

Benthic Observation System

Main housing structural analysis

François Cazenave

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Main housing tube

- OD: 11 7/8", wall thickness: 3/8" wall. Based on available size.
- Material (12" OD, 1/2" wall) has been ordered and dimensions checked.
- Analysis for housing without ports was performed using Under Pressure.
- Analysis for housing with ports was performed using Solidworks simulation.

(Not saved)

Project Parameters

Project Title **BOS 12" housing tube**

Project Description **Analysis for 12" tube for benthic observation system housing**

Project Designer **Francois Cazenave**

Design Parameters

Material

ALUMINUM, 6061-T6

Choose

Units

☒ English
☐ Metric

Pressure

☐ Internal
☒ External

Analysis Options

☐ Force Thick Wall Equations
☐ Use Working Strength for Plastic

Analysis Type

Tube

Enter Geometry

Material Database

Main Category **Metals**

Sub-Category **Aluminum**

Name **ALUMINUM, 6061-T6**

Yield Strength **35** **Ksi**

Young's Modulus **9.9** **Mpsi**

Density **0.098** **lb/cu in**

Poisson's Ratio **0.33**

Comments

Compressive Young's Modulus = 10.1 Mpsi
Compressive Yield Strength = 34 Ksi Minimum Welded
Yield Strength = 15 kpsi

Update Search

Edit Controls

Edit Record

Add

Delete

Done

Cancel

Tube Analysis - External Pressure

Pressure Range: **10 - 200 Bar** **Bar**

Report **Done**

Theoretical Failure:

- ☒ Thin Wall Buckling at 1263.1 m (sea) by 2 nodes
☐ Shell failure at 1802.2 m (sea) (Thin wall eq's)
☐ Seat failure N/A
☐ Shear failure N/A

Fail value units:

m (sea)

Material

ALUMINUM, 6061-T6

Yield Strength:
35 Ksi

Air Wt **39.168**

Water Wt **-81.850**

Units **lbs**

Units:
Pressure **psi** Depth **m (sea)** Stress **Ksi** Linear Deflection **Inches** Angle Deflection **Degrees**

Pressure psi	Depth m (sea)	Max Axial Stress, Ksi	Max Hoop Stress, Ksi	Max Equiv Stress, Ksi	d ID Inches	d OD Inches
145.04	99.544	-1.1120	-2.2239	1.9260	-0.0021571	-0.0021571
290.08	199.05	-2.2239	-4.4478	3.8519	-0.0043142	-0.0043142
435.11	298.50	-3.3359	-6.6717	5.7779	-0.0064712	-0.0064712
580.15	397.91	-4.4478	-8.8956	7.7039	-0.0086283	-0.0086283
725.19	497.28	-5.5598	-11.120	9.6298	-0.010785	-0.010785
870.23	596.61	-6.6717	-13.343	11.556	-0.012942	-0.012942
1015.3	695.89	-7.7837	-15.567	13.482	-0.015100	-0.015100
1160.3	795.13	-8.8956	-17.791	15.408	-0.017257	-0.017257
1305.3	894.32	-10.008	-20.015	17.334	-0.019414	-0.019414
1450.4	993.48	-11.120	-22.239	19.260	-0.021571	-0.021571
1595.4	1092.6	-12.232	-24.463	21.186	-0.023728	-0.023728
1740.5	1191.6	-13.343	-26.687	23.112	-0.025885	-0.025885
1845.2 (fail)	1263.1	-14.146	-28.293	24.502	-0.027442	-0.027442

Tube



Tube I.D. **11.125** **in**

Wall thickness **0.37500** **in**

Tube O.D. **11.875** **in**

Tube length **29.500** **in**

- ☒ Maintain I.D. constant
☐ Maintain O.D. constant

Update

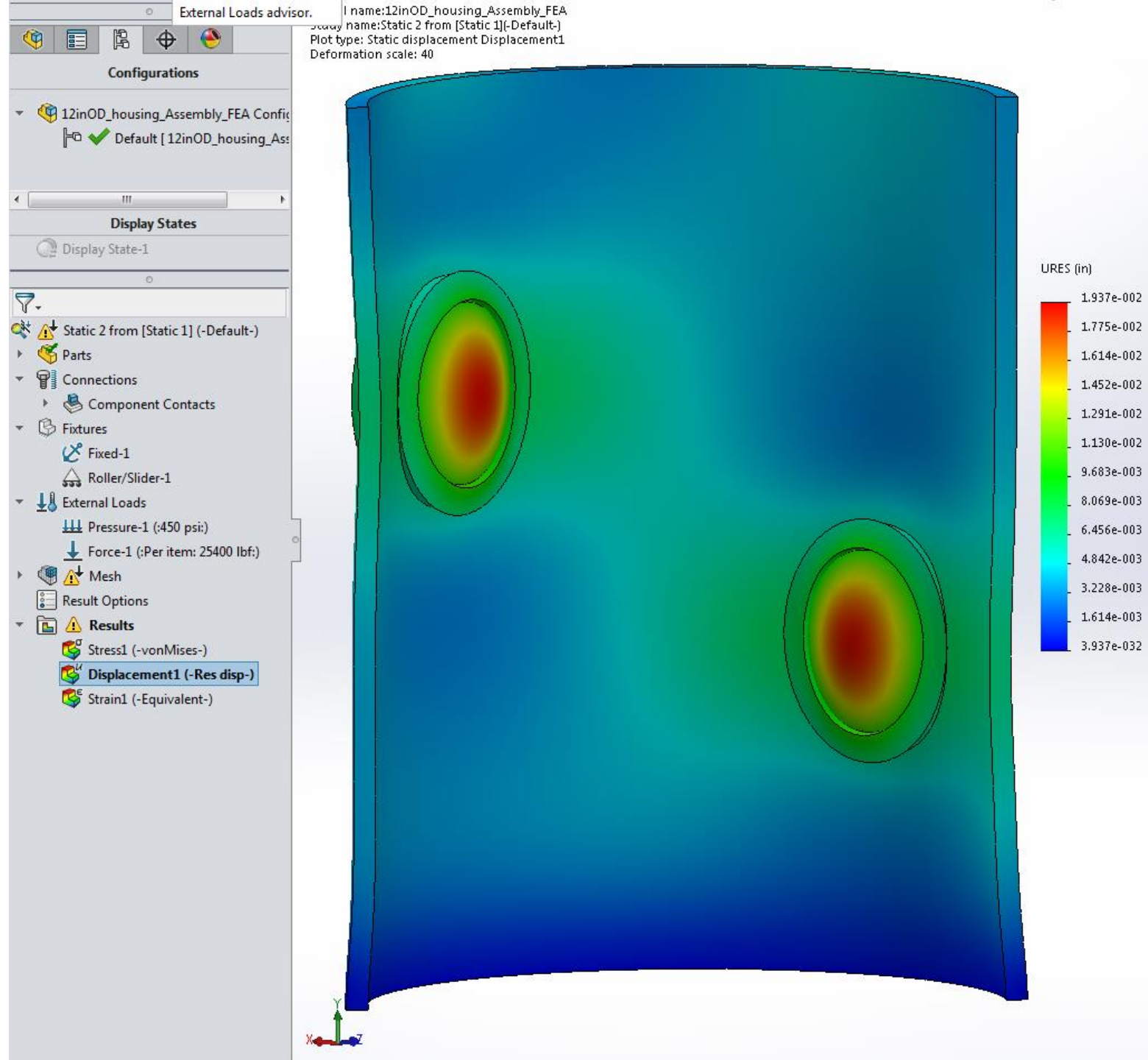
Done

Perform Analysis

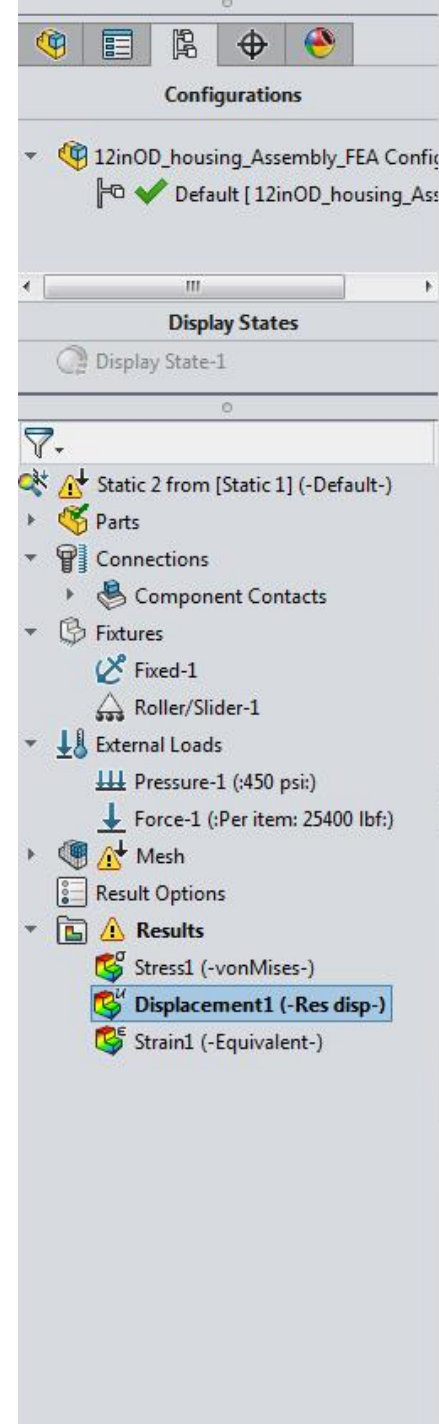
Cancel

Pipe Tables

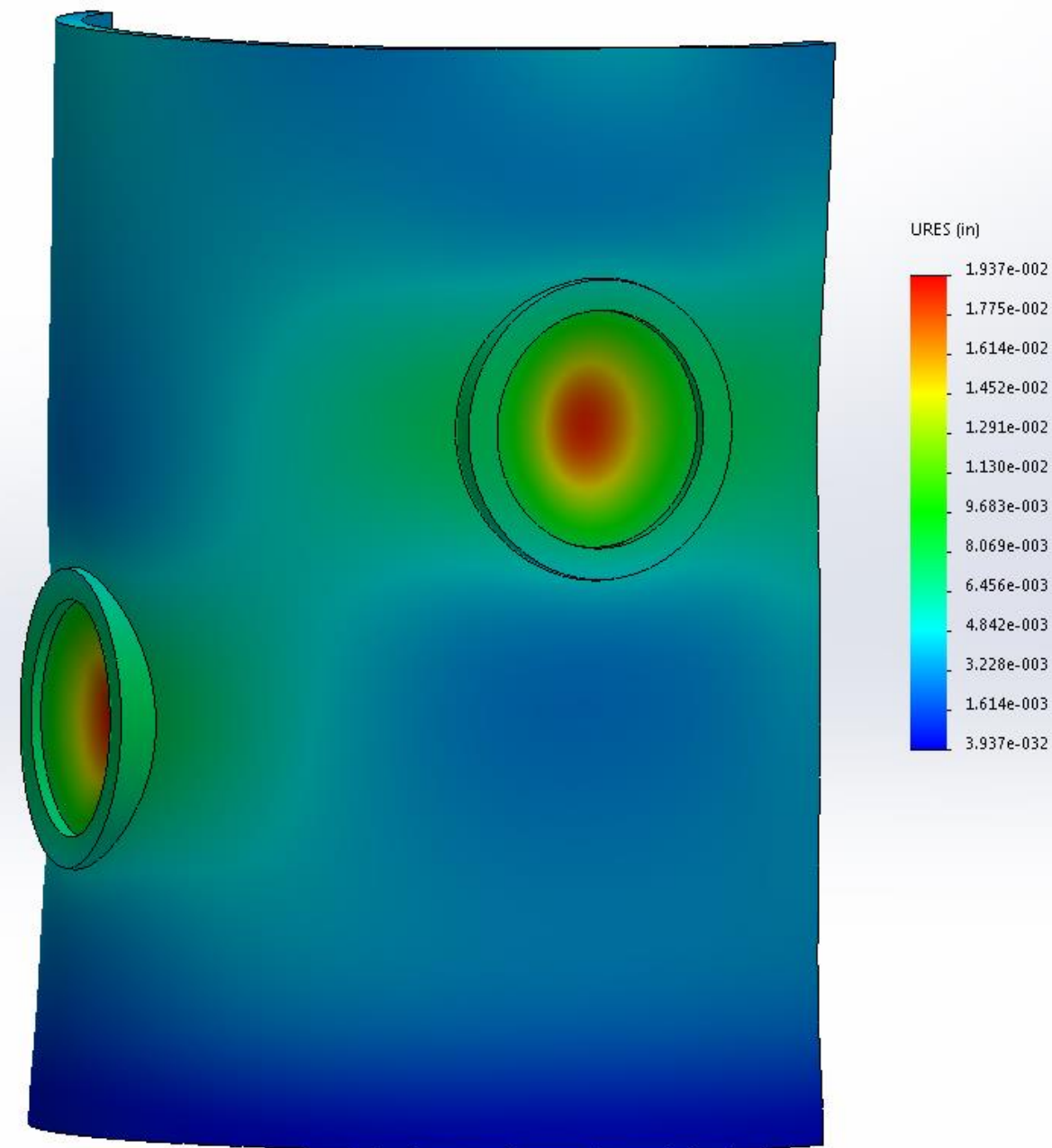
Displacement, inside.



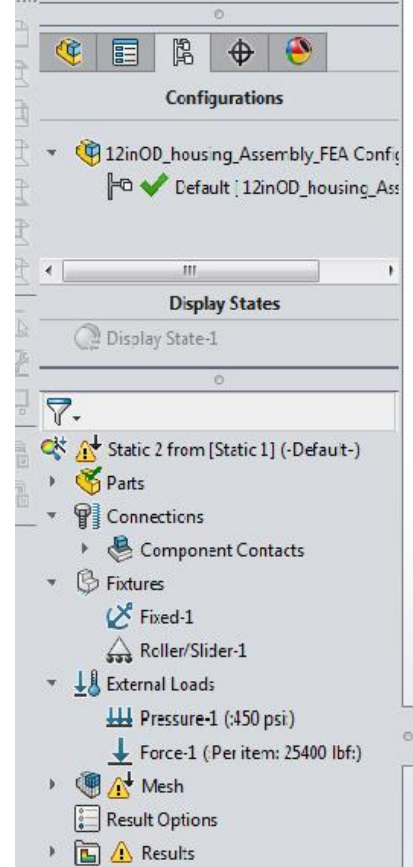
Displacement, outside.



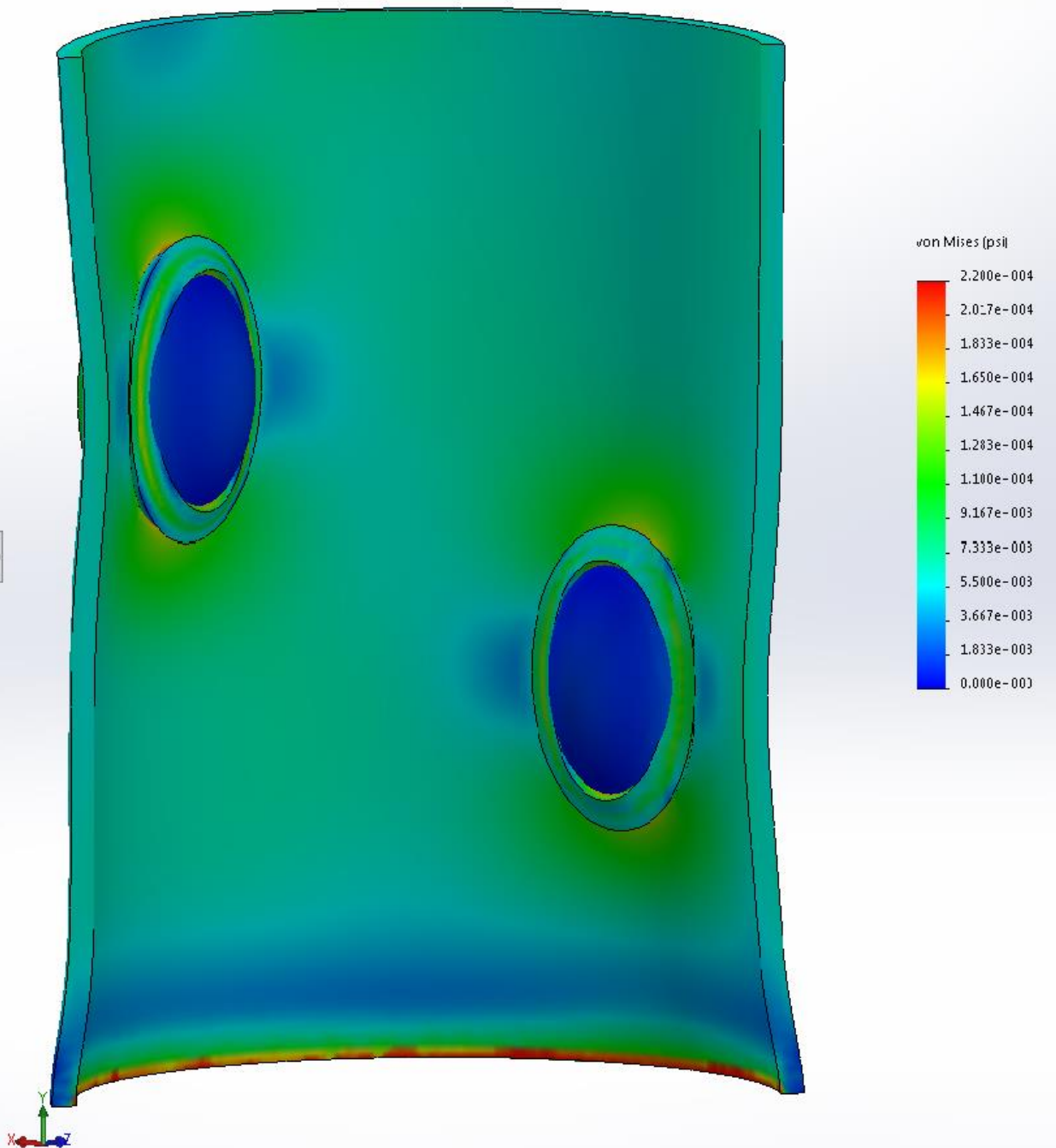
Model name: 12inOD_housing_Assembly_FEA
Study name: Static 2 from [Static 1](-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 40



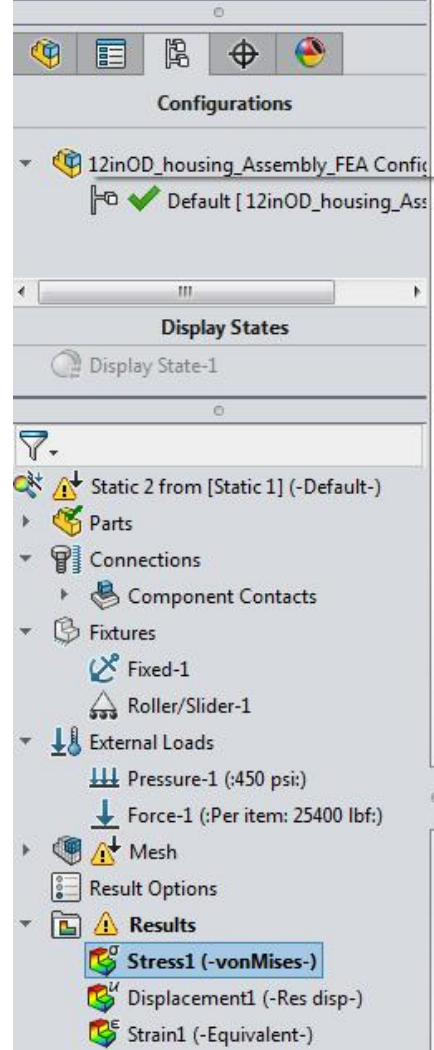
Stress, inside.



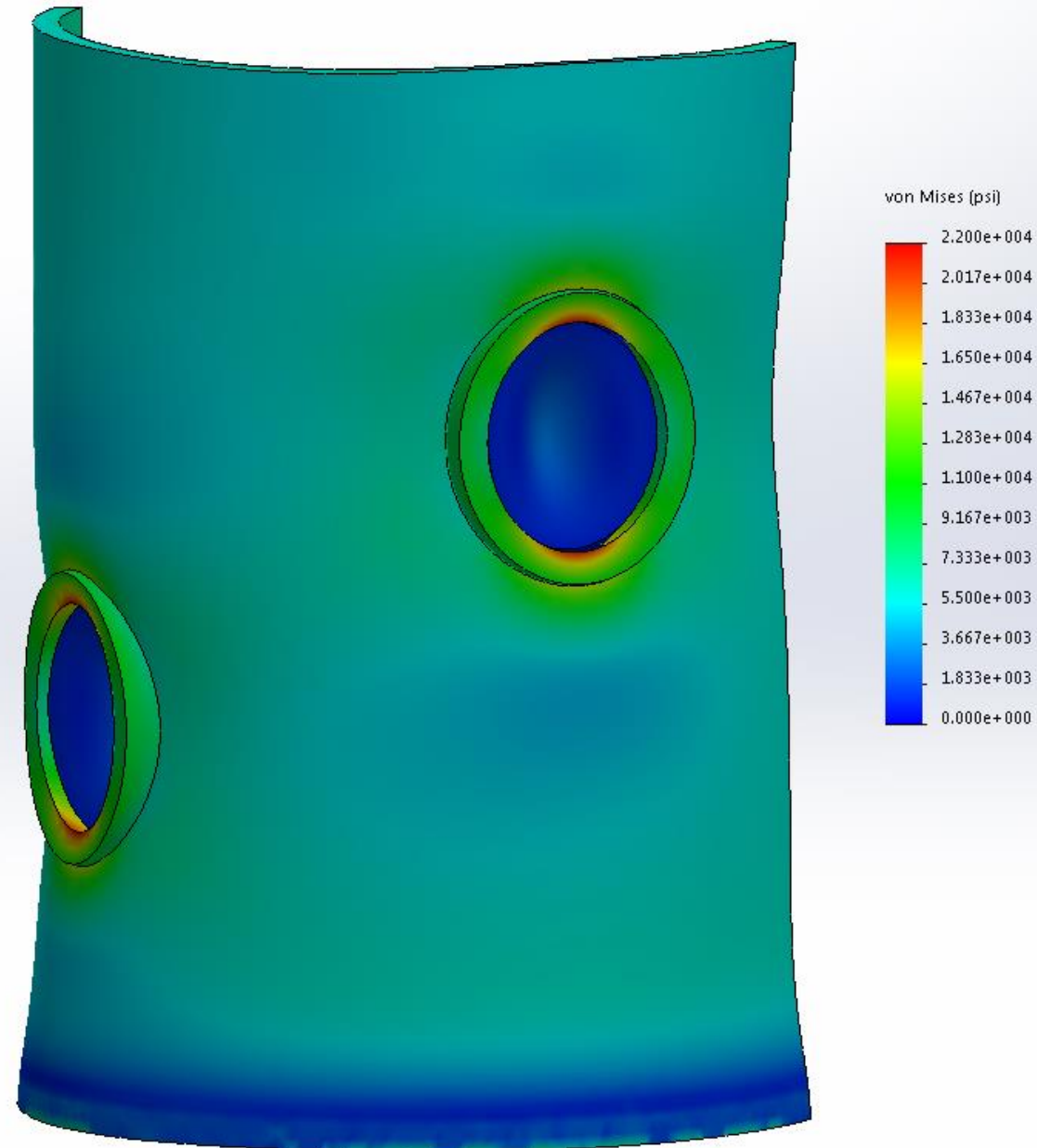
Model name: 12inOD_housing_Assembly_FEA
Study name: Static 2 from [Static 1] (-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 82.824



Stress, outside.



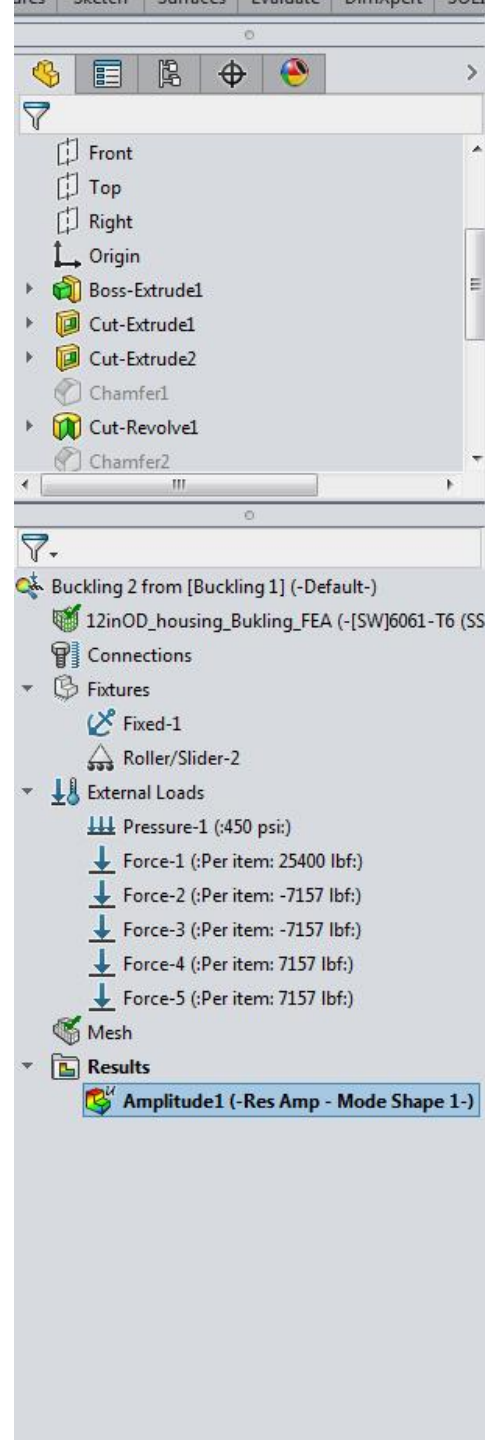
Model name:12inOD_housing_Assembly_FEA
Study name:Static 2 from [Static 1](-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 82.824



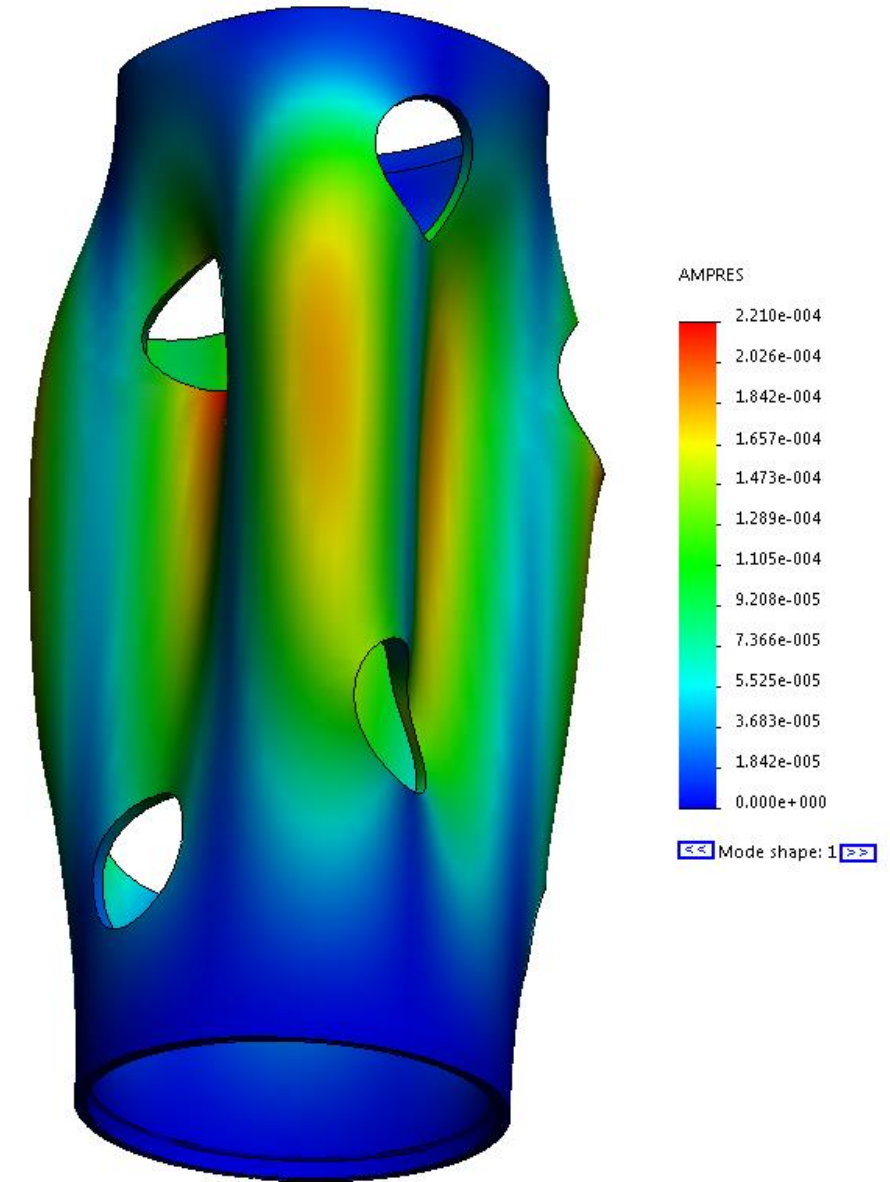
Buckling:

Load factor at 450 PSI: 4.95
(buckling at $4.95 \times 450 = 2227$ psi)

The analysis was also performed for a tube without holes. The load factor was 5.96 (buckling at $5.96 \times 450 \text{ psi} = 2682$ psi). Compare with 1950 PSI from Under Pressure analysis.



Model name: 12inOD_housing_Bukling_FEA
Study name: Buckling 2 from [Buckling 1](-Default-)
Plot type: Buckling Amplitude1
Mode Shape : 1 Load Factor = 4.9252
Deformation scale: 340.554



Endcaps

- 11.875" diameter, 0.875" thickness.
- Analysis was performed using Under Pressure and Solidworks simulation.

(Not saved)

Project Parameters

Project Title **BOS 12" housing endcap**

Project Description
Analysis for 12" endcap for benthic observation system endcap

Project Designer **Francois Cazenave**

Design Parameters

Material

ALUMINUM, 6061-T6

Choose

Units

- ☒ English
☐ Metric

Pressure

- ☐ Internal
☒ External

Analysis Options

- ☐ Force Thick Wall Equations
☐ Use Working Strength for Plastic

Analysis Type

Endcap Only

Endcap Configuration

Flat Circular

Enter Geometry

Edge Restraint Options

Simply Supported

Flat Circular Endcap Analysis - External Pressure

Pressure Range: 10 - 200 Bar

Bar

Report

Done

Theoretical Failure:

- ☒ Radial Stress Failure at 460.19 m (sea) (plate center)
☐ Tangential Stress Failure at 460.19 m (sea) (plate center)
☐ Seat failure at 2221.0 m (sea)

Material
ALUMINUM, 6061-T6

Yield Strength:
35 Ksi

Table eval dia., De = plate center for Max Radial

Fail value units:

Table eval dia., De = plate center for Max Tangential

m (sea)

Units:

Pressure

Depth

Stress

Linear Deflection

Angle Deflection

psi

m (sea)

Ksi

Inches

Degrees

Air Wt 9.4971

Water Wt 5.9076

Units lbs

Pressure	Depth	De Max Radial	De Max Tan	Avg Seat	CL Deflection	FD Shear
psi	m (sea)	Stress, Ksi	Stress, Ksi	Stress, Ksi	Inches	Stress, Ksi
145.04	99.544	7.5649	7.5649	-1.5613	-0.014975	-0.46868
290.08	199.05	15.130	15.130	-3.1226	-0.029949	-0.93736
435.11	298.50	22.695	22.695	-4.6840	-0.044924	-1.4060
580.15	397.91	30.260	30.260	-6.2453	-0.059898	-1.8747
671.03 (fail)	460.19	35.000	35.000	-7.2236	-0.069282	-2.1684

Material Database

Main Category **Metals**

Sub-Category **Aluminum**

Name **ALUMINUM, 6061-T6**

Yield Strength 35 Ksi

Young's Modulus 9.9 Mpsi

Density 0.098 lb/cu in

Poisson's Ratio 0.33

Comments

Compressive Young's Modulus = 10.1 Mpsi
Compressive Yield Strength = 34 Ksi Minimum Welded
Yield Strength = 15 kpsi

Update Search

Edit Controls

Edit Record

Add

Delete

Done

Cancel

Flat Circular Endcap - Simply Supported

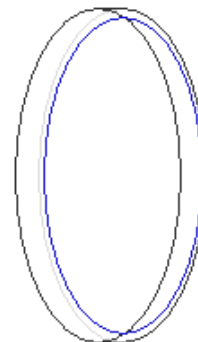


Plate Free Diameter

11.310 in

Plate Thickness

0.87500 in

Plate Outside Diameter

11.875 in

Update

Done

Perform Analysis

Cancel

Acrylic port

- 3" diameter, 0.625" nominal thickness.
- Analysis was performed using Under Pressure and Solidworks simulation.
- A thick window is used to minimize deformation. Deformation of the port could result in stereo measurement error.

(Not saved)

Project Parameters

Project Title **BOS 3.5" acrylic port**

Project Description Analysis for acrylic port for Benthic observation system

Project Designer **Francois Cazenave**

Design Parameters

Material

PLASTIC, ACRYLIC

Choose

Units

☒ English
☐ Metric

Pressure

☐ Internal
☒ External

Analysis Options

☐ Force Thick Wall Equations
☐ Use Working Strength for Plastic

Analysis Type

Endcap Only

Endcap Configuration

Flat Circular

Enter Geometry

Edge Restraint Options

Simply Supported

Flat Circular Endcap Analysis - External Pressure

Pressure Range: **10 - 200 Bar** **Bar**

Report **Done**

Theoretical Failure:

- ☒ Radial Stress Failure at 752.7 m (sea) (plate center)
☐ Tangential Stress Failure at 752.7 m (sea) (plate center)
☐ Seat failure at 1426 m (sea)

Table eval dia., De = plate center for Max Radial
Table eval dia., De = plate center for Max Tangential

Fail value units:

m (sea)

Units:

Pressure **psi** Depth **m (sea)** Stress **Ksi** Linear Deflection **Inches** Angle Deflection **Degrees**

Material
PLASTIC, ACRYLIC

Ultimate Strength:
8 Ksi
Working Strength:
0.8 Ksi

Air Wt **0.2508**

Water Wt **0.02802**

Units **lbs**

Pressure	Depth	De Max Radial	De Max Tan	Avg Seat	CL Deflection	FD Sh
psi	m (sea)	Stress, Ksi	Stress, Ksi	Stress, Ksi	Inches	Stress
145.0	99.54	1.057	1.057	-0.5570	-0.005678	-0.174
290.1	199.0	2.113	2.113	-1.114	-0.01136	-0.349
435.1	298.5	3.170	3.170	-1.671	-0.01703	-0.523
580.2	397.9	4.226	4.226	-2.228	-0.02271	-0.698
725.2	497.3	5.283	5.283	-2.785	-0.02839	-0.873
870.2	596.6	6.339	6.339	-3.342	-0.03407	-1.048
1015	695.9	7.396	7.396	-3.899	-0.03975	-1.222
1098 (fail)	752.7	8.000	8.000	-4.218	-0.04299	-1.322

Material Database

Main Category **Plastics**

Sub-Category **Thermoplastics**

Name **PLASTIC, ACRYLIC**

Ultimate Strength **8** **Ksi**

Working Strength **0.8** **Ksi**

Young's Modulus **0.35** **Mpsi**

Density **0.0417** **lb/cu in**

Poisson's Ratio **0.35**

Comments

Cast Rods or Sheets Compressive Ultimate Strength = 11 kpsi Known Commercially as Plexiglass etc.

Update Search

Edit Controls

Edit Record

Add

Delete

Done

Cancel

Flat Circular Endcap - Simply Supported

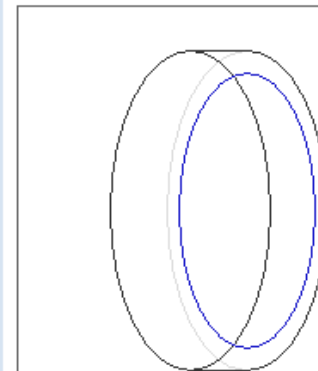


Plate Free Diameter
3.010 **in**

Plate Thickness
0.6250 **in**

Plate Outside Diameter
3.500 **in**

Update

Done

Perform Analysis

Cancel

Pressure test of prototype

A 12" long housing with 1 port is being built by the machine shop and will be tested to a depth of 400m. Endcaps will be reused in the final version. The test will be performed from R/V Paragon because the housing will not fit in MBARI's pressure chamber.

