



**Fermi National Accelerator Laboratory**

**FERMILAB-TM-1929**

# **Reducing Process Noise in Superconducting Helium Liquid Level Probes**

J. Brubaker

*Fermi National Accelerator Laboratory  
P.O. Box 500, Batavia, Illinois 60510*

March 1995

## **Disclaimer**

*This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.*

## Reducing Process Noise in Superconducting Helium Liquid Level Probes

J. Brubaker, AD Cryogenic Systems

March 10, 1995

This memo presents methods to reduce the process noise accompanying the use of superconducting helium liquid level probes in a splashing environment. The development of these methods followed unsatisfactory operation of unmodified, commercially available, level probes used in each of the 24 valve box dewars of Tevatron refrigerators. The dewars function both as reservoirs of refrigeration and as phase separators at the inlet of the cold compressors used in subatmospheric magnet cooling operation.

The valve box dewar is a 130 liter helium dewar sharing a common insulating vacuum with cold valves and distribution piping of the refrigerator. The dewar is instrumented with a 0-50 psia pressure transducer, a 0-5 inH<sub>2</sub>O differential pressure transducer measuring the liquid head, and the superconducting level probe. Three influent nozzles are situated near the top of the dewar in what is vapor space under normal operating conditions. The nozzles are directed radially inward and down at a 45 degree angle, and are roughly equally spaced around the dewar circumference.

In the plan view, the level probe is situated near to the middle of the vessel head that forms the top of the dewar. The sensing portion of the probe is 89 cm (35 inches) long, extending above and below the elevation of the nozzles. A commercially available level probe is typically constructed of a G-10 composite tube with one row of 0.23 cm (0.09 in) diameter holes spaced at 1 cm intervals along its length.

In the system configuration described above, the helium exiting the nozzles is directed in the general direction of the liquid level probe. If this helium sprays out in a small cone, it could impinge on the probe at some elevation. Through a series of tests monitoring the level probe and the differential pressure transducer while varying a nozzle flow rate and the liquid level, it was possible to deduce (the process itself can not be seen) what conditions lead to process noise in the level probe signal. Results of these tests are summarized below.

- 1) Process noise is maximum when, simultaneously, the holes of the level probe face the nozzle, the dewar pressure is low, the nozzle flow is high, and the liquid level is at the same elevation at which helium from the nozzle impinges on the probe. In this case, signal noise spikes caused by splashing can be greater than 30 percent of the full scale reading.

- 2) By far, the most important factors correlated with noise is the event of the liquid level corresponding to the elevation at which nozzle flow impinges on the probe, and operating pressure. Presumably, splashing at the liquid surface near the probe causes the sensor wire in the vapor space to superconduct, and lower pressures also promote this.

3) Rotating the level probe such that the row of holes faces away from nozzles having high flow rate reduces the noise considerably when the operation is near 3 psig. However, as operating pressure is reduced, the splashing has more affect on the signal, and rotating the probe alone does not produce satisfactory results. (it is better than not aligning the probe)

It is particularly important that the level probes work well under subatmospheric conditions since the control of liquid level is important to cold compressors operation. Concluding from these results that existing level probes would not provide an adequate control input signal, modifications were made to several probes and further testing was performed. The modifications concentrated on providing fewer and/or smaller holes in the level probe through which the liquid helium communicates with the superconducting wire sensor.

A few commercial probes specified to have holes at 2 cm or 4 cm intervals were at first purchased, and later in order to provide smaller holes, a thin Teflon tube was shrunk over some existing probes. Pin holes were placed in the Teflon tubes, first at every 1cm interval and later at 2cm and 4cm intervals. Results of these tests are summarized below.

1) Increasing the spacing of the 0.23 cm (0.09 in) diameter holes in the probes provides no measurable reduction in the noise associated with splashing. Signal noise remains very sensitive to the liquid level.

2) Teflon sheathed probes reduce splashing noise considerably, under both atmospheric and subatmospheric operation. There is little difference in performance between probes having holes pin holes at 1cm, 2cm, and 4cm intervals. Signal noise is only slightly increased when the liquid level is at the same elevation at which helium from the nozzle impinges on the probe.

3 ) At the highest fill rate achievable under normal operation (about 2 inches per minute) there is little noticeable effect on the response time of the level probe due to the small pin hole size.

A number of fabrication requirements were developed during these investigations and these are listed below.

1 ) When installing Teflon shrink tube on the probe, all holes in the G-10 body must be fully covered. It was observed that leaving even one 0.23 cm diameter hole exposed allows splashing to affect the probe signal.

2) The pin holes appear sufficient to vent helium within the small diameter probe when the probe is removed from service. In all such removal operations in these tests, however, the probe was less than half submerged at the beginning of removal.

3) Since the coefficient of thermal expansion for the Teflon tube is greater than that for G-10, the pin holes in the Teflon can move off the location of holes in the G-10 when the probe is cooled to liquid helium temperatures. In the case that one end of the Teflon is fixed to the G-10,

holes at the other end may not align and liquid will then not effectively communicate with the superconducting wire. If the Teflon adheres tightly to the probe, the Teflon will break on a circumference, potentially fully exposing a G-10 hole. To prevent these failures, the Teflon can be cut circumferentially (at calculated intervals) after it is installed.

Once the Teflon tube sheath was tried, a satisfactory solution to process noise reduction was found, and the probe configuration was not further optimized. A number of design variables remain to be characterized by those investigators so motivated.

1) What influence does the pin hole size have on the process noise, and depending on material used, is the change in this size upon cooling important.

2) What is the influence of the thickness of the Teflon tube (and therefore, the hole length) on the noise and the communication of liquid helium with the superconducting wire.

3) Is there a more suitable sheath material to cover the probe body.

4) Is there a suitable tube material for the probe body that can accommodate the smaller holes and have the appropriate thickness.

5) At what filling or emptying rate does the small hole size effect the response time of the level probe.