A CONTROL SYSTEM FOR STANDARD ALPHA AND BETA RADIOACTIVE SOURCES

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ABSTRACT

A system of alpha and beta radiation detection was designed and constructed, using a plastic scintillator, in order to control the sources used for the calibration of contamination detectors. The obtained results of the short and medium-term stabilities, linearity and energy dependence using three different measurement systems were compared.

INTRODUCTION

The systematic routine monitorations have to be conducted using sensitive detectors in any area where radioactive materials are handled and specially where the possibility of surface contamination exists. The normally used instruments for surface contamination detection are scintillators, proportional counters, semiconductor detectors and Geiger-Müller detectors provided with thin entrance windows. The calibration process of such monitors involves the use of different radioactive sources[1,2,3]. In the case of alpha radiation, the sources are unsealed, requering special care during their handling. In order to check these sources periodically a control system was developed.

DESIGN AND CONSTRUCTION OF THE CONTROL SYSTEM

The developed detection system is constituted mainly by a plastic scintillator, a light pipe (Lucite) and a photomultiplier tube. This arrangement can be seen in Figure 1. Three different measurement assemblies were tested: an electrometer Keithley 616 (System 1), an electrometer Keithley 610C (System 2) and a timer-counter (System 3).

The secondary standard set in the case of alpha radiation for calibration of surface contamination monitors is composed by ^{239}Pu, ^{238}Pu, ^{244}Cm, ^{233}U and ^{241}Am sources, with certificates of the Laboratoire de Metrologie des Rayonnements Ionisants and by ^{241}Am sources produced and calibrated at the Nuclear Metrology Laboratory of IPEN. In the case of beta radiation, the secondary standard sources are $^{90}Sr + ^{90}Y$, ^{137}Cs, ^{14}C and ^{36}Cl, all calibrated at LMRI.

RESULTS

a. Short and medium-term stabilities

A source of ^{241}Am (2305 s^{-1}) was used for this study. The best short-term stability (repeatibility test) was shown by the System 3: the obtained variation coefficient was lower than 0.11%, while in the case of Systems 1 and 2 it was respectively 0.95 and 0.19%. For the medium-term stability (10 daily measurement series) the obtained variation coefficient was 0.18% for the System 1 and 0.14% for both Systems 2 and 3.

b. Linearity

Two different methods were carried out in this test. First, an ^{241}Am source (2305 s^{-1}) was used and the irradiation time was varied between 0 and 300 seconds. In the second case the control system was exposed to several ^{241}Am sources, with the emission flux varying between 55.3 and 11100 s^{-1}. In both cases a linear behaviour was observed for all three systems.

c. Energy dependence

Alpha and beta radiation sources with different energies were utilized, in order to obtain calibration factors for the control system and to study its energy dependence.

In the case of alpha radiation, in the energy interval of 4.7 and 5.8 MeV, the obtained energy dependence was 31.0 and 37.6% for the Systems 1 and 2 and only 5.3% for the System 3. Exposing the developed instrument to beta radiation, the energy dependence showed values of 19.6, 14.0 and 12.2% for respectively Systems 1,2 and 3, in the energy interval of 511 keV and 2.0 MeV. Comparing these results, it can be verified that the arrangement with the timer-counter (System 3) demonstrated the lowest energy dependence, a desirable characteristic of such an instrument.

The efficiency of System 3 was determined: 91.8% for alpha radiation (^{241}Am) and 55.9% for beta radiation ($^{90}Sr + ^{90}Y$).

Table 1 presents the calibration factors of the control system for ^{241}Am and $^{90}Sr + ^{90}Y$ in the case of the three different measurement assemblies.

CONCLUSION

The studied characteristics of the developed control system for alpha and beta sources, ie, the short and medium-term stabilities, the linearity and the energy dependence indicate the system composed by the radiation detector and the timer-counter measurement assembly as the most suitable, although the other two systems showed their usefulness also.

REFERENCES

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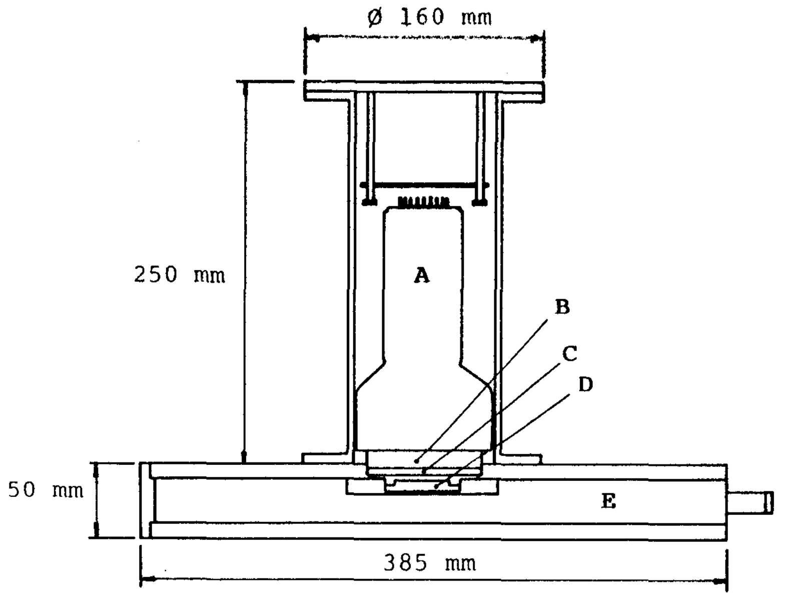

Figure 1: Alpha and Beta Radiation Detection System. **A**: Photomultiplier tube; **B**: Light pipe (Lucite, 3 in. diameter and 12 mm thickness); **C**: Plastic scintillator detector (3 in. diameter and 1 mm thickness); **D**: Radioactive source; **E**: Drawer.

TABLE 1

Calibration factors (f_c) of the control systems for alpha and beta radiation

System	f_c $(s^{-1} . ue^{-1})$	
	^{241}Am (167.2 s^{-1})	^{90}Sr + ^{90}Y (2930 s^{-1})
1	$(1.30 \pm 0.04) \times 10^{2}$	$(6.07 \pm 0.24) \times 10^{2}$
2	$(1.22 \pm 0.02) \times 10^{2}$	$(5.82 \pm 0.25) \times 10^{2}$
3	$(1.86 \pm 0.03) \times 10^{-2}$	$(2.98 \pm 0.12) \times 10^{-2}$

Systems 1 and 2 : 1 ue = 10^{-8}A
System 3 : 1 ue = 1 cpm