A New CAM System on the Basis of Proportional Counter Tubes

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CAM systems using proportional counter tubes in combination with the AERD technique are capable of determining 1 DAC value within one hour with a high statistical safety. Air flow rates of up to 30 cfm are possible.

Introduction

When handling plutonium and other actinides, the air-borne particulate activity concentration has to be monitored to ensure optimum safety at the workplace. Lowest activity concentrations (DAC values of 40 mBq/m³ relative to plutonium-239 = 1 x 10^{-12} µCi/cc) must be detected within a few hours with a high statistical safety. Usually one uses CAM systems with silicon detectors for this task. For construction reasons, however, only small dusting units can be realized, which limits the air flow to a few m³/h (= 1 cfm).

The new CAM Monitor LB 150 RD designed by EG&G Berthold operates with large-area proportional counter tubes to ensure an extremely reliable measurement of the DAC values as well as a high representativity concerning the sample quantity (nearly 50 m³/h = 30 cfm).

The AERD technique (1) (2) (3) eliminates virtually all interference factors, such as background fluctuations, dustloading on the filter, and a high ambient gamma level.

The Principle of Measurement

The acronym AERD stands for Alpha Energy Range Discrimination, a method utilizing the relationship of α energy and range (4). It is well known that all natural air-borne alpha emitters which are daughter products of the noble gases ^{222}Rn ("radon") and ^{220}Rn ("thoron") show alpha energies above 6 MeV. On the other hand, all relevant plutonium isotopes as well as ^{241}Am and other transuranics have energies below 5.5 MeV. This fact is the physical basis of a large variety of commercially available monitors utilizing the advantages of the excellent spectroscopic properties of semiconducting detectors.

At the end of the eighties, Frenzel and Kreiner have taken up this idea to create a suitable measuring method, the alpha energy range discrimination method. The essential aspect of the AERD technique is a detector system which allows the selection of alpha sources with energies of $\alpha > 6$ MeV and $\alpha <$ 6 MeV in combination with an air flow up to 50 m³/h.

This application uses a two-detector system of flow-type proportional counters. In this case, however, the separation foil between the counter tubes is dimensioned such that low-energy alpha particles (artificial) can be detected in the bottom counter tube and high-energy alpha particles (natural) in the bottom and center counter tube. Through calibration and optimization one can reach an ideal cut of approx. 5.8 MeV with this detector configuration. By means of a simple coincidence stage for the alphas of the two tubes, the alphas can easily be identified as natural alphas and distinguished from artificial alphas. Oblique running high-energy alpha particles can be detected in addition in the bottom counter tube by means of a simple pulse height analyzer mechanism.

Description of the Monitor

A powerful side-channel blower (50 m^3/h = 30 cfm) aspirates the air through a 200 mm ∅ glass fiber filter located on a sinter metal support. The detector, a proportional sandwich counter tube with suitable separation foil for high and low-energy alphas, is located directly above the dusting unit. The charge-sensitive preamplifier with built-in coincidence and anticoincidence module is located directly on the counter tubes. The data logger LB 5310 is employed for evaluation; this unit includes all common interfaces used in nuclear technology.

All components are housed in an mobile 19" rack. The air flow required for calculation of the respective activity concentration is measured and calculated on-line. Since proportional counter tubes operate in the alpha plateau, no lead shielding is required (see Fig. 1).

Performance Features

A high air flow rate is imperative for achieving a high representativity of the measurement. Using the glass fiber filter and large-area proportional counter tubes one can realize a flow rate of 50 m^3/h (= 30 cfm). The high efficiency of the detectors together with the high air flow rate guarantee an excellent statistics, which, as a consequence, results in a virtually negligible false alarm rate and an extremely low detection limit. The typical properties of proportional counter tubes, i.e. the fact that the efficiency curve is hardly dependent upon the alpha energy, ensure a consistent sensitivity of the monitor not only for plutonium-239 but also for plutonium-238 and uranic isotopes.

Dustloading is no problem for the AERD monitor, since the AERD compensation factor (the ratio of counting data of both detectors) is directly proportional to the air flow rate. A change in the air flow rate, on the other hand, is directly proportional to a change in the dustload on the filter; by measuring the flow rate, the correct compensation factor is determined and used. Since all alpha energies < 6 MeV are measured in the bottom counter tube, the problem of shifting thresholds and drifting ROI's does not exist for the AERD monitor.

Moreover, AERD monitors are easy to calibrate, so that recurring tests at site can be carried out within a few minutes.

As many experiments and measurements have shown, the AERD compensation factor does not change with varying radon or thoron activity concentrations or their fluctuations, so that this method may also be employed with success under difficult conditions, such as frequently changing ventilation conditions, fluctuating levels and dust-loaded air (see Fig. 2).

Conclusions

The combination of the semi-spectroscopic analysis with a high-volume technique has resulted in a monitor which is highly capable of mastering difficult measuring tasks. CAM monitors operating according to the AERD method are capable of determining a DAC hour with a very high statistical accuracy within a very short time. CAM monitors can be employed in any situation where air-borne alpha activity concentrations need to be monitored.

References

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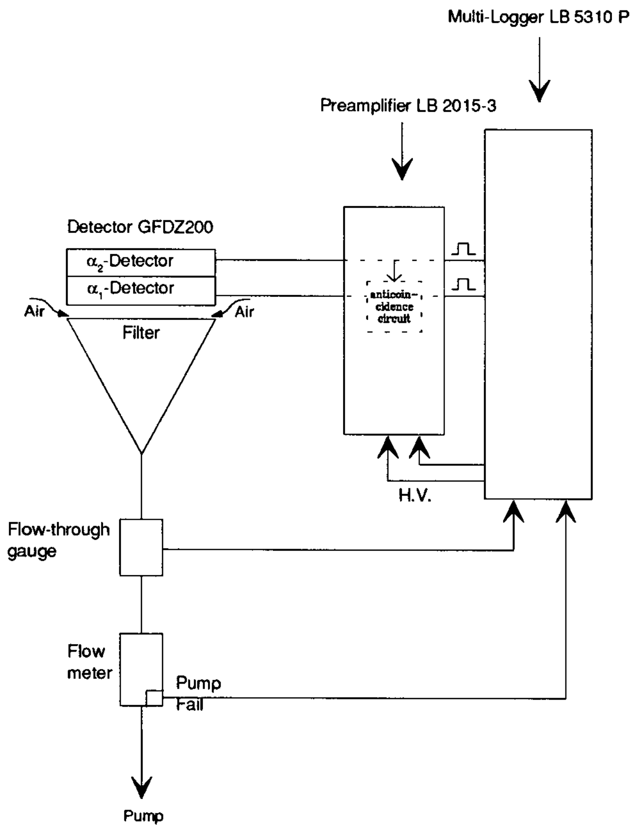

Fig. 1: Function diagram of the AERD-CAM-System

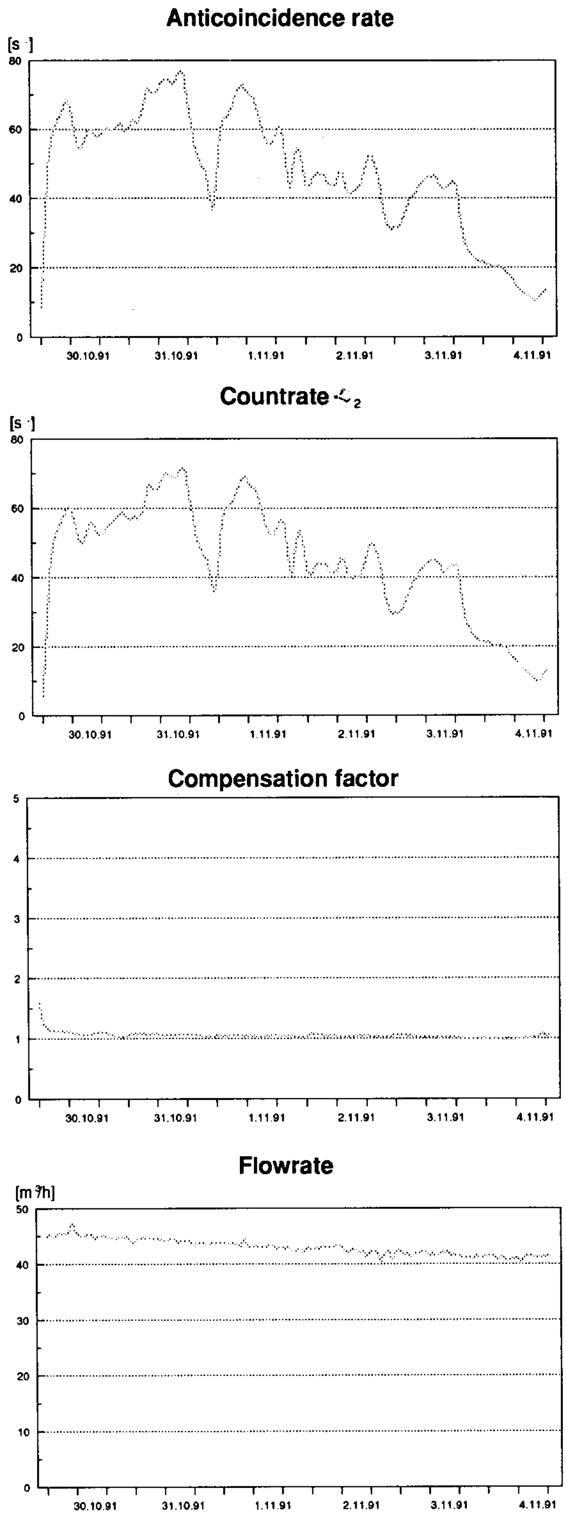

Fig 2. shows from top to bottom the curves of the anticoincidence rate, the $alpha_2$ counter tube rate (directly proportional to the natural activity concentration), the compensation factor and the flowrate