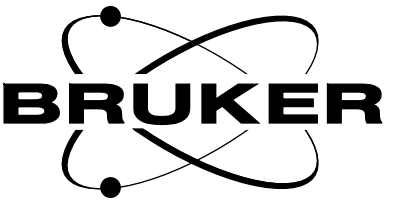


# SPECTROSPIN
# NMR Magnet System

## SPECTROSPIN NMR Magnet System
## Installation Procedures

**Version 002**

**BRUKER**

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# 5 Installation procedures for Spectrospin Cryostats Safe handling of Spectrospin NMR Magnet Systems 4



  

# 5 Installation procedures for Spectrospin Cryostats Safe handling of Spectrospin NMR Magnet Systems

## 5.1 Assembly of the NMR magnet system

**Transport fixture**

1. Disassemble the transport fixture carefully. For the details of the construction of the transport fixture see chapter 4.

**Caution**

**The transport fixtures of large NMR magnet systems contain heavy metallic parts - be careful during disassembly!**

**Assembly**

2. Check the radial fixtures of the helium and of the nitrogen can.
3. Assemble the cryostat carefully. Avoid contamination of all clean surfaces. Clean and slightly grease all O rings. For details of the assembling procedure see chapter 4.

## 5.2 Pumping of the NMR magnet system

4. Pump and flush the vacuum vessel at least three to four times with dry and clean nitrogen gas to remove moisture.
5. Pump the vacuum vessel for at least 24 hours. Final pressure should be below $5 \times 10^{-5}$ mbar, measured at the pumping unit.

## 5.3 Preparing the NMR magnet system for the Cool Down Procedure

6. Mount the helium turrets carefully to avoid any leak. Clean and slightly grease all O rings. Check the proper position of the spheres and O rings in the quench valves.
7. Insert the current lead, mark the correct depth on the lead head. Check all resistances according to chapter 3.3.
8. Check the cabling of the helium level sensor.
9. Check the zero reading of the helium level sensor.

## 5.4 Cool down procedure with Automatic Cooling Device (ACD*)

1. Remove the current lead and insert the connection lead for the ACD*. Dry the plug with warm air before insertion.
2. Test the connection lead for the ACD*. The Automatic Cooling Device shows approximately room temperature (~ 293 K).
3. **Test insertion of the auxiliary shorting plug.**
4. Make sure the magnet is dry before cool down. Flush and pump several times at room temperature with dry nitrogen gas.

**Minimum vacuum**

Do not start the cool down procedure before the pressure is below $5 \times 10^{-5}$ mbar, measured at the pumping unit.

5. Insert the precooling L-tube into the helium syphon and make sure the tube is completely inserted.
6. Install the complete Automatic Cooling Device according to the manual. Mount a one way valve on the helium turret outlets.

**600 MHz Systems only**

There is a special 22 pin connection lead for the ACD* delivered with any 600 MHz System. It will fit into the third helium neck.

7. Precool with liquid nitrogen using 200-300 mbar (3-4 psi) pressure in the liquid nitrogen storage dewar. Use a one way valve to prevent air and moisture to enter the helium vessel. For details consult the ACD* manual.
8. Above the temperature of liquid nitrogen (77 K), the Automatic Cooling Device stops the cool down and prevents overfilling of the helium vessel. Leave the ACD* connected to the dewar overnight. The magnet's temperature should be between 80˚ K and 90˚ K.
9. Keep the helium can closed at all times if below room temperature. Have the exhaust only open with a large gas flow to avoid intake of moisture.
10. Mount the safety valve on the rear nitrogen outlet. Mount the teflon tubes and the nitrogen one way valve of the nitrogen flow system on the other nitrogen outlets. Fill the nitrogen vessel slowly to the top.
11. Mount the complete nitrogen flow system according to the drawings in chapter 4.

**Pumping unit**

**Do not remove the pumping unit until collection of liquid helium starts within the helium vessel. Otherwise reduced helium and/or nitrogen hold time or even vacuum loss could result!**

12. Remove all nitrogen very carefully through the precooling tube by applying a pressure of 100-150 mbar (1.5-2 psi) through the helium turrets. Remove the precooling tube.

**Important** **Check with the dipstick through the syphon to make sure that no liquid nitrogen is left.**

## 5.5 Cool down without the Automatic Cooling Device

1. Remove the current lead and insert the shorting plug in the left-hand helium neck to prevent the connectors from icing. Dry the plug with warm air before insertion.
2. **Test insertion of the auxiliary shorting plug.**
3. Make sure the magnet is dry before cool down. Flush and pump at room temperature several times with dry nitrogen gas.

**Minimum vacuum** Do not start the cool down procedure before the pressure is below $5 \times 10^{-5}$ mbar, measured at the pumping unit.

4. Insert the precooling tube into the helium syphon, make sure the tube is completely inserted.
5. Supervise precooling in short intervals. Use either two nitrogen supply vessels, or cool the cryostat helium vessel first and the nitrogen vessel afterwards. Use a very low transfer pressure of 50 - 100 mbar. Often even the pressure built up in the transport dewar may be too high. Collection of liquid nitrogen should start after 4 hours or later.
6. Do not fill the helium can with more than 10 cm of liquid nitrogen. Mount the teflon tubes and the one way valve and close the precooling tube with a rubber plug. Wait overnight.
7. Keep the helium can closed at all times if below room temperature. Have the exhaust only open with a large gas flow to avoid intake of moisture.
8. Fill the nitrogen vessel slowly to the top. Mount the complete nitrogen flow system according to the drawings in chapter 3.

**Pumping unit** **Do not remove the pumping unit until collection of liquid helium starts within the helium vessel. Otherwise reduced helium and/or nitrogen hold time or even vacuum loss could result!**

9. Remove all nitrogen very carefully through the precooling tube by applying a pressure of 100-150 mbar through the helium turrets. Remove the precooling tube.

**Important** **Check with the dipstick through the syphon to make sure that no liquid nitrogen is left.**

## 5.6 Cool down with liquid helium

1. Pump and flush the helium vessel with helium gas 6-8 times to progressively lower pressures, starting with 900 mbar and ending below 50 mbar.

**Freezing nitrogen** **Remember that liquid nitrogen becomes solid very quickly if pumped.**
**Use short pumping times!**

2. Mount a KF25 nozzle or a helium recovery system on the helium turrets. Leave the complete nitrogen flow system mounted on the nitrogen outlets. Completely insert the helium transfer line with the extension piece into the syphon.
3. Cool down with liquid helium very slowly. Use 4-8 hours for cool down, depending on the magnet size. Apply a very low transfer pressure at the beginning and increase later.
4. Check the zero reading of the helium level sensor.

**Pumping unit** **Do not remove the pumping unit until collection of liquid helium starts within the helium vessel. Otherwise reduced helium and/or nitrogen hold time or even vacuum loss could result!**

5. Use a transfer pressure of 10-20 mbar (max. 30 mbar). Often even the pressure built up in the transport dewar may be too high. Increase to 50 mbar at 4.2 K only.
6. Fill the helium can completely. Mount the teflon tubes and the one way valve to the helium turrets.
7. Do not open the helium can more than 5 seconds while at helium temperature and never open both turrets simultaneously. Do not leave the turrets open or directly connected to a recovery system unless a large gas flow is present.

**One way valve** **Always use the teflon tubes ant the one way valve.**

## 5.7 Charging and Shimming

1. **Wait at least one night before charging after cool down** according to chapter 3. However, do not leave the NMR magnet system at helium temperature for more than a few days without charging.
2. Refill the helium can if needed. Keep the helium level above the minimum limit given for charging.
3. Remove the shorting plug and insert the current lead. Dry the leads and plugs with warm air before insertion.
4. **Test insertion of the auxiliary shorting plug**.

**600 MHz system only** **Test insertion of the 22 pin shorting plug in the third helium neck.**

5. Mount a KF25 nozzle or a helium recovery system on the helium turrets. If a recovery system is used, check the counter pressure to be below 50 mbar. Make sure there is an adequate relief valve which opens at that pressure. Do not use our special recovery line assembly during charging, as the flow is too large. Leave the complete nitrogen flow system mounted on the nitrogen outlets.
6. **Charge the magnet according to the charging table in this manual. Never leave the magnet unattended during charging. Keep a charging record.**

**Overshoot**

6. The stability of the magnet field after the charging procedure is strongly dependent on the process of reaching the final current. It is essential to reach a slightly higher current first (see chapter 3).

**Important** **Leave the magnet with open main coil switch for 10 minutes at this overshoot current.**

7. Reduce the main coil current slowly to its final value. At the final current wait a few moments until the magnet and the cryo power supply are in a stable state with minimum sense voltage.
Note the final current under "customer site" in chapter 3.1!
8. Put the main coil heater to the OFF position and supervise main coil current stability and sense voltage stability.
9. Having the magnet persistent, wait several minutes before removing the current continuously. With the B-CN100 or B-CN120 switch I-SUPPLY to the OFF position.

**600 MHz system only**

**With the 600 MHz systems insert the 22 pin shorting plug into the third helium neck to protect the main coil switch.**
**This 22 pin shorting connector will make a short circuit only across the main coil. Leave it in its place also during the shimming procedure of the magnet!**

10. Mount a shorting connector on the main current cable. **Do not disconnect the charging cables from the NMR magnet system.**
11. Mount the teflon tubes and the one way valve on the helium turrets.
12. **Wait at least 1 hour before cryoshimming; with large magnets overnight according to chapter 3. Connect only the control cable to the power supply.**

**Large coils**

Large coils with high magnetic energy must not be shimmed immediately after charging. This concerns 600 MHz and 500 MHz Standard Bore, 400 MHz and 300 MHz Wide Bore and 300 MHz and 200 MHz Superwide Bore NMR magnet systems.
**Always wait overnight before cryo shimming. Leave the control cable connected and run the shim Heater Automatic until cryoshimming. Make sure there is always enough liquid helium in the vessel. Helium boil off will be rather high during operating the Shim Heater Automatic.**

**Cryo shimming**

13. For cryo shimming always leave the main current cable connected to the magnet current lead and mount a shorting connector on the main current cable. Leave the one way valve on the helium turrets mounted. **Change cryo shim currents slowly, especially the $Z^2$ shim current. Connect only the control cable to the cryo power supply!**

**Time Constants**

**Shims that have large time constants have to be changed very carefully. Leave the shim heater open for at least 1 minute with the needed shim current flowing through the shim before closing it.**

**Shorting plug**

14. After shimming, replace the current lead by the magnet shorting plug with the correct procedure according to chapter 3.
15. The helium vessel must always be closed with a one way valve when cold. If a helium recovery system is used, this system only has to be connected with a special assembly available as an accessory from Bruker/Spectrospin. Failure to do so or modifications of the assembly will terminate the magnet systems warranty due to high quench risks.
16. After a quench, check the spheres and the O rings in the quench valves as soon as possible. Recool the magnet within an hour after a quench with liquid helium and wait at least the indicated time before charging it again according to chapter 3.
17. If the magnet can not be recooled immediately, make sure the helium vessel is closed airtight with a one way valve.

## 5.8 Discharging Procedure

1. Refill the helium can up to the minimum level given for charging.
2. Prepare the cryo power supply and all cabling before extracting the shorting plug from its place.
3. Remove the shorting plug with the correct procedure according to chapter 3.
4. Connect the main current cable and the control cable to the magnet and then to the cryo power supply.
5. Discharge all shims one by one with the following procedure:
   •Set the final shim current as noted in chapter 3.1.
   •Open the shim heater, then reduce the shim current slowly to zero.
   •Close the shim heater.
6. Discharge the magnet following the discharging table in chapter 3.

## 5.9 Warm up procedure for Cryostats

Having discharged the magnet, the system can simply be allowed to run out of liquid helium and nitrogen, and left to warm up, which will take about a month.

**Rapid warm up procedure**

Discharge the magnet. Remove the current lead and mount the turret plug **without** baffle. **The fast warm up procedure should be carried out by experienced cryogenic engineers only.**

1. Remove all liquid nitrogen by passing the special $N_2$ blow out tube through one of the filler ports and by applying pressurized **dry nitrogen gas** to the other ports.
   **Never apply a pressure of more than 350 mbar (5 psi) to the nitrogen vessel**
2. Check with a dipstick if the nitrogen can is completely empty. Verify that all open nitrogen ports are free of ice. Mount the security valve to one of the ports.
3. Remove the liquid helium by removing the one way valve, inserting the precooling tube into the syphon and passing gently **dry helium gas** through it. **This will boil off the remaining liquid.**

**Maximum pressure**

**Never apply a pressure of more than 350 mbar (5 psi) to the helium vessel.**

**Warning:**

**Never use nitrogen gas or pressurized air in the helium can. Use dry helium gas only.**

4. Check with a dipstick through the syphon if the helium can is completely empty. Immediately replace the one way valve and close the syphon entry.
5. Break the vacuum very slowly with dry nitrogen gas flowing through a needle valve connected to the vacuum valve by an O ring flange **without clamps**. The gas line is then held in position by the vacuum only. It will drop off automatically once the pressure in the vacuum chamber has reached atmospheric pressure.
6. During the first three hours after breaking the vacuum the operator should be present and check repeatedly both the helium boil off as well as the nitrogen boil off: **It may be small, but if no boil off is observed, the corresponding outlets must be checked for icing.**

**Warning:** **Once the vacuum is broken, never reclose the vacuum valve!**

7. The cryostat takes approximately four to seven days to warm up. When the room temperature bore is no longer wet and cold, the warm up procedure can be considered completed.

**Important:** **Never disassemble a dewar before the warm up procedure is completely finished. Condensing moisture will damage the dewar and the super insulation!**

## 5.10 Temperature Sensor PT100

This magnet is equipped with two platinum resistors as temperature sensors.

**Note:** **Measure the resistance with a maximum current of 1 mA.**

| Calibration data | Temperature | Resistance |
|---|---|---|
| Room temperature | 293 K | 107,8 Ohm |
| | 273 K | 100,0 Ohm |
| | 250 K | 91,0 Ohm |
| | 200 K | 71,1 Ohm |
| | 150 K | 50,9 Ohm |
| | 100 K | 30,0 Ohm |
| Liquid nitrogen | 77 K | 20,1 Ohm |

## 5.11 Safety Recommendations in the High Field NMR Laboratory

**Safety considerations**

**Superconducting NMR magnet systems cause potential safety hazards due to their extended magnetic stray field, their large attractive forces on ferromagnetic objects and their large content of cryogenic liquids. It is the sole responsibility of our customers to ensure safety in their NMR laboratories and to comply with local safety regulations. Bruker/Spectrospin is not responsible for any injuries or damages due to an improper room layout or due to improper operation routines.**

**Magnetic stray field**

It is generally accepted that stray fields are harmless below 5 Gauss (ten times the earth magnetic field). Stronger stray fields closer to the NMR magnet system may disturb heart pace makers, erase magnetic cards and storage devices and adversely affect watches and micro mechanical devices.

**Limited access**

**It is therefore recommended to mark the 5 Gauss line with warning signs and to limit access to areas with more than 10 - 20 Gauss field to the NMR staff only. Be aware that a magnetic stray field extends in all three dimensions and does not get blokked by the walls, floor or ceiling.**

For vertical NMR magnet systems the vertical extension is even larger than the horizontal one. High fields will also affect the rooms above and below the magnet.

**Ferromagnetic objects**

**Strong attraction of ferromagnetic objects may occur at close distances to the magnet, where the magnetic field is above 50 to 100 Gauss. Massive iron objects such as pressurized gas cylinders, are extremely dangerous in the vicinity of a superconducting NMR magnet system. They should be mounted very close to the door and away from the NMR magnet system, or preferably outside the magnet room. Inside the magnet room a wall mounted gas distribution system is recommended.**

| Strayfield | Remarks and recommendations |
|---|---|
| Below 0.5 mTesla | This region can be opened to the public without restrictions. |
| Between 0.5 mTesla. and 1.0 mTesla | Admission should be forbidden for persons with pace makers and clear warning signs should be fixed on all doors. |
| Over 1 mTesla | Access must be limited to NMR staff only, by a locked door or by similar means. Admission is clearly forbidden for persons with pace makers and clear warning signs must be fixed on all doors. |
| Over 5 mTesla | Plastic chains or floor markings should be used to indicate the safety limit for attraction of iron objects. |

**Note**: **1 mTesla = 10 Gauss**
**Warning signs are delivered with each NMR magnet system. Additional signs can be obtained from every Bruker or Spectrospin office**

## 5.12 Vacuum Valve KF25 and Drop Off Plate

This dewar is equipped with a permanently mounted vacuum valve with large inner diameter and with a drop off plate for enhanced safety.
Do not abuse the vacuum valve, e.g. as mounting device. Manipulations of the vacuum valve or the drop off plate are absolutely not recommended after system installation. **They may lead to a vacuum loss and a subsequent magnet quench. The consequences are not covered by our warranty.**

**Assembly**

1. Do not block or modify the drop off plate.
2. Do not use sticking tape to fix the drop off plate to the dewar plate under vacuum or during warm up.
3. If the vacuum valve has been opened or the vacuum has been accidentally destroyed, do not close the valve or block the drop off plate under any circumstances. This would lead to a dangerous pressure build up in the dewar.

**Installation instructions**

Installation should be carried out by Bruker/Spectrospin service engineers. The transport plug must be removed, the vacuum valve inserted and the dewar evacuated.

## 5.13 Installation of the Vacuum Valve during Installation of a Magnet System

**No vacuum** **The following steps have to be carried out if the magnet system is not yet pumped.**

1. Dismount both half rings and remove the sealing plug from the dewar valve flange.
2. Clean and check the O rings and the sealing surfaces on the valve flange and on the sealing plug.
3. Clean and check the O rings on the valve and the sealing surface on the dewar base plate. Apply a small amount of vacuum grease.
4. Gently insert the vacuum valve. Avoid excessive force, as this may damage the sealing surface.
5. Turn the valve in the desired position and fix it with the half rings.
6. Fix the valve stem with the split tube in the outermost position.
7. Connect the pumping unit to the magnet system. Pump and flush the OVC three to four times with dry nitrogen gas.
8. Evacuate the dewar and cool down the whole system. For details see chapters 3 to 5.
9. Close the vacuum valve by pushing the handle slowly up and turning the red knob clockwise. The sealing force is produced by a spring, so the knob doesn't need to be closed by force.
10. Close the valve with the KF25 sealing cap.

## 5.14 Operation of the Vacuum Valve to Pump an Evacuated Dewar

**Important:** **The following steps have to be carried out if the magnet system is evacuated and cold.**

**Caution:** **If pumping on a cold dewar and / or a magnet system on field is needed, the following steps must be carried out only by an experienced Bruker/Spectrospin cryogenic engineer.**
**Be sure that the pumping unit may be operated in a stray field as high as found with this magnet system.**

For details refer to the stray field plot in chapter 3!

1. Remove the KF25 sealing cap from the vacuum valve.

**Caution:** **Avoid any strong physical forces on the vacuum valve.**

2. Connect the pumping unit to the vacuum valve. Evacuate the vacuum tubing to a vacuum better than $10^{-5}$ mbar.

**Important:** **Never open the vacuum valve to a cold magnet system with a vacuum worse than $10^{-5}$ mbar in the vacuum tubing.**
**If the vacuum does not reach $10^{-5}$ mbar in the tubing, there may be a leak!**

3. Open the vacuum valve by turning the red knob counter clockwise and carefully pulling out the handle.
4. Fix the valve stem with the split tube in the outermost position.
5. Pump the magnet system as long as necessary.
6. Close the vacuum valve by pushing the handle slowly up and turning the red knob clockwise. The sealing force is produced by a spring, so the knob doesn't need to be closed by force.
7. Close the valve with the KF25 sealing cap.

## 5.15 Breaking the Vacuum

**Important:** **To break the vacuum in the vacuum chamber of the magnet system, proceed in the same way as described in chapter 5.14 to pump an evacuated magnet system.**

1. Remove the KF25 sealing cap from the vacuum valve.
2. Connect a vacuum valve and a pumping unit to the vacuum valve. Evacuate the vacuum tubing to a vacuum better than $10^{-1}$ mbar.
3. Open the vacuum valve by turning the red knob counter clockwise and carefully pulling out the handle.
4. Fix the valve stem with the split tube in the outermost position.
5. Close the vacuum valve between magnet system and pumping unit. Stop the vacuum pump.

**Important:** **To break the vacuum use dry nitrogen gas only!**

6. Break the vacuum very slowly with **dry nitrogen gas** flowing through a needle valve connected to the vacuum valve by an O ring flange **without clamps**.
   The gas line is then held in position by the vacuum only. It will drop off automatically once the pressure in the vacuum chamber has reached atmospheric pressure.

**Important:** **Check all nitrogen turrets and the helium manifold to be completely open. There must be a gas flow through these turrets, otherwise they could be blocked with ice!**

7. During the first three hours after breaking the vacuum the operator should be present and check repeatedly both the helium boil off as well as the nitrogen boil off: **It may be small, but if no boil off is observed, the corresponding outlets must be checked for icing.**

**Warning:** **Once the vacuum is broken, never reclose the vacuum valve. Strictly avoid any over pressure in the outer vacuum chamber!**

## 5.16 Vacuum Valve KF40 and Drop Off Plate

This dewar is equipped with a demountable vacuum valve with large inner diameter and with a drop off plate for enhanced safety.

**Important** **Manipulations of the vacuum valve or the drop off plate are absolutely not recommended after system installation. They may lead to a vacuum loss and a subsequent magnet quench. The consequences are not covered by our warranty.**

**Assembly**

1. Do not block or modify the drop off plate.
2. Do not use sticking tape to fix the drop off plate to the dewar plate under vacuum or during warm up.
3. If the vacuum valve has been opened or the vacuum has been accidentally destroyed, do not close the valve or block the drop off plate under any circumstances. This would lead to a dangerous pressure build up in the dewar.

## 5.17 Installation of the Vacuum Valve during Installation of a Magnet System

**No vacuum** **The following steps have to be carried out if the magnet system is not yet pumped.**

1. Remove the sealing plug from the dewar valve flange.
2. Clean and check the O rings and the sealing surfaces on the valve flange and on the sealing plug.
3. Clean and check the O rings and the sealing surfaces on the valve operator body. The valve operator body is not delivered with the magnet system and is removed after installation.
4. Slightly grease all O rings and sealing surfaces with vacuum grease.
5. Fix the sealing plug on the valve stem and tighten it slightly.
6. Insert the complete vacuum valve into the dewar's valve flange. Be careful not to damage any sealing surface!
7. Turn the valve in the desired position and fix it with the half rings.
8. Check the valve stem to be catched in the outermost position.
9. Connect the pumping unit to the magnet system. Pump and flush the OVC three to four times with dry nitrogen gas.
10. Evacuate the dewar and cool down the whole system. For details see chapters 3 to 5.

**11.** To close the vacuum valve slightly push the valve stem into the valve operator body until the sealing plug touches the dewar's valve flange. Firmly push the sealing plug into the O ring in the valve flange. The snapping in of the sealing plug is well defined and will be heard and felt!

**Closing the vacuum valve**

**The vacuum valve can be closed without danger!**
**Push the valve stem slightly into the valve operator body until the sealing plug touches the dewar's valve flange. Firmly push the sealing plug into the O ring in the valve flange. The snapping in of the sealing plug is well defined and will be heard and felt!**

**12.** Stop pumping. Carefully flood pumping unit and valve operator body with nitrogen gas.

**13.** Unscrew the valve stem from the sealing plug and carefully pull it out.

**14.** Remove the valve operator body and check the position of the sealing plug in the valve flange.

## 5.18 Operation of the Vacuum Valve to Pump an Evacuated Dewar

**Important:** **The following steps have to be carried out if the magnet system is evacuated and cold.**

**Caution:** **If pumping on a cold dewar and / or a magnet system on field is needed, the following steps must be carried out only by an experienced Bruker/Spectrospin cryogenic engineer.**
**Be sure that the pumping unit may be operated in a stray field as high as found with this magnet system.**

For details refer to the stray field plot in chapter 3!

1. Clean and check the sealing surface on the dewar's valve flange.
2. Clean and check the O rings and the sealing surfaces on the valve operator body. The valve operator body is not delivered with the magnet system and is removed after installation.
3. Slightly grease all O rings and sealing surfaces with vacuum grease.
4. Fix the sealing plug on the valve stem and tighten it slightly.
5. Insert the complete vacuum valve into the dewar's valve flange. Be careful not to damage any sealing surface!
6. Turn the valve in the desired position and fix it with the half rings.
7. Pull the valve stem into the valve operator body until it touches the sealing plug.
   Carefully screw it into the sealing plug.

**Caution:** **Avoid any strong physical forces on the sealing plug. Tighten the valve stem slightly in the sealing plug.**

8. Connect the pumping unit to the valve operator body. Evacuate the valve operator body and the vacuum tubing to a vacuum better than $10^{-5}$ mbar.

**Important:** **Never open the vacuum valve to a cold magnet system with a vacuum worse than $10^{-5}$ mbar in the vacuum tubing.**
**If the vacuum does not reach $10^{-5}$ mbar in the tubing, there may be a leak!**

9. Carefully pull out the sealing plug with the valve stem. Check the valve stem to be catched in the outermost position.

10. Pump the magnet system as long as necessary.
11. To close the vacuum valve slightly push the valve stem into the valve operator body until the sealing plug touches the dewar's valve flange. Firmly push the sealing plug into the O ring in the valve flange. The snapping in of the sealing plug is well defined and will be heard and felt!

**Closing the vacuum valve**

**The vacuum valve can be closed without danger!**
**Push the valve stem slightly into the valve operator body until the sealing plug touches the dewar's valve flange. Firmly push the sealing plug into the O ring in the valve flange. The snapping in of the sealing plug is well defined and will be heard and felt!**

12. Stop pumping, carefully flood pumping unit and valve operator body with nitrogen gas.
13. Unscrew the valve stem from the sealing plug and carefully pull it out.
14. Remove the valve operator body and check the position of the sealing plug in the valve flange.

## 5.19 Breaking the Vacuum

**Important:**

**To break the vacuum in the vacuum chamber of the magnet system, proceed in the same way as described in chapter 5.18 to pump an evacuated magnet system.**

1. - 7. Fix the valve operator body to the magnet system as described in chapter 5.18 steps 1. - 7.
8. Connect a vacuum valve and a pumping unit to the valve operator body. Evacuate the vacuum tubing and the valve operator body to a vacuum better than $10^{-1}$ mbar.
9. Carefully pull out the sealing plug with the valve stem. Check the valve stem to be catched in the outermost position.
10. Close the vacuum valve between magnet system and pumping unit. Stop the vacuum pump.

**Important:**

**To break the vacuum use dry nitrogen gas only!**

**11.** Break the vacuum very slowly with **dry nitrogen gas** flowing through a needle valve connected to the vacuum valve by an O ring flange **without clamps**.
The gas line is then held in position by the vacuum only. It will drop off automatically once the pressure in the vacuum chamber has reached atmospheric pressure.

**Important:** **Check all nitrogen turrets and the helium manifold to be completely open. There must be a gas flow through these turrets, otherwise they could be blocked with ice!**

**12.** During the first three hours after breaking the vacuum the operator should be present and check repeatedly both the helium boil off as well as the nitrogen boil off: **It may be small, but if no boil off is observed, the corresponding outlets must be checked for icing.**

**Warning:** **Once the vacuum is broken, never reclose the vacuum valve. Strictly avoid any over pressure in the outer vacuum chamber!**