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## KTeV 1.8m Vacuum Window Assembly Procedure

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### Purpose

The 1.8m diameter vacuum window is an integral part of the KTeV regenerator vessel. It is constructed by sandwiching a fabric woven from kevlar between layers of mylar. This method of construction has been used in past vacuum windows with favorable results. The KTeV window is larger in diameter than the previous four foot window and requires some assembly techniques. This procedure provides a detailed set of instructions for the assembly of the 1.8m diameter vacuum window. **To ensure the integrity of the vacuum window care must be taken to strictly follow the steps outlined in this procedure.**

### Materials Needed

- Assembly Drawing # 9220.832.MD-285394
- Upstream Flange, reference drawing # 9220.832.MD-285389
- Downstream Flange, reference drawing #9220.832.MD-285390
- Vacuum Test Vessel, reference drawing #9220.832.MD-285394
- Removable aluminum cover
- .005" x 72" roll Aluminized Mylar (MSDS#12407)
- 72" roll Kevlar fabric (MSDS#12406)
- .250" diameter urethane O-ring stock from Eagle Belting
- .250" diameter 1100 series aluminum wire stock
- Hysol 826 epoxy resin (MSDS#07625)
- Hysol 308 epoxy hardener (MSDS#06160)
- 5 ml squeeze bottle
- Tube of General Purpose RTV
- Spreader Bar, ID#62
- Two 1/2 inch swivel lifting eyes
- Oxy-Acetylene Torch set up with #1 torch tip
- Nederman Electrostatic filter fitted with a flexible extension on the exhaust side for exhausting the fumes produced by burning through the Mylar and Kevlar fabric.
- Kevlar fabric shears.

- Tongue depressors
- Six foot diameter innertube
- Six foot diameter hose clamp (made from three sections of M-200 Screw Seal material)
- Eight aluminum retainers with bolts to attach to underside of the upstream flange.
- Spacer blocks for beneath the assembly.
- (60) 7/8-9-UNRC X 3 inches ferry head cap counter bore screws.
- (60) 7/8 lock washers.

## PREPARATION

### Make O-Rings

**Urethane.** Using the groove in the upstream flange (reference drawing #9220.832.MD-285389) as a guide, make an o-ring from the .250 inch diameter Eagle Belting urethane cord stock. Check the fit and then store it in a clean place for later use. It is better if the o-ring fits snug in the groove. It will stretch some during installation and if it is too large the excess accumulates keeping the o-ring from laying flat in its groove.

**Aluminum.** Using the groove in the downstream flange as a guide, make an o-ring from the .250 inch 1100 series aluminum wire stock. This material is very soft and care must be taken to avoid nicking or scratching its surface. Start at one end of the flange and clamp the beginning of the wire into the groove. Use a tongue depressor or similar material to protect the aluminum wire from damage by the clamp. Work the wire around the flange clamping it every 20 inches to keep it following the groove. Add an extra three-sixteenths of an inch to allow for shrinkage during welding. Prepare for welding by beveling the edges on both ends leaving about an eighth inch land for alignment. After it is welded cleanup the joint with a file and 120 grit abrasive cloth. Then use a fine scotch-bright pad to polish the entire ring removing any scratches and dirt. Check the fit and store it in a clean place for later use in the final assembly.

### Assembly Setup

1. Use the vacuum test vessel reference drawing #9220.832.MD-285389 as a table to assemble the window on. Position it in a clean area away from excess traffic and dirt.
2. Set the upstream flange reference drawing #9220.832.MD-285389 up on the three nylon spacers with the correct o-ring groove facing up. In the correct position the tapped holes are facing up.
3. Clean the top surface and o-ring groove with alcohol.
4. Install the ten innertube retainers from the bottom of the upstream flange using the short five-eighths inch bolts. (See Figure 1) Ten of the holes have been tapped through to accommodate the bolts used to hold these in place.

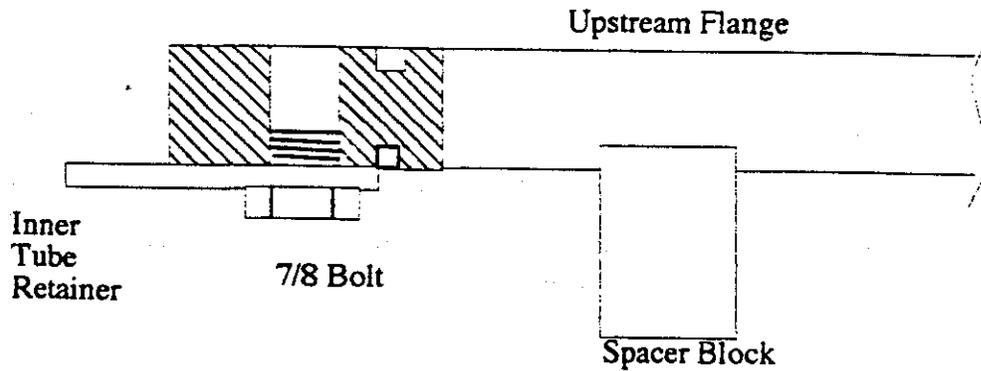


Fig. 1  
Flange and Retainer Setup

## WINDOW ASSEMBLY

### First Layer of Mylar

This step requires three people. Set up the rack containing the rolls of mylar (MSDS #12407) and kevlar (MSDS #12406) next to the flange setup. Unroll the mylar onto the flange with the aluminized side facing up. Use one person to throttle the roll while the other two pull the mylar across the flange. Cut a one inch square tab on the leading edge, fold it over the edge of the flange and secure it to the side of the flange with a piece of duct tape. Continue trimming the mylar to size leaving a one inch tab every foot. Working across from each other pull the mylar taut and tape down to the side of the flange. Continue working around the flange eliminating all of the sag and wrinkles from the mylar. When finished the mylar should be flush with the edge of the flange.

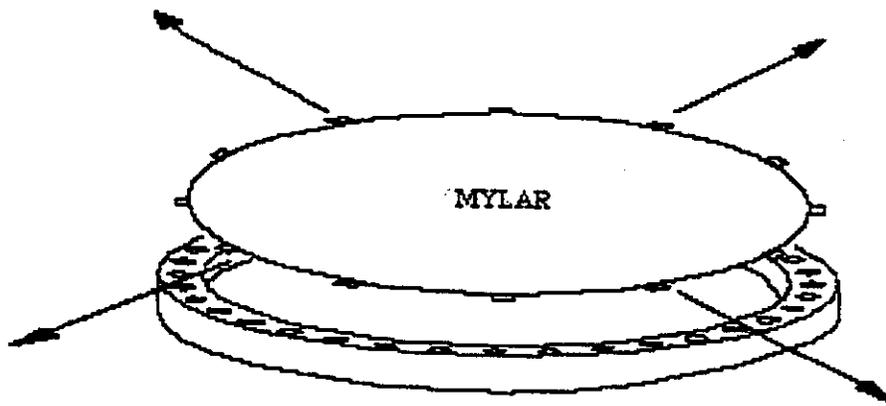


Fig. 2  
Stretching the first layer of mylar.

## Kevlar Layer

1. After the first layer of mylar is in place stretch the six foot diameter inner tube around the perimeter of the flange. Be sure that the innertube is completely deflated and the valve stems are pointing out. Position it as near to the top of the flange as possible.
2. Unroll enough kevlar to cover the flange with an extra six inches to overhang. The mylar layer beneath it will support the fabric and make it easier to work with. Check the fabric for cuts or pulled threads. The size of the window makes it difficult to eliminate all defects in the material. there are little knots that seem to be where the ends of the thread overlap in the weave. These are okay but discard the piece if there are any other obvious defects.
3. Use the special shears to trim the kevlar fabric allowing for an extra six inches on all sides. **Be careful not to pull any threads through the fabric.**
4. Locate the valve stems on the innertube and cut a small slit through the kevlar so that they can protrude. When cutting these slits avoid cutting any of the fibers that run across the diameter of the window.
5. Pull the fabric over the innertube and use the six foot diameter hose clamp to secure it tightly near the bottom of the flange. Watch for snags in the fabric; pay particular attention to where the screws from the hose clamp tighten.
6. Work your way around the perimeter and pull the slack fabric through the hose clamp, while keeping an eye out for snags. The fabric should be fairly flat with even tension across it. Check that the hose clamp is securely tightened.
7. Turn the air pressure regulator down to 20 PSI and inflate the innertube. Use enough inflation to stretch the fabric without pulling it through the hose clamp.
8. Let the fabric stretch a few minutes and then deflate the innertube.
9. Work your way around the window pulling the slack fabric through the hose clamp that has gathered near the innertube. Tighten the hose clamp and reinflate as in step seven.
10. Repeat steps seven, eight and nine until there is less than one-sixteenth of an inch of sag in the center of the window. Check by laying a straight edge across the window and measuring the gap between them.
11. The inner tube will remain inflated keeping the kevlar taut during the remainder of the assembly until the flanges are bolted together.

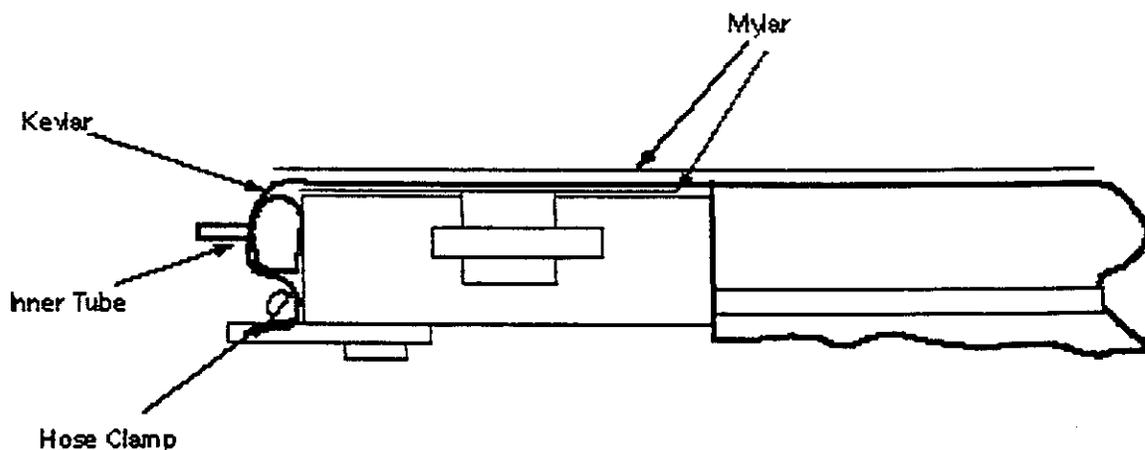


Fig. 4  
Kevlar Stretch

## Final Layer of Mylar

1. Unroll the second layer of mylar across the kevlar fabric with the aluminized side facing up. Inspect it for creases and scratches and **discard it if there are any flaws.**
2. Trim the mylar two inches larger than the flange, pull it taut and tape it down to the sides. Keep the tape off of the surface of the window where the two flanges mate.
3. To locate the holes beneath the window press down on the mylar with your finger tip and trace their outlines with a felt tip pen. Trace three consecutive holes in four different places every 90 degrees around the flange. These circles are used to time the holes in the two flanges as they mate together.

## BURNING OUT THE HOLES

### Window Set Up

1. Screw the lifting eyes into the lugs on the side of the downstream flange reference drawing #9220.832.MD-285390. Using the crane and the aluminum lifting fixture ID #62 position the downstream flange over the window assembly and lower until it is just touching. Line up the holes with the ones drawn with the felt tip pen and lower it down the rest of the way.
2. Put the aluminum cover on the window assembly to protect it from any accidental damage.
3. Remove the lifting fixture and clamp the two flanges together in four equal spaced places.
4. Inspect the hose clamp holding the kevlar fabric to be sure that it is not sliding off of the flange. Then remove the innertube retainers from the bottom of the window assembly.

### Safety

1. **Caution** : the fumes produced by burning the kevlar and mylar contain hazardous compounds that must be exhausted outside of the building.
2. Attach the long flexible hose from the oil separator to the exhaust side of the Nederman electrostatic filter. Check to see that the filters inside are clean. If the hose is not long enough to reach outside use a piece of tubing or pipe to make up the difference
3. **The Kevlar fabric burns very bright use the darkest brazing glasses available to protect your eyes.** (I found a pair with #5 shade that worked well.)

## Burning Out the Holes

1. Set up the oxy-acetylene unit with a #1 torch tip. Light torch and adjust it to a slightly oxidizing flame. Be sure the aluminum cover is in place to protect the window.
2. Put a piece of 1/16 aluminum sheet metal under the holes to protect the surface of the test vessel flange and catch the debris from the burned out holes.
3. Using a circular motion quickly burn out the fabric inside the hole. Burn four holes, 90 degrees from each other.
4. Turn off the torch and check the alignment of the holes. If the holes are not properly aligned carefully bump the flange into position until they are. Use four of the 7/8-9 UNRC X 3 inch ferry head counter bore cap screws to bolt together the flanges through the burned out holes. Tighten them snugly, this will hold the two flanges together while you burn out the rest of the holes. You can now remove the c-clamps.
5. Mark the holes that fall on top of the spacer blocks and return to these after burning out the rest of the holes.
6. Light the torch and continue burning out the holes. Work quickly and skip around a little bit so that the heat does not build up in one area and damage the mylar.
7. When you finish burning out the holes that are accessible, move the spacer blocks beneath the flange and burn out the remaining holes.

## ASSEMBLY PREPARATION

### Install Aluminum O-Ring

1. Use the same rigging technique as before to raise the flange about 1/4 of an inch, and then using a tongue depressor separate any mylar that is stuck to the bottom of the flange. When separated, remove the downstream flange from the window assembly.
2. When the downstream flange is removed the aluminum O-ring needs to be fitted into the groove using RTV to hold it in place. This will keep the ring in place while the flange is lowered down during the final assembly. Do this step first so that the RTV will have cured by the time you are ready to assemble the window.
3. Position the downstream flange so that the groove for the aluminum O-ring is facing up. Clean the groove and the surface of the flange with alcohol. Check that the aluminum o-ring is clean and free of nicks or scratches.
4. Use small dabs of RTV placed into the outer edge of the o-ring groove (about 12 places around the ring) to hold the aluminum ring into the groove. Use **RTV sparingly and clean off any excess**. Use tongue depressors and c-clamps to hold the ring in place while the RTV cures.

## **Separate the Mylar/Kevlar Layers.**

1. The top layer of mylar must now be separated from the kevlar. Use a tongue depressor to gently work the layers apart. **Be careful not to pull any kevlar fibers or tear the mylar.**
2. Lift the mylar and use light air pressure to blow away any debris that may have settled between the layers. **Be sure to keep the work area clean.**

## **Install the Urethane o-ring**

1. **Do Not use vacuum grease on the o-ring.** Our objective is to clamp the window layers tightly between the flanges. Lubricating any of these surfaces would defeat this purpose.
2. Working from beneath the window assembly push the o-ring up under the window until it pops into its groove. Continue working your way around the ring until the o-ring is fully installed.
3. Fold over the top layer of mylar and trace the ridge of the o-ring onto the kevlar with a felt tip marker. This will be your guide for applying the epoxy.

## **Final Assembly**

Allow yourself a full day to complete the final assembly.

## **Applying the Epoxy**

1. Prepare 200 ml of epoxy; mix 100 ml of Hysol 826 Resin (MSDS#07625) with 100 ml of Hysol 308 Hardener (MSDS#06160). If the resin is too thick to work with let it sit in a warm water bath until the crystals dissolve. Remove it from the bath once the crystals have dissolved because excess heat will accelerate the reaction. This mixture has a 24 hour cure time, allowing enough time to properly tighten the bolts.
2. Fill a 125 ml squeeze bottle with the epoxy mixture and save the excess epoxy in the mixing container, it will be used for application around the holes.
3. Fold over the top mylar layer without creasing it to expose about one third of the holes and o-ring that was traced with the felt tip pen. Using the squeeze bottle apply a 3/16 of an inch bead of epoxy along the ridge of the o-ring using the line as a guide. Use a tongue depressor to work the epoxy into the fabric.
4. Testing revealed that when the kevlar windows failed fabric pulled out from the area in front of the holes, so epoxy will be applied around the holes too.
5. To apply epoxy around the holes use a small piece of 1/16 wall tubing 1 1/2 inches in diameter. Dip the end of the tube into the left over epoxy, shake off the excess and stamp a ring around the hole in the kevlar fabric. This method allows you to make a consistent bead around every hole. A small amount of epoxy is all that is needed around the holes.
6. Fold the mylar back over, line up the holes and refasten the tape to the flange. Continue working your way around the flange in this manner until finished.

## Assembly

1. Check to see if the RTV holding the aluminum O-ring into the downstream flange has cured. Then remove the clamps and trim any excess RTV that may have squeezed out from the o-ring groove. **Be sure that the mating surface of the flange is clean.**
2. Using the lifting fixture ID #62 position the downstream flange on top of the window assembly with the o-ring facing down.
3. Install four of the 7/8-9-UNRC x 3 inch with a 7/8 inch lock washer 90 degrees from each other
4. Put on the protective cover, remove the rigging and install the remainder of the 60 bolts and washers finger tight.

## Required Bolt and Torque Sequence

1. Testing revealed that the torque needed to provide the maximum pull out force of the mylar kevlar window was 250 ft-lbs. It is important to follow the sequence provided.
2. Follow the sequence numbered in sequence Fig. 5 and tighten all the bolts down to 25 ft-lbs.
3. Raise the torque to 50 ft-lbs. Then continue increasing in 50 pound increments until you reach 250 ft-lbs. Make two passes at 250 ft-lbs. and then let the epoxy cure for 24 hours.

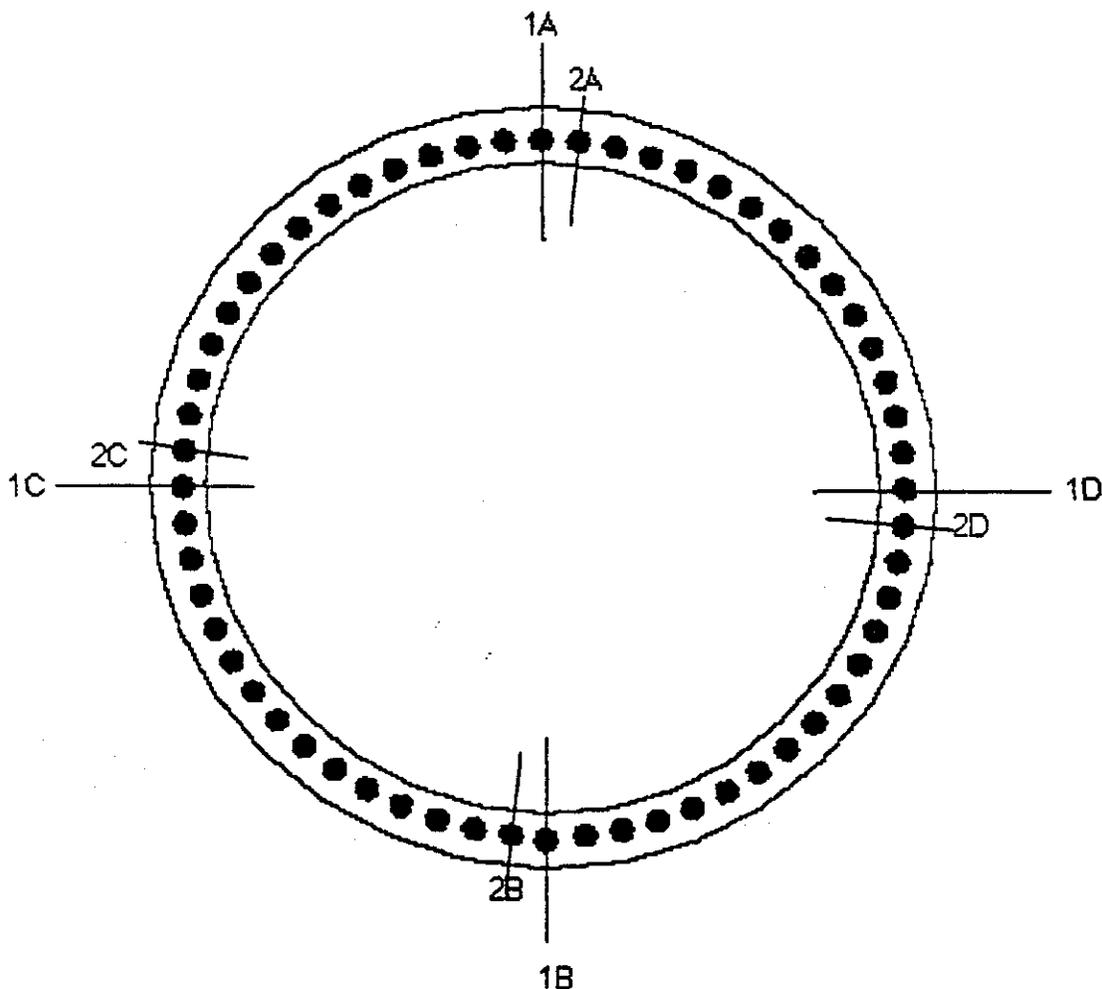


Fig. 5

## **Installation**

1. The inside layer of mylar (item #8 on the assembly drawing) will be cut out at the time of installation. For now it can be left in place to protect the kevlar.
2. To trim pull the mylar up with a piece of duct tape and trim it with a blunt nosed scissors about 1 1/2 inches from the inside edge of the flange.
3. **Damage to the kevlar will mean starting over from the beginning.**

## **LIST OF SOURCES:**

1. Andrew Szymulanski (RD/MSD): KTeV 1.8m diameter Window Design, construction drawings and procedure notes.
2. Charlie Paul, Dean Wincott (RD/MSD): *Documentation of technical procedures for the assembly of the four foot diameter vacuum window.* Design by Stanley Sobczynski (RD/MSD).
3. Dave Erickson (RD/MSD): *E-832 KTeV 1.8 Meter Window Assembly Procedure.* Draft Copy. January 15, 1994.

