SLAC–PUB–4982
June 1989
(E)

SIGNAL FEEDTHROUGHS AND CRYOGENIC SYSTEMS*

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ABSTRACT

A description of the cryogenic system for a large liquid argon calorimeter is presented. Possible designs for high density signal feedthroughs are evaluated.

Contributed to the SSC Workshop on Calorimetry for the Superconducting Super Collider, Tuscaloosa, Alabama, March 13–17, 1989.

*Work supported by U. S. Department of Energy contract DE–AC03–76SF00515.

1. FEEDTHROUGHS

The barrel module has 320,000 channels which must be brought to the outside (unless multiplexing is used), and each channel has two signal wires and one ground wire. A conservative estimate shows the cross section area of the copper in these wires to be 300 sq cm in total. If we take these wires from argon to room temperature in 200 cm of length, the total heat load ($K = 4.5$ W/cm, °K) will be 2700 W. Each of the 80 leadout pipes would have 34 W.

Thirty-four watts will boil ≈ 0.7 liters of liquid each hour; that will produce ≈ 100 liters of cold gas. Unless some effort is made to reduce this heat load by area reduction or the use of ni-cu wire (alloy 180), as done by SLD, the following devices will need to be considered.

1.1. Wire Diagram (I)

The leads to be brought from the argon to vacuum (see Fig. 1) through some, as yet unknown, seal system and then—after a distance of ≈ 2 m—taken through a warm seal system to the outside. This device has a heat leak of 34 W and produces hundreds of liters of gas each hour at the argon end. A horizontal barrier in the top of the feedthrough pipe in the argon will be needed to force the gas up the boil-off pipe to be recondensed and returned to the barrel. The total amount of liquid recirculating would be about 55 liters an hour.

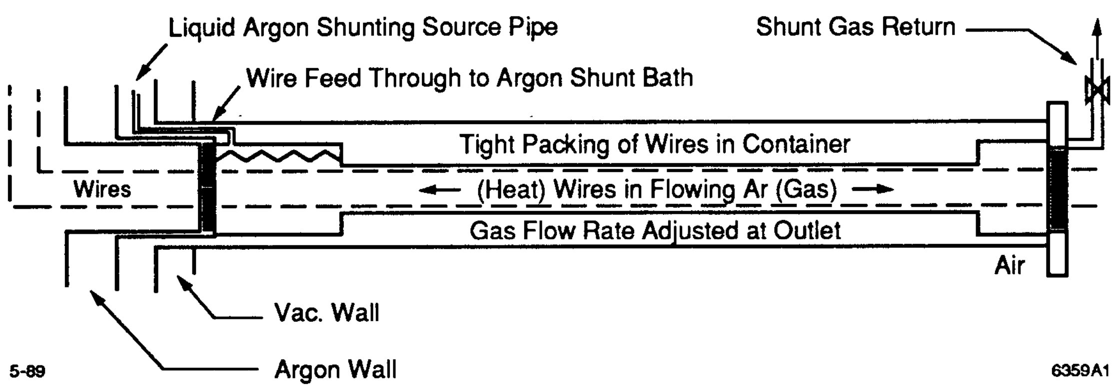

Fig. 1. Wire feedthrough with gas-shunted heat leak exchanger. Argon is used for shunting liquid. About 15 to 30 W gives one-quarter liter per hour using sensible heat. Advantages: (1) argon leaks to argon if the seal leaks and (2) nothing leaks to vacuum. A big seal leak provides argon for the shunt.

1.2. Wire Diagram (II)

In this device (see Fig. 2) the cold seal brings the wires into a region which consists first of a liquid nitrogen bath and then a tightly-packed counter flow heat exchanger to room temperature. A valve at room temperature regulates the N2 gas flow to remove all of the heat so that none gets to the argon. This is similar to a power lead for super-conducting magnets, and will work. The cold seal could leak and allow N2 into the argon, and that is bad. However, that same cold seal leaking in Item 1.1 would have stopped the experiment for a long time.

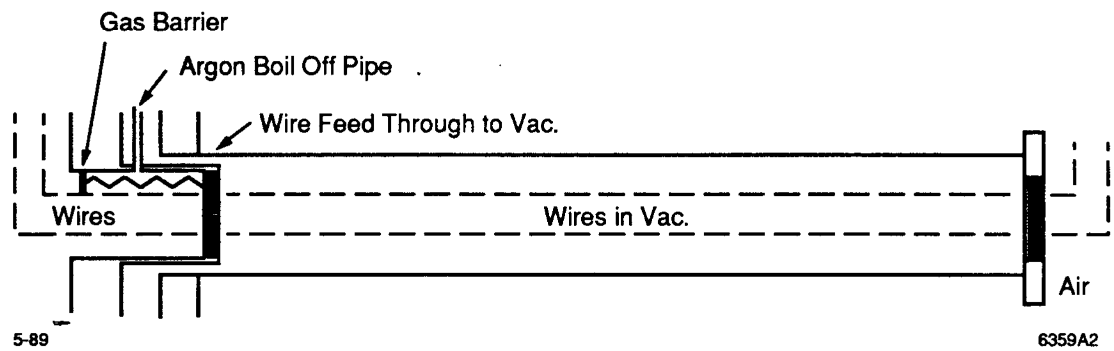

Fig. 2. Wire feedthrough with argon boil-off pipe to keep gas from going into the barrel. One-third to one-half liter per hour of argon boiled off. About 50 liters per hour of gas goes up each pipe, and there are 80 pipes. There is a boil off barrier at both ends of each pipe to force gas up. Disadvantages: the feedthrough leak spoils the vacuum and ends the experiment.

1.3. Wire Diagram (III)

This device (see Fig. 3) removes the problems mentioned above because the counter-flow gas is argon. A leak either way through the cold seal is just an argon-to-argon leak. No contamination occurs. No vacuum is lost and the experiment continues.

One alternative is the use of high density conventional feedthroughs using glass-to-metal seals. These typically can be made to a density of .012 sq in. per penetration (per connector pin). A channel count of 220,000 could then be contained in about 100 sq in. of surface, or 80 discs of radius 6.6 in. The feasibility of such large pin content in a glass-to-metal-type feedthrough must be examined. Smaller versions have successfully been used on the SLD and Mark II detectors.

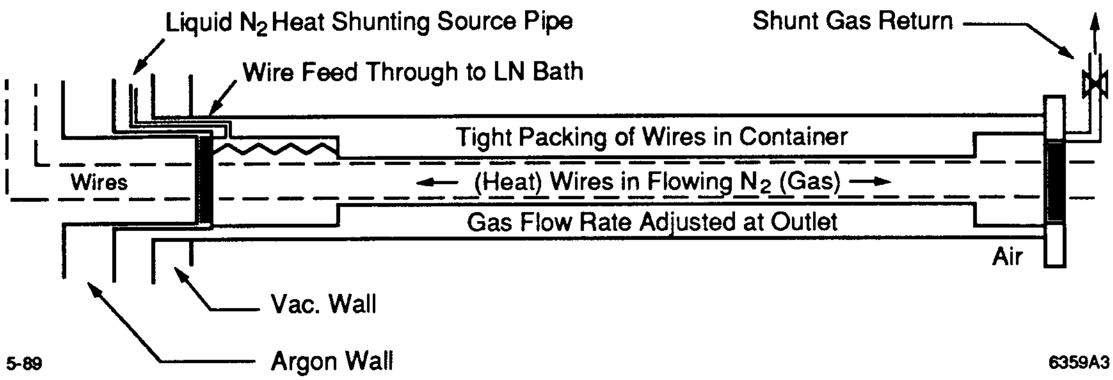

Fig. 3. Wire feedthrough with gas-shunted heat leak exchanger. Liquid nitrogen is used for shunting liquid. About 15 to 30 W gives one-quarter liter per hour using sensible heat. Disadvantage: N2 could leak into argon if the seal leaks. Advantage: nothing leaks to vacuum.

2. THE CRYOGENIC SYSTEM

The system, as shown in Fig. 4, consists of the following major components.

2.1 Argon Supply Storage Dewars

With a total storage of about 400,000 liters of liquid, these will provide a complete fill of the barrel module and both end-caps, and have a little to spare.

The dewars could be located above-ground, but for safety reasons and easier operation they should be at the same level as the experimental hall.

2.2. Liquid Nitrogen Source Storage Dewar

The liquid nitrogen source storage dewar has a volume sufficiently large to achieve cool-down use rates with a dewar refill every 12 to 24 hours.

2.3. Local Argon Conditioning Dewar

Located at the level of the calorimeter and probably slightly higher than the top level of the liquid in the barrel module, this dewar supplies liquid or gas to the gas phase of the modules and guarantees an over-pressure sufficient to prevent boiling in the top of the module.

2.4. Local Nitrogen Conditioner

The local nitrogen conditioner determines the pressure and temperature of the liquid nitrogen that will be introduced into the cooling loops.

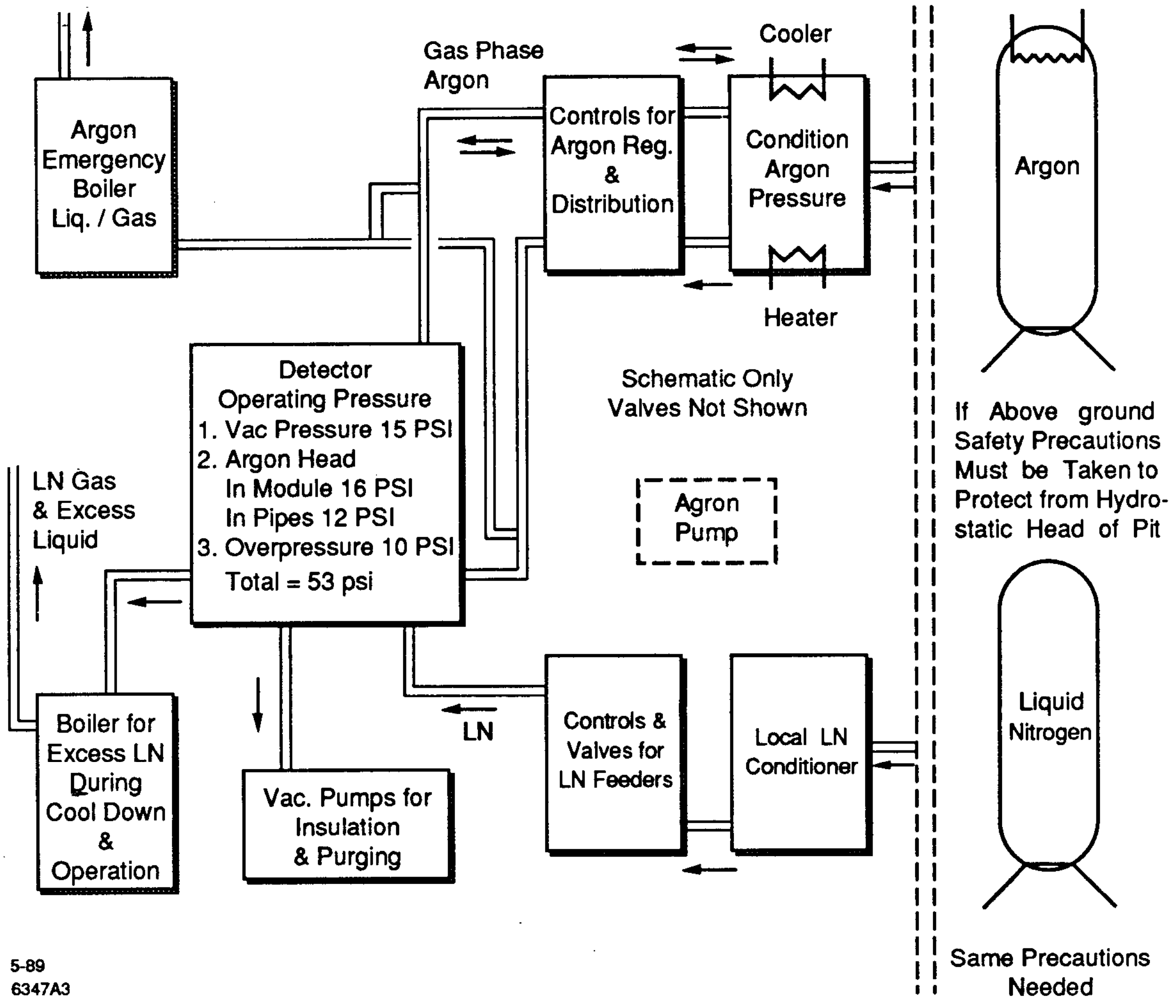

Fig. 4. Block diagram of cryogenic system.

2.5. Argon Temperature and Pressure Controls

Located near the local dewar, the purpose of these valves is control over the supply lines to and from the top and bottom of the various argon systems. These valves are used during fill.

2.6. Controls for the Various Nitrogen Valve

These valves regulate the loop flow used in cool-down and steady operation.

2.7. The Detector

Valves, lines and vacuum pumps are nearby.

2.8. The Liquid Nitrogen Boiler

The liquid nitrogen boiler vaporizes any excess nitrogen that flows through the cooling loops. This is very important because it is possible, under certain circumstances, to flow enough excess liquid to start filling the vent pipe to ground level 250 ft above. This would result in a back pressure on the liquid nitrogen in the loops and raise the temperature of the liquid within them. Refrigeration would stop and the argon temperature would rise, etc.

2.9. The Argon Boiler

The purpose of this boiler is more or less the same as described above. If it becomes necessary to dump argon for emergency reasons, it is important to keep the vent line to the surface free of liquid so the argon within the modules can boil off against an atmospheric back pressure.

The argon dewar, especially, should be placed at the detector level. The reason is explained in detail in the safety portion of the report. In general, it can be stated that the placement of the storage dewars can put a possible pressure of almost 200 psi on the modules because of the 250 ft head of liquid in the vertical fill pipe. The detectors will be designed to operate at 55 psiA. The density of a 250 ft-high liquid argon column is such that over 155 psi would be placed on the detectors and would result in total destruction. This problem does not exist if the source dewars are at the detector level.