REFRIGERATION INSULATION

Note: This is, in my opinion, an advanced DIY project as some small spacers need to be made and some specialty tools are required, ie, a 90 degree drill, a grinder to make short drill bits, short handled screwdrivers, and a tin snips or rotary saw. Also, many skills are required in order to achieve an acceptable appearance of the final product. It also took me about 2 weeks to complete the project working 4-6 hours per day. So it is not a weekend project unless you want to spend your entire summer sailing season on it, although it can be done in stages.

I will explain the process completing the freezer first. The techniques of pattern making and insulation installation are the same for both the freezer and the refrigerator.

Some of the early C350's were known to have less than adequate refrigerator and freezer insulation. Kai Lani, my C350 #103 was no exception. I read everything on the various web sites relative to the problem and decided a major refit was in order.

The first order of business was to take the advise from Catalina and make sure all the obvious things were functioning properly, such as good gaskets, no air leaks, etc. The factors that convinced me a major refit was necessary included looking up under the counter from inside the fridge & freezer and seeing the wood from the underside of the counter (Read that "no insulation at all") and the drilling of test holes in the inside liner discovering that the outboard side of the freezer, which follows the hull shape and becomes the floor of the refrigerator, had one large void under it running from 3/8 inch thick at the top outboard side to approximately 2 inches under the refrigerator floor drain at the inboard side. I did find insulation immediately behind the fore, aft, and inboard sides of the fridge and freezer walls but could not determine its thickness.

Having decided a re-fit was necessary the first thing was to remove the evaporator without disconnecting it from the compressor. This can be done by removing the 4 screws securing it to the wall of the freezer and gently removing it from the freezer, being careful not to over bend the coolant hoses or kink them in any way. Keep the plastic spacers that come out with the screws as they will be used later. Once out of the freezer, I placed the evaporator on top of the counter over a roll of paper towels to prevent it from scratching the counter top. There is sufficient movement available to be able to move the evaporator around to get into the freezer and do the work necessary once it is sitting on the counter top.

The next order of business was to drill a series of holes 4 inches apart in a square grid pattern in the area where the void was discovered.
(*See figure1: the outboard side of the freezer and figure2: the floor of the refrigerator)*





I then purchased the spray insulation called "Great Stuff" (the large gap filler version) and sprayed it into the holes starting at the corner by the drain in the fridge and continuing to fill the hole until the insulation could be seen or came out of the holes immediately next to the hole being filled. I then went to those holes and continued to fill them until the holes next to them showed insulation. This process continued until I had sprayed the insulation in every hole drilled. This resulted in a lot of waste but hopefully this also resulted in completely filling the void, since it took 3 cans of the spray insulation to complete the process. Be aware that this insulation expands greatly and you need to spray it in slowly allowing it to expand as you go. I sprayed it in fast and when I was done, it kept expanding out the holes for several minutes until it started to harden.

I later found additional voids around the sides of the top openings, around the sides of the side refrigerator door opening, and inside the opening lids. Another can of the "great stuff" took care of those areas.

After not having a fridge/freezer drain in my old boat for 22 years, I felt one was not necessary so I also filled the drain hole with the spray insulation.

The spray insulation will expanded out of the holes but do not try to clean it up until it has cured. It is then a simple matter of taking a razor blade and scraping the excess off the liner. The holes were then covered with caulk to seal them against any potential moisture intrusion.

Research had also shown that the total cubic feet of the refrigerator and freezer exceeded the recommended capacity for the refrigeration unit installed in the boat. This convinced me that reducing the cubic foot area of the fridge/freezer would also help efficiency.

I decided to install additional insulation inside the 2 boxes which would serve two purposes, 1) to increase insulation and 2) to decrease volume needing to be cooled. Having researched various marine and home types of insulation, I settled on lining the inside of the fridge/freezer with a combination of 1/4 inch radiant heat shield (see www.heatshieldmarine.com) and 1/2 inch & 3/4 inch extruded polystyrene. This combination should equal between 3 and 5 inches of additional foam insulation, or between R factors of 9 and 20 depending on what combination is used. (This estimate was assumed from information on the web site of heat shield marine, see above web site address). Assuming there is at least 1 inch of insulation installed at the factory this means the 2 boxes would have no less than 4 inches of insulation and could have as much as 7 or 8 inches in some areas.



I filled every area that would not hold food, such as under the counter top and around the top opening, with extruded polystyrene insulation. Not only to help insulate the box but also to cut down on the useless area that needed to be cooled. *(See figures 4 & 5)*





Both 1/2 inch (blue in the pictures made by Dow Chemical) and 3/4 inch (pink in the pictures made by Owens Corning) extruded polystyrene was used as there is a limited amount of space to install the evaporator and for maximum operating efficiency you need a gap of at least 1/4 inch completely around it, therefore 1/2 inch extruded polystyrene along with the 1/4 inch heat shield was all that could be used in this area otherwise the evaporator would not fit back in. All other area's got the 3/4 inch.

After filling all the voids with "great stuff" the next step is to make paper patterns or templates to transfer the design needed for the various pieces of insulation to the insulation itself. Start with the easiest pattern to make so you get the hang of it.

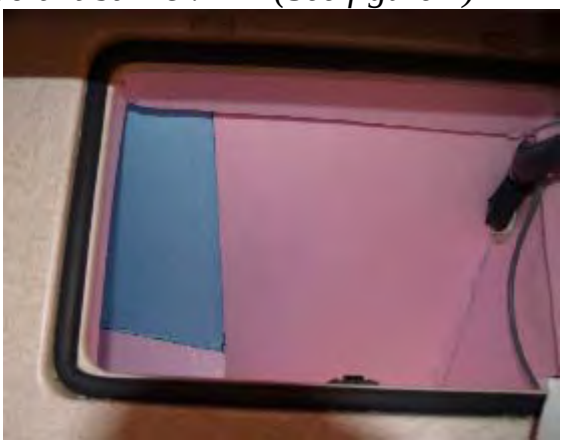
To make the patterns, cut out small pieces of newspaper and fit it along the outside of the pattern area to get the shape of the pattern, then fill in the inside to complete the pattern. It is also easier to start at one corner and run a piece of paper 2 or 3 inches wide toward the other corner to the approximate middle of the wall along the outside edge. Then take and start another piece of paper from the opposite corner and overlap the two in the middle taping them together. Do this from all four corners and you will get a much better fit.

After the pattern is made place it upon the heat shield insulation and trace it using a magic marker. Cut out the pattern with scissors. I used a 3M spray insulation adhesive to affix the pieces to the walls. Not a lot of adhesive is required so use it sparingly in case you make a mistake and need to remove the insulation. If you cannot find the spray adhesive, you can also make 2 sided tape out of some aluminum "duct tape" and use it mostly at the top of the piece to stick it to the wall.

The first layer of 1/4 inch heat shield radiant barrier insulation was installed in the entire box, *(see figure 3: the installed radiant barrier)* and then the patterns were again used to cut out the pieces of expanded polystyrene which was installed over the heat shield. Remember that you will need to resize the patterns for the extruded polystyrene. Always refit the pattern before cutting out the extruded polystyrene just to be sure they are right, the old saying "measure twice cut once" is definitely applicable to this entire project.



It is important to note that around the area of the evaporator, next to it and behind it, you must use 1/2 inch extruded polystyrene over the radiant barrier. *(See figure 4)*

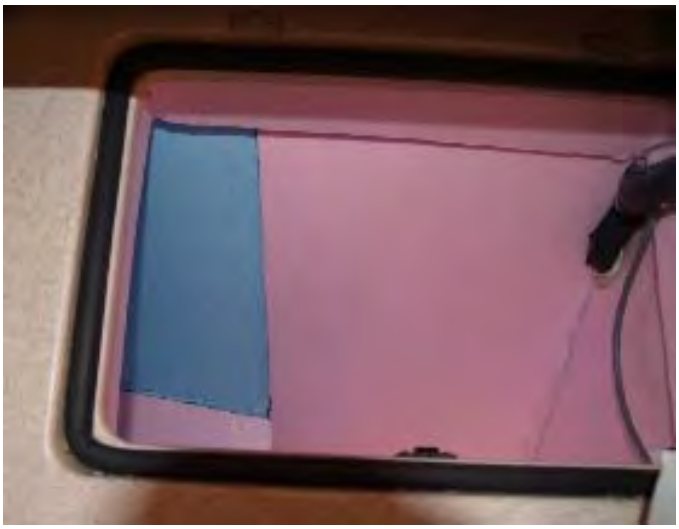


It shows the 2 sizes of extruded polystyrene, 1/2 inch (blue) and 3/4 inch (pink). Using a thicker polystyrene will prevent you from re-installing the evaporator, the tolerances are that close. Here, accurate measurement taking is imperative. Pre-calculate where the evaporator is going to end up since it will not be placed in the exact same place you took it from but will be at least 1 inch further aft in the box.

This also requires the insulation for the outboard side of the freezer (the part that is curved and goes to the bottom of the freezer) to be installed in 2 pieces, 1 piece being 3/4 inch thick and the other piece 1/2 thick. The 1/2 inch being placed next to the evaporator, again accurate measuring is needed.

I used the 3/4 thick polystyrene from the aft end of the freezer box up to the flat part of the floor which extends under the evaporator. This is in the area of the opening hole at the bottom of the box. (Note that I closed this hole entirely as it serves no function since I closed off the drain in the refrigerator floor.)

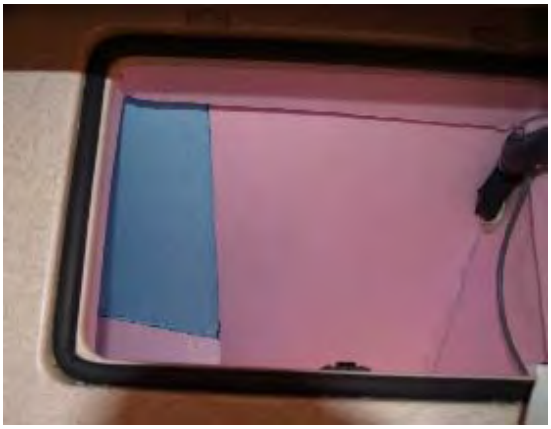
The 1/2 inch polystyrene was then used from there to the forward end of the freezer, on the stove side of the freezer and on the inboard side of the freezer up to the freezer/refrigerator dividing wall. *(See figure 4)*



If cut slightly oversize, the polystyrene can be gently “forced” into position and no adhesive is needed to hold it in place. This also insures no open spaces to make the unit less efficient. In addition, if you make a mistake it is a simple matter to cut an approximate size “plug” and squeeze it into the area that was improperly cut.

Once you have insulation around the sides, bottom, under the top and around the opening you are now ready to start installing the liner.

(See figure 4 for the freezer and 5 for the refrigerator)





I purchased a white fiberglass panel approximately 3/32 inch thick from Home Depot, although it is also available from Lowes. It is called “Glassliner FRP”. The cost here in S.W. Florida was $28 for a 4 X 8 sheet which is enough for the whole project if you don’t make too many mistakes.

The same paper patterns are again used to cut out the fiberglass (I hope you kept them). Check them first and make any necessary corrections to them before transferring the pattern to the fiberglass. Remember, as you add the insulation, the patterns will change and become slightly smaller. Here do not use a magic marker to make the transfer of the patterns to the fiberglass panels, use a water erasable marker so after you are done cutting and fitting the panels you can wipe of the marks, otherwise they may show after caulking the panels in place. Now that the polystyrene has been installed, cutting and fitting the fiberglass panels are the most crucial part of the installation. If a mistake was made with the insulation you could cut and fit a small piece to correct the mistake, but with the liner, it must be a close enough fit between panels to be sealed with a bead of caulk. In all cutting and fitting projects remember, measure twice and cut once. If in doubt, cut slightly oversize as the fiberglass panel can be sanded to a precise fit very easily. Here again, you can cut the panels slightly oversize and then gently force them into place. They should be “easily” forced with little pressure, if not, figure out where they are too large and sand them down where needed.

(See figure 6 showing the fiberglass panels fitted in place before caulking)



I should state here that the fiberglass panels bend significantly allowing each panel to be installed in one piece. The only exception is the sloping outboard panel of the freezer which must be installed in 2 pieces due to the 2 different sizes of extruded polystyrene used on that side. Even the larger of the 2 panels fits thru the top opening. The only other large panel that needs to be coaxed into place with some twisting and turning is the floor of the refrigerator, but more on that later.

The fiberglass can be held in place using the insulation adhesive if necessary. However if you have slightly oversized the panels and gently forced them into place, no adhesive is needed. Be aware that if you force them too much, they will bow and not sit flush against the sides, bottom, etc. The fit should be “snug” but not “tight”.

There is one area where you need to make the fiberglass panel really oversized; where the 1/2 inch and 3/4 inch polystyrene meet in the freezer. There is a 1/4 inch difference here in the thickness of the polystyrene panels and you need to fill that area with caulk. By making the fiberglass panel over the 3/4 inch polystyrene about 1/8 to 1/4 inch larger than necessary, you will make a gap between the liner over the 1/2 inch and the liner over the 3/4 inch polystyrene that can be filled with caulk to insure a good seal. *(See figure 7 for this area)*



Here you should stop and say “wait, the outboard polystyrene and fiberglass panels do no follow the contours of the side of the freezer.” This problem is easily rectified by taking 1 1/2 inch #8 round top wood screws with finishing washers, (stainless steel of course) and placing them in appropriate areas to force the panels to confirm to the side of the sloping box. Use your fingers to press down on the panels and see where the screws need to be placed and then drill the pilot holes and install the screws, caulking them in place. Try to make a little pattern out of the screws for aesthetic purposes. This only needs to be done on the sloping outboard side of the freezer and the floor of the refrigerator.

I used 4 screws in the outboard side of the freezer and 3 screws in the refrigerator floor. *(See figure 7 showing 2 of the screws in the freezer)*



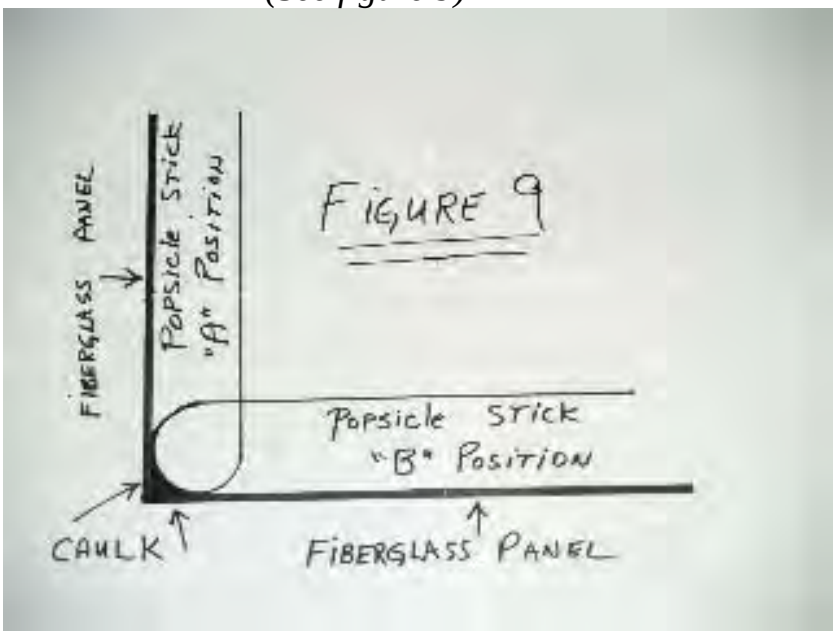
The other 2 are behind the evaporator) and *figure 8* showing the screws in the refrigerator floor). In the freezer you can do it after all the panels have been in place, but in the refrigerator you need to do it immediately after placing the fiberglass floor panel in place since its proper location affects the pattern of the later installed panels.
Once all pieces are in place you then caulk all the seams.
(Figure 8 barely shows the caulking when done properly)



I found the best caulking tool is a Popsicle stick. After laying a SMALL bead of caulk on the seam, run the Popsicle stick first along the flat side of one panel ("A" position) and then along the flat side of the adjoining panel ("B" position) and you should end up with a beautiful, clean bead of rounded caulk forced into the seam for proper sealing.

(See figure 9)

If a little more caulk is needed, get a larger stick from a Dairy Queen Dilly Bar and use it in the same manner. (I look everywhere for my "specialty tools", thus I can tell my wife I am going out to get a few new "tools". *HA HA.*



Carefully re-install the evaporator.
This is easier said than done.

Since 1/2 inch insulation was placed behind and on the sides of the evaporator, it has to be relocated in the freezer. I moved mine aft enough to allow the aft mounting holes to be about 1/2 inch past the starboard freezer/fridge divider to just about where the 1/2 inch and 3/4 inch polystyrene meet.

(See figure 8, the evaporator is at the left)



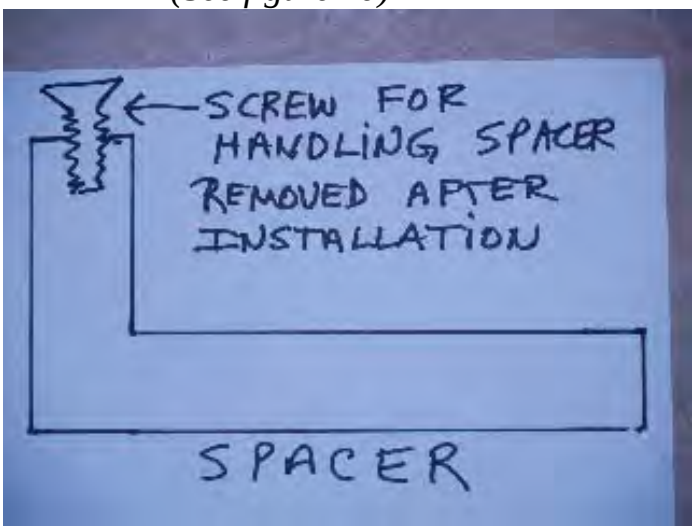
This gave me a solid area to mount the farthest aft 2 screws. Here it was necessary to have a "specialty tool" ie. 90 degree drill so you can drill the screws holes accurately. To get the drill and bit into the evaporator I cut off the shank of the drill bit making a short 1 1/2 inch drill bit. I taped and wedged (with pieces of polystyrene) the evaporator in place, then drilled the holes and placed the screws before removing the tape and wedges. This gave me an accurate mount.
The evaporator also had to also be slightly raised to clear the outboard side.

Remember you need to keep a minimum of 1/4 to 3/8 inch clearance around the entire evaporator for air circulation otherwise the unit will not cool efficiently and your project will not have a satisfactory result. This means everywhere, the top, sides, back, and bottom. To achieve this use the plastic spacers that were over the screws between the evaporator and the freezer wall when you removed the evaporator, I just cut them down to the required size.

When installing the forward 2 screws to hold the evaporator, specialty tools again come in handy. In order to install the forward 2 screws you will need to use that 90 degree drill again, but now it must also be small enough to fit totally inside the evaporator, thus the shortened drill bit mentioned earlier. It took me 4 hours to figure out how to put in those forward 2 screws because you need to place that spacer between the evaporator and the freezer wall and there is not a lot of space to work.

I used a piece of “vinyl wood” (which we will make the new shelf bracket out of for the refrigerator, discussed later) and made a spacer, attached a screw into it which served as a handle to grab and slid the spacer between the evaporator and the freezer wall, taped it in place and then drilled thru the original screw hole in the evaporator, through the spacer into the side wall. I then inserted the screw and tightened it down.

(See figure 10)



It is important to not torque the screws down too tight on the 2 forward screws since the fiberglass panel is only 3/32 inches thick, it will not take a lot of torque. Just snug those forward screws. Don’t try to make them so tight that they would hold a 100 lb. Shelf. It is not necessary.

Reposition the evaporator lines and wiring, replace the thermostatic control and caulk around where these items come through the aft panel and there you have it. The freezer is done except for installing the top opening door.

(See figure 12 finished interior of freezer)



Next is

the fridge:

Since the width and depth are going to be made 1 1/8 inch smaller by the addition of the insulation and new liner, we must first extend the length of the shelf holding bracket by a minimum of 1 inch or we will have no where to lay the shelf upon completion of the project.

Since the shelf brackets are screwed from the outside of the refrigerator there is no way that we can take them off. So the next best thing is to add to them. The shelf brackets in my C350 were 3/4 inch starboard. But there was no way I was going to pay the price for starboard. There had to be something just as good but cheaper. At Home Depot I purchased a length of "Veranda Cellular Vinyl Molding" which is used as exterior molding on homes. This product will not rot, will hold screws nicely, easily cuts with a saw, sands to a smooth finish and is generally easy to work with. Since it is an exterior product it will do well in a cold, damp environment like the inside of a refrigerator. The piece I purchased was 5/8 inches thick, 1 1/2 inches wide and about 12 ft. long. Cost about $12. Don't worry you'll use most of it.

Even though the Veranda Molding was only 5/8 inch thick, not 3/4 like the starboard, it was more than strong enough for the job. Cut the lengths you need to extend the shelf brackets in the refrigerator. Then drill 3 or 4 holes from one side of the molding thru the 1 1/2 inch width big enough for a #8 wood screw to go thru. Then align the top of the molding with the existing top of the shelf bracket and mark the existing shelf bracket where you drilled the holes in the molding. Remove the molding and drill a smaller hole for the #8 screw to screw into thru the existing shelf bracket and the inside liner. The idea is to screw the new molding shelf bracket onto the existing shelf bracket with finishing washers and screws long enough, 3 inches should work, to go completely thru the new shelf bracket, the existing shelf bracket and into the original refrigerator liner. This gives you optimum strength.



(See figure 13 showing the original shelf bracket on the left and the new shelf brackets screwed to the old shelf brackets in the center and on the right)

Once this has been done, you have extended your shelf

bracket sufficiently to start installing your radiant heat shield and extruded polystyrene as you did in the freezer and making the paper templates (patterns) for all the panel pieces.

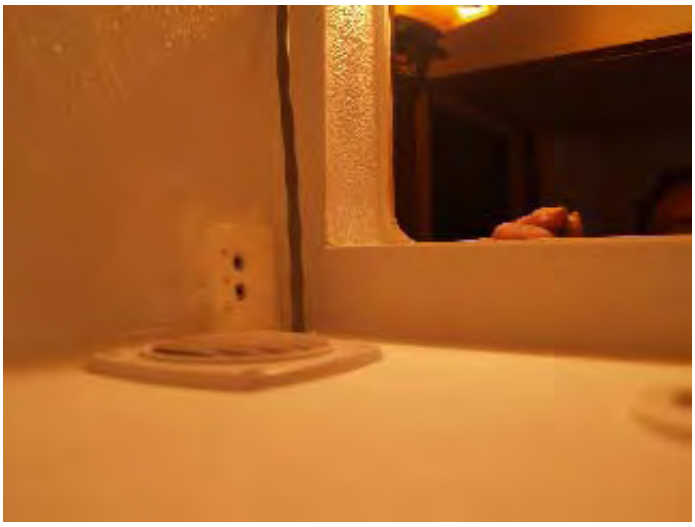
After you have installed the insulation, the floor liner needs to be the first finishing piece installed. You must put the floor liner panel in first because it is the largest piece and by putting it in first you have more working room. It is very important to get the measurements right on the floor panel because once you get it in and down on the floor, it will be very difficult to get it out again. There is not much working room since the floor slopes up toward the freezer and you must radically bend the liner to get it in, once it is down it will be next to impossible to bend it enough to get it back out. That being said, it really is easier than it sounds, just double check the pattern you use to make sure it is accurate.

Remember that immediately after the floor panel goes in, you must screw it down to the original liner in order to conform it to the shape of the floor. I used 3 screws 1 1/2 inches long to screw the floor panel to the original floor.

(See figure 8 showing the 3 screws in the refrigerator floor)



Remember that the templates (patterns) will change a little from when you made them for the insulation. Check them and make any necessary corrections before using them to cut out the fiberglass panels.



Once you have the floor panel in, the rest is a piece of cake. Make the rest of the panels as you did for the freezer and when all is completed, caulk them in place.

Remember that you need to also put insulation on top and around the opening.

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(See figure 27)

This project takes longer than the freezer because you need to fit small panels

around the side door and if your side door opening was as out of square as mine was, it takes some time to get the panels to fit properly before caulking. I also cheated here and made the panels that went around the side door opening in 3 pieces and joined them with caulk. The reason for this was, as mentioned above, it was just too difficult to fit the 3 panels as one panel all the way around the opening.

If you were to view the sides and bottom of the door as a giant "U", I made the bottom part of the "U" as one panel and the straight up and down parts of the "U" as the other 2 panels. *(Figure 22 has a good view of the heat shield, the extruded polystyrene and the fiberglass line)*



Next comes the side door itself. First I took off the small wire shelf attached to the door. I then took the Veranda 5/8 inch by 1 1/2 inch molding and made a box that fit just inside the door gasket -

(See figure 13)

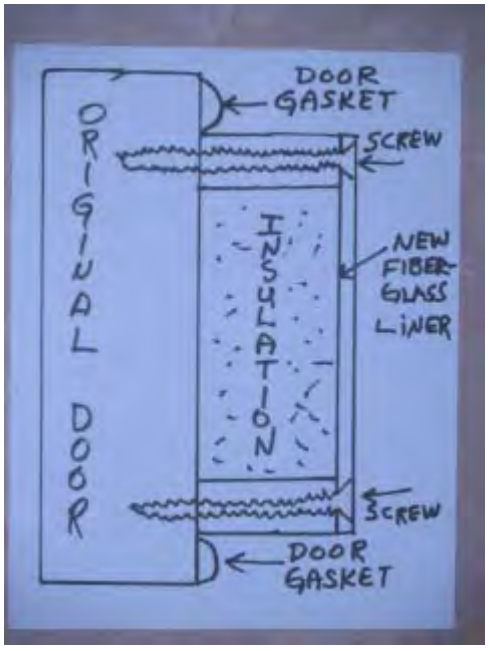


so when the door was closed, the box completely filled the door opening except for enough clearance to open and close the door. I then filled this box with 3 pieces of 1/2 inch polystyrene producing a layer of insulation 1 1/2 inches thick.

This being done I carefully measured where the box needed to be attached to the inside of the door to insure clearance to open and close the door. Once I was sure of the placement, I caulked and screwed the box onto the side door.

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(See figure 25)



This gave the door and additional 1 1/2 inches of insulation. I then purchased an additional shelf from Catalina and installed the old and new shelves on the inside door, again using screws (2 inches in length) long enough to go completely thru the new insulation into the old door for strength.



(See figures 15 and 16 showing the door open and closed (picture taken from inside in figure 16 and figure 24)

This shows the finished door with the shelves attached.





Now that all the insulation and new inner fiberglass liner is in, we must cut down the shelf to make it fit in the smaller area. This is a simple matter of measuring twice and cutting once. In my case I cut off the right (inboard) side of the 2 shelves and then the forward end of the smaller shelf. Doing it this way resulted in the least cutting.

(See figure 23)



The last item is to purchase and install small battery operated circulation fans in both the freezer and refrigerator. I purchased these at Campers World. They cost about $20 each and run for 30 days on 2 “D” size batteries. They really work with a little modification. Don’t buy the ones with the traditional fan but get the ones that use a “cage fan”, the one that looks like the exercise wheel a Gerbil likes to run in.

For the refrigerator, I took an appropriate size PVC pipe and epoxied it to the fans outlet point, making the pipe just long enough to reach the bottom of the installed shelf when you placed the fan on the floor of the refrigerator. I then took another piece of PVC pipe and made it long enough to reach from the top of the shelf to about 3 inches from the top of the refrigerator. I then purchased an “inside” union (or coupler if you prefer) and enlarged one of the existing holes in the shelf and installed this “inside” union in the hole from under the shelf. It was then a simple matter of attaching the fan with its extended PVC pipe to the bottom of the union under the shelf and the top PVC pipe to the top of the “inside” union. Do not permanently mount the fan or PVC pipes.
They need to be removable when you take out the shelves.

When the fan is turned on it can now circulate the colder air on the bottom of the refrigerator to the top of the refrigerator by direct ducting and no food, jars, cans etc. can block or disturb the air flow.

(See figure 17 the shelf and fan outside the refrigerator and figure 18 showing them in the refrigerator)





Using the same type fan, I made a different arrangement for the freezer. Because the freezer has no real floor in it but the one side slopes down to the bottom, I again epoxied the proper size PVC pipe to the outlet of the fan but then I also epoxied the proper size PVC pipe to the inlet side of the fan. This inlet pipe is just long enough to go from about 2/3 the way to the aft end of the freezer to directly under the very bottom of the evaporator. This way you can place as much food on top of the pipe and around the fan and will block the fans inlet or outlet for the air circulation.

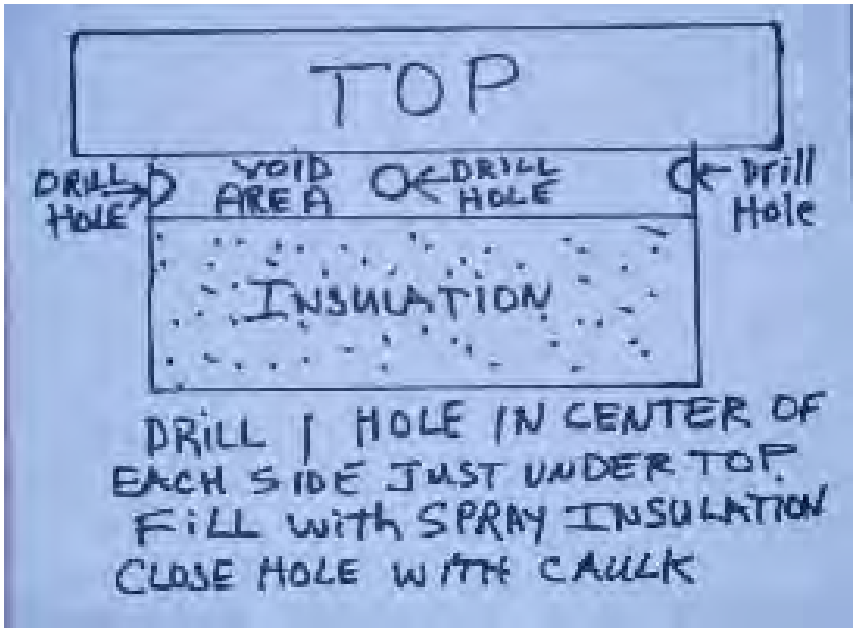
Plus, the fan is drawing the air from the coldest point of the freezer, under the evaporator, and sending it to the top of the freezer and then drawing it down again around the cold evaporator. *(See figures 19 & 20)*





Last but not least is the opening tops. These have about 1/2 inch voids in them directly under the top. Drill about a 1/4 inch hole right at the base by the top and see if the void exists in your tops. If they do, drill a hole on each side of the top and fill with the spray installation.

(See figure 21)



To install the freezer top you will need to extend the hold open bracket mount by about

1/2 to 3/4 inch to clear the new installation along the side of the opening. I used a piece of the refrigerator shelf that was cut off and made a new mount that I simply screwed onto the old mount and then screwed the hold open bracket to the new mount.

Finally, you are done!

(For completed freezer and refrigerator see figures 12 & 8)





Test it out!

I went to Radio Shack and purchased a wireless thermometer which would receive up to 3 separate transmitters. I purchased 2 transmitters and used velcro to mount them at the top of the refrigerator and freezer. This way I can check the temperature of either box with the push of a button without opening the box. By mounting them at the top, I know that the reading will be at the warmest part of the box and can rest easily that if that temperature is A-ok, then the rest of the box is also.

The results were surprising. In ambient temperatures of mid 50's at night and mid 70's during the day in S.W. Florida, I maintained 27 degree freezer temperatures and 40 degree refrigerator temperatures with a compressor run time of 21% over a 4 day period. Originally my compressor ran virtually 100% of the time. Even with an increase of compressor run time by 150 % during the hot summer months, that still means the compressor will only run 50% of the time. This of course is extrapolated from the actual test data, so we shall see the true results this spring when we head to the Bahamas for 3 months.

Good luck with your results.

Jim Gienko, C350 #103, Kai Lani