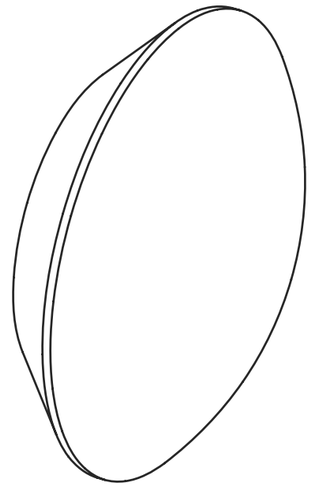
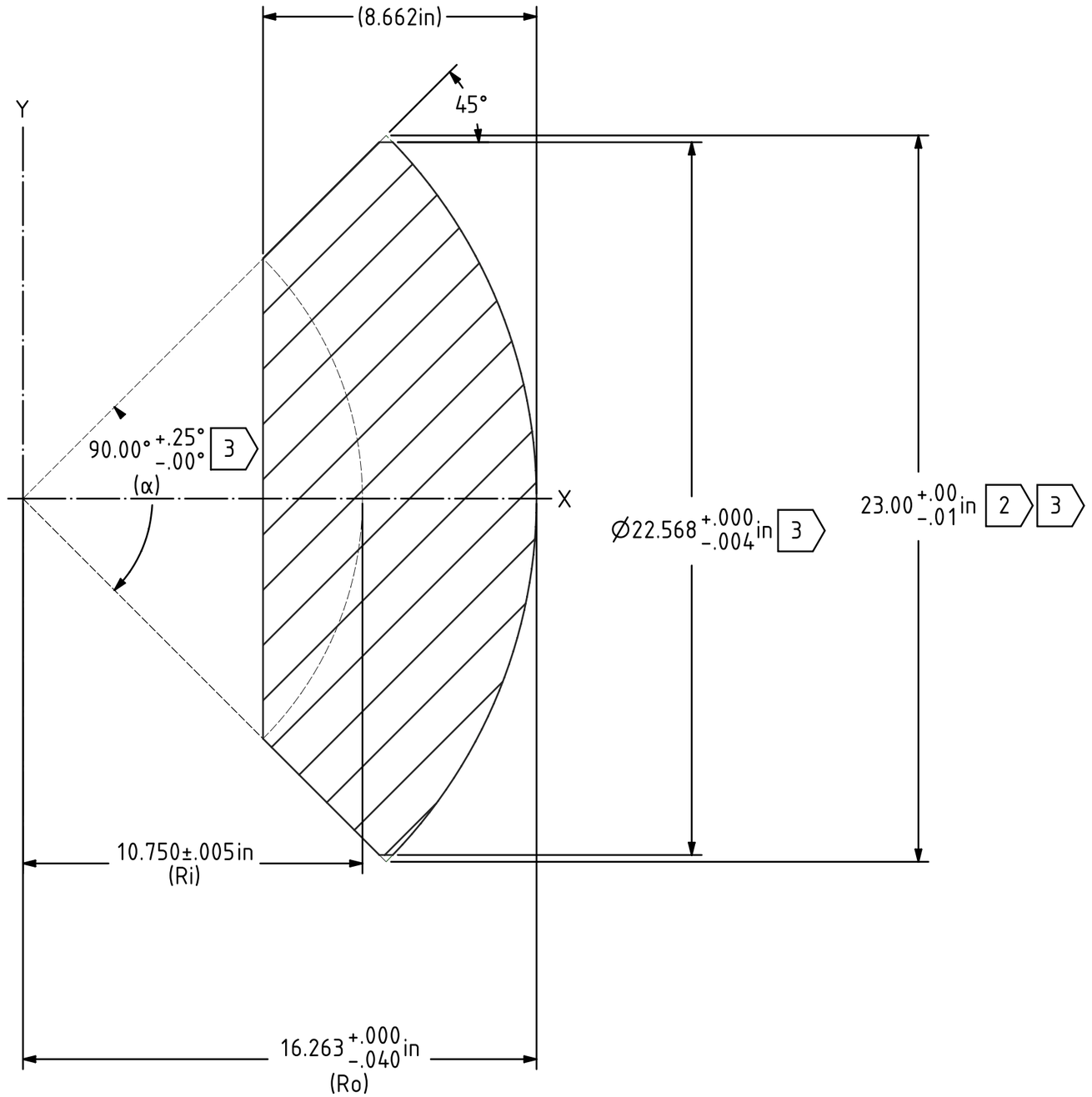
REV	DATE	DESCRIPTION	REVISED BY
--	2017/06/08	INITIAL RELEASE	[redacted]
A	2017/06/13	REFERENCE CHANGE LOG	
B	2017/10/10	REFERENCE CHANGE LOG	



NOTES:
1. MATERIAL: ACRYLIC.
2. DENSITY: 0.049 lb/in^3.
3. VOLUME: 2175.590 in^3.
4. BUOYANCY: 80.591 lbf (IN .037 lb/in^3 WATER).
5. BREAK ALL SHARP EDGES.

1. PART MARK - IN ACCORDANCE WITH OCEANGATE.INSTRUCTION.0004 SECTION 5.6.
2. USED FOR DETERMINING α AND Ro ONLY. NOT PART OF END ITEM. ACTUAL TO BE REPORTED WITH CERTIFICATION.
3. DIMENSION TO BE SYMMETRIC ABOUT X AXIS.

NEXT ASSEMBLY		CHECKER/ENGINEER	D.O.E
1S-040-MEC-000001	OceanGate	[redacted]	PROJECT: SUBMERSIBLE
			DESCRIPTION: ACRYLIC VIEWPORT
	THIS DOCUMENT CONTAINS CONFIDENTIAL AND PROPRIETARY INFORMATION THAT CANNOT BE REPRODUCED OR DIVULGED, IN WHOLE OR IN PART, WITHOUT WRITTEN AUTHORIZATION FROM OCEANGATE, INC.	THIRD ANGLE PROJECTION	SIZE: B | DWG. NO.: 1S-040-MEC-000461 | REV: B
			SCALE: 1:10 | WEIGHT: 106.603 lb | SHEET 1 OF 2



SIZE	DWG. NO.	REV
B	1S-040-MEC-000461	B
	SCALE: 1:10	SHEET 2 OF 2

HYDROSPACE Group Inc

Quote 1124-110717

[redacted]
USA

From: Hydrospace Group Inc.
[redacted]

Tel: [redacted]
Fax: [redacted]

Contact [redacted]

To: **OceanGate Inc.**
[redacted]
Attn: Stockton Rush

Date: 7-Nov-17
[redacted]

Project **1124B**

Item	Qty	Description	Each	Total
1	1	23 inch (22.568" Do) Sperical Sector Dome 90 deg Dwg: 1S-040-MEC-000461 Rev --_ Released Per ASME-PVHO-1 2016 ASME PVHO-1 Form VP1	$ 24,500.00	$ 24,500.00
2	1	PVHO Mat. Certification Testing to Table 2-3.2 Per ASME-PVHO-1 2016 PVHO Material Certification ASME PVHO-1 Form VP3 ASME PVHO-1 Form VP4	$ -	$ -
3	1	Wood Shipping Crate & Packaging	$ 450.00	$ 450.00
4	1	Shipping & Handling	TBD	
			TOTAL	$ 24,950.00

Note:
1. Job will be started with submittal of Purchase Order, Engr Dwg and PVHO Form VP2
2. Delivery: window 12 weeks
3. Prices are valid for 30 days
4. Terms are 50% Deposit, balance Net 30
5. Ex-Works Rancho Cucamonga, California
6. Hydrostatic Testing to be performed by Client

[redacted]

From: Stockton Rush [redacted]
Sent: Tuesday, November 7, 2017 5:31 PM
To: [redacted]
Cc: [redacted]
Subject: RE: 1124B Cyclops Acrylic Window

[redacted]

Thanks for the data. I am discussing this with [redacted] and we plan to have an answer/plan in the near future.

Stockton

From: [redacted]
Sent: Tuesday, November 7, 2017 5:19 PM
To: Stockton Rush [redacted]
Subject: 1124B Cyclops Acrylic Window

Hello Stockton,
Thanks for the time to go thru the window options yesterday.
I think we recognize the risks of an experimental window such as we are fabricating at the moment and there is indeed great value in performing field testing on the window with the sub. Your measurement of the behavior while diving, in particular the axial movement, will allow you to operate within the safe range of its capabilities and will provide valuable data. The biggest unknown is surely the creep behavior of the window under prolonged exposure to pressure. The window seat in the titanium dome is a fixed dimension and that is very difficult to change after the fact. Specifically the length of the seat that allows the window to slide inwards. If the window axial travel exceeds the seat support, this can result in failure of the window. The maximum depth rating of the vehicle can be de-rated to accommodate the performance of the window, but that too has its cost.

I would like to propose that you consider the advanced engr testing of this new Flat window geometry as an additional engineering R&D effort for Cyclops 2 while you have a certified, guaranteed PVHO window in hand. This would anchor your test program to a solid baseline and allow you to install the spherical window at any time if during testing or sea trials the flat window shows indications that it would limit the depth performance of the submersible. I would suggest that PLAN B be the spherical sector, PVHO certified window, identical in dimensions as the current flat rounded window. It would fit in the same seat and provide complete operational range to 4000m. It may even be advantageous to present Plan B as being Plan A (ie the baseline) and that the flat window testing be the Advanced Engr test plan to see how you can come up with a better optical performance while still operating safely to 4000m.

The current flat window we are finishing will not have a PVHO Fabrication Cert. It will come with PVHO material certs but will be registered as a commercial window with a commercial fab cert. The spherical Sector window would have a PVHO Fab Cert as well as the PVHO material certs.

I understand you plan to go to the Bahamas in April 2018. For the month you are there, it would be a good idea to have the spherical sector window in hand and be able to replace it in less than a day. This would guarantee that you can continue testing to the full operational depth of the vehicle, independent of any flat window behavior.

You shared your idea to go to a small glass window for Cyclops 3 and use this as a contingency for Cyclops 2. I would think that there is still a significant marketing value for the Titanic to have a full field of view window, such as the spherical sector viewport.

We are still all setup for the fab of this window size. I have attached a quote with a serious discount based on cost savings we can pass along if we consider cutting the two windows at the same time. It is not quite at the same time but I'd like to help strengthen the argument.

We can have the window done in 12 weeks if we decide fairly soon, before we de-tool everything.

Let me know what you think.

Best regards

[redacted]

[redacted]
President/CEO
HYDROSPACE Group Inc
[redacted]

[redacted]
USA
www.hydrospacegroup.com

HYDROSPACE Group

MECHANICAL INSPECTION REPORT

DATE: Dec-6-2017

CUSTOMER OCEANGATE **Purchase Order #** 1053 **Part Number** 1S-040-MEC-000461 Rev B

PART NAME: Conical Frustum Dome Window **Job No.:** 1124 **INSP. Station:** Rec: In-Proc: FINAL: X Recd: **MANUFACTURING**

LOT # CC-14H-08-23-17 **S/N's** 945psi-50F-HRDC-1856-2017 **Qty's Rec'd** 1 **Qty Insp** 1 **Qty Discrep.**

Item	B/P Requirements	Requirement Description	1	2	3	QA Stamp (Acc/Rej)
1						
2	23.00 +0.00 / -0.01	Large Outer Diameter	*23.000*	*By CNC Program*		
3						
4	22.568 +0.00 / -0.004	Window Do	22.563	22.565		
5						
6	8.662 (Ref)	Window Height	8.643	8.648		
7						
8	15.203 (Ref)	Window Di	15.203	15.203		
9						
10	90 deg + 0.00 / -0.25 deg	Included Angle				
11	45 deg + 0.00 / -0.125 deg	Side Angle measurement				
12	0.0065" gap allowance	Measured Gap from 3" calib. angle	< 0.002"	measured at 4 locations around		
13						
14	3.662 (Ref)	Chamfer - Height to bottom	3.700	Checked with height blocks at 4 locations around		
15	4.089 (Ref)	Chamfer - Height to top	4.110	Checked with height blocks at 4 locations around		
16	0.427 (Ref)	Chamfer width	0.410	calculated		
17						
18	INCLUSIONS:	No. 1 - Fiber Inclusion	0.375" long	PVHO diameter = 0.024" (See Report # 1124-120517i)		
19		No. 2 - Fiber Inclusion	0.25" long	PVHO diameter = 0.021" (See Report # 1124-120517i)		
20						

ACRYLIC MATERIAL

Window Manufacturer:	Hydrospace Group Inc	**Ref:**	PVHO-1 2016
Certified Conformance to Table 2-3.1	ASME-PVHO-1 Form VP3	**Date:**	23-Aug-17
Certified Conformance to Table 2-3.2	ASME-PVHO-1 Form VP4 (Exova Report 371415)	**Date:**	12-Oct-17

ANNEALING PROCESS

Final Annealing Temp:	185 Deg F	**Duration:**	52 hours		**Cooling Rate:**	2.0 Deg F / Hr

[redacted]
Window Manufacturer

12/6/2017
DATE

[redacted]

From: [redacted]
Sent: Tuesday, December 12, 2017 4:22 PM
To: [redacted]
Subject: Re: 1124 - Acrylic Window Documentation and PVHO Material Certs.

Hi,[redacted]

Thanks a bunch.

Will you send the mechanical properties for the window material? A sheet from Matweb would be helpful.

All the best,

[redacted]
Director of Engineering
OceanGate, Inc.
[redacted]
www.oceangate.com

From: [redacted]
Sent: Monday, December 11, 2017 3:00:38 PM
To: [redacted]
Cc: Stockton Rush;[redacted]
Subject: 1124 - Acrylic Window Documentation and PVHO Material Certs.

Dear [redacted]
Please find attached the fabrication inspection reports for the window along with the ASME PVHO material certs (ASME PVHO-1 FORM VP3 and VP4).
Also included is a copy of the complete material test report, which may help your engineering dept for FEA analysis of this window.
This window was fabricated per the standard procedures we use to make PVHO windows and the window was final annealed in accordance with ASME PVHO-1 recommendations. A copy of the final anneal chart is included.

As we discussed, this window is a non-standard PVHO geometry and cannot be certified as PVHO. The Mechanical inspection report verifies the dimensions per your final drawing (1S-040-MEC-000461 REV-B). According to our calculations, this window is rated to a max allowable working pressure of 945 psi at a temperature of 50 deg F.

We discovered two small fiber inclusions inside the casting. These were found after the final polishing.
The inclusion inspection report is attached to both describe the inclusions and to verify them against the ASME PVHO-1-2016 rules.
Both inclusions are of “significant” dimension but within the limits of the “critical” dimensions allowed per ASME PVHO-1 Sec. 2-5.4 (b)2.

ASME PVHO-1 does provide guidelines to establish the safe operational depth of an acrylic window that is of non-standard geometry or operated with lower CF factors.
These tests are outlined in ASME PVHO-1 Section 2-2.6

2-2.6 Nonstandard Window Geometries and Standard Window Geometries With Lower Conversion Factors

Considering that the Cyclops 2 is projected to operate at 5800 psi, this window is only safe for testing the vehicle to a fraction of its maximum operating depth.
The test program in Sec. 2-2.6 provide a baseline of tests to establish its safety margin and also allows scale model testing. I would strongly recommend Oceangate submit a Code Case to ASME PVHO for this window design.

Oceangate may also consider the parallel task of fabricating a "spherical sector" dome window of the exact dimensions but without the flat inside surface. This window would be PVHO certified to the full operating depth of 5800 psi and could be used during the testing phase of this current window. Both windows would be interchangeable in the existing window frame.

Thank you for the opportunity to work with you on this project.
The window shipped last Thursday. It should be arriving at your facility any day. [redacted] will prepare the final invoice and include the shipping charges.

I you have any questions regarding this window, ASME PVHO documents or PVHO Code Case procedures, please do not hesitate to contact me.

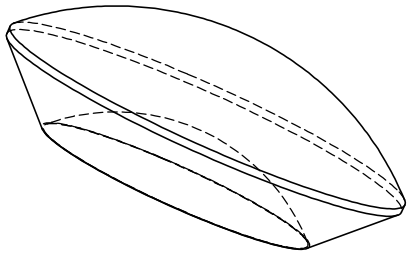
Sincerely,

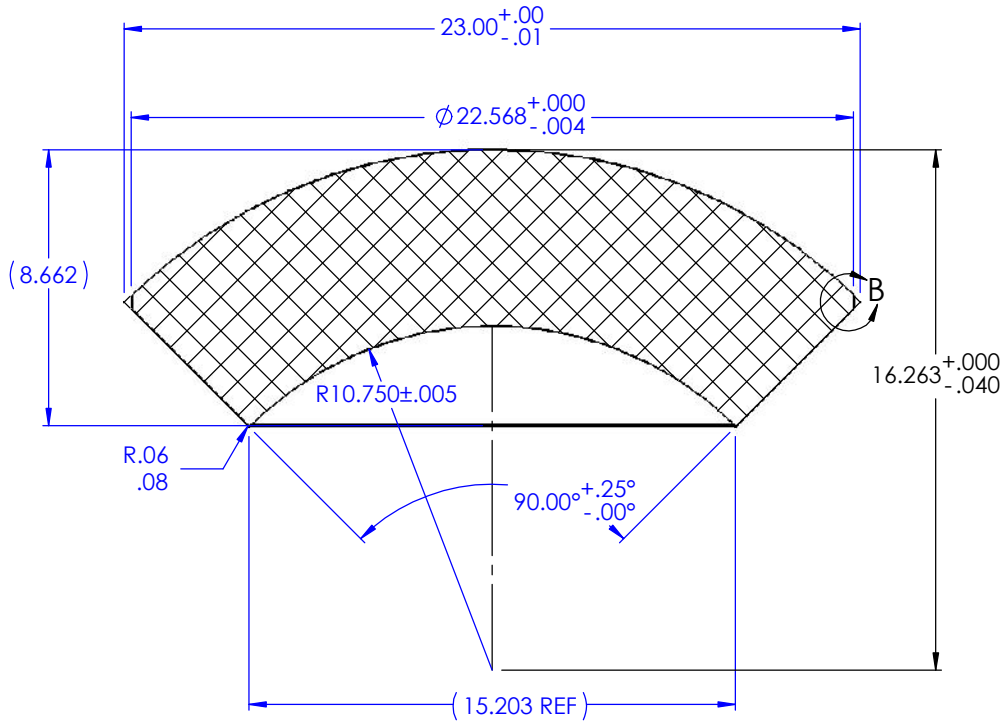
[redacted]
President/CEO
HYDROSPACE Group Inc
[redacted]

[redacted]
USA
www.hydrospacegroup.com

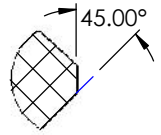
Notes:

1. MATERIAL SHALL BE CERTIFIED CAST ACRYLIC ACCORDING TO ASME PVHO-1
2. THIS WINDOW IS TO BE FABRICATED ACCORDING TO ASME PVHO-1 FABRICATION PROCEDURES. MATERIAL CERTIFICATIONS AND ANNEAL CHARTS ARE REQUIRED.
3. RELIEVE ALL SHARP EDGES
4. WINDOW VIEWING SURFACES SHALL BE POLISHED TO SATISFY ASTM D702 OPTICAL CLARITY REQUIREMENTS





SECTION A-A
SCALE 1 : 6



DETAIL B
SCALE 1 : 3

DESIGN CODE:	IN ACCORDANCE WITH ASME PVHO-1 2016
SEAT DIA (Df) ≤	14.479 in
Di/Df	1.05
DESIGN PRESSURE EXTERNAL:	5800 PSI(G) [12.41 MPa] @50°F [10°C]
DESIGN TEMPERATURE:	MAX DESIGN TEMP: 50°F [10°C] MIN DESIGN TEMP: 32°F [0°C]
CF FACTOR @ 50F:	4
SHORT TERM CRITICAL PRESSURE (t/Di):	.355
THICKNESS MINIMUM: ≥	5.397
SPECIFICATIONS	

DO NOT USE ANY ORGANIC CHEMICAL

UNLESS OTHERWISE SPECIFIED:
1. DIMENSIONS ARE IN INCHES
2. REMOVE ALL BURRS AND BREAK SHARP EDGES MAX .005
3. MACHINED FILLETRADIUS .01-.02
4. TOLERANCES:
DECIMALS .xxx ± .005
.xx ± .010
.x ± .030
FRACTIONS ±1/32
ANGLES ± 30 min.
SURFACE FINISH

MATERIAL: Acrylic

FINISH:

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	■	12/13/17
CHECKED		
APPROVED	■	12/13/17
REVISION 1		
REVISION 2		
REVISION 3		

COMMENTS:

QTY: x1

Hydrospace Group

TITLE:
1124-4000 m
Spherical Sector 90 Deg

SIZE	DWG. NO.	REV
A	1124-100-010	NC

SCALE: #:# | WEIGHT: lbs | SHEET 1 OF 1

[redacted]

From: [redacted]
Sent: Friday, December 15, 2017 10:29 AM
To: [redacted]
Subject: Re: 1124B - CYCLOPS 2 Acrylic window rated to 4000m
Attachments: 20171213_203225.jpg; 20171214_091110.jpg

Hi, [redacted]

Enjoy the attached pics.

All the best,

[redacted]
Director of Engineering
OceanGate, Inc.
[redacted]
www.oceangate.com

From: [redacted]
Sent: Wednesday, December 13, 2017 6:23:42 PM
To: [redacted]
Cc: Stockton Rush
Subject: 1124B - CYCLOPS 2 Acrylic window rated to 4000m

[redacted]
Attached is the drawing for the fully ASME PVHO rated window for Cyclops 2.
While there is no third party inspection requirement for ASME PVHO it is diligent to follow its established safety standards.
In the case of your experimental window, which is rated to 945 psi, it is very far from the intended operation of 5800 psi.

The attached drawing shows a window that will fit in exactly the same seat frame but offers a greater than 5 times operational capability and is fully certified to PVHO.

Let us know how we can continue to help you and ensure the safety and success of your project.

Sincerely,

[redacted]
President/CEO
HYDROSPACE Group Inc
[redacted]

[redacted]
USA

KEMPER
ENGINEERING SERVICES, LLC

INTEGRATED ENGINEERING AND DESIGN

[redacted]

14 Jan 2018

[redacted]
President/CEO
Hydrospace Group
[redacted]

Ref: Preliminary evaluation of Cyclops viewport design at 5800 psi

Dear [redacted]

Based on the provided materials and our conversation, Kemper Engineering Services (KES) proposes the following estimate for services:

BACKGROUND: The Client (Hydrospace) has a hypothetical design for a submersible window. It uses PVHO-1 grade acrylic (PMMA) but does not use PVHO-1 geometry. The question posed by the Client is what benefit the domed "Cyclops" design has to a traditional conical frustum PVHO-1 design with the same seat profile. The pressure designated was 5800 psi. The window is shown below.

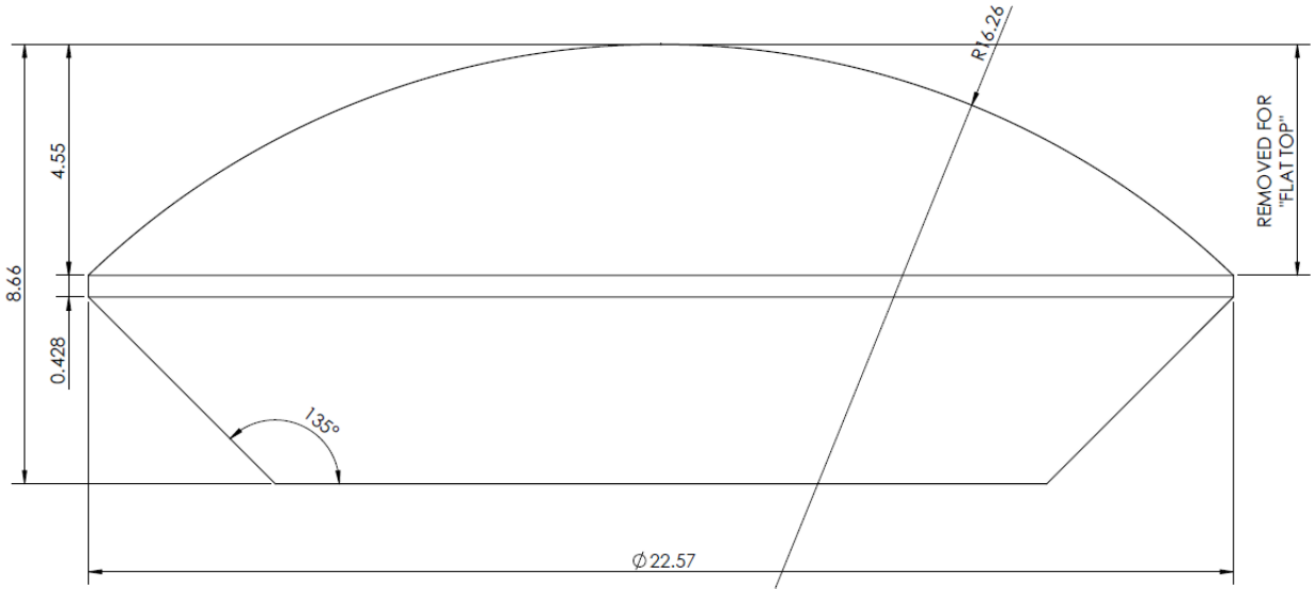


Fig. 1. Cyclops window design. Dimension are in inches. The "flat top" design is the same dimensions with the dome section removed.

METHOD: KES performed linear and nonlinear analysis. The material properties. included the stress-strain curve, is for 80F of MIL Grade 8184P acrylic. No material information was provided by the Client as this is a geometry comparison and not a design review of an actual submersible viewport. The effects of heat transfer, creep, and cyclic load are neglected in this preliminary assessment. The window seat is assumed and is only

provided to develop the boundary conditions for the viewport. Axi-symmetric modeling is used, with contact elements allowing the viewport to slide along the window seat. Nonlinear analysis is the primary focus since acrylic window is a polymer that does not behave in a purely linear manner under significant load. Linear analysis is conducted as part of a normal modeling process and is presented for reference purposes. More information is in the attached pages.

RESULTS: Given the results are above the nominal yield of 7500 psi, the strain is used to evaluate potential for failure. Axial (inwards) deflection is provided as another measure.

	Cyclops Viewport		**Flat top Viewport**	
Model	*Max Strain (in/in)*	*Deflection (in)*	*Max Strain (in/in)*	*Deflection (in)*
5800 psi Linear	0.12	0.203	0.16	0.394
5800 psi Nonlinear	0.44 (possible cyclic fail)	0.264	0.73 (catastrophic failure)	0.924
4000 psi Nonlinear	0.27 (no failure)	0.174	0.54 (failure)	0.453
2900 psi Nonlinear	0.16 (no failure)	0.123	0.33 (cyclic failure)	0.269

CONCLUSIONS: The preliminary conclusions based on the assumptions specified are as follows:

1. The Cyclops design provides more axial stiffness and generates less strain than the same seat dimensions without the domed portion.
2. The specified Cyclops design at 5800 psi indicates significant strain that is consistent with potential short cycle failure modes.
3. The specified Cyclops design at lower pressures indicate acceptable strain levels, with the 2900 psi load being most consistent with traditional PVHO windows operating within normal design conditions.
4. The “flat top” viewport design would be likely to fail at 2900 psi pressure and will fail at higher pressures.
5. Actual material data, the window seat design, and operational information would be needed to conduct a design review and performance prediction.

KES offers a full range of engineering services, including solid modeling, CAD, stress analysis, transient and dynamic analysis, fluid flow with heat transfer simulations, kinematic modeling, animations, and presentation support. While some of the services are not part of the current estimate, they are available if needed to better assist the Client in their needs.

Thank you for giving KES the opportunity to support this project.

Sincerely,

[redacted]
Principal Engineer

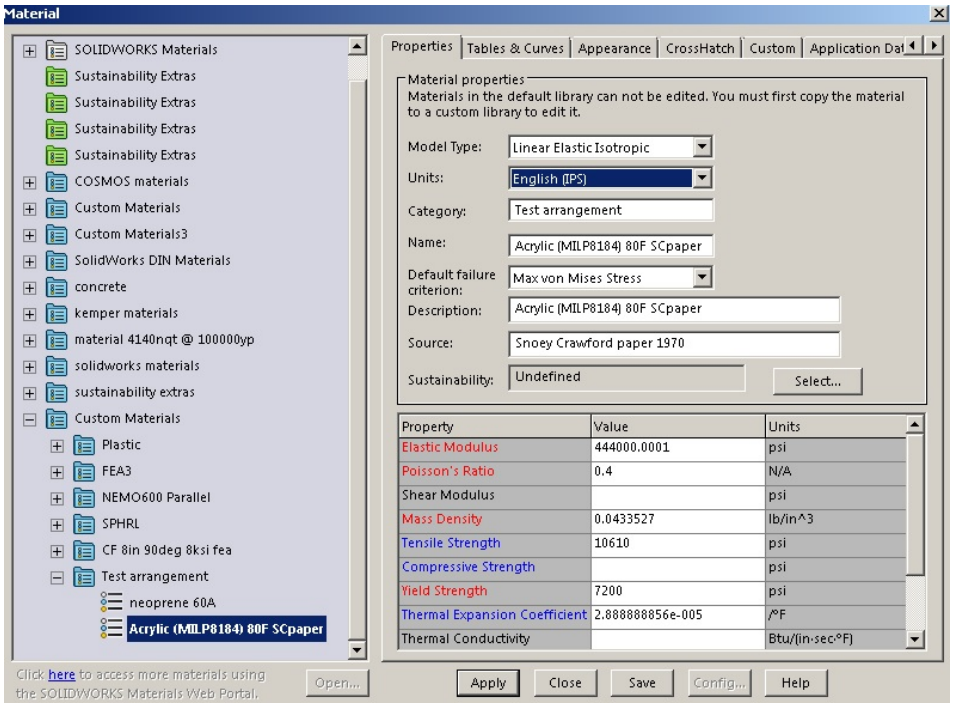


Fig. A1. Linear material specifications

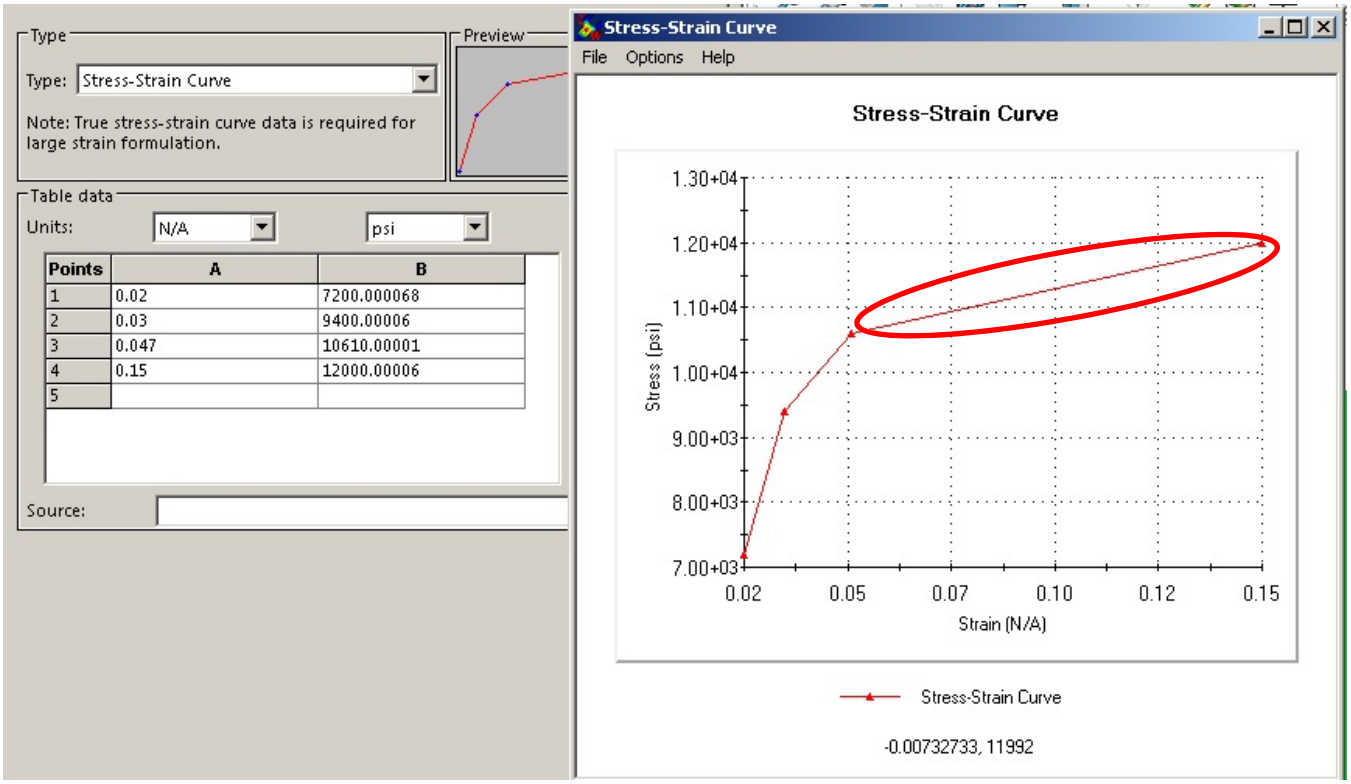


Fig. A2. Nonlinear curve used. This is for 80 degrees F, which is a mid-temperature from maximum surface ambient conditions and temperature at depth. The maximum strain is 0.05. The last segment (circled in red) is above ultimate strength to allow greater strain rate for an implicit nonlinear analysis to approximate a localized failure mode and allowing it to propagate.

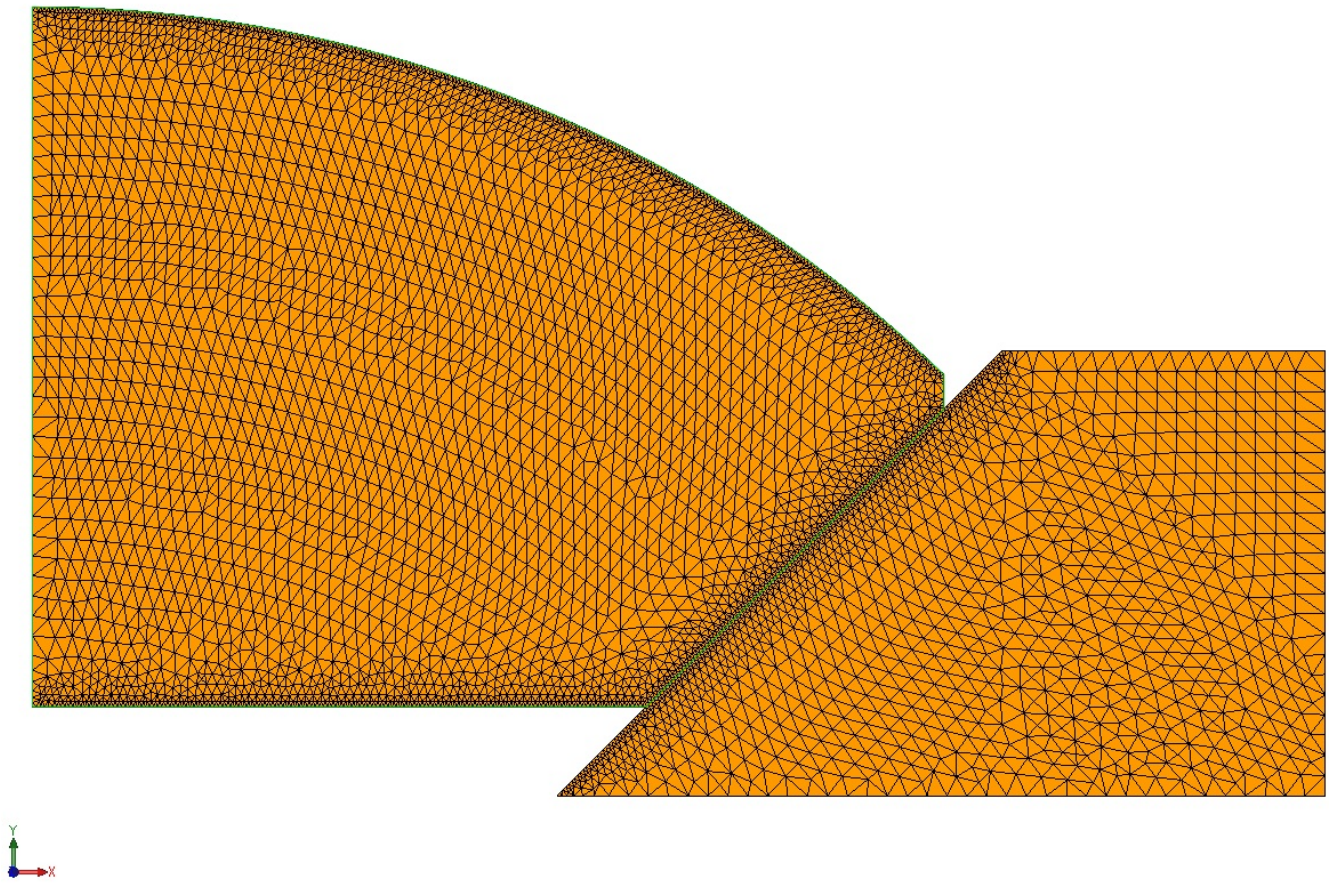


Fig. B1. Mesh for the cyclops geometry. Contact elements allow the window to slide against the fixed window seat.

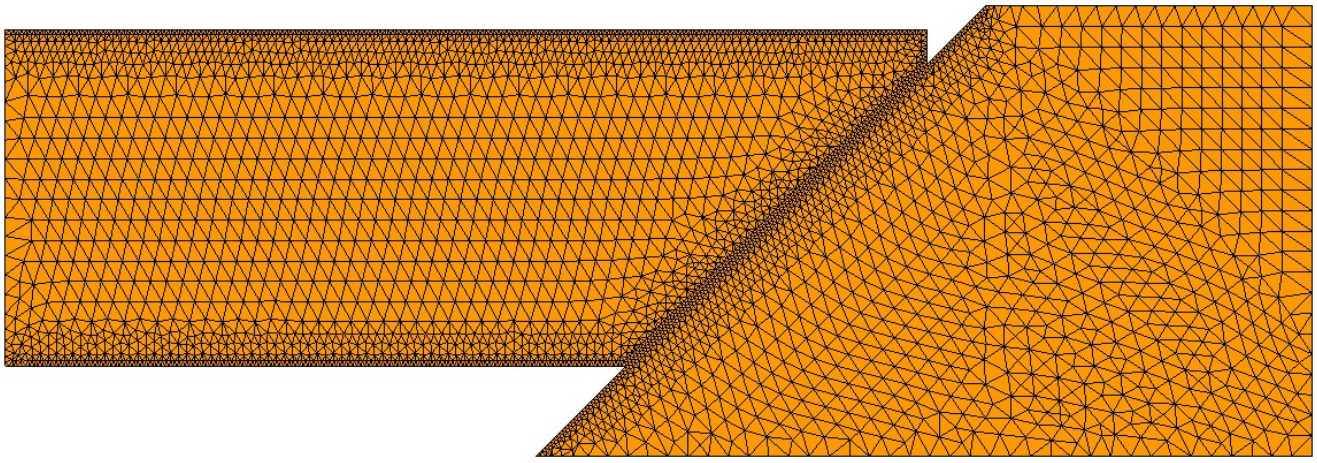


Fig. B2. Mesh for the truncated window geometry. It removes all of the material at the curved upper portion. All other dimensions are the same.

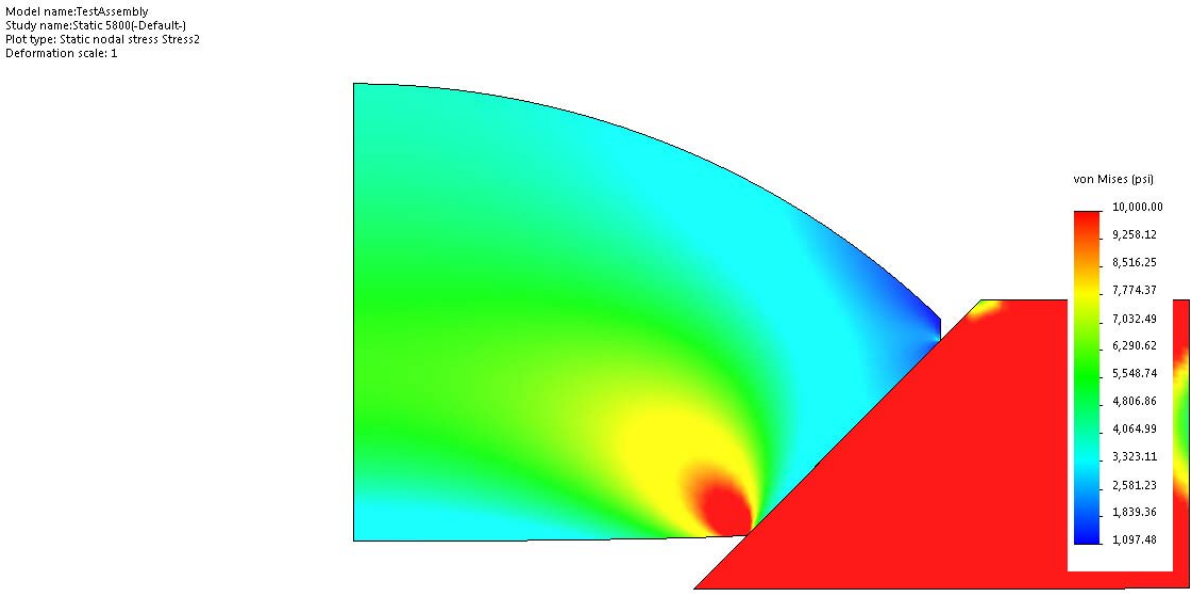


Fig. C1. Linear analysis, 5800 psi. Von mises is proportional to strain.

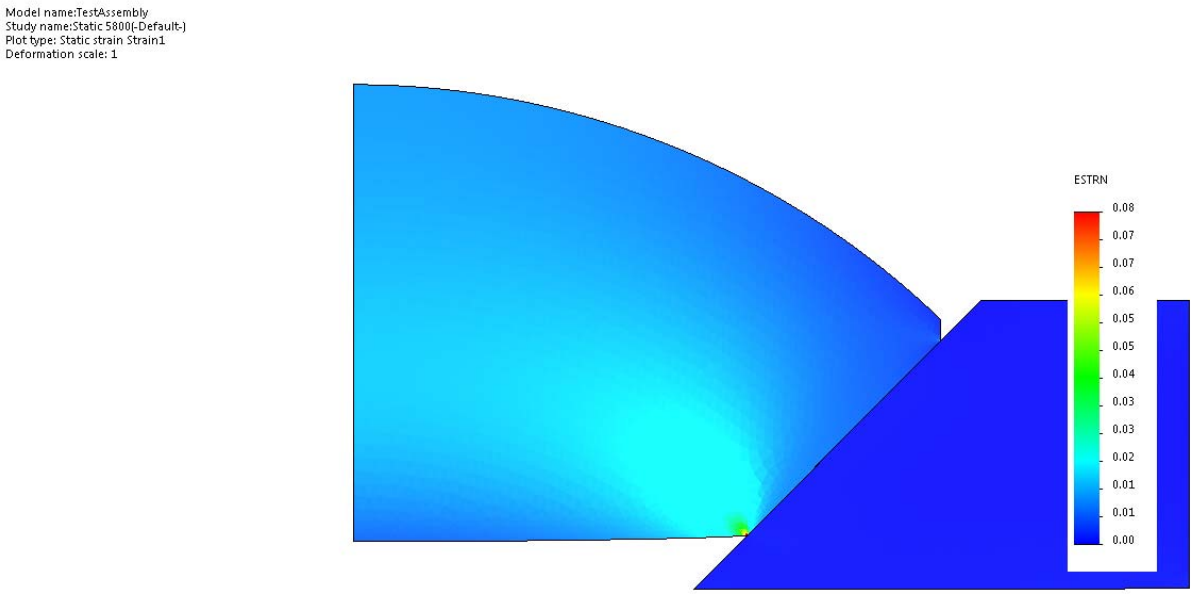


Fig. C2. Linear analysis, 5800 psi. Strain limited to 0.08 for consistency for comparison to other results. Maximum strain is 0.12.

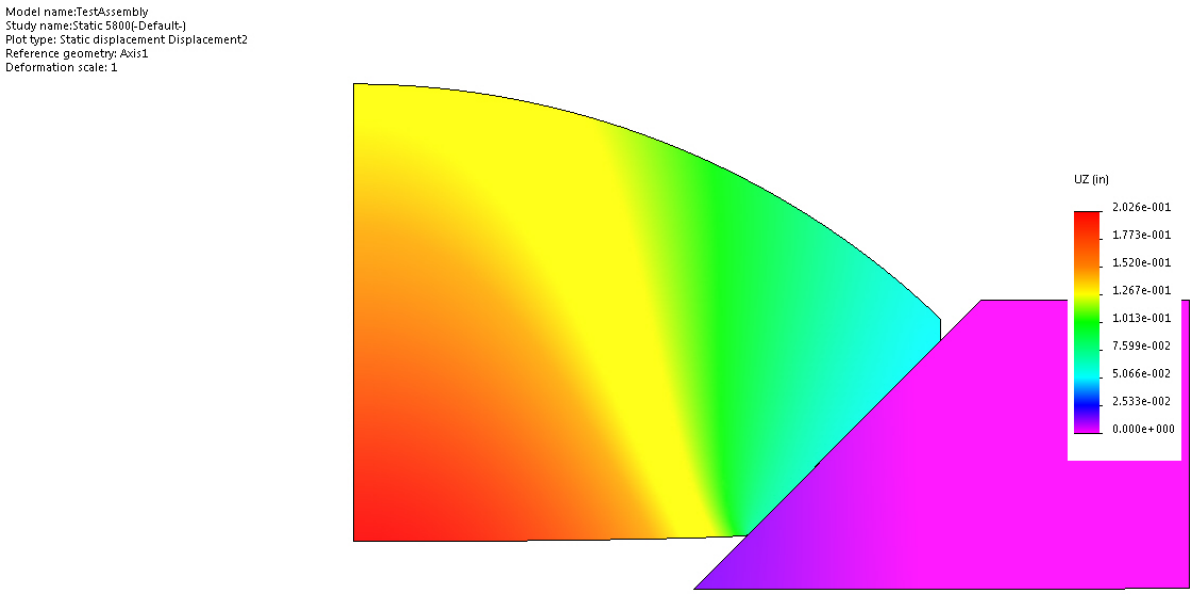


Fig. C3. Linear analysis, 5800 psi. Downwards displacement. Linear analysis is unsuitable for analyzing acrylic windows, but is being used for a purpose of comparison to the work by others.

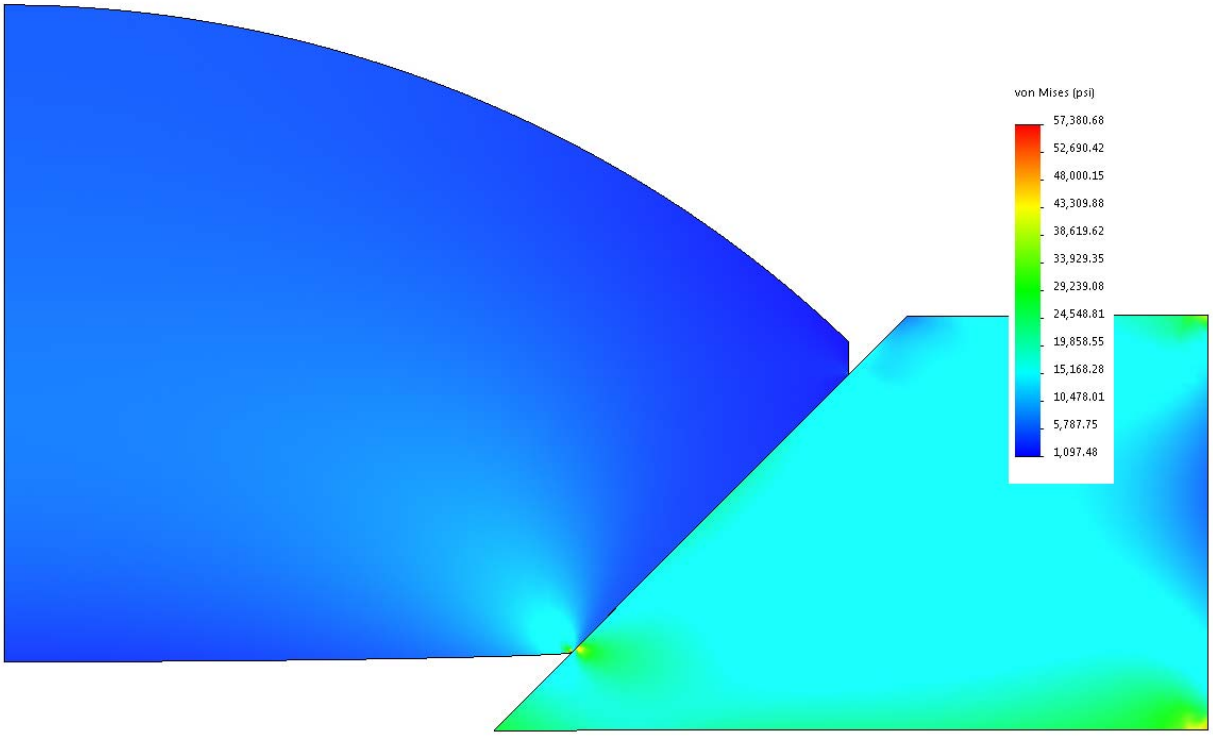


Fig. C4. Linear analysis, 5800 psi. Full range of Von Mises stresses. Peak stresses are in the window seat, which is made of steel and has a much higher yield and ultimate strength. Steel also responds in a linear manner whereas acrylic does not. Future stress plots will be limited to 10,000 psi in order to show stress differential in the viewport. The stresses in the window seat are to be disregarded. The window seat is only to provide a boundary condition for the viewport.

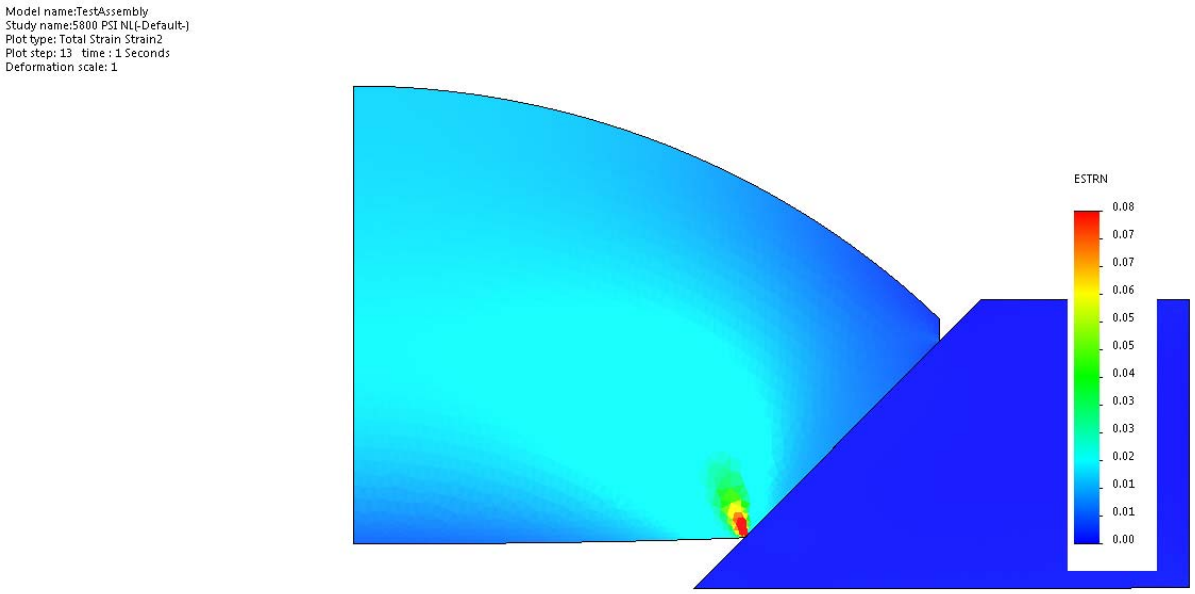


Fig. C5. Nonlinear 5800 psi strain. Strains above 0.06 (red-to-yellow) is of concern. This is consistent with cyclic failure. These results are do not account for heat transfer, dive rates, service life, or creep effects, so any conclusion regarding suitability is preliminary. The intent is to provide a preliminary comparison of the Cyclops design to a flat top design.

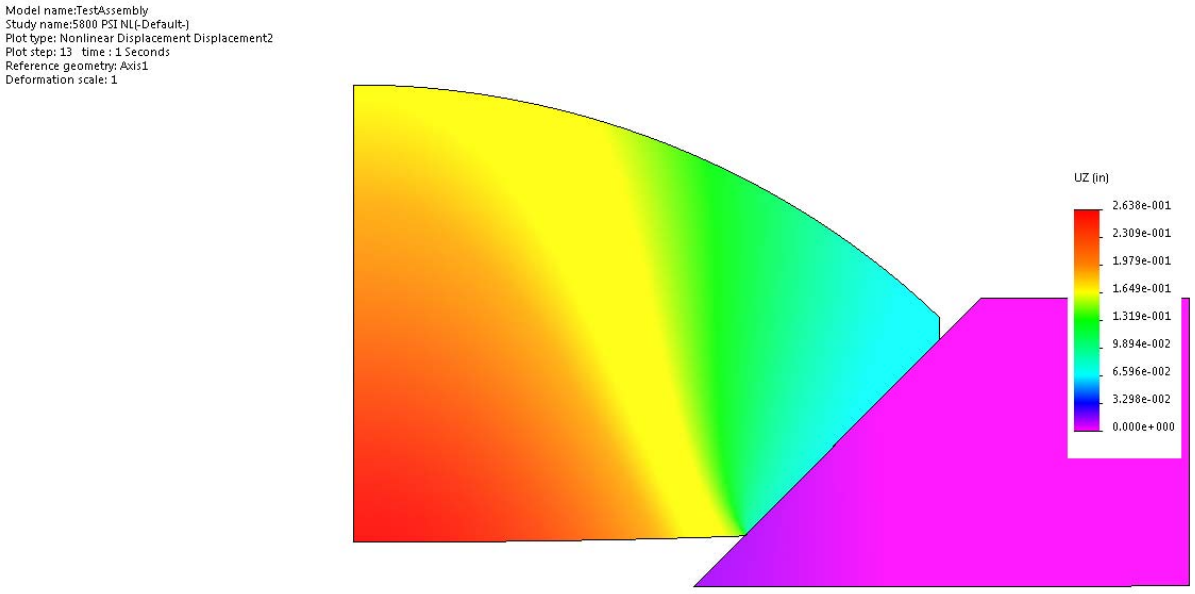


Fig. C6. Nonlinear 5800 psi displacement. Maximum downwards displacement is 0.263 inches.

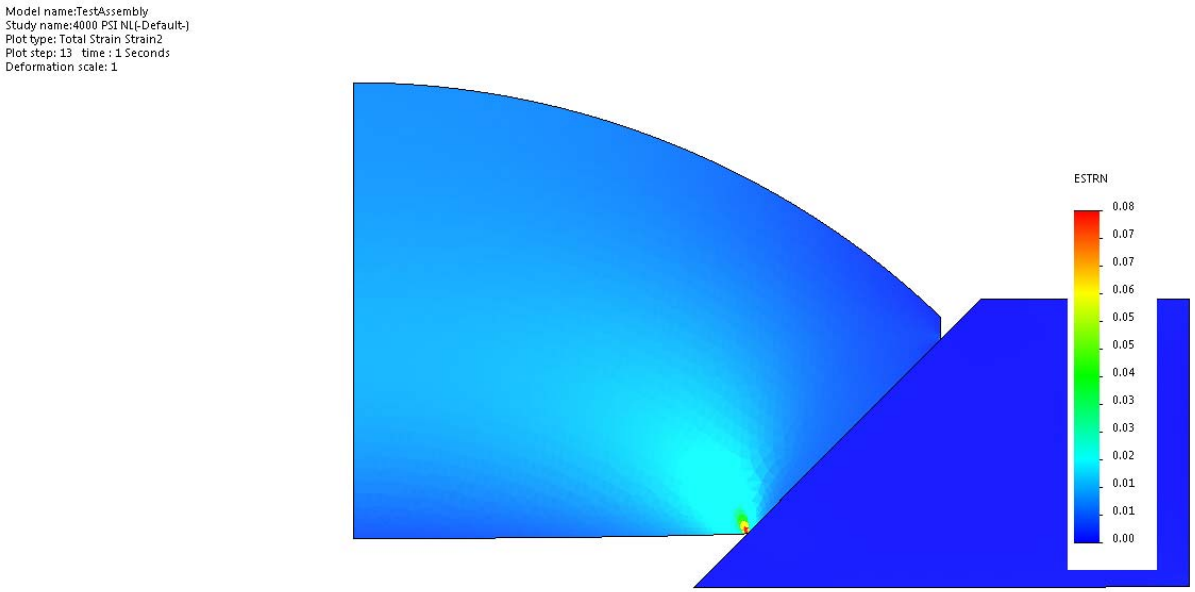


Fig. C7. Nonlinear 4000 psi. Strain constrained to 0.08. The highly localized strain indicates this is more of a case of corner stress instead of a structural concern. A corner fillet would reduce this.

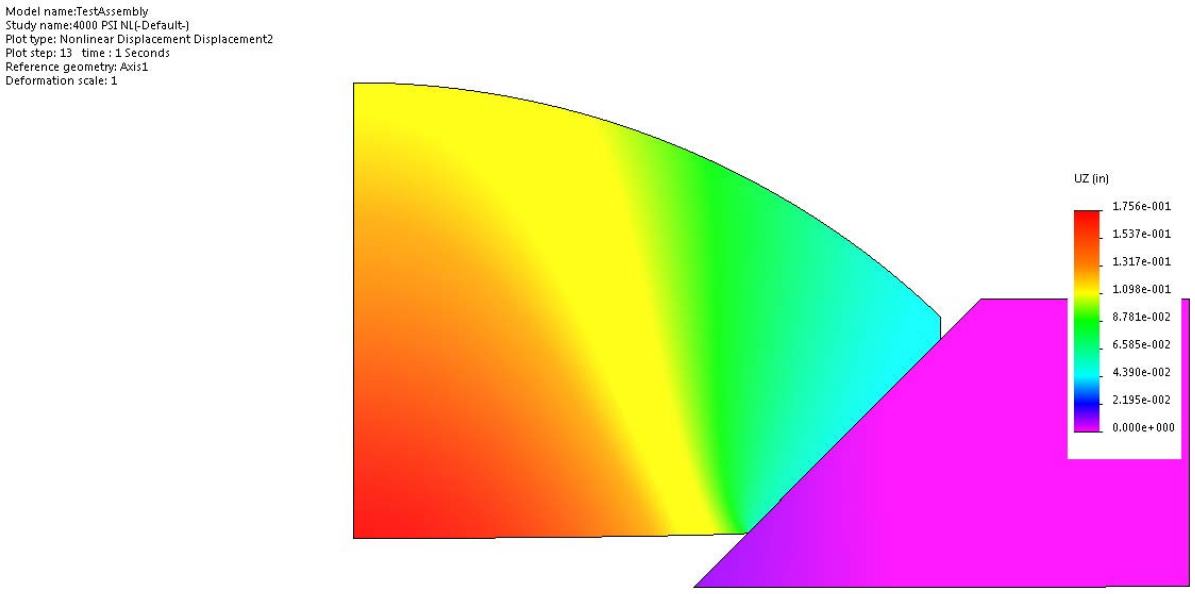


Fig. C8. Nonlinear 4000 psi. Downwards deflection is 0.176 inches

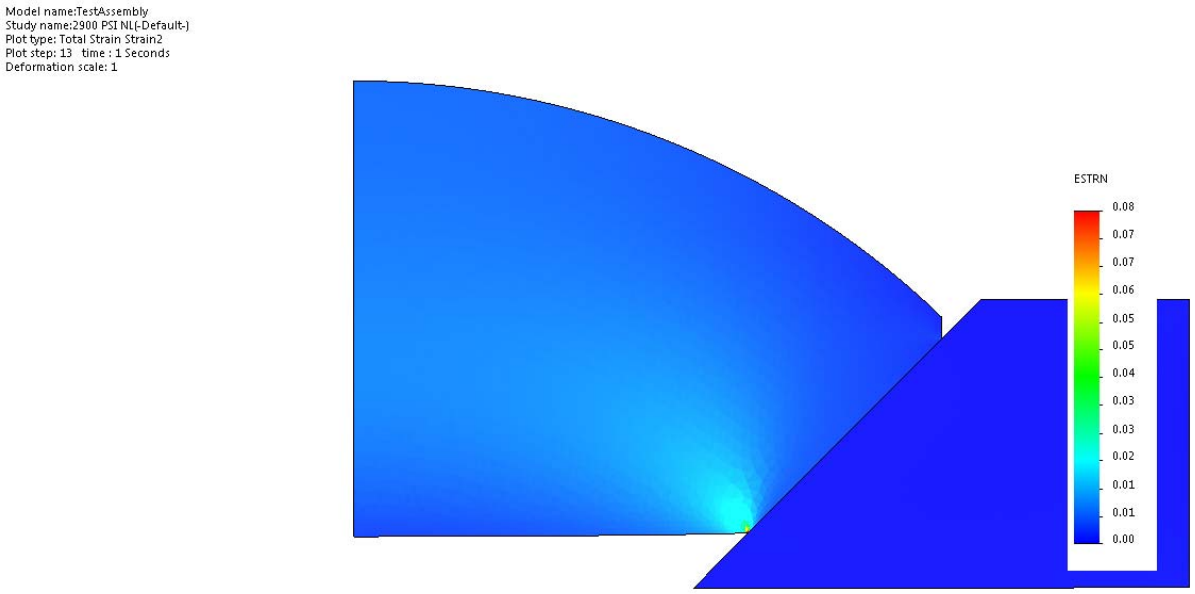


Fig. C9. Nonlinear 2900 psi. The strain is well within normal operational levels.

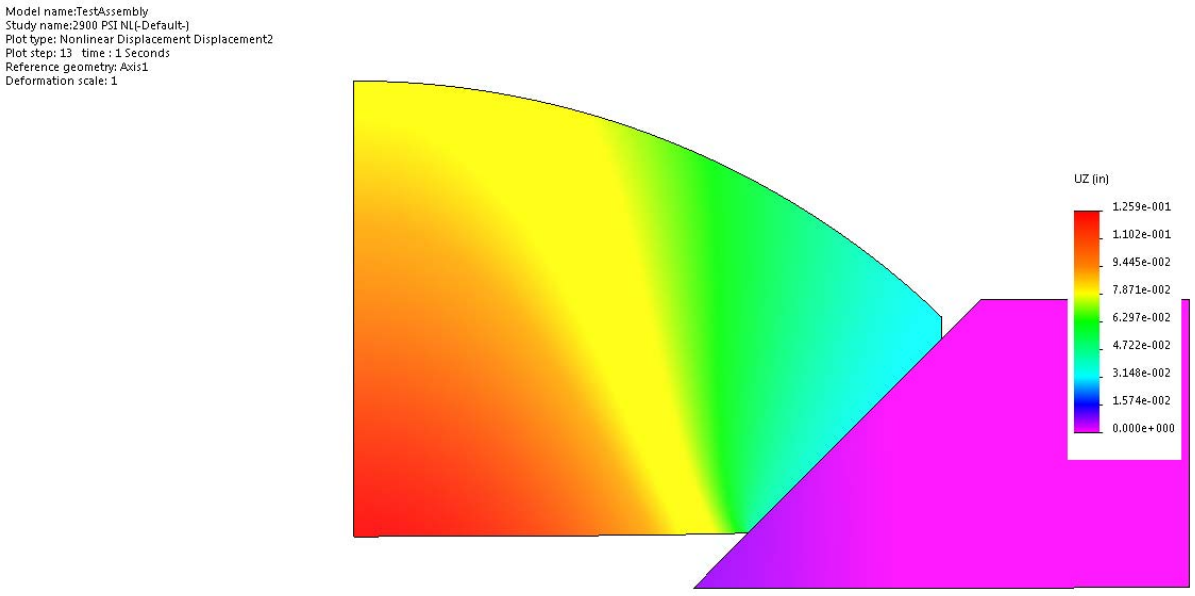


Fig. C10. Nonlinear 2900 psi. Downwards deflection.

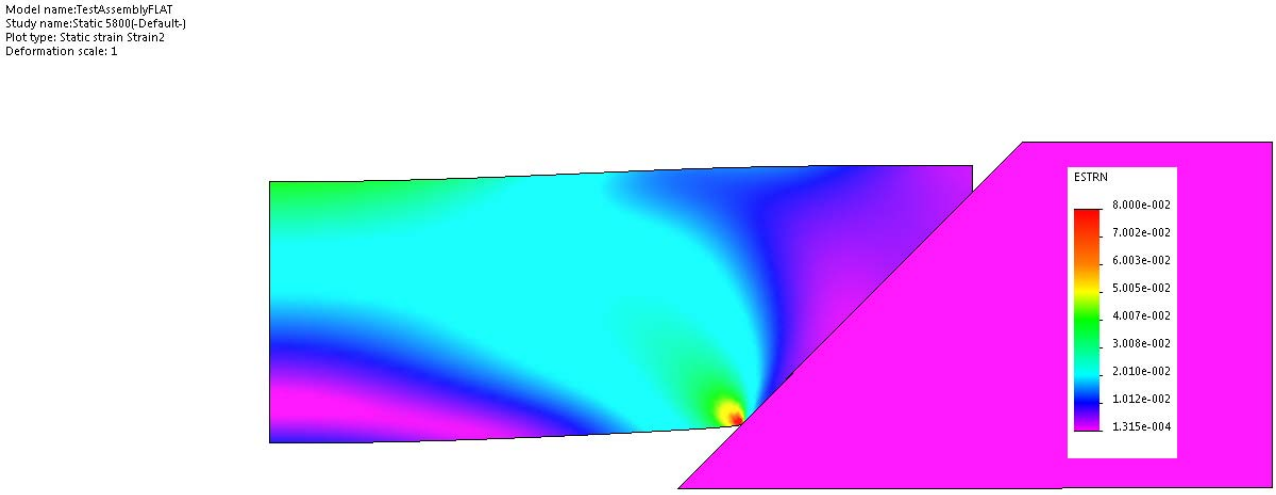


Fig. D1. Flat top, linear at 5800 psi.
The strain level is elevated in comparison to Fig. C2.

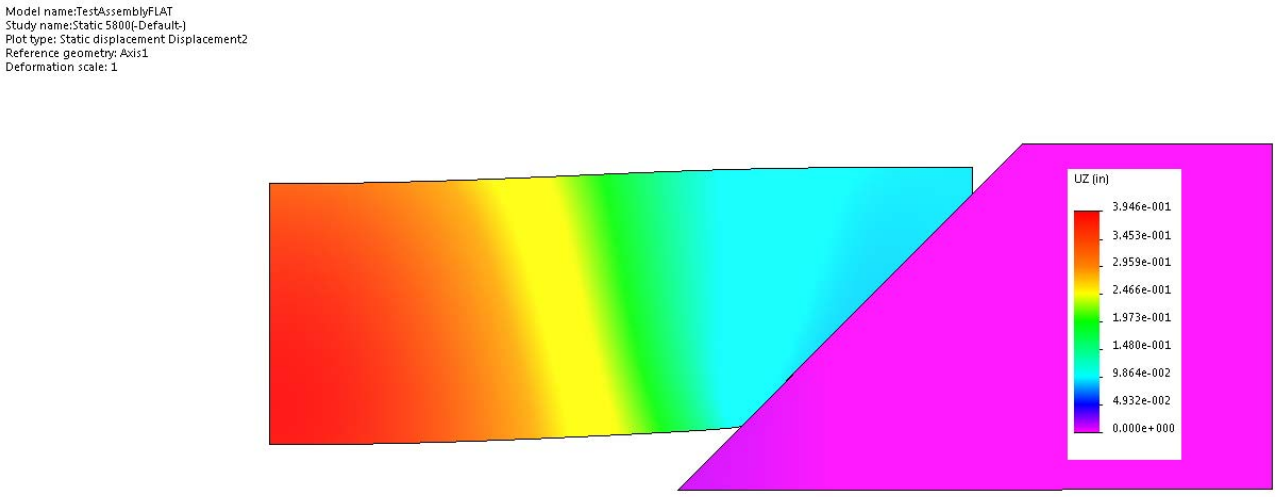


Fig. D2. Flat top, linear at 5800 psi.
The downwards deflection is almost twice the deflection of Fig. C3. The flat top design is significantly more flexible than the Cyclops design, which is consistent with the structure.

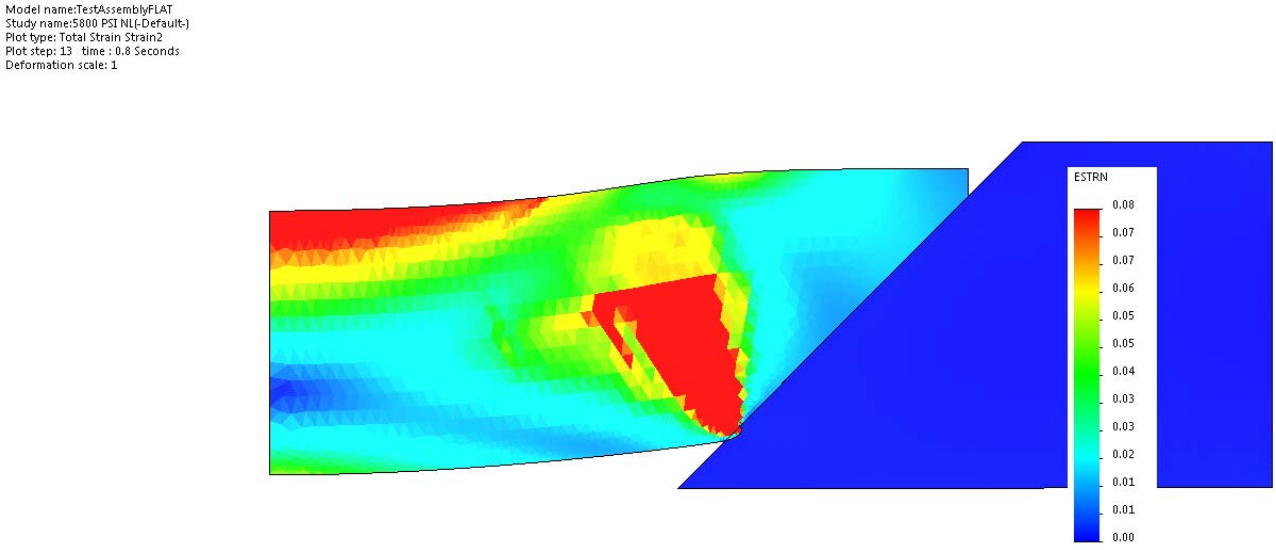


Fig. D3. Flat top window. Nonlinear at 5800 psi pressure. Strain levels and gradients indicate failure.

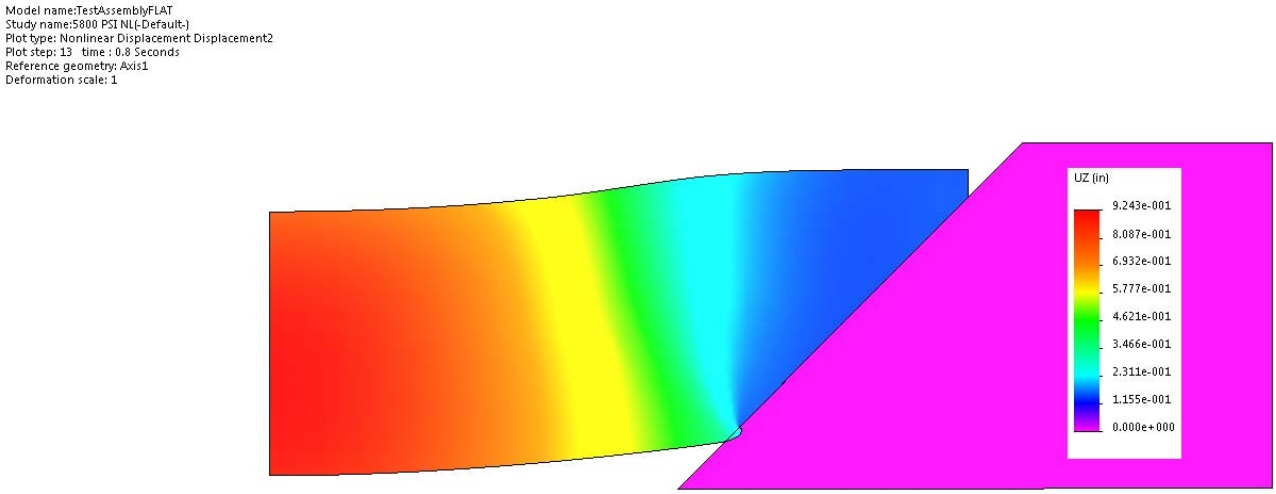


Fig. D4. Flat top window. Nonlinear deflection at 5800 psi pressure. Deflection is over 3 times the Cyclops design and is consistent with failure.

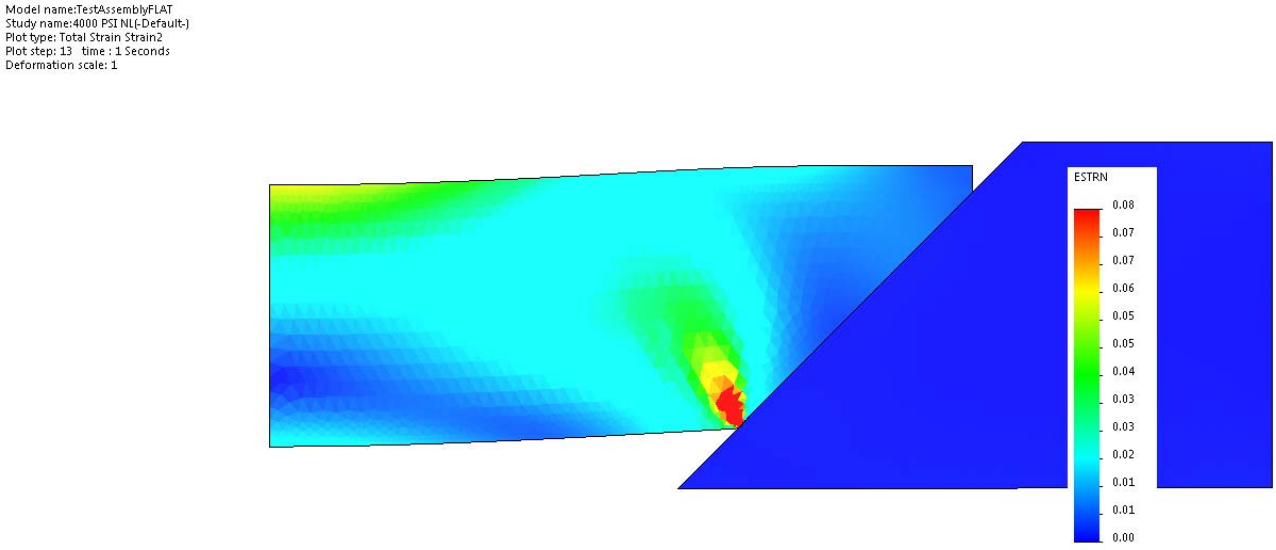


Fig. D5. Nonlinear flat top at 4000 psi. Strain profile is consistent with short cycle failure.

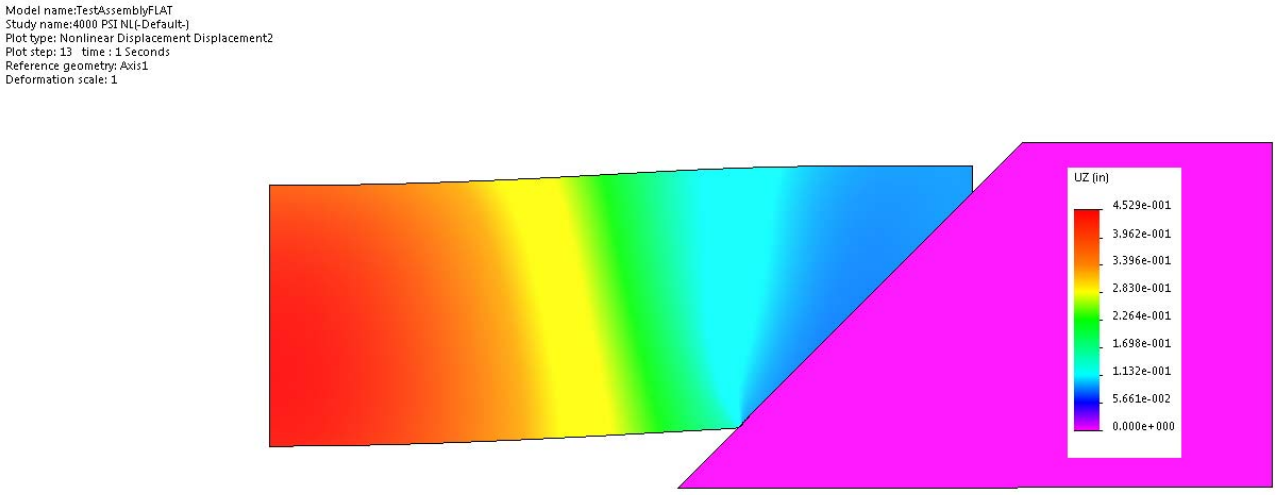


Fig. D6. Nonlinear flattop deflection at 4000 psi. Deflection is over twice the Cyclops design.

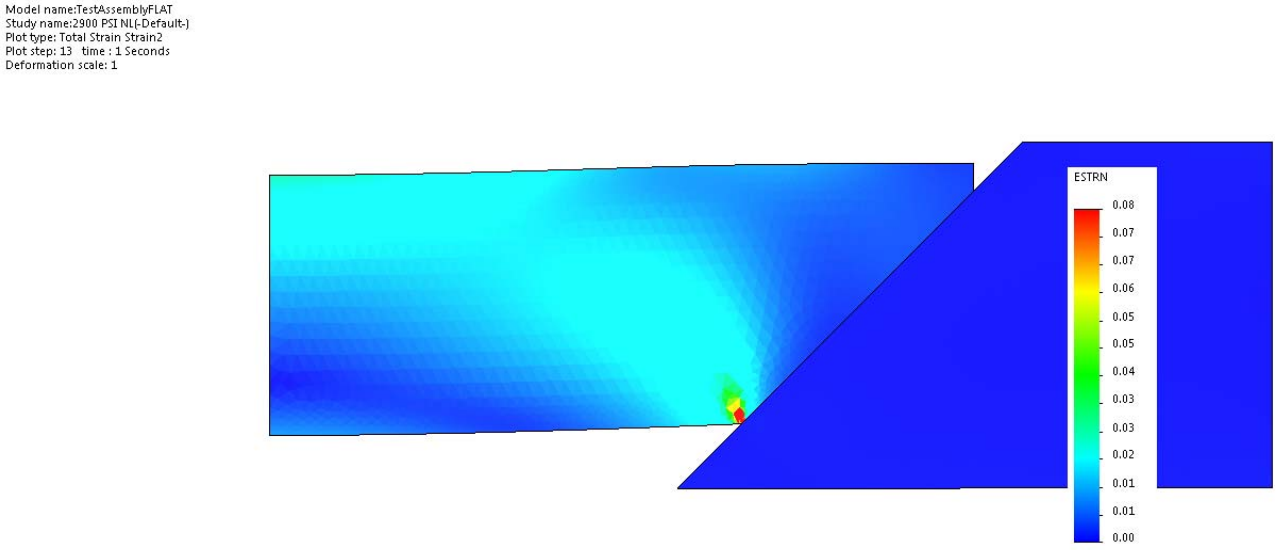


Fig. D7. Flatop strain at 2900 psi. Strain is potentially acceptable, although cyclic failure is possibly indicated.

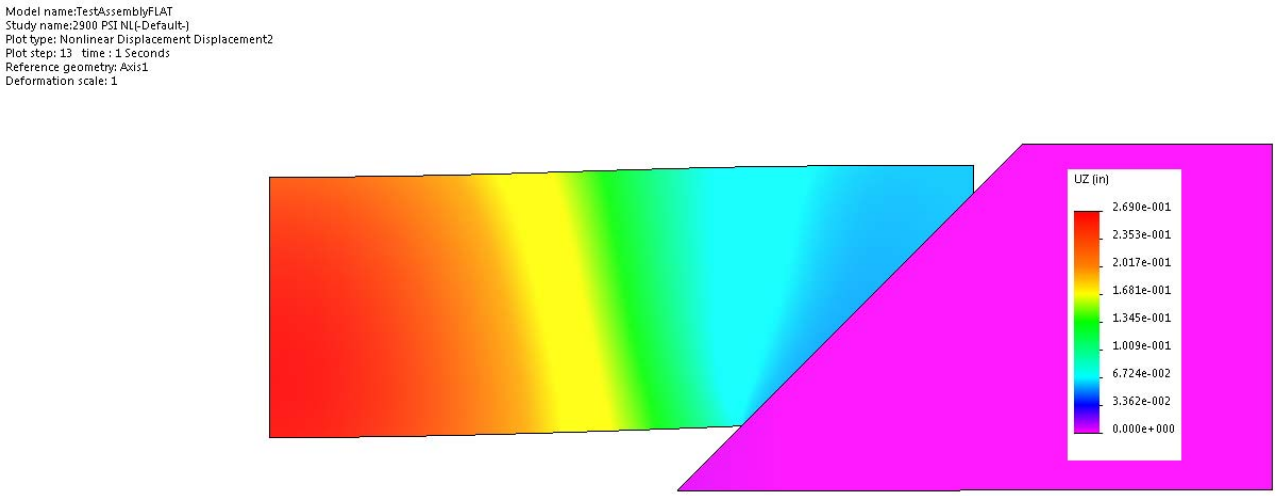


Fig. D8. Flatop deflection at 2900 psi. Downwards deflection is over twice the Cyclops design and is more than the Cyclops design at 5800 psi.

[redacted]

From: [redacted]
Sent: Tuesday, January 30, 2018 11:36 AM
To: [redacted]
Cc: Stockton Rush; [redacted]
Subject: Re: Preliminary performance behavior of Flat internal spherical sector windows

Thanks, [redacted]

I will consider and discuss with my team.

All the best,

[redacted]
Director of Engineering
OceanGate, Inc.
[redacted]
www.oceangate.com

From: [redacted]
Sent: Tuesday, January 30, 2018 11:08:23 AM
To: [redacted]
Cc: Stockton Rush; [redacted]
Subject: Preliminary performance behavior of Flat internal spherical sector windows

[redacted] Stockton,
Please find attached a prelim study of the behavior of a spherical sector window with the flat inside, low pressure, surface.
As we discussed, there is interest among other MUV manufacturers for this same type of geometry. The optical benefits are a strong motivating factor for all involved.

[redacted] is one of the leading FEA analysts in the US today, an expert in pressure vessels and a specialist in PVHO acrylics.
[redacted] is also the chairman of the PVHO viewports committee and the subject at hand is of interest to many.
I asked Bart to have a look at the interesting behavior exhibited by this geometry. I have done some analysis and others have as well on their own windows.
The results were not what was expected, which I shared with you earlier. In addition, most of the early analysis was performed with simple linear analysis. This is usually an approximation since acrylic is fundamentally non-linear. [redacted] agreed to have a precise look into this and do comparative study with linear and non-linear models.

I consider this a very generous service from Kemper Engineering to perform such a “knowledge acquisition” exercise to see the difference in behavior between a Flat Conical frustum window against that of a flat conical window with an added spherical dome, both using linear and non-linear analysis.

The Flat conical Frustum model provides a guideline of the behavior and performance of a PVHO certified design. This can then serve as a comparative baseline to evaluate the new geometry.

This was all pro-bono work based on the general interest from the PVHO community and the growing interest in this new type of geometry in the submersible industry. I would invite and encourage you to contact Kemper Engineering for their expertise and services.
[redacted] is copied herein and I am sure would be more than happy to support a study of the performance envelope of this new geometry of windows.
Please feel free to contact him directly.

Likewise, if you have any questions, please feel free to contact me.

Best regards

[redacted]

[redacted]
President/CEO

HYDROSPACE Group Inc
[redacted]
www.HydrospaceGroup.com

"Quality and Performance through Precision Engineering"
