Heavy Gas Cherenkov Detector: Window Material Pressure Test

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Purpose

As part of the prototyping process for the new Heavy Gas Cherenkov detector (HGC), we are seeking a suitable material for the entrance window. The HGC will be filled with gas at a pressure of approximately $1.5atm$, or $22.05psi$ (that is, $0.5atm$ or $7.35psi$ above normal), and must fit in the SoLID assembly at Jefferson Lab Hall A. As such the material must not only withstand the pressure difference, but do so with minimal bulging (no more than approximately 3").

Procedure

We have received a sample of three-layer tedlar-mylar (1.5 mil Tedlar, 3mil PET, 1.5 mil Tedlar) from Madico Inc.[1] to test its ability to hold pressure. We cut and mounted the material over a prototype window frame, as in the design for the HGC. The schematic for the window is shown in Fig. 1 [2]. The window was then fixed to a steel plate with an O-ring to provide an airtight seal. A precision depth-gauge was mounted above the window to measure the height of the bulging. Air was pumped through a hole in the under side of the plate using a bicycle pump attached to a pressure gauge and valve. See Fig. 2.

Measurements were taken by closing the valve at desired pressure values, and then waiting 30 seconds before measuring the bulge height (as the material continued to stretch slowly even after the valve was closed). We also performed a "soak test" by leaving the window pressurized for several hours, to test the material ability to hold pressure over an extended period of time.

Results

Window Puncture and Repair

During the first attempt to inflate the window assembly, the material expanded until taut, at which point the pressure gauge read $0psi$. As we continued to

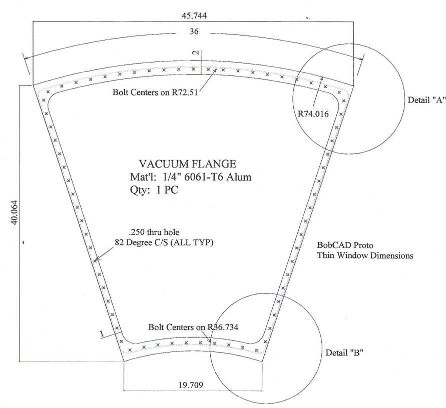

Figure 1: Schematic diagram of the HGC detector window [2].

pump, neither the air pressure nor the height of the bulge changed. It was then that a small anomaly on the material was noted. Upon closer inspection, we found that a small piece of metal had punctured the window. The window had to be removed from the plate in order to repair the puncture using a piece of tedlar-mylar and 5 minute epoxy. We noted many more small metal shavings between the window and the plate, most likely created while boring out the screws on the window frame. After thoroughly cleaning the window, the frame, and the plate, and reassembling, we began to inflate the window again, and air pressure was now rising.

Initial Inflation

Air was pumped in until the pressure gauge read $7psi$, at which point the material had bulged to a height of 5.64". The final reading was taken at 4:08pm. The height of the bulge versus the pressure is shown in Fig. 3 by the black points.

Soak Test

We then left the window over night with the valve closed to observe any changes in pressure and height over time. By 10:24am the next morning, the bulge had increased another 0.85", with no noticeable difference in pressure. By 2:33pm the bulge had increased 0.3", and the pressure had decreased by less than $1psi$.

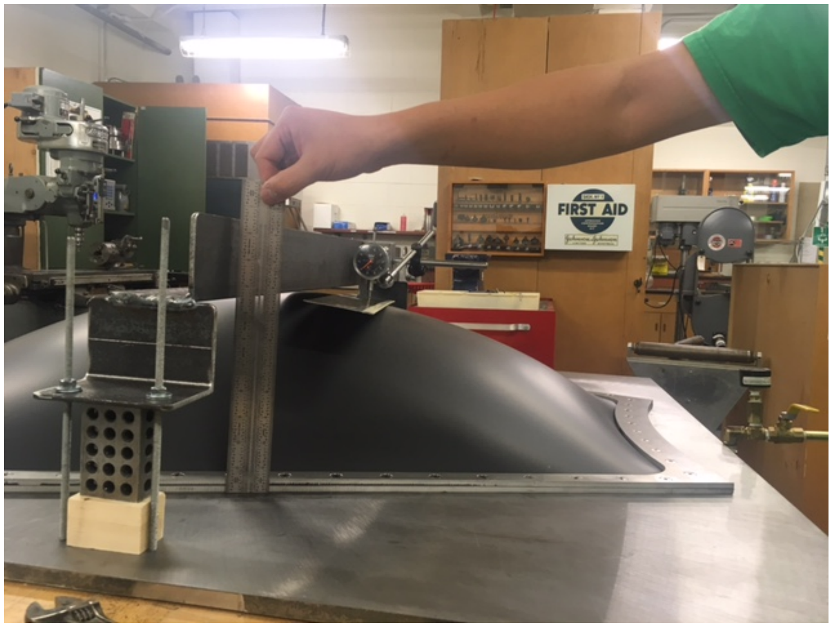

Figure 2: Photograph of experimental setup.

Deflation and Re-inflation

At this point we deflated the window to see how well the material would return to its original shape. The tedlar-mylar mostly retained its fully inflated shape, other than some slight wrinkling near the corners of the frame. We then inflated it back to $7psi$ and, assuming the window had returned to approximately the same height as before, continued to increase the pressure up to $8.5psi$. The results are displayed in Fig. 3 by the red points.

At $8.5psi$, and an increase in bulge of 1.037", we noticed leaking near the edge of the window. The air current from the leak was perceptible by touch, and appeared to be coming from in between the window and the frame. While inspecting the material for the cause of the leak, catastrophic failure occurred, and the window burst. Fig 4 shows the aftermath.

Conclusions

The leak occurred at a point along the window frame close to where the previously noted repair was. The hardened epoxy over the patch may have been a factor in the failure, as the material was not able to stretch at this point.

This material created a good air-tight seal, as demonstrated by the negligible pressure drop after being left over night. However, due to the degree to which the material expanded under pressure, we feel that the three layer tedlar-mylar will not be a suitable window material for use in the HGC.

Tedlar-mylar with a 5 mil instead of 3 mil internal PET layer had also been previously suggested, but based on the performance of the the three-layer material, we do not expect this to be sufficient either. We are currently considering using the three-layer tedlar-mylar to create the air-tight seal, with a carbon-fiber shell to strengthen the window and minimize the bulging. We will also be testing an aluminum window.

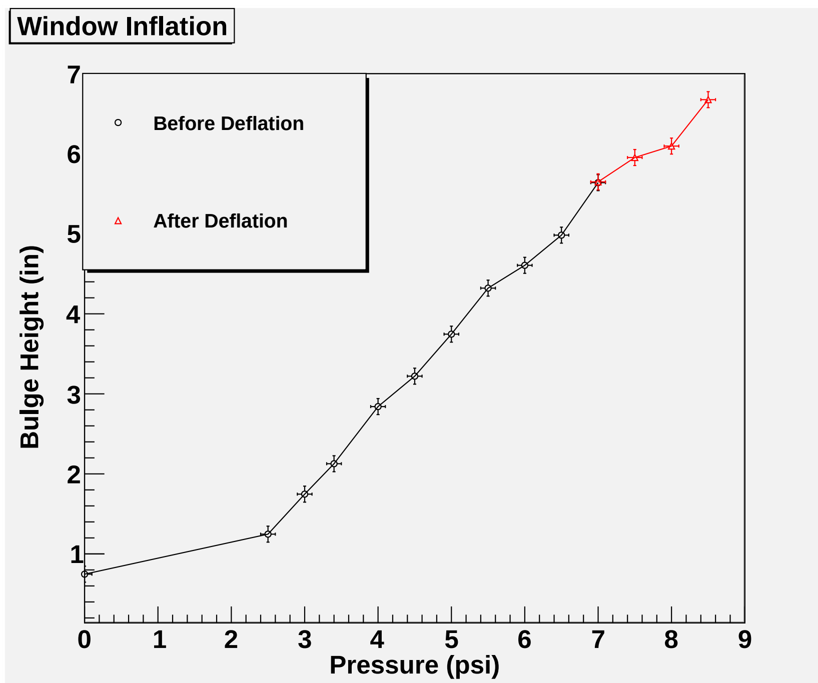

Figure 3: Graph showing height of the bulge in the window versus pressure both before and after deflating the window. We assumed that the bulge returned to within error of the same height at $7psi$ for the second inflation.

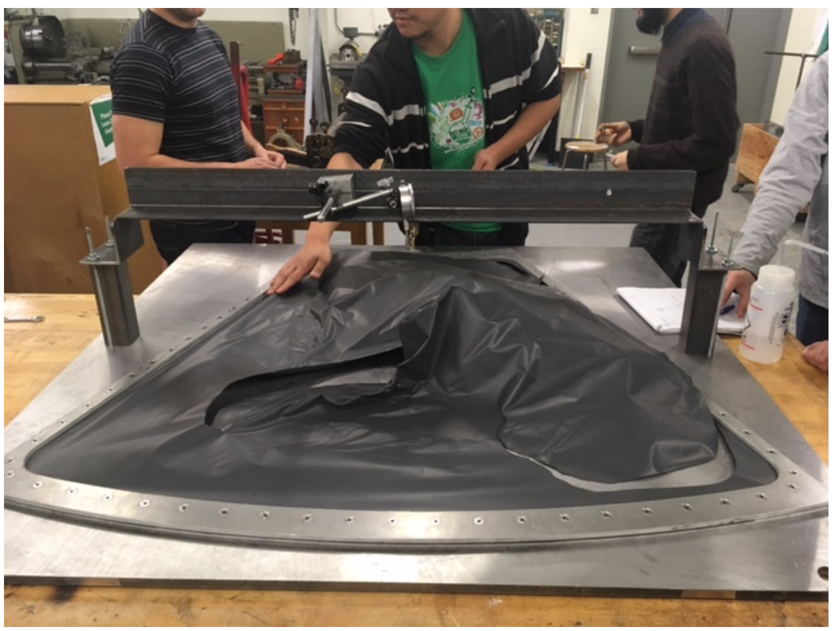

Figure 4: Photo showing the window after it burst.

References

1. Madico Inc. 64 Industrial Parkway, Woburn, MA 01801
2. Lorenz Weber, University of Regina.