SLD Trip Report

G. T. Mulholland
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Summary

The author visited the facility to gain an insight in the experience of the LAr filling of the SLD Barrel and North End Cap, and the cooldown of the South End Cap.

Visited were Bob Bell, Rafe Schindler, Art Candia, Gary _____, Dick Dodge, Ron Rinta, and Bob Watt on the subjects of the pump and purge, cooldown, filling experiences, the difficulties involved, lessons learned, and etc.. I brought back a summary and full flow schematics, a large number of 35 mm photographs, and a select set of SLD file photographs.

Preparations, Early Results

Cryogenic commissioning began mid-September, '89, and continued to Cooldown, January 3, 1990. Cryogenic commissioning followed the construction and installation of the piping. The checkout was serial and problems found "as we were going along". There was a clear message to work in parallel and certify subsystems in advance of their need. Typical problems were VJ line external bellows and ball valves that were not He leak tight.

The early preparations concentrated on the relief (singular) of the LAr 100,000 l dewar (sound familiar?). About one month was lost to the refurbishing of valves. After commissioning the dewar they accepted four LAr transfers for a total of 15,000 gallons, each in the range of 0.4-0.6 ppm O₂ measurement with equipment accurate to ± 0.1 ppm. As I watched, tests were concluding that qualified the Barrel calorimeter as having LAr with 0.6 $\pm$ 0.1 ppm O₂ to the delight of those making the measurement. There was real satisfaction in the recent HV measurement that only 55 of 40,000 channels had shorts. The ratio is essentially that predicted from the early module testing experience and another reason to celebrate.

Twelve of the twenty-four Barrel feedthroughs flanges (one end, total is forty-eight) had been fitted with Pre-Amps and that installation seemed to be going very well. There are hermetic feedthroughs at the PV wall, a length of manganin wire in the vacuum space to a warm hermetic feedthrough flange that is double "O" ring sealed in the vacuum vessel closure plate. The Pre-Amps mount directly to the atmospheric side of these feedthrough flanges

The instrumentation is "Bare Bones". There was a need for flow meters when concerns for cooling loop flows arose and it would have been very helpful to be able to measure the flow in the Argon fill lines. The inside-the-LAC vessel instrumentation (RTD's and TC's) was sparse and had no redundancy. They would have provided more instrumentation and/or redundancy knowing what they know now.

I asked questions designed to determine the time and effort necessary to pump the cryostat free of, especially, water. There didn't seem to be a clear answer to the question with the explanation that there was lots of pumping in support of the leak checking and the water was pumped along the way. I take that to mean that water was not a particular problem or a deterrent to the leak checking.

Cleaning

Modules were cleaned by procedures not known in detail by those I remembered to ask. I was referred to Bob Bell for details of what was thought to be steam cleaning, but was unable to verify. The modules were assembled in the High Bay pit (no clean room) and the provisions are most nearly described as dust cloth protected, i.e. the assembled lead plate modules were covered with plastic immediately after assembly. There was no attempt to control the atmosphere, i.e. no dry gas purge, etc.. The technicians wore cotton coveralls, changed them daily, and they had a dressing room. The modules were no more than locally alcohol wiped at installation. The VJ piping was purchased (along with the fabrication cleaning) and assembled at SLAC. There was no flow cleaning of the assembled piping.

The LAr storage dewar was cleaned at SLAC. It was steam cleaned and wiped down by a contractor. Although it was planned to alcohol wipe down the shell, that was not done in response to asphyxiation and flammability concerns for the workmen..

The cooling method is unusual. The cryostat gas is pumped and purged to GHe to improve the thermal conductivity. The GHe is pumped out and replaced with GAr when the cryostat cold and is ready to be filled. LN₂ is allowed to fill the parallel loops (attached by skip welding directly to the vacuum side of the PV shell) by pushing with a large delta P until there is liquid at the outlet. The inlet is then closed and the liquid in the loops allowed to boil away. The process is then repeated. The experimentally determined process cycle time was 1/2 hr initially and 1 hr when cold. The process grows from a concern for large gradients in the shell and the modules if continuous liquid flows are attempted (the entry, the bottom, gets cold first) .

Warmup, Repair

The (March) failure of the Barrel gaseous vent line to the vacuum space when venting cold He gas (a cold temperature precipitated leak) led to the need to warm for repairs. After learning that the heaters had voltage problems at a half atmosphere of GAr, the vacuum space was flushed with GN₂. The heaters then functioned properly and the vessel warmed at a rate of ca. 12-15K/day. This is the temperature direction in which the module thermal interferences are decidedly negative and the module rate limitations essentially removed, i.e. they could have gone even faster.

The repair that was effected was not totally satisfactory experience in the view of some. The section of the line removed could not be found to leak. It was replaced and a pipe bias that caused a cold spot was corrected. A Conflat at the PV end was tightened by "one point of a twelve point socket on two or three bolts". When the vacuum jacketing was reassembled about the problem piping it was tight. Note that the piping cut out and replaced, and both sides of the Conoflat were stainless steel. Aluminum seems to have played no part in the leak.

Note that the Al-SS transition joints are universally provided by making orthogonal connections to bonded plate. There are no axially symmetric, manufacturer supplied, transition joints.

Everyone seemed pleased with the 75kW heater warmup system once the glow discharge in GAr was understood and corrected.

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There is a welded in-line, nonremovable, flow strainer (> 50 microns) located at the LAr dewar, and no other filters or strainers of any kind located anywhere else in the system. No one I could reach on Friday could verify the actual strainer size. I will contact Frank Barrera for that answer.

Cooldown, Fill

Globally the Barrel cooldown began on January 3 and was cold at the end of February. Of those, 10 or so days were associated with the moving of the Cryobridge (a way to get the cryogens from the pit wall to the detector). The claimed average cooldown rate was 5-6K/day. Cooling loop drive pressure was a problem; the 100,000 l LN₂ dewar has a maximum operating pressure of 35-40 psig, but the operation (see cooling method below) of the loops require a source pressure of 45 psig. The problem was addressed by reducing the pressure of the small, on detector, 570 l LN₂ dewar, and filling it from the large dewar, pressurizing the small dewar, supplying cooling for 1/2 to 1 hrs from the smaller vessel, and repeating the cycle.

The cooldown rate is limited by a $\Delta T < 50K$ specification. The instrumentation (thermocouples and RTD's) provided on the modules (i.e the lead) failed one in two in a nonuniform distribution, but the shell temperature instrumentation functioned properly (lost a few in one hundred). Although the original plan was to fill when all points were within 50K of liquid temperature, delays for reasons of final safety approval for filling allowed a number of additional days of cooling and the actual filling was made at ca. 90K.

The filling went slowly and took two to three days. There were the usual problems; a soft VJ line here and there, getting lines cold, and etc.. The low transfer rates were thought to be associated with the 1" pipe and flexible line liquid lengths between (especially) the head tank and the cryostat. The much longer line (ca. 150') from the LAr dewar is 2" pipe. My notes say typical pressure differences were 6 to 15 psi.

The characteristic module temperature differences measured were 10-15 degrees from top to bottom. There were places where the temperature differences were "a lot worse". I realize that needs clarification, I'll seek it.

Cooling Method

The program lost fully one month to this failure, the warmup the repair, and the cooldown to the starting temperature.

Moving to the Collision Hall

Movement to the collision hall requires disassembly of the rigid Cryobridge (the pit wall to detector traverse) and reassembly in the collision hall. Since both the cooling and venting services are broken, the LAr is returned to LAr storage dewar to accommodate the move, and then replaced to the "reconnected" system in the collision hall. Note that to move the liquid from the cryostats requires evaporation of the liquid in the cryostat and recondensation of the GAr in the LAr dewar. That takes about 280 hrs (11.7 days) at 10,000 gls transferred and a 50kW condensation rate.

Vacuum Failure Testing

The Warmup for repair was exploited to test the rate of temperature drop of the vacuum shell on vacuum failure. There is great concern for the failure of the "O" rings of the 48 double sealed feedthrough flanges by depressed temperature. A vacuum failure could precipitate an irreversible "O" ring failure(s). The Barrel vent rate required under the vacuum failure circumstance is factors larger than that for the Fermilab CC because of much larger surface area. The data taken showed that the shell temperature fell as fast 10-15 K/hr. This would endanger the main vacuum vessel "O" ring, and might negatively impact (condense) the TAME in the central detector. Concern was expressed for the containment of the TAME when cold.

A special Argon boiler (dump tank) removes the vessel liquid to the vent at a 30 kW rate, because the 25 psig Cryostat upper relief pressure precludes pressure transferring the liquid directly to the ground level LAr dewar.

The cryostat main vacuum system pumps are Leybold Heraeus turbomolecular. They exhibited no reliability at all when first installed in the grease packed bearing version. LH, at their warranty expense, reworked the pumps to oil lubricated bearings and the performance has been satis-

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factory since.

Friday the Thirteenth

In the afternoon of my visit the South End Cap main vacuum broke to atmosphere. The cooling loop source and outlet valves were closed and the pressure in the loop went negative as the main vacuum was pumped. There appeared to be a large break somewhere in the cooling loop circuit to the vacuum space. The incident made all of my hosts very busy. I recognized the need for this visitor to politely leave and I did. I will wait till Tuesday or Wednesday before inquiring about this potentially serious misfortune. Note that all the loop arrangements have the same basic design. Unless associated with a detail peculiar to the South End Cap, there might be reason for a fundamental concern.

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