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DE-ICING INSTRUCTIONS F2000 MAGNETS

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Rev. C

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THIS IS A SAFETY ALERT SYMBOL. IT IS USED IN THIS INSTRUCTION TO ALERT YOU TO POTENTIAL HAZARDS. WHEN YOU SEE THIS SYMBOL, READ AND OBEY THE MESSAGE THAT FOLLOWS. FAILURE TO OBEY SAFETY MESSAGES COULD RESULT IN PROPERTY DAMAGE, PERSONAL INJURY OR DEATH.

TRADEMARKS

CryoCool, Flint, Kapton, Lexan, Mag-Lite, Mylar, N-Dex, Nomex, Scotch-Brite, Snoop, Rifkin, Teflon and Veeco are trademarks and registered trademarks of their respective holders and should be noted as such.

TRAINING AND SAFETY

DO NOT ATTEMPT THIS PROCEDURE WITHOUT FIRST THOROUGHLY READING AND UNDERSTANDING THE CONTENTS. FAILURE TO COMPLY MAY RESULT IN EQUIPMENT DAMAGE, SERIOUS INJURY OR DEATH.

Do not perform any of the procedures described in this manual without proper training on safety methods and required personal protective equipment. The two primary hazards associated with this procedure are cryogenic burns and asphyxiation. Minimum personal protective equipment includes: an oxygen concentration monitor, a full-face shield and safety glasses with side shields; cryogenic rated gloves with gauntlets; and a cryogenic rated vest.

Magnetic fields pose another significant hazard while working on an operating magnet. All work done inside the magnet should be performed while the magnet is de-energized.

DANGER

A QUENCH EVENT ALLOWS THE RAPID ESCAPE OF HELIUM GAS FROM THE MAGNET. THE GAS ESCAPES THROUGH THE NECK AT VERY HIGH VELOCITY AND PRESSURE. IN CONFINED SPACES, THE GAS DISPLACES OXYGEN. AN OXYGEN CONCENTRATION MONITOR SHOULD BE USED TO ALERT INDIVIDUALS OF OXYGEN CONCENTRATIONS BELOW 19.5%. THE ESCAPING HELIUM MAY ALSO CAUSE CRYOGENIC BURNS TO EXPOSED SKIN. CRYOGENIC GLOVES WITH GAUNTLETS, A CRYOGENIC VEST AND A FULL FACE SHIELD WITH SAFETY GLASSES SHOULD BE WORN.

DANGER

METALLIC OBJECTS CONTAINING FERROUS METAL MAY BECOME MAGNETIZED WHEN THE MAGNET IS AT FIELD AND WILL CREATE A HAZARD TO INDIVIDUALS IN THE VICINITY OF THE MAGNET. REMOVE METAL OBJECTS WITH FERROUS CONTENT FROM THE MAGNET AREA BEFORE ENERGIZING. NOTE ALSO THAT SURGICAL IMPLANTS, JEWELRY AND ARTICLES OF CLOTHING MAY ALSO BECOME MAGNETIZED. TAKE APPROPRIATE PRECAUTIONS IN SUCH CASES.

DANGER

CRYOGENIC GASES ARE PRESENT DURING THIS PROCEDURE. CRYOGENIC GASES CAN INFLICT FROSTBITE OR CAUSE DEATH DUE TO ASPHYXIATION. ONLY A QUALIFIED TECHNICIAN SHOULD PERFORM THIS PROCEDURE.

TOOLS AND MATERIALS

The following required tools and materials are not included with the De-icing Kit:

1	Oxygen Monitor
2	Cryogenic-Rated Gloves with Gauntlets
3	Safety Glasses with side shields
4	Full-Face Shield
5	Safety Vest
6	Gas Regulator (0 to 50 psig) with adapter fitting for gas hose
7	Leak Seeker 182® or Snoop®
8	Aluminum Wrench for lead ports
9	Spare Burst Disc and Gaskets
10	Hand-Held Propane Torch or Electric Heat Gun
11	9/16 in, 10 mm, 13 mm wrenches
12	Liquid Helium
13	Bottled Helium Gas, 12 bottles minimum (99.99% pure)

Figure 1.

Figure 2.

De-icing Tool Kit

DE-ICING KIT (Part No. 44170-52)			
	Item Name	**Part #**	**Qty**
1.	Copper De-icing Rod	44501-01	1
2.	Extension Tube	23005	2
3.	Extension Tube with Straight End	23006	1
4.	Extension Tube with 90 degree End	23007	1
5.	Extension Tool	23011	1
6.	Gas Hose with In Line Valve (Yellow Jacket)	22658	1
7.	Flashlight	22656 23022	1
8.	1/4-inch Flare Union	22659	2
9.	Hex Wrench, 5mm	22660	2
10.	De-icing Assembly Case	44503-51	1
11.	De-icing Procedure (F2000)	44171	1
12.	De-icing Procedure (Titan)	46054	1
13.	Spacer Burst Disc (F2000)	44375-51	1
14.	AA Batteries	22868	1 Pkg
15.	1/4-inch Flare to Male NPT Fitting	22912	2
16.	Rubber Stopper	22909	3
17.	1/4-inch Flare to NPT Female Fitting	22914	2
18.	Clear Access plate	46799-01	2
19.	De-icing Plate Assembly (Titan)	46796-51	1

20.	Hold Down Plate Assembly	44512-51	1
21.	Thermal Insulating Access plate	44511-51	1
22.	Spacer Burst Disc (Titan)	46810-51	1
23.	Lid Organizer	23004	1
24.	Locking Pliers	44502-01	1
25.	Inspection Mirror	44505-01	1
26.	Inspection Light	44506-01	1
27.	Spare Light Bulbs	44507-01	1 Pkg
28.	Plate, Clear Blank	44126-01	1
29.	Extension Tube	23053	1

TOP ASSEMBLY PARTS

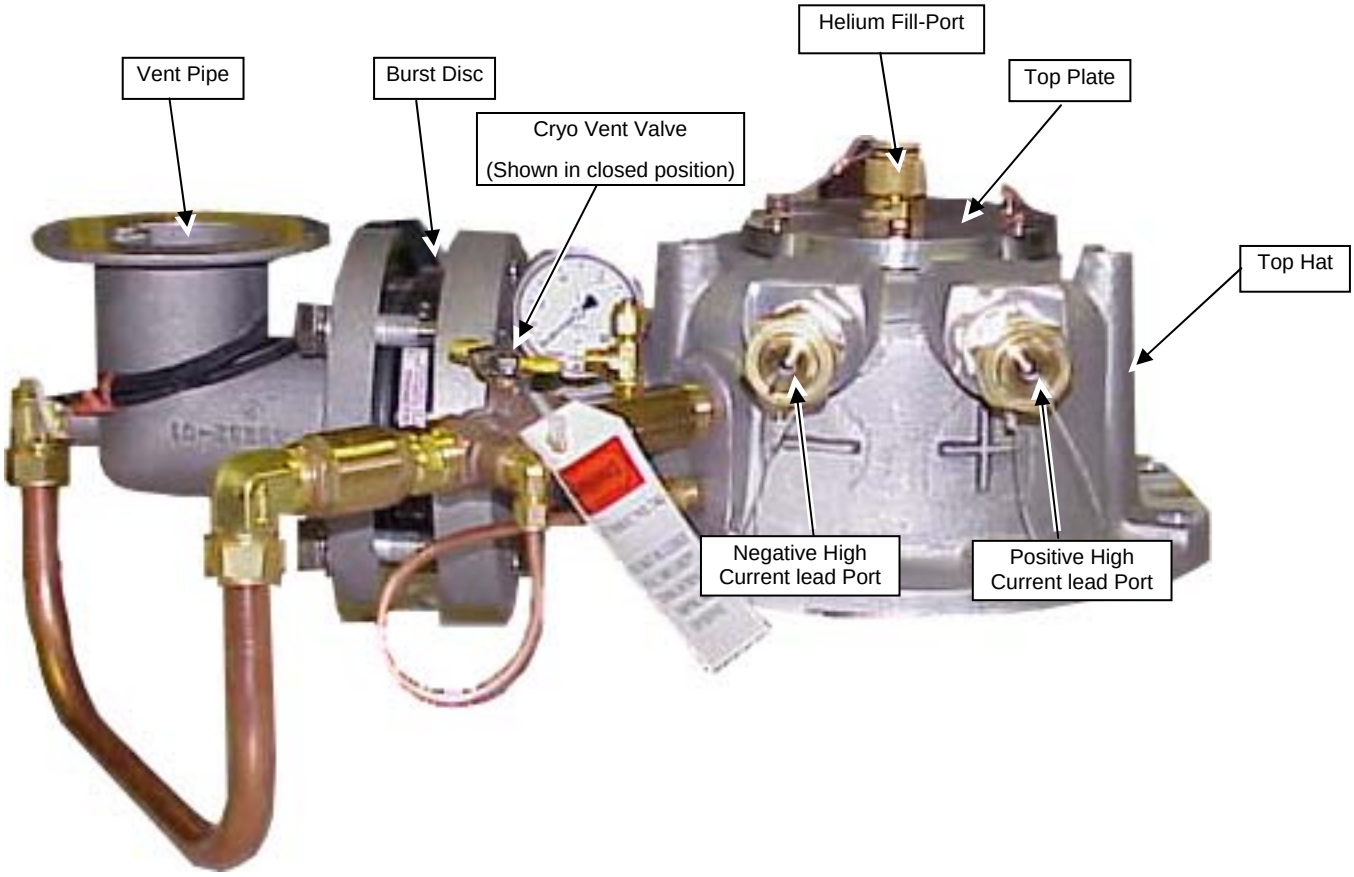


Figure 3. F2K Magnet Top Assembly

⚠ CAUTION ⚠

BE EXTRA CAREFUL WHEN HANDLING LOOSE TOOLS, HARDWARE AND MATERIALS AROUND THE OPEN NECK OF THE MAGNET. RECOVERING LOST ITEMS FROM THE INTERIOR IS COSTLY AND TIME CONSUMING. IF LEFT INSIDE THE UNIT, SUCH ITEMS CAN CAUSE IRREPARABLE DAMAGE.

⚠ DANGER ⚠

DO NOT ATTEMPT TO DEICE WHILE THE MAGNET IS AT FIELD.

- **ONLY THE SECTIION "DE-ICING A PLUGGED NECK" SHOULD BE PERFORMED ON FIELD. ALL OTHER SECTIONS OF THIS PROCEDURE SHOULD BE PERFORMED ONLY WHEN THE MAGNET IS DE-ENERGIZED.**
- **TO PREVENT DEATH BY ASPHYXIATION, DO NOT ATTEMPT THIS PROCEDURE WITHOUT ADEQUATE VENTILATION AND A WELL-PLANNED ESCAPE ROUTE TO FRESH AIR!**
- **WHEN WORKING IN CONFINED SPACES, ALL INDIVIDUALS MUST WEAR AN OXYGEN MONITOR CALIBRATED TO ALARM AT 19.5% LOW OXYGEN CONCENTRATION. IF THE ALARM SOUNDS, EVACUATE IMMEDIATELY TO FRESH AIR.**
- **ONLY QUALIFIED TECHNICIANS SHALL PERFORM THE PROCEDURES IN THIS INSTRUCTION.**
- **ALL INDIVIDUALS WORKING WITHIN THE MAGNET AREA MUST WEAR APPROPRIATE PROTECTIVE CLOTHING INCLUDING, SAFETY GLASSES WITH SIDE SHIELDS, FACE SHIELD, A CRYOGENIC VEST AND CRYOGENIC GLOVES WITH GAUNTLETS.**

OVERVIEW

This section provides an overall idea of the operations needed to deice a magnet. This is not a procedure and should not be used to replace the procedures provided in this Instruction.

NOTE: It may not be possible to accomplish this procedure in a space with a low ceiling (see Figure 22). In such cases, contact your Field Service Organization.

IMPORTANT:

- FOR THE PURPOSES OF THIS MANUAL, PRESUME THAT THE MAGNET IS OPERATING AND IS BLOCKED WITH ICE.

1. Open the negative lead port to determine if there is a vent path in case the magnet quenches.
2. If there is no quench vent path, open the helium fill port cap and use a heated copper rod to bore a hole through the ice. Vapors will escape when the rod penetrates to an open space.
3. Use the high-current leads to clear a path to the lead terminals in preparation for shut down.
4. Ramp down the magnet.

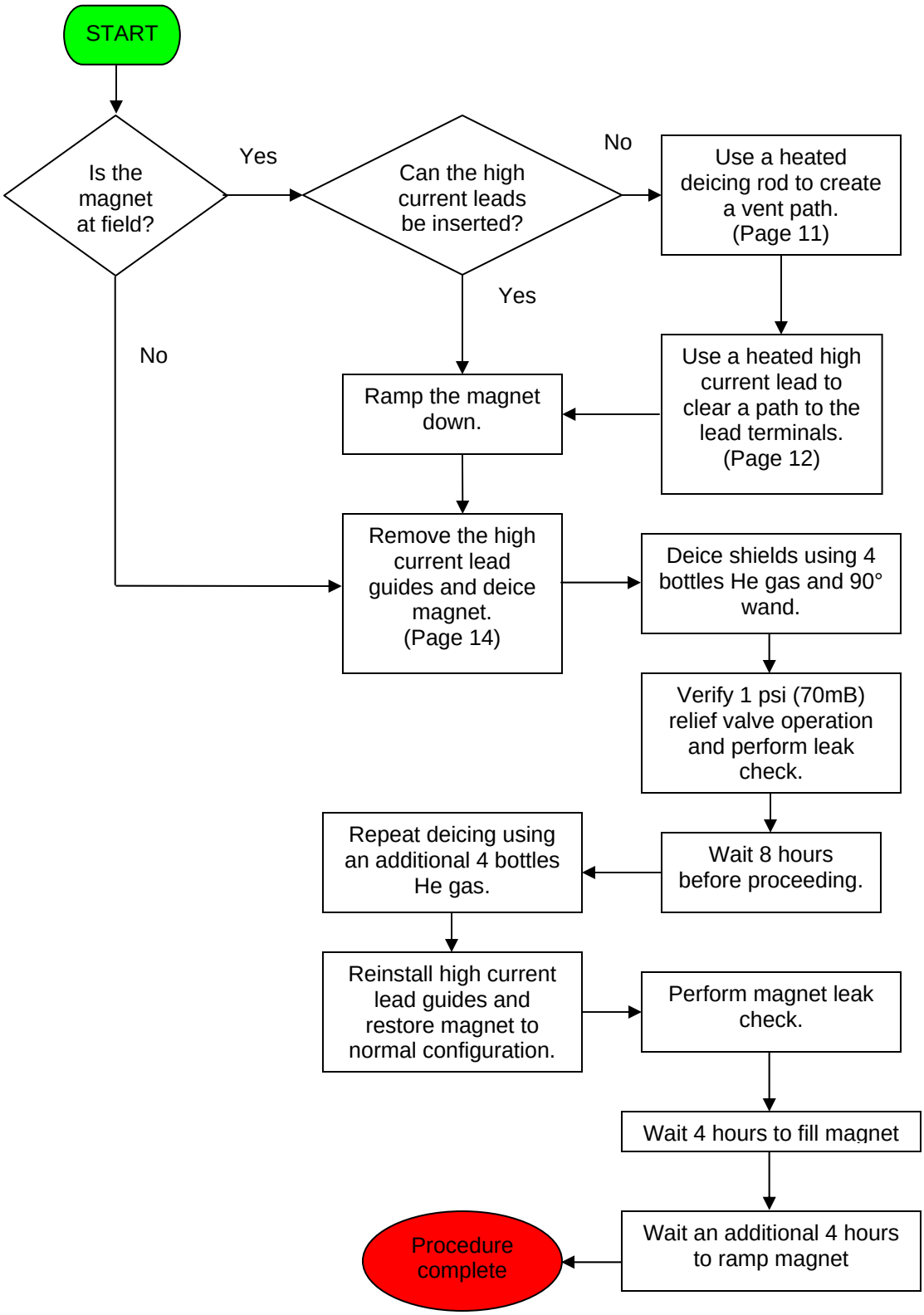
Note: The magnet LHe level should be >20% before proceeding. Fill LHe as necessary to ensure the magnet does not drop below 10% LHe level during the de-ice process.

5. Remove the top casting to access the high-current lead guides.
6. Use a de-icing wand to clear ice that is holding the lead guides in place. (Apply helium gas flow at 30 psi to 50 psi.) (Approximately 4 bottles He gas)

   IMPORTANT: Always keep a positive flow of helium directed into the unit to prevent further icing.
7. Remove the lead guides.
8. Reinstall the top casting with a view plate and the spacer in place of the burst disk.
9. Insert the de-icing wand through the view plate and look for ice buildup within the bellows area.
10. Direct the de-icing wand into the iced areas. After visible ice has been removed, use the 90° wand and expend the remainder of the 4 bottles of He gas to deice the shields.
11. After all ice has been cleared, reinstall the burst disk and top plate.
12. Verify 1 psi (70mB) relief valve operation and perform leak check.
13. Wait 8 hours.
14. Reinstall the view plate on the turret and the spacer in place of the burst disk.
15. Insert the de-icing wand through the view plate and remove any ice buildup within the bellows area.

16. After visible ice has been removed, use the 90° wand and direct the remainder of the 4 bottles of He gas to deice the shields.
17. Remove the top casting and reinstall the high-current lead guides. Remember to keep a positive flow of helium while performing this operation.
18. Reinstall the top casting, burst disk and normal top plate.
19. Perform the magnet leak check.
20. De-icing is complete.
21. Wait 4 hours to fill magnet.
22. Wait an additional 4 hours to de-ice terminals and ramp magnet.

DE-ICING DECISION TREE



DE-ICING A PLUGGED NECK

CAUTION

- **DO NOT TURN-OFF THE COLDHEAD WHILE THE MAGNET IS AT FIELD.**
- **DO NOT PUSH THE ERDU BUTTON!**

Verify Ice Blockage

The most difficult de-icing circumstance is when the magnet is at field, and the neck is plugged with ice. Successful de-icing is dependent on accurately determining the extent of the blockage and noting ice deposit locations.

A plugged neck could have one or more of the following indicators:

- No exhaust out of the vent pipe after opening the Cryo Vent Valve.
- After opening the helium fill port or a high current lead port, either no venting or only a "puff" sound of venting gas is heard. Normally there will be a strong "whoosh" sound and vapors are visible.
- An ice plug blocks the insertion of a transfer line or high-current leads.
- Helium transfer efficiency is reduced to less than 50%.

Note: This step is to determine if ice is blocking the vent path through the neck.

1. Open the Cryo Vent Valve (yellow ball valve). If it is not blocked, this valve allows escaping gases to vent.
2. When the pressure is at or below 20 millibar, slowly remove the cap to the negative high-current port. Be careful. If the ports are not blocked, gases will vent from this port. Stand away from the port (to one side).
3. If no vapor escapes, ice is blocking the port and needs to be cleared.
4. Reinstall the lead port cap.
5. Go to "Clear A Vent Path".

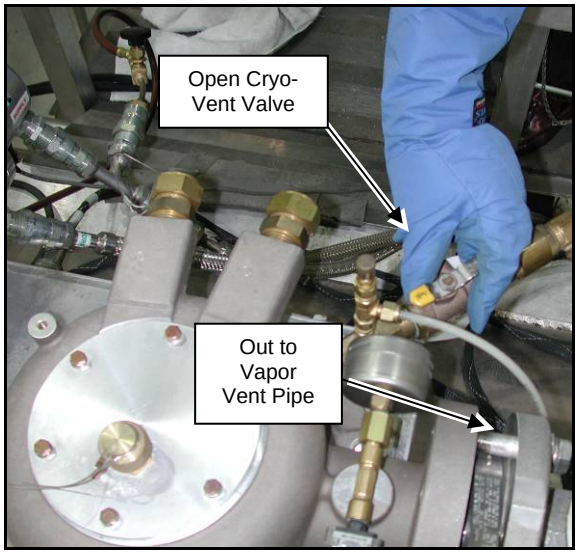


Figure 4. Vent gases out the vent pipe.

WARNING

DO NOT ALLOW VENTING VAPORS TO CONTACT YOU DIRECTLY. FREEZING VAPORS CAN FREEZE UNPROTECTED SKIN.

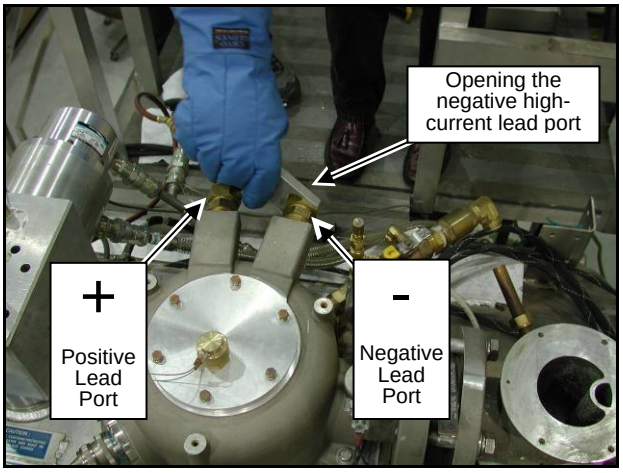


Figure 5. Checking for ice blockage in the neck.

Figure 6. Check the negative high-current lead port for blockage.

Clear a Vent Path

Clearing a vent path is very important for providing an exhaust path in case the magnet quenches.

1. Remove the helium fill port cap.

2. Assemble the ½-inch de-icing wand extension tubes and the copper de-icing rod to create a de-icing rod.

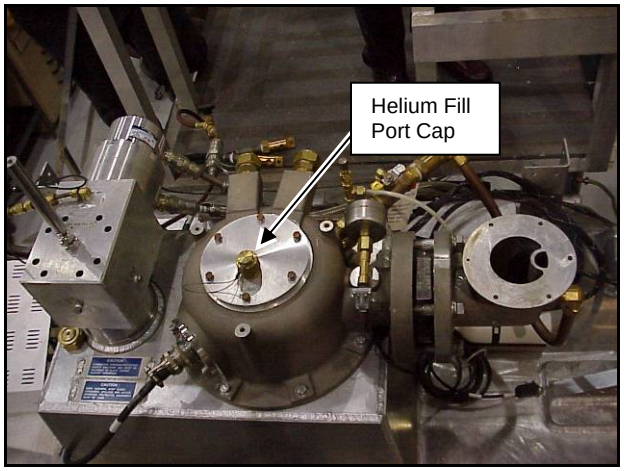


Figure 7. Create a vapor vent through the helium fill port.

3. Heat the end of the ½-inch copper de-icing rod for 30 seconds. This can be done with a propane torch or electric heat gun (Figure 8).

Figure 8.: Heating the 1/2" de-icing rod .

4. Insert the heated de-icing rod down the helium fill port and allow it to melt the ice. Keep your face away from the fill port. Gases will vent as the de-icing rod bores past the blockage.

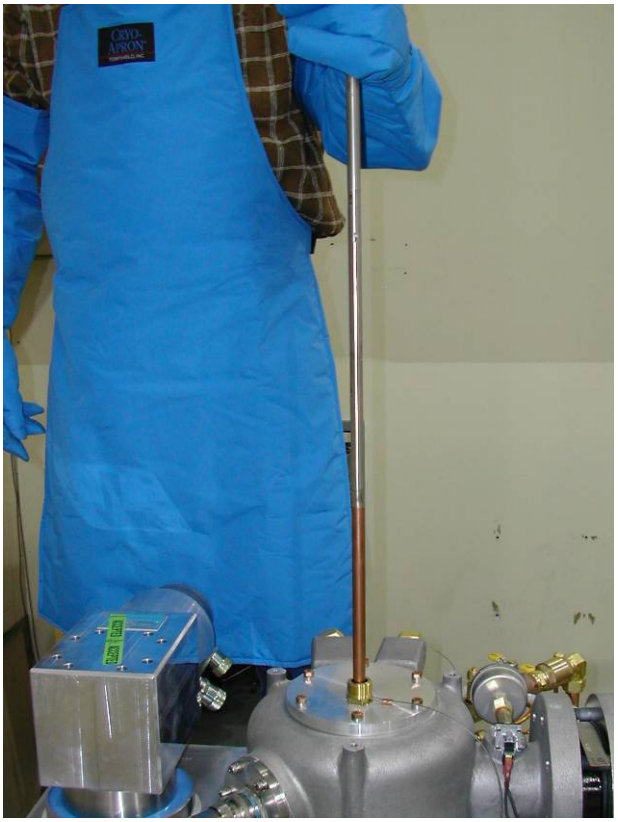


Figure 9. Boring through the ice with a heated de-icing rod.

5. As boring gets progressively slower, remove the de-icing rod, reheat it, and then reinsert it into the fill port.

6. Vapors will escape through the fill port as the de-icing rod bores through the ice block. This indicates that a vent path has been created.

7. Continue heating and boring through the ice block until the de-icing rod bottoms-out in the fill funnel.

8. Remove the de-icing rod and allow the gases to vent until they subside. You may have to reinsert the de-icing rod periodically if the vent ices over.

9. Go to "Clear the High-Current Lead Ports."

⚠ DANGER ⚠

THERE IS A HIGH PROBABLIITY OF A QUENCH EVENT AFTER A VENT PATH IS CLEARED.

- **DO NOT ATTEMPT TO STOP A QUENCH FLOW! LEAVE THE AREA IMMEDIATELY!**
- **PLAN AND PRACTICE AN ESCAPE ROUTE AWAY FROM THE QUENCH AREA INTO A WELL-VENTILATED AREA.**
- **ESCAPING VAPOR AND GASES CAN CAUSE SEVERE FROSTBITE AND POSSIBLY DEATH BY ASPHYXIATION.**
- **ONLY QUALIFIED TECHNICIANS SHOULD PERFORM THIS PROCEDURE.**
- **WEAR APPROPRIATE PROTECTIVE CLOTHING.**

Clear the High-Current Lead Ports

Use this procedure to open ice blockages in the high-current lead ports. This will enable you to connect the high-current leads to the terminal connectors. If you can already connect the leads to the terminals, skip to Step-9.

1. Remove the negative high-current port plug (Figure 10).

2. Connect the ground cable on the negative high current lead to the grounding post.

3. Warm the tip of the negative high-current lead to room temperature (Figure 11). This can be done with either a hand-held propane torch or an electric heat gun.

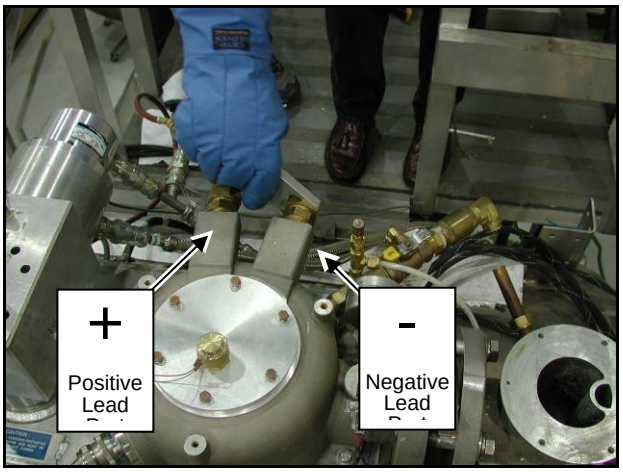


Figure 10. Removing the plug to the negative high-current lead port.

⚠ CAUTION ⚠

HEAT ONLY THE TIP OF THE LEAD. THE NYLON INSULATION CAN BE DAMAGED IF THE CONNECTOR GETS TOO HOT. HOLD THE LEAD TIP WITH YOUR HAND AND STOP HEATING WHEN THE TIP BECOMES TO HOT TO HOLD. (FIGURE 11)

Figure 11. Heat the high-current lead to deice the lead guides. (Note the position of the thumb to monitor lead temperature.)

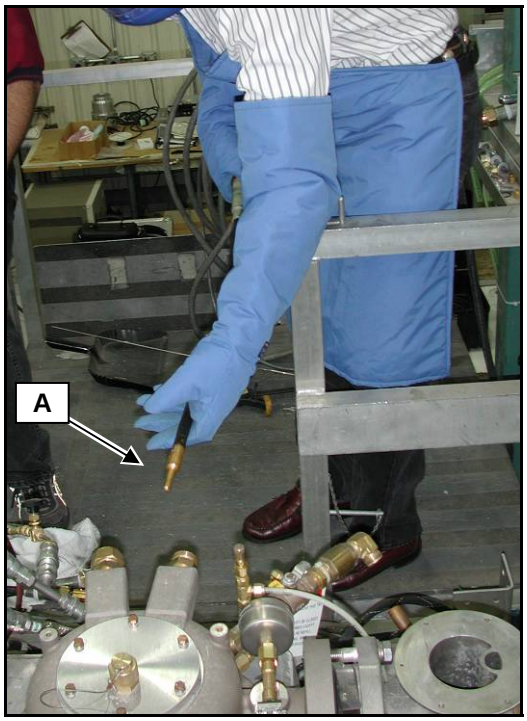


Figure 12. Use a heated high-current lead (A) to clear the lead guides.

4. Insert the warmed high-current lead into the negative high-current port and allow it to melt a path to the terminals. Do not force the lead. Allow it to melt through the ice without too much pressure. Periodically remove the lead, reheat the tip to room temperature, and then reinsert it.

Figure 13. Carefully insert the high-current lead into the negative lead port.

5. Vapor will vent when the lead melts through the ice blockage. Stand away from the vapors and allow the gases to vent completely.
6. After the gases vent, continue de-icing the port until you reach the high-current terminal. As the lead reaches the end of its length, you will feel it contact the metal of the high-current terminal.
7. Rotate the lead while applying forward pressure until the lead tip seats fully into the terminal. Tighten the nut (on the lead) to the lead port.

Figure 14. Vapors venting from the high-current lead port.

8. Repeat Steps 1 through 6 to clear the positive lead port. Check the helium fill port for adequate venting. Deice a fresh path with the copper tube if ice blocks the vent.
9. After successfully seating the high current leads into their terminals, discharge the magnet. Check for the lead voltage drop, and then ramp-down the magnet. For this adverse condition, a lead voltage drop of 100 mV is adequate.

REMOVE THE HIGH-CURRENT LEAD GUIDES

DANGER

THE MAGNET MUST BE DE-ENERGIZED BEFORE ATTEMPTING TO INSTALL A VIEW PLATE. A QUENCH EVENT WITH THE ACCESS PLATE REMOVED IS LIFE THREATENING.

DANGER

THIS PROCEDURE REQUIRES EXCEPTIONAL VENTILATION TO PREVENT DEATH BY ASPHYXIATION!

- **AN OXYGEN MONITOR IS REQUIRED IN CONFINED SPACES.**
- **DO NOT WORK ALONE.**
- **WHEN WORKING IN A CONFINED SPACE, DIVERT THE HELIUM GAS OUT OF THE ROOM BY INSTALLING A USED BURST DISC INTO THE VENT PIPE.**
- **ON MOBILE MAGNETS, OPEN THE AREA TO OUTDOOR AIR (E.G. OPEN ROOF).**

Before de-icing:

- Turn-OFF the coldhead.
- Open the RF door (for ventilation).
- Turn-ON the normal systems for air circulation.
- Disconnect one of the air hoses used for gradient cooling and position close to the top of the magnet.

Note: The magnet LHe level should be >20% before proceeding. Fill LHe as necessary to ensure the magnet does not drop below 10% LHe level during the de-ice process.

CAUTION

USE CARE WHEN INSERTING THE DE-ICING WAND INTO THE NECK OF THE MAGNET. THE WALLS OF THE BELLOWS ARE VERY THIN BUT PROVIDE THE ONLY BARRIER PROTECTING THE MAGNET'S VACUUM. DAMAGING THE BELLOWS COULD DESTROY THE MAGNET CRYOSTAT'S VACUUM.

DUE TO THE FRAGILE NATURE OF THE BELLOWS, THE TIP OF THE DE-ICING WAND IS MADE OF G10 MATERIAL. USE ONLY THE WANDS PROVIDED FOR THIS PURPOSE.

Removing the guides can be difficult depending on the amount of ice holding them in place and the ceiling height. Use the following procedure to remove the lead guides and deice the neck region.

NOTE: This procedure for removal of the high current lead guides is meant for magnets with a ceiling height that is adequate to allow removal of the guide tube assembly. If the distance from the bottom of the top casting to the ceiling is less than 60 cm (Figure 22), contact the Field Service Organization.

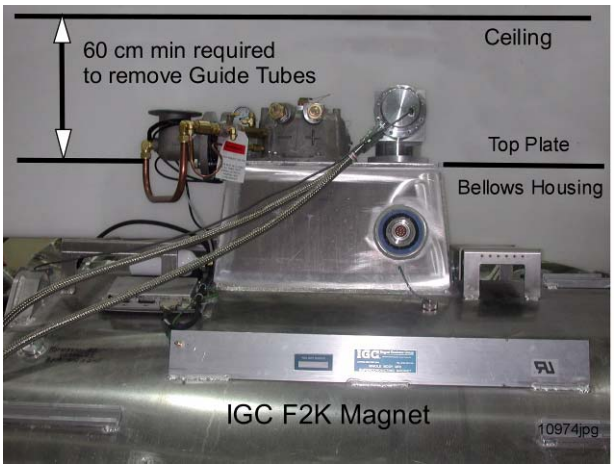


Figure 15.

1. Remove the eight screws (Figure 23) that secure the top assembly to the magnet. Move the screws away from the unit.

***NOTE*:** Do not drop fasteners or tools into the magnet. Recovering them can be time consuming and costly.

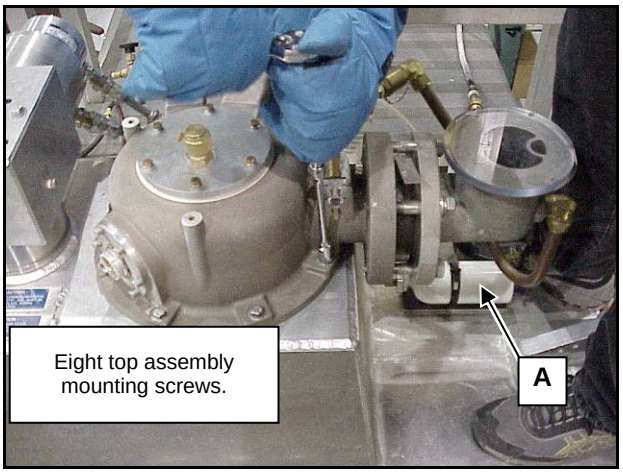


Figure 16. Removing the top hat assembly.

CAUTION

BE SURE NOT TO DAMAGE THE WIRE BUNDLE. THE MAGNET CANNOT OPERATE WITHOUT IT.

2. Disconnect the 1/4-inch plastic tube connected to the Taconis Bottle (A, Figure 23).

3. Remove the top hat assembly and set aside (Figure 24). Keep in mind that there is a wire bundle and o-ring under the high hat. Take care not to damage them.

   If necessary, remove the four bolts holding the burst disc in place to separate the vent piping from the top casting.

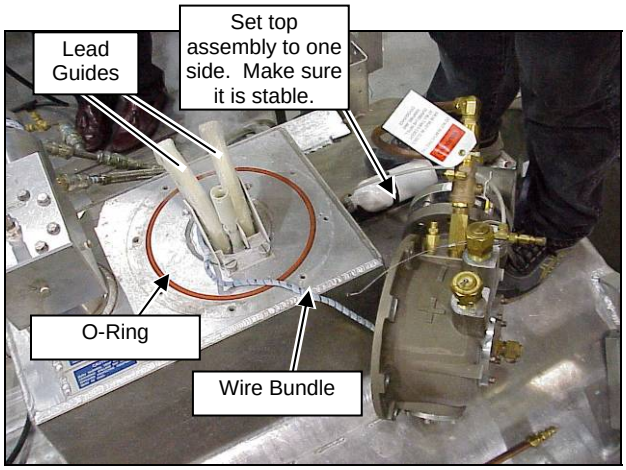


Figure 17.

4. Loosen the two lead guide mounting screws (Figure 25).

CAUTION

USE CARE WHEN REMOVING THE GUIDE TUBE ASSEMBLY. EXCESSIVE FORCE WILL RESULT IN A BROKEN GUIDE TUBE ASSEMBLY. THIS RENDERS THE MAGNET INOPERABLE.

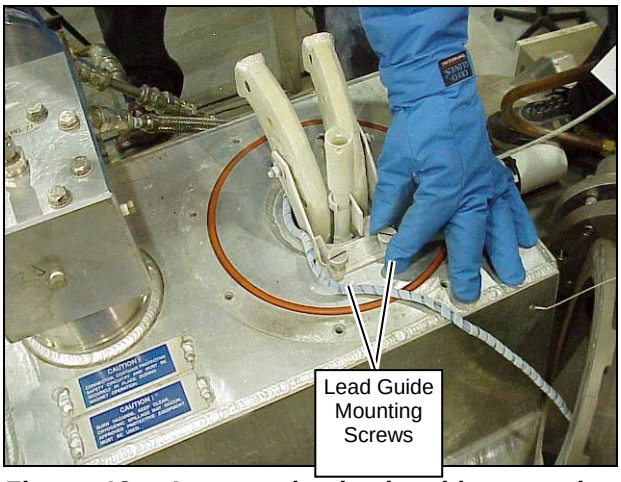


Figure 18. Loosen the lead guide mounting screws.

5. Gently lift the guide baffles out (Figure 26), but DO NOT FORCE THEM. If they won't come out, ice is holding them in place. Gently determine, by the resistance, what area of the neck is holding the guides tubes and then direct warm gas to that area. If the guide baffles DO come out, skip to Step 11.

Figure 19. Lift the lead guides to see if they are frozen in place. DO NOT FORCE THEM.

6. Assemble the stainless steel de-icing wand.

7. Connect an inline regulator valve adapter between the de-icing wand and the helium tank hose. Be sure to turn the valve OFF.

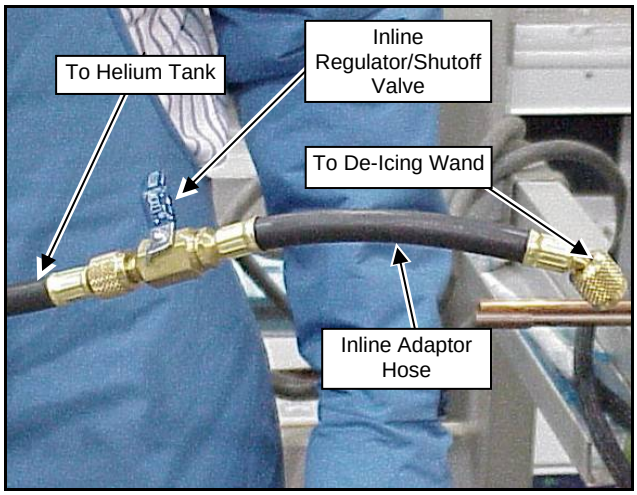


Figure 20. Attaching the inline regulator valve to the de-icing wand.

8. Set the regulator valve on the gas bottle to 50 psi. The pressure can now be regulated from 0 psi-to-50 psi with the inline regulator valve. The pressure will not exceed the maximum recommended pressure of 50 psi.

9. Localize the gas flow to those areas holding the guides in place. Direct the de-icing wand in between, and all around the lead guides. You may need to increase the pressure to deice hard to get areas. Continuously check for lead guide movement while de-icing.

10. Remove the lead guides from the magnet when they become free.

    NOTE: Keep positive helium gas pressure while checking the lead guides for movement. Outside air can freeze and form further ice deposits.

Figure 21.

11. Immediately reinstall the top assembly.

12. Go to “Install the View Plate.”

Install the View Plate

1. Remove the six screws that secure the access plate to the top hat (Figure 15) and move them away from the magnet. Hold the access plate down with one hand to maintain the seal.

   NOTE: It is important to keep as much air out of the unit as possible. Air will freeze and cause further ice deposits.

   NOTE: Before installing the view plate, make sure that the 41-pin wire bundle does not obstruct the interior view or the de-icing wand path. It may be necessary to gently move the bundle out of the way.

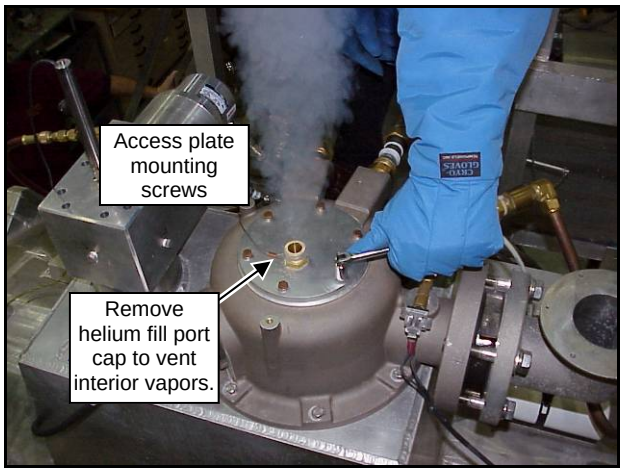


Figure 22. Removing the access plate mounting screws.

2. While sliding the access plate off the top hat, slide the view plate on. Try not to let outside air into the unit.

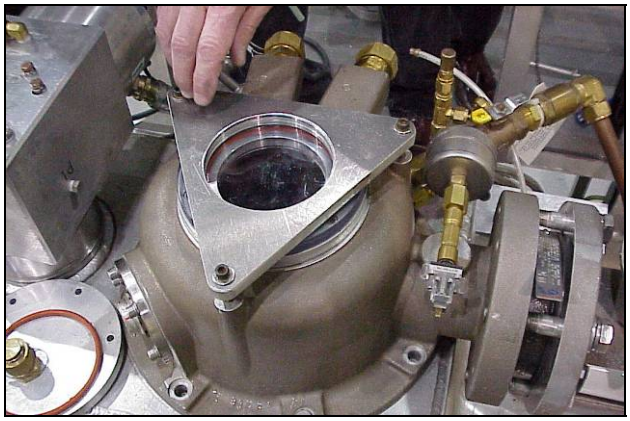


Figure 23. Installing the view plate with the mounting bracket.

3. Use a flashlight to look into the neck region. Focus the light beam for the area you are searching and look for ice on the high current lead terminals and neck region.
4. Noting ice buildup will enable you to aim the de-icing wand directly into icy areas for more efficient de-icing. If you cannot see the high-current terminals, icing is significant.
5. Go to “Install the Spacer Burst Disc”.

Figure 24. Searching for ice buildup.

Install the Spacer Burst Disc

Install the spacer burst disc to vent gases created during de-icing.

1. Remove the two top bolts (A, Figure 29) and loosen the two bottom bolts that secure the vent pipe to the top hat assembly.

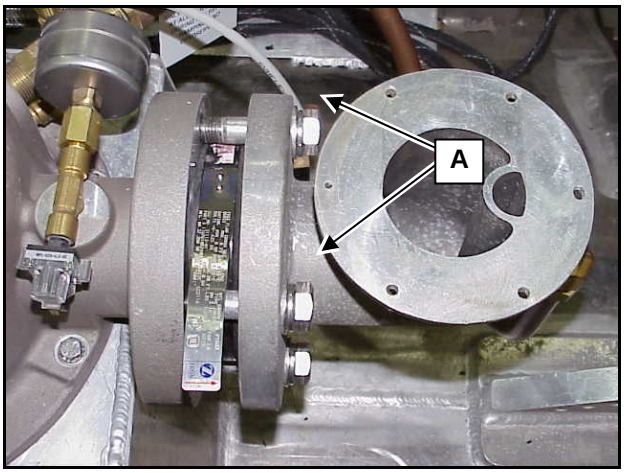


Figure 25.

2. Remove the good burst disc and install the spacer burst disc.

Figure 26. Spacer burst disc.

3. Retighten the bolts

4. Go to "De-icing the Neck Region".

De-icing the Neck Region

DANGER

THIS PROCEDURE REQUIRES EXCEPTIONAL VENTILATION TO PREVENT DEATH BY ASPHYXIATION!

- **AN OXYGEN MONITOR IS REQUIRED IN CONFINED SPACES.**
- **DO NOT WORK ALONE.**
- **WHEN WORKING IN A CONFINED SPACE, DIVERT THE HELIUM GAS OUT OF THE ROOM BY INSTALLING A USED BURST DISC INTO THE VENT PIPE.**
- **ON MOBILE MAGNETS, OPEN THE AREA TO OUTDOOR AIR (E.G. OPEN ROOF).**

Before de-icing:

- Turn-OFF the coldhead.
- Open the RF door (for ventilation).
- Turn-ON the normal systems for air circulation.
- Disconnect one of the air hoses used for gradient cooling and position close to the top of the magnet.

Use the following procedure to clear ice from the interior of the magnet.

CAUTION

USE CARE WHEN INSERTING THE DE-ICING WAND INTO THE NECK OF THE MAGNET. THE WALLS OF THE BELLOWS ARE VERY THIN BUT PROVIDE THE ONLY BARRIER PROTECTING THE MAGNET'S VACUUM. DAMAGING THE BELLOWS COULD DESTROY THE MAGNET CRYOSTAT'S VACUUM.

DUE TO THE FRAGILE NATURE OF THE BELLOWS, THE TIP OF THE DE-ICING WAND IS MADE OF G10 MATERIAL. USE ONLY THE WANDS PROVIDED FOR THIS PURPOSE.

Visually determine the location of the ice. If the ice is high in the neck direct the flow of helium gas onto the top of the ice accumulation. In severe cases a gurgling sound can be heard as the ice vaporizes. The de-icing helium cools quickly and loses its effectiveness. Inject more warm helium when this occurs.

NOTE: The vapor produced when de-icing is caused by displaced air. This is a good indicator that the process is working.

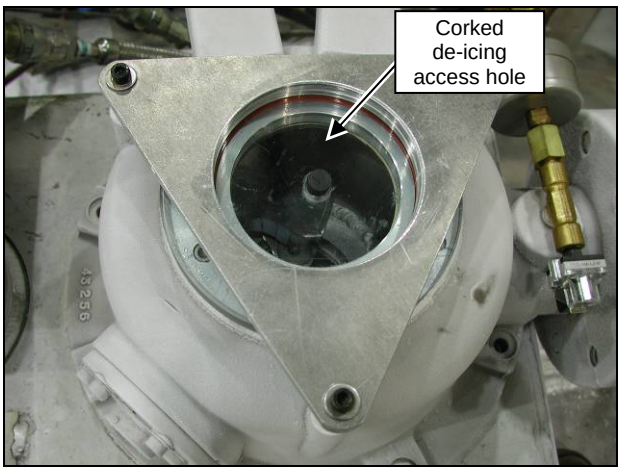


Figure 27. Installed view plate.

NOTE: Inspecting for ice is difficult without a view plate. The only view path is down the neck and the neck will ice up very quickly when exposed to air.

1. Insert the de-icing wand down the neck with 30 to 50-psi of warm helium gas.

   NOTE: Cold gas created while de-icing will vent out of the spacer burst disc.

2. Direct gas along the sides of the neck and at the terminal board at the base of the neck. The exhausting gas lifts the vaporized air up and out of the neck. Gurgling can be seen and heard while performing this step. Visibility is important when performing this step. The heat from the de-icing wand produces helium boil-off which helps clear the fog in the neck.

   NOTE: There is a space between the base of the neck and the terminal board. When you deice, make sure you direct the de-icing wand into this area.

3. Continue blowing the entire contents of the gas cylinder down the neck even if vapors and gurgling cease. Use as many gas cylinders as necessary to completely deice the area.

Procedure: *(See Figure 27.a)*

a. Use the extension tube with a 90 degree end. (See item No. 4 from the De-Icing Kit.)

b. Position the wand 0.5 to 1 cm above the terminal board.

c. Blow helium gas through the extension tube into the shields.

d. (Keeping the wand 0.5 to 1 cm above the terminal board) make circles of 360 degrees.

	NOTE
	*It is not possible to see the de-ice results. Ice which has to be removed is NOT visible from the service turret*.

e. Repeat the procedure until 4 bottles (minimum) of helium gas have been fully discharged.

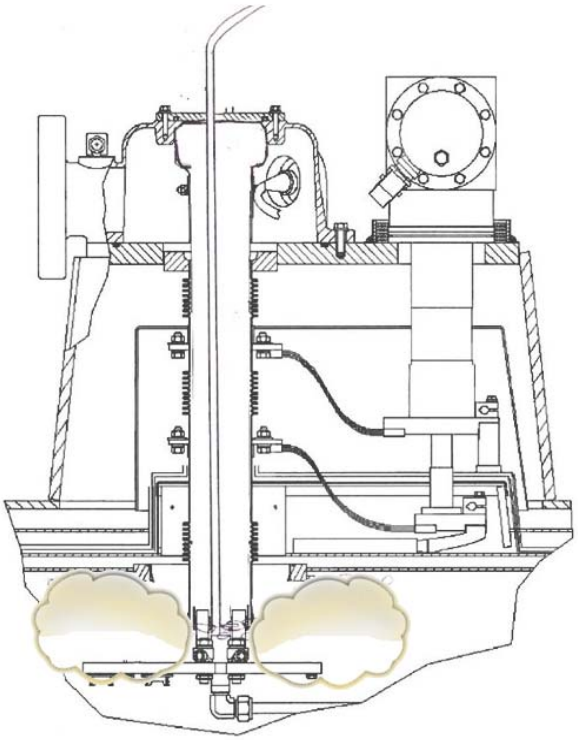


Figure 27.a: 90/360 degree de-icing

DANGER

ICE LEFT IN THE MAGNET CAN OBSTRUCT THE QUENCH PATH. THIS IS POTENTIALLY DANGEROUS IF THE UNIT QUENCHES.

4. Remove the wand and cork the view plate. Do this as quickly as possible to prevent air from entering the chamber.

5. Use a flashlight to check for residual ice in the neck of the magnet. You should be able to clearly see both high current lead terminals and the liquid helium fill port. Also check the base of the neck. You should see a gap between the neck and the terminal board. If any of these areas are not visible, continue de-icing.

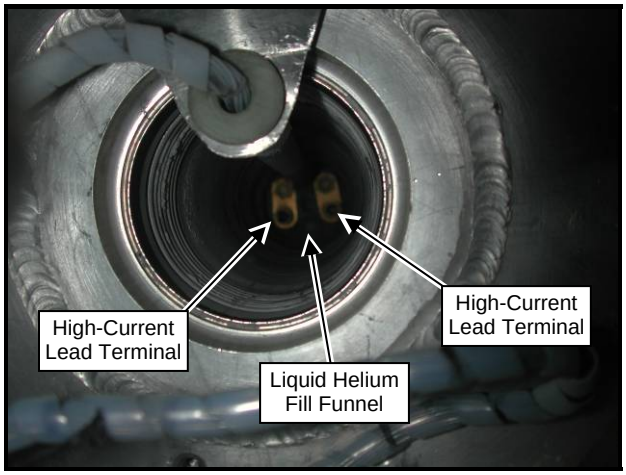


Figure 28. Check lead terminals and liquid helium fill funnel for ice.

6. After all ice has been cleared, reinstall the burst disk and top plate. Proceed to "Verify the Relief Valve Operation".

Verify the Relief Valve operation

1. Attach the inline adaptor hose to the taconis bottle tee on the magnet turret.

2. Close the Cryo Vent Valve (yellow ball valve).

3. Remove the ¼" copper vent tube from the magnet vent line elbow and bag the copper vent tube using an exam glove. Be sure the glove is wrapped tight to the line.

4. Slowly open the inline adaptor hose valve and pressurize the magnet. When the glove starts to inflate indicating the relief valve is opening, close the inline adaptor hose valve and note the magnet pressure on the pressure gauge. If the pressure is outside the range of 70mb +/- 35mb, the valve should be replaced.

5. Remove the exam glove from the copper vent tube and reconnect the tube to the magnet vent line elbow.

6. Leak check the magnet as described in "Section II: Leak Checking".

7. After a successful leak check, wait 8 hours before proceeding to "Step 2 Deicing".

Step 2 Deicing

1. After a period of at least 8 hours, reinstall the view plate and spacer burst disk.

2. Repeat steps 1 thru 5 in "Deicing the Neck Region" using a minimum of 4 bottles He Gas. Particular attention should be made to the magnet shields.

3. After completing Step 5, proceed to "Reinstall the Lead Guides".

Reinstall the Lead Guides

⚠ CAUTION ⚠

THIS STEP MAKES IT EASIER TO SEE WHEN THE HIGH CURRENT TERMINALS ARE CORRECTLY INSERTED INTO THE HIGH CURRENT LEAD GUIDES.

IF THE HIGH CURRENT TERMINALS ARE NOT SEATED INTO THE GUIDE BAFFLES PROPERLY, THE LEAD VOLTAGE DROP CAN EXCEED 100MV. AFTER THE UNIT IS REASSEMBLED, THE CAUSE OF THE A LEAD VOLTAGE DROP IS DIFFICULT TO DETERMINE. A QUENCH EVENT COULD OCCUR IF THE DROP IS NOT RECOGNIZED PRIOR TO RAMPING-UP THE MAGNET.

An alignment rod is used to assist in reinstalling the lead guide assembly. If the alignment rod is not used, it can be difficult to align the assembly correctly over the terminals. The high current lead guides have a tendency to slide off to one side of the terminals. It is extremely important to correctly install and verify the installation of the lead guide assembly before reassembling the magnet top works.

NOTE: Keep positive helium flow in the neck while performing this procedure.

1. Assemble the de-icing tubes and the copper de-icing rod to create an alignment rod.

2. Insert the alignment rod into the liquid helium fill funnel. The liquid helium fill funnel is a hole located between the two high-current lead terminals (Figure 33).

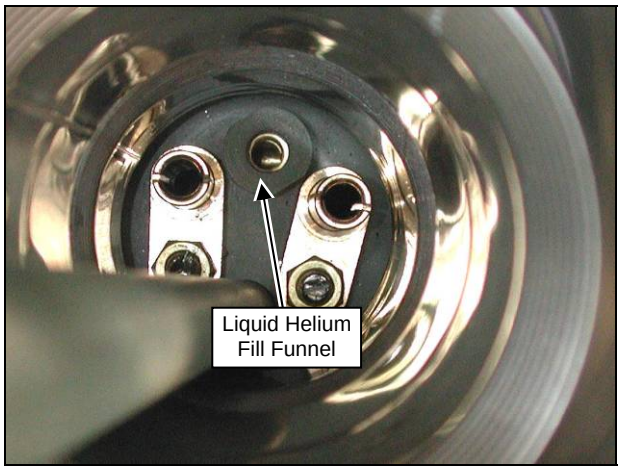


Figure 29. Insert the alignment wand into liquid helium fill funnel to help direct the lead guides into place. (Picture shows neck region of a warm magnet.)

3. Slide the fill line guide tube (Figure 34) of the lead guide assembly over the alignment rod.

Figure 30. High-Current Lead Guides

Figure 31. Using the alignment rod to direct the lead guides into place.

4. As soon as the lead guides are secured in place tighten the two screws that secure the guide tubes, connect both high current leads to make sure that they seat properly into their terminals. You may need to "tug" to remove the leads after they seat into the terminal.
5. Reinstall the top casting and good burst disc.
6. Leak check the magnet as described in "Section II: Leak Checking".
7. Restart the cold head.

   NOTE: When the cold head is turned on the warm gas in the cryostat will condense and cause the pressure to go negative. Turn on the B0 heater to help build positive pressure.
8. After a successful leak check, wait 4 hours before refilling the magnet.
9. Wait an additional 4 hours before deicing the terminals and ramping the magnet.

   If the lead drop is less than 40 millivolts the magnet can be ramped to field.

   If the lead drop is greater than 40 millivolts perform the terminal de-icing procedure as outlined in the magnet operation manual.

SECTION II: LEAK CHECKING

HOW ICING OCCURS

Icing typically occurs when outside air (due to leaks) is introduced into the sealed cryogenic chamber. Air displaces helium gas in the magnet. Temperatures are low enough inside the chamber to cause the air to freeze and obstruct the chamber. This can cause the following problems:

Air flows down into the neck of the magnet and freezes when it reaches the 10-60°K areas.

The upper straight section of the neck is connected to the first stage of the cold head and normally operates at approximately 60°K when the cold head is running. This temperature is sufficient to freeze air, which freezes at 65°K.

The lower straight section of the neck normally operates at 10°K when the cold head is running. Most of the air from a leak will freeze out in the neck.

Ice will continue to build up as long as the leak exists.

A quench event will activate the burst disc making it necessary to replace it within 30 minutes to avoid icing. After a quench event, and before the magnet is ramped up again, the neck must be inspected for ice using a view plate.

WHEN TO CHECK A MAGNET FOR LEAKS

- After servicing the vent piping.
- After initial site installation
- After loosening a plumbing fitting.
- After a quench event.
- After a helium fill.
- If force is placed on the vent assembly.
- Any time the DPS indicates a low-pressure situation.

CORRECTING THE CAUSE OF ICING

Air leaking into the cryogenic chamber of a magnet is the primary cause of icing. Leaks must be found and repaired to prevent quenches. The following section provides information on detecting leaks.

LEAKS

How To Determine if a Magnet Has a Leak

Use the following information to help determine if there is a leak. Do not restrict leak detection to just this set of circumstances.

WARNING

SOME LEAK TESTS REQUIRE THE MAGNET TO BE DE-ENERGIZED. IF IN DOUBT – TURN RAMP DOWN THE MAGNET.

NOTE: The pressure gauge can become unreliable after a quench. Check the gauge and make sure it reads zero after a quench but before replacing the burst disc.

The DPS switch is normally open when there is no pressure inside the magnet. When pressure builds to 20 mb the switch closes. Look at the pressure gauge. If the pressure is above 20 mb, the switch should be closed. If the pressure is below 20 mb and this switch is open, switch ON the $B_{\oslash}$ switch heater. The pressure will rise at the rate of approximately 10 mb per hour with the switch heater energized.

Check fittings and gaskets with Snoop.

WARNING

DO NOT USE SNOOP ON VALVES. THE CHEMICAL MAY FREEZE AND INTERFERE WITH THE VALVE OPERATION.

What Happens If There Is A Leak?

- Inability to insert the high current leads.
- Inability to insert the liquid helium transfer tube or poor LHe transfer efficiency.

Where to Check For Leaks

- Check all caps, gaskets, seals, o-rings, and plumbing joints on the upstream side of the pressure relief valves and burst disc.
- Check the pressure relief control valve.
  - On Stationary Magnets, the control valve is a 1-psi circle seal valve. This valve should maintain a pressure of approximately 80 mb when the 10 mb check-valve is inline. Tolerance for this valve is +/- 35 mb.
  - On Mobile Magnets, the relief control valve is called an Absolute Pressure Relief Valve (APRV). The expected pressure depends on:
    - The altitude above sea level of the magnet
    - The tolerance of the valve, and the variation in atmospheric pressure.

    NOTE: It could take weeks for a magnet to reach equilibrium operating pressure after the magnet has been opened up for a helium refill.
- Check the burst disc surface for cracks. On rare occasions this surface has developed cracks that leak. This condition is most easily diagnosed using a hand held helium detector.

ICING

How To Remove Ice

Magnet At Field - Clear a vent path through the ice by inserting a heated copper de-icing wand down the LHe fill port until it makes contact with the LHe fill funnel which is mounted on the terminal board (TB1).

Magnet Off – Room temperature helium gas is directed down the neck.

Where Ice Goes

Most of the melted and evaporated ice is blown out of the magnet with the escaping helium gas.

Some ice accumulates on the terminal board and the high current terminals and must be removed.

The rest of the ice falls to the bottom of the magnet where it is inconsequential.

Consequences of Icing

- An unattended quench event can result if the magnet is at field and the neck is plugged with ice.
- Ice reduces fill efficiency.
- Ice can plug the neck of the cryostat and prevent venting of boil-off gases. This can lead to dangerous pressure build-up within the helium chamber.
- Ice can cause a voltage drop in the high current lead terminal, which can cause a quench event.

DE-ICING TIPS:

Be sure to have all the required personal protection equipment, and the proper tools and supplies before you begin de-icing.

- Read this instruction thoroughly before de-icing.
- Always be aware of your safety and the integrity of the magnet. **Provide for adequate ventilation.**
- **Do not inspect for ice with the magnet at field.**
- Do not turn off the cold head until you start to deice.
- Learn to recognize the symptoms of a magnet with a plugged neck. **Clear a vent path with the heated de-icing rod.**
- Provide for a generous supply of warm helium gas. (5 bottles)
- Make sure you have a high intensity-focusing flashlight with fresh batteries.
- Put tip of wand in direct contact with the ice.
- Use multiple view plates. They frost up.
- **Always** maintain positive pressure in the magnet to avoid the necessity of de-icing.
- If a magnet will not maintain a positive pressure – do not give up until you locate the leak or faulty relief valve.
- To reduce or eliminate fogging, turn the gas regulator down and move the wand up and down the neck.
- Change view plates when vision is obstructed.
- Ice must be cleared from the terminals as well as the intersection between the 4K container and the TB1 Board.

- Open up lead ports to vent the cold gas. The view plate will fog-up quickly if cold gas vents around the view plate.
- When de-icing with warm gas, use a hose with a valve. Have an assistant manage the gas pressure.

Why De-icing is Important:

- The most important reason to deice is to provide a vent path for escaping gases due to normal helium boil-off and for a possible quench event of the magnet.
- Thorough de-icing provides for a low lead voltage drop so that the magnet does not quench during ramping.
- Thorough de-icing also is essential for LHe transfer efficiency.