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THE USE OF PASSIVE DETECTORS TO MONITOR TRITIUM ON SURFACES

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Abstract — Commercially available BeO exoelectron dosemeters and electret ion chambers (EICs) are being adapted and applied to *in situ* field monitoring of tritium on surfaces. Thin-layer BeO on a conductive graphite substrate is of the order of 50 times more sensitive to tritium than the EIC. At the US Department of Energy release limit for fixed surface tritium of 5000 dpm per 100 cm^2, the exposure time for quantification with the exoelectron dosemeter is of the order of one hour. A multipoint Geiger counter was used for reading exoelectron emission. An alternative ceramic BeO dosemeter (Thermalox 995) has low electrical conductivity and will require a different reader to overcome problems of surface charging during exoemission. The electret is very easy to use and read. Its practical use will be for surfaces with relatively high levels of tritium contamination.

INTRODUCTION

Pioneering work with thermally stimulated exoelectron emission (TSEE) for applied dosimetry was conducted at ORNL in the 1960s/70s by Becker and Gammage. Tritium monitoring on contaminated surfaces was identified as perhaps the best application[1]. Investigation of tritium detection with thin-film BeO was continued by Kreigseis *et al*[2]. More recently, electret ion chambers (EICs) have been adapted for practical monitoring of tritium in air[3]. The latest adaptations for making in-the-field measurements of tritium on surfaces at contaminated DOE facilities are here reported.

EXPERIMENTAL

The majority of TSEE dosemeters studied were 0.38 cm^2, thin-film BeO on graphite substrates (Staatliches Materialprufungsamt Nordrhein-Westfalen, Germany). Some measurements were also made with 1.22 cm^2, ceramic BeO disks (Thermalox 995 from Brush Beryllium Co., Elmore, Ohio, USA). The TSEE reader is made by Fimel Corp. (Fontenay-aux-Roses, France). This reader is a multipoint Geiger counter with cathodic focusing to reduce dead time to 2 μs. The 49 cm^2 EICs and handheld voltage reader were obtained from Rad Elec, Frederick, Maryland, USA. The lip of the standard electret holder extends about 4 mm from the electret surface, which fortuitously matches the range of the tritium betas in air. Thus the standard holder conveniently serves as the ion chamber when making surface tritium measurements. When making exposure measurements on tritiated surfaces, wire mesh screens were deployed to prevent transferring tritium to either the TSEE or EIC dosemeters. For purposes of tritium calibration, a NIST traceable, anodised aluminium foil emitting 16.5 betas $s^{-1}.cm^{-2}$ was used.

RESULTS AND DISCUSSION

The responses of the TSEE dosemeters and EICs to the calibrated tritium source are shown in Figures 1 and 2, respectively. The Thermalox 995 has a very limited range of linearity because there is no provision for grounding of its exoemitting surface inside this particular reader; build-up of positive surface charge increasingly impedes exoemission as readout proceeds. The data in Table 1 give the exposure times needed to detect tritium surface contamination (at the current US DOE contamination release limit for total tritium of 5000 dpm per 100 cm^2) at a 3:1 signal-to-noise ratio. Although thin-film BeO and Thermalox 995 dosemeters have nearly identical intrinsic efficiencies, the area of the latter is 3–2 times the area of the former, hence the 3-fold difference in exposure times listed in Table 1. Compared to the TSEE devices, the electret is much less sensitive (50–100 fold). Measurements at the tritium release limit would require exposure times of several days.

The results of the first field tests at the Westinghouse Savannah River Company site (Augusta, GA, USA) are summarised in Table 2. The exposure time was 17 h. First, it is obvious that removable contamination (smears) is, in most cases, considerably less than the total tritium (fixed and removeable) measured with the passive dosemeters. Second, the EIC estimates are 3 to 62 times higher than analogous measurements with thin-layer BeO dosemeters. The reasons for this bias are speculative at this time. False positives with the EICs are a possibility because the 17 h exposure time would have been insufficient for measuring activities below 37,000 dpm per 100 cm^2. Tritium contamination might indeed have been below this level because the maximum exoelectron result shown in Table 2 was only 34,200 dpm per 100 cm^2. The EICs might have suffered small voltage drops caused by extraneous events (e.g. dirt and dust), which translated into the large apparent surface tritium activity.

Further measurements at ORNL at a former tritium handling facility are planned. Precision and accuracy will be determined and parallel measurements made with an open-faced proportional counter. The sensitivity of the larger area EIC is considerably less than that of the TSEE dosemeters by a factor of about 50. Because the EIC device is so easy to use and read immediately after exposure, it may still prove to be the passive integrating monitor of choice if tritium levels are high.

Determining tritium in the presence of gamma radiation is quite practical[1,4]. The problem of discrimination would be more difficult if the tritium betas were mixed with alpha radiation. In general, tritium and alpha emitting radionuclides were found to be spatially separated at contaminated facilities.

Table 1. Comparison of detectors.

Detector	Exposure time* (h)	Intrinsic efficiency (exoelectrons per beta)
BeO thin-film	2.2	0.27 ± 0.07
Thermalox 995	0.7	0.26 ± 0.07
EIC	125	—

*Time necessary to quantify 5000 dpm per 100 cm^2.

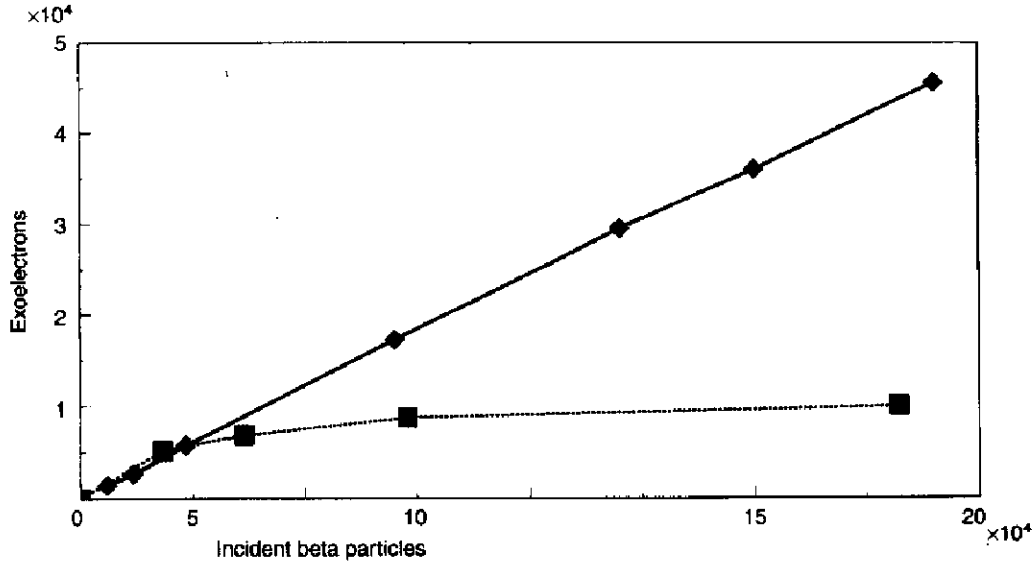

Figure 1. BeO thin-film (◆) and Thermalox 995 (■) responses to the calibrated tritium source (effective incident beta rate = 6 s^{-1}).

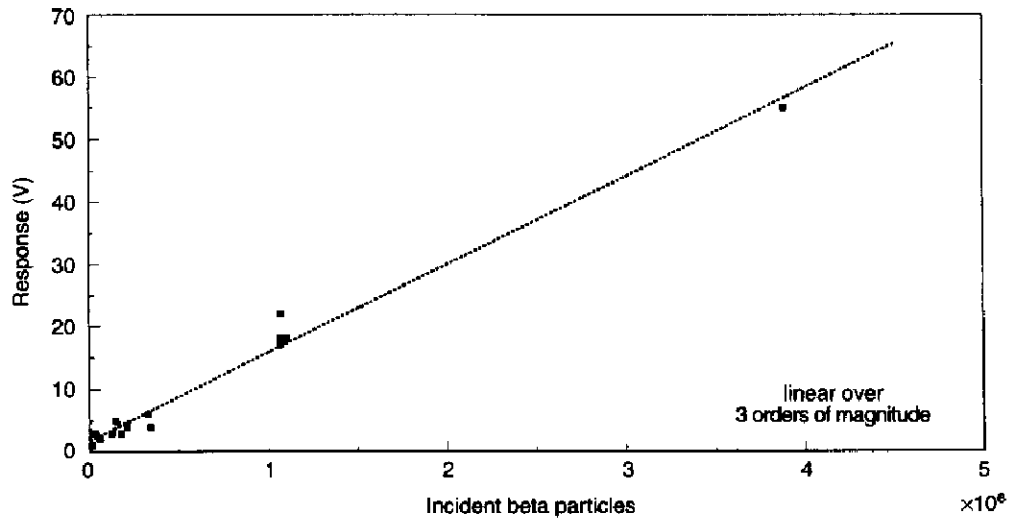

Figure 2. EIC tritium response curve (effective incident beta rate = 81 s^{-1}).

CONCLUSION

Exoelectron dosemeters are shown to have the capability for making *in situ* field measurements of total surface tritium at the current DOE release limit using exposure times of an hour or two. The very easy to use and read electret ion chambers have of the order 50 times less sensitivity than the exoelectron devices. Nevertheless, they should find application for measuring surfaces with significant tritium contamination. The next phase will require rigorous field testing for precision, accuracy and failure rate, as well as overcoming the inevitable glitches presented by real-world conditions.

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Table 2. Tritium contamination estimates, C-Reactor, Savannah River.

Location	Smear (dpm per 100 cm^2)	Thin-film BeO (dpm per 100 cm^2)	Electret ion chamber (dpm per 100 cm^2)
40/1 Bingham pump	4400	31,800	95,000
40/2 SSS cage	6350	34,200	157,000
14/1 floor drain	430	5,900	157,000
14/2 floor drain	343	2,400	78,000
20/1 chemical pump	2700	18,600	not detected
20/2 trench	4600	23,400	153,000
20/3	5600	2,100	130,000

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