

Appendix 2: Silicon sealant slides from CMS Inner Tracker for reference

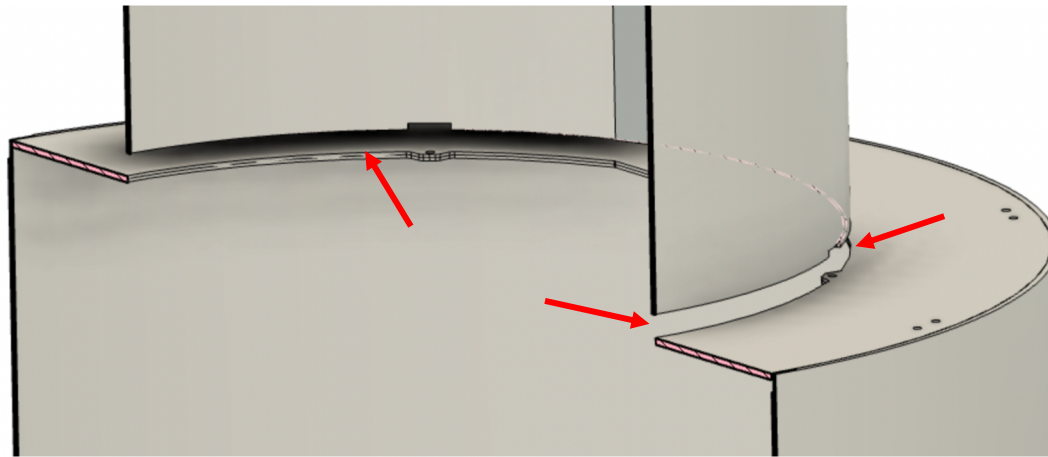
6th November 2023

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Purdue U.



Goal

- Create an airtight seal between the tube and the interface plate. It must sit in the "internal corner" on the outside of the tube.

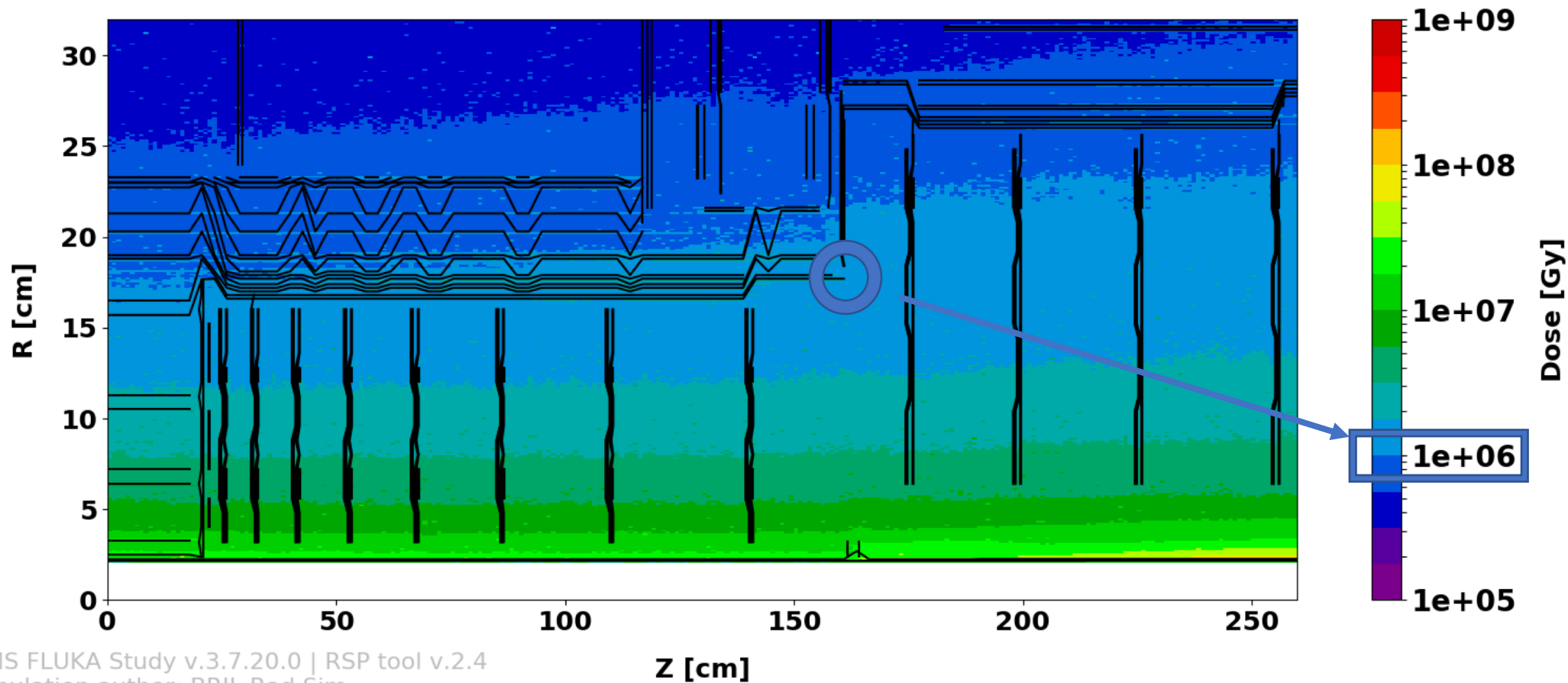


for internal CMS use only

CMS Phase2 HGCaMod pp 7TeV FLUKA v3.7.20.0pixel extended :

PIXEL Absorbed Dose

4000.0 fb⁻¹ ($\sigma_{\text{inel}} = 80.0$ mb)



CMS FLUKA Study v.3.7.20.0 | RSP tool v.2.4
simulation author: BRIL Rad Sim

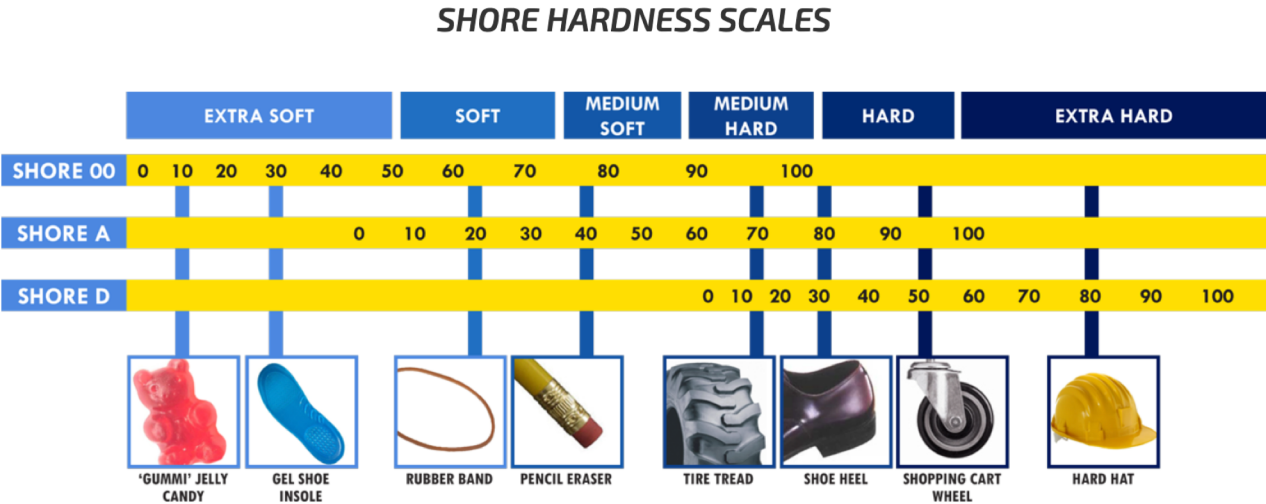
Material (Silicone rubber)

Smooth-On (Platinum cured)

- Mold Star 20T / Mold Star 30

AB Specialty Silicone (Methyl Phenyl Polymers)

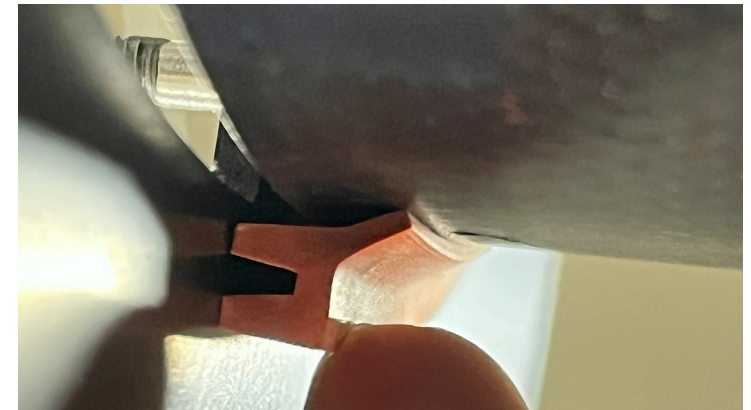
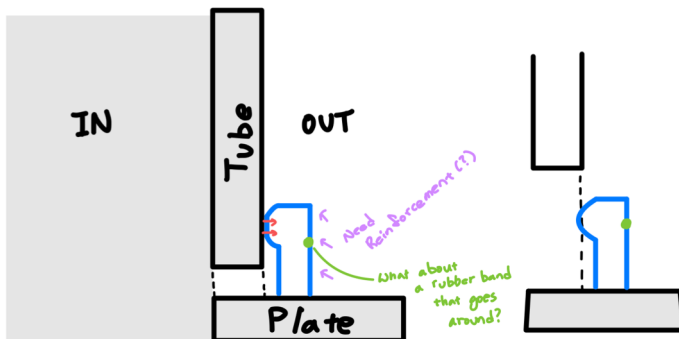
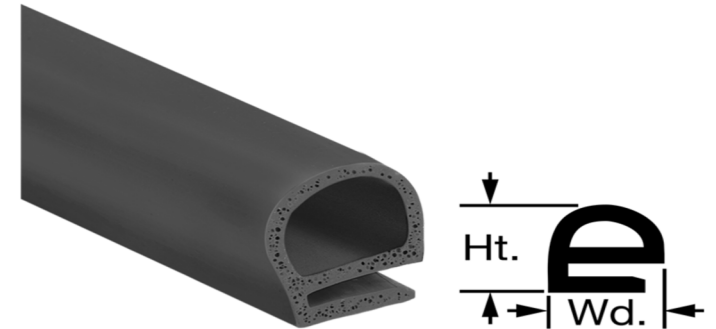
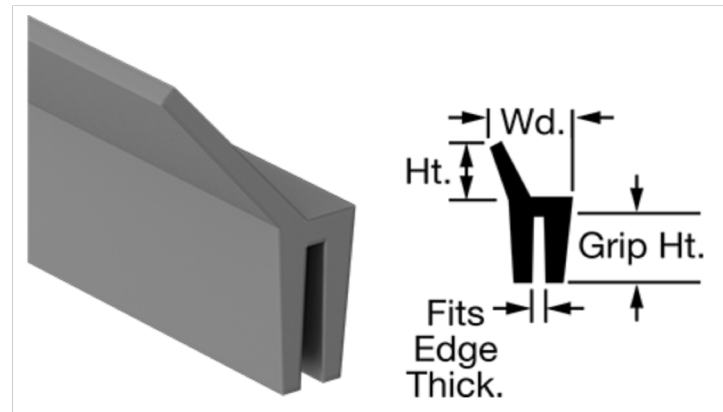
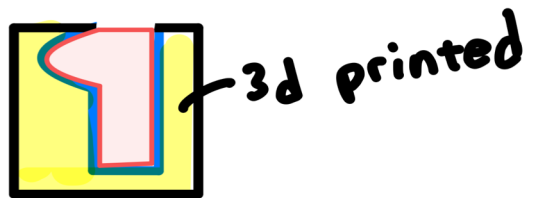
- Andisil SF 1721 / 6550CV



Cross section profile

Previous options

1 Part Casting



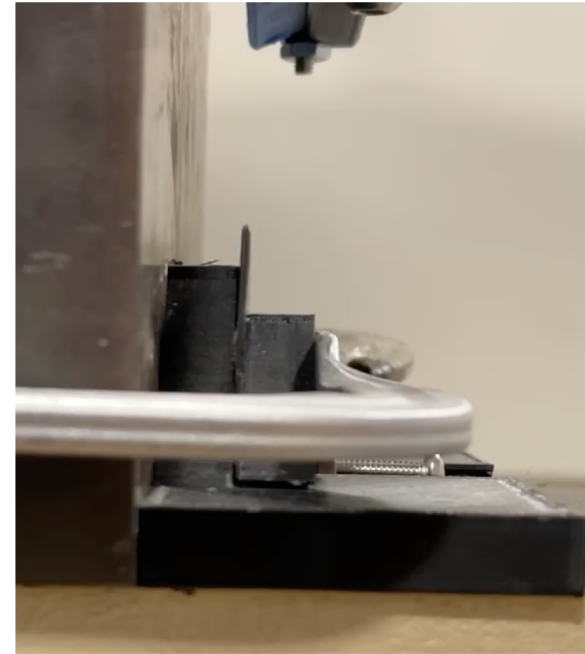
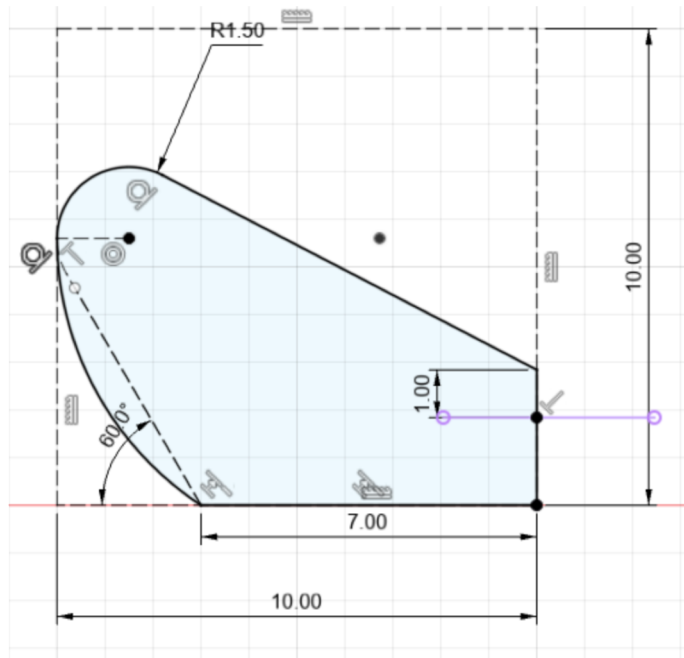
Profile test



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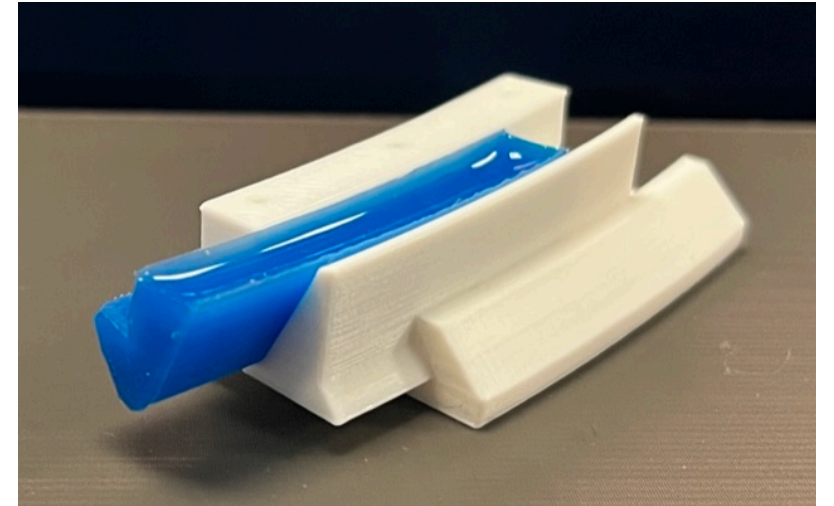
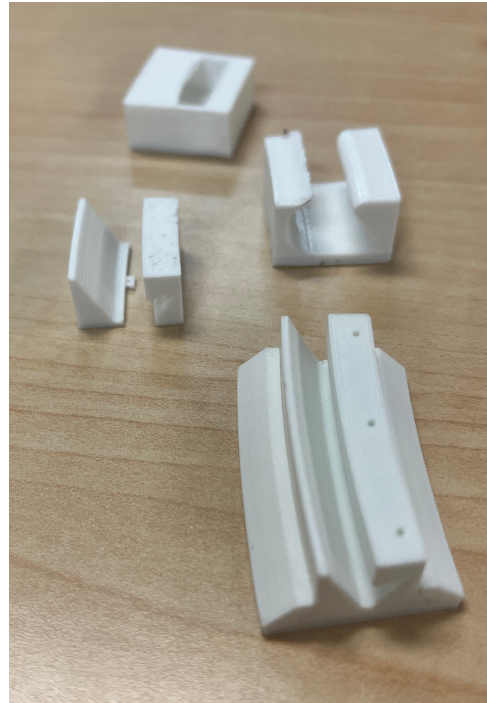
Profile #4



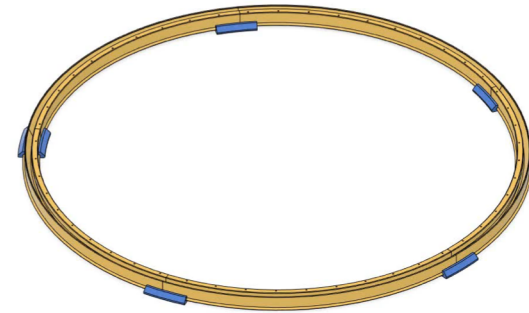
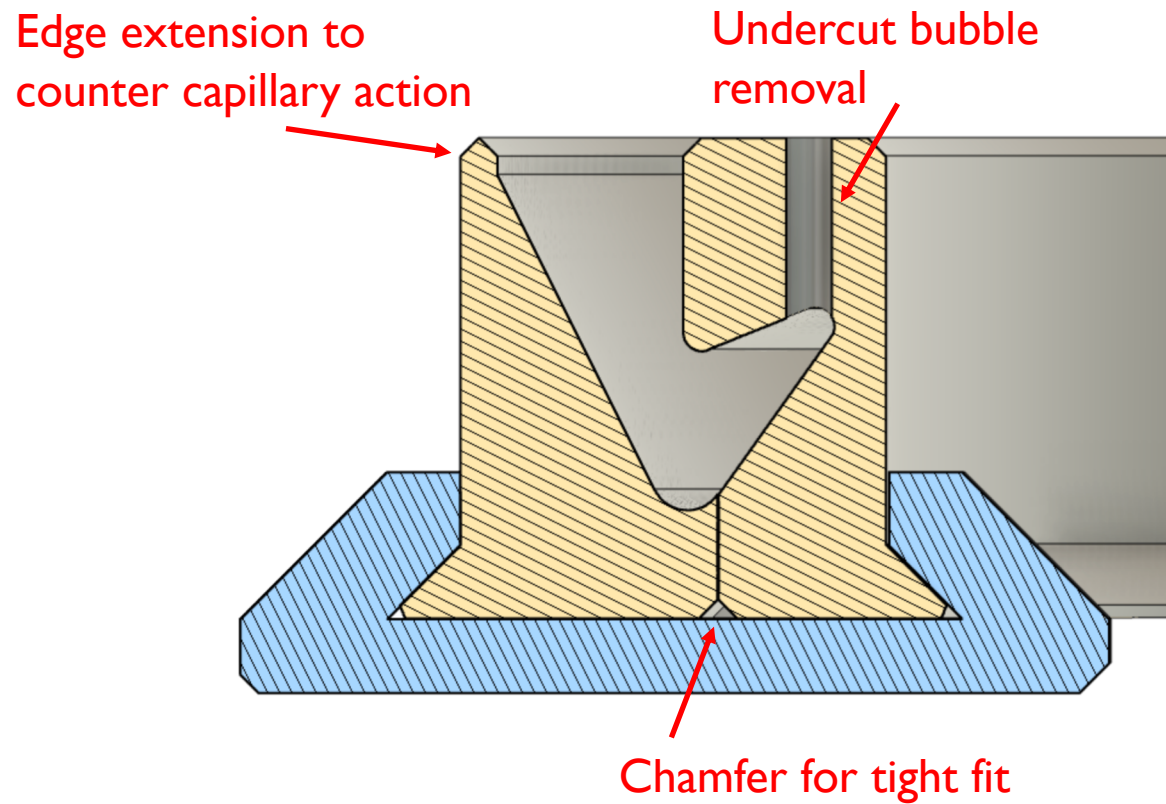
Mold / cAST

3d printed mold

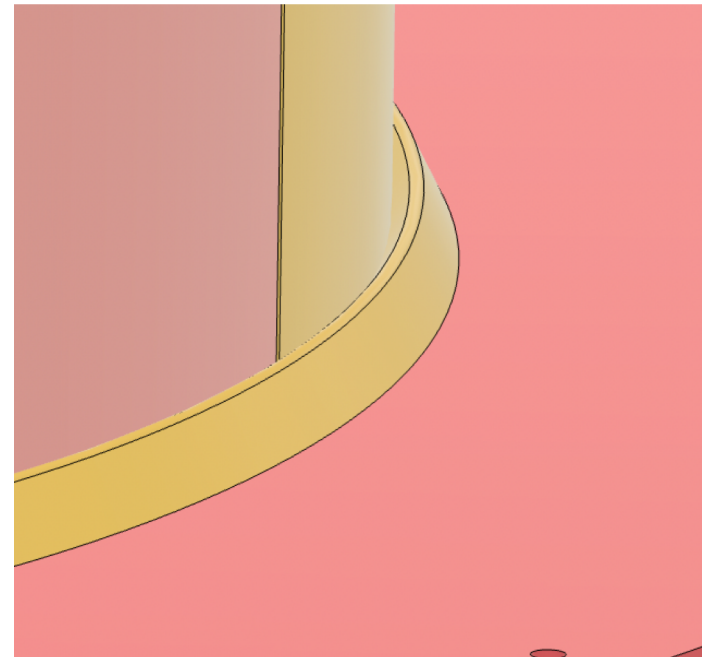
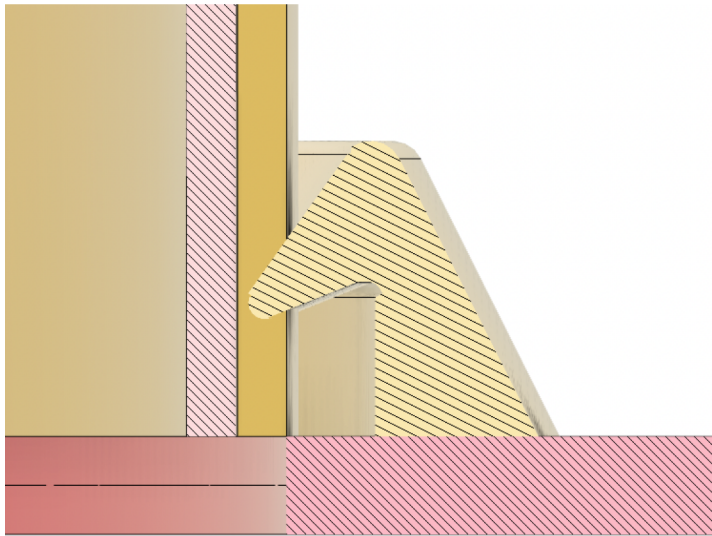
- Does not require release spray
- Easy to iterate design
- Preserves fine details
- Vacuum tight (w/ 2 or more walls)
- Tolerance = ± 0.05 mm (btw surfaces)



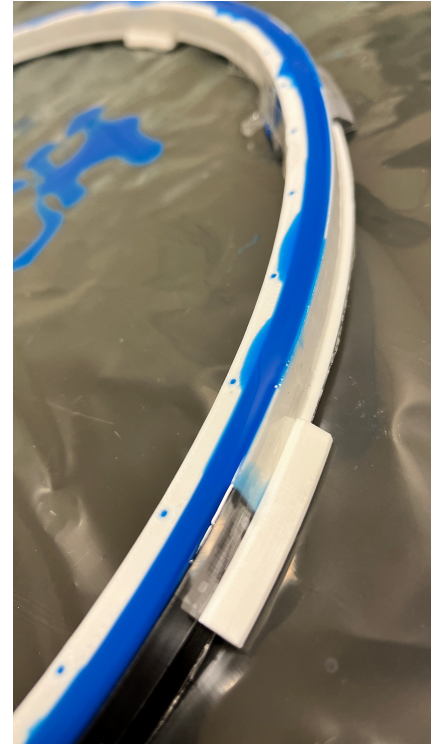
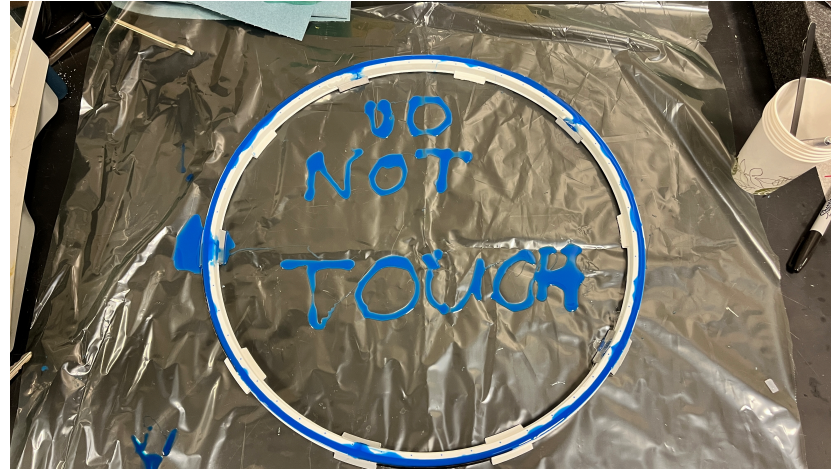
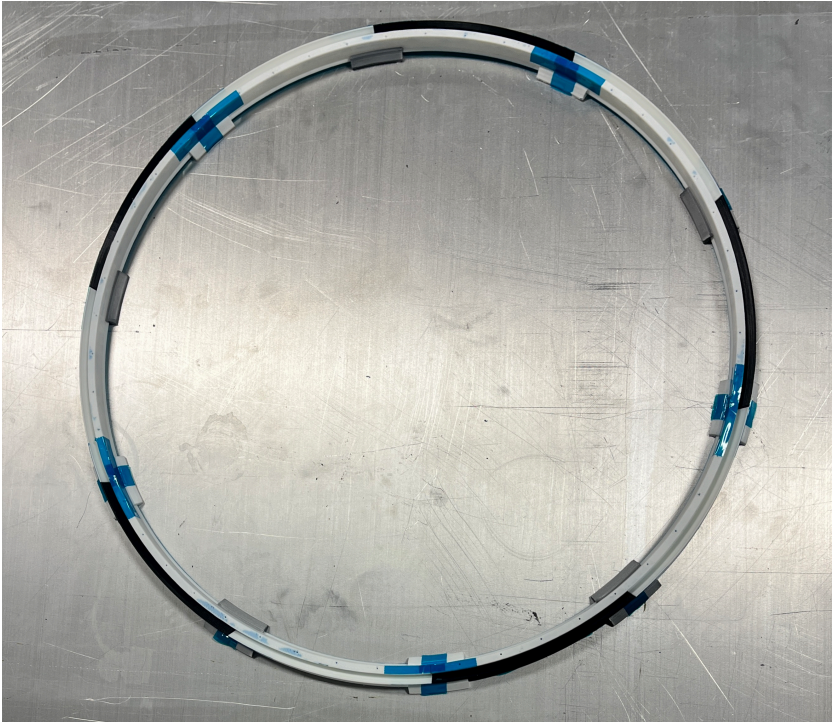
Final profile



cad model



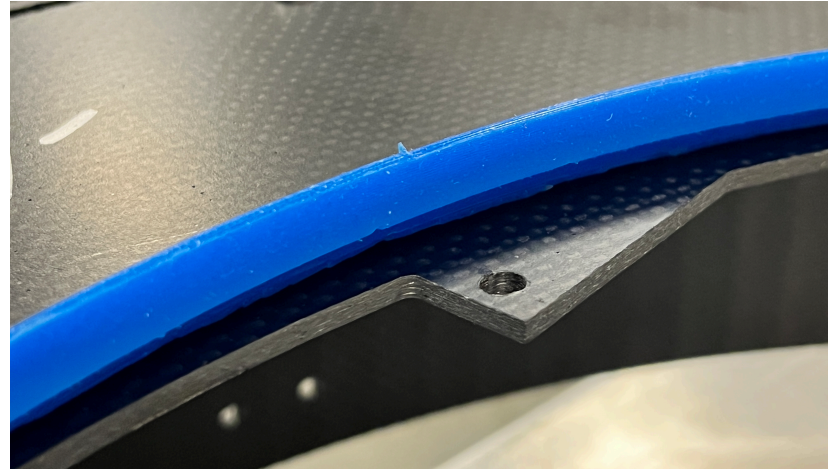
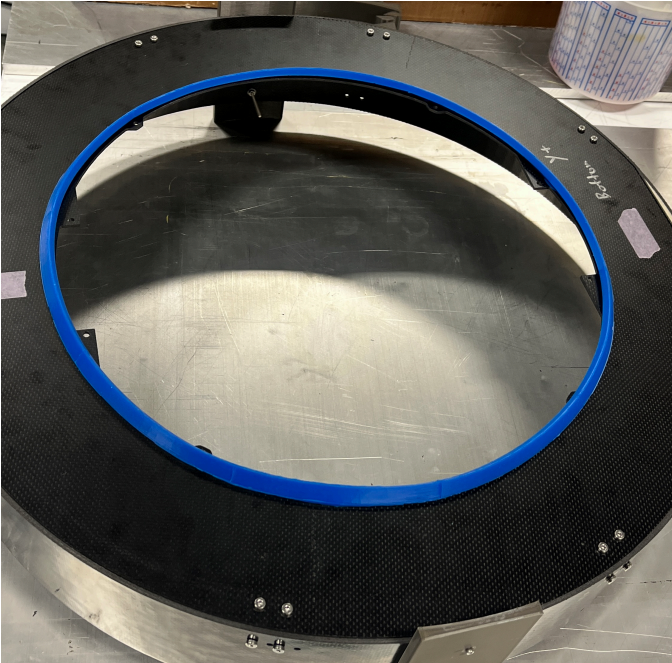
Casting silicone



For this, Mold Star 30 was used w/o any additives

* Scraping with a wooden stick seems to help flatten the top surface

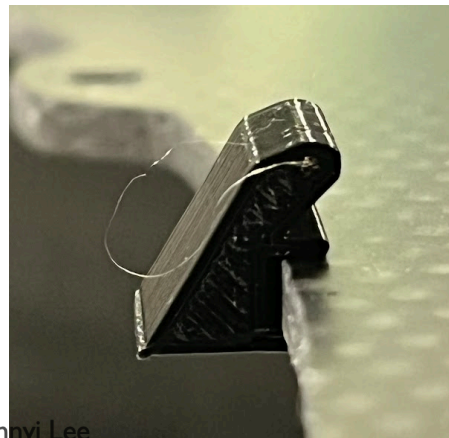
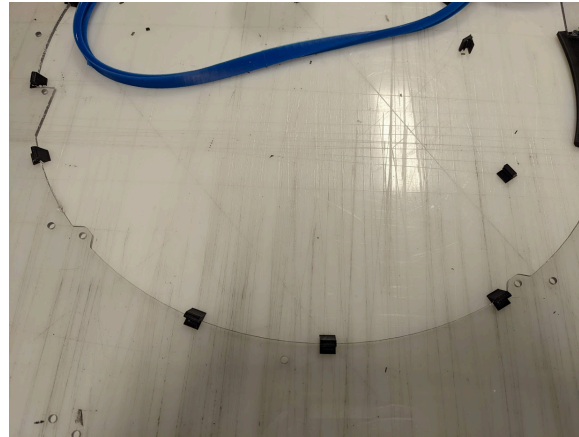
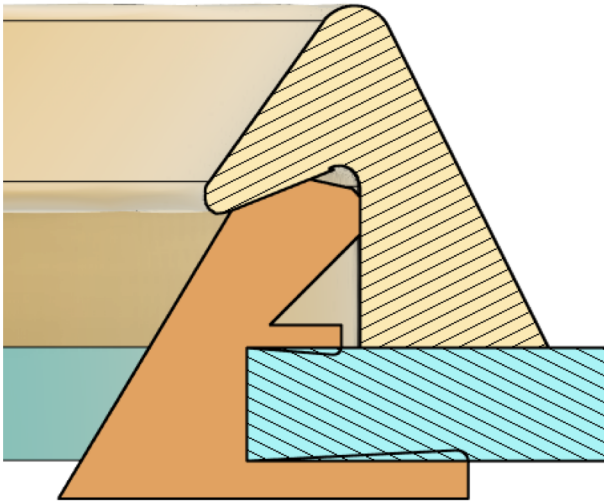
Cast result



Things learned:

1. Needs a circular guide clip to position the seal perfectly circular
2. Bottom surface (against the plate) is not flat

seal holder clips



Tensile strength test

Dynamic Mechanical analyzer (DMA)

- Tensile Film Test
 - Stress relaxation
 - Multi-strain rate



additive

- Methyl Phenyl Polymer
 - Improves low temp characteristics
 - Increase strength in anti-radiation
 - AB Specialty SF1721
 - AB Specialty SF 6550 CV
 - <https://www.andisil.com/methyl-phenyl-sil>

Methyl Phenyl Silicones

Methyl Phenyl silicones are specialty products that have varying refractive index values that increase with phenyl concentration. The presence of phenyl offers many enhancements to formulations:

- Oxidation resistance
- Thermal stability
- Shear resistance
- Optical clarity
- Radiation resistance
- Extreme temperature resistance

List				
Part Name	Mold Star		AB Specialty	
(MS)(AB)_(Mix%)	30	20T	SF 1721	SF 6550 CV
2000_00		1		
2017_05		1	5%	(percentage by weight)
2017_10		1	20%	
2017_20		1	40%	
2017_30		1	60%	
2065_05		1		5%
2065_10		1		10%
2065_20		1		20%
2065_30		1		30%
3000_00	1			
3017_05	1		5%	
3017_10	1		10%	
3017_20	1		20%	
3017_30	1		30%	
3065_05	1			5%
3065_10	1			10%
3065_20	1			20%
3065_30	1			30%

AB Specialty additive: Andisil SF (Phenyl polymer)
Smooth-On: Platinum cured silicone rubber
-Softness (20A and 30A)

Additive Concentration

0% 0%

SF 1721

5% 5%

42% 10%

20% 20%

60% 30%

After

20A

30A

Before

30A

After

20A

30A

Before

30A

Irradiation

SF 6550 CV

5% 5%

10% 10%

20% 20%

30% 30%

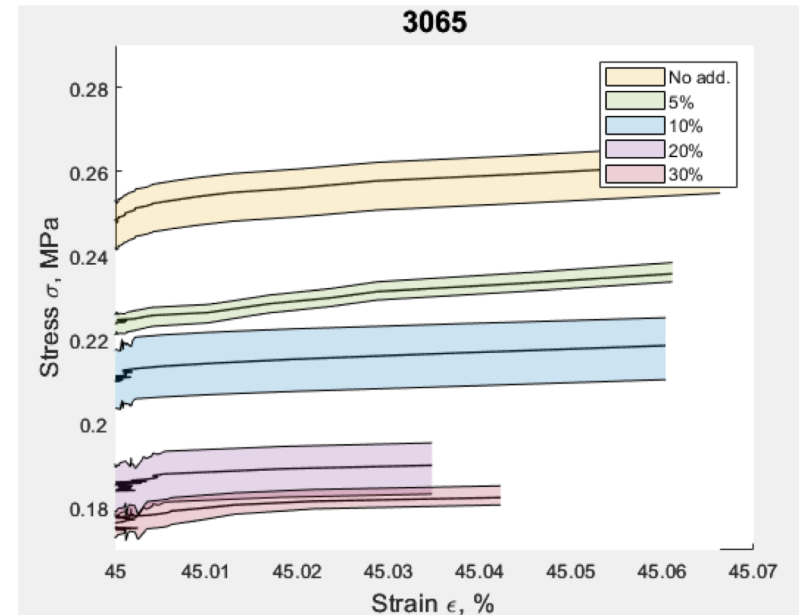
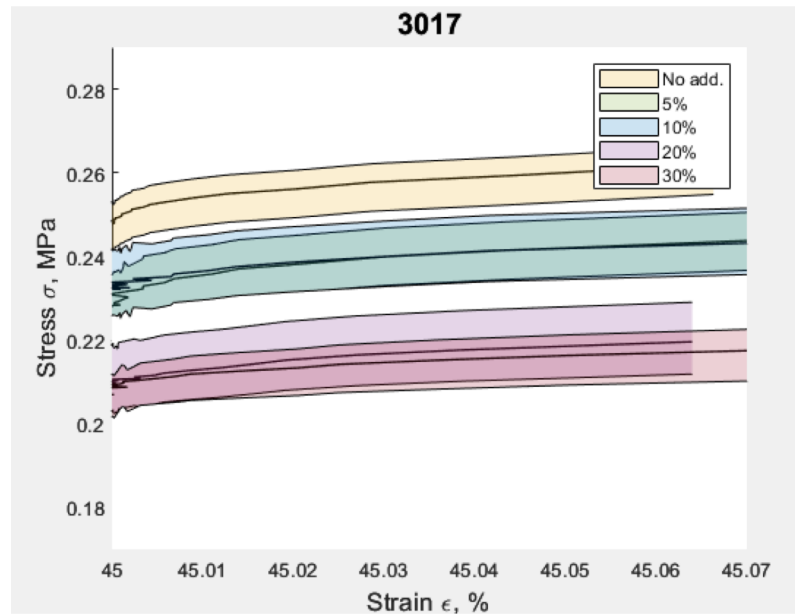
RTV Silicone Adhesive

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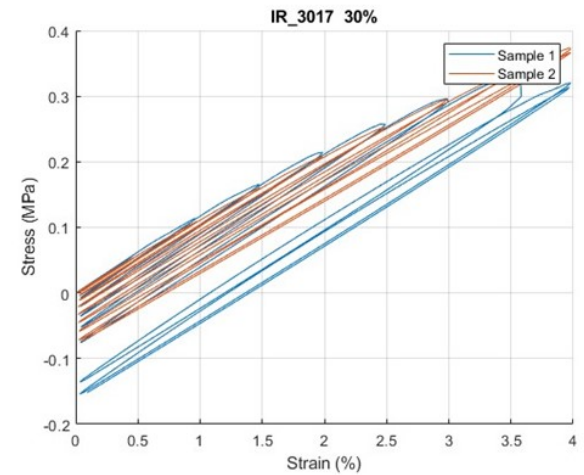
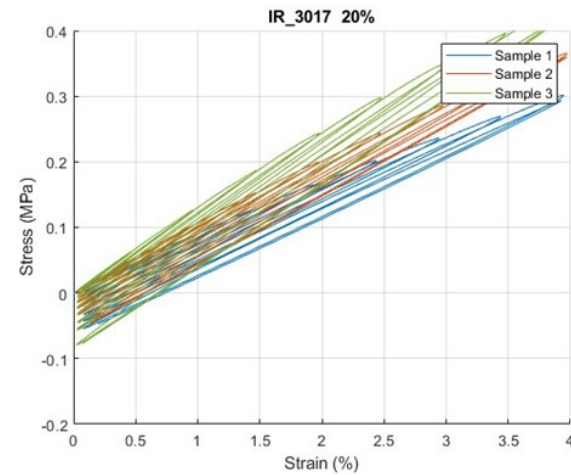
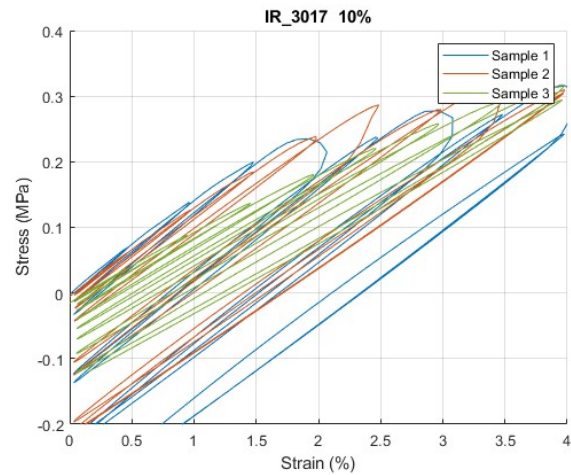
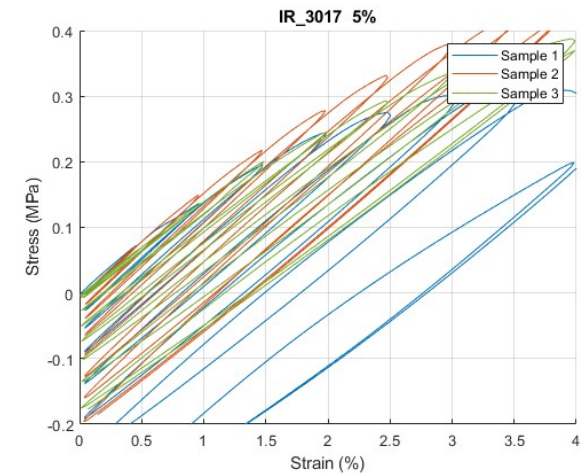
Result: pre-irradiation

- More additive = Less elastic
 - If the sample holds the elasticity for longer period, it is okay to start less elastic.



Result: post-irradiation

- Inconsistent reading
 - Possible mistake in mixing: non-homogenous mixture. (Pot life ~ 30min)



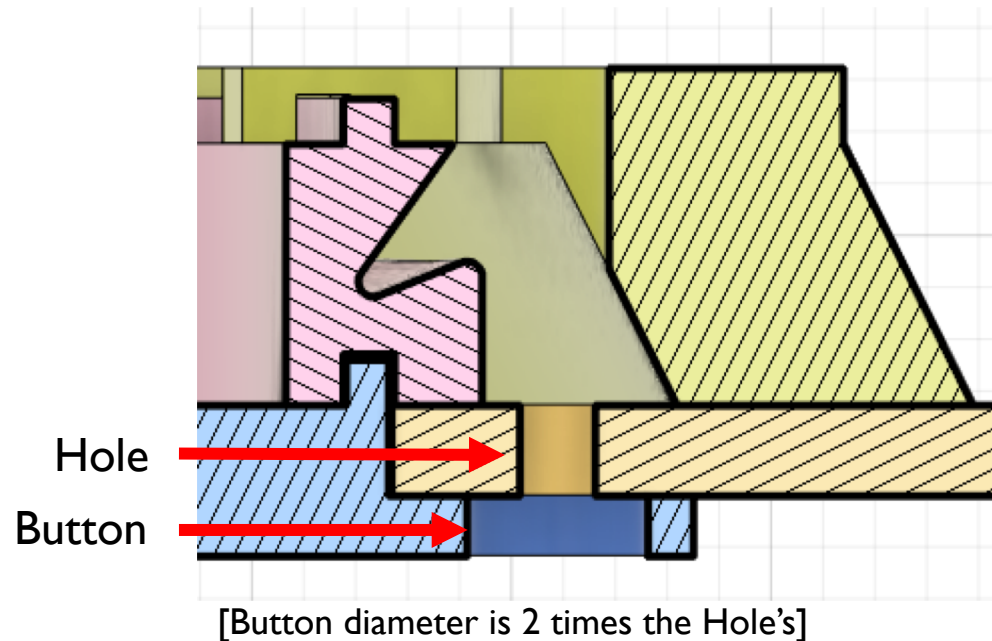
Adhesive / bond

Mechanical bond (button)

- Mechanical bond secures the seal in place by creating a **button-like extrusion through the plate**, mechanically locking the structure.

- It is not possible to cast silicone onto an already cured silicone rubber. Thus, we cast the silicone onto the plate with the mold surrounding the plate.

hole size



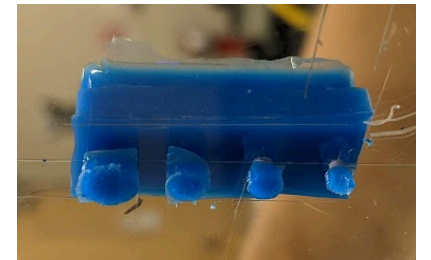
Test sizes [$1/8''$ – $3/32''$ – $5/64''$ – $1/16''$]

Strength test:

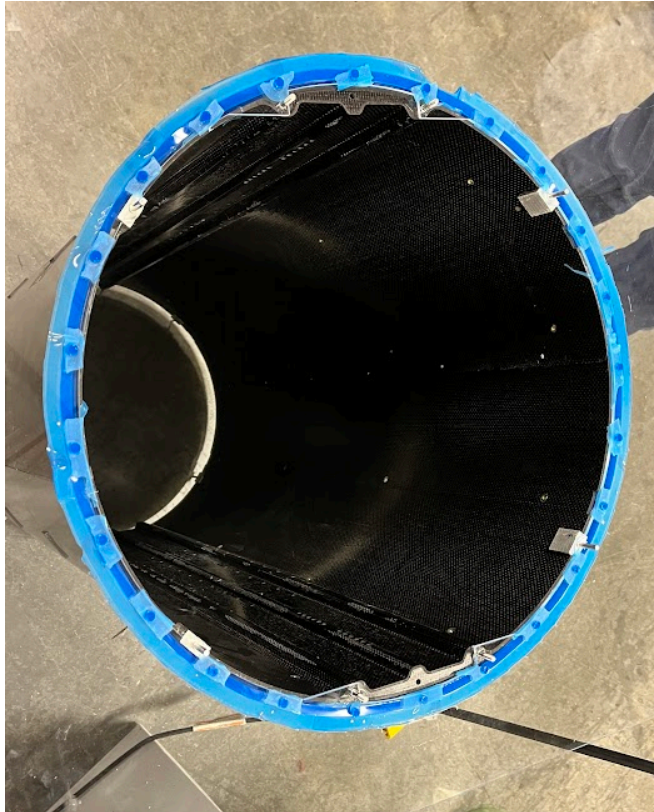
$1/8''$ diameter (with $1/4''$ button) survived up to 3 lbs. of force

Conclusion:

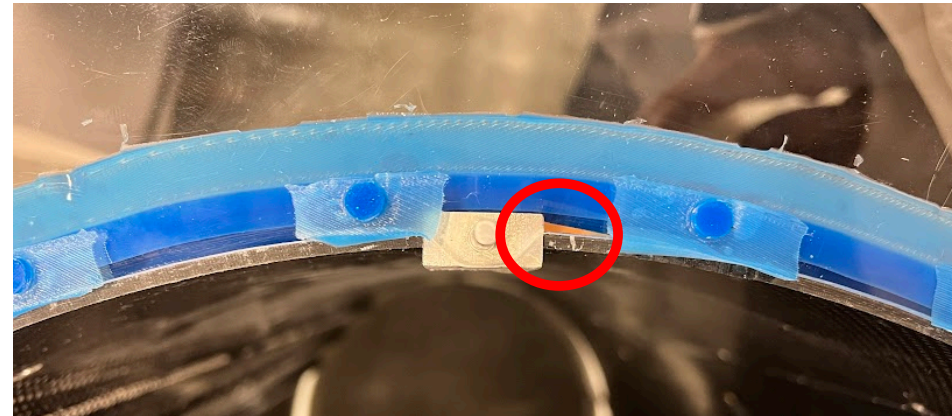
$1/8''$ & $3/32''$ showed sufficient resistance to a tensile stretch
(Any size below were too elastic)



Installment test



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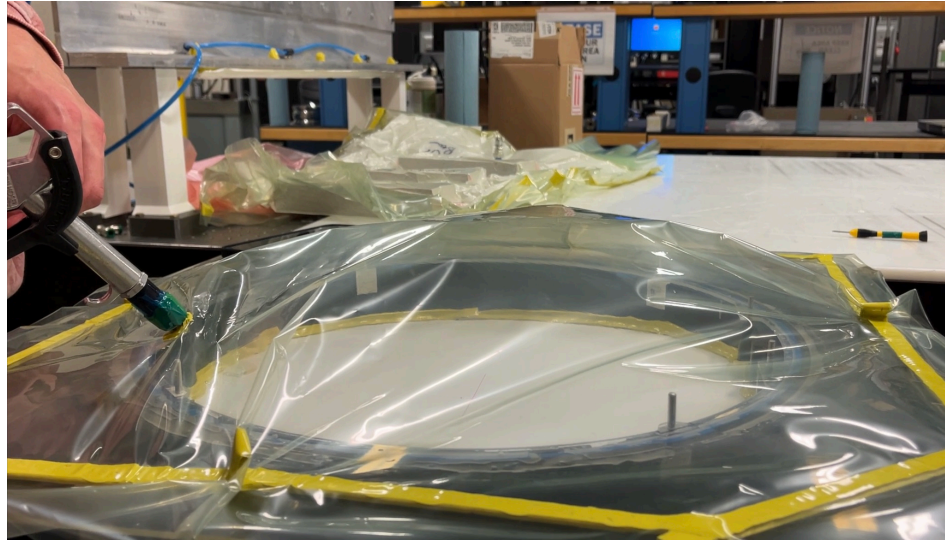
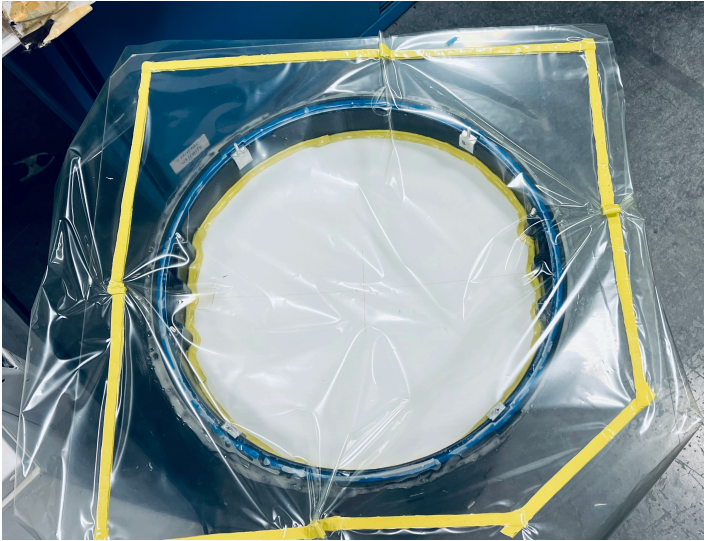
Observed:

- Weak connection
- Fragile buttons
- Pin bracket gaps

Solution:

- Harder silicone (30 – 50)
- Bigger diameter holes?
- Rectangular cutouts

Seal test



Input:

40 psi

Reading:

30 psi while full throttle
(= partially restricted flow)

Observation:

Feel of resistance when
pressing down the top
membrane

Q: How does one quantitatively measure the effect of the seal?