CC Operating Procedures

3740.214-EN-308

March 21, 1991

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7.0 CC CRYOSTAT

These procedures describe the operation of the cryostat on the platform. Refer to the cryogenic flow diagram, 3740-ME-222394, revision V for platform operations.

Paragraphs 7.1.0, 7.1.15-7.1.18, 7.1.24, 7.2.1 and 7.3.0 contain information necessary for the safe operation of this pressure vessel. Only subsequent changes or modifications of or related to these paragraphs which affect the safety of the vessel will be updated in the CC Cryostat Engineering Note and in DØ Note #3740.EN-263.

7.1.0 Inner Vessel Pump and Purge

The following assumes that the platform piping has been installed, leak checked, and pressure tested as required, the connections to the CC cryostat have been made, helium has been provided to the cold valve (PV219A), I/A (open MV1400I/1401I) and GN2 purge are connected and flowing to the platform, all valves have been stroked and are operational, EC cryostat and UV branches are properly capped or (welded) closed, and the cryocorner jumpers have been fabricated and tested, and are ready to install. Note that the u-tubes that connect the storage dewar to the cryostat must be removed at this time; the cryostat must be isolated from the LAr dewar when not in operation.

7.1.1 Install the cryocorner jumper lines in order according to their designations; 406V, 416E, 430LA, 424UV, 421GA, and 411LN, in strict accordance with 10.2 of the special procedures.

7.1.2 Start pumping down the CC insulating jacket according to 3.5. This operation is independent of the pressure vessel and may be performed in parallel with those that follow.

7.1.3 To Pump and Purge the Inner Vessel CLOSE:

Cryostat	— mv205A(test)	— PV214A
	— PV215UV	— mv217N
	— PV219A	— PV228A(vent)
	— MV241A(sample)	— MV243A(sample)
Pump room	— PV706V	— PV707UV
	— MV712UV(vent)	— EV714UV
	— MV727N	— MV722A

Note: the liquid sample valves, MV241A and MV243A, are closed to eliminate the long lines to the Cryocorner. Those lines must be separately pumped and purged at the Sample panel in the cryocorner before either of the sample

valves are opened or a sample attempted, see Appendix S for the LAr Sample Procedure .

7.1.4 To Pump and Purge the Inner Vessel OPEN:

Cryostat	— mv203A	— mv224A (outer)
	— MV244A	— mv245A
Cryocorner	— MV454UV	
Pump Room	— MV705UV	— mv728UV
	— mv729UV	— mv734UV

7.1.5 Backfill the UV manifold with GN_2 to 1 psi as read on PI716UV (PT717UV) by opening MV727N and EV714N. Close EV714N.

7.1.6 Vent any inner vessel positive pressure greater than 1 psi through PV215UV by opening the vent valve, MV712UV, and then closing it tightly. Note: PV215UV is interlocked CLOSED and will have to be temporarily overridden to release the pressure. Close PV215UV. Check MV712UV tightly closed before proceeding.

7.1.7 Start the utility roughing pump and begin pumping on the inner vessel by opening PV707UV to the manifold and PV215UV to the cryostat.

7.1.8 If there is an unacceptable cryostat vacuum due to bakeable outgassing components, the warm-up heaters may be used to bake out the detector according to the procedures in 10.5. UNDER NO CIRCUMSTANCES SHOULD THE HEATERS BE OPERATED AT ANY LEVEL WHILE THE CRYOSTAT IS UNDER VACUUM.

7.1.9 Continue pumping the pressure vessel until the pressure reaches at least 100μ as read on TG258A. This process may take several days to weeks for a tight system, depending on the cryostat pump history and the current rate of outgassing of the contents. Open all trapped (capped) volumes to the vessel while pumped down and until back filled. Do not include these volumes in any long term pumping or in ROR measurements, and be sure to leave them closed at the procedures end. Indicate completion of the opening of the trapped volumes; mv205A, MV241, and MV243. Please be careful not to inadvertently open any of the VPT charging valves; mv253, 254, or 255.

7.1.10 Isolate the UV pump from the header, close PV707UV.

7.1.11 Check the ROR of the inner vessel for one hour or a 50μ rise, and record the data in the logbook.

7.1.12 Check PI742N to ensure that the supply pressure from PRV725N is between 2 and 3 psig. Start backfilling the cryostat with GN_2 by opening EV714N.

7.1.13 Continue to fill the cryostat with nitrogen gas. When the pressure in the cryostat reaches 1 psig as read by PT717UV and checked with PI716UV, close MV727N.

7.1.14 Open PV707UV and pump the cryostat to at least 100 μ once again.

7.1.15 If the condenser outlet overflow switch, TS232E, has not been tested *in situ*, special permission should be obtained from the safety panel if necessary in order to flood the condenser with LN2 in an attempt to trip the temperature switch. If the switch has been tested *in situ* recently, continue to 7.1.20.

7.1.16 Once the necessary safety approval has been granted, install the LN2 dewar/cryostat jumper at the storage dewar and pump and purge the nitrogen transfer line as described in 7.2.3 through 7.2.7.

7.1.17 Ensure that PV513N is closed and MV535N, MV493N are closed and locked. Open or check open all valves from the N2 storage dewar through the condenser steady state cooling coil and into the condenser exhaust. Specifically, OPEN

— MV543N — MV477N — MV491N
— PV202N@100% — PV210N@100%

7.1.18 Open PV513N, cool down the transfer line and flood the condenser. The condenser outlet overflow switch, TS232E, should open when liquid flows past PV210N. If TS232E fails to open when there has been a reasonable amount of time allotted to flood the condenser, then the switch must be repaired and the "flood test" repeated until reasonable confidence is attained with this device.

7.1.19 When the testing is complete, close PV513N and allow the boil off in the transfer line and loops to vent out of the building. The remaining liquid may be flushed out by connecting the utility vacuum at MV535N and using 3 psig nitrogen gas.

7.1.20 Backfill with GN₂ a second time, following the same procedure described in 7.1.10-7.1.13. Close MV727N.

7.1.21 Open PV707UV and pump the inner vessel to at least 100 μ a third time prior to backfilling with GAR.

7.1.22 Open EV714N and pump out the small volume from the UV manifold to MV727N and MV722A to at least 150 μ , then close PV707UV. Check that the output of PRV818A is set and locked at 150 psig and the PRV822A is set between 2 and 3 psig.

7.1.23 Continue to backfill with argon gas until the pressure in the cryostat reaches 1.5 psig (compare PT204A and PT230A), and then close MV722A.

7.1.24 Open PV228A, disconnect the air supply from the solenoid, and mechanically secure the main relief vent manifold block valve in the OPEN position by switching the position of the rack stop (drg. no. 3740.512-MC-295020). Check to see that the PV228A position switch indicates open in the Expresslink graphic and is armed, but not "in alarm". Record all these actions in the log book.

7.1.25 Close PV215UV. Activate the interlock and, redundantly, "lock" PV215UV closed. Close MV454UV. Note that MV454UV redundantly closes downstream of PV215UV.

7.1.26 Pump down the UV manifold to 20μ to demonstrate the UV manifold isolation valve, MV454UV, is tight.

7.2.0 Transfer Line Pump and Purge

The following assumes that the necessary safety approval has been granted in order to allow the u-tubes which connect the storage dewars to the cryostats to be installed. All platform piping is assumed to have been pressure tested, leak checked, and UV and EC cryostat branches capped or (welded) closed. All building piping is assumed to have been pressure tested, leak checked, the alternate cryocorner connections and purge valves are closed and/or capped. and both helium and air supplies to pneumatic valves are fully functional.

7.2.1 Lock MV617A, the argon dewar relief selector 3-way valve, in the OPERATION (16 psi relief valve) position at the argon storage dewar. Note that this operation limits the pressure of the LAr dewar and insures the safe operation of the CC cryostat. Record this action in the logbook.

7.2.2 Using a portable vacuum pump with monitoring hardware, ensure that all insulating vacua of the following lines are 30μ or less:

- LN2 to cryostat withdrawal stub at N2 dewar
- LN2, N2 dewar to cryostat u-tube, 443LN
- LN2, N2 dewar to cryocorner manifold, 412LN, 4 vac. spaces
- LN2, cryocorner to platform u-tube, 411LN
- LN2 platform manifold, 409LN, 2 vac. spaces
- LAr withdrawal stub at Ar storage dewar
- LAr, Ar storage dewar to cryostat u-tube, 440LA
- LAr, Ar storage dewar to cryocorner, 427LA, 4 vac. spaces
- LAr, cryocorner to platform u-tube, 430LA,
- LAr platform manifold, 429LA
- GAr withdrawal stub at Ar storage dewar
- GAr, Ar storage dewar to cryostat u-tube, 441GA
- GAr, Ar storage dewar to cryocorner, 422GA, 4 vac. spaces
- GAr, cryocorner to platform u-tube, 421GA
- GAr platform manifold, 419GA, 2 vac. spaces
- GAr/GN2 platform manifold, 414E, 2 vac. spaces
- GAr/GN2 platform to cryocorner u-tube, 416E

_ GAr/GN2 cryocorner to outdoor manifold, 417E, 5 vac. spaces

(Note that each EC will have the insulating vacua of two articulating spool pieces for each LN₂, LAr, GAr, UV, IV, and exhaust line, and a separate vacuum space for two valve boxes. The installed EC female bayonets/connectors are closed with vacuum-insulated/PO-equipped males. Those insulating vacua and POs should be checked as well.)

Record all the data in the Cryo Logbook.

7.2.3 Install the jumper and line up the valves in the following order to pump and purge the liquid nitrogen piping. The pumped line here is between the LN2 dewar, PV513N, and the outlet of the cooling loops, PV210N. Install the jumper line 443LN in strict accordance with 10.2.

<u>GN₂ P&P</u>	<u>CLOSED</u>	<u>OPEN</u>
N2 dewar	- PV513N - mv559N (bypass) - mv535N	- MV543N - mv559N (shut-offs)
Cryocorner	- mv439N - mv481N (bypass) - mv485N (bypass) - MV493N	- MV477N - mv481N (shut-offs) - mv485N (shut-offs) - MV491N
Cryostat	- PV210N - mv217N - PV1403N	- PV201N - PV202N - mv216N - mv493N (capped)

7.2.4 Run the flex-line from the utility vacuum header to the pres/vac fitting at MV535N outside, near the LN2 dewar. Unlock and open MV535N and MV573UV and pump on the nitrogen piping from the N2 storage dewar (PV513N) to the cryostat condenser outlet valve, PV210N. Attain a minimum of 20 μ in order to eliminate the water. Tighten packings, flanges as necessary. If 20 μ can not be attained, close MV491N at the cryocorner and pump on the nitrogen piping upstream of MV491N to 20 μ . The piping downstream of MV491N may have to be flow purged because of small flow-through leaks in the cooling loop control valves.

7.2.5 Unlock and cycle the capped MV493N and pumpout the trapped volume.

7.2.6 After valving off the pump, measure the ROR, and record it in the log book. Then backfill with GN2 to 1 psig as read on PT717UV (and checked with PI716UV) through EV714UV by opening MV727N. Close MV727N.

7.2.7 Pump the line again to 20 μ and backfill to 1 psig, close and lock MV535N,

and MV493N, place a cap on pres/vac flange, and cap and secure the flex-line end.

7.2.8 Install the jumper and line up the valves in the following order to pump and purge the liquid argon piping. The pumped line here is between the LAr dewar, PV638A, and the cryostat cold valve, PV219A. Install the jumper line 440LA in strict accordance with 10.2.

<u>LAr P&P</u>	<u>CLOSED</u>	<u>OPEN</u>
Ar dewar	<ul style="list-style-type: none"> _ PV638A _ MV658A _ MV678UV _ mv667A (bypass) _ mv668A (bypass) 	<ul style="list-style-type: none"> _ MV660A _ MV661A (capped) _ mv667A (shut-offs) _ mv668A (shut-offs)
Cryocorner	<ul style="list-style-type: none"> _ mv437A (capped) 	<ul style="list-style-type: none"> _ MV476A
Cryostat/ Platform	<ul style="list-style-type: none"> _ PV219A _ mv237A (bypass) _ mv494A (capped) 	<ul style="list-style-type: none"> _ PV218A _ mv237A (shut-offs)

7.2.9 Run the flex-line from the utility vacuum header to the pres/vac fitting at MV658A in the argon dewar room. Unlock and open MV658A, and MV678UV and pump on the liquid argon piping from the Ar storage dewar (PV638A) to the cryostat argon cold valve, PV219A. Attain a minimum of 20 μ in order to eliminate the water. Tighten packings, flanges as necessary.

7.2.10 Unlock and cycle the capped valves, MV661A and MV494A on the LAr line, to pumpout the trapped volumes. Cycle MV643A (capped), mv667A(bypass), mv668A (bypass), and mv237A(bypass), as well.

7.2.11 After valving off the pump, test the ROR and record it in the log book. Backfill with GAr to 1 psig as read on PT717UV through EV714UV by opening MV722A. Close MV722A.

7.2.12 Pump the line to 20 μ again and backfill to 1 psig, lock closed MV658A, MV661A, and MV494A and place a cap on pres/vac flange and secure the flex-line.

7.2.13 Install the jumper and line up the valves in the following order to pump and purge the gaseous argon piping. Install the jumper line 441GA in strict accordance with 10.2.

<u>GAr P&P</u>	<u>CLOSED</u>	<u>OPEN</u>
Argon dewar	<ul style="list-style-type: none"> _ PV611A _ MV643A _ mv677A (bypass) 	<ul style="list-style-type: none"> _ MV646A (capped) _ MV648A _ mv677A (shut-offs)

Cryocorner	_ mv435A (capped)	_ MV474A
Cryostat/ Platform	_ PV214A	_ MV483A (capped)

7.2.14 Run the flex-line from the utility vacuum header, MV678UV, to the pres/vac fitting at MV643A in the argon dewar room. Unlock and open MV643A and pump on the gaseous argon piping from the Ar storage dewar (PV611A) to the GAR control valve, PV214A, at the cryostat by opening MV678UV. Attain a minimum of 20 μ in order to eliminate the water. Tighten packings, flanges as necessary.

7.2.15 Unlock and cycle the capped MV646A and mv483A to pumpout the trapped volumes.

7.2.16 Valve off the pump, measure a ROR, and record it in the log book. Backfill with GAR to 1 psig as read on PT717UV through EV714UV by opening MV722A. Close MV722A.

7.2.17 Pump the line again to 20 μ and argon backfill to 1 psig, lock closed MV643A, MV646A, and mv483A, place cap on pres/vac flange and secure the flex-line.

7.3.0 Cooldown

The following procedures assume that both sections 7.1, Inner Vessel Pump and Purge, and 7.2, Transfer Line Pump and Purge, have been successfully completed. Additionally: all the safety approvals necessary to bring cryogenics into the assembly building high bay have been granted, EF7 ventilation fan (4,500 cfm) is running and EF6 (13,000 cfm) is operational and in standby, all trough bellows/ducting is installed and sealed as appropriate, the ODH monitoring and warning system is fully commissioned, the nitrogen warming purge is connected and flowing into the vent line (open MV498N), the overflow switch (TS232E) is operational and interlocked to the condenser inlet valves, and the nitrogen dewar is at or near its maximum fill level of 14000 gallons.

7.3.1 At the nitrogen dewar check MV510N open and set the back pressure regulator, PRV530N, to vent the nitrogen dewar at 45 psig (60 psia) Turning the adjusting screw in, increases the set pressure. Raise the dewar pressure as required to make this adjustment. Put the LN2 dewar pressure build control loop, PV501N, in automatic at 40 psig (55 psia) The pressure build loop will normally be active during this period supplying the large amounts of nitrogen required by the cooldown of the CC Cryostat. Watch the dewar pressure, PT501N, to ensure that the proper operation of the pressure build circuit, and that the regulator venting and pressure build operations are mutually exclusive. The LN2 dewar pressure should not exceed 60 psia or fall below 55 psia.

7.3.2 Set the argon storage dewar condenser inlet controller, PIC612N, to a dewar pressure of 25 psia, and the condenser outlet controller, PIC615N, to maintain this loop pressure at 45 psia. Check MV610A and MV664A open to the pressure building coil and raise and set PIC601A to 20 psia. Watch the dewar pressure, PT653A, to ensure that the vaporizer circuit is functioning properly and that the condensing and vaporizing operations are mutually exclusive. The LAr dewar pressure should not exceed 25 psia or fall below 20 psia.

7.3.3 Confirm that the valve positions in 7.2.3, 7.2.8, and 7.2.13 have not changed with the following exceptions: CLOSE MV646A, MV661A, mv483A, and mv494A. Check and record that the inner line pumpout valves, MV535N, MV643A, and MV658A are closed and the adjacent pres/vac fittings are capped and securely locked. Set the manual valves on the nitrogen flow meter to the cryostats to their "cooldown" positions. The valve positions are now arranged to support the CC Cooldown.

7.3.4 Change PIC214A (makeup/vent) to MAKE-UP (reverse acting: no) mode, the clamped SP limit; low to 17 psia, and the clamped SP limit; high to 25 psia on the PLC loop page for cooldown. Set PIC214A in automatic at 20 psia. Set ML611A to 100% open, and check the pressures of the cryostat, PT230A, and the dewar, PT653A, to ensure that argon storage dewar gas is pressurizing the cryostat. As the cooldown proceeds and the temperatures fall, PV214A will open as necessary to provide the gas needed to keep the cryostat pressure approximately constant as the gas density increases.

7.3.5 Adjust the low clamped set points on PIC201 and 202N to 24 psia and PIC210N to 16 psia. This will help to avoid sub-atmospheric cryostat pressures and frozen argon on the fins of the condenser coils. Place both PIC201N and 202N in automatic and adjust their set points to 60 psia. The condenser inlets are now set to cool the gas within the cryostat without condensing it.

7.3.6 Open the LN2 dewar to the cryostat cooling loops by setting ML513N to 100%. Set PIC210N to automatically control the cryostat pressure at 18 psia. The transfer line is probably warm and it will take several minutes before liquid will enter the condenser. A decreasing pressure trend should be observed in the cryostat; recheck valves, pressures and line up if this is not the case.

7.3.7 Throughout the cooldown, the temperature gradients within the cryostat shall be closely watched and maintained within the limits summarized in table 1. In order to decrease the cooling, INCREASE the setpoint(s) of PIC210N, PIC201N and/or PIC202N. Some trial and error will be required to determine what the best combination of setpoints is for various phases of the cooldown. Conversely, if more cooling is required, DECREASE the setpoint(s) of PIC210N, PIC201N and/or PIC202N. Take additional care when the condenser pressure is set below 50 psia since condensation will occur on the cooling coil surfaces and large temperature gradients on the module skins will develop rapidly. Avoid subatmospheric pressures and pressures greater than 14 psig, the cryostat relief valve setting. Note that control of the cooldown rate is a constantly monitored function; the

concern is excessive temperature gradients due to a high cooldown rate, this rate can be slowed to zero nearly instantaneously. Alarms may be provided to aid in monitoring, but the cooldown must not be left to proceed unattended.

TABLE 1. Temperature Gradient Limits

<u>LOCATION</u>	<u>QUALIFIER</u>	<u>MAXIMUM DELTA T</u>	<u>REMARKS</u>
Intra-module	CH	100K	within a module
	FH	100K	within a module
	EM	50K	within a module
Module end plates	any two	100K	each type; CH, FH, EM,
	any adjacent	20K	each type; CH, FH, EM
Module-Beam	nearest Beam	25K	modulskin avg.nearest beam-beam avg.
Beam-Cryostat shell	nearest Beam	20K	shell avg. nearest beam-beam avg.

7.3.8 Activate the pressure, temperature, and level alarms and set up the historical trending of these cryostat parameters and the flow through the nitrogen line using the monitoring software.

7.3.9 Make daily checks of the delta p across the filters on the LN2 lines to the cryostat and storage dewar condensers, and most importantly, the filter on the GAR line to the cryostat and record the data in the log book. If the delta p exceeds 1 psid on the argon filters and 5 psid on the nitrogen filters, plans should be made to have the line isolated, warmed, and the filter element inspected and cleaned/replaced.

7.3.10 When the detector structural components reach an average temperature of 100K (10K above equilibrium temperature) and the temperature gradient limits of Table 1. can be maintained, the cryostat LAr is "fill ready".

7.4.0 Filling the Cryostat

This procedure assumes the cryostat is free of contaminants and cold, and must be preceded by section 7.2, Transfer Line Pump and Purge and 7.3, Cooldown, or, if recently disconnected and moved, by section 7.2, Transfer Line Pump and Purge. If there is any question of the tightness of the transfer lines it should be verified by repeating section 7.2.

The cryostat internal temperatures should be checked prior to LAr filling and the cryostat convection cooled, as necessary, before filling until the temperatures are below those specified as "fill ready" in 7.4.10.

There should be a minimum of 5200 gallons of LAr in the storage dewar that has been tested for purity according to section 6.0 just prior to filling the cryostat. If the

argon is deemed to be unacceptable, it will have to be pressure transferred back to a ground level trailer transport (see 5.5).

7.4.1 Valve positions and control settings to fill the cryostat are as follows:

<u>FILL LAr</u>	<u>CLOSED</u>	<u>OPEN</u>
N2 dewar	<ul style="list-style-type: none"> _ MV535N (capped) _ MV546N (capped) 	<ul style="list-style-type: none"> _ PIC501N@45 psia _ PV513N _ PRV530N@50 psia _ MV543N _ MV544N _ PV548N
Ar dewar	<ul style="list-style-type: none"> _ PV625A _ MV638A _ MV646A (capped) _ MV658A (capped) _ MV661A (capped) _ MV663A (capped) _ MV683N 	<ul style="list-style-type: none"> _ PIC601A@20 psia _ PV611A _ PIC612N@25 psia _ PIC615N@45 psia _ MV648A _ MV686N, 694N (SS pos.)

Ensure that MV617A is locked open to the low pressure relief side (PSV620A, RD621A)

Cryocorner	<ul style="list-style-type: none"> _ mv435A (capped) _ mv437A (capped) _ mv439A (capped) _ MV483A (capped) _ MV493A (capped) _ MV494A (capped) 	<ul style="list-style-type: none"> _ MV474A _ MV476A _ MV477N _ EV480N, 487N (CD pos.) _ MV491N
Platform/ Cryostat	<ul style="list-style-type: none"> _ PV201N _ PV219A 	<ul style="list-style-type: none"> _ PIC202N@60 psia _ PIC210N@18 psia

OPEN

- _ PIC214A@20 psia
- _ PV218A

7.4.2 Set the cooling loops, PIC201N to 40 psia in automatic. Set the cryostat pressure controller, PIC210N, to 18 psia in automatic. This will enable the heat exchanger to condense LAr at a pressure slightly above atmospheric - OPERATION BELOW THIS POINT MAY LEAD TO A NEGATIVE PRESSURE DIFFERENTIAL AND ARGON CONTAMINATION. Flow through the condenser is automatically governed by the pressure in the cryostat.

7.4.3 Increase the set points of PIC612N, dewar condenser inlet valve controller, to 29 psia and PIC601A, the vaporizer controller, to 28 psia. The set point of PSV620A is approximately 30.5 psia. Check that the vaporizer and condenser are not running concurrently, and that the relief is not weeping. The pressure differential should be sufficient to fill the cryostat one half full at a reasonable rate. When initially filling the cryostat the modules (avg. temp. approx. 100) heat capacity will limit the transfer rate to that determined by the condenser capacity.

7.4.4 Place PIC214A in the MAKE-UP (reverse acting: no) mode and set the controller to make-up gas at 17 psia; this will protect the cryostat from experiencing a subatmospheric pressure by flowing gas from the dewar if the pressure decreases below 17 psia. Verify that the SP limits, high and low, of 7.3.4, 7.3.5, 7.3.6, and 7.3.7 are in place on the respective loop pages before proceeding.

7.4.5 Open the cold valve, PV219A, and open the LAr dewar outlet valve, PV638A, initially to 5% and increase the opening SLOWLY while observing the cryostat pressure from PT230A is being maintained at its setpoint. Make adjustments to the PID loops if necessary. The cryostat pressure should increase rapidly at first due to the surge of warm gas resulting from the warm transfer line.

7.4.6 As liquid starts to accumulate in the cryostat, the level can be read from the fill level LEDs, EI250A, and level transmitter, DPT222A, that are monitored and recorded by the PLC. Record LED voltages every hour or so in the Cryo Logbook throughout the duration of the fill. Vapor pressure can be read using PT233A (upper), PT234A (lower) and PT240A (middle). The relative fill rate and an estimate of the instantaneous value can be obtained from the flow meter FM671A at the argon storage dewar.

7.4.7 If the cryostat was recently drained (still very cold) the cryostat will initially fill at a relatively rapid rate. The fill rate will slow as the liquid level rises due to the decrease in transfer pressure caused by the static head in the cryostat. The filling rate can be slowed by decreasing the setting of LAr dewar pressure, PIC601A, or for more immediate results, close down on LAr dewar outlet, PV638A.

7.4.8 After the liquid level reaches the half way point, the liquid flow from the storage dewar will seriously slow or stop due to the loss of a sufficient transfer pressure between the storage dewar and cryostat. At this point, close PV219A and then close PV218A after 15 minutes. The rest of the liquid will have to be condensed into the cryostat.

7.4.9 Set the cooling loops,, PIC201N and PIC202N, to control a 26 psia in the automatic mode. Increase the PIC210N setting to 20 psia.

7.4.10 Ensure that PIC214A is still in the direct acting mode and set it in auto to supply the cryostat to a pressure of 22 psia. The dewar is now supplying gas to the cryostat where it is being condensed by the steady state coils to build liquid level.

7.4.11 During this final phase of the fill, close PV214A and tune the PID loops for PI201N, PI202N, and PI210N if necessary to minimize the pressure fluctuations in the cryostat. As the ullage volume in the cryostat decreases, the effects of this loop will be increasingly faster.

7.4.12 As the level approaches its final operational height, between the 8th and 12th LEDs (one inch above the top of the CH endplate) on the top level probe or 9.33 psid on DPT222A, compare the argon liquid temperatures as read from the VPTs, with the saturated temperature associated with the cryostat operating pressure (90.3 K @ 20 psia). This will should indicate the direction and magnitude of the volumetric changes toward the steady state, i.e. indicate whether the liquid will shrink or swell after filling.

7.4.13 Stop condensing at a level either slightly above or below the final operating height depending on the temperature of the liquid. A final level adjustment may have to be made to compensate for the shrinking/swelling of the liquid. Condense into the cryostat or vent gas to the storage dewar until the temperature equilibrium operating level is achieved.

7.4.14 Record the cryostat vapor pressure temperatures and final level in the Cryo Logbook.

7.5.0 Steady State Operations

7.5.1 In steady state operation, the argon storage dewar will be prepared to accept gaseous argon from the cryostat should the need arise. Reduce the settings of the dewar vaporizer, PIC601A, to 15.5 psia, the dewar pressure, PIC612N, to 17 psia, and the condenser pressure, PIC615N, to 44 psia. Change PIC214A to the VENT (reverse acting) mode (increasing cryostat pressure increases the valve opening) on the PLC, and set it to vent the CC cryostat to the storage dewar at 22 psia in automatic.

7.5.2 PIC210N should be controlling the cryostat pressure at 20 psia and PIC202N/PIC202N controlling the condenser pressure at 26 psia. Adjustments to the condenser pressure change the LN₂-LAr temperature difference and the wetted area directly.

7.5.3 The level in the cryostat should continue to be carefully watched immediately after being filled. Relatively small changes in fluid temperature toward the steady state value will measurably change the level. Make level adjustments as required after an equilibrium is clearly demonstrated. Activate low liquid level alarm as indicated by the operating level probe.

7.5.4 Less flashing of the liquid nitrogen across the inlet valve, PV202N, will occur if the liquid nitrogen storage dewar pressure is reduced. Set the nitrogen dewar vaporizer pressure, PIC501N, to 40 psia and adjust PRV530N to vent the dewar pressure at 45 psia.

7.5.5 At the cryocorner, close MV477N and switch the positions of manual shutoff valves to FM478N and 479N to the OPERATE mode. The nitrogen flow meter, FM479N, is now in its lower range to monitor the steady state, operate, flow.

7.5.6 Check PS471N, the GN₂ purge manifold pressure switch, to confirm that the nitrogen warming purge is flowing through the restricting orifice to the vent line.

7.5.7 The nitrogen manifold subcooling valve, PV1403N, position should be adjusted to 60% open in manual to assure a subcooled source to cooling loop inlet valves.

7.5.8 The argon in the cryostat should be checked periodically for purity as in 6.0.

7.6.0 Emptying and Warming the Cryostat

7.6.1 Maintain the same original steady state PIC settings as in 7.5.1 and 7.5.2, i.e.;

<u>Controller</u>	<u>PV</u>	<u>SP</u>
PIC612N	LAr dewar pressure	17 psia
PIC615N	LAr dewar condenser pressure	44 psia
PIC214N	Cryostat GAr vent	22 psia
PIC202N/202N	Cryostat condenser pressure	26 psia
PIC210N	Cryostat pressure	20 psia

7.6.2 Check that the valves in the cryostat fill/drain line are in the following positions:

Draining LAR

OPEN:

- _ mv203A
- _ MV476A

CLOSE:

- _ PV214A
- _ PV219A
- _ mv437A (capped)
- _ MV494A (capped)
- _ MV638A
- _ MV658A (capped)
- _ MV660A
- _ MV661A (capped)

7.6.3 Check that the LAr dewar pressure is 17 psia, the cryostat pressure is 20 psia, and open MV638A and MV660A to connect the LAr dewar to the outlet of PV218A. Open the cold valve, PV219A, and then open PV218A in 5% increments; gradually increase the opening as the storage dewar condenser demonstrates it can maintain a pressure less than 25 psia. Note that the liquid head 0.6 psi/ft, or about 10 psi, provides all the initial transfer pressure difference required. The current PIC615N (condenser pressure controller) setting ensures that the pressure

in the storage dewar will not drop below one atmosphere.

7.6.4 Check the LAr dewar gas phase valve, PV611A, open, and change the PLC, if necessary, to assure that PIC214A is in the VENT (reverse acting) mode. Set the pressure on PIC214A to 17 psia. This will put the cryostat and dewar at approximately the pressure, leaving the head (about 10 psi) as the transfer pressure difference. Set the cryostat pressure controller, PIC202N to 25 psia to allow higher pressure cryostat operation as the cryostat empties.

7.6.5 The LAr drain flow rate can be obtained from FM671A on the PLC. The flow rate will be relatively large at first and decrease as the static head in the cryostat decreases. Flow can be increased by raising the VENT pressure set point of PIC214A to compensate for the loss of head. Flow can be decreased at anytime by reducing the opening of PV638A.

7.6.6 Since the bottom of the cryostat is only 14 in. above the centerline of the dewar, it will be necessary to make adjustments to maintain a transfer pressure difference. The normal heat leak is just about that required to maintain the cryostat pressure as it empties. If it is necessary, or significantly faster, the heaters at the bottom of the cryostat can be energized to pressure transfer the remaining liquid. Heater operation is described in 10.5. If the incipient heat leak is sufficient proceed to 7.6.9.

7.6.7 Set PIC214A to 25 psia. Set EH220A power to zero and turn on. SLOWLY increase power until the pressure in the cryostat is maintained at a constant level below 25 psia, the condenser controlling pressure.

7.6.8 When the cryostat is empty (cryostat and LAr dewar pressure difference disappears, flow drops to zero), close PV219A and maintain the cryostat pressure with PIC214A set to vent at 20 psia. Secure the cooling loop flow, close PV513N.

7.6.9 If the cryostat is to be moved to the collision hall at this point, then proceed to chapter, 10.3, Moving the Platform.

7.6.10 If the cryostat and contents are to be warmed, continue to follow the rest of the procedures in this section. Heater operating procedures are found in 10.5.

7.6.11 Follow all required safety guidelines related to the use of 208/480VAC power. Increase EH220A power to about 10 kW in small steps. The temperature gradients limits of 7.3.7, Table 1. must be observed just as they were on cooldown. A more liberal temperature gradient table is possible, but not available at this writing. The gas generated in the warming process, about 1300 scft, will be driven toward the storage dewar and condensed at 17 psia.

7.6.12 Temperatures within the cryostat MUST be continually monitored while making adjustments to the heater power. The anticipated limiting concerns are the skin temperatures just above the heater locations, see dwg. # (the development drawing), and the beam-cryostat shell delta T. Under no circumstances should the

warm up proceed unmonitored.

7.6.13 The diffusion pump may be secured by closing the inlet valve, PV225V, and securing power to the DP heater. After 30 minutes, close PV221V.

7.6.14 When the average temperature of the modules in the cryostat reaches the temperature specification, the heater EH220A is secured according to 10.5.