Development of Molded Foam Egg Protectors

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Summary

The purpose of this project was to create a new type of payload protection for use in model rockets. Some payloads, like raw eggs, could use something more sophisticated than just “dog barf” wadding and a plastic bag. I felt that a molded foam protector, that completely conformed to the surface of the egg would give better cushioning.

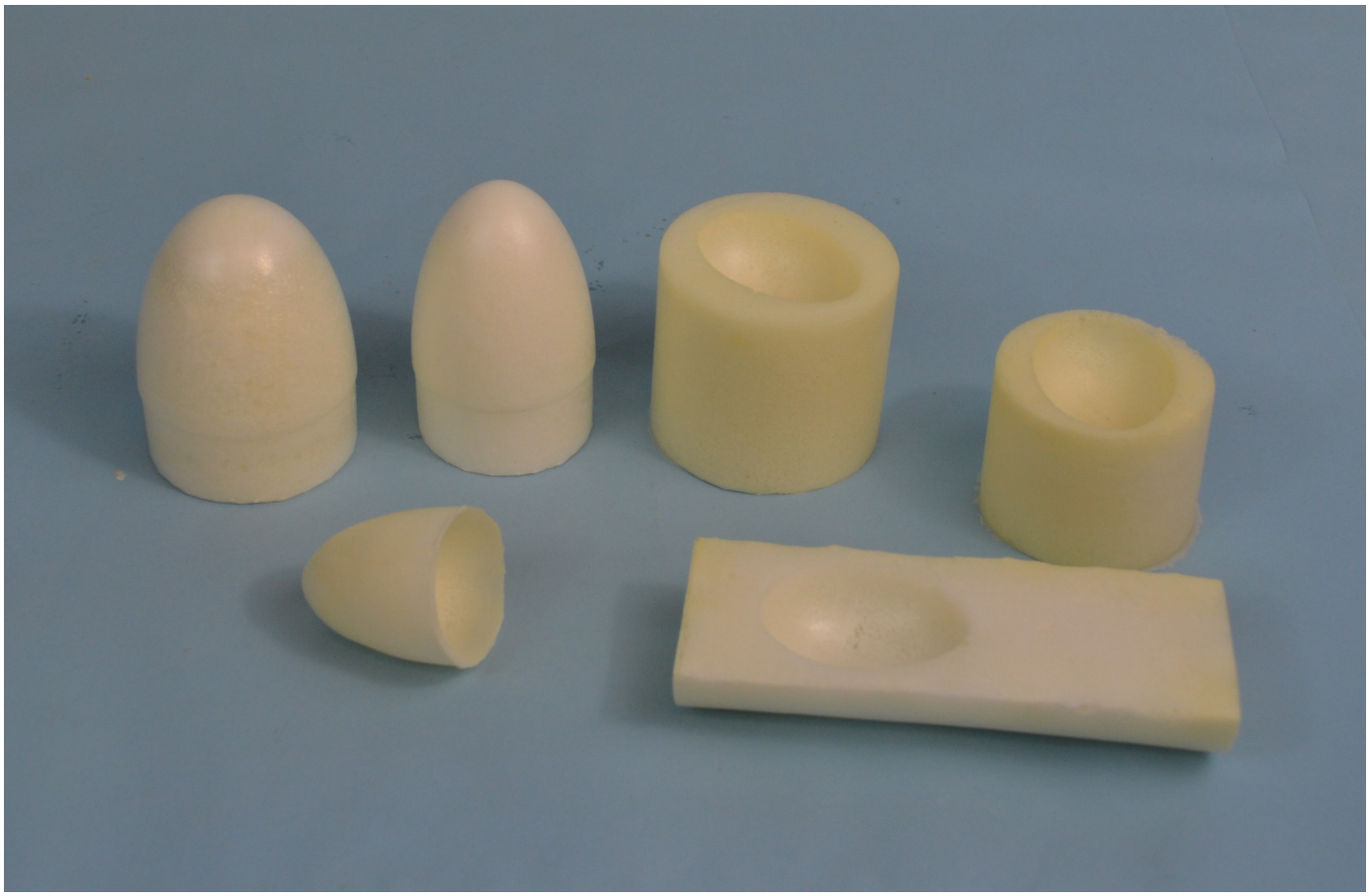
The research aspect of the project was trying to track down a supplier of foam that would provide good cushioning. This took several weeks of searching, and one was found that sold in reasonably small quantities.

The next step was to make a life-size prototype of the part. This would be a hard part, because it would be used to make a silicone rubber mold. Because eggs don’t have a defined surface shape, this process was difficult.

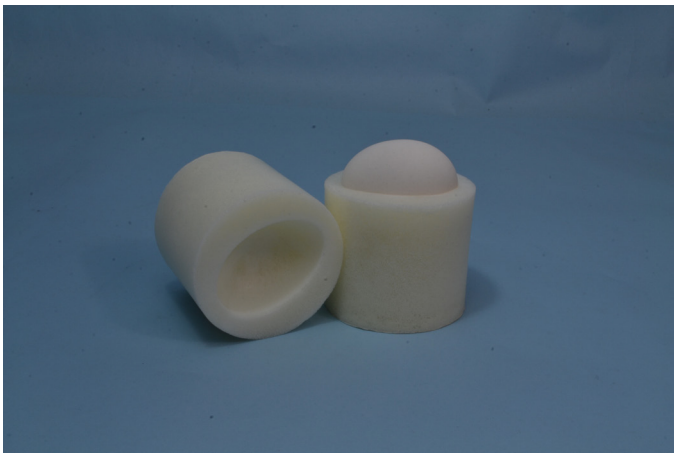
Finally, the silicone rubber mold was made that could be used to make the cast foam parts.

The process was further extended to make a hard-sided mold out of casting resin. The advantage of the hard-sided mold over a rubber mold, as I found out, is that the urethane is sticky and will even stick to silicone. The hard-sided mold allows you to use a mold release that makes the parts slick and smooth.

This report documents the steps a person might have to take if they would like to duplicate the creation of molded foam parts for their rockets. It worked so well for me, that I have created six different types of foam protectors for eggs as well as for altimeters.



The objectives of the work



The objective of this project was to figure out how to make soft foam protectors that completely conform to the shape of an egg.

This project started in response to a need I saw in the TARC competition for the 2012-2013 contest year. What I felt made the contest harder was orienting the egg sideways in the rocket. My question was, "how do you determine that the egg is actually sideways in the rocket?"

I thought that if the students had some sort of cradle to hold the egg, then it would be easy to prove that it was sideways. Moreover, if the cradle was made from soft foam, then it would also protect the egg better. One of the chief reasons eggs break is because of uneven padding. If the padding, say crumpled up dog-barf wadding (loose cellulose insulation) is uneven, the egg can shift within the padding. And it is not as uniform as the modeler hopes it will be. Sections within the wadding where it is less dense, compress more. Where it is more dense, it compresses less, and creates a pressure point on the egg.

The egg is obviously better protected when the padding compresses evenly, and doesn't create any pressure points.

I felt the key to making such a foam cradle was finding the right foam to make it out of. I knew that rigid grow-foam was available, so I figured that a soft foam must also be out there somewhere.

It took many days, but I finally found a company near Hollywood, California, in the special-effects industry that had such a soft foam. As soon as I found it, I ordered a sample from them, and after mixing up a sample in a cup, I knew it would work for making the egg protectors.

The approach taken

Once I had the soft grow-foam in house, I needed to make a physical model of the cradle. This has to be made solid, so that a silicone rubber mold can be made of it.

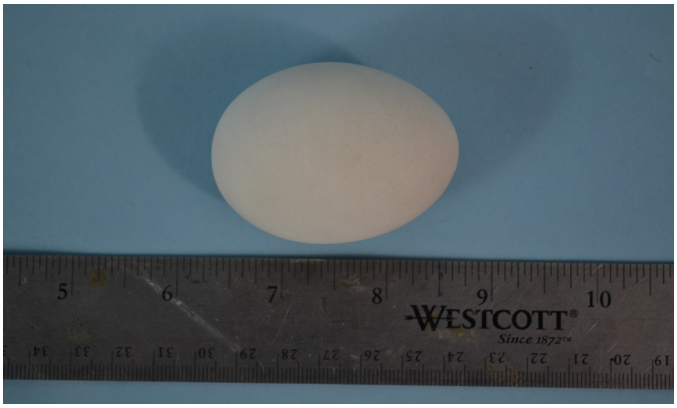
Making this first prototype is something that I found hard to accomplish. The objective is for a cylinder with a egg impression in it. But it is the "impression" that is the hard part. Initially, I thought that pressing an egg into soft modeling clay would work. But my experience with making molds of clay prototypes had me wanting for something better. I have a hard time making a perfectly smooth surface in clay, and I knew I'd eventually need a smooth surface to make the final rubber mold.

I decided to use an actual egg to make the impression. I thought I could pour in some solid casting resin around the egg, and then crack the egg and peel out the hard shell. This is the technique I settled on initially, and it did work.

Making the egg impression

Step 1: Create a dam to prevent the casting resin from flowing around the full perimeter of the egg.

You only need half of the egg (side profile). To create the dam, I needed a flat plate that the egg would just fit through. Since every egg is a little bit different, created an outline of the egg by photographing it, and used that to create a template. The photo printout was transferred to paper, and that was glued to a stiff piece of plastic, and the egg shape was cut out.



A photo of the egg was used to make an outline that could be pasted to a stiff piece of plastic.

Cutting out the pattern isn't exact, so there were some gaps around the perimeter. These were sealed with modeling clay.

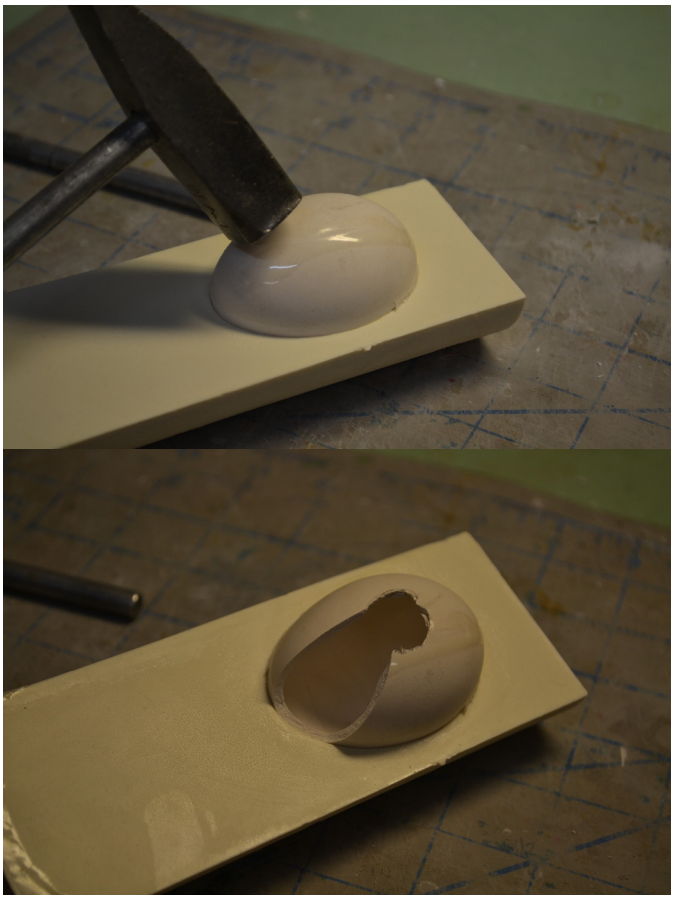
After the egg was sealed into the floor, perimeter walls can be assembled around the egg to hold the casting resin. In this case, I used a BT-80 tube coupler around the egg, since I wanted the part to fit into a BT-80 tube. Again, sealing the edges where the tube meets the floor is the critical part of the process, as no resin can leak out once it is poured. The tube was sealed with white glue. The advantage of white glue is that it doesn't stick to plastic, so it is easy to remove once the resin has cured.

When all the glue is dry, a two-part urethane casting resin is mixed, and then poured into the mold. The depth of the resin in the mold should be greater than the height of the final part. It is easy to make a mold smaller, than it is to make it larger.

The nice characteristic of casting resin, is that it cures within an hour. And then the mold box is completely removed from around the perimeter of the resin.

Exactly one-half of the egg surface is needed, so the thickness of the plastic must be accounted for.

The egg is cracked to remove it from the mold. Even if it is hard boiled, the egg sweats because of the heat generated by the chemical reaction in the casting resin. The resin seems to stick to the egg shell really well because of this, even if it covered in mold release. Normally I don't use mold release with casting resin, because the mold box that I use is not reused. I just cut or sand off anything that sticks to the resin.



The shell is cracked to aid in removing the egg from the resin mold.

Later I found life-size ceramic eggs at Hobby Lobby that work better than real eggs. They are just as fragile, but they don't sweat from the heat of the reaction in the casting resin, and the broken shards don't smell and ooze once they are broken out of the mold.

The end goal of the process up to this point is to make a solid model of the part you desire in soft foam. The only other difference, is that you want the surface to be glass smooth.

Even if you had a glass smooth surface in your mold box, I've never seem to get a glass smooth resin part out of a mold. It usually has small pitting and voids on the surface where the resin didn't make good contact with the mold.

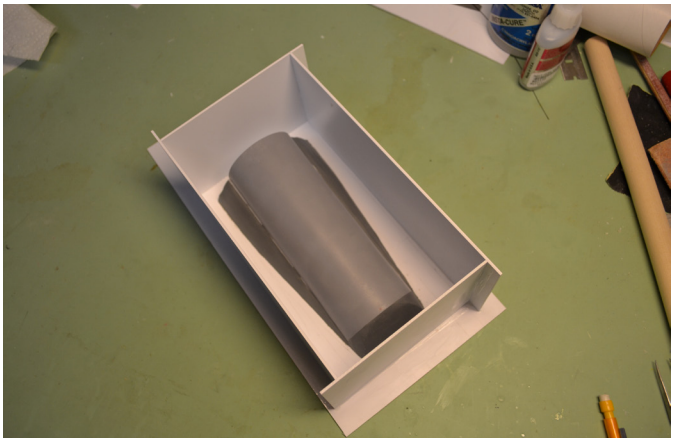
Imperfections in the solid prototype can be filled with filler and then sanded smooth.

These surface imperfections need to be fixed. Fortunately, it isn't a hard process to fix the surface. The same modeling skills that are used to make a slick finish on a rocket are adequate for this process too. It is just sanding, filling gaps with filler, and painting it. For paint, I use a sandable automotive primer. It may take several coats to fill the imperfections, but it is worth it. Seeing a slick finished model is one to the pleasures I get out of the process.

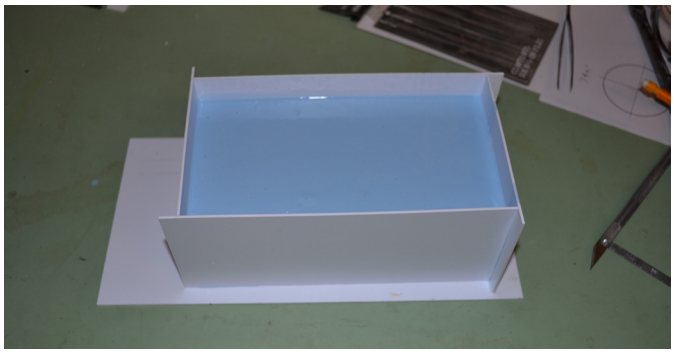
Turning the Model Into Foam

The next step in making foam parts, is to make another mold of this slick model. This mold will be made from silicone RTV rubber. It would be just like making a duplicate of a part from casting resin, where you need a silicone mold to pour the resin into. But instead of casting resin, we can use flexible urethane foam.

You can't simple just pour the liquid silicone RTV rubber over the model. It would ooze all over your table. So you have to build another mold-box to contain the rubber until it hardens. Again, as we did previously, a mold box is built from sheet styrene around the model.


A temporary box is built around the prototype to hold the silicone RTV rubber.

The model usually has one flat surface. This will be the glued to the piece of mold-box that is the bottom. And then sides are build up around the model. Again, white glue is what I use, because it allows the mold-box to be disassembled quickly. But you do have to make sure the glue is completely dry before you pour silicone rubber into box. Wet glue has no strength, and the sides will come apart when the heavy liquid silicone RTV is poured into it (I speak from experience... been there, done that).

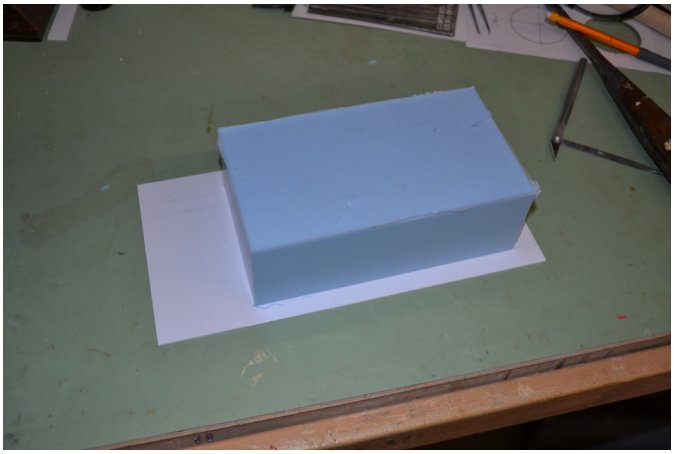


The silicone RTV rubber is then mixed in the

proper ratio, and poured slowly into the box. The reason is to try to limit the number of air bubbles that get caught in the rubber. For making foam parts, this isn't as big of an issue as making cast resin parts, but it is always good to stay in practice for when making other parts.

It takes a good 24 hours for the RTV to fully cure to its finally hard state. In cold weather, I like to put the curing rubber in a warm place to accelerate the chemical cure.

When the rubber is hard as it is going to get (when it doesn't feel sticky), the mold sides are ripped off, and the original prototype is removed.



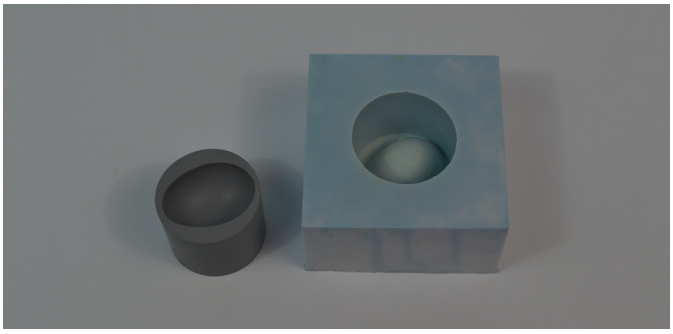
Once the sides are removed, the flashing is cut off.

The rubber usually has excess flashing that oozed in the cracks of the mold box, or clung to the sides. This is cut off either with a pair of scissors or a sharp hobby knife. After clean-up, the mold is ready to use (maybe...)

Making the Flexible Foam Parts

The urethane foam is very similar to casting resin. It comes in a 2-part mixture that creates a chemical reaction and foams up. The typical growth for adequately mixed resin is over 20 times the original volume.

The silicone rubber mold, as described above, might work with the foam material. It really depends on the type of foam being used. For the lightweight foam that I used to make the egg protectors seems to work just fine with the silicone RTV rubber.



The prototype part, and the finished rubber mold.

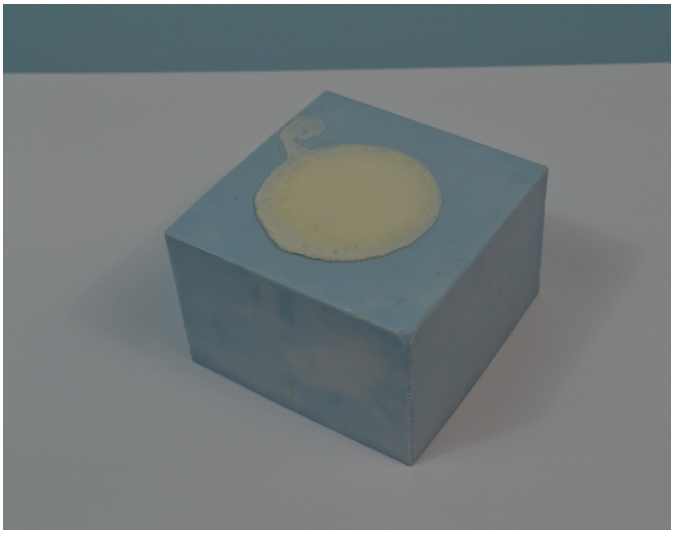
Other foams, such as the denser (4-lb per cubic foot) mix that I use to make protective nose cones, sticks to the silicone RTV rubber. So pulling the part out of the mold always leaves behind the skin of the foam. The manufacturer of the foam recommends a "hard mold" and the use of mold release. This process will be described later.

For the type of foam that can be poured directly into the silicone RTV molds, the process of making parts is straight forward. Simply mix up the the two-part mixture, and pour it into the mold. The only extra step that you have to do is to put a lid on the mold to force the growth of the foam to the top corners of the mold.

A lid for the mold can be made out of a stiff piece of plastic. It must have a coating of mold release so the foam doesn't stick to it.

For the lid, I simply use a piece of thick (stiff) plastic sheet. A little bit of mold release applied to the surface will keep the urethane foam

A heavy weight needs to be applied to the top to prevent the lid from being pushed off. But it can't block the vent hole in the lid.



A finished part, ready to be pulled out of the mold.

from sticking to the lid.

A hole also needs to be cut into the lid to allow the expanding foam a place to escape the mold if you pour in too much resin. I use a hole about 1/4-inch diameter for venting. The resin will foam up through this hole, and create a mushroom shape on the upper side. Because the resin is on both sides of the lid, you have to make sure to apply mold release to both sides of the lid. The urethane foam will stick like Gorilla Glue to anything without mold release. This is why I use lids that I can throw away should I forget to put mold release on the top side.

Even with vent hole, the resin will still try to push the lid off the mold. To prevent this from happening, and ending up with a muffin-top part, you have to place weights on the upper side of the lid. They have to be placed strategically on the lid – it is desirable to have them in the middle so they are effective in keeping the lid from rising up. But at the same time, if they are too close to the vent hole, the excess resin that oozes out can cover the weights too. I like to use old silicone molds that I have lying around as the weights, because then I don't have to cover them with mold release too.

The reaction in the resin that creates the foaming bubbles occurs very quickly. It will start foaming in as little as 20 seconds. This means you have to mix the resin quickly and pour it into the box without any delay. Otherwise, you end up trying to pour foam. And "foam" doesn't like to pour, nor will it flow into the corners of your mold. At that point, you end up with large voids in the part that make it useless. Therefore, if you're not quick in pouring the resin, you will end up with a mess and a lot of wasted material.

At the same time, if the "mix" is not done thoroughly, then the final part will be inconsistent. In some areas, where the chemicals were not mixed enough, the foam might be soft, and form a depression in the final part. Again, that will result in a ruined part.

Voids formed in this part because it was already foaming when the resin was poured into the mold.

Self-Skinning Foams

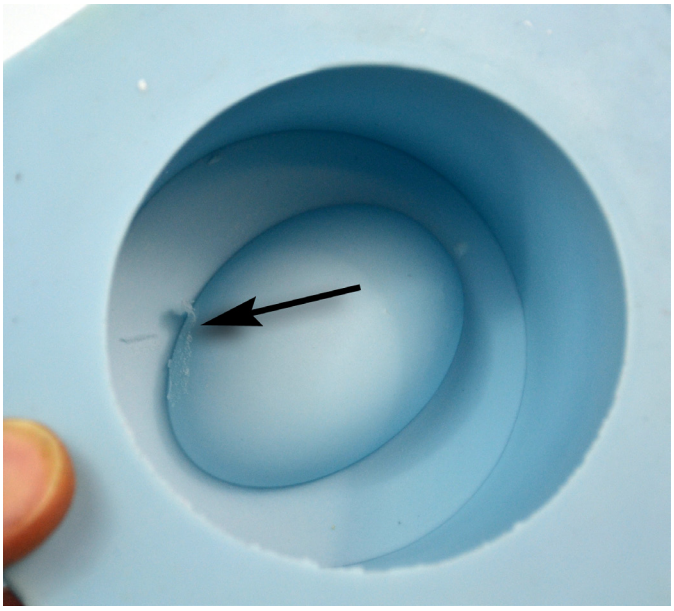
The higher density foams are billed as being self-skinning. The cells inside the foam form complete bubbles. When all squished together, a complete wall is formed along the edges. That means the outer layer that touches the walls of the mold form a tougher skin than the foam that is not self-skinning. The advantage of this for rocketry is that smoother surfaces that are in the airstream have lower drag.

The other advantage is that for “egg lofters,” the skin makes clean up of the yoke easier, should the egg break. Instead of washing out a sponge-like part that absorbs water, it is more like wiping down the surface of a rubber stress-ball. It makes a lot of difference in effort.

I’ve tried the denser, self-skimming foams in a silicone RTV mold, but it sticks to the surface too much, and the skin peals away from the surface. I’ve also tried a variety of mold releases in the silicone mold to prevent the foam from sticking. But they don’t work that well. Some liquid mold releases, because they are petroleum based, are very aggressive and will attack the silicone RTV material. In that case, you degrade the rubber mold very quickly.

The spray-on wax mold releases, which work really well in “hard molds” don’t do an adequate job when sprayed on silicone RTV rubber. It seems to be some sort of chemical reaction between the silicone and the mold release.

Because of this, it is better to use a hard mold rather than a silicone RTV rubber mold. In that case, the mold should theoretically last forever. So if the plan is making a lot of parts, then making a hard mold is definitely worth the effort.



Part of the skin remained in the mold. For external parts, like nose cones, this will mean the surface will be rough and draggy.

Making a Hard Mold

The process of making a hard mold picks up right after the silicone rubber mold is pulled off from the original prototype. You have to make that original rubber mold first, so you aren’t wasting any time here.

What comes next is making a rubber mold using the original rubber mold as the “prototype.”

While it sounds straight forward, it is a bit more complex than making the original mold. There are two reasons that it is more complex. First, pouring fresh silicone RTV over the top of cured silicone RTV rubber makes a solid part. In other words, the silicone fuses so well to silicone, that you’ll never be able to pry them apart. You need a barrier on top of the first silicone RTV mold before you can pour fresh rubber on top of it. Fortunately, a light misting of spray paint makes an effective barrier that prevents the second pouring of silicone from meshing with the first mold.

The second thing that makes it more complex, is that you have to start thinking ahead and determine if you want "full" mold, or a "partial" mode. The advantage of the partial mold, is that it uses less silicone, and therefore is less expensive to make. The downside is that once the "partial" reverse silicone mold is made, you have to build a secondary mold box to contain the casting resin. So it becomes more labor

intensive to make and takes a bit longer.

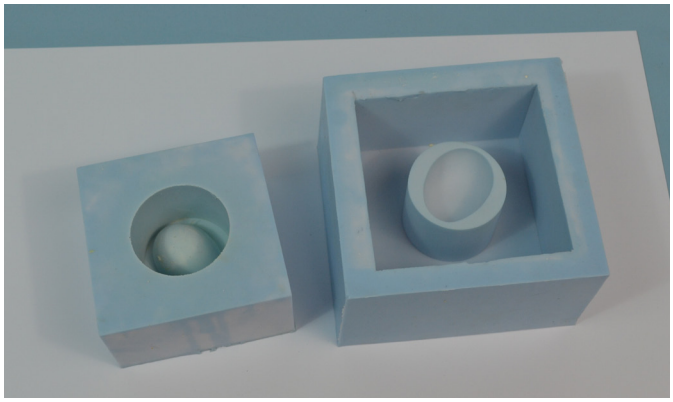
The "full" mold means building a box around the entire mold, leaving a 1/2-inch to 1-inch gap around the perimeter of the first mold. This will fill up with silicon RTV rubber, and when cured, it will create a complete mold box around the part. The advantage is that once you remove the first prototype mold, you can simply pour casting resin into the cavity, and have a hard mold in a couple of hours. It is fast, but it can be expensive. I probably would only recommend this if you need several hard molds to create a lot of soft foam parts quickly and for a long production run.

The end result of the second silicone RTV rubber mold, is that you've reversed the first mold. So if you pour casting resin into it, you'll end up with a duplicate of the first mold, but it will be "hard" instead of rubbery like the first mold.

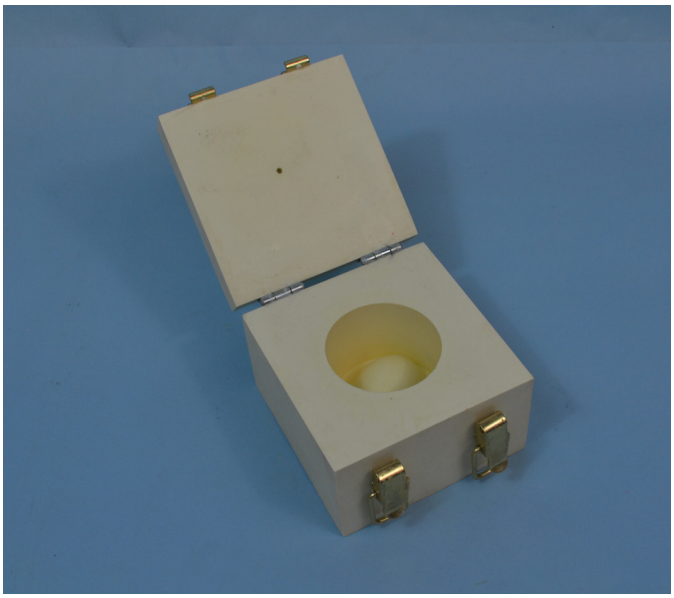
Like the first silicone RTV mold, it will have an open top that needs to be covered when the urethane foam is poured into it. Again, a simple sheet of thick plastic with a hole in it works fine. As before, it needs to be weighted down to prevent the foam from creating a muffin-top.

But because the mold sides are hard, there exist the possibility to put hinges into the mold and create a top that swings open. Once you do this, it quickly becomes apparent that you can put a clasp (or two) on the side opposite the hinge to hold the top shut during the expansion of the foam. But you still must have a vent hole in the lid to allow for the excess urethane foam to ooze out, or the internal pressure would blow apart the hinge and possibly ruin the whole mold.

The big advantage of a hinged top is that it allows you to quickly shut the mold and lock down the lid. It is significantly faster than trying to arrange the weights on the lid to prevent them from being covered in urethane foam. If you are doing several molds at the same time, this speed really helps, because you have so little time to pour the mixture before it starts foaming up.



A full mold (right side) creates a "walled" box around the part. This allows you to pour casting resin directly into the box. This saves time if you are making multiple molds for producing foam parts. But it uses a lot of expensive silicone RTV rubber.



A replica of the original mold, but made from hard casting resin. A solid top can also be added, and hinged to make closing the mold easier and quicker. The added clasps hold the lid tightly closed, which also makes clean-up easier.

Mold Preparation

Before you can pour the urethane foam into the new hard mold, you have to do a little preparation to it. The surface of the inside, because the original silicone RTV was sprayed lightly with paint as a barrier to keep the two layers of silicone from touching, will have a slightly rough texture. It isn't much, and just a little light sanding with some 400 grit sandpaper will make the sides of the hard mold shiny smooth.

Having smooth surfaces in the mold is always good, as it is less likely for the urethane foam to stick to the walls. As mentioned previously, the urethane is like Gorilla Glue, and really sticks to anything it touches.

Even if you have highly polished metal surfaces (the ultimate mold), the urethane foam would still stick to the insides. So a mold release must be used with a hard hold.

The manufacturer of the urethane foam had a pretty good mold release called "Challenge 90" mold release. It is a liquid mold release that is painted on the inside surfaces of the mold with a soft paint brush. It has a lot of petroleum products in the release, so it evaporates and dries very quickly (in less than five minutes). But it also requires that you do the prep work in a well ventilated room.

The manufacturer of Challenge 90 recommends two coats of mold release before you pour the foaming urethan resin into the mold. For the first pour into the new mold, I would give it three coats.

I also recommend coating the outside of the mold with the release agent too. The urethane will leak out on you besides coming out the vent hole in the lid. And if you don't have release agent on the surface, the urethane will stick to it.

Incidentally, removing stuck urethane is a major chore. It involves scraping and sanding the surface. And that can easily mar the mold. And any scratches you put in the mold, are just additional places for the next pour of urethane to grasp on to.

Another mold release that I found to work well, is the "Mold Release and Protector #3470" by Crown. It is typically used in rocketry for people in FAI competitions. It is sprayed onto mandrels before fiberglass is applied. In this way, very lightweight fiberglass tubes can be made.

The big difference is that it comes in aerosol form. That essentially means applying it is easy.

The Crown mold release is more waxy than the Challenge 90 brand. And therefore it covers the surfaces a little bit better. Especially after you've used the mold several times. The mold release doesn't really stick to the part when it is removed, so a build-up of wax grows inside the mold. This is a good thing, in than that less mold release has to be sprayed in, and the parts come out easier.

When too much build-up of the way is in the mold, and the part dimensions are starting to change significantly, the wax can be removed by heating the surface with a heat-gun, and then wiping off the melted wax with a paper towel.

The benefit of heating and melting the wax, is that the surface becomes highly polished. Because of this, the next parts that come out of the mold are very shiny and smooth. For nose cones made with the foaming urethane, this gives you the best looking and lowest drag parts. But it is time consuming to do in production cycles, so I only do it when the molds really need to be cleaned out.

The part on the left came out of a mold where the wax was removed with a heat gun. It left the inside surface of the mold very slick and smooth, so the finished part is very shiney.

Removing Parts From Hard Molds

Because the hard-sided molds don't deform like the silicone RTV rubber molds do, removing the flexible foam parts from the mold is a little different. In the rubber molds, the sides of the molds are flexed and the parts are easy to grasp and to pull out. Because of this feature, rubber molds allow for undercuts

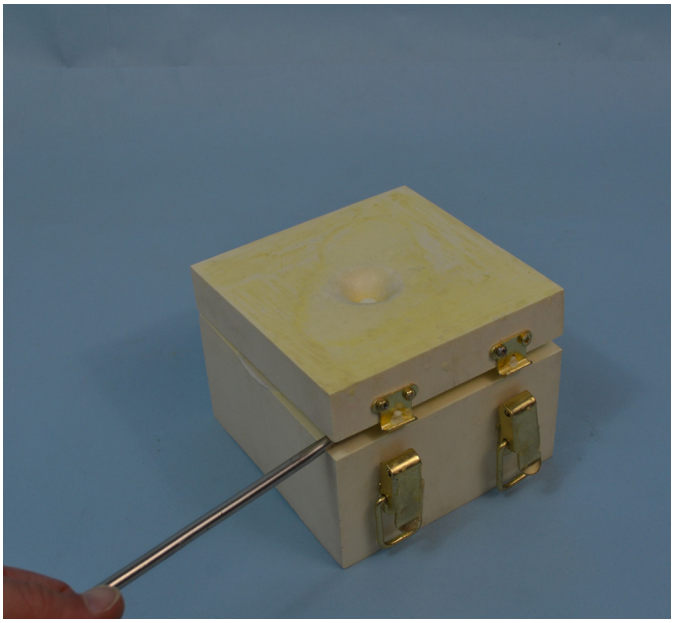
in the parts. An undercut occurs when the opening where the resin is poured in, is smaller than the inside of the mold. Undercuts always make the part harder to remove from the mold; but with silicone RTV rubber, the ability to flex the mold allows the part to be wiggled out.

With hard sided molds, undercuts present a challenge. If the part being manufactured was also solid, like a cast-resin part, it would be impossible to remove the part from the mold. So it would require a mold that had multiple parting-planes and could be disassembled to remove the part.

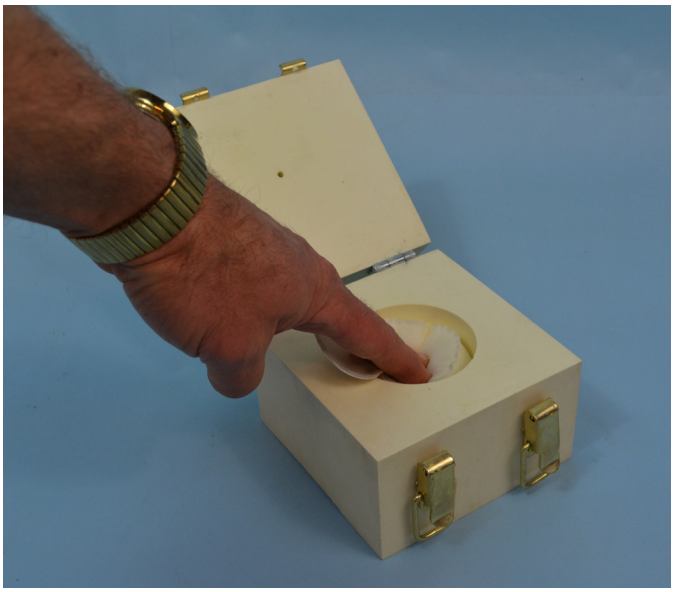
Fortunately, the flexible urethane foam don't require the mold to be disassembled (other than removing the lid with a screw-driver). To remove the parts from the mold, you just compress the part. So instead of deforming the mold, you deform the part.

The manufacturer also recommends massaging the part by compression to work out any stinky vapors that remain in the part, and to "mix" the resin more. They say that a more uniform density is created this way. But it is my opinion that this is a load of huuey. If the resin is already cured, then no amount of kneading is going to mix the remaining resin. I think they say this to pacify the customers that call them and say the foam is inconsistent when cured. At least it gives the customer something to do (stress relief).

For parts made with the self-skimming foam, and are intended to be used as nose cones, I try not to compress them very much. Compression is going to wrinkle the surface, which makes the nose cones have higher drag. To remove them from the mold, I don't push down to compress the foam, but pull the sides inward while wiggling the foam. As soon as the vacuum around the surface is broken, then the part easily pops out of the mold.



A flat blade screw driver is used to pry open the mold. It is really just to break the suction inside.



To remove the part from the hard-sided mold, the foam is compressed so an edge can be grabbed.

Once the part is removed, it does have a slight odor. But this usually goes away within a couple of days.

Two-Part Molds

Up to this point, all the molds were assumed to be one-sided. In other words, one side of the mold was flat, so a flat lid could be put on. All the curvature was in the underside, which is inside the cavity of the mold.

It is possible to put detail (such as curvature) in both sides of the mold. This requires a two-part mold, which adds to the complexity of the process. Making a two-part mold essentially means you get to do each of the steps of the mold-building process twice.

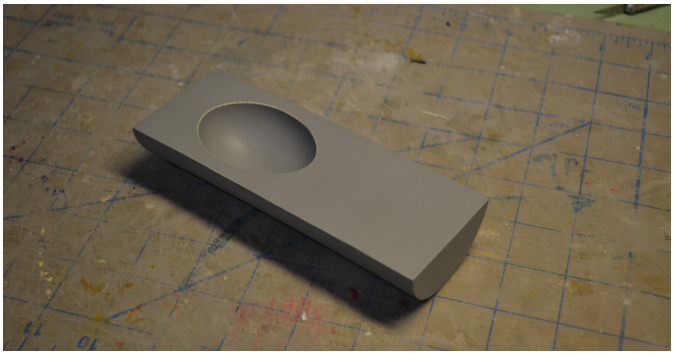
The hardest part of making a two-part mold is actually the very first step. That is mounting the part within the mold box. Since the part may not have a flat surface, mounting it may be difficult. You simply cannot tack-glue it to the base of your mold-box.

The solution to this is to mount the part on a pedestal of clay (use only the Klean Klay brand, as other modeling clays can react with the silicone RTV and prevent it from hardening). By mounting it on a pedestal, you control where the part line will be (along the surface where where the clay touches the part), and you can orient the prototype better. This orientation can be critical for the foaming process of the flexible urethane.

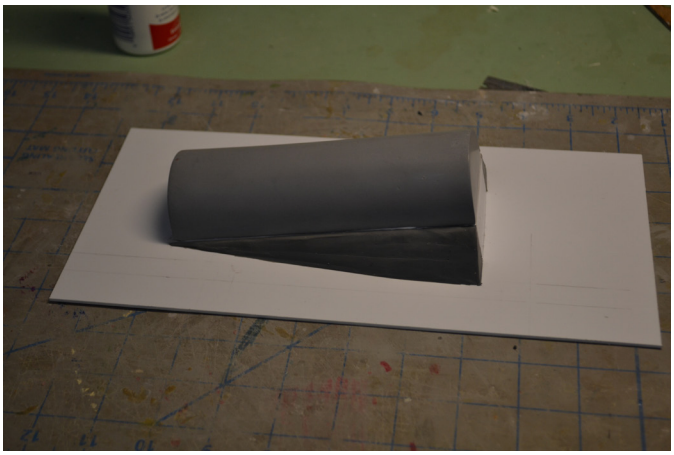
You want the part to foam upward into the mold cavity to take advantage of its natural tendency to expand against gravity. If you can help it, you don't want to try to force the foam to travel horizontally while it expands, as the surface tension will slow the rate of travel of the foam. In the worst case situation, the foam could harden before it travels to the far reaches of the mold cavity.

When I made the BT-70 size, vertical egg protector, I mounted the mold pattern at an angle so that the foam would be take advantage of the foams tendency to grow upwards. The reason I didn't put it totally in a vertical direction, is because it would have had a "side cut" that could only be filled by the foam growing sideways in the cavity. I knew that this would caused a void in the foam, and a useless part.

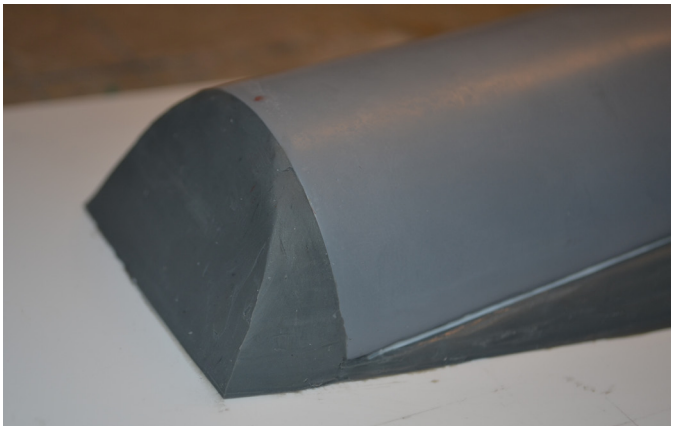
When you mount the part on a pedestal, you have to think "backwards." The side stuck into the pedestal of clay will actually be the TOP of the part. This reverse mode of thinking has caused me to make several mistakes in creating molds, because I thought I was looking at the bottom of the final part, when in effect, I was looking at the top. To further complicate the process, you still have to realize that you're actually building a "cavity," into which the foam has to grow upwards.



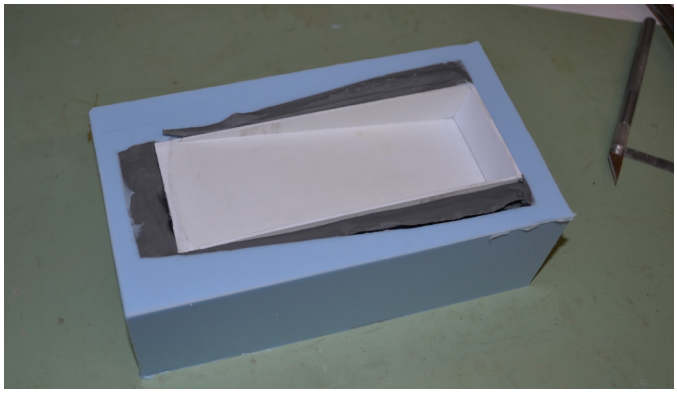
I felt that this prototype part could only be duplicated properly with a 2-sided mold.



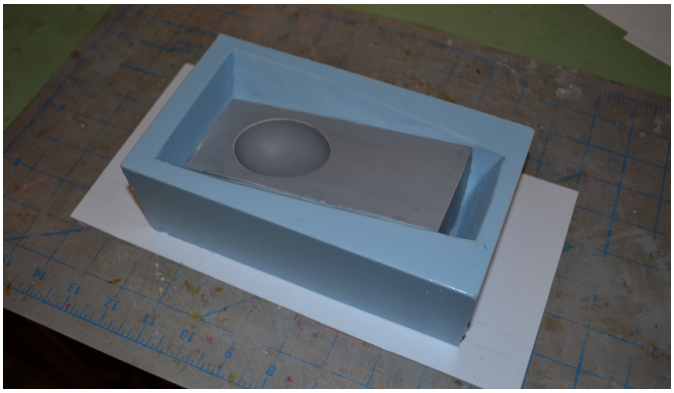
Mounting the prototype on a pedistal of Klean-Klay allows the orientation to be controlled. You want to take advantage of the foam's natural tendency to grow upward, not outward.



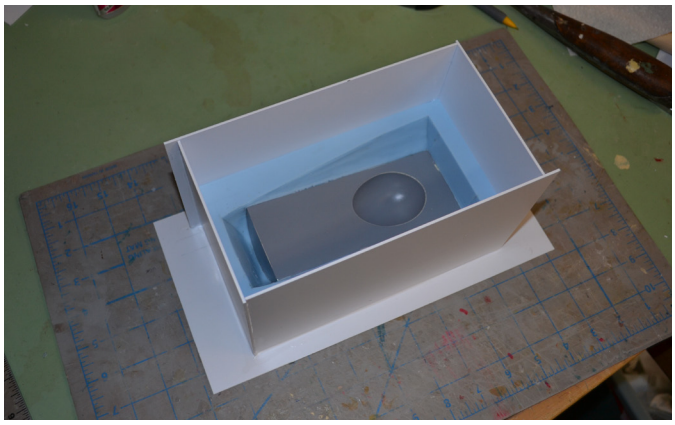
This is an example of "thinking backwards" as well as "thinking ahead." The clay will be in the top section of the "hard mold." The clay was shaped to create a draft angle to allow the mold halves to be put together without an undercuts.



1) The first side of the mold has been made. At this point, the clay and the pedistal can be removed so another layer of silicone RTV rubber can be poured around the part to form the lid of the two part mold.

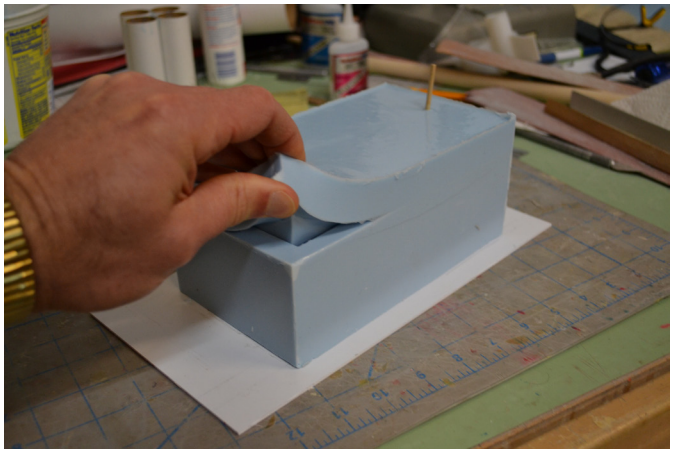


2) The pedistal and the Klean-Klay have been removed from the mold, but the prototype part must not be disturbed during the process. Moving the part will break the seal along the surface and allow silicone to get under the part.

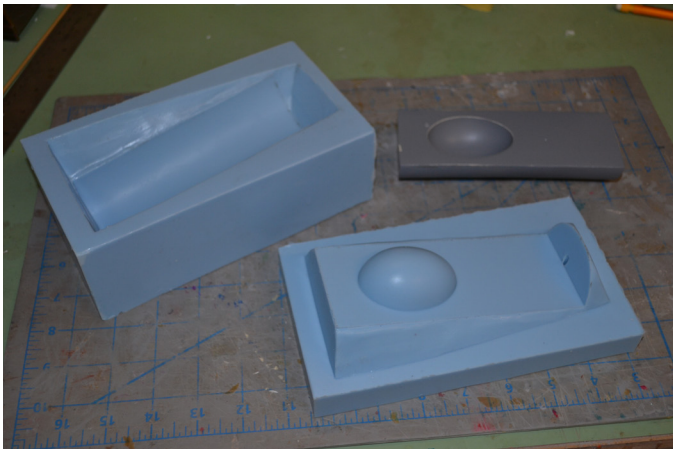


3) Side walls have been built up around the bottom side of the mold. Before more silicone rubber can be poured in, the exposed surface of the rubber must be inhibited to prevent the layers from fusing together. A light mist of spray paint works fine for this task.

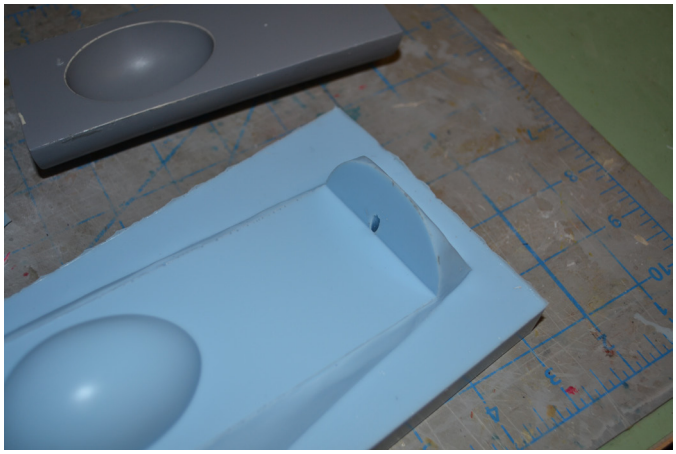
4) I tack-glued a dowel to the top edge of the prototype, because I wanted to create a vent hole for the foam to escape. Later I found out this hole was too small. It needs to be about 1/4-inch diameter. Then I poured in the lid layer of silicone and allowed it to harden.



5) Prying apart the two halves of the mold.



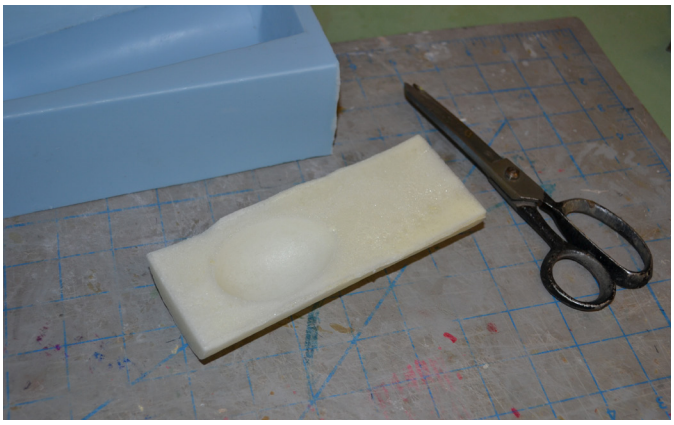
6) The halves apart, and the prototype removed.



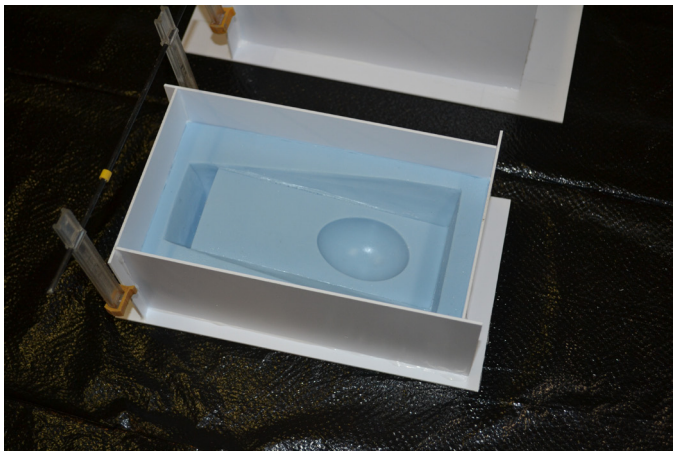
7) Close-up of the vent hole left in the silicone after the dowel was removed.

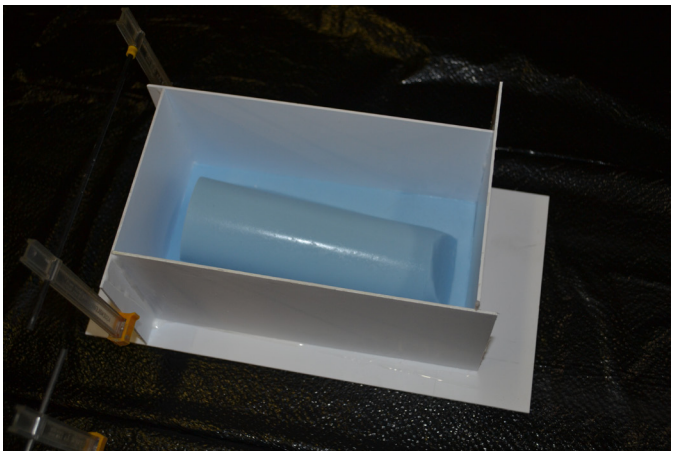
8) The first pour of urethane foam into the mold. Too little foam came out the vent hold, and too much out of the sides. It takes several pours to figure out how much urethane to mix up.

9) The lid is removed, and we can see the first part.

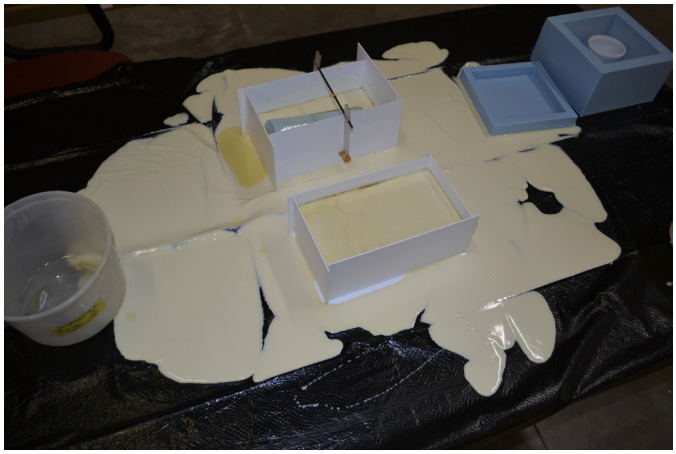


10) The flashing is removed with a sissors to yield the first foam part.

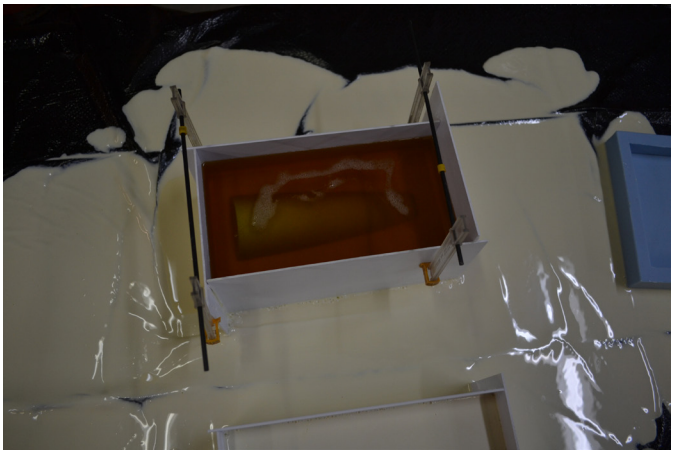




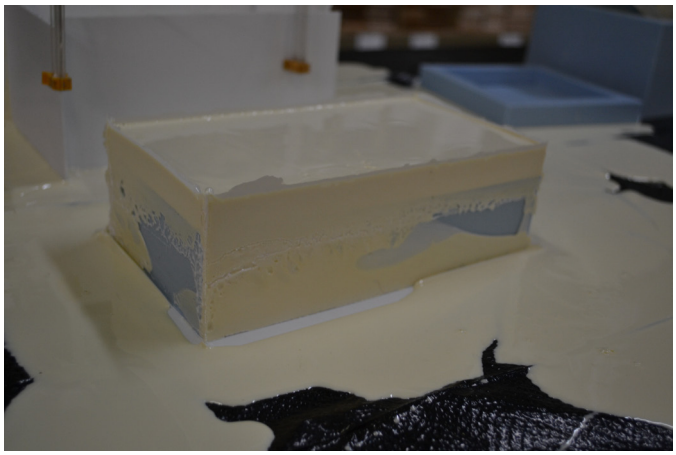
11) Each side of the original rubber mold was "reversed" and are readied for making the hard molds for production foam parts. These "reverse" molds were made by building up walls around the mold halves, and pouring silicone RTV directly over them. Remember, the surface must be inhibited to keep the sides from sticking together. These are "partial molds," since they don't contain walls of silicone around the piece, like shown on page 8.



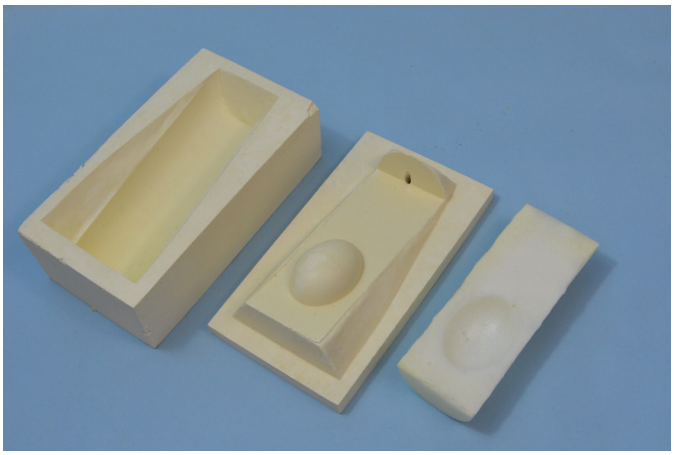
12) A mold mishap. The casting resin leaked out of the mold and pooled on the table. Thank goodness I put plastic sheeting down first.



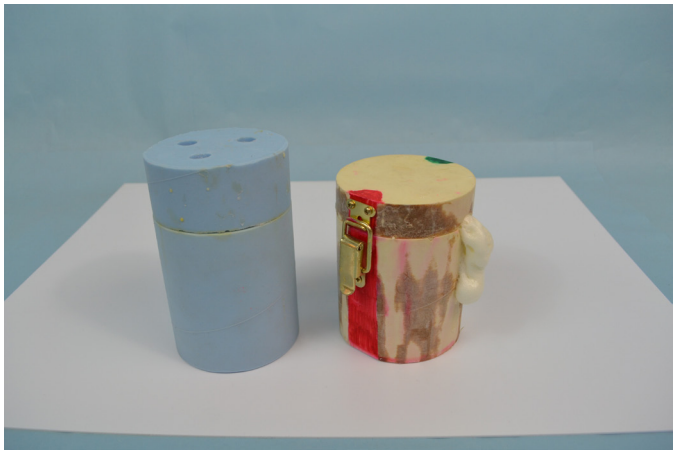
13) A new batch of casting resin was poured into the mold and is just beginning the solidification process. A little bit is still leaking from the mold.



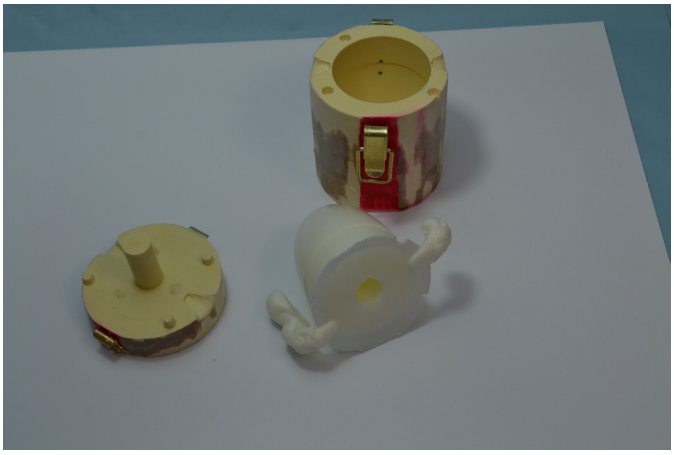
14) The plastic sides of the mold box have been removed. You can see how the resin found its way along the sides of the box. With clean-up, this is a good mold.



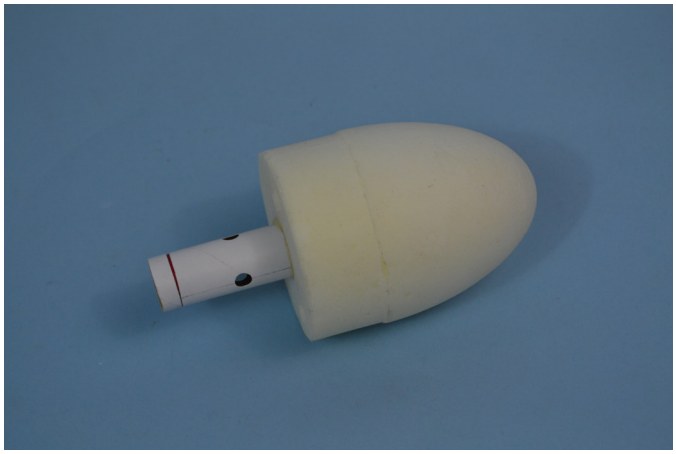
15) The final hard-sided mold and a foam part created in the mold.



The mold box doesn't have to have square corners. You can use a body tube around the mold to make a cylindrical mold. But putting clasps on it is a little bit harder...

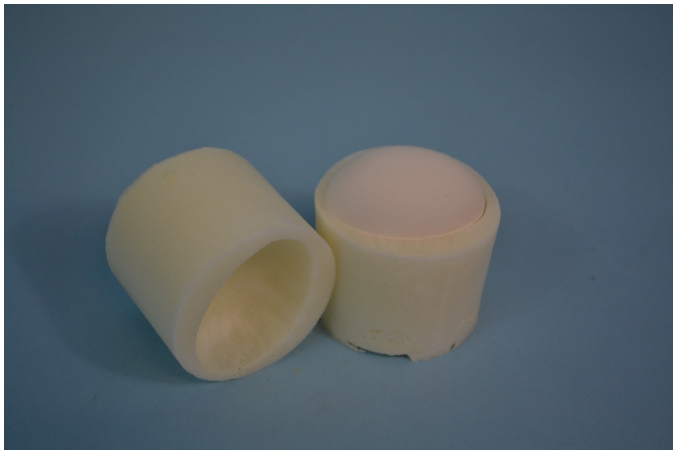


On this mold, I choose to put the vent holes near the side of the part, to make it easier to trim them off. The denser foam that I use for nose cones is harder to trim, so side vents make things easier.

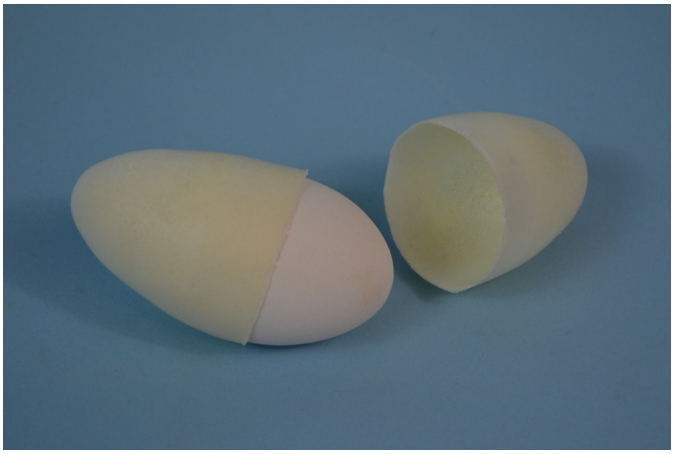


The hole in the base of the nose cone centers up a small body tube, where the altimeter is housed. Not only is it protected, but the egg gets extra protection too.

Gluing parts to the foam can be done with a urethane glue, like Gorilla Glue. Once installed, it is impossible to remove without tearing out the foam.



The sideways mounted egg protector for the TARC competition was my first successful part. It turned out so well that I expanded the number of molds to other sizes and shapes too.



The thin walls of the Apogee egg capsule protector are harder to make. The resin can seem lumpy in thin walls.

The process of building 2-sided molds is further discussed in Apogee Technical Publication #12, *"Making Cast Parts With Silicone Rubber Molds"* (http://www.apogeerockets.com/Rocket_Books_Videos/Pamphlets_Reports/Tech_Pub_12).

When you're done making the two sides using silicone RTV rubber, you still have to remember that you'll have to reverse both sides if you want a hard-sided mold. It can be a very time-consuming and complicated. If you're impatient and you rush through the process (like I sometimes do), you can make mistakes that further lengthen the time it takes to make a mold.

Hard-sided two-part molds can be difficult to hinge together. So you may just have to put clasps on two sides of the mold. The alternative, is to put heavy weights on the top as the foam grows inside.

List of any related R & D Reports previously entered by the author, if any, with brief summaries

No R&D reports were previously entered by the author on this topic.

References to previous work done on the subject, found in research preparatory to this report

"*Making Cast Parts with Silicone Rubber Molds* – Apogee Technical Publication #12" by Tim Van Milligan (http://www.apogeerockets.com/Rocket_Books_Videos/Pamphlets_Reports/Tech_Pub_12)

"Pressure Cast Resin Parts For Model Rocket Applications" – R&D report for NARAM-54 by Matt Steele (Pod Bay Doors Team T-201)

Polyurethane Foam Systems Explained - http://www.youtube.com/watch?v=_O_vd_I_ojI

The Equipment Used

To make flexible foam resin parts, you will need standard modeling tools.

- Gram scale to weight out resin and silicone RTV rubber.
- Vacuum pump and chamber – not necessarily required, but it helps to remove air bubbles from the silicone RTV rubber to make a denser rubber that lasts longer.
- Air compressor and "pressure pot" (see Matt Steel's R&D report). After the silicone RTV rubber has been degassed to remove air, the entire rubber mold can be put into the pressure pot to compress any remaining air. Again, this is done to make the silicone rubber more dense, so that it lasts longer an creates a better part.
- Heat Gun – Used to melt the mold release wax that may build up inside a hard mold. When the wax is melted, it can be wiped out with a paper towel.

Consumable Suppliers:

Urethane Foams and Silicone RTV Rubbers available from:

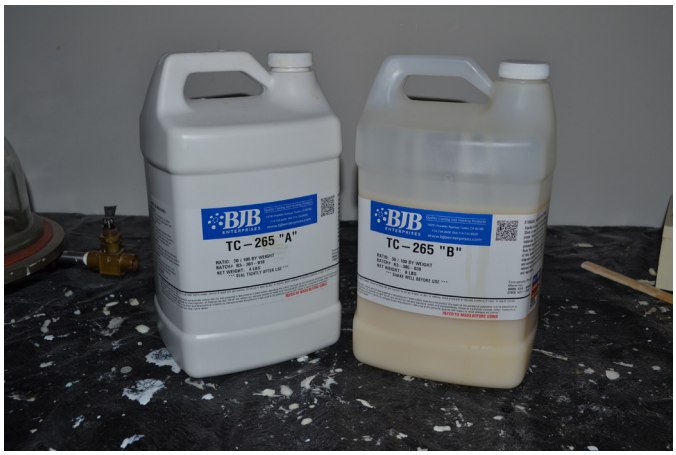
BJB Enterprises
14791 Franklin Avenue, Tustin, CA 92780
http://www.bjbenterprises.com

Cast-resin for making hard-sided molds
Glenmarc Industries
2001 S. Blue Island Ave
Chicago, IL 60608

Another Silicone RTV Rubber Supplier

Circle-K
P.O. Box 909
Temecula, CA 92593

Spray-on Mold Release
Aervoe Industires Incorporated
Gardnerville, NV 89410



The Facilities Used:

No special facilities are required to make foam parts. A standard modeler's workshop is sufficient. When I did this work, I used my workshop at Apogee Components.

The money spent on the project (budget)

TC-265 Flexible Foam Resin (3-lb density) - $55 per quart from BJB Enterprises
TC-277 Self Skinning Foam Resin (4-lb density) - $115.50 per gallon from BJB Enterprises
Challenge 90 Mold Release - $45 per quart from BJB Enterprises
Crown Mold Release & Protector (spray-on wax) - $5.92 per can from Aervoe Industries
Casting Resin - $25.88 per 2-quart kit from Glenmark Industries
Silicone RTV base and activator - $124.50 per gallon from Circle K
Total cost: $371.80

The data collected

This project did not have numerical data collected. It was more subjective, such as determining which of the final parts were good versus bad. And throughout the process, I had to be subjective about which construction methods would yield the best part with the least amount of effort, material used, and money used.

I also had to determine through testing how much resin to mix up without making too little, or mixing too much and throwing it away. Incidentally, it takes about 48 grams to make a BT-70 nose cone. You do have to overfill the cavity to make sure it grows into all the corners.

The results obtained

When I started this project, one of my ultimate goals was to be able to produce foam parts for other modelers, particularly the TARC (Team America Rocketry Championship – www.rocketcontest.org) students. Using foam that is molded to the shape of the item you want to protect is ideal because it prevents the payload from shifting at all, and since the foam is uniform in density, there aren't any hard spots that would create pressure points on the surface of the payload. This gives superior protection to the payload.

Personally, I have used my own egg protectors in NAR competitions, including D-engine dual eggloft altitude in the very thin Apogee egg capsules. This is pushing the concepts to the limits, because the wall thickness of the flexible foam is so thin. In six competition flights, I only had the eggs crack one time, and that was because the rocket came down ballistically.

I felt the process was quick and economical enough, that in total, I've done 6 different types of flexible foam shapes, and I have one new one planned for later this summer:

3" Diameter sideways laying egg for TARC
2.6" Diameter sideways laying egg for TARC
BT-70 Diameter vertical egg protector for general competition use (TARC and NAR)
Apogee egg-cone protector for NAR competitions
3" Diameter nose cone with protection for the altimeter
2.6" Diameter nose cone with protection for the altimeter

Future egg protector: BT-70 Diameter vertical egg for dual-egg lofting (useful for TARC)

The Conclusions Drawn

Payload protection, which is what I call making flexible foam cast parts, is very doable with modern resins. There are a number of delicate payloads that could use a flexible foam, such as egg lofters, and delicate electronic payloads. While launching live biological payloads is very much frowned upon in model rocketry, there may be some universities that might benefit from this research.

Further Work That Would Clarify Or Extend The Results Obtained

One of the foams that I would like to try in the future, are the memory-foams that are popular in the mattress industry. When I originally searched for a flexible foam, this is what I was actually looking for. At the beginning, I did not find a memory-foam resin. But since I created my first parts, I did discover that BJB Enterprises does make a memory-foam resin that looks interesting. I would like to find out how the density of the resin compares to the two foams that I use now. The manufacturer says the foam is self-skimming, which I'd like to see. The skin on the high-density foam that I currently use isn't that thick, which means it isn't very tough.