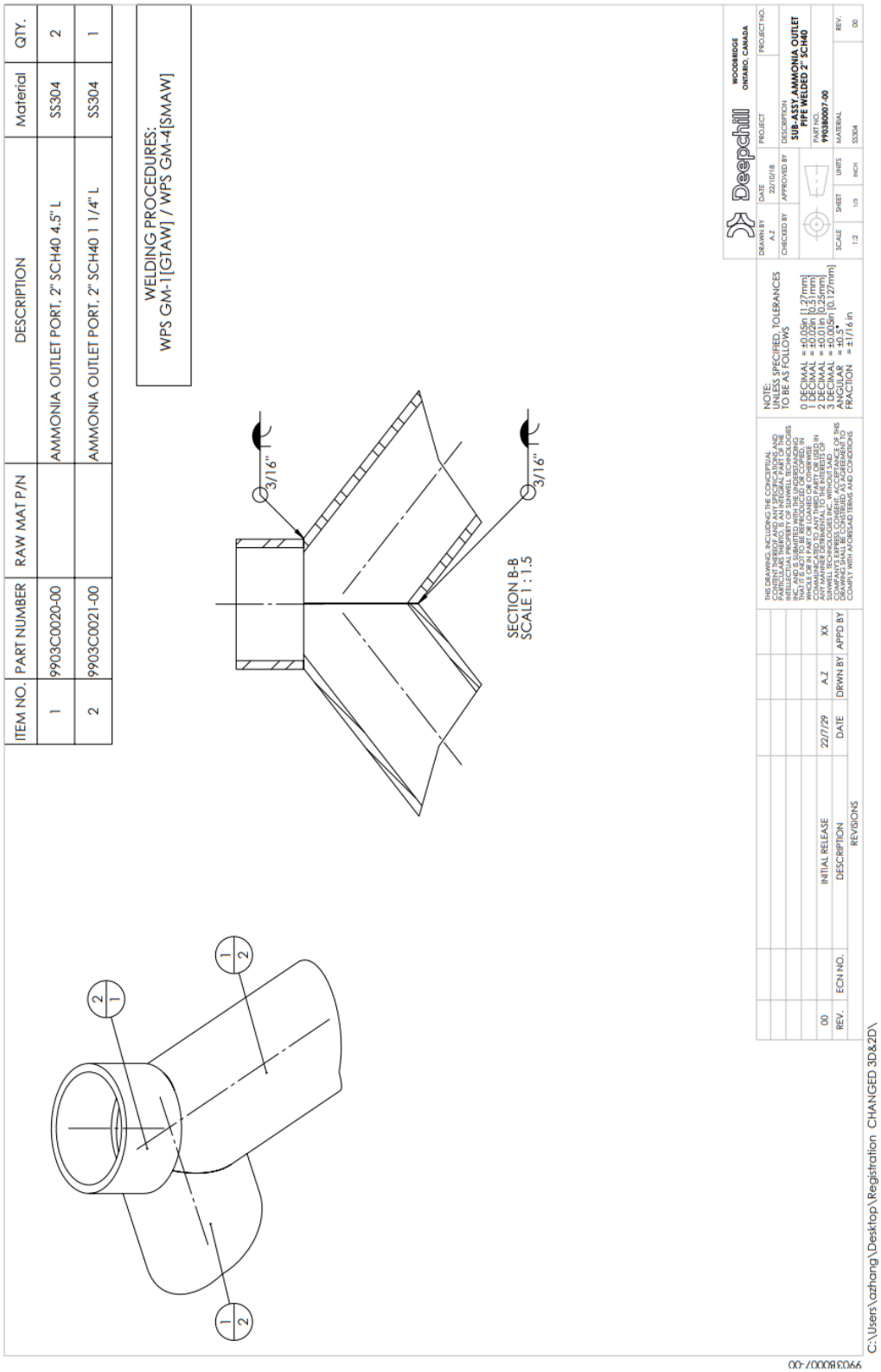
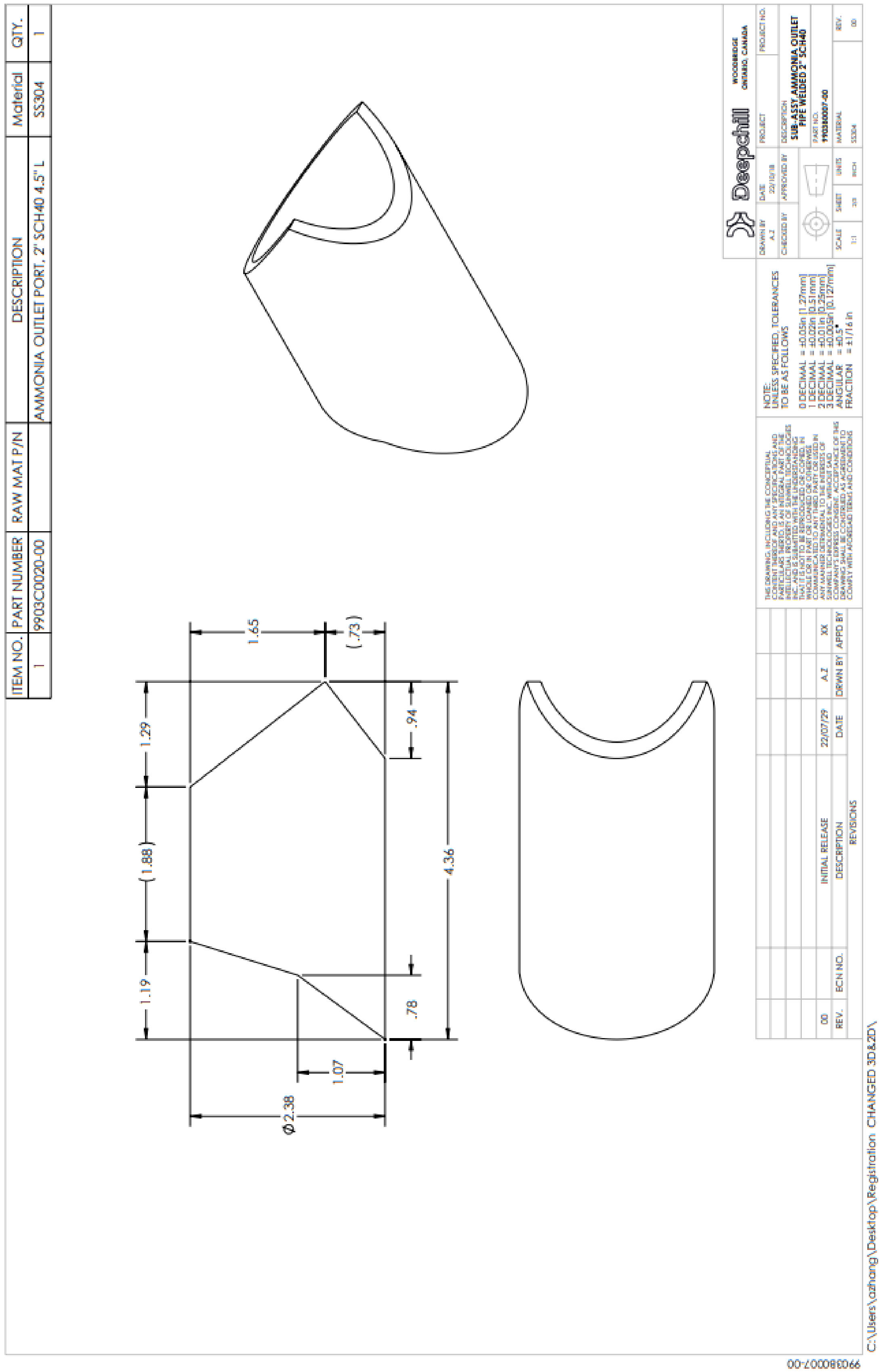
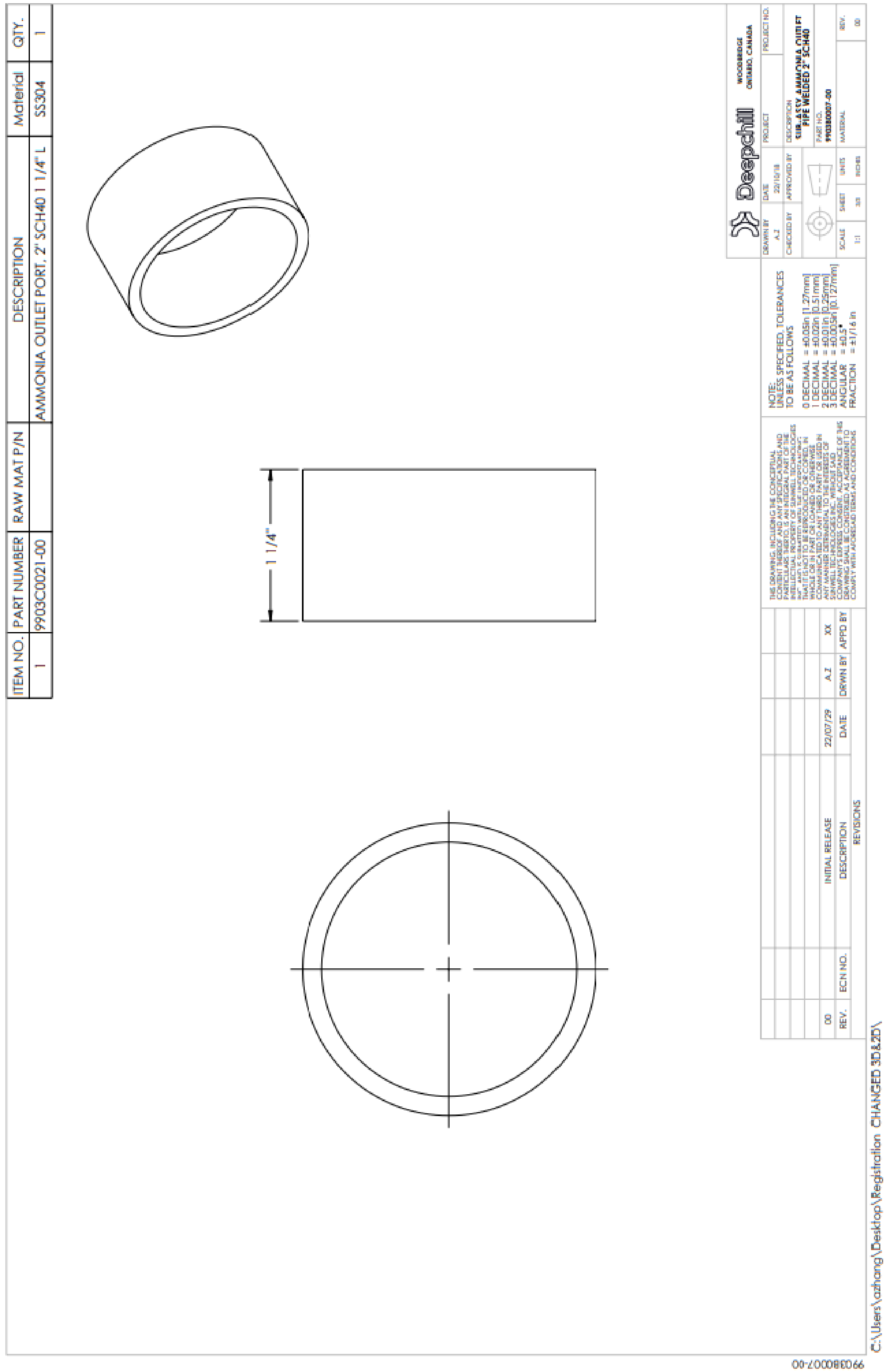
Part Drawings




ITEM NO.
PART NUMBER
RAW MAT P/N
DESCRIPTION
Material
QTY.
1
9903C0020-00
AMMONIA OUTLET PORT, 2" SCH40 4.5" L
SS304
1
1.65
(.73)
1.29
(1.88)
1.19
.94
4.36
.78
1.07
Ø2.38
NOTE:
UNLESS SPECIFIED, TOLERANCES TO BE AS FOLLOWS
ANGULAR = ±0.5°
FRACTION = ±1/16 in
Deepchill
WOODBRIDGE ONTARIO, CANADA
SUB-ASSY, AMMONIA OUTLET PIPE WELDED 2" SCH40
SS304
REV.
ECN NO.
DESCRIPTION
DATE
DRWN BY
APPD BY
00
INITIAL RELEASE
22/07/29
A.Z
XX
REVISIONS
C:\Users\azhang\Desktop\Registration CHANGED 3D&2D\
9903B0007-00


ITEM NO.
PART NUMBER
RAW MAT P/N
DESCRIPTION
Material
QTY.
1
9903C0021-00
AMMONIA OUTLET PORT, 2" SCH40 1 1/4" L
SS304
1
1 1/4"
INITIAL RELEASE
22/07/29
REVISIONS
9903B0007-00

Executive Summary

Goal:

The SUB-ASSY, AMMONIA OUTLET PIPE WELDED 2" SCH40 (DWG#: 9903B0007), a WYE, will be used under ASME VIII-1 service. This WYE cannot be calculated due to the complexity of the geometry. The rules of VIII-2 are used with VIII-1 allowable stresses to determine the acceptability.

Summary Conclusions:

Analysis Software
Solidworks Simulation 2022

Analysis Type
Static linear elastic Study is performed

Materials
Material strength properties used in this report are obtained from ASME IID and are suitable for VIII-1 components. The rules of ASME VIII-2 are used to set the stress limits.

Model and Mesh
The model used in this report represents WYE. The WYE is modelled using a 2" SCH 40 Pipe. The global mesh size used is 0.05" and a standard 3D tetrahedral solid mesh was applied to reduce the reported error to less than 5% for general areas.

Restraints and Loads
The two ends of the WYE are fixed to prevent the translation of the model in all three primary planes. The inside of the WYE is pressurized to 305 psi, the design MAWP of the part. The model is in balance and can be used for displacement and stress analysis

Results
The model has a maximum displacement of 0.0008". The displaced shape of the model is as expected, and the magnitude of the displacement is acceptable. The model has a maximum peak stress of 10310 psi. All stresses in the model are below the primary general membrane stress limit of 17000 psi and is acceptable for ASME VIII-1 use.

Analysis Conclusion:

All stresses in the model are below the primary general membrane stress limit based on ASME VIII-2 and the design is acceptable. Calculated reaction forces fall within 2% of the analysis reaction forces; the model is balanced and the results are valid. The error% on general areas for the model falls below 5%, the study is acceptable. The SUB-ASSY, AMMONIA OUTLET PIPE WELDED 2" SCH40 (DWG#: 9903B0007) is acceptable for ASME VIII-1 use at 305 psi and 80 °F.

Material Stress Limits

1	***Material and Conditions:***			
2	**80.000**	Design Temperature ºF		
3	**SA-312 TP304**	Material		
4	**17000**	S [psi] - allowable stress level		
5	**30000**	Sy[psi] – minimum specified yield strength at design temperature		
6	**30000**	YS[psi] – minimum specified yield strength at room temperature		
7	**75000**	UTS[psi] – minimum specified ultimate tensile strength at room temperature		
8	**27500000**	E [psi] - moduli of Elasticity @design Tº (II-D TM-1)		
9	**0.31**	V – poisson's ratio		
10	**0.29**	Density		
11	**1.00**	E1 - Weld Efficiency		
12	***Stress Limits:***			
13	**Pm [psi] =**	E1 * S - general primary membrane stress limit	1*17000 =	**17000.000**
14	**Pl [psi] =**	1.5*E1*S - local membrane stress limit	1.5*1*17000 =	**25500.000**
15	**Pl + Pb [psi] =**	1.5*E1*S - primary membrane + primary bending stress intensity l	1.5*1*17000 =	**25500.000**

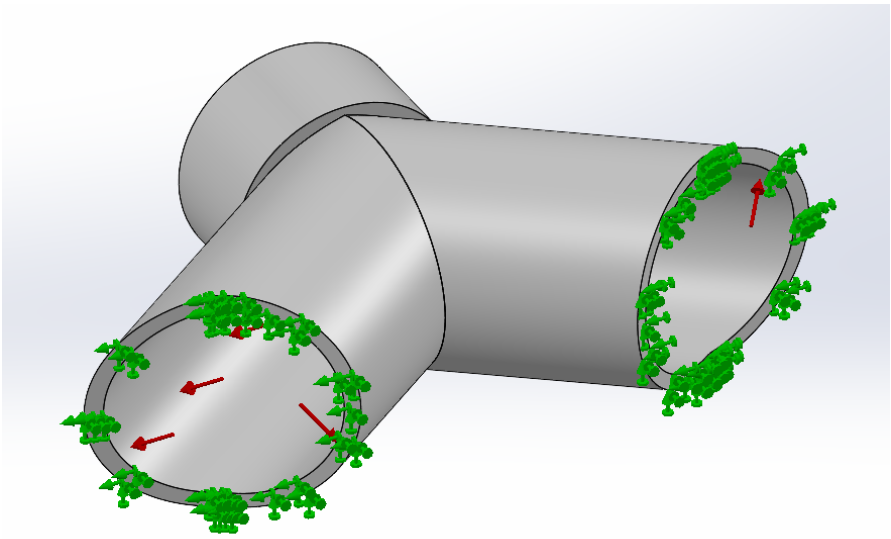
Study Properties

Study name	Static 1
Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effects from SOLIDWORKS Flow Simulation	Off
Solver type	Automatic
Inplane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction	Off
Use Adaptive Method:	Off
Result folder	SOLIDWORKS document (C:\Users\ksingh\Sunwell Engineering Co\Operations - Drive\2. R&PD\2. R&PD Projects\R403 Superpack Development\05 Engineering\01 Gen 0\Mechanical\GEN0 Rev2\WYE FEA - Christy\WYE -Analysis)

Units

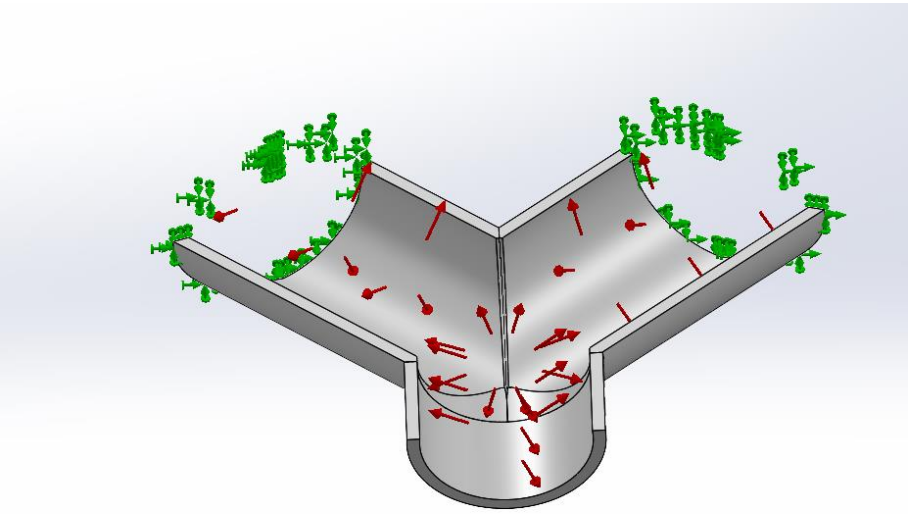
Unit system:	English (IPS)
Length/Displacement	in
Temperature	Fahrenheit
Angular velocity	Hertz
Pressure/Stress	psi

Loads and Fixtures

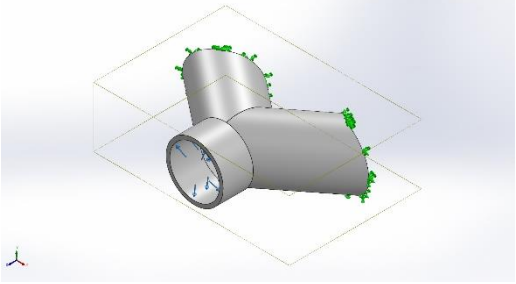
Fixture name	Fixture Image	Fixture Details
Fixed-1	 Fig A- An Image showing the fixed faces. These faces will be joined to the vessel by welding.	**Entities:** 4 face(s) **Type:** Fixed Geometry

Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(lbf)	0.0352013	0.00632174	-1,076.02	1,076.02
Reaction Moment(lbf.in)	0	0	0	0

Load name	Load Image	Load Details
Pressure-1	 Fig B A sectional view showing the 305 psi internal pressure applied to the inside surfaces of the WYE (shown in red markings).	**Entities:** 5 face(s) **Type:** Normal to selected face **Value:** 305 **Units:** psi **Phase Angle:** 0 **Units:** deg

Interaction Information

Interaction	Interaction Image	Interaction Properties
Global Interaction		**Type:** Bonded **Components:** 1 component(s) **Options:** Continuous mesh

Mesh information and error plot

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	On
Include Mesh Auto Loops:	Off
Jacobian points for High quality mesh	16 Points
Element Size	0.05 in
Tolerance	0.0025 in
Mesh Quality	High
Remesh failed parts independently	Off

Mesh information - Details

Total Nodes	648604
Total Elements	416194
Maximum Aspect Ratio	28.401
% of elements with Aspect Ratio < 3	99.6
Percentage of elements with Aspect Ratio > 10	0.0257
Percentage of distorted elements	0
Time to complete mesh(hh;mm;ss):	00:00:17
Computer name:	DCTI-LT10

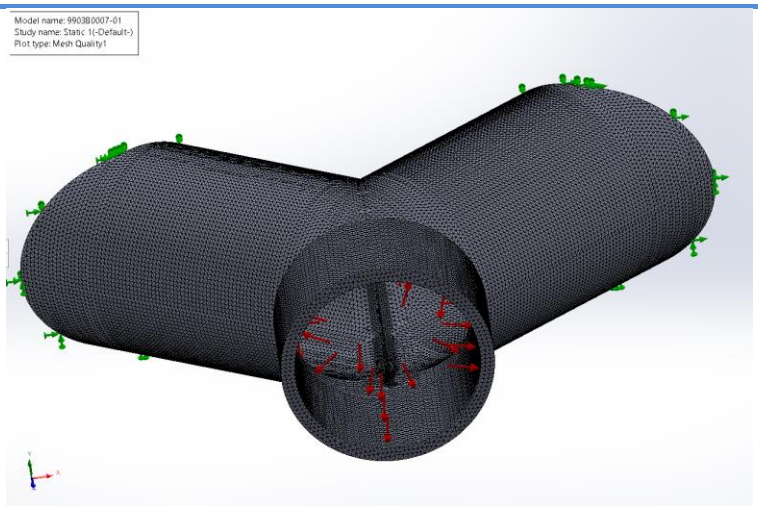


Fig-A A view of the mesh applied to the model. A global mesh size of 0.05" is used with 3D tetrahedral solid elements. Mesh is refined at the intersection of pipe joints for better accuracy.

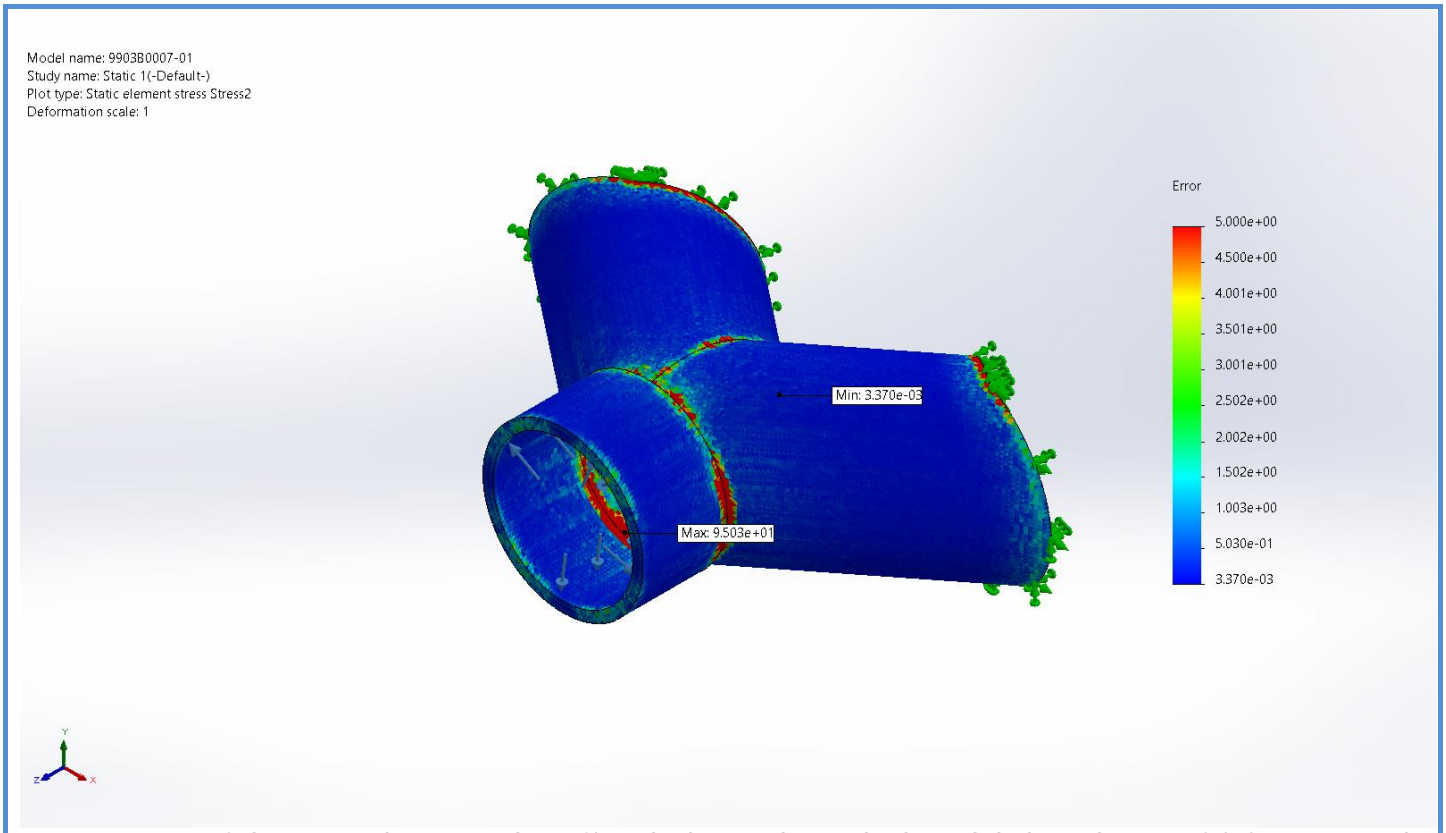


Fig-B A view of the error plot capped at 5% with the mesh overlaid. A global mesh size of 0.05" was used for the entire model. Error exceeding 5% is located at areas of applied load and areas of discontinuity. The error is acceptable, and the model may be used for results

Reaction Forces

Reaction forces

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	lbf	0.0352013	0.00632174	-1,076.02	1,076.02

305	P[psi] - Pressure		
X Axis:	Reaction foces in the YZ Plane caused by loads in te X direction		
0	XArea [in2] - Pressurized area on YZ Plane		
0	XForce [lbs] - Added force in the X direction		
0.035	XReaction [lbf] -Reaction force in X direction reported by FEA program		
Treaction X [lbf] =	XArea*P +XForce Theoretical Reaction force	0*305+0=	0
Y Axis:	Reaction foces in the XZ Plane caused by loads in te X direction		
0	YArea [in2] - Pressurized area on XZ Plane		
0	YForce [lbs] - Added force in the Y direction		
0.006	YReaction [lbf] -Reaction force in X direction reported by FEA program		
Treaction X [lbf] =	YArea*P +YForce Theoretical Reaction force	0*305+0=	0
Z Axis:	Reaction foces in the XZ Plane caused by loads in te X direction		
3.51	ZArea [in2] - Pressurized area on XZ Plane		
0	ZForce [lbs] - Added force in the Y direction		
1076.02	ZReaction [lbf] -Reaction force in X direction reported by FEA program		
Treaction X [lbf] =	ZArea*P +ZForce Theoretical Reaction force	3.51*305+0=	1070.55
Resultant of reaction forces in X, Y and Z:			
TResultant [lbf] =	sqrt(Treaction X^2 +Treaction X^2+Treaction X^2), Theoretical resultant		
		SQRT(0^2+0^2+1070.55^2) =	1070.55
Resultant [lbf] =	sqrt(Treaction X^2 +Treaction X^2+Treaction X^2), Actual resultant		
		SQRT(0.035^2 +0.006^2 +1076.02^2	1076.02
Error (%) =	100*(TResulant -Resultant)/Resultant		-0.508
CheckError =	abs(Error)<2 Error should be less than 2%	ABS(Error) <2	Acceptable
Calculated reaction forces = Analysis Reaction forces within 2%; Model is balanced and resulst are valid			

Study Results

Name	Type	Min	Max
Stress1	VON: von Mises Stress	2.771e+01psi Node: 443934	1.031e+04psi Node: 279479

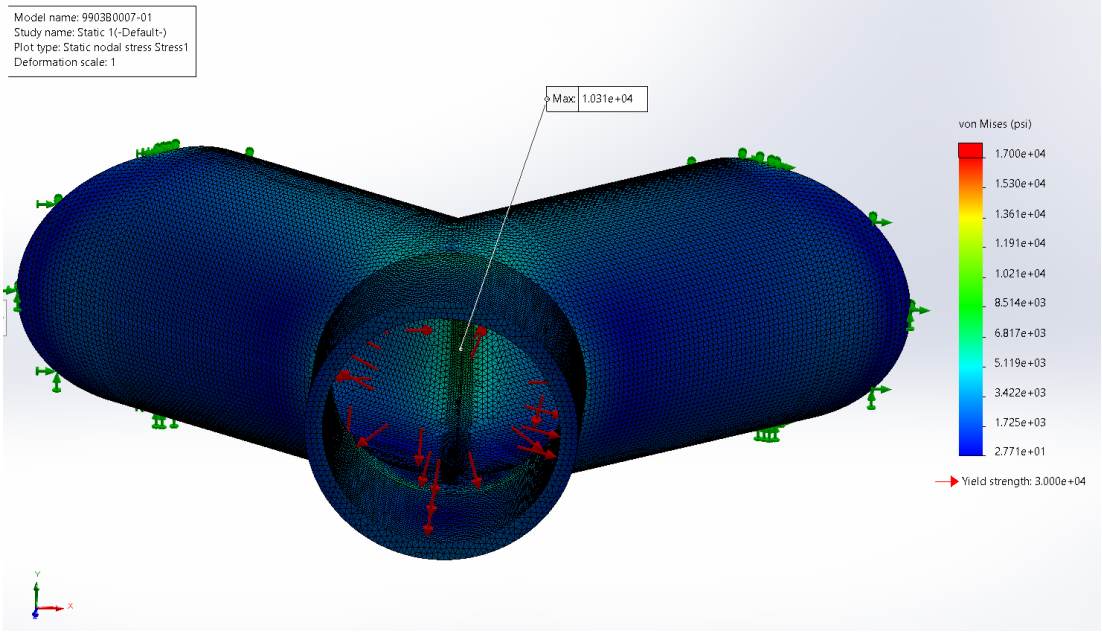


Fig-A A view of the stress plot capped at the general allowable of 17000 psi. Maximum stress is at the pipe intersection.

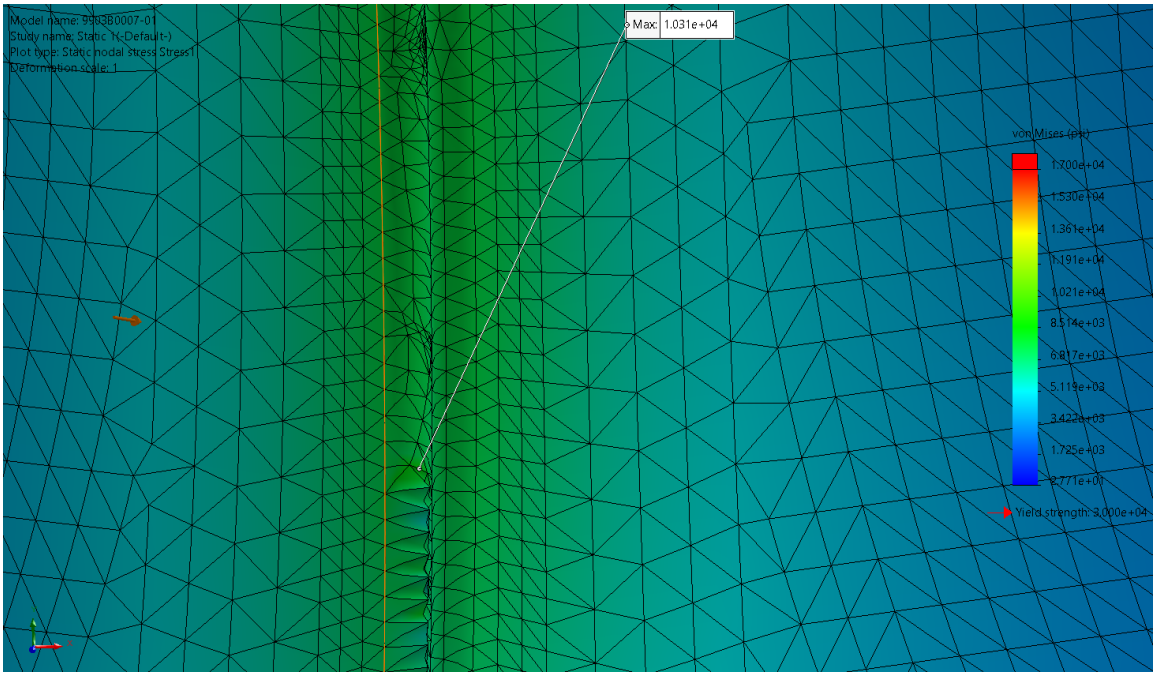


Fig-B Zoomed in view of the maximum stress area. Maximum stress capped at 10310 psi.

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00in Node: 795	8.954e-04in Node: 149710

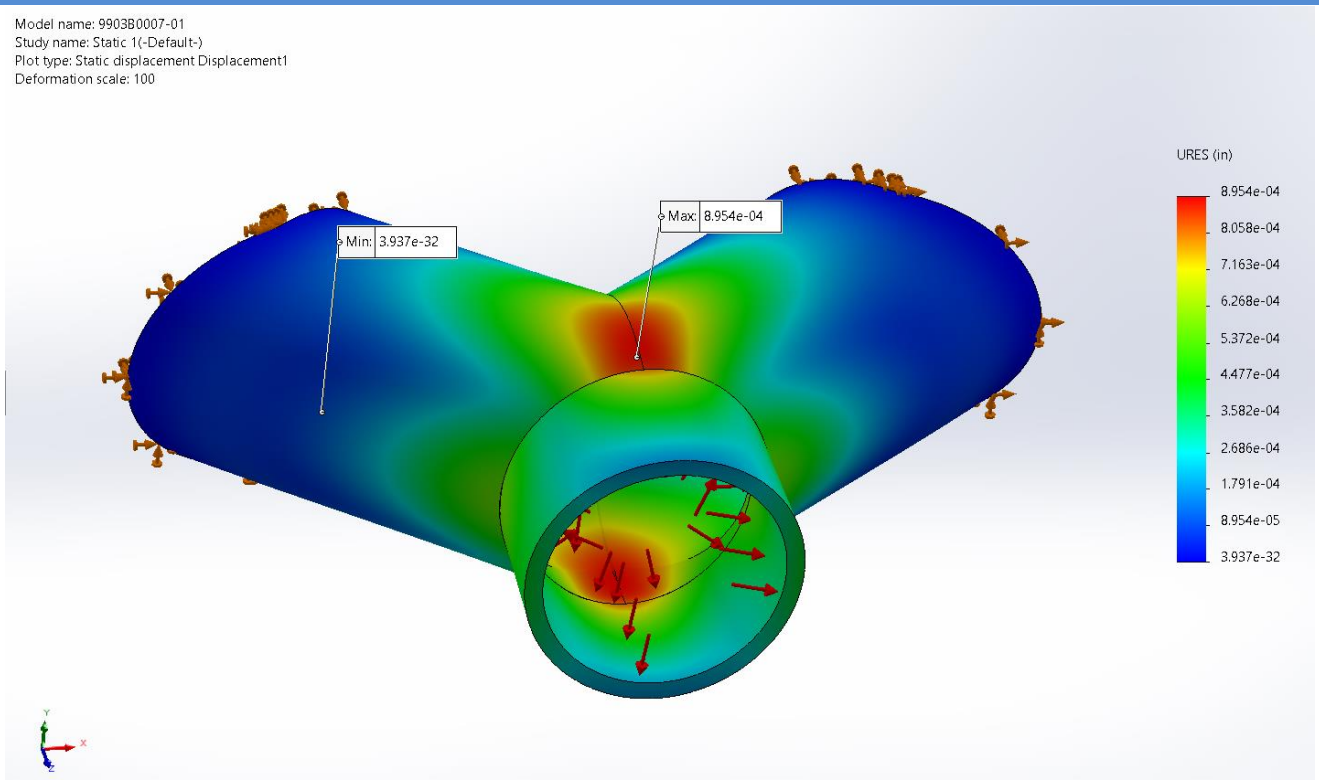


Fig-A A view of the displacement plot with results magnified to 100X. The WYE bulges at the intersection of the pipes

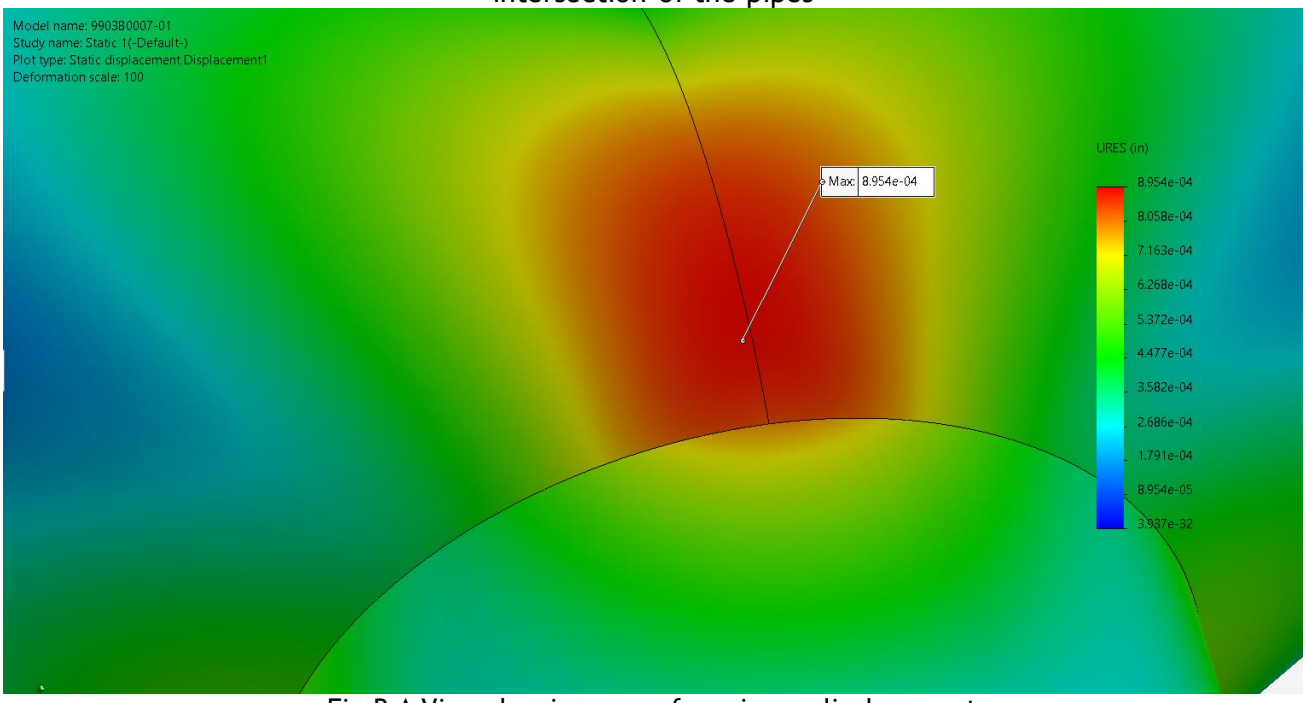


Fig-B A View showing area of maximum displacement

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	1.541e-06 Element: 44418	3.149e-04 Element: 152835

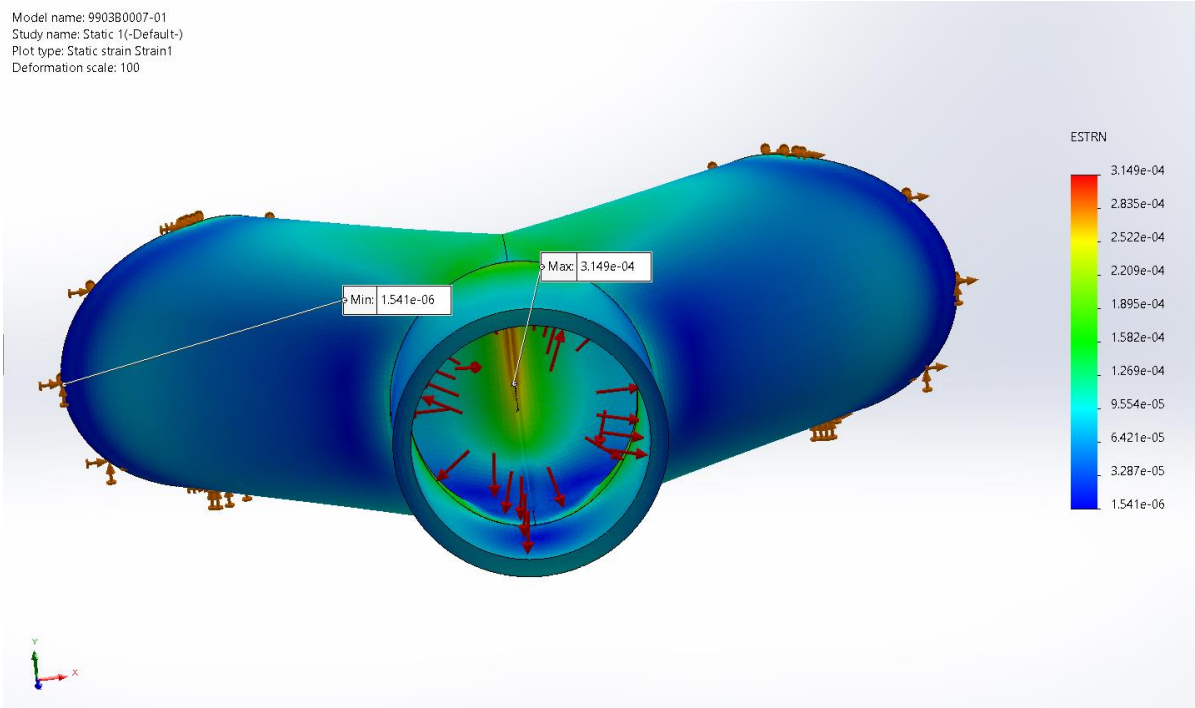


Fig A A view showing areas of maximum and minimum strain. Deformation scale is at 100X

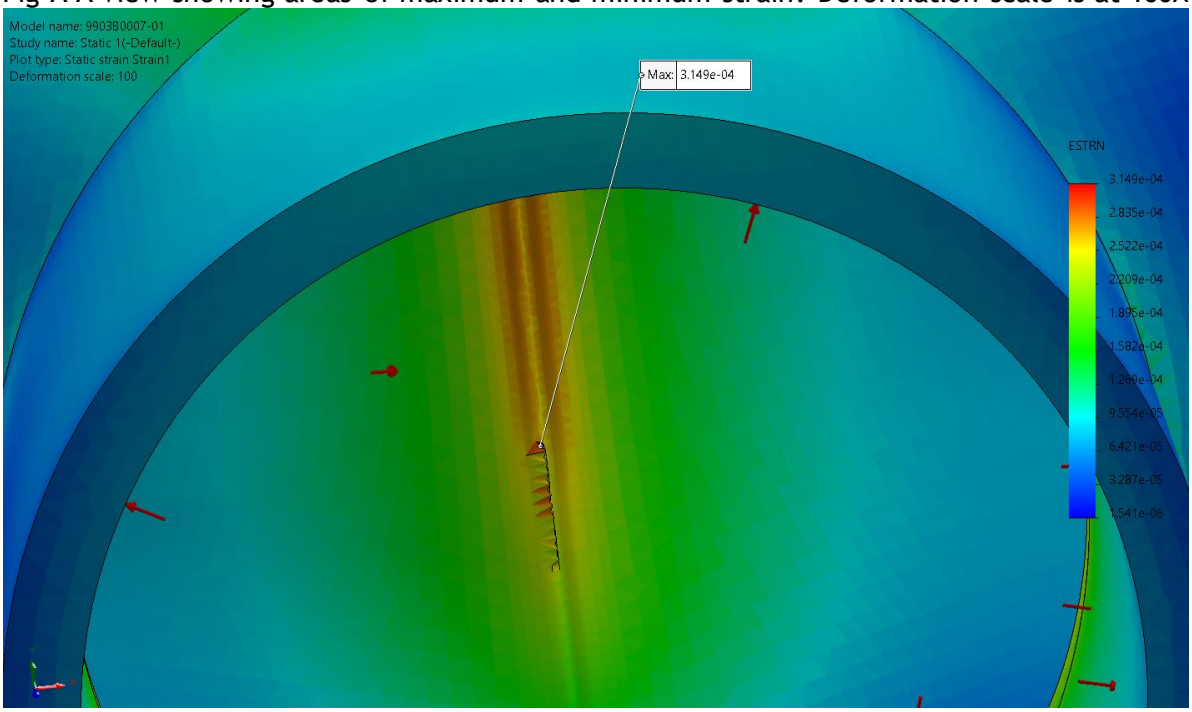


Fig B Zoomed in image of the maximum strain area for reference. Maximum strain occurs at the intersection of the of the pipe.