs] = sqrt(TReactionX^2+TReactionY^2+TReactionZ^2)	Theoretical resultant	SQRT(1723^2+1817^2+1723^2) = **3,040**
Resultant [lbs] = sqrt(XReaction^2+YReaction^2+ZReaction^2)	Actual resultant	SQRT(-1723^2+1817^2+1723^2) = **3,040**
Error [%] = 100*(TResultant-Resultant)/Resultant		100*(3040-3040)/3040 = **0.0**
CheckError = abs(Error)<2	Error should be less than 2%	ABS(0)<2 = **Acceptable**

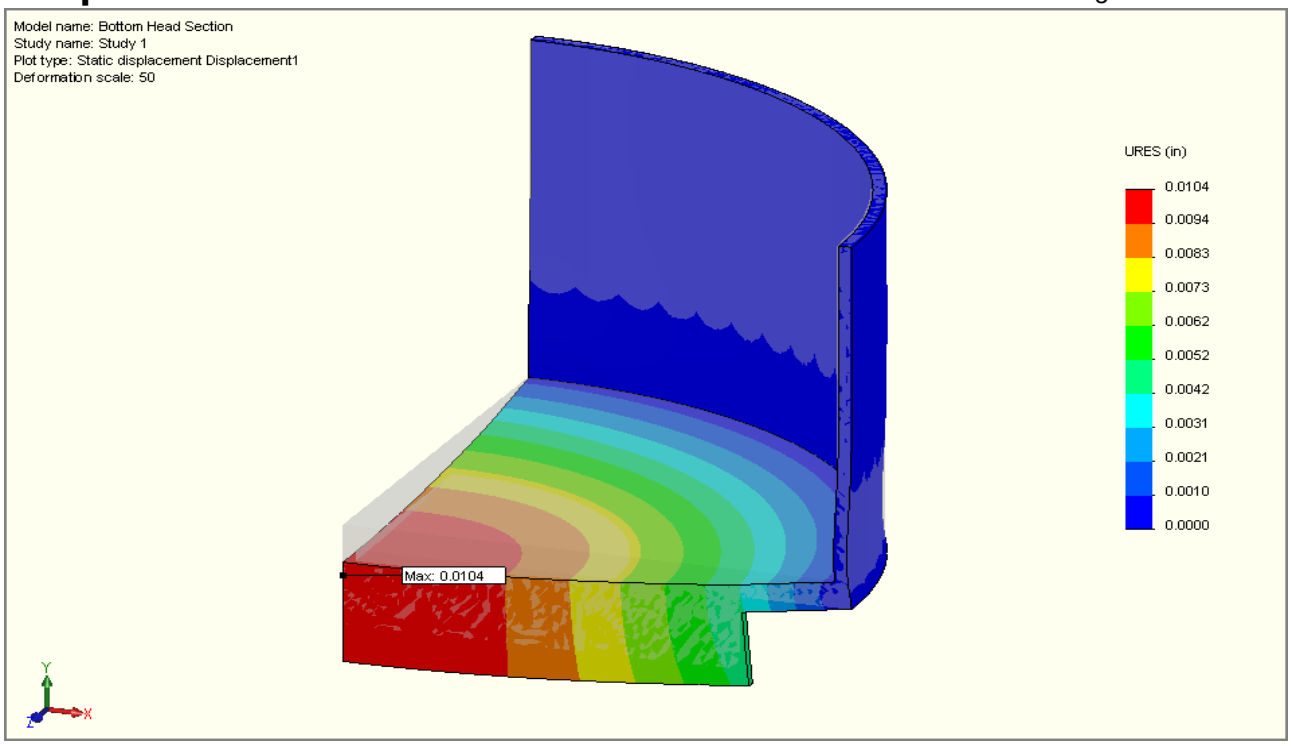


Fig-A A view of the displacement plot with superimposed original geometry. Results are magnified 50X. The displacement of the bottom head is outward due to internal pressure.

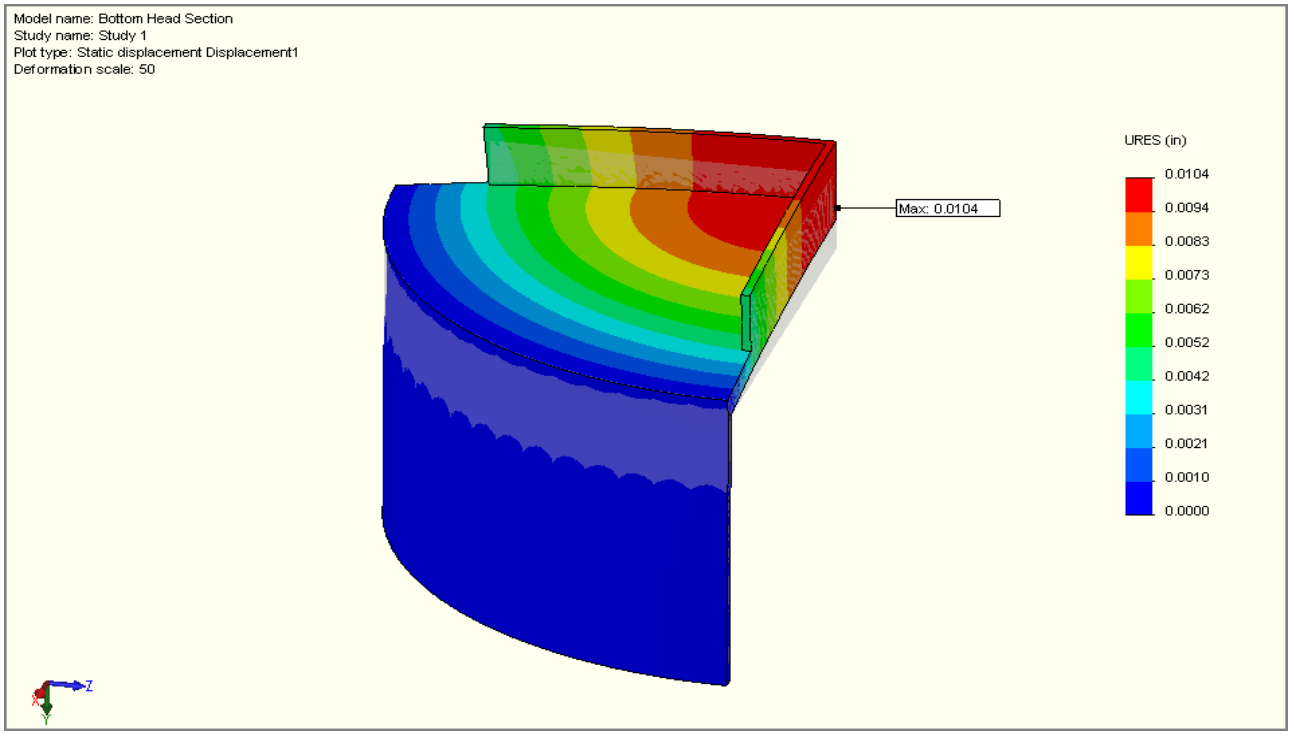


Fig-B An alternate view of Fig-A showing the acceptable maximum displacement of 0.0104".

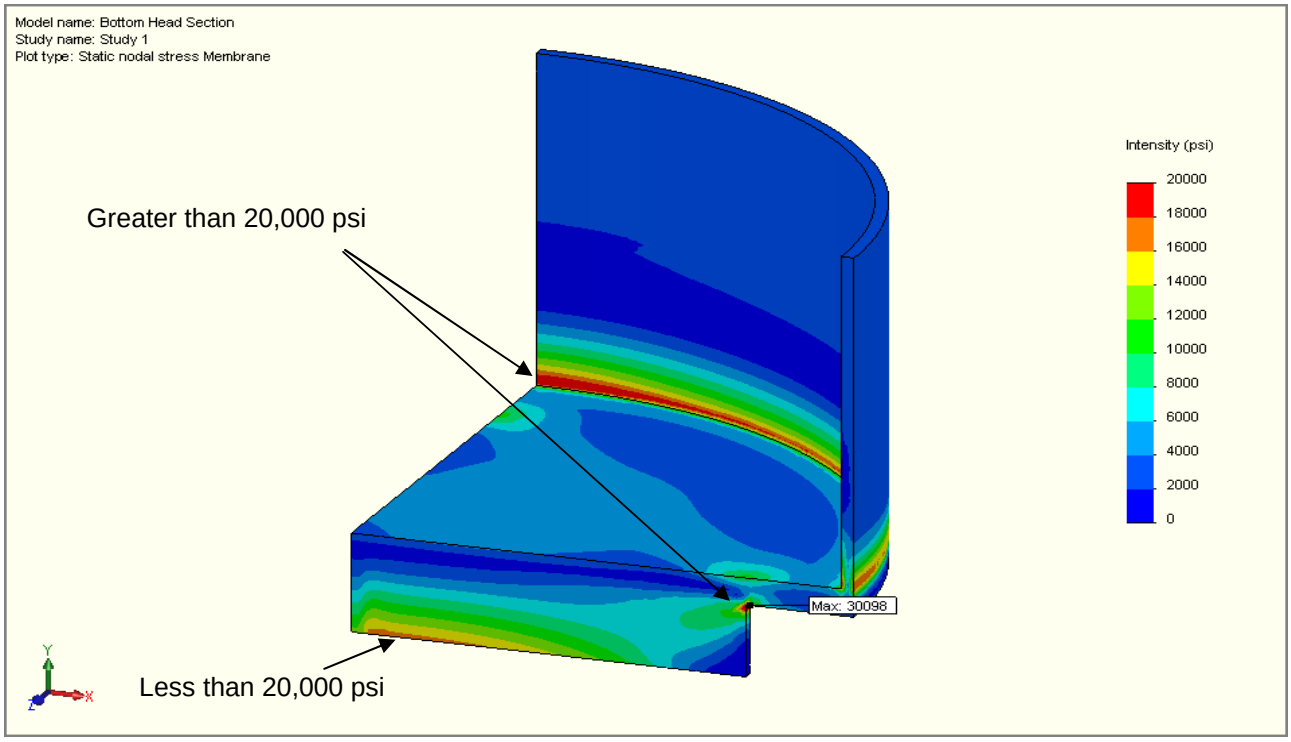


Fig-A A view of the membrane stress plot (Intensity) capped at the general membrane allowable of 20,000 psi. Maximum stresses are at the shell to head junction. This is due to tension created by the opposing rotations of the head and shell. Membrane stress is acceptable

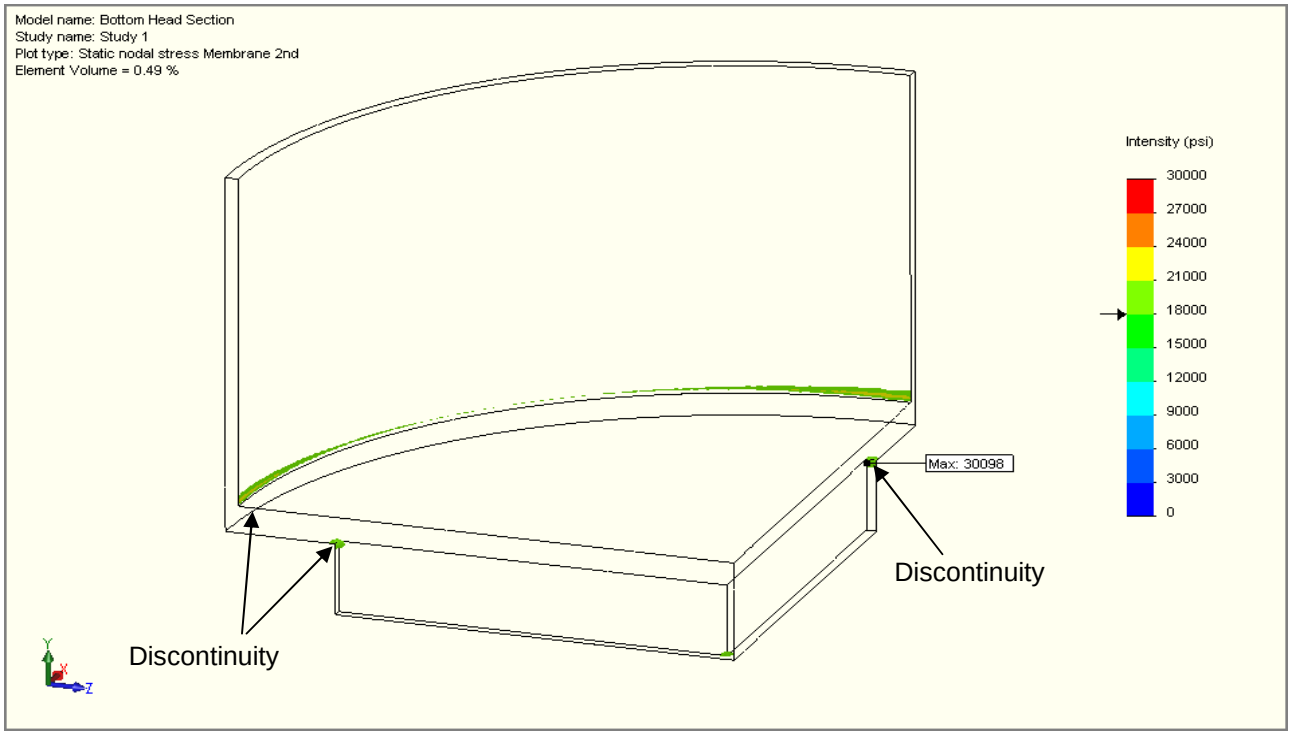


Fig-B A view of the local membrane stress plot (Intensity) capped at the local membrane allowable of 30,000 psi. The plot is iso-clipped at 18,000 psi. Areas in excess of the allowable are limited to areas of discontinuity. Head stresses are acceptable

Reference List:

Please refer to the following links for additional information;

Including reference components in an FEA to provide appropriate boundary and load conditions.
http://www.pveng.com/documents/content_80.pdf

The use and effects of 2nd order integration elements.
http://www.pveng.com/documents/content_151.pdf

Mesh Refinement Using the Error Function Results for Areas at Discontinuities.
http://www.pveng.com/documents/content_250.pdf

Mesh Refinement Using the Error Function Results for Areas near Discontinuities.
http://www.pveng.com/documents/content_251.pdf

Error Plots for Bolt Heads and Surface to Surface Contacts Areas.
http://www.pveng.com/documents/content_248.pdf

FEA Software Validation - A comparison to theoretical results.
http://www.pveng.com/documents/content_249.pdf

COSMOSWorks Validation Examples.
http://www.pveng.com/documents/content_247.pdf