D Zero Collider Detector

CC Cooldown/Fill, An Overview

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Getting Ready

The cooldown will be immediately preceded by two trial pump downs; the insulating vacuum and the detector volume. The insulating vacuum must be established to a level below 10^{-4} MM Hg to minimize the conduction heat load. The detector, aka cryostat, vacuum pump down must be able to reproduce the ultimate and rate-of-rise (ROR) values demonstrated in the clean room. It is anticipated, barring newly generated problems, it will take a few days to accomplish both of these tasks once the construction is complete, even though there has been incidental scavenger vacuum pumping . When the leak detectors are put away, the real Pump and Purge (P&P) begins.

Pump and Purge the Cryostat

Since the worst detector dry contaminant is oxygen, the P&P will minimize that background constituent, in particular. The cryostat, one atmosphere air assumed, will be pumped to P_{min} and back filled with gaseous nitrogen to one atmosphere, twice. This reduces the oxygen background from 20.7% (207,000 ppm) to $(P_{min}/1 \text{ Atmos})^2$ (207,000 ppm), neglecting oxygen outgassing. For a pump down to P_{min} = 100 microns, that's 0.0036 ppm oxygen taken literally. As a practical matter we will take this to be < 1 ppm at room temperature and one atmosphere (ambient T and P or ATP). Each pumpdown will be followed by a ROR to 200 microns or for one hour, whichever comes first. The cryostat will be declared tight, dry, and ready for GAr when the ROR < 100 microns/hour and the Residual Gas Analyzer (RGA) demonstrates the major background is other than 80:20 air components (an air leak) and water (the major clean room background was hydrogen). Reference should be made to the final RGA taken in the clean room.

Pumping the cryostat once again to P_{min} = 100 microns and back filling with gaseous argon of ca. 1 ppm oxygen displaces the nitrogen to (P_{min}/1 atmos) ppm = 131 ppm at ATP and leaves the oxygen unchanged at 1 ppm at ATP. Cooling down to 90K and filling with argon of 0.0 ppm oxygen and nitrogen will reduce these values by ca. the ratio of the ATP density of argon to its 1.3 atmosphere saturated liquid density, or 2.133/1378 = 0.00155. It should be clear that the P&P described will not measurably contribute to the expected contamination of the purchased liquid argon (expectation values; 0.3-0.7 ppm oxygen, <1 ppm nitrogen).

Building LAr Inventory

If the CC cryostat holds 5,000 gls (calculated by Kroon to be 5,200 gls, est.) it will take two, full, 4,000 gls. LAr tankers (largest possible because of the 80,000 lb. over the road limit) to fill it. If filling is to be a direct and continuous operation, the 5,200 gls., plus a margin and a residual for the storage dewar (2,000 gls. minimum), should be on hand before a filling of the cryostat is attempted. The GAr purge gas will be separately provided by HP bottles as a matter of operational convenience.

Cooldown

Once the vacua are established at the necessary ultimates and the ROR's are acceptable, the LAr inventory delivered and verified as detector quality, and the Oxygen Deficiency Hazard (ODH) equipment and system controls are commissioned and tested, the cooldown can begin in earnest. LN_2 coolant temperature (loop pressure) will be controlled in automatic mode, and the flows adjusted in "clamped low SP" limit mode, to 1) cooldown without condensing liquid on the modules, 2) set an upper pressure limit of 24 psia, 3) set a lowest pressure possible to guard against subatmospheric operation, while 4) providing a “manual” means to control the cooldown flow. Gas is automatically made-up to the cryostat at ca. 20 psia by the gas make-up valve from the gas space above the liquid in the LAr dewar. The *operating* loop will be set to control the maximum cryostat pressure at 24 psia, and the *cooldown* loop (special low gain chosen) will be set to control the cryostat pressure at <20 psia. The net effect will be to add gas at cryostat pressures below 20 psia as required by the cooldown, cool and maintain the gas inventory at a cryostat pressure of 24 psia in the absence of *cooldown* loop flow, and cool with the *cooldown* loop. Both cooling loops are clamped at a lower set point (SP) of 18 psia. The cooldown and fill will be conducted in strict accordance with the *Operating Procedures,* and constantly guided and monitored by operators to guard against computer failure modes that might lead to exceeding the temperature gradient limitations.

TABLE 1. Temperature Gradient Limits[1]

LOCATION	QUALIFIER	MAXIMUM DELTA T	REMARKS
Intra-module	CH	100K	within a module
	FH	100K	within a module
	EM	50K[2]	within a module
Module end pls	any two	100K	each type; CH, FH, EM,
	any adjacent	20K	each type; CH, FH, EM
Module-Beam	nearest Beam	25K	module skin avg. nearest beam-beam avg.
Beam-Cryostat shell	nearest Beam	20K	shell avg. nearest beam-beam avg.

The cooldown operation is considered complete and the cryostat ready to fill when the average temperature of the structural components is < or = 140K[3] . The cooldown to 140K can take as little as two weeks, dependent on the final disposition of the cooldown temperature gradient maxima specified. The current temperature gradient limits are from Table 1. in the *CC Cryostat Operating Procedures.*

[1] See D0 Engineering Note 273.

[2] As increased 1/30/91 by CC designers from the original 30K.

[3] Note that the filling operation is still subject to the Limits of Table 1.

Filling is a two step process; 1) liquid is drawn into the cryostat by condensing the gas vaporized as the liquid contacts > 90K detector parts until ca. 2/3 full, and 2) the last 1/3 is condensed into the cryostat to address the changing liquid head and the liquid level-cooling loop interface. There is no plan to partially fill, empty, and open and inspect the in-line filter during filling.

If it is deemed important to test the liquid in the cryostat while filling, that should be done only if assurance can be provided the testing will not be a source of a contamination. If the "good" LAr fails to meet the minimum detector specification[4] as a result of transfer to the cryostat, the fill should continue to completion for the following reasons; 1) if the cryostat has something poisoning the LAr there is no reason to believe it exists only below the equator; and the upper reaches should be "washed" with LAr as well, 2) we certainly can use some experience in filling this vessel with the large head and the condensing to top it off, and 3) it would put us well ahead to establish a pressure control capability below operating level and to approach the correct operating level slowly. All of that might take two or three days, but it makes good use of the unique opportunity to test major features of the cryogenic system.

If the LAr detector qualities are deemed unacceptable, it is pressure transferred to the storage dewar in one large batch transfer, the necessary U-tube disconnections made to isolate the cryostat, the dewar's relief switched to 65 psig and the load pressure transferred to the surface to the vendor's 4,000 gls. liquid trailer in two batch transfers (one/day), and then a clean up and refill begun immediately. It will take one week, or more, to exchange the LAr and be in a position to refill. If warming of the cryostat for vacuum pumping is required, the turn around period is estimated as a month or more. There are no provisions for purification of the LAr at the D0 Assembly Building (DAB), exchange is the only current option.

When the CC Cryostat must be moved as the platform is moved to accommodate the movement of the EC from the clean room to the north

[4] For current definition see J. Blazey or P. Mooney.

sidewalk, the LAr will be drained to the LAr storage dewar and the lines pumped and purged, and the jumpers, trough connection, and control cables pulled. When the platform is returned to its assembly hall location the jumpers, trough connection, and control cables will be reinstalled, the lines pumped and purged, the insulating vacuum reestablished, and the cold cryostat refilled. If the ROR of the insulating vacuum is sufficiently small or the volume pumped by auxiliary means when undocked, there should be no need to cooldown the detector before refilling (see Temperature Gradient Limits). The current, nominal, time estimate for these operations are;

DRAIN and REFILL estimates [5].

Operation	Drain	Refill	
A. Drain	two shifts		
B. P&P&P	one shift		
C. I&P&P		two shifts	
D. Fill		five shifts	
Totals	3 shifts	7 shifts	
Grand			10 shifts

Note that the CC must be emptied of liquid, but need not be warmed, to tie-in the ECN cryostat piping because of venting requirements. All the manifolds of the CC cryostat must be opened and extended to serve the ECN. The cryogenic manifold piping for the ECS is in place. Both EC's require that the manifolds be opened for rotary bayonet fit and installation.

Specific Hazard Provisions; Oxygen Deficiency Hazard

The DAB, South side, ODH system (ventilation and monitoring), that provides the coverage necessary for operation of the el. 707', 20,000 gls., LAr dewar, has been installed and operating successfully for a year.

[5] Assumes the detector does not need to be cooled down.

The platform ODH detection and warning system is the first of two major safety systems installed, tested and commissioned in preparation for the flow of cryogens to the CC cryostat. It includes strategically placed ODH heads, strobes, horns and warning signs throughout the platform and adjacent areas. The ODH classification for the platform area will be "zero" (no hazard) due to the sound engineering which has minimized the probability of significant oxygen displacing leaks, the ventilation provided by the small circulation fans within the platform, and the large building blowers which are routed to nearby supply and return ducts[6] ; this is the platform working area ventilation system.

The second major safety system consists of the cryostat's large LN_2 and LAr fluid spill containment ductwork, large spill monitors, and associated forced ventilation. The containment ductwork begins with a sheet metal reservoir enclosing the cryogenic and gas piping at the top of the cryostat which communicates to the inner carriage volume of the vessel by means of sealed sheet metal channels on the east and west sides that utilize the vessel wall and its stiffening rings. A large duct ties the carriage volume to one end of two large flexible hoses routed to a 2 ft. dia. pipe. This pipe runs under the sidewalk area and is pitched down to the cryogenic sump. A continuous 4,500 cfm and 13,000 cfm backup blower, each tied into the building emergency power source, draw air and any gaseous vapor from the top of the cryostat through the sump pit and safely out of the building. A large liquid spill, due to its own weight, flows naturally into the sump pit and will be sensed either by strategically placed temperature sensors in the trough and sump, or by flow switches placed in both the liquid argon and nitrogen transfer lines which feed the cryostat. If a spill is sensed, the large blower will be energized and start flowing, and the smaller unit will deenergize[7] .

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[6] See D0 Engineeing Notes 229, 258.

[7] See D0 Engineeing Notes 50, 136.