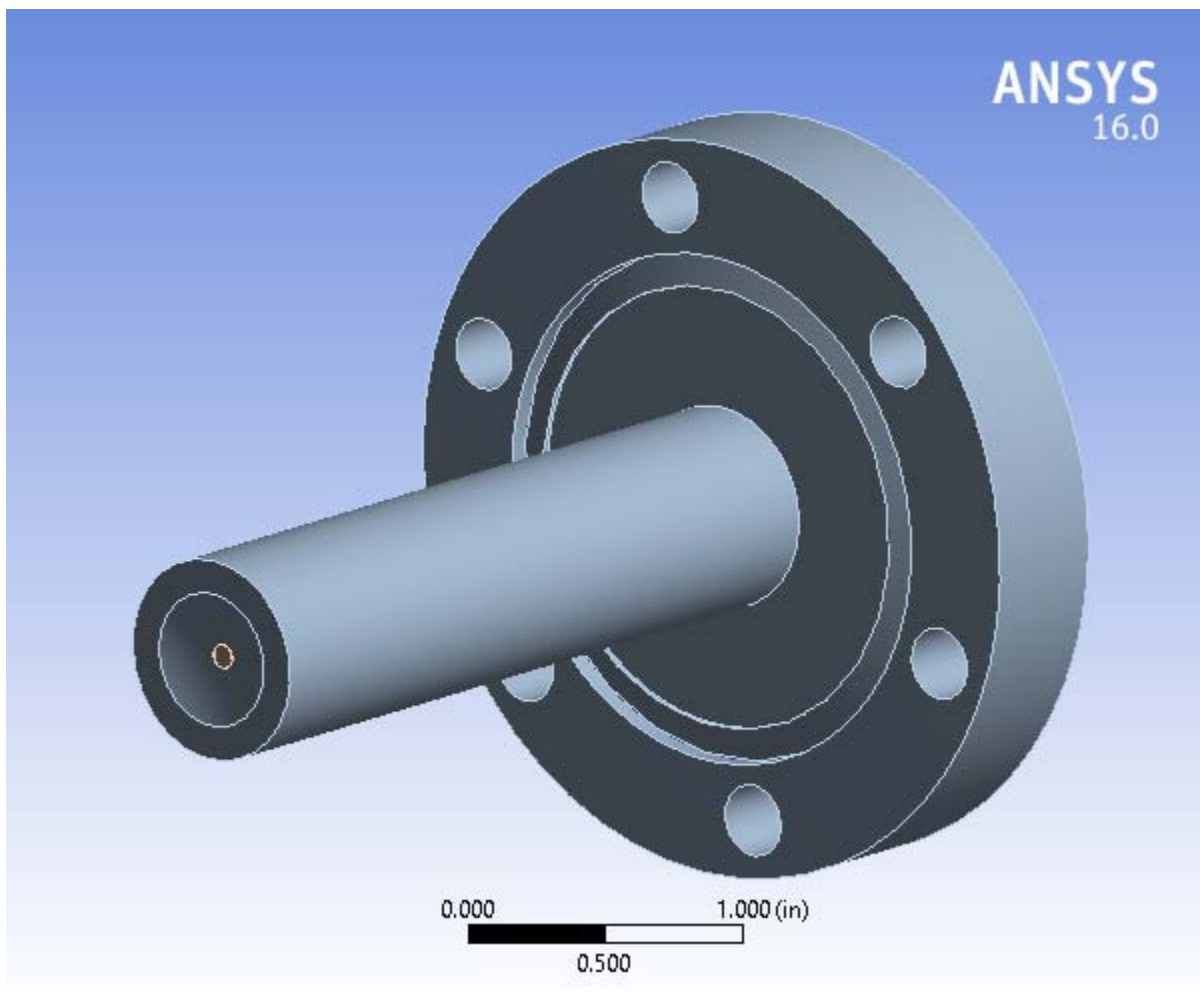




## Thermal stress analysis in entrance window

Author	Dave Meekins
Number	TGT-CALC-103-012
Revision	0
Applicable Code	ASME B31.3 (2012)



### Units

TABLE 1

Page 1 of 42

Unit System	U.S. Customary (in, lbm, lbf, s, V, A) Degrees rad/s Fahrenheit
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Fahrenheit

## Model/Assumptions

TGT-CALC-103-012

Note: Calculation is not required by Code.

Assumptions are:

- beam current 20 microA
- pressure in cell is 400 psi even when cold (more conservative than operational plan)
- raster 2x2 mm
- beam heat 3W
- power density 3 W/m<sup>3</sup>
- material model is from MPDB
- Local plastic failure from ASME BPVC VIII D2 Part 5.3.3

Reference Drawings: TGT-103-1000-0100

Reference Docs: TGT-CALC-103-002

## Model (C4)

### Geometry

**TABLE 2**  
**Model (C4) > Geometry**

Object Name	Geometry
State	Fully Defined
<b>Definition</b>	
Source	D:\Meekins\GoogleDrive\JLAB\Hall A\Trtium\Calculations\ANSYS\cell beam heating\Assembly1.iam
Type	Inventor
Length Unit	Centimeters
Element Control	Program Controlled
Display Style	Body Color
<b>Bounding Box</b>	
Length X	13.156 in
Length Y	2.7876 in
Length Z	3. in
<b>Properties</b>	
Volume	3.2815 in <sup>3</sup>

Mass	0.32241 lbm
Scale Factor Value	1.
<b>Statistics</b>	
Bodies	4
Active Bodies	2
Nodes	165099
Elements	109581
Mesh Metric	None
<b>Basic Geometry Options</b>	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Yes
Parameter Key	DS
Attributes	No
Named Selections	No
Material Properties	No
<b>Advanced Geometry Options</b>	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	No
Compare Parts On Update	No
Attach File Via Temp File	Yes
Temporary Directory	C:\Users\David\AppData\Local\Temp
Analysis Type	3-D
Mixed Import Resolution	None
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

**TABLE 3**  
**Model (C4) > Geometry > Parts**

Object Name	<i>main body:1</i>	<i>entrance:1</i>	<i>exit beam:1</i>	<i>ent beam:1</i>
State	Suppressed	Meshed	Suppressed	Meshed
<b>Graphics Properties</b>				
Visible	No	Yes	No	Yes
Transparency		1		1
<b>Definition</b>				
Suppressed	Yes	No	Yes	No
Stiffness Behavior	Flexible			
Coordinate System	Default Coordinate System			
Reference Temperature	By Environment			
<b>Material</b>				
Assignment	7075 (UNS A97075)			
Nonlinear Effects	Yes			

Thermal Strain Effects	Yes			
<b>Bounding Box</b>				
Length X	12.656 in	3.329 in	1.399e-002 in	1.1983e-002 in
Length Y	2.7876 in	2.75 in	8.8976e-002 in	
Length Z	3. in	2.75 in	8.8976e-002 in	
<b>Properties</b>				
Volume	48.914 in <sup>3</sup>	3.2814 in <sup>3</sup>	7.455e-005 in <sup>3</sup>	6.2178e-005 in <sup>3</sup>
Mass	4.8059 lbm	0.32241 lbm	7.3247e-006 lbm	6.1091e-006 lbm
Centroid X	0.4986 in	5.0611 in	-7.494 in	2.3977 in
Centroid Y	3.4577 in			
Centroid Z	1.3328 in			
Moment of Inertia Ip1	6.0664 lbm·in <sup>2</sup>	0.25323 lbm·in <sup>2</sup>	7.6633e-009 lbm·in <sup>2</sup>	6.0227e-009 lbm·in <sup>2</sup>
Moment of Inertia Ip2	65.449 lbm·in <sup>2</sup>	0.32838 lbm·in <sup>2</sup>	3.9253e-009 lbm·in <sup>2</sup>	3.0641e-009 lbm·in <sup>2</sup>
Moment of Inertia Ip3	67.103 lbm·in <sup>2</sup>	0.32838 lbm·in <sup>2</sup>	3.9257e-009 lbm·in <sup>2</sup>	3.0641e-009 lbm·in <sup>2</sup>
<b>Statistics</b>				
Nodes	0	164609	0	490
Elements	0	109520	0	61
Mesh Metric	None			

## Coordinate Systems

**TABLE 4**  
**Model (C4) > Coordinate Systems > Coordinate System**

Object Name	<i>Global Coordinate System</i>
State	Fully Defined
<b>Definition</b>	
Type	Cartesian
Coordinate System ID	0.
<b>Origin</b>	
Origin X	0. in
Origin Y	0. in
Origin Z	0. in
<b>Directional Vectors</b>	
X Axis Data	[ 1. 0. 0. ]
Y Axis Data	[ 0. 1. 0. ]
Z Axis Data	[ 0. 0. 1. ]

## Connections

**TABLE 5**  
**Model (C4) > Connections**

Object Name	<i>Connections</i>
State	Fully Defined
<b>Auto Detection</b>	
Generate Automatic Connection On Refresh	Yes
<b>Transparency</b>	
Enabled	Yes

**TABLE 6**  
**Model (C4) > Connections > Contacts**

Object Name	<i>Contacts</i>
State	Fully Defined
<b>Definition</b>	
Connection Type	Contact
<b>Scope</b>	
Scoping Method	Geometry Selection
Geometry	All Bodies
<b>Auto Detection</b>	
Tolerance Type	Slider
Tolerance Slider	0.
Tolerance Value	3.4446e-002 in
Use Range	No
Face/Face	Yes
Face/Edge	No
Edge/Edge	No
Priority	Include All
Group By	Bodies
Search Across	Bodies
<b>Statistics</b>	
Connections	1
Active Connections	1

**TABLE 7**  
**Model (C4) > Connections > Contacts > Contact Regions**

Object Name	<i>Contact Region</i>
State	Fully Defined
<b>Scope</b>	
Scoping Method	Geometry Selection
Contact	3 Faces
Target	3 Faces
Contact Bodies	entrance:1
Target Bodies	ent beam:1
<b>Definition</b>	
Type	Bonded
Scope Mode	Automatic
Behavior	Program Controlled
Trim Contact	Program Controlled
Trim Tolerance	3.4446e-002 in
Suppressed	No
<b>Advanced</b>	
Formulation	Program Controlled
Detection Method	Program Controlled
Penetration Tolerance	Program Controlled
Elastic Slip Tolerance	Program Controlled
Normal Stiffness	Program Controlled
Update Stiffness	Program Controlled
Pinball Region	Program Controlled

<b>Geometric Modification</b>	
Contact Geometry Correction	None
Target Geometry Correction	None

## Mesh

**TABLE 8**  
**Model (C4) > Mesh**

Object Name	<i>Mesh</i>
State	Solved
<b>Display</b>	
Display Style	Body Color
<b>Defaults</b>	
Physics Preference	Mechanical
Relevance	0
<b>Sizing</b>	
Use Advanced Size Function	Off
Relevance Center	Fine
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	High
Transition	Slow
Span Angle Center	Fine
Minimum Edge Length	0.196350 in
<b>Inflation</b>	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
<b>Patch Conforming Options</b>	
Triangle Surface Mesher	Program Controlled
<b>Patch Independent Options</b>	
Topology Checking	No
<b>Advanced</b>	
Number of CPUs for Parallel Part Meshing	Program Controlled
Shape Checking	Standard Mechanical
Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)
Extra Retries For Assembly	Yes
Rigid Body Behavior	Dimensionally Reduced
Mesh Morphing	Disabled
<b>Defeaturing</b>	
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No

Automatic Mesh Based Defeaturing	On
Defeaturing Tolerance	Default
<b>Statistics</b>	
Nodes	165099
Elements	109581
Mesh Metric	None

## Static Structural (C5)

**TABLE 9**  
**Model (C4) > Analysis**

Object Name	<i>Static Structural (C5)</i>
State	Solved
<b>Definition</b>	
Physics Type	Structural
Analysis Type	Static Structural
Solver Target	Mechanical APDL
<b>Options</b>	
Environment Temperature	-387.67 °F
Generate Input Only	No

**TABLE 10**  
**Model (C4) > Static Structural (C5) > Analysis Settings**

Object Name	<i>Analysis Settings</i>
State	Fully Defined
<b>Step Controls</b>	
Number Of Steps	1.
Current Step Number	1.
Step End Time	1. s
Auto Time Stepping	Program Controlled
<b>Solver Controls</b>	
Solver Type	Program Controlled
Weak Springs	Program Controlled
Solver Pivot Checking	Program Controlled
Large Deflection	Off
Inertia Relief	Off
<b>Restart Controls</b>	
Generate Restart Points	Program Controlled
Retain Files After Full Solve	No
<b>Nonlinear Controls</b>	
Newton-Raphson Option	Program Controlled
Force Convergence	Program Controlled
Moment Convergence	Program Controlled
Displacement Convergence	Program Controlled

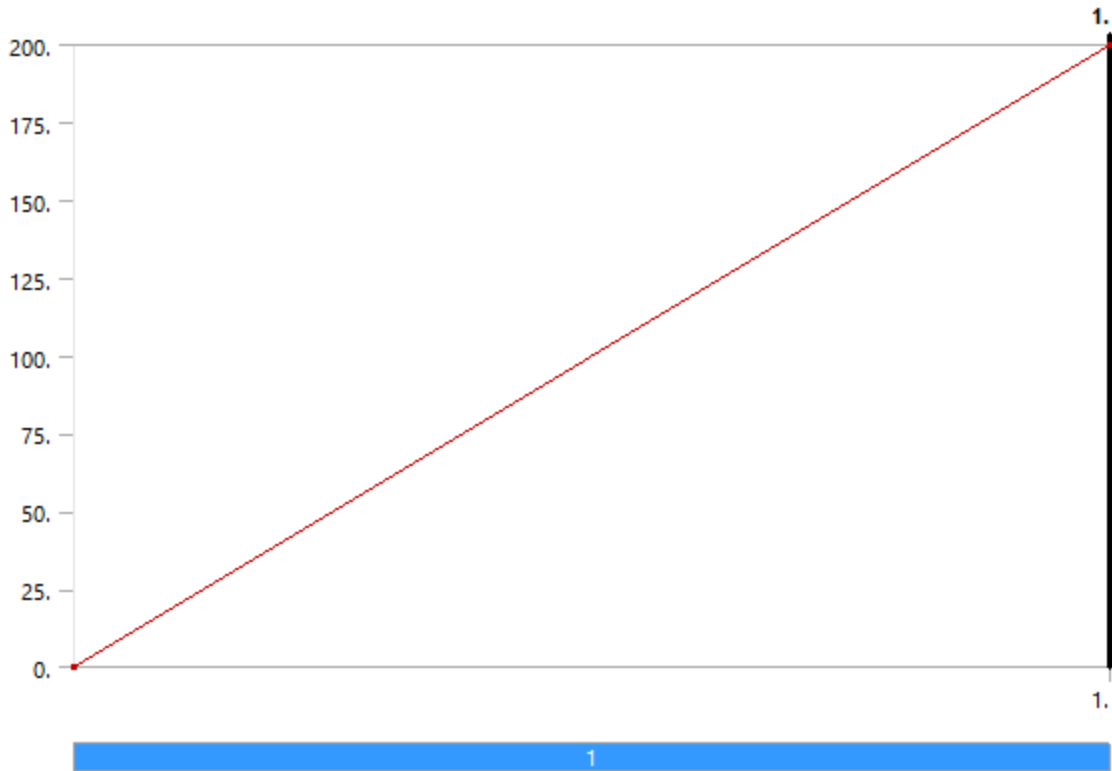
Rotation Convergence	Program Controlled
Line Search	Program Controlled
Stabilization	Off
<b>Output Controls</b>	
Stress	Yes
Strain	Yes
Nodal Forces	No
Contact Miscellaneous	No
General Miscellaneous	No
Store Results At	All Time Points
<b>Analysis Data Management</b>	
Solver Files Directory	D:\Meekins\GoogleDrive\JLAB\Hall A\Trtium\Calculations\ANSYS\cell beam heating\beam heating_files\dp0\SYS-2\MECH\
Future Analysis	None
Scratch Solver Files Directory	
Save MAPDL db	No
Delete Unneeded Files	Yes
Nonlinear Solution	Yes
Solver Units	Active System
Solver Unit System	Bin

**TABLE 11**  
**Model (C4) > Static Structural (C5) > Loads**

Object Name	<i>Pressure</i>	<i>Fixed Support</i>
State	Fully Defined	
<b>Scope</b>		
Scoping Method	Geometry Selection	
Geometry	5 Faces	1 Face
<b>Definition</b>		
Type	Pressure	Fixed Support
Define By	Normal To	
Magnitude	200. psi (ramped)	
Suppressed	No	

**FIGURE 1**  
**Model (C4) > Static Structural (C5) > Pressure**





**TABLE 12**  
**Model (C4) > Static Structural (C5) > Imported Load (B6)**

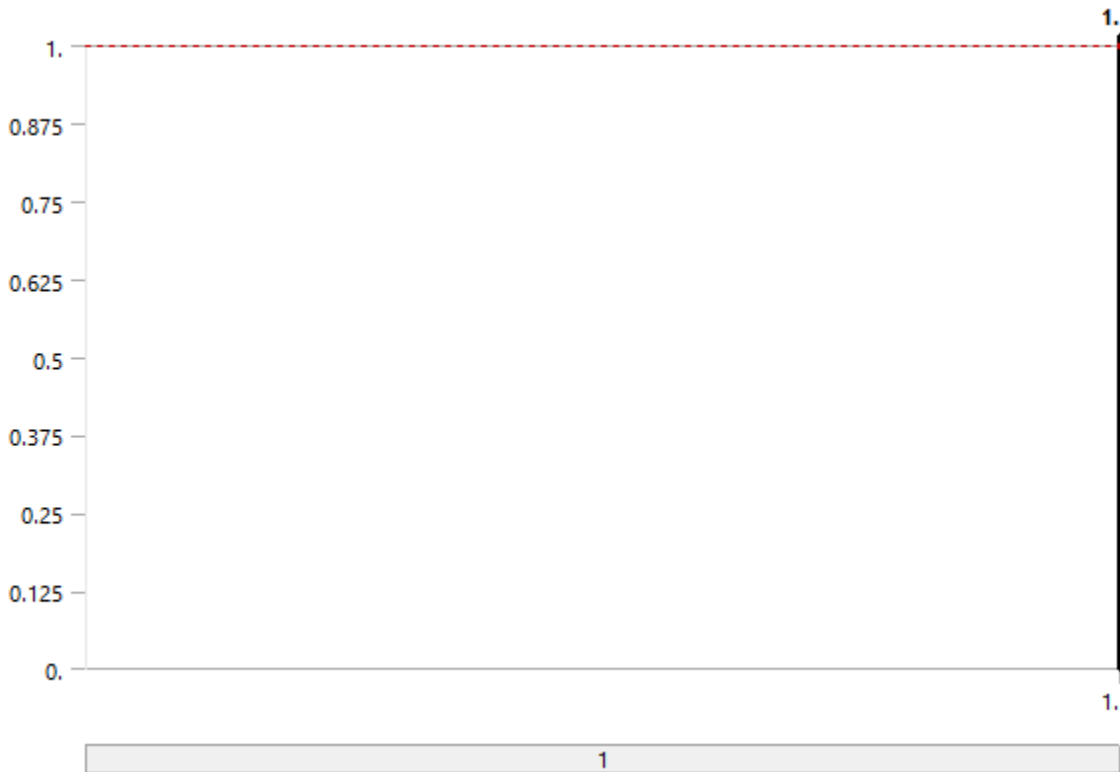
Object Name	<i>Imported Load (B6)</i>
State	Fully Defined
<b>Definition</b>	
Type	Imported Data
Interpolation Type	Mechanical Results Transfer
Suppressed	No
Source	B6::Solution

**TABLE 13**  
**Model (C4) > Static Structural (C5) > Imported Load (B6) > Imported Body Temperature**

Object Name	<i>Imported Body Temperature</i>
State	Solved
<b>Scope</b>	
Scoping Method	Geometry Selection
Geometry	2 Bodies
<b>Definition</b>	
Type	Imported Body Temperature
Tabular Loading	Program Controlled
Suppressed	No
Source Bodies	Automatic
Tolerance	1. %
Source Time	Worksheet
<b>Settings</b>	

Mapping Control	Program Controlled
Mapping	Profile Preserving
Weighting	Shape Function
Transfer Type	Volumetric
<b>Rigid Transformation</b>	
Mesh Alignment	Use Origin and Euler Angles
Origin X	0. in
Origin Y	0. in
Origin Z	0. in
Theta XY	0. degree
Theta YZ	0. degree
Theta ZX	0. degree
<b>Graphics Controls</b>	
Display Source Points	Off
Display Source Point Ids	Off
<b>Legend Controls</b>	
Legend Range	Program Controlled
Minimum Source	-387.67 °F
Maximum Source	-245.38 °F
<b>Named Selection Creation</b>	
Unmapped Nodes	Off
Mapped Nodes	Off
Outside Nodes	Off

**FIGURE 2**  
**Model (C4) > Static Structural (C5) > Imported Load (B6) > Imported Body Temperature**



**Model (C4) > Static Structural (C5) > Imported Load (B6) > Imported Body Temperature**

	Source Time (s)	Analysis Time (s)
1	End Time	1
*		

**Model (C4) > Static Structural (C5) > Imported Load (B6) > Imported Body Temperature > Imported Load Transfer Summary**

Target Body	Source Material Id	Volume Difference (%)	Distance Between Centroids (m)	Bounding Box Diagonal (m)	Distance Between Centroids/Bounding Box Diagonal (%)
entrance:1	1.	2.1227e-008	2.7317e-005	0.13003	2.1008e-002

Fri Aug 28, 2015 01:13:50

Using multiple cores: [Yes]

Number of cores requested: 8

Number of source nodes: 164609

Number of target nodes: 164609

Number of nodes mapped : 164609

Number of nodes not mapped : 0

Number of nodes outside : 0

Percent nodes mapped: 100%

Weight calculation time: 1.214 (s)

Interpolation time: 1.e-002 (s)

Target Body	Source Material Id	Volume Difference (%)	Distance Between Centroids (m)	Bounding Box Diagonal (m)	Distance Between Centroids/Bounding Box Diagonal (%)
ent beam:1	2.	3.6056e-007	1.0283e-006	3.2106e-003	3.2029e-002

Fri Aug 28, 2015 01:13:52

Using multiple cores: [Yes]

Number of cores requested: 8

Number of source nodes: 490

Number of target nodes: 490

Number of nodes mapped : 490

Number of nodes not mapped : 0

Number of nodes outside : 0

Percent nodes mapped: 100%

Weight calculation time: 2.3e-002 (s)  
Interpolation time: 0. (s)

### Solution (C6)

**TABLE 14**  
**Model (C4) > Static Structural (C5) > Solution**

Object Name	<i>Solution (C6)</i>
State	Solved
<b>Adaptive Mesh Refinement</b>	
Max Refinement Loops	1.
Refinement Depth	2.
<b>Information</b>	
Status	Done
<b>Post Processing</b>	
Calculate Beam Section Results	No

**TABLE 15**  
**Model (C4) > Static Structural (C5) > Solution (C6) > Solution Information**

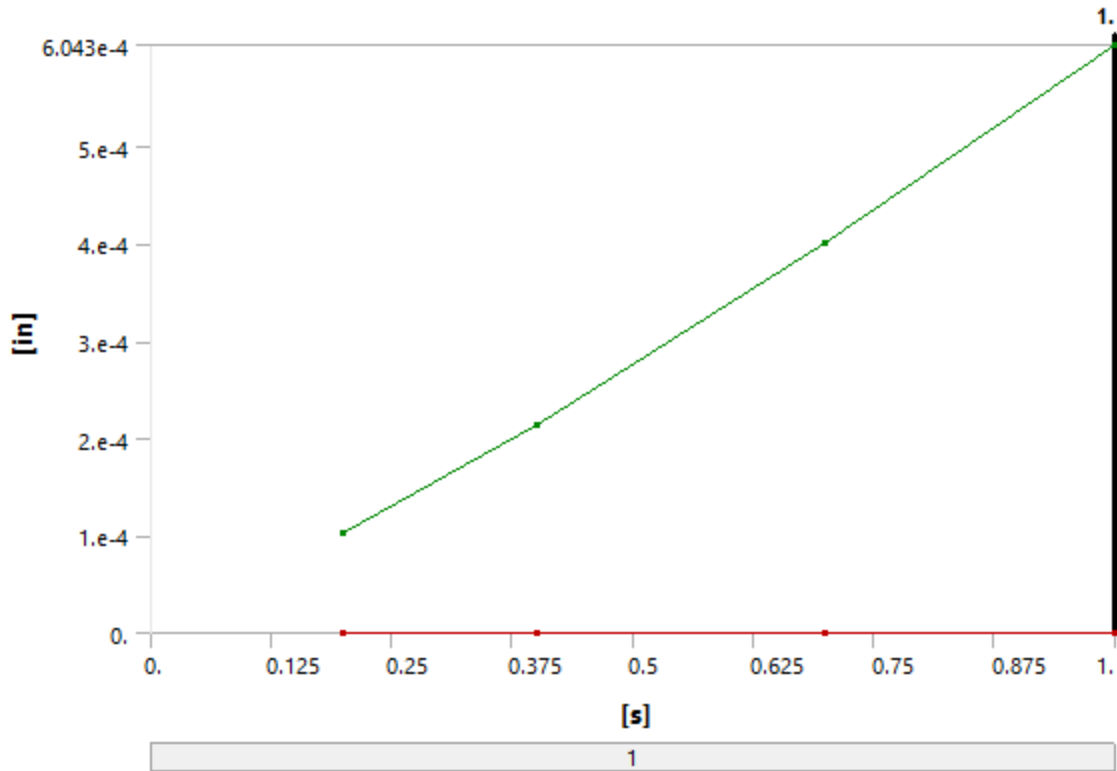
Object Name	<i>Solution Information</i>
State	Solved
<b>Solution Information</b>	
Solution Output	Solver Output
Newton-Raphson Residuals	0
Update Interval	2.5 s
Display Points	All
<b>FE Connection Visibility</b>	
Activate Visibility	Yes
Display	All FE Connectors
Draw Connections Attached To	All Nodes
Line Color	Connection Type
Visible on Results	No
Line Thickness	Single
Display Type	Lines

**TABLE 16**  
**Model (C4) > Static Structural (C5) > Solution (C6) > Results**

Object Name	<i>Total Deformation</i>	<i>Equivalent Stress</i>	<i>Maximum Principal Stress</i>	<i>Maximum Shear Stress</i>
State	Solved			
<b>Scope</b>				
Scoping Method	Geometry Selection			
Geometry	All Bodies			
<b>Definition</b>				
Type	Total Deformation	Equivalent (von-Mises) Stress	Maximum Principal Stress	Maximum Shear Stress
By	Time			

Display Time	Last			
Calculate Time History	Yes			
Identifier				
Suppressed	No			
<b>Results</b>				
Minimum	0. in	17.23 psi	-2539.4 psi	9.0008 psi
Maximum	6.043e-004 in	9928. psi	9721.2 psi	5109.3 psi
Minimum Occurs On	entrance:1			
Maximum Occurs On	ent beam:1	entrance:1		
<b>Minimum Value Over Time</b>				
Minimum	0. in	3.4502 psi	-2539.4 psi	1.8039 psi
Maximum	0. in	17.23 psi	-464.14 psi	9.0008 psi
<b>Maximum Value Over Time</b>				
Minimum	1.0183e-004 in	1937.8 psi	1890.6 psi	995.95 psi
Maximum	6.043e-004 in	9928. psi	9721.2 psi	5109.3 psi
<b>Information</b>				
Time	1. s			
Load Step	1			
Substep	4			
Iteration Number	8			
<b>Integration Point Results</b>				
Display Option	Averaged			
Average Across Bodies	No			

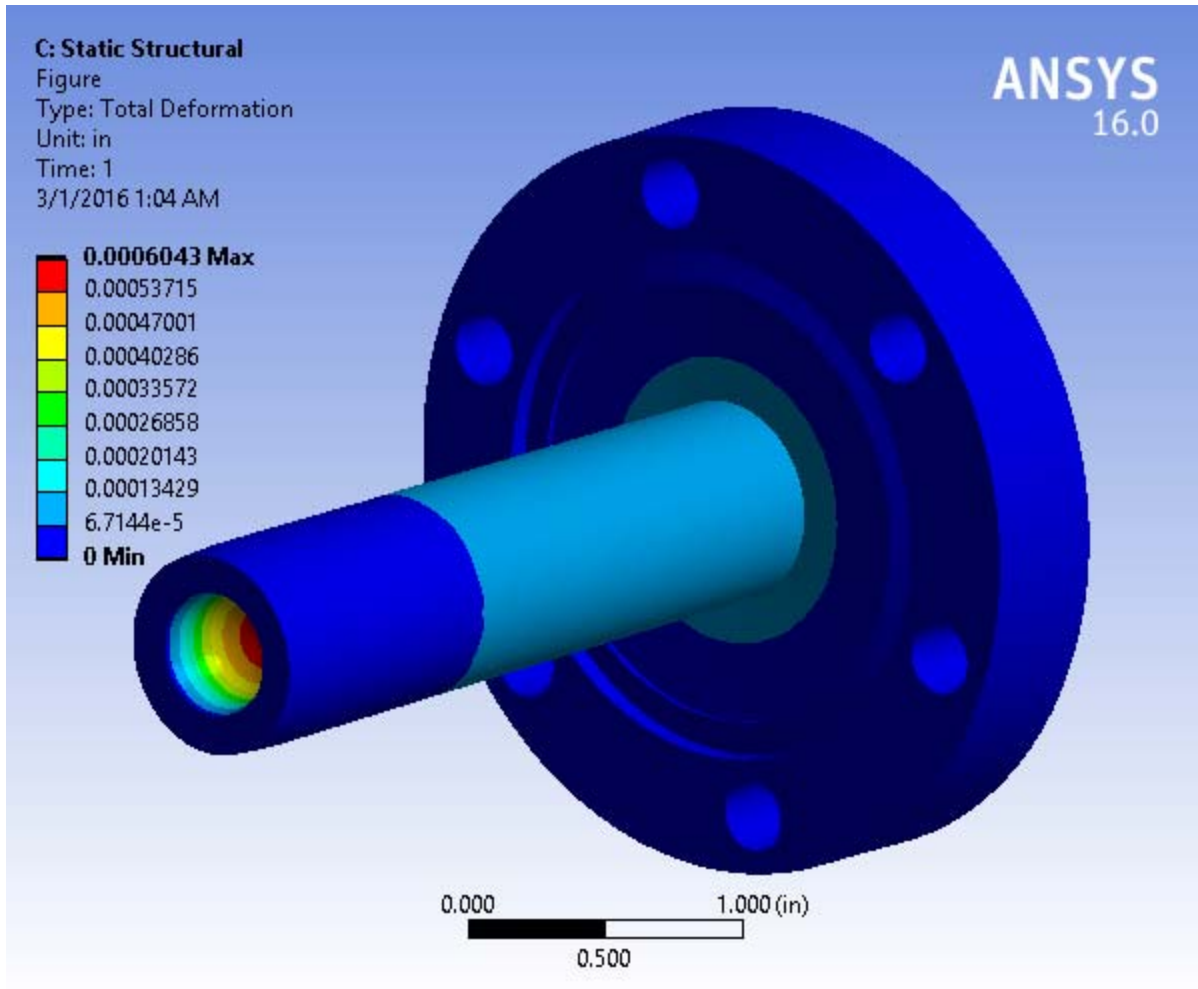
**FIGURE 3**  
**Model (C4) > Static Structural (C5) > Solution (C6) > Total Deformation**



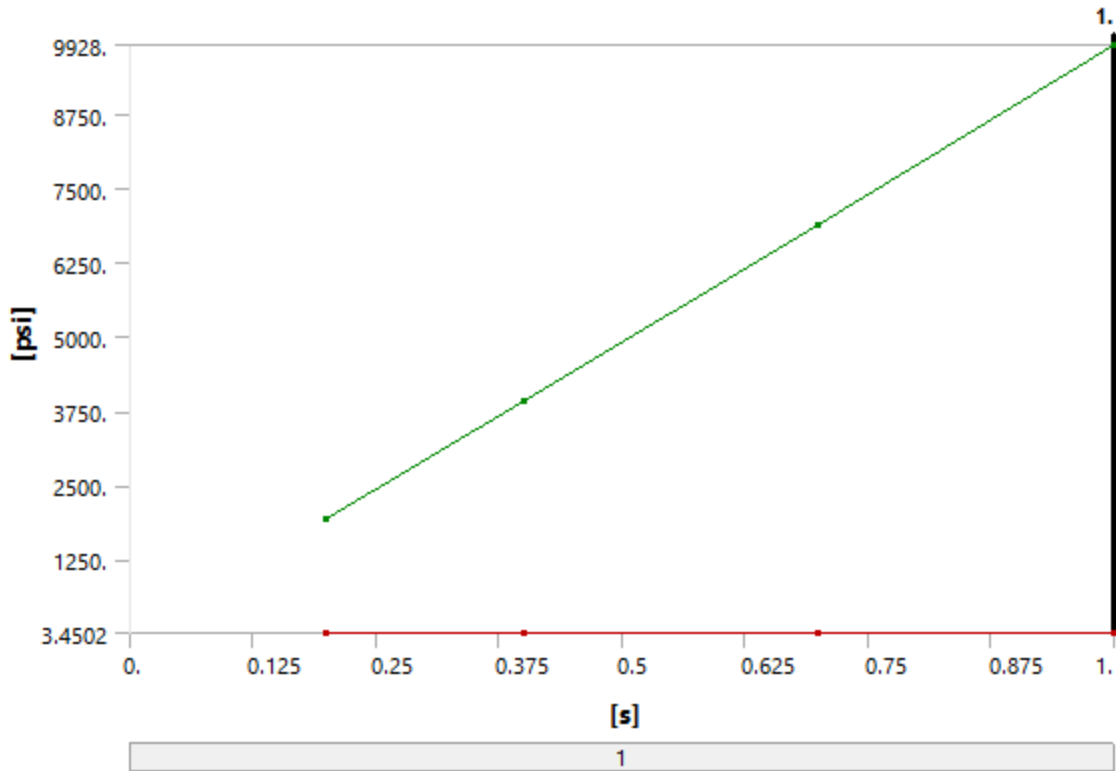
**TABLE 17**  
**Model (C4) > Static Structural (C5) > Solution (C6) > Total Deformation**

Time [s]	Minimum [in]	Maximum [in]
0.2	0.	1.0183e-004
0.4		2.1443e-004
0.7		4.0032e-004
1.		6.043e-004

**FIGURE 4**  
**Model (C4) > Static Structural (C5) > Solution (C6) > Total Deformation > Figure total deformation**



**FIGURE 5**  
Model (C4) > Static Structural (C5) > Solution (C6) > Equivalent Stress

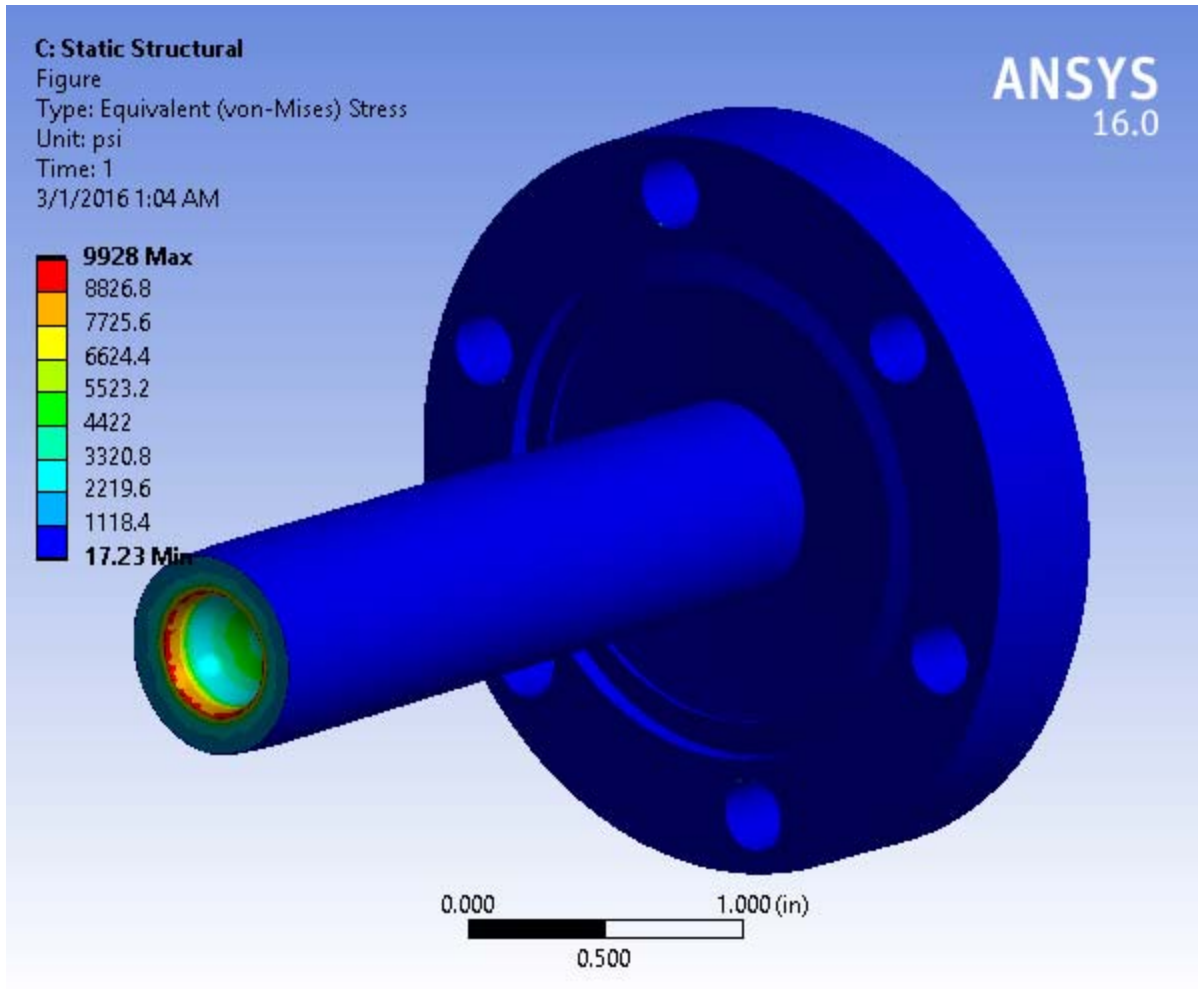


**TABLE 18**  
**Model (C4) > Static Structural (C5) > Solution (C6) > Equivalent Stress**

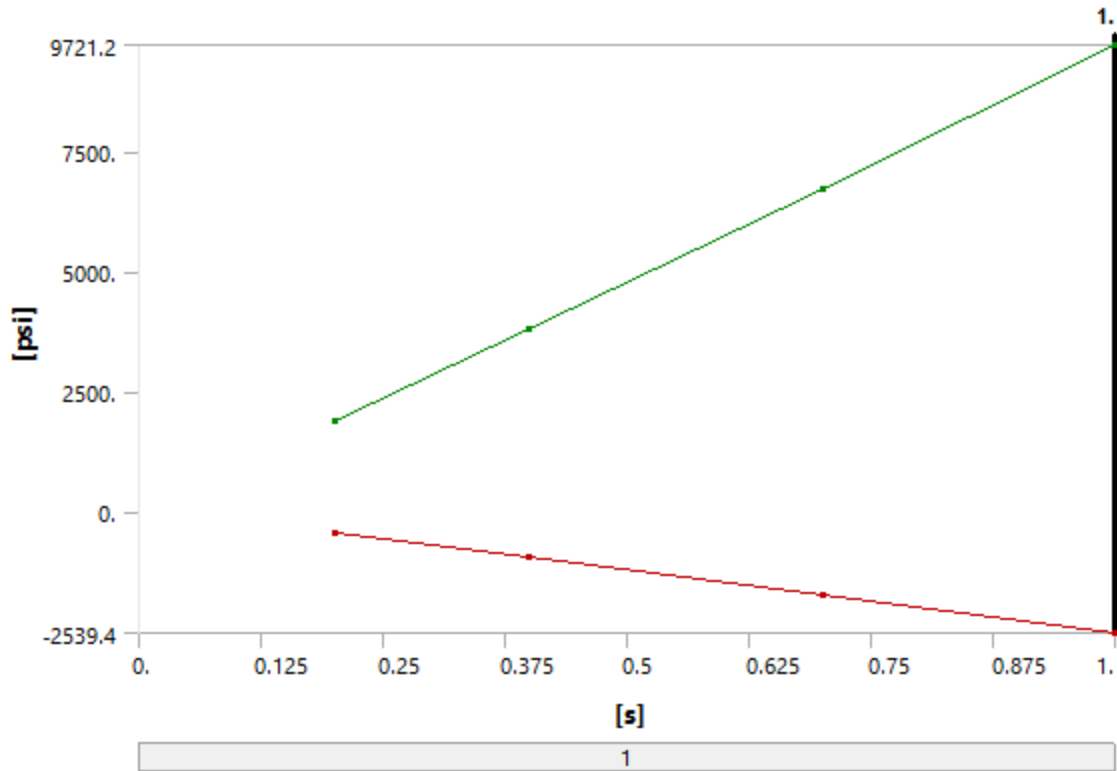
Time [s]	Minimum [psi]	Maximum [psi]
0.2	3.4502	1937.8
0.4	6.8981	3903.5
0.7	12.066	6891.1
1.	17.23	9928.

**FIGURE 6**  
**Model (C4) > Static Structural (C5) > Solution (C6) > Equivalent Stress > Figure Equivalent stress**





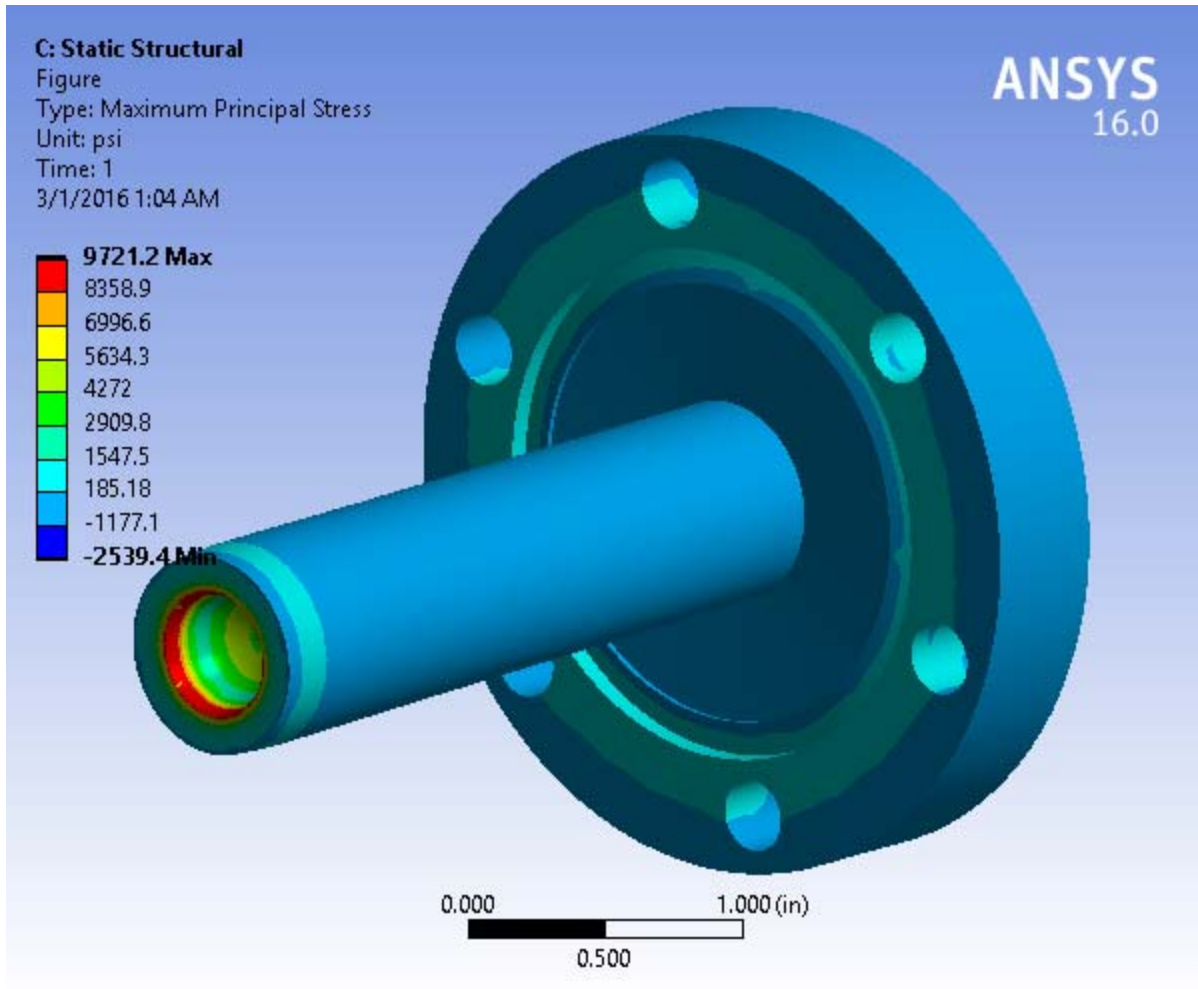
**FIGURE 7**  
Model (C4) > Static Structural (C5) > Solution (C6) > Maximum Principal Stress



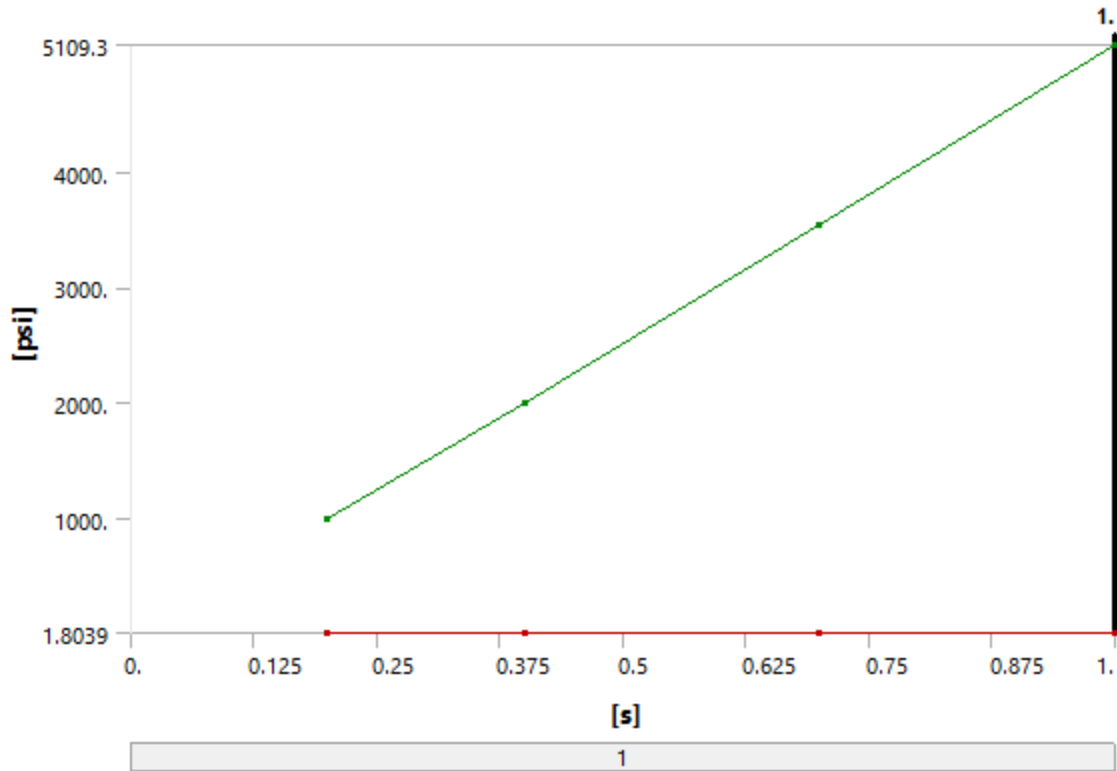
**TABLE 19**  
**Model (C4) > Static Structural (C5) > Solution (C6) > Maximum Principal Stress**

Time [s]	Minimum [psi]	Maximum [psi]
0.2	-464.14	1890.6
0.4	-957.03	3812.2
0.7	-1730.4	6738.8
1.	-2539.4	9721.2

**FIGURE 8**  
**Model (C4) > Static Structural (C5) > Solution (C6) > Maximum Principal Stress > Figure Max principle stress**



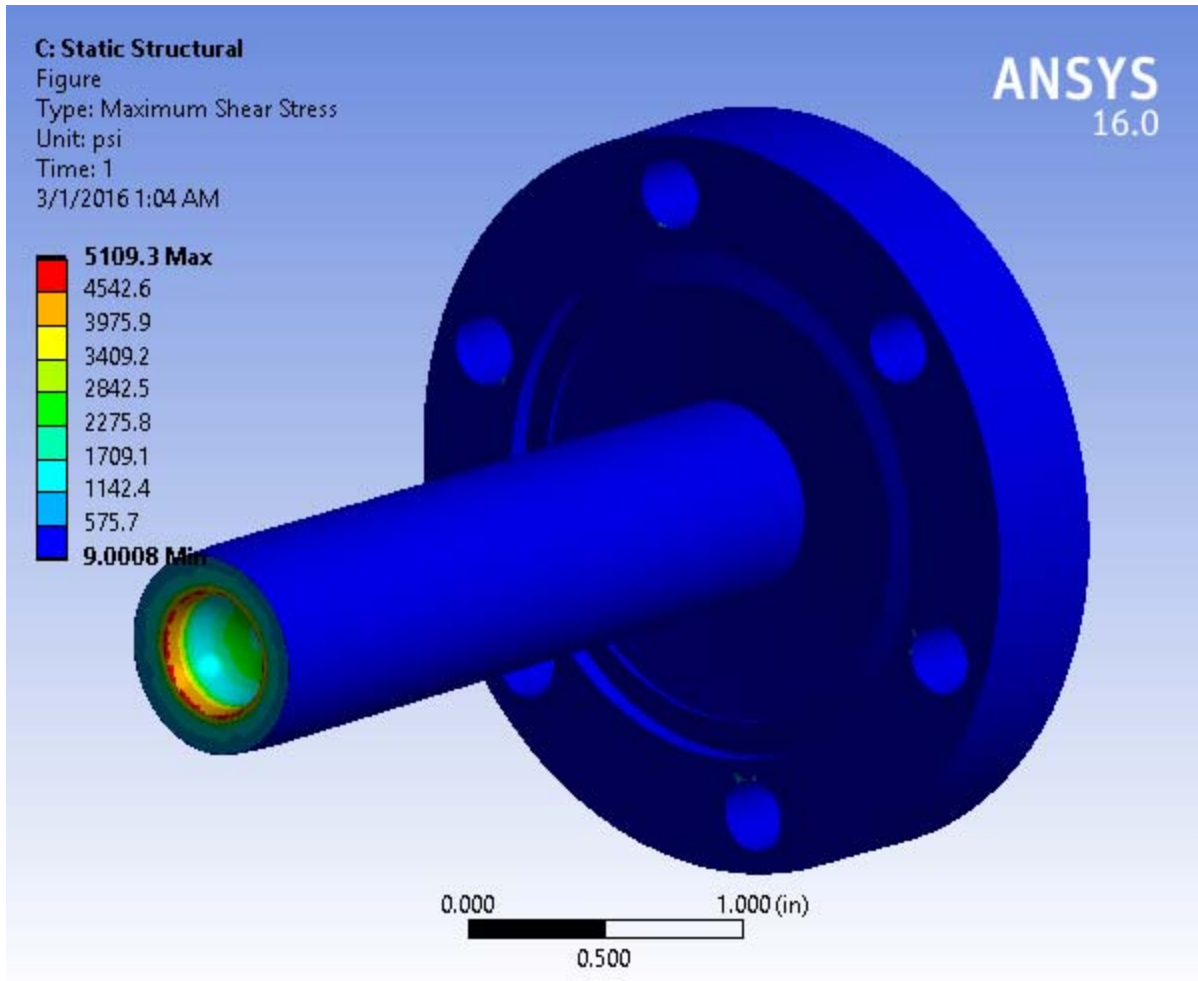
**FIGURE 9**  
Model (C4) > Static Structural (C5) > Solution (C6) > Maximum Shear Stress



**TABLE 20**  
**Model (C4) > Static Structural (C5) > Solution (C6) > Maximum Shear Stress**

Time [s]	Minimum [psi]	Maximum [psi]
0.2	1.8039	995.95
0.4	3.6058	2006.9
0.7	6.3052	3544.7
1.	9.0008	5109.3

**FIGURE 10**  
**Model (C4) > Static Structural (C5) > Solution (C6) > Maximum Shear Stress > Figure Max shear stress**



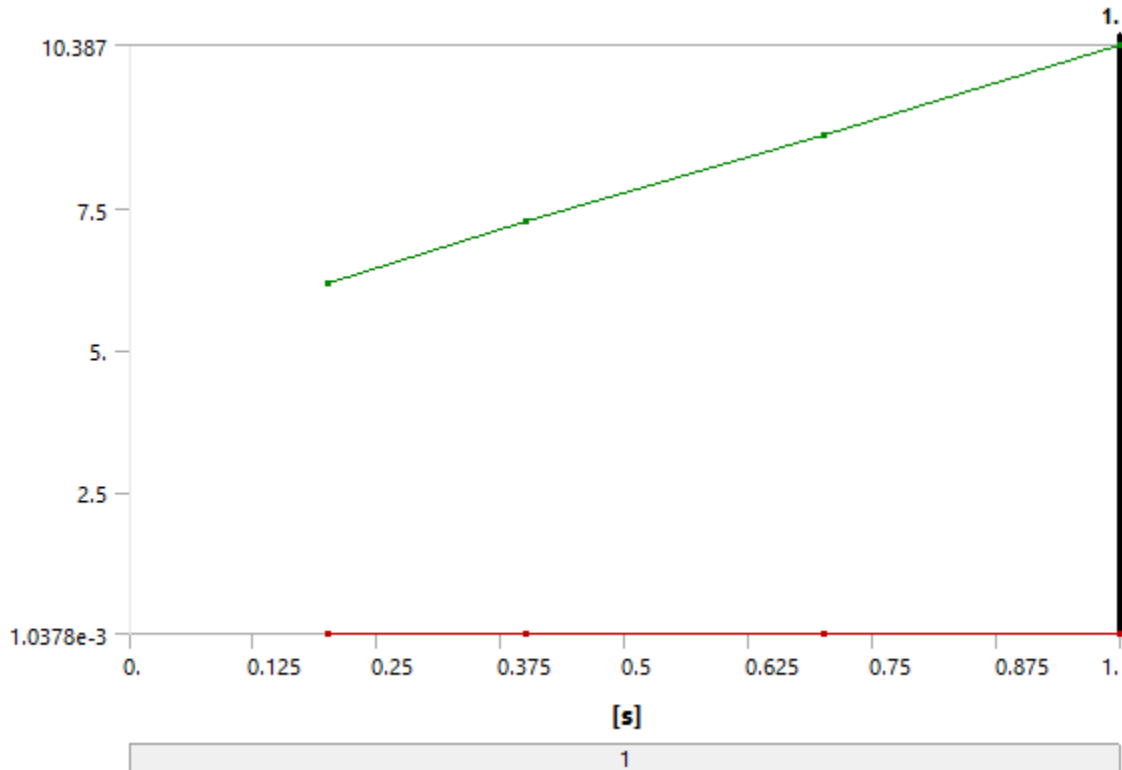
**TABLE 21**

**Model (C4) > Static Structural (C5) > Solution (C6) > EL = 0.069\*2.72<sup>-2.06\*(S1+S2+S3)/(3\*SEQV)-0.333</sup>**

Object Name	$EL = 0.069 \cdot 2.72^{(-2.06 \cdot (S1+S2+S3)/(3 \cdot SEQV) - 0.333)}$		EL-EPPLEQV_RST
State	Solved		
<b>Scope</b>			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
<b>Definition</b>			
Type	User Defined Result		
Expression	$= 0.069 \cdot 2.72^{(-2.06 \cdot (S1+S2+S3)/(3 \cdot SEQV) - 0.333)}$	= EL-EPPLEQV_RST	
Input Unit System	U.S. Customary (in, lbm, lbf, °F, s, V, A)		
Output Unit			
By	Time		
Display Time	Last		
Coordinate System	Global Coordinate System		
Calculate Time History	Yes		
Identifier	EL		
Suppressed	No		

Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
Minimum	1.0378e-003
Maximum	10.387
Minimum Occurs On	entrance:1
Maximum Occurs On	entrance:1
Minimum Value Over Time	
Minimum	0.
Maximum	0.
Maximum Value Over Time	
Minimum	0.
Maximum	0.
Information	
Time	1. s
Load Step	1
Substep	4
Iteration Number	8

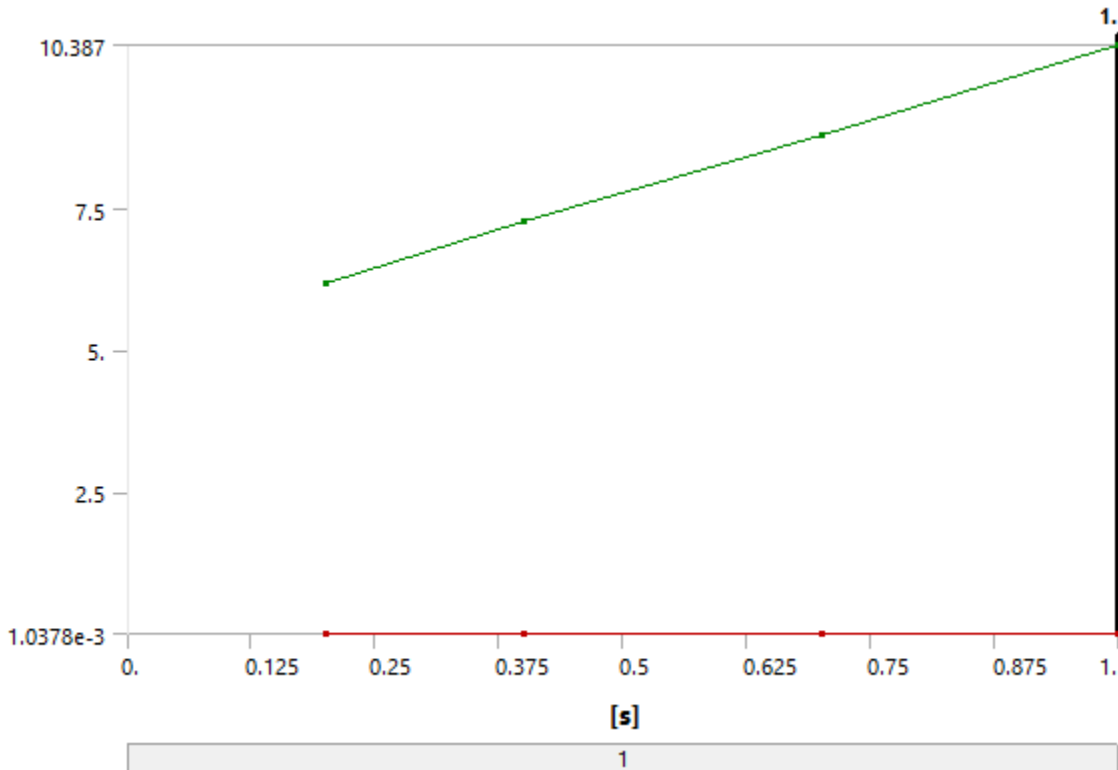
**FIGURE 11**  
**Model (C4) > Static Structural (C5) > Solution (C6) > EL = 0.069\*2.72^(-2.06\*(S1+S2+S3))/(3\*SEQV)-0.333)**



**TABLE 22**  
**Model (C4) > Static Structural (C5) > Solution (C6) > EL = 0.069\*2.72^(-2.06\*(S1+S2+S3))/(3\*SEQV)-0.333)**

Time [s]	Minimum	Maximum
0.2	1.0378e-003	6.1873
0.4		7.2759
0.7		8.7912
1.		10.387

**FIGURE 12**  
**Model (C4) > Static Structural (C5) > Solution (C6) > EL-EPPLEQV\_RST**



**TABLE 23**  
**Model (C4) > Static Structural (C5) > Solution (C6) > EL-EPPLEQV\_RST**

Time [s]	Minimum	Maximum
0.2	1.0378e-003	6.1873
0.4		7.2759
0.7		8.7912
1.		10.387

**Model (C4) > Static Structural (C5) > Solution (C6) > EL-EPPLEQV\_RST > Comment**

delta > 0 for all elements

This satisfies 5.3.3.1 Eq (7)

## Material Data

### 7075 (UNS A97075)

**TABLE 24**  
**7075 (UNS A97075) > Density**

Density lbm in <sup>-3</sup>	Temperature F
9.9505e-002	-459.67
9.9504e-002	-446.94
9.9503e-002	-434.22
9.9503e-002	-421.49
9.9505e-002	-408.76
9.9503e-002	-396.03
9.9498e-002	-383.31
9.949e-002	-370.58
9.9479e-002	-357.85
9.9465e-002	-345.12
9.9449e-002	-332.4
9.9431e-002	-319.67
9.941e-002	-306.94
9.9388e-002	-294.22
9.9363e-002	-281.49
9.9336e-002	-268.76
9.9308e-002	-256.03
9.9278e-002	-243.31
9.9247e-002	-230.58
9.9214e-002	-217.85
9.918e-002	-205.12
9.9145e-002	-192.4
9.9109e-002	-179.67
9.9071e-002	-166.94
9.9033e-002	-154.22
9.8994e-002	-141.49
9.8953e-002	-128.76
9.8912e-002	-116.03
9.8871e-002	-103.31
9.8829e-002	-90.579
9.8786e-002	-77.852
9.8742e-002	-65.125
9.8698e-002	-52.397
9.8654e-002	-39.67
9.8609e-002	-26.943
9.8564e-002	-14.215
9.8519e-002	-1.4882
9.8473e-002	11.239
9.8427e-002	23.966
9.838e-002	36.694
9.8334e-002	49.421



9.8287e-002	62.148
9.824e-002	74.875
9.8192e-002	87.603
9.8145e-002	100.33
9.8097e-002	113.06
9.805e-002	125.78
9.8002e-002	138.51
9.7954e-002	151.24
9.7905e-002	163.97
9.7857e-002	176.69
9.7808e-002	189.42
9.776e-002	202.15
9.7711e-002	214.88
9.7662e-002	227.6
9.7612e-002	240.33
9.7563e-002	253.06
9.7513e-002	265.78
9.7464e-002	278.51
9.7414e-002	291.24
9.7363e-002	303.97
9.7313e-002	316.69
9.7262e-002	329.42
9.7211e-002	342.15
9.716e-002	354.88
9.7109e-002	367.6
9.7057e-002	380.33
9.7005e-002	393.06
9.6953e-002	405.78
9.69e-002	418.51
9.6847e-002	431.24
9.6794e-002	443.97
9.674e-002	456.69
9.6687e-002	469.42
9.6632e-002	482.15
9.6578e-002	494.88
9.6523e-002	507.6
9.6467e-002	520.33
9.6412e-002	533.06
9.6356e-002	545.78
9.6299e-002	558.51
9.6243e-002	571.24
9.6186e-002	583.97
9.6128e-002	596.69
9.6071e-002	609.42
9.6013e-002	622.15
9.5954e-002	634.88
9.5896e-002	647.6
9.5837e-002	660.33

9.5778e-002	673.06
9.5719e-002	685.78
9.5659e-002	698.51
9.56e-002	711.24
9.554e-002	723.97
9.548e-002	736.69
9.542e-002	749.42
9.5361e-002	762.15
9.5301e-002	774.88
9.5241e-002	787.6
9.5182e-002	800.33

**TABLE 25**  
**7075 (UNS A97075) > Tensile Yield Strength**

Tensile Yield Strength psi	Temperature F
95145	-452.47
92552	-437.76
90024	-423.05
88694	-408.34
87443	-393.63
86266	-378.92
85160	-364.22
84122	-349.51
83149	-334.8
82236	-320.09
81382	-305.38
80581	-290.67
79831	-275.96
79128	-261.25
78469	-246.54
77851	-231.83
77269	-217.12
76721	-202.42
76204	-187.71
75713	-173
75245	-158.29
74798	-143.58
74367	-128.87
73948	-114.16
73540	-99.452
73138	-84.743
72738	-70.034
72338	-55.325
71934	-40.615
71523	-25.906
71100	-11.197
70663	3.5118
70209	18.221
69733	32.93

69233	47.639
68705	62.348
68145	77.057
67551	91.766
66918	106.48
66244	121.18
65524	135.89
64756	150.6
63936	165.31
63061	180.02
62126	194.73
61130	209.44
55335	224.15
48861	238.86
42739	253.57
37132	268.28
32156	282.98
27881	297.69
24324	312.4
21457	327.11
19203	341.82
17436	356.53
15980	371.24
14709	385.95
13622	400.66
12641	415.37
11758	430.08
10965	444.78
10254	459.49
9617.4	474.2
9048.1	488.91
8539.2	503.62
8084.4	518.33
7677.6	533.04
7312.7	547.75
6984.5	562.46
6687.7	577.17
6417.5	591.88
6169.4	606.58
5939.3	621.29
5723.2	636
5517.6	650.71
5319.4	665.42
5125.7	680.13
4934	694.84
4742.1	709.55
4548	724.26
4350.3	738.97

4147.7	753.68
3939.3	768.38
3724.6	783.09
3503.3	797.8
3275.6	812.51
3041.8	827.22
2802.7	841.93
2559.4	856.64
2313.3	871.35
2066.1	886.06
1820	900.77
1577.2	915.48
1340.5	930.18
1113	944.89
898.08	959.6
699.39	974.31
521	989.02
367.26	1003.7

**TABLE 26**  
**7075 (UNS A97075) > Tensile Ultimate Strength**

Tensile Ultimate Strength psi	Temperature F
1.1095e+005	-452.47
1.1058e+005	-437.76
1.1014e+005	-423.05
1.0786e+005	-408.34
1.0573e+005	-393.63
1.0374e+005	-378.92
1.0189e+005	-364.22
1.0016e+005	-349.51
98557	-334.8
97067	-320.09
95686	-305.38
94409	-290.67
93228	-275.96
92140	-261.25
91136	-246.54
90211	-231.83
89359	-217.12
88574	-202.42
87850	-187.71
87181	-173
86560	-158.29
85982	-143.58
85441	-128.87
84930	-114.16
84443	-99.452
83975	-84.743
83519	-70.034

83069	-55.325
82620	-40.615
82164	-25.906
81697	-11.197
81211	3.5118
80702	18.221
80162	32.93
79586	47.639
78968	62.348
78301	77.057
77579	91.766
76797	106.48
75949	121.18
75028	135.89
74028	150.6
72943	165.31
71768	180.02
70495	194.73
69119	209.44
63047	224.15
56144	238.86
49474	253.57
43214	268.28
37506	282.98
32450	297.69
28112	312.4
24518	327.11
21655	341.82
19475	356.53
17890	371.24
16774	385.95
15857	400.66
14939	415.37
14088	430.08
13299	444.78
12568	459.49
11891	474.2
11266	488.91
10687	503.62
10152	518.33
9657	533.04
9199.1	547.75
8775	562.46
8381.7	577.17
8016.2	591.88
7675.8	606.58
7357.8	621.29
7059.6	636

6778.7	650.71
6512.9	665.42
6259.9	680.13
6017.6	694.84
5784	709.55
5557.2	724.26
5335.5	738.97
5117.3	753.68
4900.9	768.38
4685	783.09
4468.3	797.8
4249.7	812.51
4027.9	827.22
3802.2	841.93
3571.6	856.64
3335.5	871.35
3093.1	886.06
2844.2	900.77
2588.1	915.48
2324.8	930.18
2054.1	944.89
1775.9	959.6
1490.3	974.31
1197.5	989.02
897.88	1003.7

**TABLE 27**  
**7075 (UNS A97075) > Isotropic Secant Coefficient of Thermal Expansion**

Coefficient of Thermal Expansion F <sup>-1</sup>	Temperature F
7.9029e-006	-459.67
8.1015e-006	-446.94
8.3002e-006	-434.22
8.505e-006	-421.49
8.7421e-006	-408.76
8.9684e-006	-396.03
9.1842e-006	-383.31
9.3898e-006	-370.58
9.5857e-006	-357.85
9.7722e-006	-345.12
9.9496e-006	-332.4
1.0118e-005	-319.67
1.0278e-005	-306.94
1.0431e-005	-294.22
1.0575e-005	-281.49
1.0712e-005	-268.76
1.0841e-005	-256.03
1.0964e-005	-243.31
1.108e-005	-230.58
1.119e-005	-217.85

1.1294e-005	-205.12
1.1392e-005	-192.4
1.1485e-005	-179.67
1.1572e-005	-166.94
1.1655e-005	-154.22
1.1732e-005	-141.49
1.1806e-005	-128.76
1.1875e-005	-116.03
1.194e-005	-103.31
1.2001e-005	-90.579
1.2059e-005	-77.852
1.2114e-005	-65.125
1.2165e-005	-52.397
1.2214e-005	-39.67
1.226e-005	-26.943
1.2303e-005	-14.215
1.2345e-005	-1.4882
1.2384e-005	11.239
1.2421e-005	23.966
1.2456e-005	36.694
1.249e-005	49.421
1.2522e-005	62.148
1.2553e-005	74.875
1.2583e-005	87.603
1.2612e-005	100.33
1.2641e-005	113.06
1.2668e-005	125.78
1.2695e-005	138.51
1.2722e-005	151.24
1.2748e-005	163.97
1.2774e-005	176.69
1.28e-005	189.42
1.2826e-005	202.15
1.2852e-005	214.88
1.2878e-005	227.6
1.2904e-005	240.33
1.2931e-005	253.06
1.2958e-005	265.78
1.2986e-005	278.51
1.3014e-005	291.24
1.3043e-005	303.97
1.3072e-005	316.69
1.3102e-005	329.42
1.3133e-005	342.15
1.3165e-005	354.88
1.3197e-005	367.6
1.323e-005	380.33
1.3264e-005	393.06

1.3299e-005	405.78
1.3335e-005	418.51
1.3372e-005	431.24
1.3409e-005	443.97
1.3447e-005	456.69
1.3486e-005	469.42
1.3526e-005	482.15
1.3567e-005	494.88
1.3608e-005	507.6
1.365e-005	520.33
1.3692e-005	533.06
1.3735e-005	545.78
1.3779e-005	558.51
1.3823e-005	571.24
1.3868e-005	583.97
1.3912e-005	596.69
1.3958e-005	609.42
1.4003e-005	622.15
1.4048e-005	634.88
1.4093e-005	647.6
1.4138e-005	660.33
1.4183e-005	673.06
1.4227e-005	685.78
1.4271e-005	698.51
1.4315e-005	711.24
1.4357e-005	723.97
1.4399e-005	736.69
1.444e-005	749.42
1.4479e-005	762.15
1.4517e-005	774.88
1.4554e-005	787.6
1.4589e-005	800.33
Reference Temperature F	
67.73	

**TABLE 28**  
**7075 (UNS A97075) > Specific Heat**

Specific Heat BTU lbm <sup>-1</sup> F <sup>-1</sup>	Temperature F
0.13665	-250.87
0.14014	-240.25
0.14351	-229.63
0.14676	-219.02
0.14989	-208.4
0.15291	-197.78
0.15582	-187.16
0.15862	-176.54
0.16132	-165.92
0.16392	-155.31
0.16642	-144.69



0.16883	-134.07
0.17115	-123.45
0.17338	-112.83
0.17553	-102.22
0.1776	-91.597
0.1796	-80.979
0.18152	-70.361
0.18337	-59.743
0.18515	-49.125
0.18687	-38.506
0.18852	-27.888
0.19012	-17.27
0.19165	-6.6518
0.19314	3.9664
0.19457	14.585
0.19596	25.203
0.1973	35.821
0.1986	46.439
0.19985	57.057
0.20107	67.675
0.20225	78.294
0.2034	88.912
0.20451	99.53
0.2056	110.15
0.20666	120.77
0.20769	131.38
0.2087	142
0.20969	152.62
0.21066	163.24
0.21162	173.86
0.21256	184.48
0.21348	195.09
0.2144	205.71
0.2153	216.33
0.2162	226.95
0.21709	237.57
0.21798	248.18
0.21886	258.8
0.21974	269.42
0.22062	280.04
0.2215	290.66
0.22239	301.28
0.22327	311.89
0.22416	322.51
0.22506	333.13
0.22597	343.75
0.22688	354.37
0.2278	364.98

0.22874	375.6
0.22968	386.22
0.23064	396.84
0.23161	407.46
0.23259	418.08
0.23359	428.69
0.2346	439.31
0.23563	449.93
0.23668	460.55
0.23774	471.17
0.23882	481.78
0.23992	492.4
0.24104	503.02
0.24218	513.64
0.24333	524.26
0.24451	534.88
0.2457	545.49
0.24692	556.11
0.24815	566.73
0.2494	577.35
0.25068	587.97
0.25197	598.58
0.25329	609.2
0.25462	619.82
0.25597	630.44
0.25735	641.06
0.25874	651.68
0.26015	662.29
0.26158	672.91
0.26302	683.53
0.26449	694.15
0.26597	704.77
0.26746	715.38
0.26898	726
0.2705	736.62
0.27205	747.24
0.2736	757.86
0.27517	768.48
0.27675	779.09
0.27834	789.71
0.27994	800.33

**TABLE 29**  
**7075 (UNS A97075) > Isotropic Thermal Conductivity**

Thermal Conductivity BTU s <sup>-1</sup> in <sup>-1</sup> F <sup>-1</sup>	Temperature F
1.0373e-003	-250.87
1.0695e-003	-240.25
1.1005e-003	-229.63
1.1303e-003	-219.02

1.1591e-003	-208.4
1.1868e-003	-197.78
1.2135e-003	-187.16
1.2392e-003	-176.54
1.2639e-003	-165.92
1.2878e-003	-155.31
1.3108e-003	-144.69
1.3329e-003	-134.07
1.3543e-003	-123.45
1.3749e-003	-112.83
1.3949e-003	-102.22
1.4141e-003	-91.597
1.4328e-003	-80.979
1.4509e-003	-70.361
1.4684e-003	-59.743
1.4854e-003	-49.125
1.502e-003	-38.506
1.5181e-003	-27.888
1.5339e-003	-17.27
1.5493e-003	-6.6518
1.5645e-003	3.9664
1.5793e-003	14.585
1.594e-003	25.203
1.6084e-003	35.821
1.6228e-003	46.439
1.637e-003	57.057
1.6512e-003	67.675
1.6653e-003	78.294
1.6795e-003	88.912
1.6938e-003	99.53
1.7081e-003	110.15
1.7226e-003	120.77
1.7373e-003	131.38
1.7521e-003	142
1.7673e-003	152.62
1.7828e-003	163.24
1.7986e-003	173.86
1.8147e-003	184.48
1.8314e-003	195.09
1.8484e-003	205.71
1.866e-003	216.33
1.8841e-003	226.95
1.9028e-003	237.57
1.9222e-003	248.18
1.9422e-003	258.8
1.9629e-003	269.42
1.9843e-003	280.04
2.0065e-003	290.66

2.0296e-003	301.28
2.0535e-003	311.89
2.0784e-003	322.51
2.1041e-003	333.13
2.1309e-003	343.75
2.1587e-003	354.37
2.1876e-003	364.98
2.2175e-003	375.6
2.2486e-003	386.22
2.2809e-003	396.84
2.2937e-003	407.46
2.3017e-003	418.08
2.3091e-003	428.69
2.316e-003	439.31
2.3224e-003	449.93
2.3283e-003	460.55
2.3337e-003	471.17
2.3385e-003	481.78
2.3428e-003	492.4
2.3466e-003	503.02
2.3499e-003	513.64
2.3526e-003	524.26
2.3548e-003	534.88
2.3565e-003	545.49
2.3577e-003	556.11
2.3583e-003	566.73
2.3585e-003	577.35
2.3581e-003	587.97
2.3572e-003	598.58
2.3557e-003	609.2
2.3538e-003	619.82
2.3513e-003	630.44
2.3483e-003	641.06
2.3448e-003	651.68
2.3407e-003	662.29
2.3362e-003	672.91
2.3311e-003	683.53
2.3255e-003	694.15
2.3194e-003	704.77
2.3127e-003	715.38
2.3055e-003	726
2.2978e-003	736.62
2.2896e-003	747.24
2.2809e-003	757.86
2.2716e-003	768.48
2.2618e-003	779.09
2.2515e-003	789.71
2.2407e-003	800.33

**TABLE 30**  
**7075 (UNS A97075) > Isotropic Resistivity**

Resistivity ohm cmil in <sup>-1</sup>	Temperature F
1.3838	-452.47
1.3854	-443.34
1.3871	-434.22
1.3887	-425.09
1.3926	-415.96
1.3984	-406.84
1.406	-397.71
1.4152	-388.59
1.426	-379.46
1.4383	-370.33
1.4521	-361.21
1.4674	-352.08
1.484	-342.95
1.502	-333.83
1.5212	-324.7
1.5416	-315.58
1.5632	-306.45
1.5858	-297.32
1.6095	-288.2
1.6342	-279.07
1.6597	-269.94
1.6862	-260.82
1.7134	-251.69
1.7415	-242.56
1.7702	-233.44
1.7995	-224.31
1.8294	-215.19
1.8599	-206.06
1.8908	-196.93
1.9221	-187.81
1.9538	-178.68
1.9858	-169.55
2.018	-160.43
2.0505	-151.3
2.083	-142.18
2.1156	-133.05
2.1483	-123.92
2.1809	-114.8
2.2134	-105.67
2.2457	-96.544
2.2779	-87.417
2.3097	-78.291
2.3413	-69.165
2.3725	-60.038
2.4032	-50.912
2.4335	-41.786

2.4632	-32.659
2.4923	-23.533
2.5207	-14.407
2.5484	-5.2805
2.5754	3.8458
2.6015	12.972
2.6267	22.098
2.651	31.225
2.6743	40.351
2.6965	49.477
2.7176	58.604
2.7376	67.73

**TABLE 31**  
**7075 (UNS A97075) > Isotropic Elasticity**

Temperature F	Young's Modulus psi	Poisson's Ratio	Bulk Modulus psi	Shear Modulus psi
-459.67	1.1431e+007	0.32387	1.0817e+007	4.3172e+006
-445.62	1.1432e+007	0.32391	1.082e+007	4.3174e+006
-431.56	1.1429e+007	0.32398	1.0822e+007	4.3162e+006
-417.51	1.1423e+007	0.32407	1.0822e+007	4.3138e+006
-403.45	1.1415e+007	0.32418	1.0821e+007	4.3102e+006
-389.4	1.1404e+007	0.32431	1.0818e+007	4.3056e+006
-375.34	1.139e+007	0.32446	1.0814e+007	4.2999e+006
-361.29	1.1374e+007	0.32463	1.0809e+007	4.2932e+006
-347.23	1.1355e+007	0.32481	1.0803e+007	4.2857e+006
-333.18	1.1335e+007	0.32501	1.0796e+007	4.2773e+006
-319.12	1.1312e+007	0.32521	1.0787e+007	4.2682e+006
-305.07	1.1288e+007	0.32543	1.0777e+007	4.2583e+006
-291.02	1.1262e+007	0.32566	1.0766e+007	4.2478e+006
-276.96	1.1234e+007	0.32589	1.0754e+007	4.2366e+006
-262.91	1.1205e+007	0.32613	1.0741e+007	4.2249e+006
-248.85	1.1175e+007	0.32637	1.0727e+007	4.2126e+006
-234.8	1.1143e+007	0.32662	1.0712e+007	4.1999e+006
-220.74	1.1111e+007	0.32687	1.0696e+007	4.1867e+006
-206.69	1.1077e+007	0.32713	1.0679e+007	4.1732e+006
-192.63	1.1042e+007	0.32738	1.0661e+007	4.1593e+006
-178.58	1.1006e+007	0.32763	1.0642e+007	4.1451e+006
-164.52	1.097e+007	0.32788	1.0623e+007	4.1306e+006
-150.47	1.0933e+007	0.32813	1.0602e+007	4.1159e+006
-136.42	1.0895e+007	0.32838	1.0581e+007	4.101e+006
-122.36	1.0857e+007	0.32862	1.0558e+007	4.0859e+006
-108.31	1.0819e+007	0.32885	1.0535e+007	4.0707e+006
-94.252	1.078e+007	0.32908	1.0512e+007	4.0553e+006
-80.197	1.074e+007	0.32931	1.0487e+007	4.0399e+006
-66.143	1.0701e+007	0.32953	1.0462e+007	4.0243e+006
-52.088	1.0661e+007	0.32974	1.0436e+007	4.0088e+006
-38.034	1.0621e+007	0.32995	1.041e+007	3.9931e+006
-23.979	1.0581e+007	0.33014	1.0383e+007	3.9775e+006
-9.9245	1.0541e+007	0.33033	1.0355e+007	3.9618e+006

4.13	1.0501e+007	0.33052	1.0326e+007	3.9462e+006
18.185	1.0461e+007	0.33069	1.0298e+007	3.9306e+006
32.239	1.0421e+007	0.33086	1.0268e+007	3.915e+006
46.294	1.038e+007	0.33102	1.0238e+007	3.8994e+006
60.348	1.034e+007	0.33117	1.0208e+007	3.8839e+006
74.403	1.03e+007	0.33131	1.0177e+007	3.8684e+006
88.457	1.026e+007	0.33145	1.0145e+007	3.8529e+006
102.51	1.022e+007	0.33158	1.0114e+007	3.8375e+006
116.57	1.018e+007	0.33171	1.0081e+007	3.8221e+006
130.62	1.014e+007	0.33183	1.0049e+007	3.8067e+006
144.68	1.01e+007	0.33194	1.0016e+007	3.7914e+006
158.73	1.006e+007	0.33205	9.9828e+006	3.776e+006
172.78	1.002e+007	0.33216	9.9493e+006	3.7607e+006
186.84	9.9795e+006	0.33226	9.9156e+006	3.7453e+006
200.89	9.9393e+006	0.33236	9.8817e+006	3.7299e+006
214.95	9.8989e+006	0.33246	9.8475e+006	3.7145e+006
229	9.8584e+006	0.33257	9.8132e+006	3.699e+006
243.06	9.8176e+006	0.33267	9.7787e+006	3.6835e+006
257.11	9.7766e+006	0.33278	9.7441e+006	3.6678e+006
271.17	9.7353e+006	0.33289	9.7094e+006	3.6519e+006
285.22	9.6935e+006	0.33301	9.6746e+006	3.636e+006
299.28	9.6513e+006	0.33313	9.6397e+006	3.6198e+006
313.33	9.6086e+006	0.33327	9.6048e+006	3.6034e+006
327.38	9.5652e+006	0.33342	9.5699e+006	3.5867e+006
341.44	9.5212e+006	0.33358	9.535e+006	3.5698e+006
355.49	9.4764e+006	0.33375	9.5002e+006	3.5525e+006
369.55	9.4308e+006	0.33394	9.4654e+006	3.5349e+006
383.6	9.3842e+006	0.33416	9.4307e+006	3.5169e+006
397.66	9.3365e+006	0.33439	9.3961e+006	3.4984e+006
411.71	9.2877e+006	0.33465	9.3616e+006	3.4795e+006
425.77	9.2377e+006	0.33493	9.3272e+006	3.46e+006
439.82	9.1863e+006	0.33525	9.293e+006	3.4399e+006
453.88	9.1334e+006	0.33559	9.259e+006	3.4192e+006
467.93	9.0788e+006	0.33598	9.2252e+006	3.3978e+006
481.98	9.0226e+006	0.3364	9.1916e+006	3.3757e+006
496.04	8.9645e+006	0.33686	9.1582e+006	3.3528e+006
510.09	8.9044e+006	0.33736	9.125e+006	3.3291e+006
524.15	8.8421e+006	0.33792	9.0921e+006	3.3044e+006
538.2	8.7776e+006	0.33852	9.0595e+006	3.2788e+006
552.26	8.7106e+006	0.33918	9.0272e+006	3.2522e+006
566.31	8.6411e+006	0.33989	8.9952e+006	3.2245e+006
580.37	8.5688e+006	0.34067	8.9635e+006	3.1957e+006
594.42	8.4935e+006	0.34152	8.9321e+006	3.1657e+006
608.48	8.4153e+006	0.34243	8.9011e+006	3.1343e+006
622.53	8.3337e+006	0.34342	8.8704e+006	3.1017e+006
636.58	8.2487e+006	0.34448	8.8401e+006	3.0676e+006
650.64	8.1602e+006	0.34563	8.8102e+006	3.0321e+006
664.69	8.0678e+006	0.34687	8.7807e+006	2.995e+006

678.75	7.9714e+006	0.34819	8.7516e+006	2.9563e+006
692.8	7.8709e+006	0.34961	8.7229e+006	2.916e+006
706.86	7.7659e+006	0.35114	8.6947e+006	2.8739e+006
720.91	7.6564e+006	0.35277	8.667e+006	2.8299e+006
734.97	7.5421e+006	0.35451	8.6397e+006	2.7841e+006
749.02	7.4228e+006	0.35636	8.6129e+006	2.7363e+006
763.08	7.2982e+006	0.35834	8.5867e+006	2.6864e+006
777.13	7.1682e+006	0.36045	8.561e+006	2.6345e+006
791.18	7.0325e+006	0.36269	8.5359e+006	2.5804e+006
805.24	6.8908e+006	0.36507	8.5113e+006	2.524e+006
819.29	6.7431e+006	0.36759	8.4875e+006	2.4653e+006
833.35	6.5889e+006	0.37026	8.4642e+006	2.4042e+006
847.4	6.4281e+006	0.37309	8.4418e+006	2.3407e+006
861.46	6.2603e+006	0.37608	8.4201e+006	2.2747e+006
875.51	6.0855e+006	0.37925	8.3992e+006	2.2061e+006
889.57	5.9032e+006	0.38258	8.3793e+006	2.1348e+006
903.62	5.7132e+006	0.38611	8.3604e+006	2.0609e+006
917.68	5.5153e+006	0.38982	8.3427e+006	1.9842e+006
931.73	5.3092e+006	0.39373	8.3262e+006	1.9047e+006

**TABLE 32**  
**7075 (UNS A97075) > Multilinear Isotropic Hardening**

Stress psi	Plastic Strain in in <sup>-1</sup>	Temperature F
72100	0	67.73
74119	5.7895e-003	67.73
75898	1.1579e-002	67.73
77471	1.7368e-002	67.73
78867	2.3158e-002	67.73
80113	2.8947e-002	67.73
81234	3.4737e-002	67.73
82252	4.0526e-002	67.73
83188	4.6316e-002	67.73
84058	5.2105e-002	67.73
84878	5.7895e-002	67.73
85661	6.3684e-002	67.73
86417	6.9474e-002	67.73
87154	7.5263e-002	67.73
87877	8.1053e-002	67.73
88590	8.6842e-002	67.73
89293	9.2632e-002	67.73
89985	9.8421e-002	67.73
90661	0.10421	67.73
91316	0.11	67.73

**TABLE 33**  
**7075 (UNS A97075) > Alternating Stress R-Ratio**

Alternating Stress psi	Cycles	R-Ratio
50442	4000	-1
49352	4677.6	-1



48261	5469.9	-1
47166	6396.4	-1
46067	7479.9	-1
44962	8746.9	-1
43853	10229	-1
42739	11961	-1
41620	13987	-1
40499	16356	-1
39375	19127	-1
38251	22367	-1
37129	26156	-1
36010	30586	-1
34896	35767	-1
33790	41826	-1
32695	48910	-1
31612	57195	-1
30546	66883	-1
29498	78213	-1
28471	91461	-1
27468	1.0695e+005	-1
26492	1.2507e+005	-1
25546	1.4626e+005	-1
24632	1.7103e+005	-1
23753	2.e+005	-1
22911	2.3388e+005	-1
22108	2.7349e+005	-1
21346	3.1982e+005	-1
20627	3.7399e+005	-1
19953	4.3734e+005	-1
19325	5.1143e+005	-1
18744	5.9806e+005	-1
18210	6.9936e+005	-1
17724	8.1782e+005	-1
17285	9.5635e+005	-1
16894	1.1183e+006	-1
16548	1.3078e+006	-1
16247	1.5293e+006	-1
15989	1.7884e+006	-1
15771	2.0913e+006	-1
15590	2.4455e+006	-1
15442	2.8598e+006	-1
15324	3.3442e+006	-1
15230	3.9106e+006	-1
15155	4.5731e+006	-1
15092	5.3477e+006	-1
15035	6.2535e+006	-1
14976	7.3128e+006	-1
14816	1.e+007	-1

