Jülich Transfer Cryostat Operations

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Contents

1 Overview

The transfer cryostat is an integral component of the *HDice* target system. The goal of the system is the production and use of frozen-spin polarized deuterium hydride ice targets for nuclear physics experiments. The transfer cryostat moves the HD ice between the other cryostats which make up the system: 1) the dilution refrigerator, where the ice is polarized, 2) the storage cryostat, where the target is stored and shipped between laboratories, 3) the inbeam cryostat, where the target is exposed to the gamma beam while surrounded by the detector array, and 4) the production dewar, where the HD ice is frozen and vaporized. In order to understand how the transfer cryostat accomplishes its mission, a brief review of the target system is required.

1.1 HD Target

The current target design is for a 50 mm long by 15.0 mm diameter cylinder of HD ice. That cylinder is contained between two, 0.5 mm thick pCTFE cups, one inside the other. The outer one is 86.2 mm long and the inner one is 26.1 mm long. The inner, shorter cup is 26.2 mm OD and ends in a 45 degree cone with a 3 mm hole at its vertex. The 1.03 grams of HD liquid enters the target via this hole. The outer cup is enlarged to 29.7 mm ID in the region of the inner one to create a 1.75 mm gap. The gap is sealed at the top of the cups by the copper target support ring to which both cups are attached. Roughly 700 aluminum cooling wires, 51 microns in diameter are soldered to the support ring and extend through the gap down into the HD ice cylinder. The target support ring has a central clearance of 24.5 mm in order for the gamma ray beam to traverse the length of the target. The outer surface of the ring has a right-handed M35x1.0 thread for attachment of the ring into each of the four cryostats mentioned above. The inner surface of the ring has a left-handed M26x1.0 thread. This allows the transfer cryostat to attach to the ring with the left-handed inside thread and then unscrew the right-handed outside thread to release the target when the attachment screw of the transfer cryostat rotates counter-clockwise (as seen from above) or to attach the ring inside the appropriate cryostat and then detach from the transfer cryostat with clockwise rotation.

In order for the unsealed target not to sublime appreciably, its temperature must be maintained below 5 Kelvin, although brief excursions up to 7 Kelvin are tolerable. Table 1 gives the vapor pressure inside and sublimation rate from our HD target with its 3 mm hole.

It is even more important to maintain the target at cold temperatures in order to reduce the rate of polarization loss as we shall see in the next section.

Table 1: HD vapor pressure and sublimation rate vs. temperature

Temperature	Vapor Pressure	Sublimation Rate
7 K	7.8×10^{-4}torr	181 milli-gm/day
5 K	4.4×10^{-7}torr	123 micro-gm/day
4.216 K	3.9×10^{-9}torr	1.16 micro-gm/day

Table 2: H and D polarization lifetimes vs temperature

Field	10 Tesla (storage)		1 Tesla (inbeam)		0.12 Tesla (transfer)	
Temperature	H	D	H	D	H	D
4.2 K	27 days	80 days			1 day	3 days
1.5 K	80 days	240 days	14 days	42 days	3 days	9 days
0.4 K			35 days	100 days		

1.2 Target Cycle

The target is filled with HD by condensing HD vapor at just above the triple point of HD, 16.6 K. This temperature regime is reached with a specialized cryostat called the production cryostat or IceMaker, or by utilizing the vertical temperature gradient in a dilution refrigerator with its inner vacuum filled with exchange gas. After filling, the target is transferred to a He3-He4 dilution refrigerator with a 10 mK base temperature and a 17 Tesla superconducting solenoid. With the aid of a 10^{-4} doping of metastable ortho-H2, the H reaches equilibrium polarization of up to 80% within a few days. This polarization can be transferred to the D with an adiabatic fast passage technique and the H repolarized. Repeating the fast passage transfer allows D polarizations of up to 50% to be reached. After 6 to 9 weeks of aging the ortho-H2 and para-D2 have decayed to such an extent that the polarization approach to equilibrium is extremely slow. This allows the target to be removed from such extremes of temperature and magnetic field. The target can be transferred to a storage cryostat, where the target can be stored and shipped between laboratories, and then to the inbeam cryostat, where the target is exposed to the gamma beam surrounded by the detector array. After the target polarization has decayed too low to be useful, it is transferred to the production cryostat for vaporization of the HD and re-generation of the ortho-H2 at room temperature. The HD gas is then ready to begin a new cycle. Table 2 gives the polarization lifetime goals for a fully aged target as a function of temperature for both H and D at the nominal fields of the three relevant cryostats : storage, inbeam and transfer.

2 Transfer Cryostat

Thus we see that in order for the transfer cryostat to perform its job it must extend a 4 K left-handed screw thread into each of the cryostats and rotate that thread multiple times. To keep the radiant thermal load on the 4 K section at a manageable level, it must be surrounded by a 77 K liquid nitrogen shield. Further, when the target is withdrawn from any of the cryostats, it must at all times see a magnetic holding field of at least 0.12 Tesla. In the following subsections, each of the components of the transfer cryostat will be examined in detail (see Figures 1, 2, and 3).

2.1 LHe Reservoir

The transfer cryostat is a series of concentric cylindrical or toroidal volumes, of which the center most is the liquid helium (LHe) reservoir. This volume extends some 3.3 meters, from the cross at the top of the cryostat to the target attachment screw on the reservoir's bottom. It is filled with LHe through the opening at the top of the cross. It has a capacity of 1.1 liters of LHe. Helium boiloff vents through one of the side arms of the cross. The other arm carries the electrical feedthroughs for a temperature sensor at the bottom of the helium reservoir and for a liquid level sensor.

2.2 LN2 Reservoir

A toroidal reservoir for liquid nitrogen (LN2) is contained in the vacuum space. It is supported by a rod from the reservoir to the top of the bellows and by three tubes extending out the top of the vacuum space. Two of the tubes serve as the fill and vent lines. The third carries the capacitive level sensor for the top, larger-diameter section of the reservoir. The reservoir has a 1.8 liter capacity. The top 0.29 meters are larger diameter than the rest, roughly corresponding to the compressed length of the bellows. The bottom of the reservoir is a smaller outer diameter radiation shield which covers the LHe reservoir for an additional 1.6 meters. Attached to the bottom of the shield is a permanent magnet array in an Holbach configuration which provides the holding field for the polarized target while it is in the transfer cryostat, 0.12 Tesla transverse. A calculation of the external magnetic field contours is given in Figure 4. Below the magnet is a multi-leaf, spring-operated shutter that seals the bottom from room temperature radiation. Note that lowering the top of the bellows causes extrusion of the lower portion of the LN2 reservoir and the shutter through the gate valve at the bottom of the bellows.

2.3 Insulating Vacuum Space

The liquid cryogen reservoirs are isolated from room temperature by an enclosing vacuum space, termed the insulating vacuum. This volume includes the double wall of the LHe reservoir tube from the cross at the top of the cryostat down approximately half of the length of the LHe reservoir. It contains the LN2 reservoir and the HD

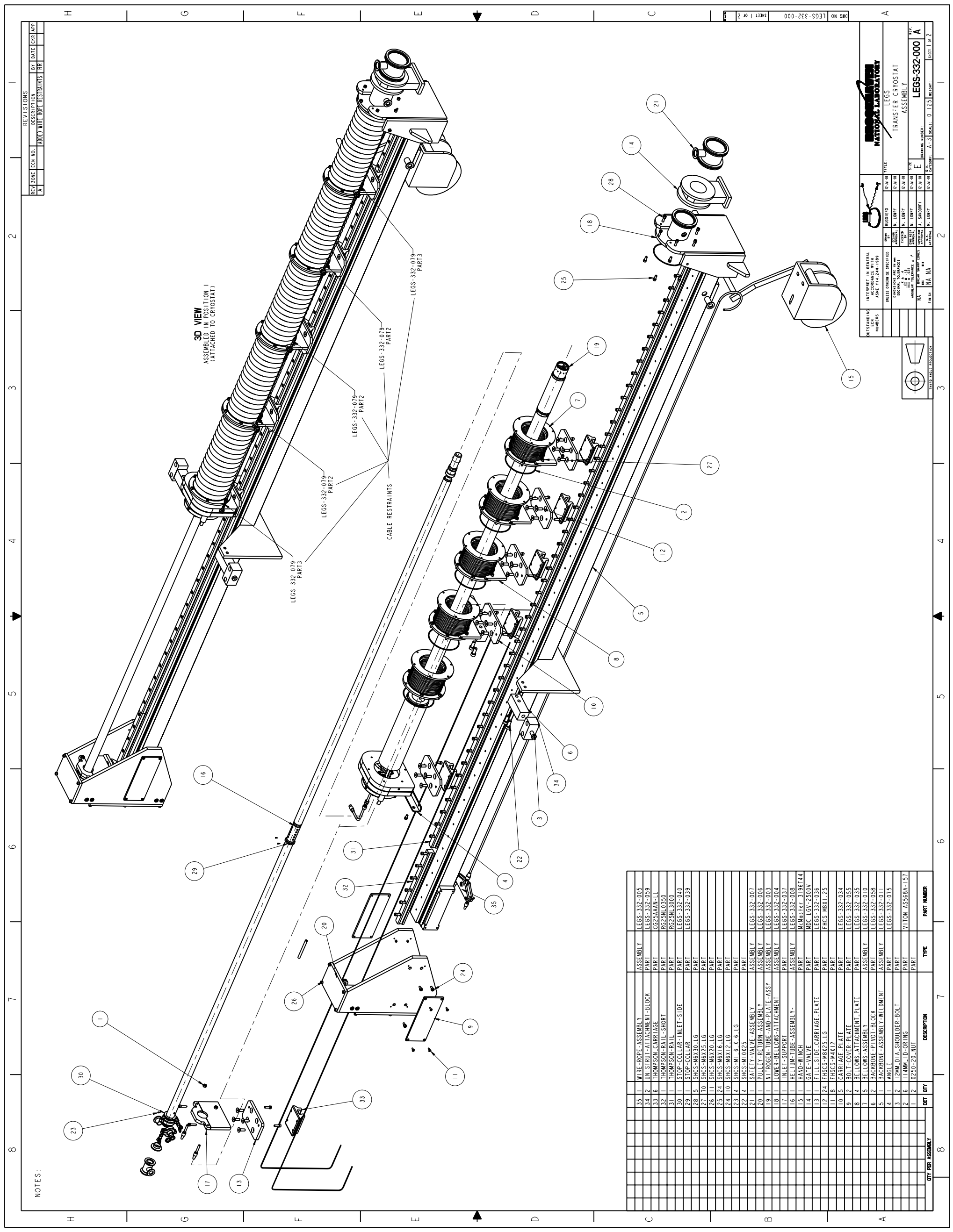

Figure 1: Transfer Cryostat Drawing

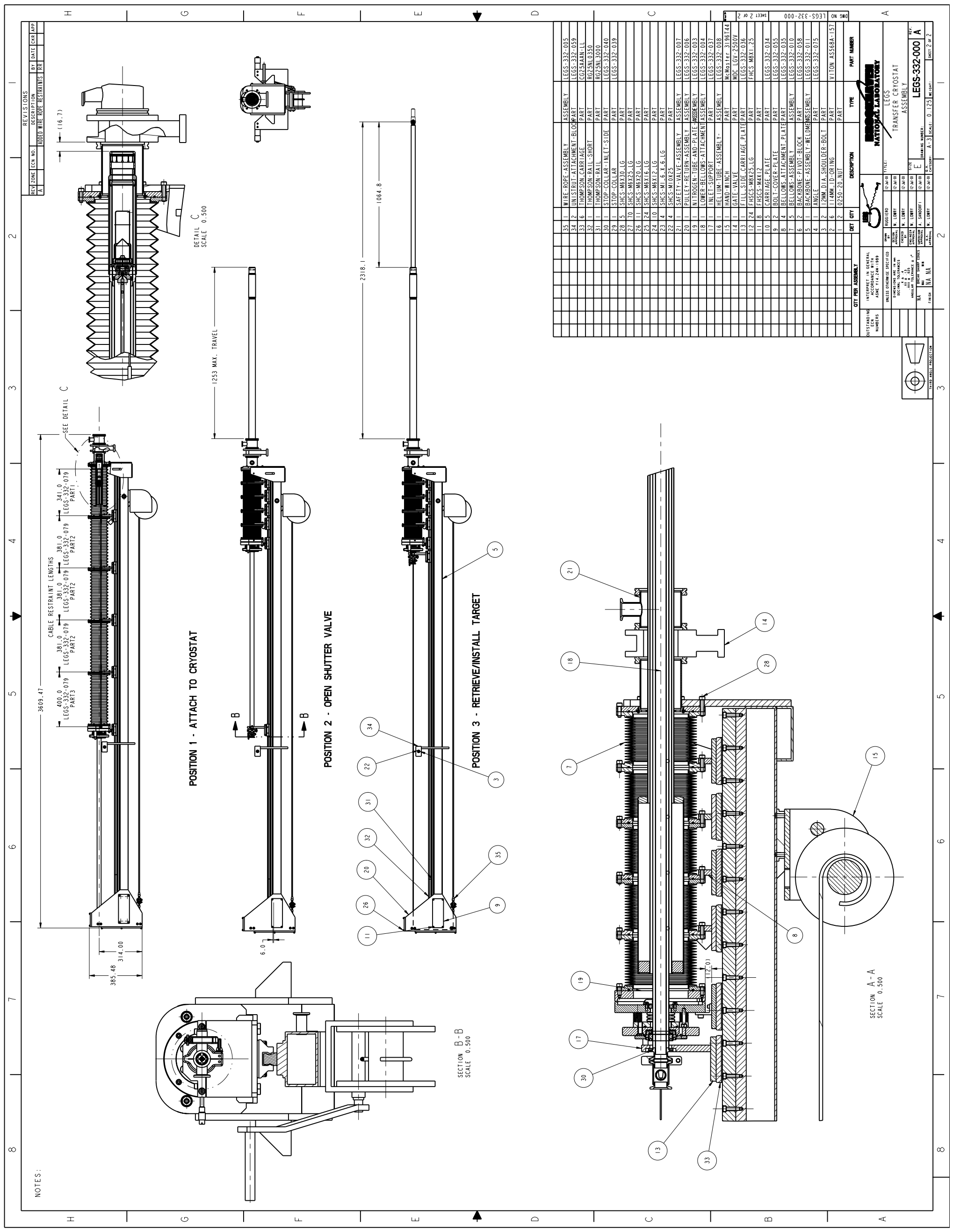

Figure 2: Transfer Cryostat Drawing

Transfer Cryostat Piping and Valves

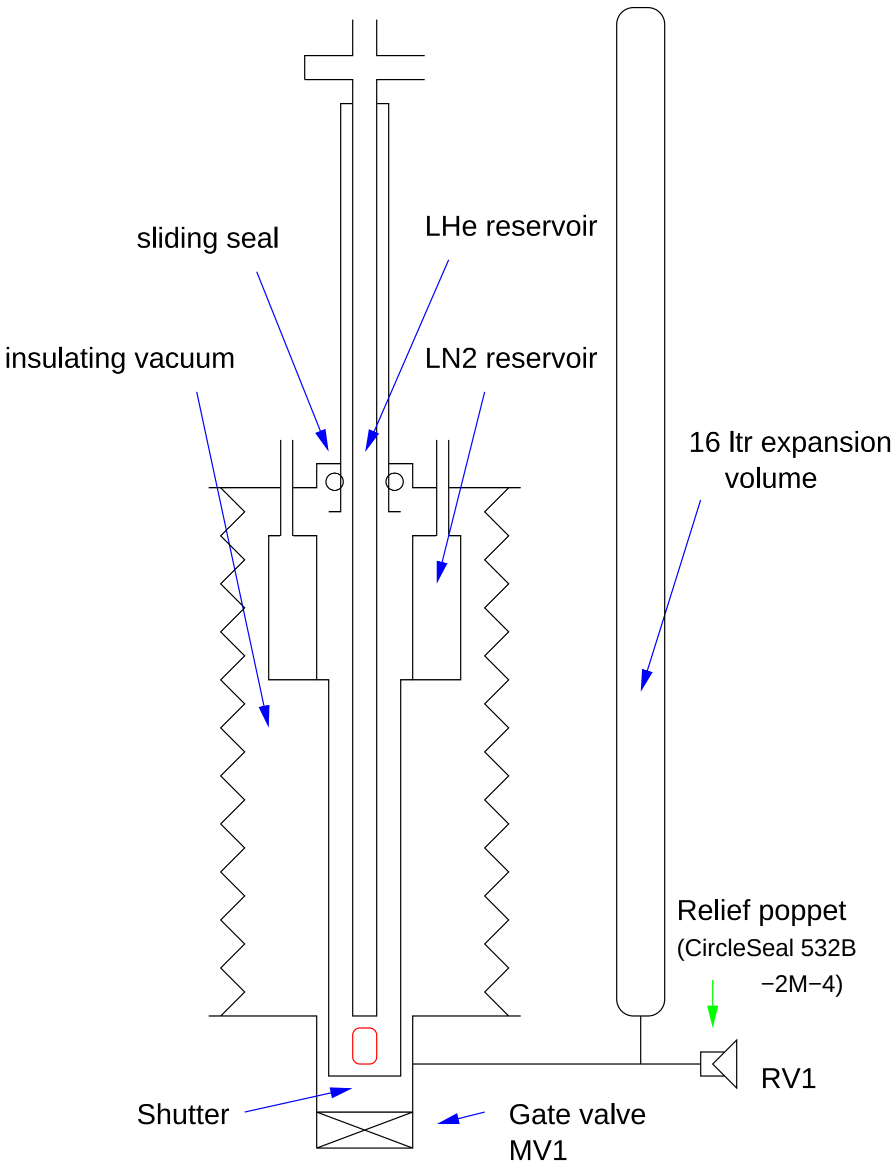

Figure 3: Transfer Cryostat Piping and Valves Schematic

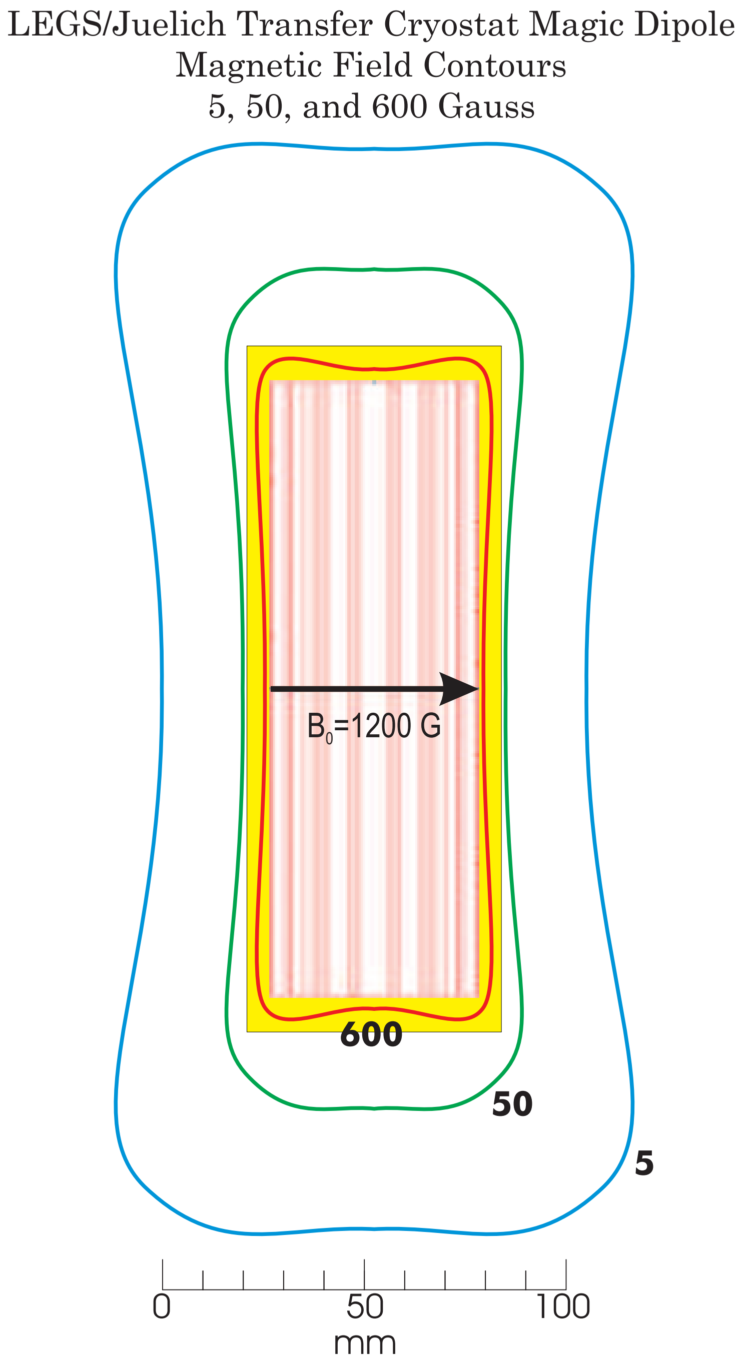

Figure 4: Magnetic field contours in plane containing external field maximum.

target itself. This vacuum space can be evacuated through the gate valve, MV1, at the bottom of the cryostat. Just above that gate valve is a connection to an NW16 tee that carries a relief poppet valve, RV1 (4 psi), and provides connection to the 10 cm x 5 cm x 3.3 meter long backbone tube. This tube adds 16 liters of expansion volume to the 15 liters of insulating vacuum and thus guarantees that the cryostat will remain below atmospheric pressure should cooling be lost and a target vaporize (21.6 liters).

The outside wall of the double wall section makes contact with the sliding seal at the top of the bellows. This seal allows translation and rotation of the target attachment screw thread. Care must be taken to ensure that the wall in contact with the sliding seal remains at room temperature to prevent freezing of the O-ring and loss of vacuum integrity.

The outside wall of the lower section is a 1.9 meter long, highly compressible bellows. This allows vertical motion of the bellows top along with the attached LN2 reservoir and the LHe reservoir captured by the sliding seal located on the bellows top.

2.4 Support Frame

The cryostat weight and motions are supported and guided by an aluminum backbone, which spans nearly the full, 3.6 meter length of the cryostat. At the bottom of the backbone is a winch whose cable supports the vacuum force and controls the motion of the LHe tube and the bellows. On top of the backbone is a linear track. Four small carts ride the track to guide the bellows sections and one cart rides it to guide and support the top of the bellows. The cross at the top of the LHe reservoir is also guided by a cart riding on the backbone track. The interior of the backbone serves as an additional 16 ltr expansion volume for the cryostat.

2.5 Ancillary Equipment

Two additional pieces of equipment have been constructed to aid in safely moving and storing the cryostat.

2.5.1 Cryostat Cart

A cart has been provided with a cradle to hold the cryostat at a 30° angle as well as space to hold the liquid cryogen level and temperature readouts.

2.5.2 Lifting Arm

A specially made arm, Dwg. 326-301-5, has been constructed to lift and hold the cryostat off-center from the hoist. The cryostat may be held at any angle between 0° and 90° to horizontal. At 90°, the cryostat is held at the top of the LN2 space and balanced by a counter weight hung on the other end of the arm. A large mechanical advantage allows gentle placement of the transfer cryostat on top of the storage cryostat, production cryostat and dilution refrigerator. By attaching the other end of the arm to the bottom of the cryostat, and moving the lift point, the cryostat may be held at a 30° angle for placement either on the supports for transfers in and out of the inbeam cryostat or on the cryostat cart.

3 Safety

3.1 Liquid Cryogens

The total volumes of liquid cryogens are quite small, 1.8 liters of liquid nitrogen and 1.1 liters of liquid helium. The liquid nitrogen is at atmospheric pressure and vents through a 3/8" tube. The liquid helium vents through a 3/4" tube.

3.2 Solid Hydrogen

The cryostat can transport one solid hydrogen target which corresponds to 21.6 liters STP. The internal volume into which the target would expand is 31 liters. So if cooling were lost, the internal pressure would rise to 0.7 Bar absolute, still less than the external 1.0 Bar. In the event of a slow leak of air or nitrogen, significant quantities could acumulate on the LHe tube prior to loss of cooling. In this case, the air or nitrogen plus hydrogen mixture could exceed the 31 liter internal volume and a 4 psi relief valve will vent the excess to the room. Note that, considering only the latent heats, 1.1 liters of LHe can at most condense 18 mL of LN2 which corresponds to only 14 liters of gas. This, plus the hydrogen, would result in a pressure of 2.2 psig, insufficient to trigger the 4 psi relief. There is no ignition source in the vacuum space.

3.3 Pressure Vessel

There is only one vacuum space so the maximum differential occurs with 14.7 psia external and zero internal. The maximum differential in the other direction is governed by the 4 psi relief valve, 14.7 psia external, 18.7 psia internal. These values fall outside the scope of ESH Standard 1.4.1. The bellows, gate valve and reservoirs are stainless steel type 304L except for the bottoms of the reservoirs which are copper type C10100. The backbone is aluminum type 6061-T6. There are no glass or plastic windows.

3.4 Magnetic Field

The Holbach array configuration for a permanent magnet results in a high central field, 1200 Gauss in this case, but small external fields. The accessible external field is quite similar in magnitude to that of the previous transfer cryostat which has only a 150 Gauss central field. The 600 Gauss contour line of this magnet falls entirely within the vacuum envelope and is normally inaccessible. The 5 Gauss contour extends outside the 76 mm diameter of the spool pieces (see Figures 2 and 4) so that a low exposure is possible. The cryostat is only used in areas already posted for static magnetic fields and will be surveyed, assessed and will have the appropriate controls implemented by the NSLS.

3.5 Lifting Fixture

The lifting arm utilized by this device is the same one used on the previous generation cryostat, supplied by Orsay group. The design has been checked by plant engineering, and the device has been inspected, tested and certified for this application by the plant engineering crane inspector. It undergoes annual inspection by the plant engineering crane inspector.

4 Procedures

Before attempting any of the procedures detailed in the following sections, all personnel should acquaint themselves with standard laboratory safety procedures, including vacuum pumping, liquid cryogen handling, magnetic field safety and proper hoist operation. All personnel must have read this manual fully and be certified by the head of the SPHICE target group at BNL. This equipment is for experimental use only and requires handling by trained personnel only. If the cryostat performance deviates from the performance expected in this manual, consult with the head of the SPHICE target group or other expert immediately.

4.1 Cooling to LN2

This procedure cools the cryostat from room temperature to that of liquid nitrogen, 77 Kelvin. It is recommended that the transfer cryostat be on its cart to start.

1. Check the LN2 and LHe level readouts to make sure both are connected and working properly. The sensor fail lights should not be lit and both should read at ot below zero.

2. Check the LHe temperature sensor readout, which should be 300 Kelvin.

3. Record the time and readings in the cryostat logbook.

4. Attach a turbo pumping station to the gate valve MV1 at the bottom of the cryostat. Evacuate the insulating vacuum space to better than 8×10^{-6}torr.

5. Attach a roughing pump to one vent port of the LN2 reservoir and plug the other one with a rubber stopper. Pump the reservoir to below 50 microns and then back fill with He gas. If the reservoir fails to pump down, it may indicate the presence of water from the previous cold cycle. Continue pumping and flushing until the water has been removed.

6. Repeat previous step for the LHe reservoir, attaching the pump to the vent and putting the stopper in the fill.

7. Add LN2 to the LN2 reservoir. Because of the large surface to volume ratio of the LN2 reservoir, this should be done somewhat slowly, allowing approximately 15 minutes for the filling operation. When the LN2 boiloff from the LN2 reservoir has slowed and the level meter indicates full, the cryostat has been pre-cooled to LN2 temperature.

8. Record the time and LN2 level reading in the logbook.

4.2 Cooling to LHe

This procedure cools the cryostat from that of liquid nitrogen to that of liquid helium, 77 to 4.2 Kelvin. It is recommended that the transfer cryostat be on its cart for this operation. This procedure requires that pre-cooling, Procedure 4.1, has been completed immediately prior to this one.

1. Remove the plug from the LHe fill port. Insert the fill lance into the LHe reservoir. Make sure the lance is firmly seated in the initial transfer cone. Direct the helium exhaust gas away from the cryostat with temporary tubing.

2. Place the withdrawl lance in a LHe supply dewar and begin the transfer. Adjust the pressure in the supply dewar, by adding heat or venting, as necessary, to maintain a steady light breeze of helium exhaust from the cryostat. The filling should take about 40-60 minutes.

3. Monitor progress with the LHe temperature meter and note time and readings in the logbook.

4. Re-fill the LN2 reservoir when necessary as indicated by the LN2 level meter.

5. After blowoff from the LHe reservoir has reached a steady state and the LHe level meter indicates 140 cm or more, the cryostat is considered cooled to LHe temperature.

6. Record the time , LN2 and LHe level, and LHe temperature readings in the logbook.

7. Remove the fill lance from the LHe reservoir and remove the fill lance from the LHe supply dewar. Insert the plug in the LHe fill port.

4.3 Warming up the Cryostat

This procedure warms the cryostat to room temperature from that of liquid helium, 4.2 Kelvin. It is recommended that the transfer cryostat be on its cart for this operation.

1. Cease to replenish the LHe and LN2 reservoirs. The cryostat will warm up on its own in 12 to 24 hours.

WARNING: Do not attempt to speed up this process by adding exchange gas to the vacuum space. This may freeze the sliding O-ring, causing a vacuum failure and excessively rapid venting of the liquid cryogen boiloffs.

WARNING: Do not attempt to pour out the liquid cryogens by tilting the cryostat on the lifting arm. The LN2 reservoir cannot be drained in this way because of the position of the vents. Sudden contact of the LHe with the upper, warmer part of the LHe reservoir may result in flash boiling and excessively rapid venting.

4.4 Lifting the Cryostat

This procedure details hoisting the cryostat from its cart. This operation is considered a pre-engineered, production lift and requires Incidental Overhead Crane Operator certification on the crane to be used.

1. Obtain the crane key from the NSLS control room. Inspect the crane and the lifting arm, Dwg. 326-301-5, for damage or wear.

2. Inspect the transfer cryostat and its cart to make sure the cryostat is properly positioned on the cart and that the cart casters are in working order.

3. Check that the electrical safety guard is installed on the top of the transfer cryostat.

4. Check the clearances and remove any obstructions that could interfere with the motion of the cart or the swing of the lifting arm during the lift. Reposition the cart if necessary.

5. Secure the area for lifting operations.

6. If the lifting arm is not already in place, position the arm over the cryostat and attach it to the cryostat at the lifting pins near the top of the side rails. Attach the cable between the counterweight end of the lifting arm and the bottom of the transfer cryostat.

7. Adjust the movable lifting point to the marked position for 30°support.

8. Position the crane over the movable lifting point. Attach the hook and make sure it is properly moused.

9. Slowly hoist. The lifting arm will rise to a horizontal position. Care must be exercised to avoid swinging the arm too rapidly. Use the tether to help minimize swinging. Continue lifting an additional 5 to 10 cm so that one end of the cryostat has lifted off the the cart.

10. Re-adjust the lifting point if necessary so that both ends are free of the cart, the cryostat is hanging parallel to its cradle on the cart and the lifting arm is level.

4.5 Rotating to 90°

This procedure details rotating the cryostat from the lift position 30° from the horizontal to the 90° vertical position preparatory to attaching to the storage cryostat. This operation is considered a pre-engineered, production lift and requires Incidental Overhead Crane Operator certification on the crane to be used. It requires that Procedure 4.4 has been performed. This procedure cannot be performed on the the 1-169 I-Beam monorail crane do to a lack of overhead clearance.

1. Check the overhead clearance. The cryostat is approximately 4 meters long. Reposition the crane and or rotate the arm horizontally if necessary.

2. Hoist the cryostat so that the lift point is at least 2.1 meters (7 feet!) off the floor. Use the tether to control any swing. Secure the crane.

3. Adjust the lift point towards the cryostat so that the counterweighted end and the cryostat swing downward. Continue adjusting until the cable connecting the bottom of the cryostat to the arm goes slack and the cryostat hangs vertically.

4. Detach the connecting cable from the lifting arm by opening the shackle. Store the cable by looping it around the body of the gate valve and shackling it to itself.

5. Adjust the lifting point back towards the counterweighted end of the arm so that that end swings up. Use the tether to prevent undesirable rocking or swinging. Continue adjusting until the arm is horizontal. The cryostat will pivot on its lifting pins to remain vertical but will swing out and down.

4.6 Rotating to 30°

This procedure details rotating the cryostat to 30° from a vertical position on the crane such as from mounting atop the production cryostat. This operation is considered a pre-engineered, production lift and requires Incidental Overhead Crane Operator certification on the crane to be used. It assumes that Procedures 4.4 and 4.5 have been performed.

1. Check the clearances and remove any obstructions that could interfere with the motion of the cryostat or of the lifting arm during the procedure. Reposition the cryostat if necessary.

2. Lower the cryostat to within about 30 cm of the floor. Secure the crane.

3. Adjust the lift point towards the cryostat so that the counterweighted end swings downward. Use the tether to eliminate rocking and swinging. Continue adjusting until the cable connecting the bottom of the cryostat to the arm can be attached (the position is marked).

4. Attach the cable between the bottom of the cryostat and the arm. Un-shackle the cable from itself, unwrap from the gate valve and re-shackle it to the eye on the lifting arm.

5. Adjust the lifting point back towards the counterweighted end of the arm so that that end and the cryostat swing upward. Continue adjusting until the arm is horizontal (the position is marked) and the cryostat hangs beneath it at 30° from horizontal.

4.7 Lowering the Cryostat

This procedure details lowering the cryostat to its cart. This operation is considered a pre-engineered, production lift and requires Incidental Overhead Crane Operator certification on the crane to be used. It assumes the cryostat is hanging beneath the lifting arm at 30° from horizontal as at the end of Procedure 4.4 or Procedure 4.6.

1. Inspect the transfer cryostat cart to make sure the cradle is clear and the cart casters are in working order.

2. Check the clearances and remove any obstructions that could interfere with the motion of the cart or the swing of the lifting arm during the procedure. Reposition the cart if necessary.

3. Slowly lower the cryostat to within 2 to 6 cm of the cart. Adjust the lifting point so that the bottom end of the cryostat rests against its stop on the cart.

4. Slowly lower the top end of the cryostat onto the cart. Continue lowering until the lifting arm rests on its support.

5. Unhook the crane and secure it from hoisting operations.

6. Return the key to the NSLS control room.

4.8 Attaching to the Production Cryostat

This procedure describes positioning the transfer cryostat on the production cryostat or other vertical cryostat in preparation for inserting or removing a target. This operation is considered a pre-engineered, production lift and requires Incidental Overhead Crane Operator certification on the crane to be used. It assumes the transfer cryostat is on its cart ready to be lifted (see Procedure 4.2).

1. Ensure the production cryostat is positioned so that a clear path to the ISO-NW 63 flange on the gate valve exists and requires motion of the crane in only one direction (either trolley or bridge).

2. Perform Transfer Cryostat Procedures 4.4 and 4.5 to lift the cryostat and rotate it to vertical.

3. Position the crane so that the two cryostats are near each other and on the line of the clear path. The transfer cryostat should not be over the production dewar but displaced 20 to 30 cm.

4. **CAUTION**: the controls on the crane are too crude to allow vertical adjustments while the transfer cryostat is over the production cryostat.

5. Raise the transfer cryostat to a height such that the ISO-NW 63 flange on the vacuum lock on the bottom of the transfer cryostat is 2 to 4 cm higher than the top flange of the gate valve atop the storage cryostat.

6. Move the transfer cryostat into position over the production cryostat with the crane. De-energize (Lock-Out) the crane.

7. Adjust the lift point as necessary to fine tune the position.

8. Insert an ISO-NW 63 centering ring and O-ring between the two flanges then gently (approximately 0.4 kilogram/cm or 2 lbs/in is required) pull down on the transfer cryostat to shift the balance of the lifting arm and close the gap. Secure the flange with 4 half-claw clamps and screws.

9. Attach a pumping station to the vacuum lock. Evacuate the vacuum lock to better than 8×10^{-6} torr. Valve off the pumping station.

10. Open the gate valves on both cryostats.

The cryostats are now ready for Procedure 4.12 or 4.13.

4.9 Detaching from the Production Cryostat

This procedure describes separating the transfer cryostat from the production dewar or other vertical cryostat. This operation is considered a pre-engineered, production lift and requires Incidental Overhead Crane Operator certification on the crane to be used. It assumes the transfer cryostat is hanging vertically on the crane attached to the production cryostat (see Procedure 4.8).

1. Check that the winch controling the LHe reservoir and the LN2 reservoir is in its fully withdrawn position.

2. Close the gate valves on the both cryostats.

3. Vent the vacuum lock. Remove the 4 half-claw clamps closing the ISO-NW63 flange and guide the transfer cryostat as it rises to its balance position. Remove the centering ring and O-ring.

4. Re-energize the crane.

5. Trolley or bridge the crane so that the transfer cryostat is no longer over the storage cryostat. Lower the transfer cryostat to within 30 cm of the floor.

6. Return the transfer cryostat to its cart with Procedure 4.7.

4.10 Attaching to the InBeam Cryostat

This procedure describes positioning the transfer cryostat on its supports upstream of the inbeam cryostat in preparation for inserting or removing a target. This operation is considered a pre-engineered, production lift and requires Incidental Overhead Crane Operator certification on the crane to be used. It assumes the transfer cryostat is ready to be lifted from its cart (see Procedure 4.2).

1. Prepare the supports for receipt of the transfer cryostat by clamping the stop on the downstream support in the retract position.

2. Consult the inbeam cryostat manual for the procedures for readying and positioning the inbeam cryostat for target insertion or removal. If it is necessary to preserve target polarization, activate the inbeam main solenoid.

3. Perform Procedure 4.4 on the beam line crane. Position the transfer cryostat to be several centimeters above its cart and at 30° as viewed from the side. Slowly raise the cryostat so that the bottom end of the LN2 section is 10 cm higher than the lower, downstream support and the top end is more than 10 cm higher than the upstream support.

4. Rotate the cryostat in a horizontal plane to place the top above the upstream support and the bottom over the downstream one.

5. Trolley the crane as necessary to position the bottom end so that it will engage the stop on the downstream support when lowered.

6. Slowly lower the transfer cryostat onto the downstream support, making sure the stop on the downstream support properly engages the bottom of the cryostat.

7. Move the lifting point away from the upstream support, reducing the side angle, and lowering the upper end onto the upstream support. Insure the plate attaching the transfer cryostat to the lifting arm lies between the guides on the upstream support so as to properly align the cryostat on the supports.

8. De-energize (Lock-Out) the crane.

9. Insert an ISO-NW 63 centering ring and O-ring between the two flanges. Unclamp and then, using the lever mechanism, gently lower the stop on the downstream support to slide the transfer cryostat down and close the gap. Secure the flange with 4 half-claw clamps and screws.

10. Attach a pumping station to the vacuum lock. Evacuate the vacuum lock to better than 8×10^{-6} torr. Valve off the pumping station.

11. Open the gate valves on both cryostats.

The cryostats are now ready for Procedure 4.12 or 4.13.

4.11 Detaching from the InBeam Cryostat

This procedure describes separating the transfer cryostat from the inbeam cryostat and lifting it off the supports upstream of the inbeam cryostat. This operation is considered a pre-engineered, production lift and requires Incidental Overhead Crane Operator certification on the crane to be used. It assumes the transfer cryostat is attached to the beamline crane in the 30° attitude, resting on the supports upstream from the inbeam cryostat and attached to that cryostat (see Procedure 4.10).

1. Check that the winch controling the LHe reservoir and the LN2 reservoir is in its fully withdrawn position.
2. Close the gate valves on both cryostats.
3. Vent the vacuum lock. Remove the 4 half-claw clamps closing the ISO-NW63 flange. Move the stop on the lower support to the retract position to slide the transfer cryostat up and separate the two cryostats. Clamp the stop. Remove the centering ring and O-ring.
4. Re-energize the crane.
5. Hoist the transfer cryostat off the supports.
6. Rotate the lifting arm and cryostat counterclockwise in the horizontal plane.
7. Lower the cryostat to within 30 cm of the floor.
8. Return the transfer cryostat to its cart with Procedure 4.7.

4.12 Retrieving a Target

This procedure describes transferring a target from an external cryostat into the transfer cryostat. Although this procedure does not require any hoisting itself, it does require that a crane be in operation and as such this operation is considered a pre-engineered, production lift and requires Incidental Overhead Crane Operator certification on the crane in use. This procedure requires that the transfer cryostat be attached to either the production cryostat (or similar vertical cryostat, see Procedure 4.8) or the inbeam cryostat (see Procedure 4.10) and not contain a target.

1. Check the cryogen levels in the transfer cryostat and confirm that the gate valves on both cryostats are fully open.
2. If attached to the dilution refrigerator, open its radiation baffle.
3. Attach a pump to the double seal and begin pumping.

4. Slowly un-wind the winch, compressing the bellows and extending the LN2 reservoir into the other cryostat. Look for the touch of the shutter on the shutter opener (the position is marked on the side rail). The tension on the cable will be drastically reduced as the majority of the vacuum force is taken up by the shutter opener. It is essential that the position be positively identified in order to confirm that the shutter is fully open and no damage will result from passing the LHe reservoir through it.

5. If attached to the inbeam cryostat, open its radiation baffle.

6. Loosen but do not remove the locking clamp on the LHe reservoir. Start the pump on the intermediate volume between the double O-rings of the sliding seal.

7. Continue to unwind the winch and slowly insert the LHe reservoir into the vacuum space. (The operation is more controlling the sucking in of the tube by the vacuum.) Feel for the touch of the left-handed threads on the target (the position is marked on the backbone rail).

8. Slowly rotate the LHe reservoir clockwise. Feel for the slight drop (1 mm) of the reservoir when the threads align. It is essential that this be positively identified so as to avoid crossthreading the delicate copper threads.

9. Rotate the reservoir counterclockwise to screw the left-handed thread of the transfer cryostat into the target base. The reservoir should continue to descend 1 mm per turn. After 4 turns, the reservoir should be felt to bottom out.

10. A significantly stronger torque must now be applied to release the target from its old home and firmly attach it to its new one.

11. Continue unscrewing the target and the reservoir will rise 1 mm per turn for 8 turns (the pitch of the left and right threads are identical, 1 mm per turn).

12. Continue turning and feel for the drop of the LHe reservoir when the threads re-align. Turn an additional half turn to insure the threads are free.

13. The LHe reservoir must now be slowly pulled from the vacuum with the winch. Note that the portion of the tube inside the vacuum will have been radiatively cooled by the LN2 reservoir. It is therefore essential to wear protective gloves and to direct a stream of warm air from a heat gun on the emerging tube.

14. After the LHe reservoir has been pulled out to its maximum, tighten the locking clamp and turn off the pump on the sliding seal.

15. If attached to the inbeam cryostat, close its radiation baffle.

16. Continue to wind up the winch to pull the LN2 reservoir back inside the transfer cryostat.

17. If attached to the dilution refrigerator, close its radiation baffle.

18. Continue pulling the LN2 reservoir out until the marked home position is reached.

19. Stop pumping the double seal and detach the pump.

4.13 Placing a Target

This procedure describes transferring a target into an external cryostat from the transfer cryostat. Although this procedure does not require any hoisting itself, it does require that a crane be in operation and as such this operation is considered a pre-engineered, production lift and requires Incidental Overhead Crane Operator certification on the crane in use. This procedure requires that the transfer cryostat be attached to either the production cryostat (or similar vertical cryostat, see Procedure 4.8) or the inbeam cryostat (see Procedure 4.10) and contain a target as a result of Procedure 4.12.

1. Check the cryogen levels in the transfer cryostat and confirm that the gate valves on both cryostats are fully open.

2. If attached to the dilution refrigerator, open its radiation baffle.

3. Attach a pump to the double seal and begin pumping.

4. Slowly un-wind the winch, compressing the bellows and extending the LN2 reservoir into the other cryostat. Look for the touch of the shutter on the shutter opener (the position is marked on the side rail). The tension on the cable will be drastically reduced as the majority of the vacuum force is taken up by the shutter opener. It is essential that the position be positively identified in order to confirm that the shutter is fully open and no damage will result from passing the LHe reservoir through it.

5. If attached to the inbeam cryostat, open its radiation baffle.

6. Loosen but do not remove the locking clamp on the LHe reservoir. Start the pump on the intermediate volume between the double O-rings of the sliding seal.

7. Continue to unwind the winch and slowly insert the LHe reservoir into the vacuum space. (The operation is more controlling the sucking in of the tube by the vacuum.) Feel for the touch of the right-handed outer threads of the target on the target holder (the position is marked on the backbone rail).

8. Slowly rotate the LHe reservoir counterclockwise. Feel for the slight drop (1 mm) of the tube when the threads align. It is essential that this be positively identified so as to avoid crossthreading the delicate copper threads.

9. Rotate the LHe reservoir clockwise to screw the right handed outer thread of the target into the target holder. The reservoir should continue to descend, 1 mm per turn. After 8 turns, the tube should be felt to bottom out.
10. A significantly stronger torque must now be applied to release the target from its old home and firmly attach it to its new one.
11. Continue screwing in the target (actually unscrewing the left handed thread on the LHe reservoir) and the reservoir will rise for 4 turns, 1 mm per turn).
12. Continue turning and feel for the drop of the reservoir when the threads re-align. Turn an additional half turn to insure the threads are free.
13. The LHe reservoir must now be slowly pulled from the vacuum. Note that the portion of the reservoir inside the vacuum will have been radiatively cooled by the LN2 reservoir. It is therefore essential to wear protective gloves and to direct a stream of warm air from a heat gun on the emerging tube.
14. After the LHe reservoir has been pulled out to its maximum, tighten the locking clamp and turn off the pump on the sliding seal.
15. If attached to the inbeam cryostat, close its radiation baffle.
16. Continue to wind up the winch to pull the LN2 reservoir back inside the transfer cryostat.
17. If attached to the dilution refrigerator, close its radiation baffle.
18. Continue pulling the LN2 reservoir out until the marked home position is reached.
19. Stop pumping the double seal and detach the pump.