Calibration Of An Alpha-Beta Moving Filter Particulates Monitor

Alfred Klett, Leo DeMey, Wolfgang Erath and Peter Nemecek

Abstract--**Sampling and detection of airborne particulates is a dynamical process and depends on the detailed characteristics of monitoring instruments. A clear understanding of the impact of these details is essential for superior designs and optimized conditions of operation. Therefore the new moving filter particulates monitor BAI 9128-ENV for environmental monitoring of airborne activity was carefully calibrated by injection of known activity concentrations. These experiments were conducted at the NRG calibration facilities in Petten, the Netherlands. The instrument's calibration factor and its dynamic behavior were determined from these measurements. Different techniques for the compensation of natural activities were applied and investigated. Detection limits in the presence of Radon were determined. Index Terms – Air Monitoring, environmental, particulates.**

I. INSTRUMENT'S DESCRIPTION

The particulates monitor BAI 9128-ENV is a moving filter monitor with pumping unit and with a silicon semi-conductor detector for the detection of charged particles. This monitor is considerably smaller than another monitor type with fixed filter that was described earlier [1].

The silicon detector with a large sensitive area of 600 mm² is a ruggedized version to resist rapid pressure drops during operation. The detector bias is 70 V. The analog signals from the detector were processed by a low noise preamplifier and discriminating module with α-β particle discrimination capability. Natural activity levels from radon, thoron and their progeny were determined for subtraction using pseudo-coincidence or α-β ratio compensation techniques, which will be described below.

The pumping unit provides an airflow of 4 m³/h, which is continuously measured by a mass flow meter. The filter cassette unit transports glass fiber filters at speeds 5, 10, 12.5 or 15 mm/h in semi-continuous mode. The maximum autonomous operation period is 8000 h.

The μ-processor electronics acquires gross alpha, gross beta, total, random and net pseudocoincidence counting rates. A personal computer for visualization, analysis and storage of the measured data is connected through RS232 to the data buffer of the electronics module. The principal setup of the instrument is shown in Fig. 1 and the signal processing schematics in Fig. 2. The specifications of the instrument are summarized in Table I. More details about this system [2] and about another air monitoring system test [3] can be found elsewhere.

Manuscript received November 24, 2001, revised April 15, 2002. The authors are with Berthold Technology GmbH & Co. KG, Calmbacherstr. 22, 75323 Bad Wildbad, Germany (email: Alfred.Klett@BertholdTech.com).

TABLE I
TECHNICAL DATA MOVING FILTER MONITOR BAI 9128-ENV

Detector	Ion implanted Silicon detector 600 mm² area, 300 μ depletion
Detection efficiency	20% for α (^{241}Am) 25% for β (^{36}Cl)
Nominal airflow	4 m³/h
Measuring range (at 20 Bq/m³ Radon level)	0.3 – 10^6 Bq/m³ for artificial α's 0.5 – 10^6 Bq/m³ for artificial β's
Shielding against external γ	30 mm Pb
Temperature range	0°C – 40°C
Maximum autonomy	8000 h

II. TESTS OF THE SAMPLING SYSTEM

The calibration is not only affected by the radiation detection, but also by the sampling system. Therefore the accuracy of the filter speed and of the airflow measurement was carefully investigated. The accuracy of the filter speed was determined at the begin, in the middle and at the end of a filter tape. The maximum deviation from the nominal speed was only 1.2%. The accuracy of the flow meter was better than 2%.

III. CALIBRATION WITH ^{24}NA INJECTION

The calibration of the instrument was tested at the NRG calibration facility in Petten, the Netherlands, by injection of known activity concentrations of particulates labelled with ^{24}Na. The NaCl aerosols were produced at NRG in a TSI 3076 particulates generator. The distribution of the size of the particles was measured. Their mean diameter was 50 nm.

The data were recorded at measuring periods of 10 minutes and at filter speed 12.5 mm/h. The results are shown in Fig. 3. The injected activity concentration is indicated by a solid line, while the measured values of the beta-activities are represented by dots. The dynamic behavior as well as the accuracy of the calibration can easily be extracted from these data. The response was 12% higher than the injected reference activity concentration. The overall accuracy of the calibration is excellent. It includes all effects of particulates retention in the sampling system and it also includes the efficiency of the radiation detection and the impact of the background compensation on the result. The instrument's risetime from 10% to 90% was 1.33 h.

IV. MINIMUM DETECTABLE ACTIVITY

One of the main issues in monitoring of airborne radioactivity is a reliable subtraction of natural background.

The instrument makes use of two different compensation techniques (see fig.4).

The pseudocoincindence method utilizes a characteristic feature of the Radon decay chain. ^{214}Po is generated by a beta-decay. It disintegrates by alpha emission with a half-life of only 164 µs. This pseudocoincident beta-alpha sequence can be used to identify and measure Radon progeny levels.

The alpha-beta ratio compensation technique assumes that all detected alphas are only from natural background and that the natural alpha-beta ratio is constant. With the assumption of zero artificial alpha concentration it can only be used for monitoring beta activities. In general the pseudocoincidence method is superior, because it allows simultaneous alpha- and beta- measurement. These techniques were also discussed in reference [4].

TABLE II
DETECTION LIMITS

Measurement	Compensation technique	Minimum Detectable Activity [mBq/m^3]
α artificial	Pseudocoincidence	109
β artificial	Pseudocoincidence	342
β artificial	α-β ratio	240

Both methods have been studied at varying Radon levels. The detection limits obtained with a peak Radon level of 6 Bq/m^3 are summarized in table II. The alpha-beta ratio compensation shows a lower beta detection limit.

V. SUMMARY

The moving filter particulate monitor was carefully investigated and tested. The accuracy of the overall calibration of the activity concentration measurement was found to be 12% using ^{24}Na labelled aerosol injection. The minimum detectable activities of artificial airborne beta activity concentrations were reported and were well below 0.5 Bq/m^3. The response time was 1.33 h. The detection limit for artificial alphas was at 0.1 Bq/m^3.

VI. REFERENCES

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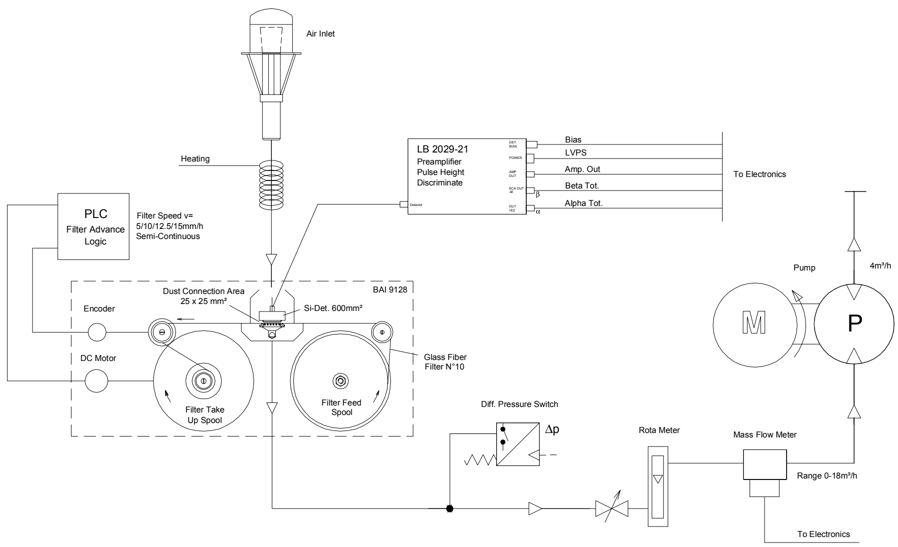

Fig. 1. Schematic arrangement of the sampling and detection unit.

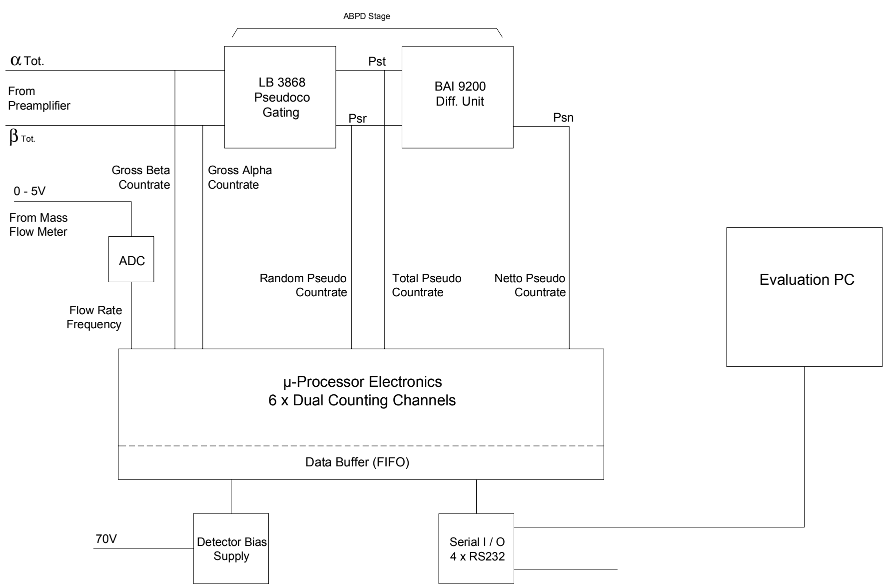

Fig. 2. Schematic diagramm of signal processing

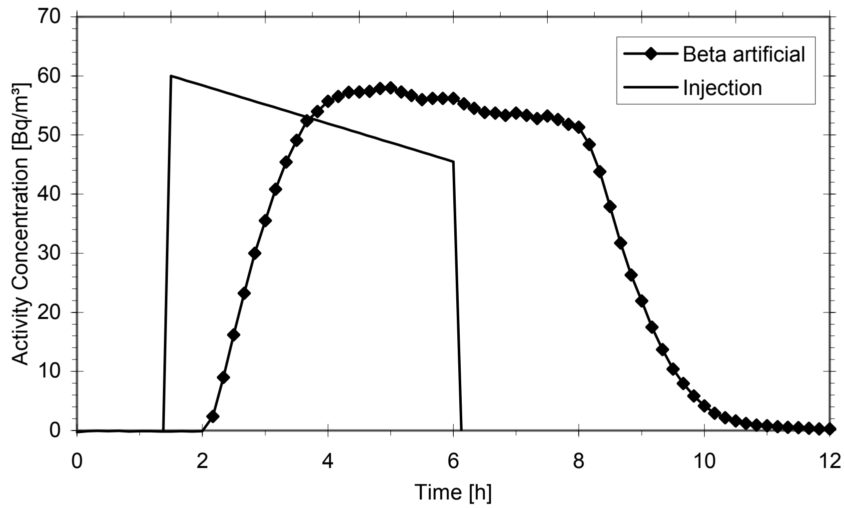

Fig. 3. Injection of known activity concentration and beta-artificial reading as a function of time.

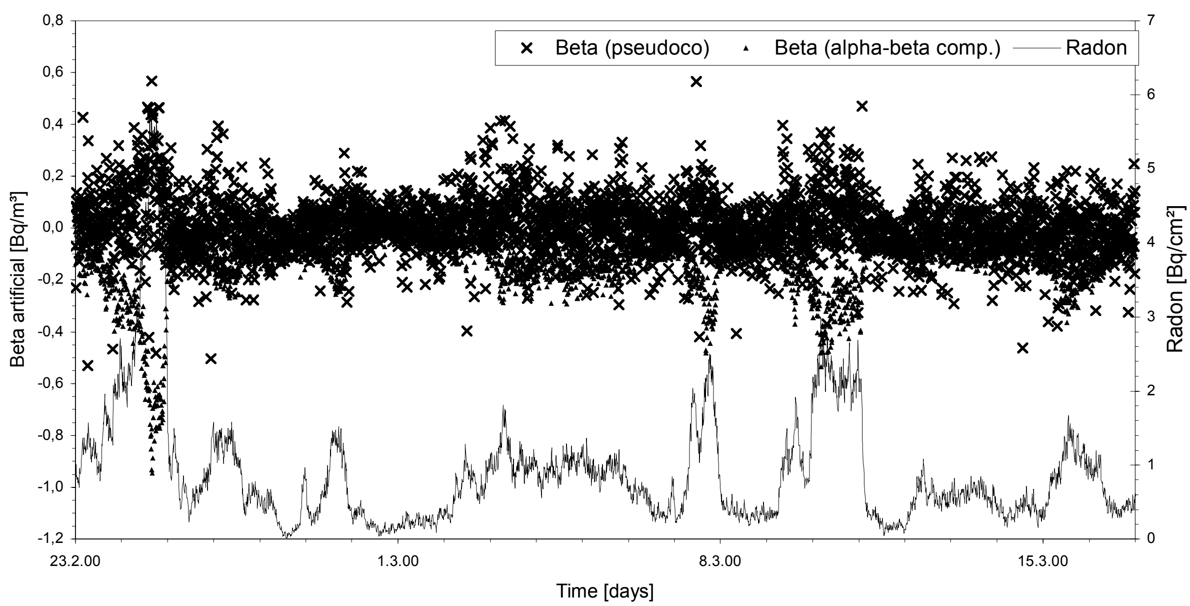

Fig. 4. Comparison of background compensation with pseudocoincidence and alpha-beta ratio techniques.