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ZERO DISPLACEMENT, LIQUID NITROGEN LEVEL MONITOR
FOR SEMICONDUCTOR DETECTORS

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ABSTRACT

Lithium Drifted Germanium [Ge(Li)] and Lithium Drifted Silicon [Si(Li)] detectors are operated at liquid nitrogen temperatures. If the detector is warmed while the bias voltage is applied, the detector is destroyed. Proper use of a strain gauge to monitor the liquid nitrogen in semiconductor detector assemblies constitutes the least expensive system that

- *Does not induce statistically significant detector-sample displacement.*
- *Monitors continuously.*
- *Reads directly and linearly in units of liquid nitrogen volume or weight.*
- *Provides a signal which can trigger an alarm.*
- *Does not use liquid nitrogen to operate.*
- *Is fail-safe. Any measurement system component failure will cause an alarm.*

ZERO DISPLACEMENT, LIQUID NITROGEN LEVEL MONITOR FOR SEMICONDUCTOR DETECTORS

INTRODUCTION

Lithium Drifted Germanium [Ge(Li)] and Lithium Drifted Silicon [Si(Li)] detectors are operated at liquid nitrogen temperatures. If the detector is warmed while the bias voltage is applied, the detector is destroyed. In many analytical systems the detector position cannot be allowed to vary with respect to the sample geometry. Any liquid nitrogen monitor system which will be useful in a broad spectrum of detector installations must accurately determine a danger point requiring immediate attention, while not varying the position of the detector system in the performance of normal analyses.

SUMMARY

A strain gauge continuously monitors weight which can be translated into liquid nitrogen volume. It provides a signal which can trigger an alarm. The movement imparted to the detector system over the entire measured range is not detectable as a contributor to counting statistics.

DISCUSSION

MONITORING OPTIONS

There are several possibilities for monitoring liquid nitrogen level in semiconductor detector dewars.

A floor scale may be read directly and continuously in terms of liquid nitrogen weight and hence volume. Trigger points may be installed to sound an alarm below any

predetermined minimum weight. However, unless all sample geometries are physically indexed directly to the detector, there is no way of damping the motion of the scale platform or of reducing its displacement with weight loss.

A simple dip stick is by far the cheapest means of measuring liquid nitrogen level in a dewar. It has merit in reliability as there is no surer means of measuring than a direct scale reading. The dip stick will not read out continuously. A vacuum loss in the dewar or a blockage of the passage between the dewar and the cryostat cold finger will accelerate evaporation and may cause total loss of liquid nitrogen in the time interval between dipstick samplings.

There are a variety of phase detectors which will determine the liquid nitrogen level in a dewar. Such a detector is usually introduced into the dewar and set to trigger an alarm at the minimum allowable level of liquid nitrogen. It does not monitor continuously and one is usually reduced to using a dipstick to determine intermediate levels. In addition, phase detectors act as heaters. Either they passively conduct heat from outside the dewar or they actively introduce heat as a mechanism of measurement. In either case they reduce the liquid nitrogen holding period of the dewar.

The strain gauge combines the desirable features of all of the alternative measuring systems with none of the faults. As used at Atlantic Richfield Hanford Company the strain gauge

- Monitors continuously.
- Does not induce statistically significant detector-sample displacement.
- Reads directly and linearly in units of liquid nitrogen (volume or weight).
- Provides a signal which can trigger an alarm.
- Does not use liquid nitrogen to operate.

- Is fail-safe. Any measurement system component failure will cause an alarm.

Only the loss of alternating current power will make the strain gauge liquid nitrogen monitoring system inoperative during the period of the outage. In this event, means ought to be already in place in the form of latching relays to prevent the reapplication of power until bias voltage has been removed from the semiconductor detectors. Reapplication of AC power to the liquid nitrogen monitors will cause them to trigger the alarm if the liquid nitrogen has fallen below a minimum safe level. The monitor AC power supply should not be latched. It must be able to function independently of the detector circuitry.

LIQUID NITROGEN MONITOR SYSTEM

The liquid nitrogen level monitor systems in use at Atlantic Richfield Hanford Company are built around a Stratham Universal Transducing Cell, Model UC 3 (Gold Cell) [trade name, Honeywell]. The compression force range for the Gold Cell by itself is 60 grams; therefore it is used with a Stratham Load Cell Accessory [trade name, Honeywell] which expands the usable force range. To date the Model No. UL4-100 has covered all of the referenced detector configurations; however 11 load cell models are available. The force range is 100 pounds and this can be biased mechanically from 0 to 50 pounds with an internal adjustment screw. To put it in terms of the detector assemblies that will be monitored, a weight range of 100 pounds can be measured in any system with a fully loaded weight of up to 150 pounds.

A Stratham Model SC100 Bridge Amplifier [trade name, Honeywell] amplifies the signal from the Universal Transducing Cell to provide a signal suitable for driving most galvanometers directly.

For the galvanometer an API Instrument Company Optical Meter-Relay, Model 502-L, 0 to 1 milliampere DC, signal high meter is used. The meter reads amperage and has a single, adjustable set point value. The working component is a precision D'Arsonval meter mechanism with a shutter on the moving element. At the set point the shutter blocks the light (from an internal source) to a photoconductive cell. This interaction occurs when the meter deflection indicates less liquid nitrogen volume than the set point.

The optical meter-relay is controlled by an API Instrument Company Model 901B optical control module which provides taps to trigger the chosen alarm system. Bells, flashing lights, klaxons, or whatever means is needed to sound a warning are triggered.

The meter movement is calibrated by adjusting the mechanical adjustment screw in the load cell to the proper load range setting. The output amperage from the strain gauge is set to full-scale on the meter-relay when the detector dewar is filled, using the balance and sensitivity controls of the bridge amplifier. The meter-relay set point is set to the same point as the meter element when the liquid nitrogen reached the minimum safe level. This will be the alarm level.

Safe liquid nitrogen levels vary with the types of dewars. A chicken-feeder dewar can be operated safely regardless of its capacity on the last liter of liquid nitrogen. Types of dewar-cryostats in which the cryostat cold finger is let into the bottom or side of the dewar require at least enough liquid nitrogen to cover the cold finger. Dipstick cryostats must be covered to at least one-third their lengths. In some dewars this could mean as much as half of their capacities.

The amount of meter scale between the alarm set point and full-scale is linearly equal in weight or volume to the liquid nitrogen between minimum and maximum levels in the tested

dewar. The volume or weight has to be measured only once and the monitor system is calibrated. If the need is present the system calibration can easily be made sensitive to ± 0.05 liter of liquid nitrogen.

TYPICAL INSTALLATIONS

The only requirement for installing a strain gauge as a liquid nitrogen level monitor is that it representatively samples the weight of the liquid nitrogen vessel. The simplest installations involve a lever point and a fulcrum consisting of either an edge or two support points. Figure 1 typifies the edge-fulcrum installation. The detector is a 25-cc Ge(Li) diode in a right angle, chicken-feeder cryostat with a 17-liter dewar. The entire detector-dewar assembly is free to rotate on the fulcrum edge, causing a high proportion of the total weight of the system to rest on the strain gauge.

Figure 1 and all the subsequent examples illustrate an additional desirable feature. The direction of liquid nitrogen monitor motion should be at right angles to the counting axis of the detector. The maximum displacement of the Stratham Load Cell Assessories is 0.10 mm for their full load range. In a poorly designed installation this could result in a measurable detector geometry change relative to a sample. However, with the reaction axis at right angles to the detector counting axis, the maximum of 0.10 mm strain gauge displacement is converted to detector displacement in an arc of like length. The detector-sample geometry remains unchanged--there is zero displacement.

Other variations of edge-fulcrum installations are presented in Figures 2 and 3. Figure 2 represents a detector system identical to that in Figure 1 but from a different supplier. The fulcrum edge is the rear edge of the Plexiglas box supporting the dewar. The Stratham components are seen

at the opposite end of the support box, next to the detector shield.

The detector assembly in Figure 3 contains an array of four coaxial Ge(Li) detectors in a common dipstick dewar and it is used in passive plutonium-239 package counting.^[1] In this case the detector assembly is movable along a floor rail and the sample position is fixed. The rail aligns the detectors with the sample and provides positive pin positions to locate the detectors in pre-calibrated geometries. The surface of the cart on which the detector-dewar rests is hinged at the rear, with the strain gauge lever point located at the front.

Figure 4 shows an anticoincidence guarded, Ge(Li) detector system during shield assembly.^[2] Figure 5 details the strain gauge installation in a three-point configuration. This system is a vertically-down, chicken-feeder configuration. It is the only system illustrated in which the detector counting axis aligns with the dewar axis. However it will be noted that the load cell reaction axis is effectively at right angles to the detector counting axis. In the final installation the rear support rods were encased in Teflon sleeves at the contact points and contact at the strain gauge was made through electricians' "fishpaper." In this way the detector was electrically isolated from shield ground.

An additional benefit was derived from the liquid nitrogen monitor illustrated in Figure 4. The anticoincidence guard detector in the system is an annulus NaI(Tl), which can be seen through the open shield doors. It is raised around the Ge(Li) detector by a lift table. Samples are placed between the end of the Ge(Li) detector and an NaI(Tl) plug detector which fills the opposite end of the annulus. If the annulus and sample are raised too high there is danger that either or both detectors could be damaged. However, pressure on the Ge(Li) detector cap records in the same fashion as liquid nitrogen loss.

The annulus plug detector is spring-loaded to assure sample contact with both detectors; but if the sample should be oversize or cock and jam or if more than 10 pounds of pressure would be applied to the Ge(Li) cap, the liquid nitrogen level monitor alarm will sound.

At every liquid nitrogen level monitor station there are posted instructions to guide the actions taken as a result of an alarm. A typical example is Figure 6. The building in which most of these monitors are located is operated 24 hours a day so there is always someone to be alerted by a flashing light alarm, as illustrated, or by a sound alarm. Figure 6 contains the meter-relay monitors for the systems in Figures 1 and 2. Two additional flashing light alarms are located at the top of the unit. Outputs could as easily be connected to a telephone call service or a remote alarm similar to fire alarm systems.

REFERENCES

1. W. H. Zimmer, *The Ge(Li) IV Plutonium-239 Package Counter*. ARH-1993, Atlantic Richfield Hanford Company, Richland, Washington, March 1971.
2. W. H. Zimmer, *An Anticoincidence Guarded, Ge(Li) Detector for Environmental Level Gamma Energy Analysis*, ARH-SA-101, Atlantic Richfield Hanford Company, Richland, Washington, September 1971.

FIGURE 1

AN EDGE-FULCRUM STRAIN GAUGE INSTALLATION

The fulcrum edge is inlaid in the Plexiglas base at the right. The top surface of the base is recessed between the fulcrum edge and the Stratham Transducing Cell-Load Cell contact point on the left.

FIGURE 2

AN EDGE-FULCRUM STRAIN GAUGE INSTALLATION
The fulcrum is at the end of the support box
opposite the shield.

FIGURE 3

AN EDGE-FULCRUM STRAIN GAUGE INSTALLATION

The platform supporting the detector-dewar is hinged at the rear. The Stratham Transducing and Load Cells are in the inverted position, at the front. The meter-relay is mounted in the side of the detector cart with the amplifier, meter control, and bell alarm inside the cart.

FIGURE 4

AN ANTICOINCIDENCE GUARDED, $\text{Ge}(\text{Li})$ DETECTOR SYSTEM
ILLUSTRATING A THREE-POINT STRAIN GAUGE INSTALLATION

FIGURE 5

STRAIN GAUGE MOUNTING DETAIL ON
ANTICOINCIDENCE GUARDED, Ge(Li) DETECTOR SYSTEM

The three contact points originate from a support collar between cryostat and dewar. The Stratham components are mounted under the front support point which is also a large leveling screw and locknut.

FIGURE 6

A TYPICAL NITROGEN LEVEL MONITOR ALARM STATION

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