Separation Connector

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Team 19

Analysis of Final Design Concepts

Document

Submitted towards partial fulfillment of the requirements for
Mechanical Engineering Design – Fall 2012

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Table of Contents

ABSTRACT

By request of Mary Rogers and Orbital Sciences Corporation, our team has begun analysis on two final design concepts. Both designs have undergone many modifications to meet the customer's specifications. We will present our evidence to Mrs. Rogers to choose a final design to continue the analysis on. The two designs being considered in this report are:

1. Spring-loaded latch and lever release mechanism
2. Ball Bearing detent

This report will explain each design and list the renovations each have undergone. It will also list the assumptions made and demonstrate the preliminary analysis that was used to decide which of the two design ideas is the best fit for our client. Lastly, our team will give a recommendation of the design we believe is the best solution to our client's problem.

PROBLEM STATEMENT

The goal of this project is to design and prototype a perfectly reliable, inexpensive, and manufacturable separation connector.

SELECTED DESIGNS

Originally, we chose to do the "Spring-Hammer" and "Ball Bearing" designs (see Report #2 for design descriptions). However, after consulting with our client we found that our designs had a major flaw. Our designs required modifications to both ends of the separator connector, but our client informed us that the male end of the connector must remain unchanged. This required our designs to be modified to meet the customer's requirement. Below are the newly modified design concepts.

1. Spring-loaded latch and lever release mechanism
   a. **Original –** This design is a modification of the original "Spring-Hammer" design. The original design incorporated a hammer that would, when released, spring forward and hit the male end causing the de-mate. We found that the hammer was unnecessary because the rocket would provide a sufficient pulling force to de-mate the device on its own.

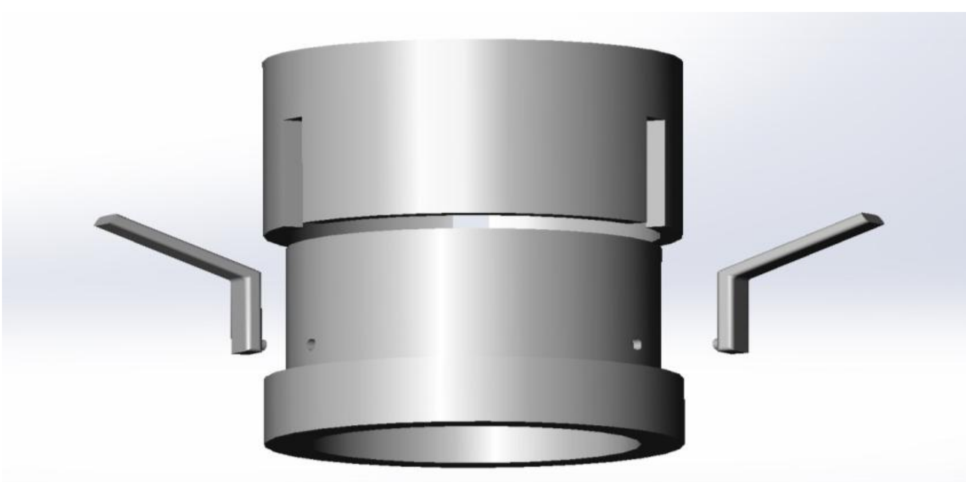


Figure 1: Original lever-action design concept

b. **Modified –** We decided to remove the hammer and change it to latches that hold the connector together. The latches are on the outside of the device and are spring-loaded to keep them in constant tension with the outside of the female sleeve. When the male end is twisted into the mating position, the latches “click” onto the outside of the male end and complete the mate. The male end in this design is the original design. The male end twists into the coupling connector and mates with the female end. The female end is inserted into the coupling and is stopped by a small extrusion on the inside of the coupling connector. The last component of this design is an outer collar. The outer collar has three grooves cut on the inside of it that act as tracks for the latches and a leash (not shown) attached to the outside. The notches on the bottom of the sleeve push the levers/latches down when the collar is pulled down. When this occurs, the latches will detach from the male end and both ends are pulled away from each other; thus, achieving de-mate.

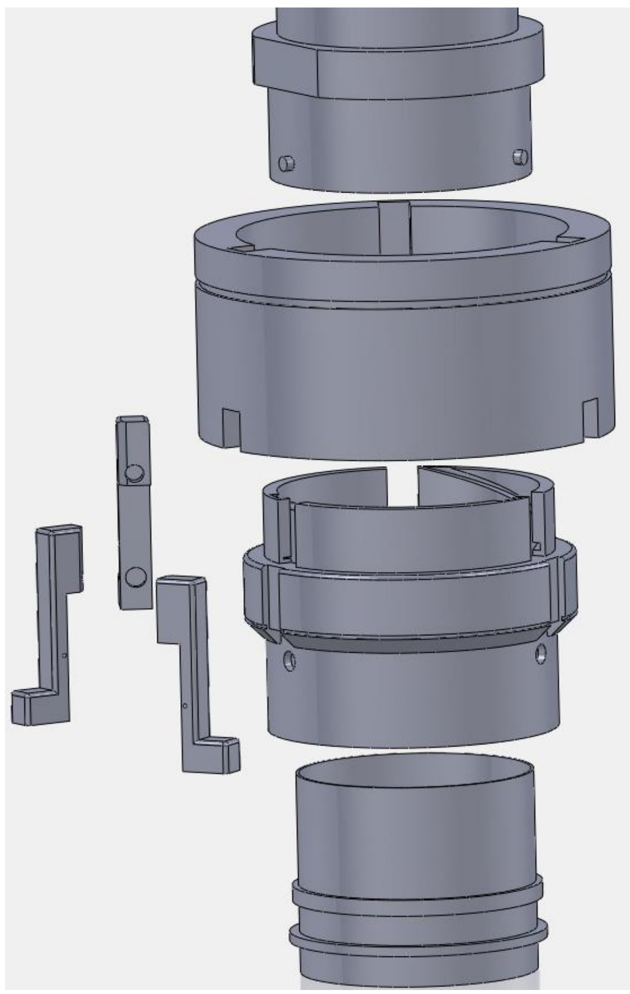


Figure 2: Modified spring-loaded latch and lever release mechanism (exploded view)

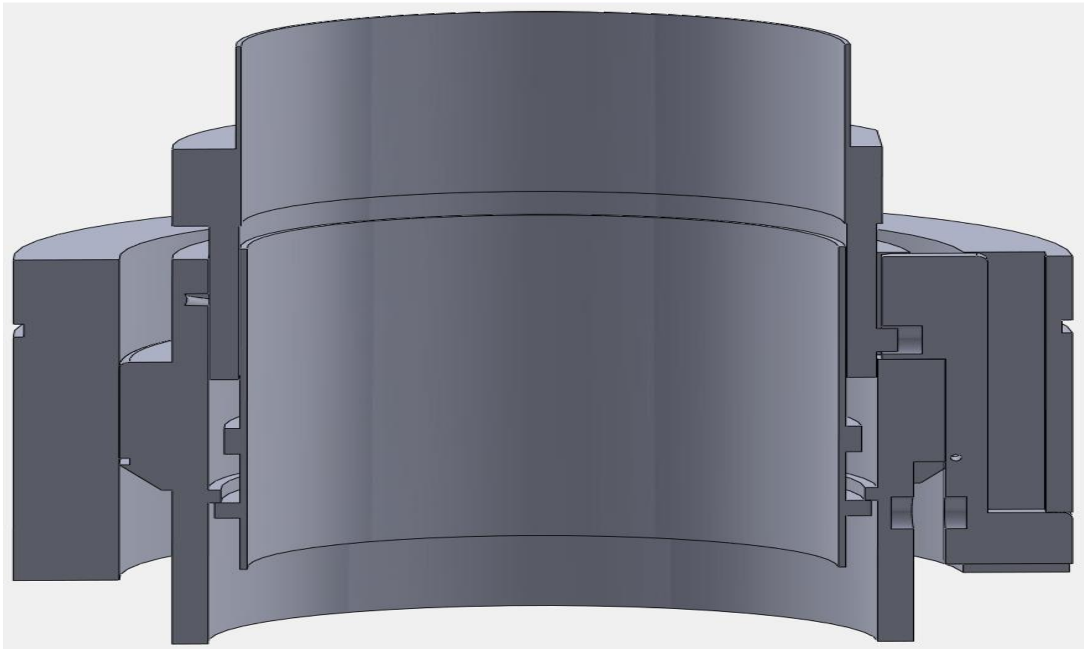


Figure 3: Modified spring-loaded latch and lever release mechanism (cross-sectional view)

2. Ball bearing detent
    a. **Original –** This design is a modification of the original “Ball Bearing” design. The original design was very simplistic. It required the male end to have ball bearings with springs installed into it and a female receiving end. The main concern with this design was that it might prematurely de-mate and it did not have the bayonet pins that our client wanted.

Figure 4: Original ball bearing design concept

b. **Modified –** For this design, we decided to make a coupling attachment that avoided modifying the male end. The coupling has the original one-third turn grooves cut into it, but it also contains a slot cut into it where the ball bearings can insert themselves. The female end of this separation connector contains four evenly spaced ball bearings near the bottom of the piece and a leash connected on the bottom extrusion. To mate the device, simply twist the male end one-third of a turn into the coupling and push the female end into the coupling until it "clicks". To de-mate the device, either twist the male end counter-clockwise or pull on the leash located on the female end with enough force to compress the springs and retract the ball bearings.

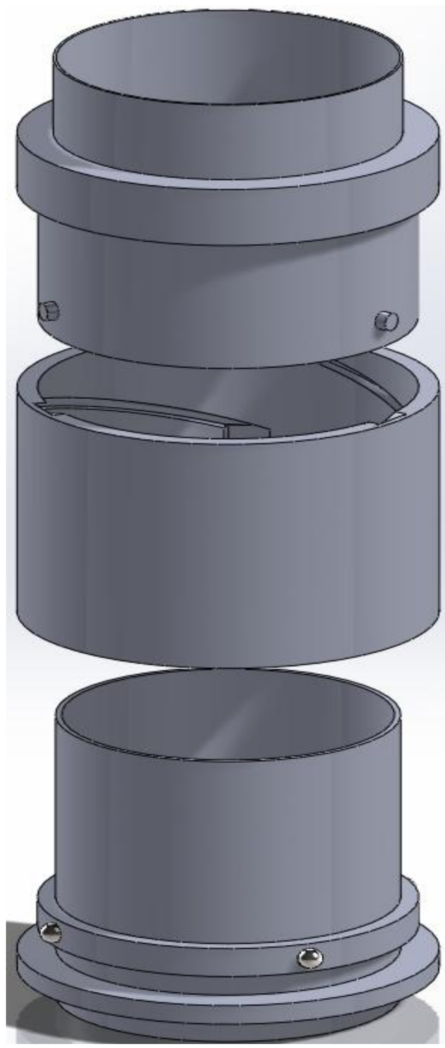


Figure 5: Modified ball bearing detent design (exploded view)

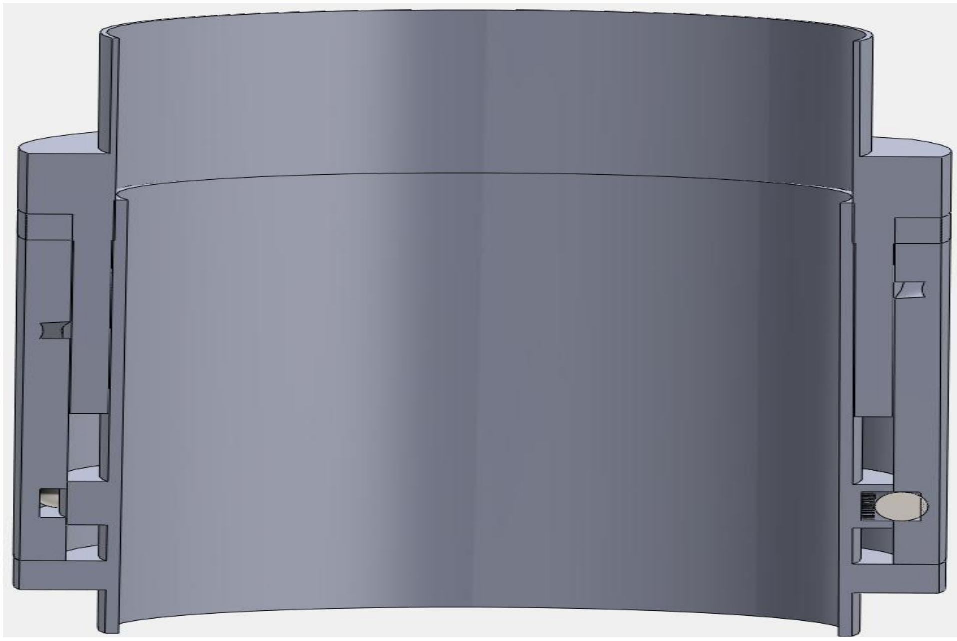


Figure 6: Modified ball bearing detent design (cross-sectional view)

SPECIFICATIONS

This section includes the specifications to which our design must abide by. These specifications were given by our client to ensure the separation connector meets Orbital Sciences Corporation's rigorous standards. Below is a list of the required specifications:

- Bayonet grooves must match military specifications
- Minimum of 200 lbf for dynamic de-mate
- Between 10-30 lbf for static de-mate
- Leash must be able to withstand a minimum pulling force of 300lbf
- Must be able to statically mate/de-mate a minimum of 50 times
- Must withstand a temperature gradient of -34°C – 71°C with no damage to the material
- Must withstand a static acceleration of 15 G-Force
- Must not fail during a drop test
    - From a height of 3 feet dropped onto a concrete floor
- Must pass a "rattle test"
    - The object is shaken by hand or a vibration machine and must not rattles or becoming de-mated
- Must not exceed an increase in size of 25 % greater than the original ~1.43" inner diameter for male end
- Must not exceed an increase in size of 25 % greater than the original ~1.42" outer diameter for female end

ASSUMPTIONS IN ANALYSIS

We have not finalized the dimensions for our designs; therefore, the calculated values for our analysis are all approximates. Additional assumptions for the analysis of the designs include:

1. Material used is Aluminum 6061 alloy
2. Horizontal de-mate (no pull angle)
3. No friction while de-mate occurs
4. Perfect reliability
5. Dimensions of the device are correct

ANALYSIS OF COMPONENTS

Using SolidWorks' stress analysis function, we were able to perform a simple analysis on both of our designs. The stress analysis function helped create stress diagrams of certain components of each design.

1. Spring-loaded latch and lever release mechanism

   Latch:

   a. Tension at hole where spring is attached

   b. Forces of male and female end create opposing forces on connection

   Lever:

   a. Fixed point at the point where the lever is connected to latch

   b. Constant bending stress from spring resistance and release

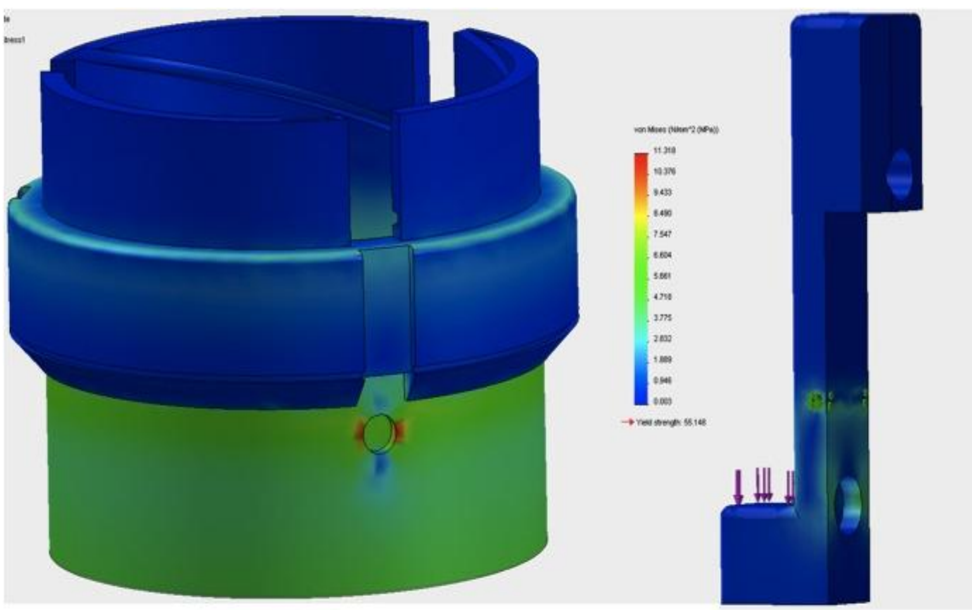


Figure 7: Stress analysis of spring-loaded latch and lever release mechanism

2. Ball bearing detent
   a. Stress point where bayonet pin locks in place, this point is fixed
   b. Inner collar for bearing connection does not have sufficient enough stress to be considered

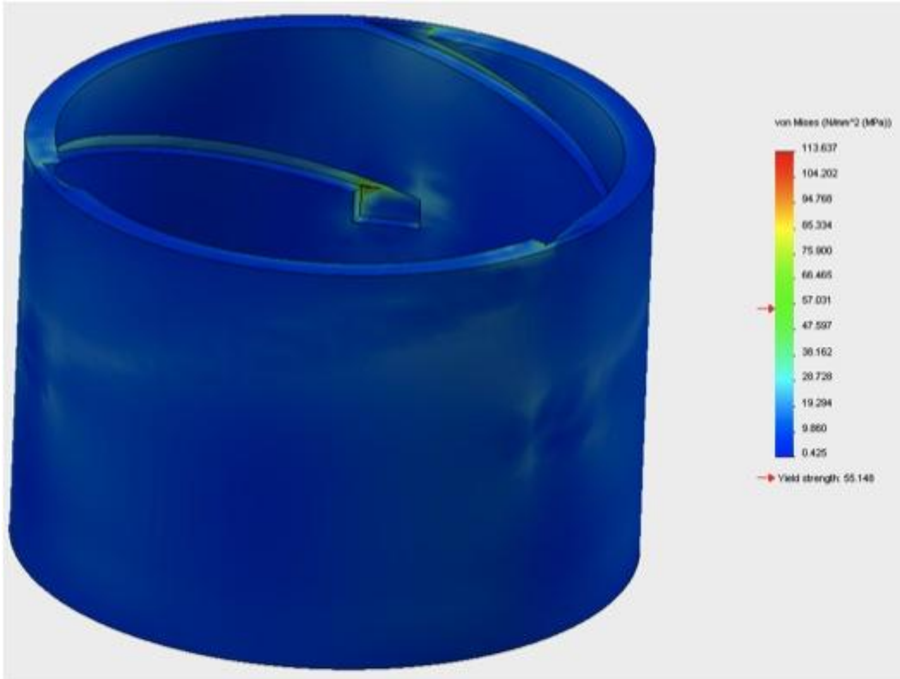


Figure 8: Stress analysis of ball bearing detent design

We also analyzed specific components of the ball bearing detent design where crucial forces and stresses were located. These parts were analyzed using SolidWorks, a 3D CAD package with a Finite Element Analysis simulator. The individual components are listed below with their stress analysis summarized. Appendices A, B, and C show the simulations of each part we built using SolidWorks. An important addition that is not seen in our analysis is the pressure applied by the ball bearings. There must be enough pressure for the ball bearings to be in contact with the center coupling to avoid pre-mature de-mating.

UPDATED GANTT CHART

This section contains our updated Gantt chart. The Gantt chart shows the deadlines we need to meet as well as deliverables that have already been completed. This schedule is tentative and is subject to change. See figure 9 below for updated Gantt chart. (Updated 11/16/2012)

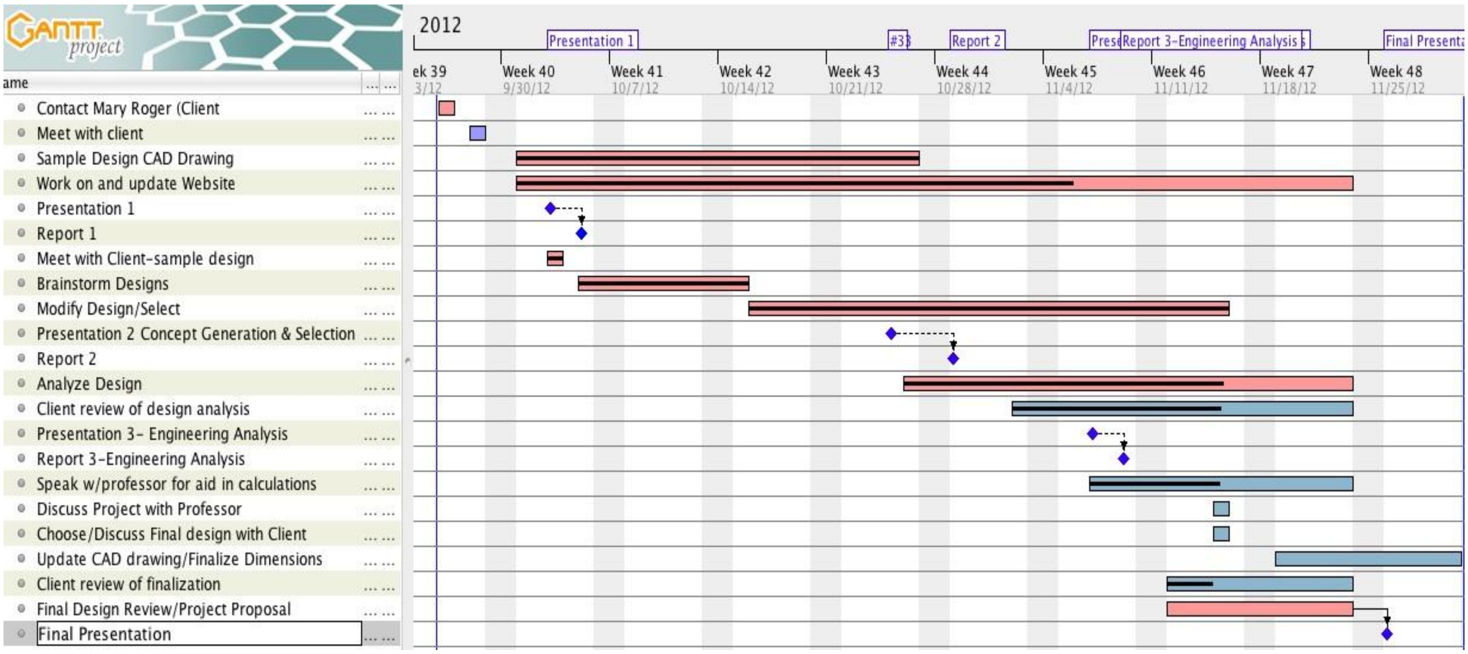


Figure 9: Updated Gantt chart

WORKS CITED

"A World of Interconnect Solutions." *Glenair*. Glenair, 2012. Web. 4 Oct 2012. <http://www.glenair.com/interconnects/mildtl38999/>.

"Amphenol Tri-Start Subminiature Cylindrical Connectors." *Powell Electronics*. Powell Electronics, n.d. Web. 4 Oct 2012. <http://www.powell.com/Amphenol/D38999/D38999catalog.pdf>.

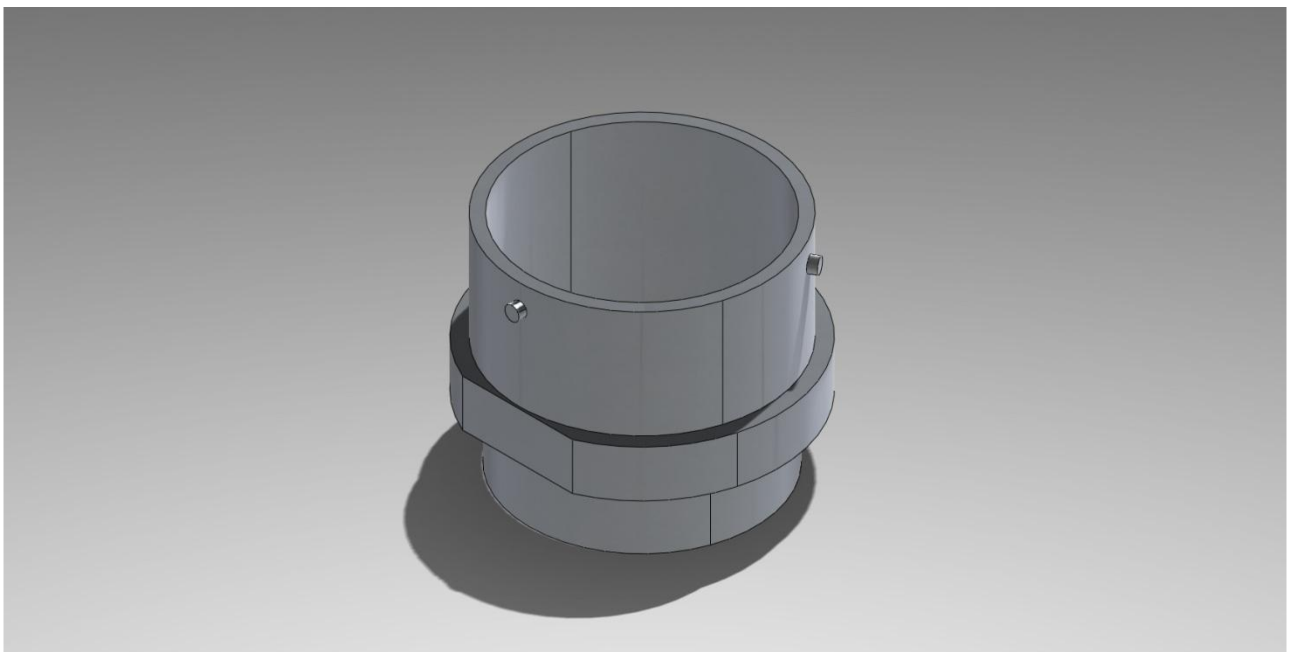
"CADimensions Store Catalog." *CADimensions Inc*. CADimensions Inc., 2012. Web. 6 Nov 2012. <http://shopping.netsuite.com/s.nl/c.635262/sc.2/category.1926/.f>.

"Conduit and Wire Weight Calculator." *Muska Electric Co*. Muska Electric Co, 2008. Web. 6 Nov 2012. <http://www.muskaelectric.com/tools/conduit-and-wire-weight-calculator>.

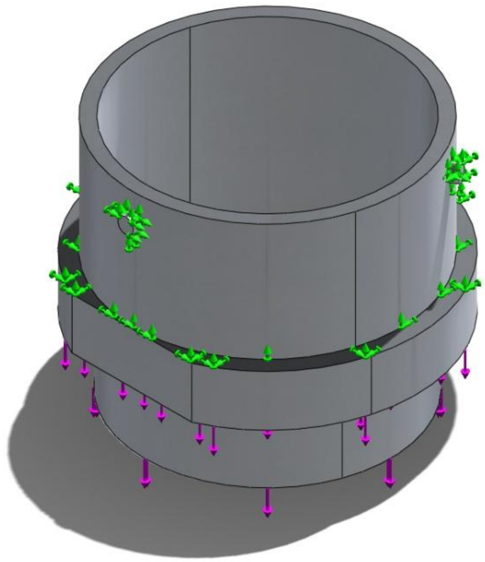
APPENDIX A

Simulation of Male connector with pins

Date: Wednesday, November 07, 2012
Designer: Solidworks
Study name: SimulationXpress Study
Analysis type: Static

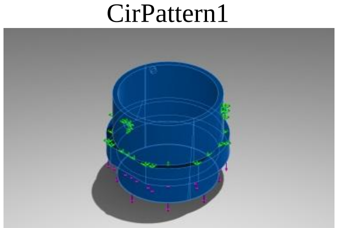


Model Information

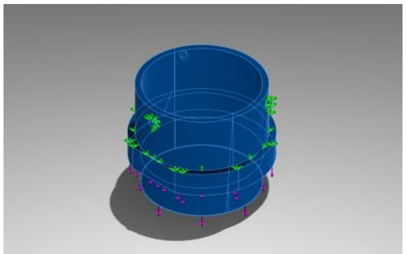


Model name: Male connector with pins
Current Configuration: Default

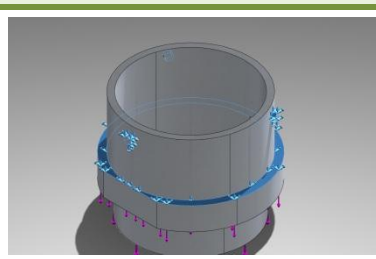
Solid Bodies

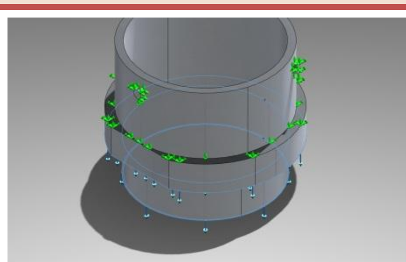
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
CirPattern1 	Solid Body	Mass:0.0487637 lb Volume:0.499917 in^3 Density:0.0975437 lb/in^3 Weight:0.0487306 lbf	\\EGRSHARES\Homes\zl33\Desktop\ME 476C Presentation 3\123\Male connector with pins.SLDPRT Nov 06 23:03:23 2012

Material Properties

Model Reference	Properties	Components
	Name: **6061 Alloy** Model type: **Linear Elastic Isotropic** Default failure criterion: **Max von Mises Stress** Yield strength: **7998.61 psi** Tensile strength: **17996.9 psi**	**SolidBody 1(CirPattern 1)(Male connector with pins)**

Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** **4 face(s)** **Type:** **Fixed Geometry**

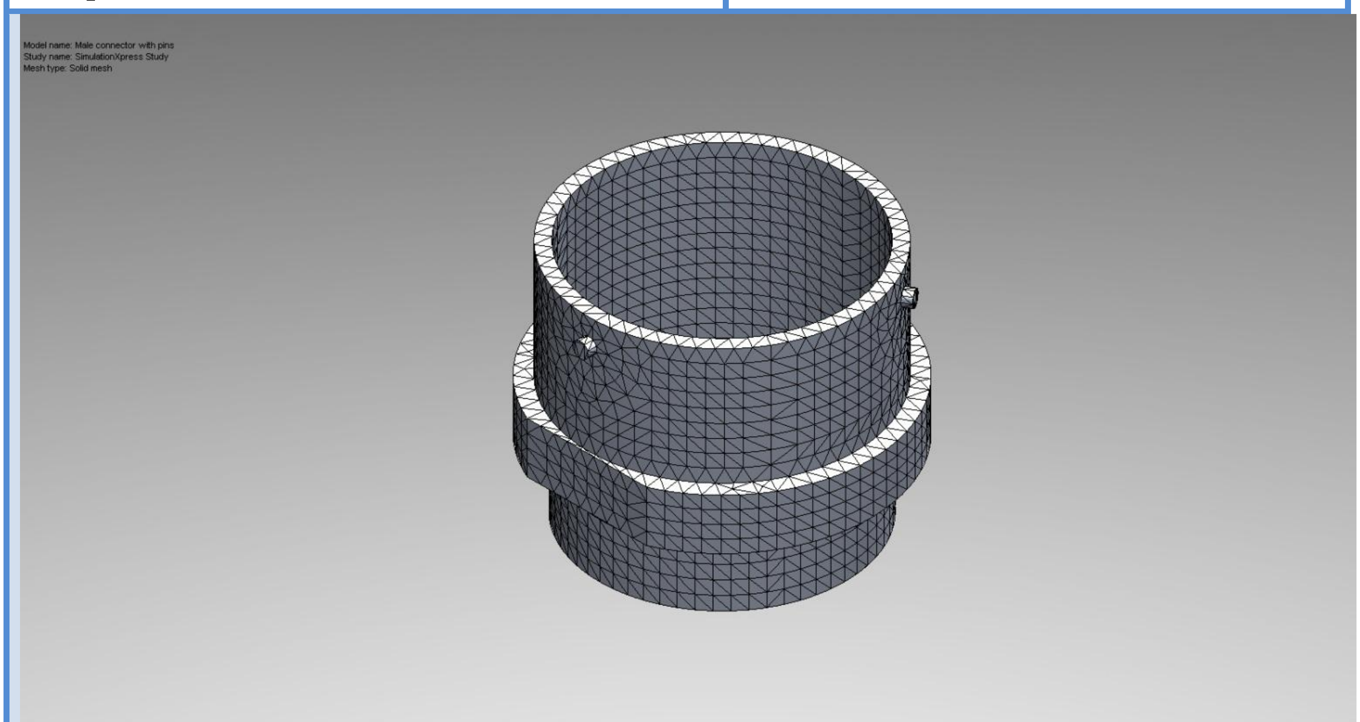
Load name	Load Image	Load Details
Force-1		**Entities:** **2 face(s)** **Type:** **Apply normal force** **Value:** **-120 lbf**

Mesh Information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	0.0793966 in
Tolerance	0.00396983 in
Mesh Quality	High

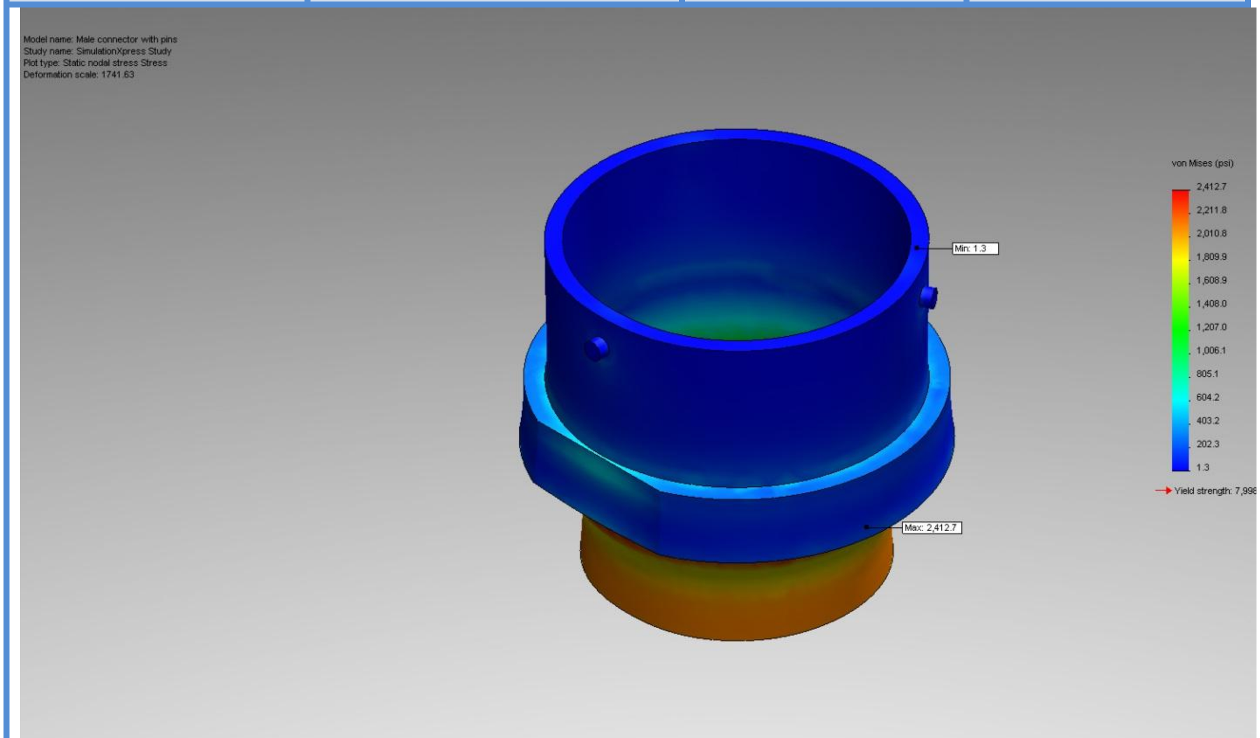
Mesh Information - Details

Total Nodes	17191
Total Elements	9129
Maximum Aspect Ratio	18.657
% of elements with Aspect Ratio < 3	76.8
% of elements with Aspect Ratio > 10	0.175
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:02
Computer name:	EGR317-31



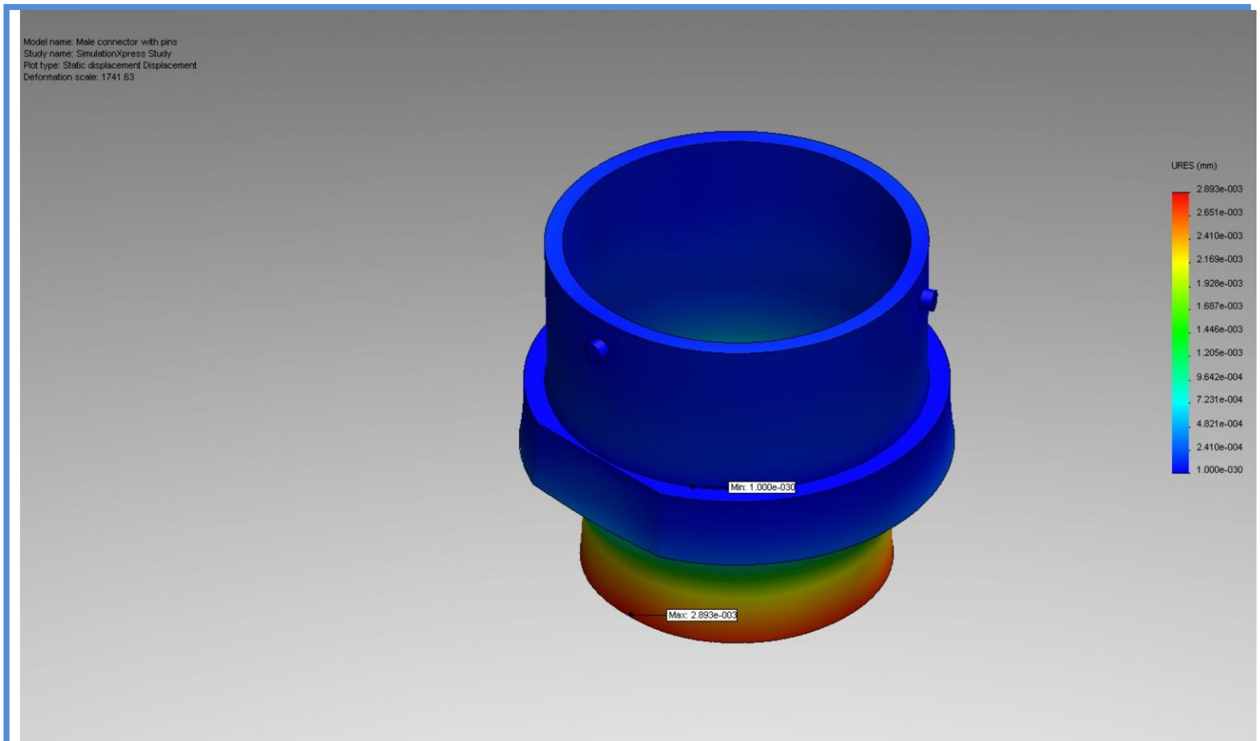
Study Results

Name	Type	Min	Max
Stress	VON: von Mises Stress	1.30404 psi Node: 7084	2412.71 psi Node: 15872



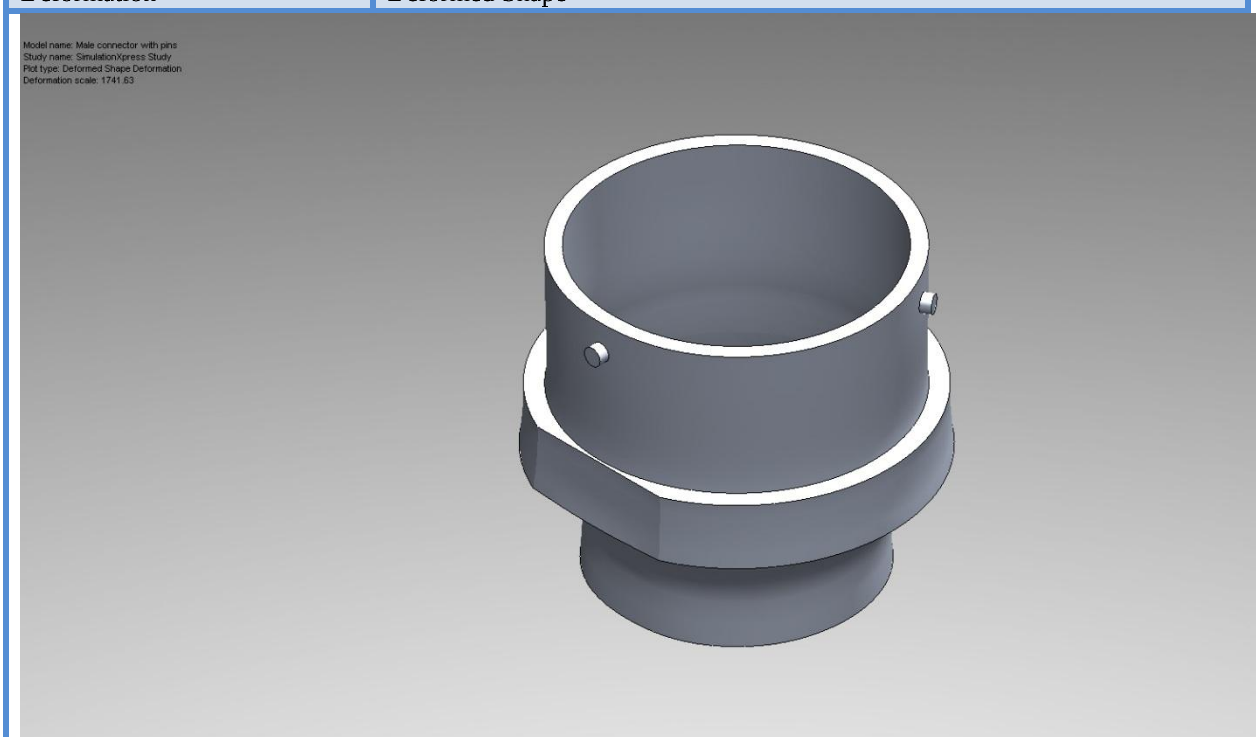
Male connector with pins-SimulationXpress Study-Stress-Stress

Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0 mm Node: 1	0.00289251 mm Node: 698



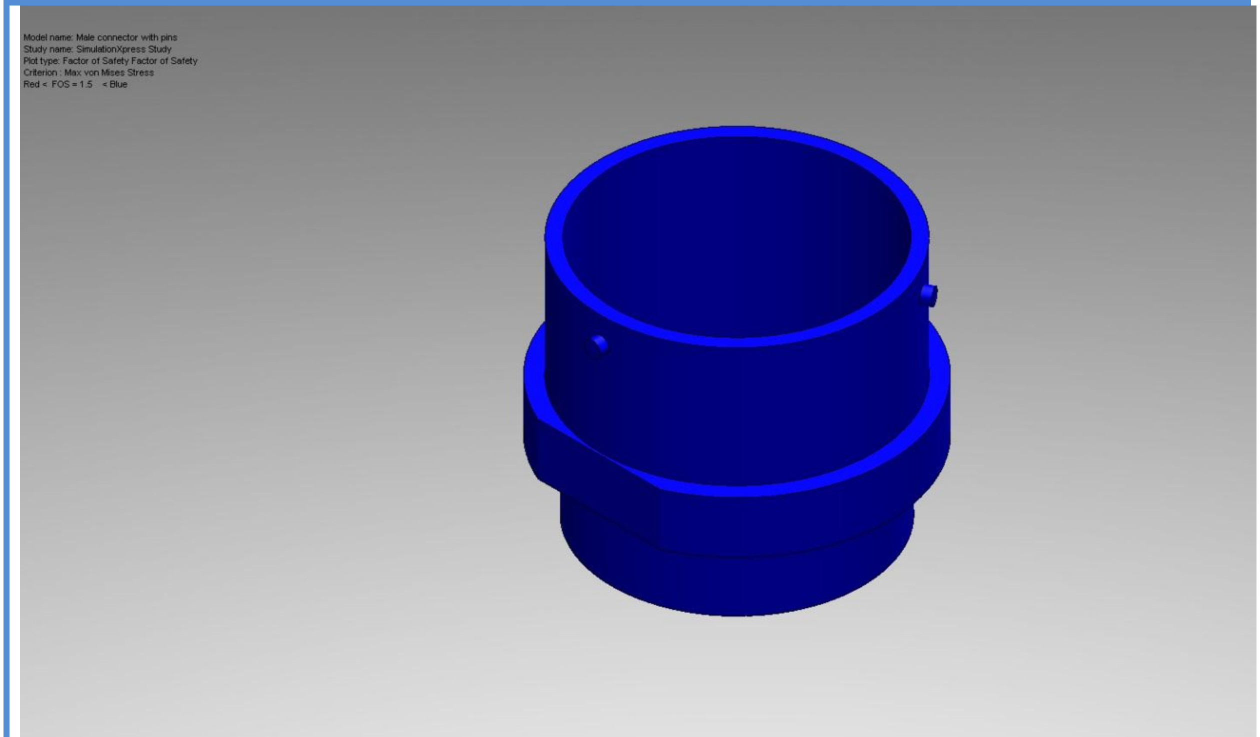
Male connector with pins-SimulationXpress Study-Displacement-Displacement

Name	**Type**
Deformation	Deformed Shape



Male connector with pins-SimulationXpress Study-Displacement-Deformation

Name	Type	Min	Max
Factor of Safety	Max von Mises Stress	3.3152 Node: 15872	6133.71 Node: 7084



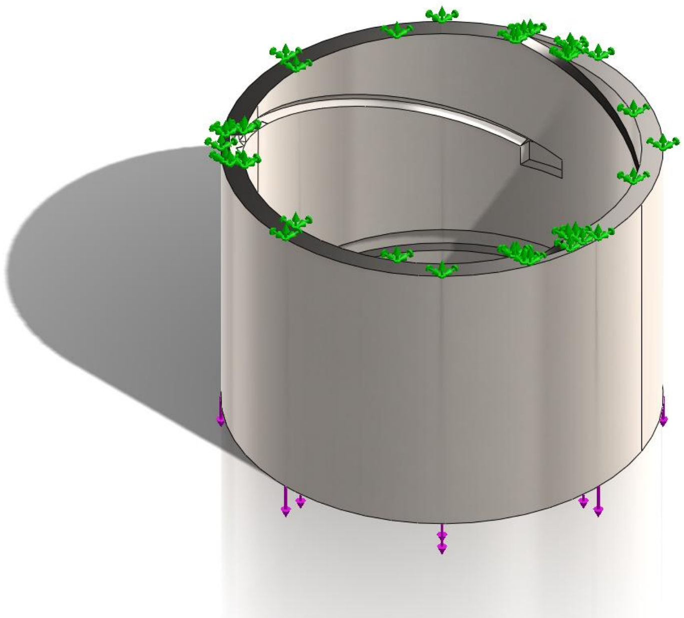
Male connector with pins-SimulationXpress Study-Factor of Safety-Factor of Safety

APPENDIX B

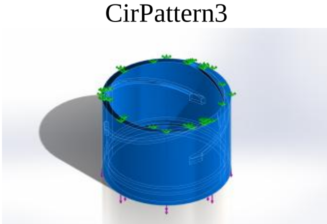
Simulation of detach part

Date: Wednesday, November 07, 2012
Designer: Solidworks
Study name: SimulationXpress Study
Analysis type: Static

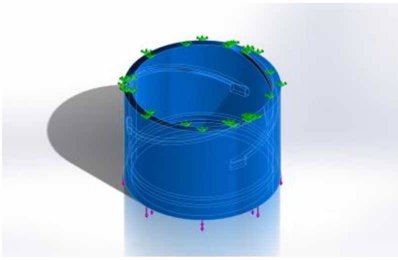
Model Information



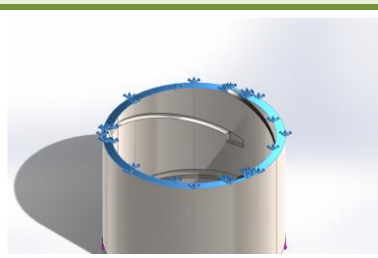
Model name: detach part
Current Configuration: Default

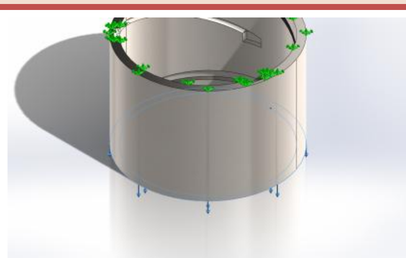
Solid Bodies			
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
CirPattern3 	Solid Body	Mass:0.136502 lb Volume:0.490696 in^3 Density:0.27818 lb/in^3 Weight:0.136409 lbf	\\EGRSHARES\Homes\zl33\Desktop\ME 476C Presentation 3\123\detach part.SLDPRT Nov 07 18:13:31 2012

Material Properties

Model Reference	Properties	Components
	Name: **Alloy Steel** Model type: **Linear Elastic Isotropic** Default failure criterion: **Max von Mises Stress** Yield strength: **89984.6 psi** Tensile strength: **104982 psi**	**SolidBody 1(CirPattern3)(detach part)**

Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-3		**Entities:** **1 face(s)** **Type:** **Fixed Geometry**

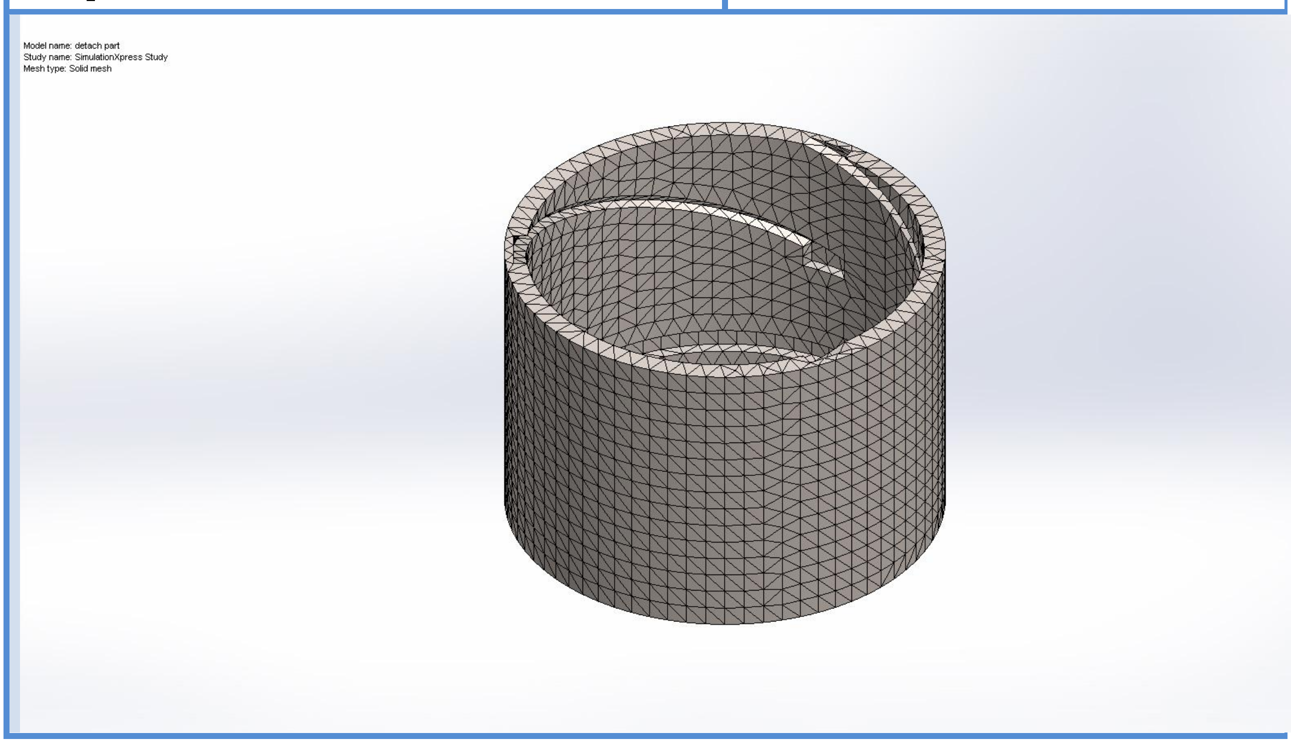
Load name	Load Image	Load Details
Force-2		**Entities:** **1 face(s)** **Type:** **Apply normal force** **Value:** **-200 lbf**

Mesh Information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	0.0790378 in
Tolerance	0.00395189 in
Mesh Quality	High

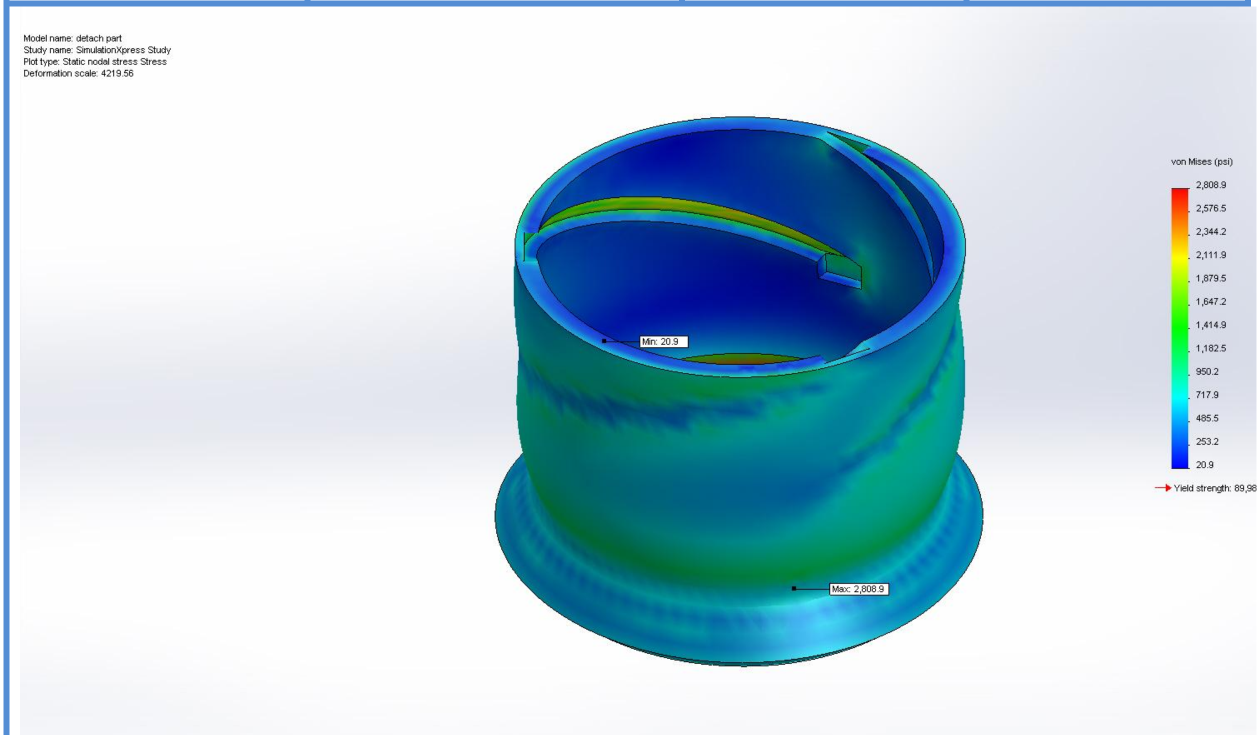
Mesh Information - Details

Total Nodes	17894
Total Elements	9481
Maximum Aspect Ratio	24.04
% of elements with Aspect Ratio < 3	85.6
% of elements with Aspect Ratio > 10	1.94
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:02
Computer name:	EGR317-31



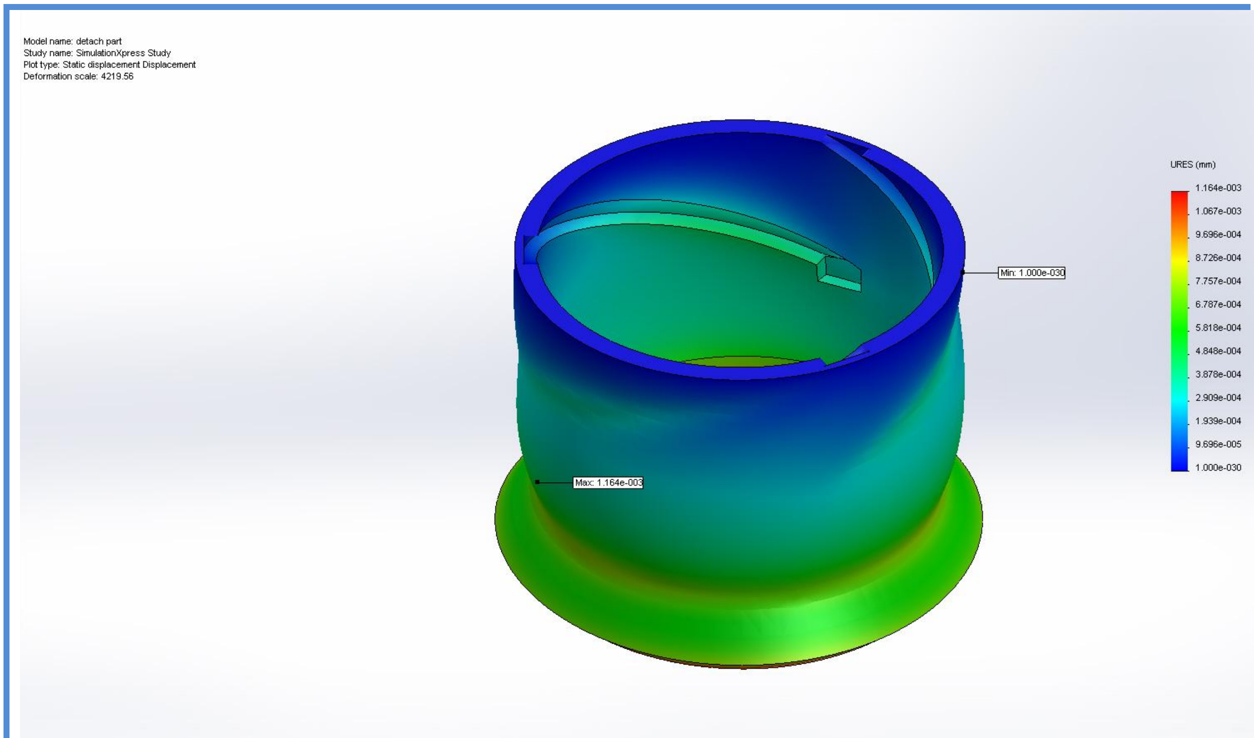
Study Results

Name	Type	Min	Max
Stress	VON: von Mises Stress	20.8509 psi Node: 8868	2808.85 psi Node: 74



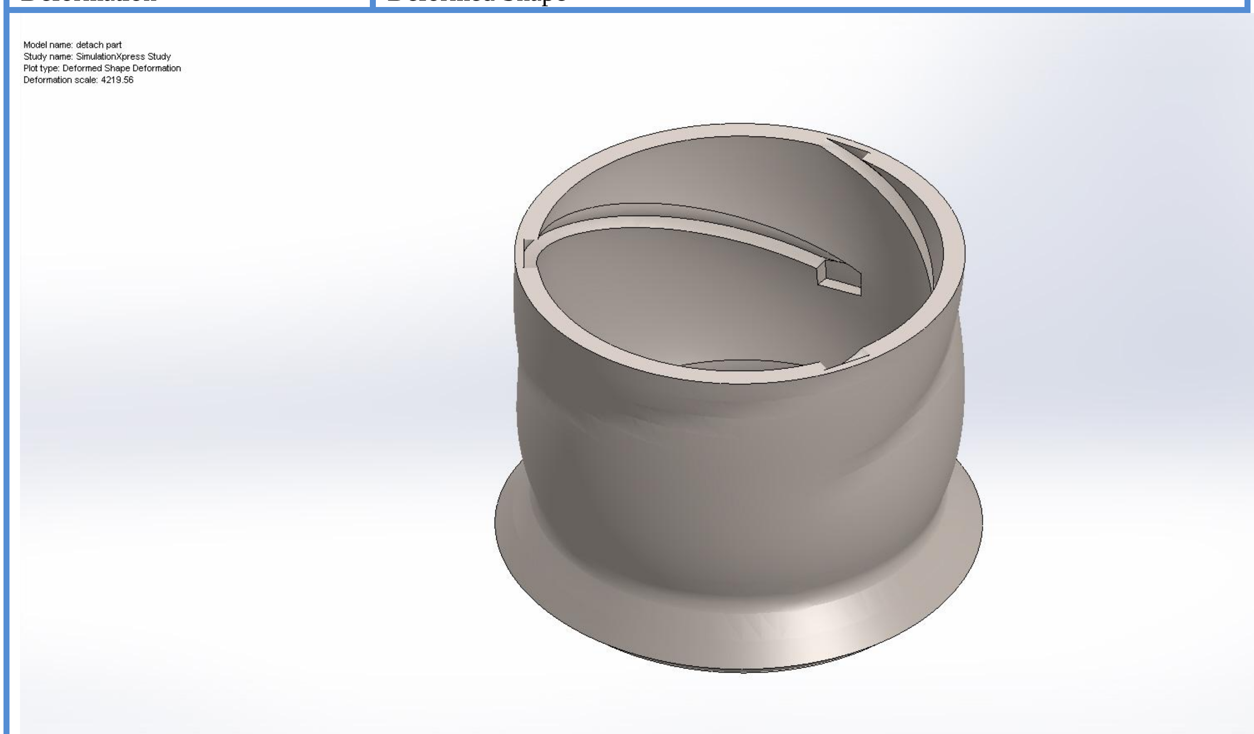
detach part-SimulationXpress Study-Stress-Stress

Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0 mm Node: 98	0.00116353 mm Node: 910



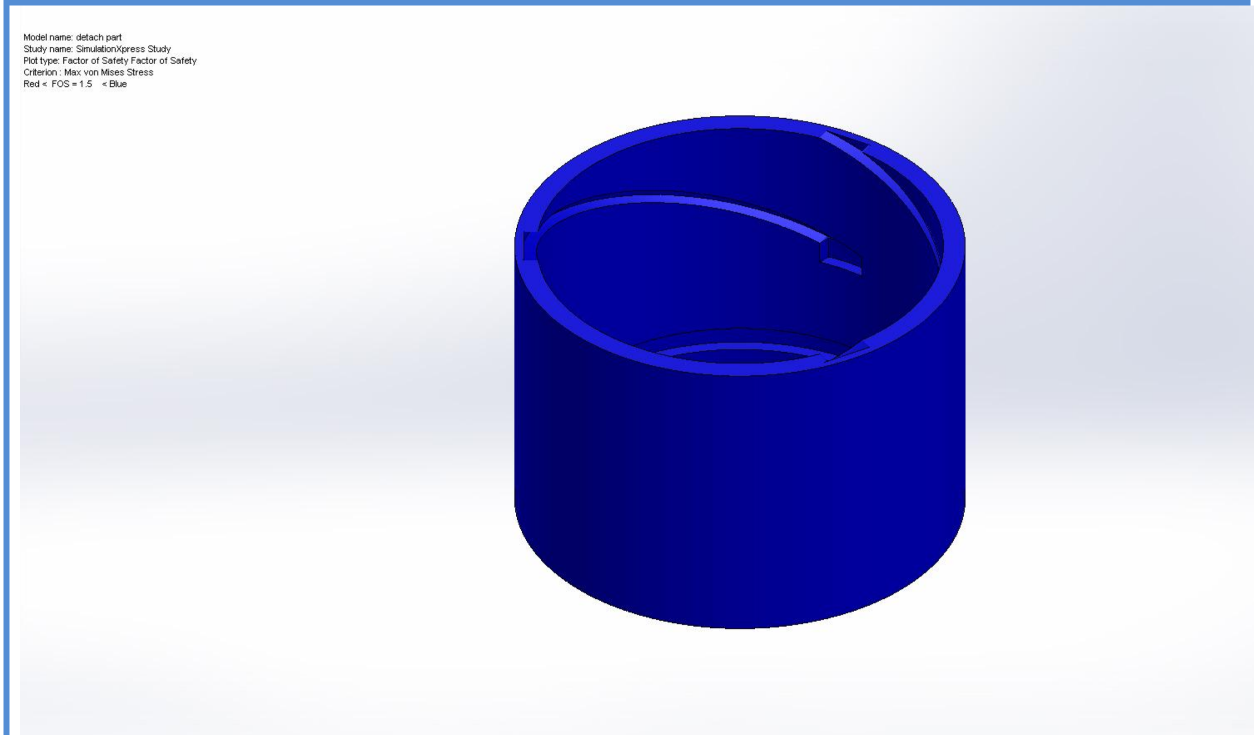
detach part-SimulationXpress Study-Displacement-Displacement

Name	**Type**
Deformation	Deformed Shape



detach part-SimulationXpress Study-Displacement-Deformation

Name	Type	Min	Max
Factor of Safety	Max von Mises Stress	32.0361 Node: 74	4315.62 Node: 8868



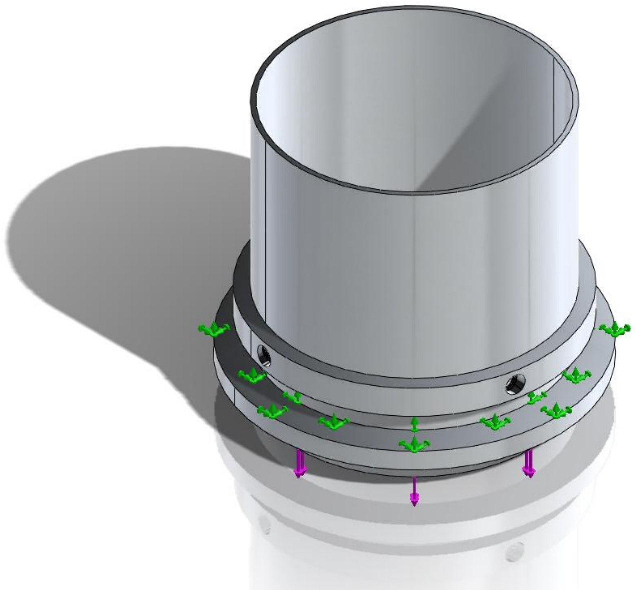
detach part-SimulationXpress Study-Factor of Safety-Factor of Safety

APPENDIX C

Simulation of INT male mate

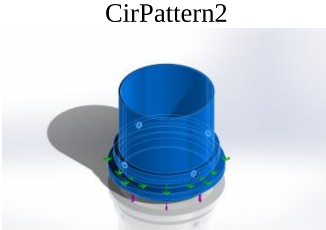
Date: Wednesday, November 07, 2012
Designer: Solidworks
Study name: SimulationXpress Study
Analysis type: Static

Model Information

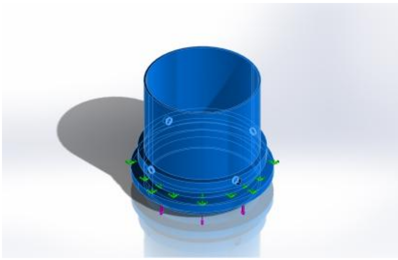


Model name: INT male mate
Current Configuration: Default

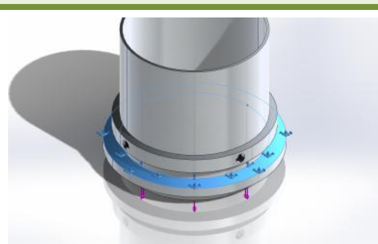
Solid Bodies

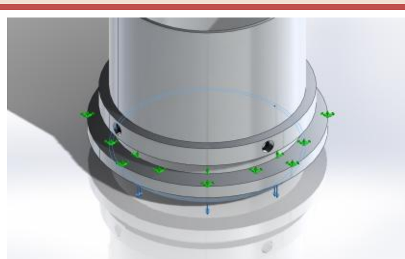
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
CirPattern2 	Solid Body	Mass:0.0289483 lb Volume:0.296773 in^3 Density:0.0975437 lb/in^3 Weight:0.0289287 lbf	\\EGRSHARES\Homes\zl33\Desktop\ME 476C Presentation 3\123\INT male mate.SLDPRT Nov 07 18:13:34 2012

Material Properties

Model Reference	Properties		Components
	Name: Model type: Default failure criterion: Yield strength: Tensile strength:	**6061 Alloy** **Linear Elastic Isotropic** **Max von Mises Stress** **7998.61 psi** **17996.9 psi**	**SolidBody 1(CirPattern2)(INT male mate)**

Loads and Fixtures

Fixture name	Fixture Image	Fixture Details	
Fixed-1		**Entities:** **Type:**	**1 face(s)** **Fixed Geometry**

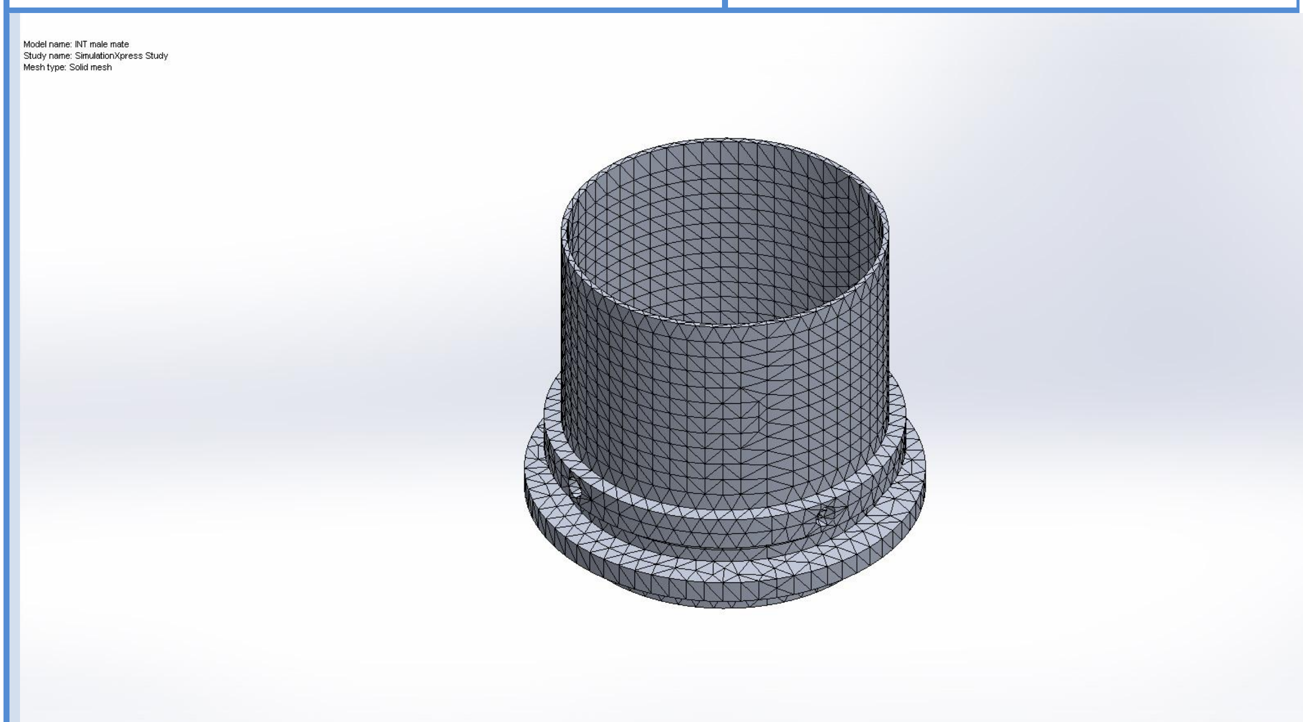
Load name	Load Image	Load Details	
Force-1		**Entities:** **Type:** **Value:**	**1 face(s)** **Apply normal force** **-120 lbf**

Mesh Information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	0.0801434 in
Tolerance	0.00400717 in
Mesh Quality	High

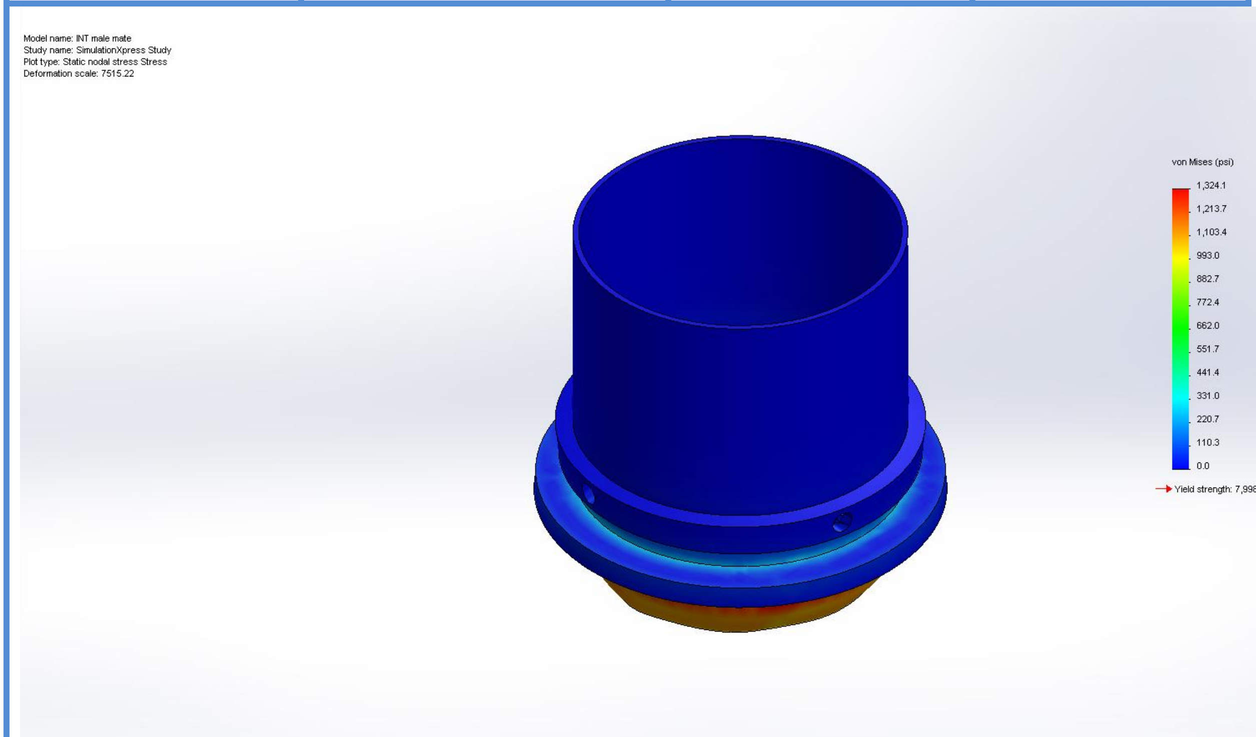
Mesh Information - Details

Total Nodes	16675
Total Elements	8455
Maximum Aspect Ratio	17.506
% of elements with Aspect Ratio < 3	52.1
% of elements with Aspect Ratio > 10	0.177
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:52
Computer name:	EGR317-31



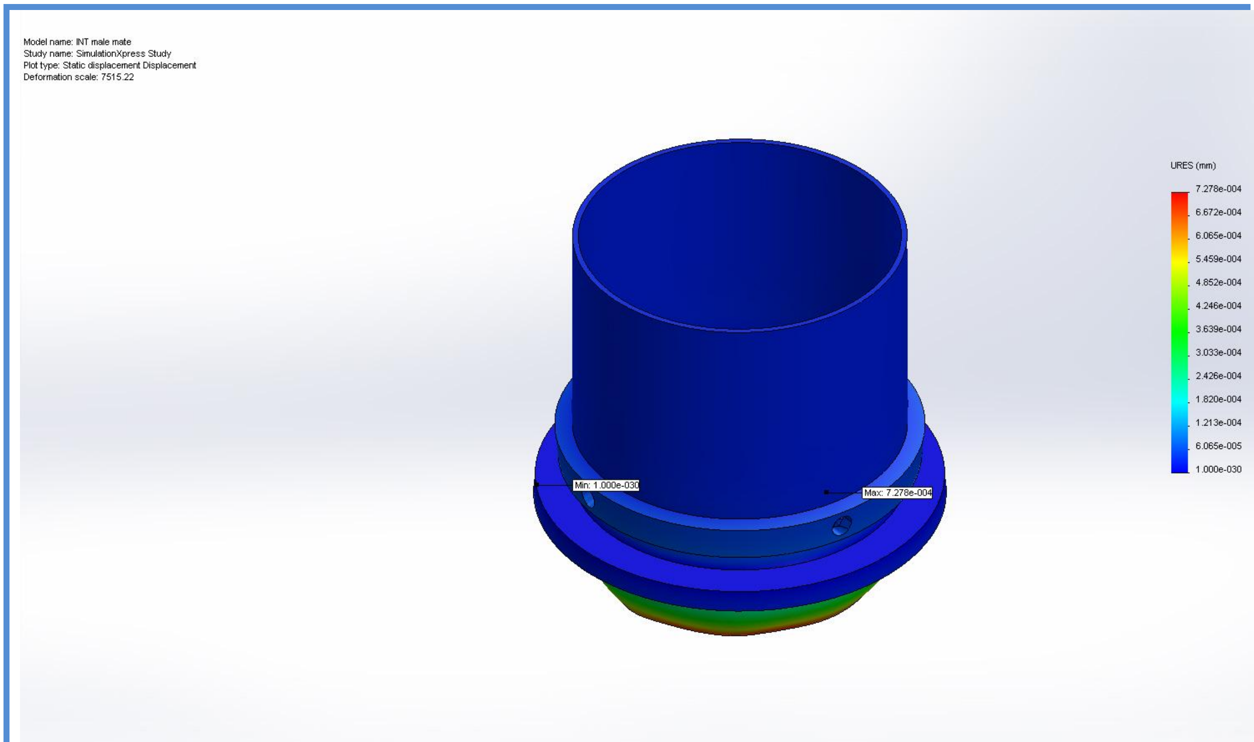
Study Results

Name	Type	Min	Max
Stress	VON: von Mises Stress	0.00543075 psi Node: 12245	1324.06 psi Node: 7378



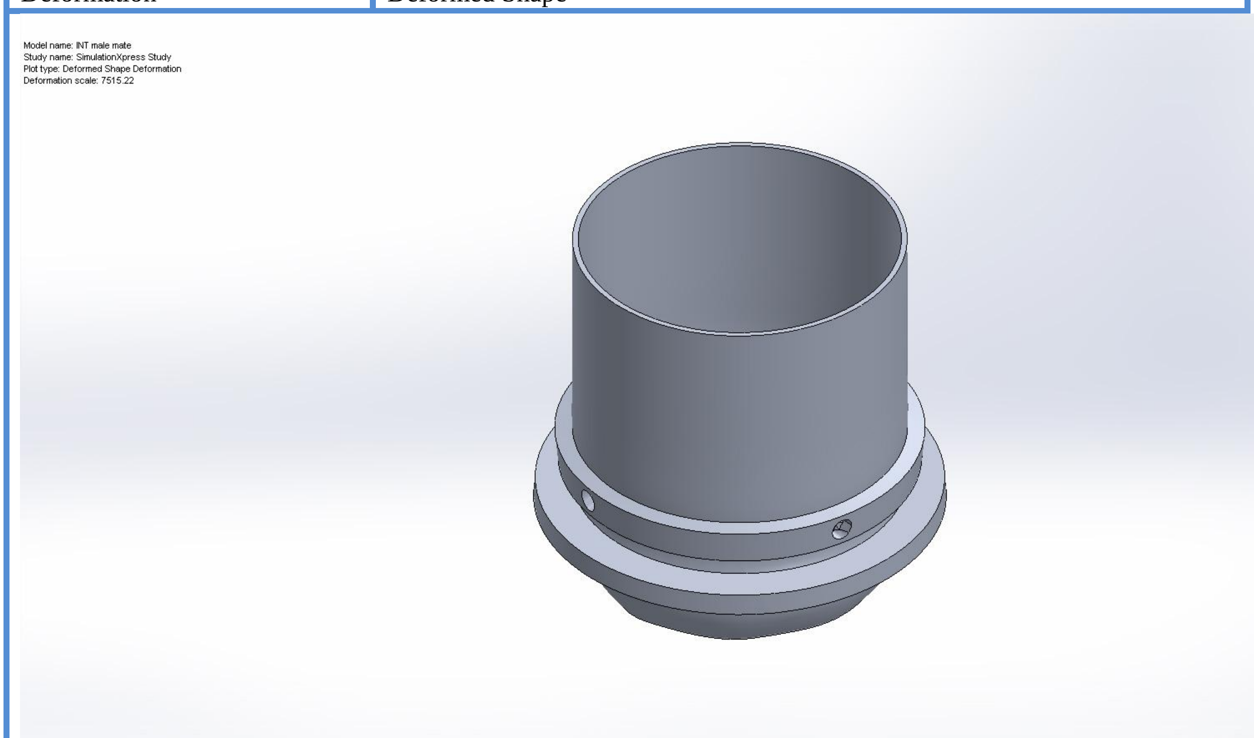
INT male mate-SimulationXpress Study-Stress-Stress

Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0 mm Node: 199	0.000727802 mm Node: 1797



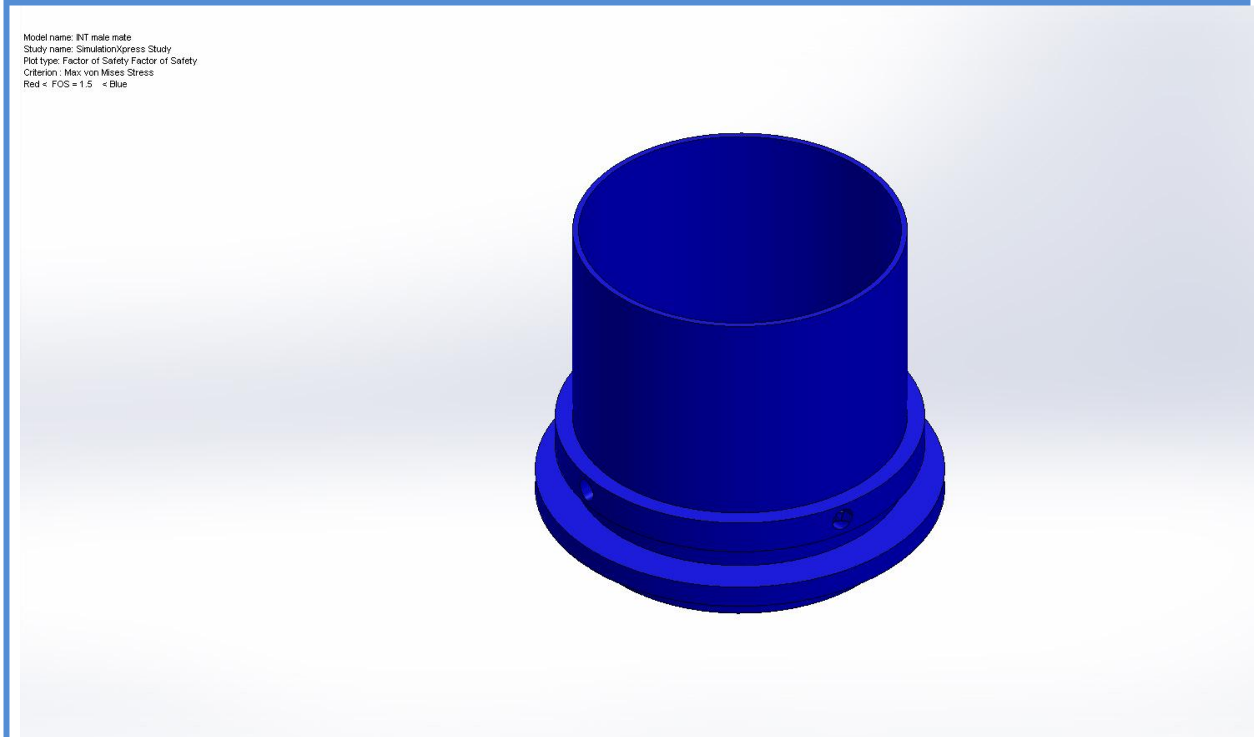
INT male mate-SimulationXpress Study-Displacement-Displacement

Name	Type
Deformation	Deformed Shape



INT male mate-SimulationXpress Study-Displacement-Deformation

Name	Type	Min	Max
Factor of Safety	Max von Mises Stress	6.041 Node: 7378	1.47284e+006 Node: 12245



INT male mate-SimulationXpress Study-Factor of Safety-Factor of Safety