Glove Box Sealing Options

Steve Hardy

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1 Overview

The following is a summary of the various options for sealing the acrylic panels to the stainless steel panels that make up the frame of the glovebox. I remind you that the acrylic panels will be constructed of $\frac{3}{8}$in static dissipative acrylic (it will likely be purchased from the TuBro Company), and the panels making up the glovebox are $\frac{1}{16}$in thick stainless steel. During our testing, we used $\frac{1}{4}$in thick sheets of lucite from the machine shop (as a side note, we did not experience any breakage, or crazing, of the panels during our testing, therefore, I do not foresee any structural problems upon scaling up to the larger size).

The original plans called for strips of Buna-N to be compressed between the adjacent panels, and also between the panels and the acrylic. Early tests show that it is highly unlikely that we can compress this sealing material without bending the SS panels around the screw holes, or damaging the acrylic. Ultimately, the choice was made to try several soft materials which, due to Rn emanation concerns, will be partially covered with a metallic foil tape. The materials chosen are as follows:

Material	Size	MMC Num
Expanded Teflon Sealing Material	$\frac{3}{4}$x$\frac{19}{64}$	45925K77
EPDM Bulb Seal	$\frac{3}{4}$	1142A48
Copper Foil Tape	1 x 0.0035	76555A714
304SS Foil Tape	1 x 0.003	76055A694

Four samples were created, and they will be referred to as below:

Sample Number	Seal	Tape	Hole Position
1	EPDM Bulb	SS	Center
2	Teflon	Cu	Offset to Outside
3	Teflon	Cu	Center
4	EPDM	Cu	Center

2 Construction

The process for creating the samples was to first cut and drill pieces of acrylic to compress the seals with. The sealing material was then cut to size, and taped, or clamped, to the SS panel to which it was to mate. Pushpins were then placed in the center of each of the holes, and once all holes were marked, the seal was removed and the holes punched with a $\frac{7}{32}$" diameter cork borer (it should be noted that the holes were punched in the area between the two bulbs on the EPDM seal). The tape was then cut to length and placed such that it did not cover up the holes whilst providing a good seal around the edge that will protrude into the glovebox. As expected, the Cu tape was much more cooperative when it came to bending the tape, especially around the EPDM bulb seal. The adhesive on both tapes was very strong, which does make it almost impossible to reposition a piece of tape on expanded teflon without tearing the teflon. The expanded teflon has an adhesive backing which was removed and then placed on the mating SS panel, however, the EPDM did not have an adhesive backing, so, short lengths of fishing line were used to tie the seal, through the bolts holes, to the panels; once the bolts were in place, the fishing line was removed. In order to ensure that all of the samples were evaluated under identical conditions, a torque wrench was used to tighten each fastener to 1 ft·lb.

3 Testing

After each of the seals were tightened to the aforementioned torque specification, a visual analysis was performed on all of the seals to look for any obvious spots where the two surfaces did not mate. Another visual test was then performed by turning the lights out in the room and then running an led down the surfaces to look for any light leaks. As a final test, a hypodermic needle was placed through an o-ring whose outer diameter matched the inner diameter of a $\frac{1}{4}$in piece of polyethylene tubing. The tube, o-ring, and needle assembly was held together by a small piece of heat shrink tubing and ample amounts of electrical tape. Nitrogen gas was then allowed to flow through this assembly at a pressure of approximately 5 PSIG. The needle assembly was then slowly moved around the interior of the seal while a small piece of a kim-wipe was synchronously moved on the exterior of the glove box, any leaks were indicated by a deflection of the kim wipe from its "equilibrium" position. In the end, every one of the sample seals passed all of the above tests, except at the corners of the joints.

4 Evaluation of Seal Performance

4.1 Performance At Corners

As was mentioned at the end of the last section, I do foresee a problem as to how we will seal the glove box at the corners. The ability of the expanded teflon to expand in the direction parallel to the panel - seal interface represents a sizable advantage over the EPDM. The EPDM is compressed very easily when a load is applied on top of the bulbs, but is very resistant to expansion along the direction parallel to the tabs on the glove box panels. The expanded teflon holds an extreme advantage in this field, however, one must still exercise a reasonable degree of precision when cutting the teflon to length to ensure that it comes as close as possible to mating with its perpendicular partner.

4.2 Structural Properties of The Seal

We ultimately strive to be able to produce a consistent set of seals, and spares, that will work without failure during installation and subsequent removal of panels, acrylic, etc. The EPDM material is far easier to work with than the expanded teflon, mostly due to the "memory" that the EPDM possesses. Boring the bolt holes in the EPDM is a very simple process, whereas the teflon is very easy to tear if one does not make a clean cut and take care when withdrawing the bore. However, just as one would think, applying the tape to a rectangle is much easier than it is to a flat bottom and a rounded surface, especially with the stainless steel tape (the Cu tape essentially eliminates this problem). The EPDM is also much more forgiving when one needs to correct a misalignment of the tape, the strong adhesive on the tape tends to tear the teflon into strips. I must also strongly recommend that we place the bolt holes in the center of the seal, as Figure 4 shows, the off center placement of the bolt holes causes the seal to rip away from itself under bolt insertion and compression.

4.3 Foil Tape Issues

While all of the seal samples passed the quasi-tests that I put them through, there are a few items that bear further discussion. As figure 5 shows, during the construction, application, or compression of the seal, creases of varying depth and spacing form on the tape. These creases are more frequent and more severe in the Stainless Steel tape than with the Copper tape. I think that these creases only pose a serious problem if they span the width of the seal, thus allowing a path for Rn from CR4 to enter the glove box if the pressure ever goes negative (or, in the case of the EPDM seal, allow Rn from the area between the bulbs to enter the glove box under the same conditions). Thus, I feel that a visual check for these creases after seal application and compression is sufficient to alleviate any concerns. Additionally, I feel that that the challenges one encounters when trying to cut, apply, or otherwise work with the Stainless Steel tape make the Copper tape a clear choice (as long as we can fight off any concerns about Cu in the glove box).

5 Summary & Recommendation

After all is said and done, I am slightly dismayed at the fact that I was not able to create a test which any of the samples failed, however, I think there are several other issues that combine to make the choice relatively easily. To summarize:

Sample	Corner Performance	Tape Quality	Overall Recommendation
1	Poor	Mediocre	A Last Resort
2	Very Good	Excellent	Highly Recommended
3	Good	Good	Not Recommended*
4	Poor	Excellent	Recommended if # 2 fails**

* Seal tore at bolt holes

** Easiest configuration to construct

Thus, as the above table indicates, my personal recommendation is $\frac{3}{4}$in width expanded teflon with Copper foil tape used as a Radon barrier. This does not alleviate the need to exercise extreme care in cutting the teflon to length to ensure that the corners are sealed adequately. Several figures, some of which were referenced above are provided in the following pages for reference, more pictures can be found at www.phys.vt.edu/ borex/GB.

Figure 1: Sample 1 Exterior Edge

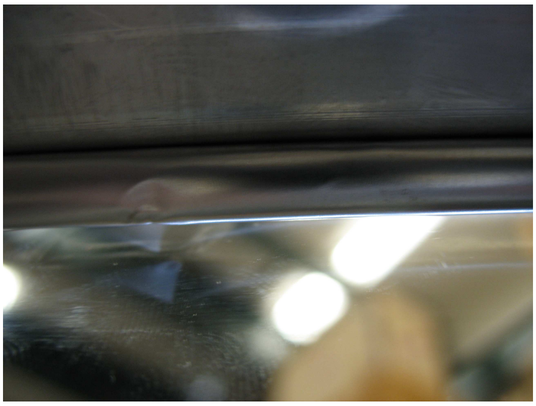

Figure 2: Sample 1 Interior Edge Closeup

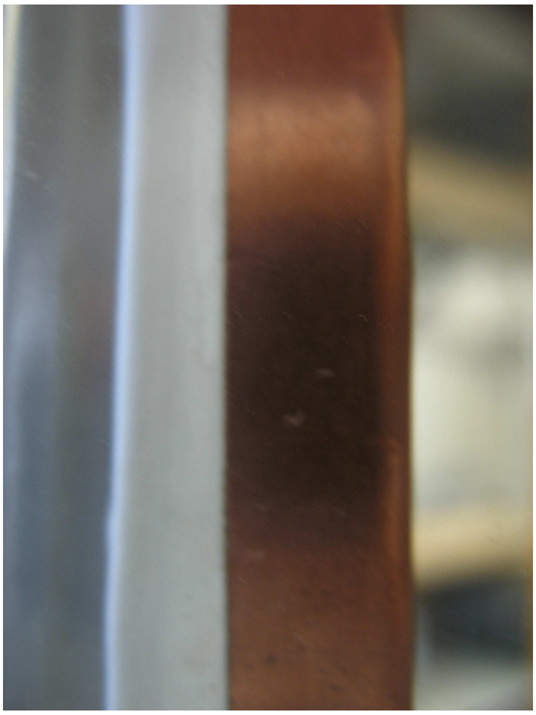

Figure 3: Sample 2 Front View

Figure 4: Sample 3 Exterior View, Note that the seal has ripped around bolts

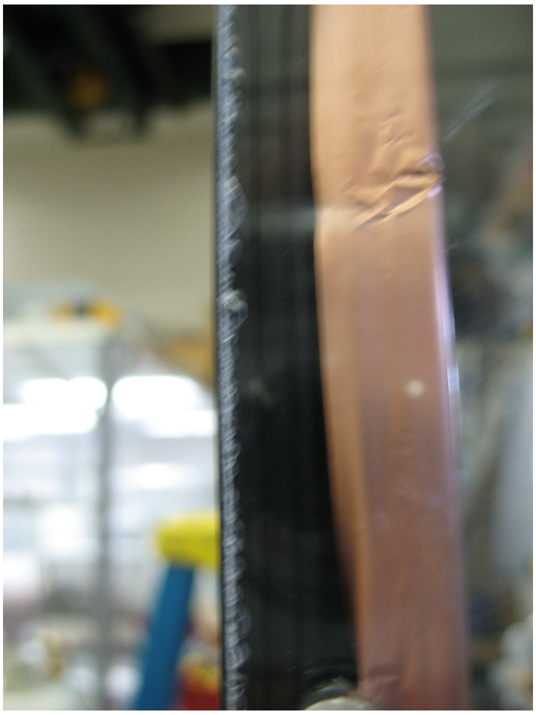

Figure 5: Sample 4 Front View

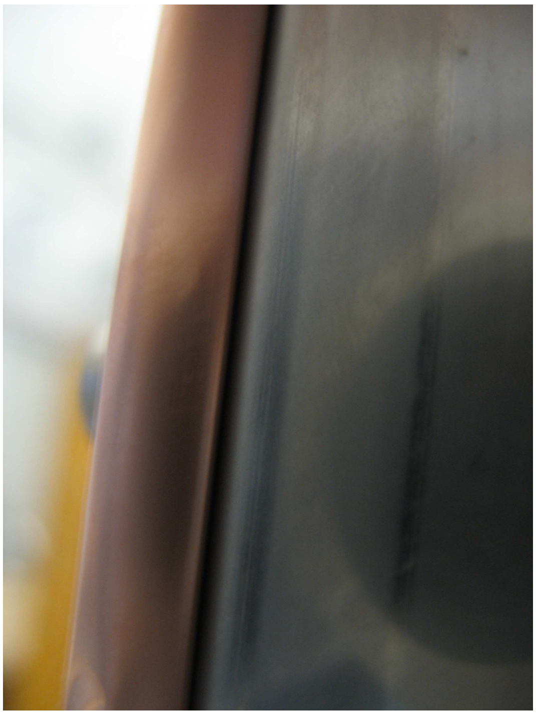

Figure 6: Sample 4 Interior View