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DP-34

Instrumentation

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A MONITOR FOR SURFACE ADSORBED TRITIUM

by

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ABSTRACT

A monitor for detection of surface-adsorbed tritium beta particles has been developed. The detecting element is a windowless Geiger tube with the counting gas flowing through it. The normal limit of detection of a single-tube probe is 800 d/m of tritium, while a three-tube probe is probably limited to about 2000 d/m. Both probes have a counting efficiency of about 10% for tritium.

TABLE OF CONTENTS

INTRODUCTION	Page 6
SUMMARY	6
DISCUSSION	6
General	6
Geiger Tube Characteristics	7
Monitoring Probes	7
FIGURES	
Figure 1. Photograph of auxiliary equipment on a cart (scaler and gas supply).	9
Figure 2. Three-tube probe for flat surfaces	10
Figure 3. Single-tube probe for rough surfaces	11
Figure 4. Typical plateau curve for windowless Geiger tube (tritium source).	12
Figure 5. Effect of gas flow rate on counting rate (single tube).	13
Figure 6. Flushing time required for a given gas flow rate (single tube).	14
Figure 7. Effect of gas flow rate on a counting rate on the three-tube probe.	15

INTRODUCTION

Safety considerations in the handling of tritium or tritiated compounds require detection of any tritium radioactivity, either adsorbed on surfaces or in the air, for the protection of personnel. Prior to this project, no adequate means existed for detection of surface-adsorbed tritium. Proportional counters, such as the Hanford "Pete", proved unreliable and only qualitative in measurement. Tritium emits very soft beta particles whose maximum range is less than a centimeter in air. This characteristic of the emitted electrons drastically limits the available kinds of detectors since any successful detector must have less than 0.7 mg/cm^2 of material between the surface and the sensitive element so that the beta particles can get through.

SUMMARY

A monitor for the detection of surface-adsorbed tritium beta particles has been developed. The detecting element is a windowless Geiger tube with the counting gas flowing through it. The Geiger tube counts tritium with about 30% efficiency, and operates on a plateau about 300 volts wide. Two separate mounts have been devised for the Geiger tube: (1) a single tube mounted in a rubber cushioned plastic case for detection on odd shaped or small surfaces, and (2) a probe mounting three parallel-connected Geiger tubes for monitoring flat surfaces. Both probes have a counting efficiency of about 10% for tritium. The limit of detection depends upon the background counting rate of the tube, but 800 d/m of tritium is the normal limit of detection of the single-tube probe, while the three-tube probe is probably limited to about 2000 d/m. Operating prototypes of the two probes have been turned over to the Health Physics Section of Works Technical for incorporation into field instruments.

DISCUSSION

GENERAL

A Geiger tube has been found to be capable of operating as a flow counter; with the window removed and a counting gas flowing through, it has been found to have a high efficiency for detection of weak beta particles (1). The counting gas mixture is helium, saturated with ethyl alcohol at 0°C . Since the adaptation of this instrument into a semi-portable Health Physics monitor required the elimination of as much equipment as possible, "Q" gas, (98% helium, 2% isobutane) has been substituted as the counting gas, and

found to work satisfactorily. The monitoring device consists of a counting rate meter or scaler and a tank of counting gas mounted on a cart (Figure 1) with appropriate gas and electrical connections to the detecting probe. Two types of probe have been developed; a probe mounting three Geiger tubes for monitoring flat surfaces, and a probe mounting a single Geiger tube attached to a rubber cushion for monitoring edges and corners (Figures 2 and 3). Operating prototypes have been tested and turned over to the Health Physics Section of Works Technical.

The Geiger tubes used were Tracerlab Model TGC-1 or TGC-2, with the mica window removed and a glass tube sealed to the top of the Geiger tube to provide an entrance for the counting gas. Metal tubes, such as the Tracerlab TGC-9, would be preferable for field use, but none were available.

• GEIGER TUBE CHARACTERISTICS

The tube characteristics are those of a normal Geiger tube. The average plateau is about 300 volts, with less than 3% slope, and the betas of tritium are detected with about 30% counting efficiency. (This figure is based on the assumption of 50% efficiency for a flow-type proportional counter.)⁽¹⁾ The normal operating voltage is about 1500 volts. A typical⁽¹⁾ curve of counting rate plotted against voltage shows these data (Figure 4).

The pulse put out by the Geiger tube is of the order of 0.5 volts, making a pre-amplifier unnecessary. The counting tube is hooked to the scaler or counting-rate meter directly. The breakdown voltage is of the order of 2000 volts, but after arcing the tube at 2500 volts, it was found to operate satisfactorily when returned to normal operating voltage. The counting rate depends on gas flow-rate below 100 cc/min; above this flow-rate, the counting rate is unaffected by gas flow (see Figure 5). The tube must be swept free of oxygen, water and other gases with the property of high electron attachment before it will operate. The time necessary for flushing the tube depends on the gas flow-rate (see Figure 6). The background of the tube varies with the surrounding; however, it is seldom less than 200 to 300 counts per minute. On the basis of 30% counting efficiency and a detection level of 20% of the counting rate of this background, a single tube is capable of detecting 200 d/m of tritium.

MONITORING PROBES

The probe for monitoring flat surfaces utilizes three windowless Geiger tubes connected in parallel, a scaler (or counting rate meter), and a source of counting gas. The tubes must be chosen to have plateaus in the same voltage

(1) Grey, Ikeda, Benson and Kritchevsky, R.S.I. 21 1022 (1950)

range, otherwise, the arrangement is unworkable. The gas flow rate must be at least 1 liter/minute (see Figure 7). The tubes are mounted in a lucite block with about 1/4" separating the tube and the surface. This geometry lowers the counting efficiency to about 10%, and the background is of the order of 1000 c/m or more; the detectable level of contamination using this probe is estimated to be 2000 d/m. This probe has the advantage of covering a large area at one time, and in actual monitoring, if pushed along a surface without lifting, it remains operable with no delay for flushing.

The probe for edges and corners is a similar tube, mounted in a lucite case and taped to a foam rubber mat. The mat can be held down on an irregular object to prevent gas leakage so the tube will remain operating. The use of very high gas flows (~ 2 liters/minute) aids in this application. When used on flat surface, this tube counts with about 8% efficiency and is capable of detecting 800 d/m of tritium.

Best use of the instrument in the field requires some thought on the part of the operator since, in addition to counting tritium, it counts alpha particles and other beta emitters as well. These other emitters can be distinguished from tritium, since tritium cannot penetrate one thickness of Mylar film (0.9 mg/cm^2). Three thicknesses of Mylar will stop most alpha particles. The counting rate of the average beta emitter will be only slightly affected by Mylar placed between the Geiger tube and the source.

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FIGURE 1

DP-34
Page 9

PHOTOGRAPH OF AUXILIARY EQUIPMENT ON
A CART (SCALER AND GAS SUPPLY)

FIGURE 2

DP-34
Page 10

THREE-TUBE PROBE FOR FLAT SURFACES

SINGLE TUBE PROBE FOR ROUGH SURFACES

FIGURE 4

DP-34
Page 12

TYPICAL PLATEAU CURVE FOR WINDOWLESS
GEIGER TUBE (TRITIUM SOURCE)

FIGURE 5

DP-34
Page 13

EFFECT OF GAS FLOW RATE ON COUNTING
RATE (SINGLE TUBE)

FIGURE 6

DP-34
Page 14

FLUSHING TIME REQUIRED FOR A GIVEN
GAS FLOW RATE (SINGLE TUBE)

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FIGURE 7

DP-34
Page 15

EFFECT OF GAS FLOW RATE ON COUNTING
RATE IN THE THREE-TUBE PROBE

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