If you are using a printed copy of this procedure, and not the on-screen version, then you MUST make sure the dates at the bottom of the printed copy and the on-screen version match. The on-screen version of the Collider-Accelerator Department Procedure is the Official Version. Hard copies of all signed, official, C-A Operating Procedures are available by contacting the ESSHQ Procedures Coordinator, Bldg. 911A

C-A OPERATIONS PROCEDURES MANUAL

15.8.3 Valve Box and In-Ring Magnetic Element/Interconnect Repair, RHIC

(Collider Accelerator Mechanical Support Group Procedure C-A-CMS-525)

Text Pages 2 through 21

Note: This document was formerly a C-A Group Procedure. The content of the group procedure was reviewed by the Technical Supervisor. All approvals and/or issue dates of the original group procedure are maintained for present use.

Hand Processed Changes

HPC No.	Date	Page Nos.	Initials
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Approved: _____***Signature on File***_____ _____
Collider-Accelerator Department Chairman Date

G. McIntyre

Collider Accelerator Mechanical Support Group
Procedure C-A-CMS-525

REVISION RECORD

Rev. No.	Date	Page	Subject
A	05/07/01	all	Inclusion of new repair techniques
B	05/17/04	4-5	ODH Safeguards
C	11/28/06	4-5	ODH Safeguards Upgrades

1. SCOPE

1.1 This procedure defines the process, equipment, parts, safety precautions and associated procedures required to open a RHIC Magnet Interconnect, RHIC Warm-to-Cold Transition (WtC), Triplet or DX for repairs. The techniques detailed in this procedure may be used for any RHIC-related vacuum vessel repair including Vacuum Jacketed Return (VJR) and valve box repairs, as determined applicable by RHIC engineering and technical supervision. This document is to act as a guide and does not have to be followed in a step-by-step fashion. With prior approval from the Technical Supervisor or the Cognizant Engineer any procedure section may be used alone or may be combined with any other section to execute and complete a repair.

2. RESPONSIBILITIES

2.1 This procedure is to be executed by properly trained personnel from the Collider Mechanical Support Group (CMS) of the Collider -Accelerator Department.

3. APPLICABLE DOCUMENTS

3.1 The procedures listed below are to be used as reference documents for the replacement and reassembly of parts.

RHIC-CR-IP-0115-501	Arc Splice Preparation, RHIC Tunnel
RHIC-CR-IP-0115-502	Arc Electrical Splice, RHIC Tunnel
RHIC-CR-IP-0115-503	Arc Helium Interconnect Bellows Attachment, RHIC Tunnel
RHIC-CR-IP-0115-504	Arc Interconnect Helium Lines Installation, RHIC Tunnel
RHIC-CR-IP-0115-507	Arc Interconnect Cold Mass and Helium Lines Insulation and Heat Shield Installation, RHIC Tunnel
RHIC-CR-IP-0115-508	Installation of Interconnect Cryostat Shell, RHIC Tunnel

4. ASSOCIATED EQUIPMENT

4.1 The following equipment and materials may be required to execute this procedure.

Note: AR is an abbreviation for "as required".

1	Plasma Cutter w/torch	L-TEC Plasma, Torch #PT17A or equivalent
1	Knife, Utility	Retractable blade
AR	Gloves, work	Leather palm or equivalent.
1	Drill, electric	3/8" chuck, cordless.
1	Wheel, Wire	for cleaning rust from mild carbon steel, to be used only for this purpose.
1	Face-shield, Safety	Safety approved
1	Roll, Foil	Aluminum, vacuum quality
1	Cover, Plastic	100mm ISO flange

4. ASSOCIATED EQUIPMENT (continued)

AR	Roll, Masking Tape	½" - 1" wide.
1	Roll, Tape; polyester	1" wide, DWG# 1200072.
1	Cutter, sheet metal	pneumatic, w/length of air hose to reach interconnect & air supply in tunnel ceiling, able to cut 0.125" thick aluminum.
1	Screwdriver, Cordless	3/8" drive with #2 Phillipshead bit.
1	Jigsaw, Hand held	Bosch 1584VS or equiv. w/ TB118B blades.
1	GTAW Welding equipment	For welding up to 0.109" wall SST pipe & 0.125 " thick aluminum.
1	Cutter, Split Ring, 2.88"/2.38 Dia	Wachs SW-2 7/8 or equivalent.
1	Collet Set, Cutter, 2.875" Dia	For Wachs cutter listed above.
1	Collet Set, Cutter, 2.375" Dia.	For Wachs cutter listed above.
1	Collet Set, Cutter, 2.5"/3.63" Dia.	For Wachs cutter listed above.
1	Collet Set, Cutter, 3.0"/3.63" Dia.	For Wachs cutter listed above.
1	Tube, 3" long, Brass for 3" OD	w/ deburred ends, passes into 3" EV Tube & over magnet electric lines
1	Tube, 3" long, Brass for 2.5" OD	w/ deburred ends, passes into 2.5" EV Tube & over magnet electric lines
1	Gun, Poprivet-type	With required spot drill, ~_".
AR	Rivets, ~Ø3/16, aluminum	For rivet gun above.
AR	Sheet, aluminum, Type 1100-0.	thickness & width as required by process
AR	Plate, hot-rolled carbon steel	thickness & width as required by process.
1	Vacuum, shop-type	Shop-vac, Wet/Dry, 16 gallon or equivalent
1	Grinder, 4" or less	Pneumatic or electric
1	Grinder, 8"	Hand-held, electric or pneumatic.
AR	Hearing Protection	C-AD approved
1	Purge Gas Evacuation System	Blower, cart & hoses

5. Prerequisites

5.1 While work is underway and an abnormal condition arises, re-review the job against criteria in applicable SBMS Subject Areas, and/or work planning requirements. If unsure of further actions, discuss situation with supervisor.

5.2 Prior to opening any in tunnel component, verification of the correct item to be opened must be given by the Technical Supervisor or the Cognizant Engineer in writing on an interconnect repair traveler with the interconnect number and work

plan filled in. All work done in the repair must be outlined in the traveler, with any unusual situations noted.

5.2.1 Clearance must be received from the Cryogenics and Vacuum Sections that the cryogenic piping and the vacuum vessel are at atmospheric pressure. Both verification releases on the traveler must be signed and dated by the Cognizant Engineer, the Technical Supervisor or the Technical Supervisor's designee prior to opening a vacuum vessel. A vacuum vessel may be opened with pressure in the cryogenic lines but a work permit must be written and approved then read and signed by those carrying out the work. If a repair is to be done with pressure in the cryogenic lines, the appropriate work permit number must be written in the space marked "Cryogenic clearance given by:"

5.3 All personnel executing this procedure shall have been trained by the CMS Group in the proper use and function of all tools and equipment. Personnel not having received this training shall not attempt these tasks.

5.4 A repair traveler (type IREP –) must be initiated prior to the start of work. Specific instructions must be given by the Technical Supervisor or the Cognizant Engineer in the traveler before beginning this procedure as to how far into the interconnect this procedure should be followed.

5.5 If beam has passed through the area in which work is to be done, a radiation safety assessment must be done by a FS representative prior to work beginning. Additional equipment and/or precautions may have to be introduced depending on the outcome of the assessment.

5.6 General Notes and Cautions

5.6.1 Always tape welding blanket strips behind areas to be welded if sparks may reach the MLI blankets.

5.6.2 When pressing soft heatshields into the interconnect center to gain more air-gap between the MLI and outer shell never compress MLI to less than 50% of original height.

5.6.3 Strips of weld blanket may be rolled up and placed between the shell and the outer heatshield MLI to obtain a minimal air gap. The 50% compression rule still holds.

5.6.4 Grinding paint off of shells can cause the smoke-type fire protection system to false alarm. Through the BNL Fire Department, turn off alarms in proximity to work area. Avoid aiming the grind-spray towards the fire sensors.

5.6.5 Cutting shells and heatshields can produce a spray of hot chips. Always use a full faceshield and wear gloves, long sleeves and long pants when performing this task.

5.6.6 Vibration caused by sawing on the outer shell can cause the interconnect "blow-off" port to fall off. If this occurs, check and repair port after cutting is complete.

5.6.7 Use proper UV protection when welding or plasma cutting.

5.6.8 When plasma cutting is used smoke alarms in the work area must be disabled, through the BNL Fire Department,.

5.6.9 Shell sections must never have a flat or concave area when re-installed. This situation could cause the shell to become unstable and fail under vacuum. If this flatness/concavity occurs notify supervision or engineering.

5.6.10 The RUSH lines may be welded leak-tight using custom-fit backing rings. If this technique is chosen, prepare these rings as soon as the RUSH lines are cut out. Use of these rings is due to the difficulty in predicting the quantity and flow of any gas in the lines to be welded. The welding machine used, automatic or manual, should be adjusted to accommodate this technique.

5.7 Oxygen Deficiency Hazard (ODH) Safeguards

5.7.1 If a helium carrying line is to be cut and an inert gas purge is to be passed through that line during the work the following precautions must be started prior to cutting the line. Nitrogen flow into a sextant shall be controlled by Cryogenic Section Operations Group to a maximum of 10 CFM in a sextant. If the flow will exceed this rate, the Accelerator Systems Safety Review Committee must review this proposal prior to its execution.

5.7.1.1 Meet with the Cryogenics Control Room staff to discuss the work to be done and to initiate a plan for opening of a purge gas carrying line.

5.7.1.2 The work area shall be roped off and posted that access is limited to those specifically trained in this job and that POM's are to be worn by all entrants into the work area. The work area posting shall be at least 100 feet from the magnet opening in both aisles. The postings shall be on either side of the opening and, for ease, can be located at the gates in the ring. At the entrance to the tunnel / work area warnings must be posted cautioning those entering of the possibility of an ODH scenario. The warning must be posted at a point that allows an unrestricted path of egress, excluding a path through the work area.

5.7.1.3 The posting must spell out the words "**Portable Oxygen Monitor Required for Entry, Possible Oxygen Deficiency Hazard**". The warning must state how to obtain a monitor, listing contacts and extension numbers.

5.7.1.4 The affected sextant will be posted ODH 0 at the entrance gates as part of the work planning process. Request the MCR to have the C-AD CRTs display the location of this safety condition. Notify Paul Sampson/John Benante/Ray Zaharatos of the location of this condition and that work is being done.

5.7.1.5 The entrance to the area is to be controlled by RHIC Access cards ensuring that personnel entering the area are trained in ODH 0 or properly escorted.

5.7.1.6 If a walkway is to be provided past the work area, an ODH Canary box, provided by the Access Controls Group (J. Reich x5335), that alarms locally at 19% shall be in place within 20 feet of the open area to warn of a local ODH condition.

5.7.1.7 ODH sensors in the area shall be operable.

5.7.1.8 ODH fans should be operable, if possible, but are not necessary.

5.7.1.9 Workers within the postings shall wear POMs that alarm at 19.5%. A mixing fan with at least 60 CFM capacity shall blow at the open magnet area to disperse the nitrogen gas away from workers and mix the purge gas into the large tunnel volume. If a POM alarms work shall cease and workers shall leave the tunnel and alert the Cryogenics Control Room (x3837) to reduce or shutoff the purge gas. Work shall cease if the mixing fan is not operational and work shall not continue until the fan is replaced.

5.7.1.10 The Cryogenics Control Room must be notified before the line is cut that the line will be opened and that purge monitoring must begin.

5.7.1.11 It must be verified daily that the air re-circulation system is working. This verification can be done by noting air exiting the duct registers in the tunnel ceiling.

5.7.1.12 The oxygen concentration must be check daily to verify it is >19.5%. A log may be kept at the entrance to the work area noting the date and the percentage. This is to be done by the Cryogenics Group. Contact the Cryogenics Control Room (x3837) for support.

6. Procedure

6.1 Verify that the interconnect number on the repair traveler corresponds with the tunnel identification number of the interconnect about to be opened.

WARNING

Once any magnet line or process lines is open, purge gas mixing fans must be in place, connected and operating and personal oxygen monitors (POMs), or equivalent, must be worn by all personnel working on the interconnect or passing through the posted work area. Anytime the interconnect is not actively being worked on the interconnect itself must be barricaded (e.g. orange safety fencing wrapped around it) and posted. The purge gas mixing fan must be operating at all times (24 hours/day) until the purge is shutoff and/or the process line(s) are welded closed. If a POM alarms back away from the open line and wait 30 seconds for the alarm clears. If the alarm continues leave the tunnel and alert others working in the area to leave and alert your supervisor

And

NOTE

This procedure includes details for opening an interconnect down to cold mass end volumes. It is not written to provide instructions on a specific repair or modification but to give a "road map" of how to properly obtain access into the interior of an interconnect, VJR, magnet or valve box. Repair specific -instructions must be given by the Technical Supervisor or the Cognizant Engineer.

6.2 Have the vacuum valve removed from the port on the upper interconnect shell by the RHIC Vacuum Section (ext. 4084 or 4627). Cover the shell port with clean aluminum foil and, if available, a plastic port cap.

6.3 Outer Shell Opening Guidelines. The opening of a standard magnet interconnect can be executed using two different approaches: A) removal of the outer shell with a plasma torch/grinder or B) outer shell removal with a metal cutting jigsaw. There is a separate section (6.4) for the opening of triplet or DX interconnects / vacuum vessels.

6.3.1 Approach A: Removal of the Outer Shell with a Plasma Torch

CAUTION

Plasma cutting/grinding can cause the in-tunnel smoke detectors to false alarm. Arrange to have the *smoke alarms only* turned off during the plasma cutting and weld portion this procedure.

WARNING

All plasma cutting/grinding shall be performed only after the proper shielding is in place. All personnel not directly involved in the cutting process shall be outside the shielding during cutting. Any personnel inside the shielding shall wear proper protective gear to guard against eye, hearing and burn injury.

WARNING

When cutting the vacuum vessels' weld neck flanges and the interconnect shells' longitudinal flanges care must be taken to remove as little material as possible. A test pass cutting away about 0.25" of material should be tried first over the length of an inch or two of weld. From the results of this test-cut more or less material should be removed to insure easy removal of the shells with minimal material loss.

6.3.1.1 With a welding blanket, cover any equipment or electronics that cannot be easily removed to protect it from plasma sparking. Place copper shields under the weld neck flange, then plasma cut the circumferential weld on both sides of the interconnect for the upper and/or lower shell. Initially, only the welds holding the upper shell shall be cut. Most repairs can be done with just the upper shell removed. If both upper and lower shells must be removed, plasma cut the entire circumferential welds at each end of the interconnect. Clamp the shells to the return flange using 1" Armstrong clamps or equivalent. Plasma cut the longitudinal seam welds.

WARNING

Eye protection and hearing protection must be worn when grinding or cutting metal items. Failure to do so may result in injury.

6.3.1.2 Giving the freshly cut shell adequate time to cool and wearing work gloves remove the upper shell. Place the shell on the ground and take care not to damage the vacuum flange. Prepare the shell(s) for reinstallation by removing the rough oxidized material from the cut edges with a dedicated file and a drill with a dedicated wire wheel and/or grinder. To re-install the shell(s) clamp the shell seams, longitudinal and circumferential, together with 1" Armstrong clamps or equivalent and weld using the GTAW process, for details see section 6.23.

6.3.2 Approach B: Outer Shell Removal with a Metal Cutting Jigsaw.

WARNING

Eye protection and hearing protection must be worn when grinding or cutting metal items. Failure to do so may result in injury.

6.3.2.1 Mark a rectangle on the outer shell to a size that will offer adequate leak checking and repair space. Do this by laying-out a circumferential line 1.5 inches, towards the center of the interconnect, from the end of the

interconnect shell or shells to be removed. Layout two longitudinal lines that will allow for the desired amount of shell to be removed. ***Note: This method allows the technician to disregard the production longitudinal seams which are awkward to cut due to their position.*** The two newly drawn longitudinal lines will redefine the upper and lower shells. These cuts will allow one or both shells to be removed as long as the cuts are 180 degrees apart. The longitudinal welds may be cut in their entirety. Check with the Technical Supervisor or the Cognizant Engineer to verify the proper size opening has been drawn out.

CAUTION

Care must be taken when cutting the outer shell that the blade does not penetrate into pipes residing below the shell. A jigsaw blade cut to a length of 1.25" or less is to be used.

CAUTION

Care must be taken when drilling the outer shell. A drill stop that limits the drills entry into the shell by 1.25" or less (1.0" for WtC) should be employed.

6.3.2.2 Using a drill stop set at ½" deep, drill a Ø3/8" hole in each corner of the marked out rectangle. Remove the paint from the shell in an area 1-2" on either side of the lines forming the rectangle. Redraw the lines by placing a straight edge across the 4 holes drilled previously. ***Note: when convenient and prior to cutting a section of shell free, wrap winch straps around the shells to secure them. Maintain a hold on the shell prior to cut through to prevent the section falling into the interconnect.*** Using a jigsaw with a properly trimmed blade, connect the holes by cutting with the jigsaw along the redrawn lines until the shell section(s) is free. When a production longitudinal seam is encountered, use a reciprocating saw (e.g., Sawzall®) to cut through it. The same caution holds: Do not allow the saw blade to extend beyond the shell to damage anything inside the interconnect. Remove the rectangle from the shell exposing the heat shield MLI blankets. Deburr the shell section with a wire wheel and/or file.

6.3.2.3 To reinstall the shell section(s) see section 6.23.

6.4 Outer Shell Opening Guidelines for DX / Triplet. The opening of a DX or Triplet interconnect can be executed using two different approaches: A) removal of the outer shell with a plasma torch / grinder or B) outer shell removal with a metal cutting jigsaw. There is a separate section (6.3) for the opening of standard magnet interconnects / vacuum vessels.

6.4.1 Removal of an Entire Triplet or DX Shell: Approach A: Removal of the Outer Shell with a Plasma Torch or grinder.

CAUTION

Plasma cutting / grinding can cause the in-tunnel smoke detectors to false alarm. Arrange to have the *smoke alarms only* turned off during the plasma cutting and weld portion this procedure.

WARNING

All plasma cutting shall be performed only after the proper shielding is in place. All personnel not directly involved in the cutting process shall be outside the shielding during cutting. Any personnel inside the shielding shall wear proper protective gear to guard against eye and burn injury.

WARNING

When cutting the vacuum vessels' or interconnects' longitudinal flanges, care must be taken to remove as little material as possible. A test pass cutting away about 0.25" of material should be tried first over the length of an inch or two of weld. From the results of this test-cut more or less material should be removed to insure easy removal of the shells.

WARNING

Eye protection and hearing protection must be worn when grinding or cutting metal items. Failure to do so may result in injury.

6.4.1.1 With a welding blanket, cover any equipment or electronics that cannot be easily removed to protect it from plasma sparking. Plasma cut or grind the longitudinal seams at the outermost end of the shells' flanges. Remove the minimum amount of material to free the shell. Allow the shell adequate time to cool and prepare the shell(s) for reinstallation by removing the rough oxidized material (scale) from the cut edges with a dedicated file and/or a drill with a dedicated wire wheel and grinder. Clamp the longitudinal seams together using 1" Armstrong clamps or equivalent. Using an abrasive wheel grinder cut a groove approximately ¼" deep just inboard (~0.12" minimum) of the circumferential welds on both sides of the shell to be removed. Finish the cuts from the longitudinal seam to the abrasive-wheel cut groove using a reciprocating saw (e.g., Sawzall®) or jigsaw.

6.4.1.2 Wearing work gloves remove the shell using the chain falls at each Triplet or properly rated mobile lifting device and the lifting ears in each Triplet interconnect shell. Place the shell on the ground and take care not to damage the vacuum flange, if applicable. Prepare the shell(s) for reinstallation by removing the rough oxidized material from the cut edges with a dedicated file and a drill with a dedicated wire wheel and grinder.

To re-install the shell(s), clamp the shell seams together, the longitudinal seams with 1" Armstrong clamps, or equivalent, and circumferential seams with winch straps. Weld using the GTAW process. For welding details see section 6.23.

6.4.2 Approach B: Outer Shell Removal with a Metal Cutting Jigsaw, DX and Triplet.

WARNING

Eye protection and hearing protection must be worn when grinding or cutting metal items. Failure to do so may result in injury.

CAUTION

Care must be taken when drilling the outer shell. A drill stop that limits the drills entry into the shell by 1.25" or less (1.0" for WtC) should be employed.

6.4.2.1 Mark a rectangle on the outer shell to a size that will offer adequate repair space. Do this by laying-out a circumferential line 1.5 inches, towards the center of the interconnect, from the end of the interconnect shell or shells to be removed. Layout two longitudinal lines that are at least 1" from the longitudinal seams. Check with the Technical Supervisor or the Cognizant Engineer to verify the proper size opening has been drawn out. Using a drill stop set at ½" deep, drill a Ø3/8" hole in each corner of the marked out rectangle. Remove the paint from the shell in an area 1" on either side of the lines forming the rectangle.

CAUTION

Care must be taken when cutting the outer shell that the blade does not penetrate into pipes residing below the shell. A jigsaw blade cut to a length of 1.25" or less is to be used.

6.4.2.2 Redraw the lines by placing a straight edge across the 4 holes drilled previously, reforming the rectangle. ***Note: when convenient and prior to cutting a section of shell free, wrap winch straps around the shells to secure them. Maintain a hold on the shell prior to cut through to prevent the section falling into the interconnect.*** Using a jigsaw with a properly trimmed blade, connect the holes by cutting with the jigsaw along the redrawn lines until the shell section(s) is free. When a production longitudinal seam is encountered, use a reciprocating saw (e.g., Sawzall®) to cut through it. The same caution holds: Do not allow the saw blade to extend beyond the shell to damage anything inside the interconnect. Remove the rectangle from the shell exposing the heat shield MLI blankets. The outer shell weights approximately 50 lbs / 670 in^2 use this as a guide in determining a safe lift. Deburr the shell section with a wire wheel and/or file.

Internal Stringers

6.4.2.3 If an internal stringer, which run vertically in the middle of the interconnect shell, is encountered it must be cut with a Sawzall® or a jigsaw with a full length blade.

External Stingers

6.4.2.4 If an external stringer, which run vertically on the shell, is encountered, it must be cut with a Sawzall® or a jigsaw with a full length blade. Remove a 2" long piece of the external stringer with the piece centered about the layout line. Remove the paint within an 1" of the space left by the missing piece.

6.4.2.3 To reinstall the shell section(s) see section 6.23.

CAUTION

Care must be taken when cutting blankets that the blade does not penetrate into blanket(s) residing below the blanket being cut. Adjust the utility blade accordingly.

6.5 Fold back the Outer Heatshield MLI blanket by pulling apart the blanket's ultra-sonically welded seam. If excessive tearing occurs around the spot welds, longitudinally slit the blanket about 5" above the heatshield weld seam.

6.6 Take care when removing the heatshield blanket keeper, found only in 8cm interconnects, not to overstress and break the transverse conduits' legs, which hold the keeper in place.

6.7 Repeat the step 6.4 process for the Inner Heatshield MLI blanket but offset the slit, if slitting is necessary, about 3" from the opening in the Outer Heatshield MLI blanket.

6.8 Fold back both MLI blankets and secure to the lower shell with masking or polyester tape.

6.9 Heatshield Removal and Replacement Techniques

WARNING

All welding shall be performed only after the proper ultra-violet (UV) shielding is in place. A firewatch may be required when welding open gap welds with MLI material underneath. Check with supervision. All personnel not directly involved in the weld process shall be outside the shielding during welding. Any personnel inside the shielding shall wear proper protective gear to guard against eye and burn injury.

CAUTION

Care must be taken to ensure proper grounding of welding equipment when any part of the heatshield is being welded. Use a jumper cable to ground the interconnect heatshield to the magnet heatshield. Failure to do so could damage the BPM cable and cause extensive programmatic delays.

6.9.1 Upper Heatshield Removed Entirely (0.020" to 0.032" thick) - When the entire length of an interconnect has been removed, the heatshield should only be cut horizontally. The circumferential ends of the shield are accessible and can be reached with horizontal cut(s). One or two horizontal cuts can be used depending on whether or not it is required to remove a section of shield or simply bend it back out of the way. ***Note: If a section is removed in excess of 576 in^2 it must be welded back together on one side to allow for proper heat transfer. The only guideline for the horizontal cut is that it must be made at least ½" above the original production horizontal weld to allow for re-installation.*** If required a saw or air chisel may be used to separate the horizontal weld in lieu of slitting. To re-install the shield, fabricate 2" wide X .032" thick type 1100-0 aluminum strips. Install them over the cut in the shield using all aluminum pop rivets every 6" (minimum). The splice strips must cover any cut area. If the production weld was split, the split must be backed up with welding blanket (Tillman® #595 or equivalent) and welded as in production (see RHIC-CR-0115-507).

6.9.2 Heatshields in Any Access Cut and Any Ring Location (0.020" to 0.032" thick)- Heatshields of a thickness of 0.020" to 0.032" will be encountered in most 8cm upper interconnects (some 8cm interconnects in sector 5 contain 0.12" thick upper shields), the vertical stacks of the warm-to-cold transitions, the triplets, VJRs and the DX/DO transfer lines. The shield cut is to be drawn at least 1" in toward the center of the vacuum vessel cut. This will allow access for reinstallation. Use a utility knife to cut the shield. Avoid cutting into the blanket behind the shield. For heat transfer considerations, it is always preferred to not completely remove a section of shield, but rather to leave one edge intact and "hinge" the shield section out of the way. In some cases it may be necessary and is allowable to completely remove a cut section. If the removed section is >576 in^2 in area it will have to be welded back into place along at least one side. If welding, back the weld with strips of welding blanket (Tillman® #595 or equivalent), 4" width minimum. To re-install the remaining shield cut sides, fabricate 2" wide X .032" thick type 1100-0 aluminum strips. Install them over the cut in the shield using all aluminum _" pop rivets every 6" (minimum). The splice strips must cover any cut area.

6.9.3 Removing and Re-Installing Heatshield Sections 0.090" to 0.125" thick and < 576 in^2 in Area - The shield cut is to be drawn at least 1" in toward the center of the shell opening. This will allow access for reinstallation. Using a drill stop set at ¼" deep, drill a Ø3/8" hole in the corners of layout lines. Make the cut with a jigsaw, Kett® saw, DeWalt 18V circular saw, router, carbide cutoff wheel, hand keyhole saw or any combination required. In each case, the cutting blade or disk must be of the proper size to avoid damage to the interconnect components under the shield cut line. ***Note: Soft aluminum tends to clog cutting tools. Coat the saw blades with beeswax before using them on this material.*** Avoid cutting into the blanket behind the shield. To re-install, fabricate 2" wide X .032" thick type 1100-0 aluminum strips. Install them over the cut in the shield using all aluminum _" pop rivets every 6" (minimum). The splice strips must cover any cut area.

6.9.4 Removing and Re-Installing Heatshield Sections 0.090" to 0.125" thick and > 576 in^2 in Area - The shield cut is to be drawn at least 1" in toward the center of the vacuum vessel cut. This will allow access for reinstallation. Using a drill stop set at ¼" deep, drill a Ø3/8" hole in the corners of layout lines. Make the cut with a jigsaw, Kett® saw, DeWalt 18V circular saw, router, carbide cutoff wheel, hand keyhole saw or any combination required. In each case, the cutting blade or disk must be of the proper size to avoid damage to the interconnect components under the shield cut line. ***Note: Soft aluminum tends to clog cutting tools. Coat the saw blades with beeswax before using them on this material.*** Avoid cutting into the blanket behind the shield. To re-install, position the removed shield section so that one of the section's edges overlap the intact shield by ½". Place 4" wide (minimum) strips of welding blanket (Tillman® #595 or equivalent) behind the overlapped edge and fully fillet weld the removed shield section to the intact shield. For the remaining sides, fabricate 2" wide X .032" thick type 1100-0 aluminum strips. Install them over the cut in the shield using all aluminum _" pop rivets every 6" (minimum). The splice strips must cover any cut area.

6.9.5 Removing Sections of Lower Heatshields Containing Coolant Sleeve Welds - In some cases it is necessary to remove a heatshield or a heatshield section that is welded to coolant sleeves, either for access or to replace a section of heatshield pipe. To do this, cut above and below the production weld in the "H" - slots using a Kett® saw, DeWalt 18V circular saw, grinding wheel or other method which will not permit the cut to penetrate the coolant sleeve by more 0.050". Once the heatshields or heatshield section is cut free of the sleeves, any of the methods described in sections 6.9.3 and 6.9.4 can be used to remove the desired section. Use the guidelines in sections 6.9.3 and 6.9.4 to re-install the shield. Along the cutline, weld the shield to the shield fragments attached to the sleeves where possible.

6.10 When bending back the upper shield, to gain access, take care to avoid injury from the cut edge. If accessing the interconnect helium supply, return, utility and heatshield pipes attempt to pull apart the ultra-sonically welded seam of the Outer Helium Line MLI blanket. If excessive tearing occurs slit the blanket longitudinally about 5" from the weld seam.

6.11 Remove the Outer Helium Line MLI blanket from the interconnect or fold out of the way.

6.12 Repeat the step 6.10 process for the Inner Helium Line MLI blanket but offset the slit, if slitting is necessary, about 3" from the opening in the Outer Helium Line MLI blanket.

6.13 Remove the Inner Helium Line MLI blanket from the interconnect or fold out of the way.

6.14 Repeat the step 6.10 process for the Cold Mass MLI blanket, attempting to pull the blanket apart and if unsuccessful slit the blanket longitudinally. If removal is necessary, take care when removing the heatshield blanket keeper not to overstress and break the cage transverse conduits' legs, which hold the keeper in place. If the legs break repair or replace as necessary.

6.15 Remove the Cold Mass MLI blanket from the interconnect or fold out of the way.

CAUTION

When removing the screws from the cold mass cage and when removing the cage itself from the interconnect care must be taken to avoid injury from the cage edges and to avoid damage to BPM cables and ultra-high vacuum components (e.g., gauge conduits and beam tube bellows assemblies). Notify the C-A Vacuum and Beam Component & Instrumentation Groups to see if removal or test of their interconnect components (i.e., UHV bellows and BPM/cables) is required.

6.16 With the cordless screwdriver in the reverse mode remove the screws holding the interconnect cage seam together.

6.17 Carefully remove the cage from the interconnect.

6.18 At this point the interconnect is completely exposed. All diagnostic and repair work can begin.

NOTE

Listed below are established techniques for interconnect repair work. Each subsection can be used independent of each other and should only be executed under the direction of the Technical Supervisor or the Cognizant Engineer.

WARNING

Prior to opening a RUSH line, end volume line or end volume contact the Cryogenics Control Room (CCR X3837) to inform them that a process line is about to be opened and that CCR-supported purge gas monitoring must begin. Inform the CCR that the pressure in the line must be reduced to allow safe cutting of that line. Verify with the CCR that the pressure has been reduced before starting the cut. If high pressure gas is released it may cause injury.

WARNING

Once any magnet line or process lines is open, the purge gas - removal ventilation system must be connected and operated and personal oxygen monitors (POMs), or equivalent, must be worn by all personnel working on the interconnect. The exhaust of the ventilation system must be barricaded and posted for possible O_2 deficiency situation. The barricade must be located a distance from the exhaust such that POMs register an O_2 reading greater than 19.5%. Anytime the interconnect is not being actively worked on the interconnect must be barricaded and posted. The purge gas - removal ventilation system must be operating at all times (24 hours/day) until the purge is shutoff and/or the process line(s) are welded closed. If a POM alarms, back away from the open line to see if your POM clears. If the alarm continues leave the tunnel and alert your supervisor.

6.19 Interconnect return, utility, supply, and heatshield (RUSH) line repair.

6.19.1 If leak checking identifies a leak in a RUSH line, pinpoint the leak.

6.19.2 With a backing purge in the line, wash over the leak using the GTAW process.

6.19.3 If wash weld proves ineffective remove the interconnect section of the faulty RUSH line.

6.19.3.1 Mount an appropriate Wach's split-ring cutter to the leaking RUSH line on the magnet side of the leak (as opposed to the interconnect side of the leak). The entire interconnect portion of the line should be removed. The cut-lines must be at least an 0.070" to the magnet sides of each weld to eliminate the welds' heat affected zones (HAZs).

6.19.3.2 Verify the cutter collet is properly tightened about the pipe and that the cutting bit is orientated in the rotating direction of the cutter. Lower the cutter to within 0.030" of the pipe OD.

6.19.3.3 Attach the drive to the cutter and cut the pipe.

6.19.3.4 Repeat step 6.19.3.1 through 6.19.3.3 at the other end of the interconnect.

6.19.3.5 Examine the newly cut magnet RUSH line. Remove any burrs that may hinder welding. Remove any chips that may have fallen into the magnet pipes during cutting.

6.19.3.6 Measure for a RUSH line replacement, if required, and weld in place using RHIC-CR-IP-0115-501 and RHIC-CR-IP-0115-504, respectively. The RUSH lines may be welded leak-tight using custom-fit backing rings. If this technique is chosen, at supervision/engineering discretion, prepare these rings as soon as the RUSH lines are cut out.

6.20 Repair or Removal of Helium Interconnect Bellows or Rolled Flange.

6.20.1 If leak checking identifies a leak in a Helium Interconnect Bellows or Rolled Flange, pinpoint the leak.

6.20.2 With a backing purge in the line, wash over the leak using the GTAW process.

6.20.3 If the wash weld proves ineffective cut the leaking end of the Helium Interconnect Bellows free. Note that steps 6.20.3.1 through 6.20.3.6 are also to be followed for bellows removal for an electrical repair.

6.20.3.1 Mount a Wach's split ring cutter, with the appropriate size collet, to the dipole/DU end volume pipe containing the leaking bellows (or bellows removed for electrical repair). The cutter makes a very tight fit with the

end volume and rolled flange. An effort must be made to remove as small a portion of the rolled flange/bellows cuff as possible since the flange and possibly the cuff may be used again.

6.20.3.2 The cutlines should be approximately 0.070" in from the weld joint to avoid the weld's HAZ. Verify the cutter collet is properly tightened about the pipe and that the cutter is orientated in the rotating direction of the cutter. Lower the cutter to within 0.030" of the pipe OD.

6.20.3.3 Attach the drive to the cutter. Start the cut. If the 0.070" distance is too small, cut in towards the bellows in 0.020" increments until the bellows is cut free of the flange.

6.20.3.4 Repeat step 6.20.3.1 through 6.20.3.3 at the other end of the interconnect.

6.20.3.5 Slide the bellows back over the CQS/DU end volume pipe taking care not to damage the bellows' convolutions. Examine the newly cut rolled flange and Helium bellows. Remove any burrs or chip pieces that may hinder welding.

6.20.3.6 Disconnect electrical splice, if necessary, in accordance with RHIC-CR-IP-0115-502 if flange or bellows removal is necessary. If flange or bellows removal is not required make the electrical repair.

6.20.3.7 If the rolled flange must be replaced, mount the appropriate Wach's split ring cutter to the end volume pipe as in step 6.20.3.1. The cutting tool must cut outside of the HAZ, approximately 0.070" from the centerline of the weld.

6.20.3.8 Verify the cutter collet is properly tightened about the pipe and that the cutter is orientated in the rotating direction of the cutter. Lower the cutter to within 0.030" of the pipe OD.

6.20.3.9 Attach the drive to the cutter and cut the flange free.

6.20.3.10 Remove the flange or bellows, as necessary, and replace in accordance with RHIC-CR-IP-0115-501 or RHIC-CR-IP-0115-503, respectively.

6.20.3.11 Execute electrical testing of splice, if disconnected, and vacuum leak check the flange and bellows weld joints.

6.20.3.12 Once leak and electrical check are complete re-closing of the interconnect can begin.

CAUTION

Prior to closing, verify with the Technical Supervisor or the Cognizant Engineer that all work and testing within the interconnect is complete.

6.18 For MLI blankets that required slitting, the cut ends must be butted tight, edge of one side of the slit to the other side, and then taped with polyester tape across the slit no less than 10 times and twice along the longitudinal direction. If light can pass through the taped slit then a patch of the same thickness blanket must be weaved into the slit and welded as the MLI blankets are in RHIC-CR-IP-0115-507.

WARNING

All welding shall be performed only after the proper ultra-violet (UV) shielding is in place. A firewatch is required when welding open gap welds with MLI material underneath. All personnel not directly involved in the weld process shall be outside the shielding during welding. Any personnel inside the shielding shall wear proper protective gear to guard against eye and burn injury.

CAUTION

Care must be taken to ensure proper grounding of welding equipment when any part of the heatshield is being welded. Use a jumper cable to ground the interconnect heatshield to the magnet heatshield. Failure to do so could damage the BPM cable and cause extensive programmatic delays.

6.22 Close the heatshield in accordance with RHIC-CR-IP-0115-507, RHIC-CR-IP-0115-508 and/or the guidelines listed section 6.9, at supervision/engineering's discretion.

6.23 Shell reinstallation (which technique used is at the discretion of engineering and technical supervision)

WARNING

All welding shall be performed only after the proper ultra-violet (UV) shielding is in place. A firewatch is required when welding open gap welds with MLI material underneath. All personnel not directly involved in the weld process shall be outside the shielding during welding. Any personnel inside the shielding shall wear proper protective gear to guard against eye and burn injury.

6.23.1 Any portion of an outer shell which is removed and does not include an internal support stringer can be re-installed using an 0.12 (minimum)"X 1" to 2" hot rolled steel strips. The strips are to be arranged external to the shell in a picture frame configuration such that the center of the 1"(to 2") dimension aligns with the gap between the replaced rectangle and the remaining outer shell. This "picture-framing" technique requires that the steel strips fully encompass the seam of the shell section with the vacuum vessel opening. This process protects the multi-layer insulation (MLI) from welding sparks that could ignite the insulation. The MLI blankets directly below the strips must be protected by 4" minimum-width strips of Tillman ® #595(or equivalent) weld blanket prior to closing. The steel strips must be tight-fitting with gaps kept to a minimum. If external strips are used for triplet /DX repairs, notch out the strips to clear the stringers and weld around the notch. Pre-weld the strips onto the shell section. This makes the sections easier to mount. Secure the sections using clamps and winch straps. The repair is closed by first tacking the rectangle and strips in place and then fillet welding the inside, outside and mitered joints of strip frame with an 0.12" minimum weld. The weld must be leak tight to< 2

X 10^{-9} Atm cc/sec.

6.23.1.1 If an internal stringer was cut, fabricate two external stringers made of ½" by 1" hot-rolled steel strip with an internal radius of 50". Place these stringers over the cut internal stringer starting from the longitudinal seam and proceeding at least 6" beyond the shell cut. Install one at the top and one at the bottom of the removed shell. If a port, flange or other obstruction prevents the repair stringer from meeting the 6" rule, make the stringer as long as possible while still allowing the port or flange to be bolted or clamped to a mating flange. Attach the stringers to the shell with 3/16" fillet welds, 1" in length every 3" on centers, minimum.

6.23.1.2 If an external stringer was cut, fabricate two external repair stringers made of ½" by 1" hot-rolled steel strip with an appropriate internal radius. Repair stringers should be placed alongside the existing stringers with an overlap of at least 3" on either side of the removed piece. If a port, flange or other obstruction prevents the repair stringer from meeting the 3" rule, make the stringer as long as possible while still allowing the port or flange to be bolted or clamped to a mating flange. Install one repair stringer at the top of the removed shell section and one at the bottom. Attach the stringers to the shell with 3/16" fillet welds, 1" in length every 3" on center, minimum.

6.23.2 If required, as determined by Technical Supervisor or the Cognizant Engineer, the strips can be tack welded to the inner diameter of the outer shell, again in a picture frame fashion, as internal backing strips. The MLI blankets directly below the strips must be protected by 4" minimum-width strips of Tillman ® #595(or equivalent) weld blanket prior to closing. The gap between the cut rectangle and the outer shell is to be tacked in a way to minimize the gap. The internal strips shall be tacked to the vacuum vessel inner diameter using very small tacks (~ 0.062") so as not to inhibit the shell from seating properly. Weld closed using the GTAW process with the appropriate welding rod. The weld must be leak tight to < 2 X 10^{-9} Atm cc/sec.

6.23.3 Any portion of an outer shell removed that contains an internal support stringer shall be installed in accordance with section 6.23.1.1, above, with the following addition: two (2) external stringers made of ½" X 1" hot rolled steel, having an internal radius equal to the outer shell's outer radius shall be installed directly along the centerline of the internal stringer with an overlap of 6 " on either end of the seam in the shell. The external support stringer can be notched to clear any steel frame strips. The paint in the area where the external stringer is to be placed must be wire-wheeled away 2" on either side of the weld area. The support is to be welded, using the GTAW process, with 1" every 3" stitch welds of a 3/16" all around the external support. All welds into the outer shell must be leak tight to < 2 X 10^{-9} Atm cc/sec.

6.23.4 Any portion of an outer shell removed that contains an external support stringer shall be installed in accordance with the sections 6.23.1.2 above with the following addition: the external support stringer which is attached to the removed portion of outer shell shall be chamfered 3/16"X 45 at four locations to allow welding to the

supports remaining on the shell. Patch plates, the same thickness as the shell support, may be used if required to bridge any gap between the removed and remaining supports. Paint must be wire-wheeled away 2" on either side of the weld area. The supports are to be welded together using the GTAW process, with the appropriate welding rod. All welds into the outer shell must be leak tight to $< 2 \times 10^{-9}$ Atm cc/sec.

6.23.5 Closing Vacuum Group Investigation ("Sniffing") Holes
The Vacuum Group will often drill ¼" diameter holes through the outer shells of the vacuum vessels and/or interconnect shells to assist them in pinpointing leaks, After the process is complete these holes are to be closed in the following fashion:

6.23.5.1 Fabricate a patch, ¾" X ¾" X 0.12" thick, of hot-rolled steel for each hole. Remove the paint within a 2" radius of the hole. Tack weld a patch over each hole in the magnet or shell. Hammer each patch to the contour of the magnet or shell. Weld the patch to the shell using a full fillet with the GTAW process.

7. Required Documentation

7.1 The supervisor or designated person shall be responsible for signing and dating the boxes on the traveler (REPAIR TRAVELER Form# IREP- -).

8. Attachments

None