FIRST RESULTS OF TESTING A STEPWISE ROTATED AEROSOL FILTER SYSTEM FOR ENVIRONMENTAL MONITORING

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INTRODUCTION

The monitoring of the gross beta aerosol activity released from nuclear facilities is of great importance for environmental surveillance. In order to measure this activity by one monitor, both during normal operation (down to 10^{-2} Bq/m^3) and in the case of an accident (up to 10^6 Bq/m^3) this device must cover a range of more than eight orders of magnitude. Moreover this equiqment should not be too expensive in construction and operation, it should be very simple in regard to the sampling technique and it should comply with all requirements made by national regulations and modern data handling. Until now no such monitor has been available. In the past few years the Nuclear Research Center Jülich has developed a stepwise rotated aerosol filter system for environmental monitoring. The system and the first results of its tests will be reported in this paper.

BASIC CONSTRUCTION AND SPECIFICATIONS

The basic construction of the stepwise rotated filter system is shown in Fig. 1. The air enters from the right. The filter is contaminated in the contamination chamber, from where the air goes to the pump. There are 43 filter spots, 41 to measure the air concentration, one for the calibration of the detectors, and one for the background measurements. Three end-window detectors measure the contaminated filter spots: D1 during contamination, D2 immediately after contamination and D3 after the decay of

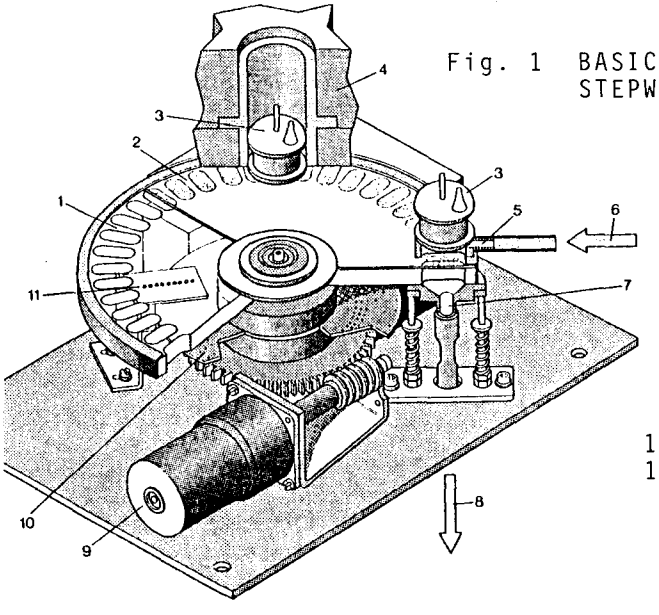

Fig. 1 BASIC CONSTRUCTION OF THE STEPWISE ROTATED FILTER SYSTEM

1 rotated disc with holes
2 filter
3 end-window detector
4 shielding
5 contamination chamber
6 air input
7 suck-in device
8 to the pump
9 motor to rotate the disc
10 coded position disc
11 position control

the short-lived natural activity. To guarantee an operation without interruption two such devices form one unit. For a good decay analysis of the detector D2 a contamination time of each of the filter spots should last one day at least. Various criteria cause software to initiate a rotation of the filter under the chosen detector. The air passes at 1 m^3/h through the filter spot of 6 x 20 mm^2. The rotating disc has a diameter of 200 mm. The measured specification of the three detectors, their efficiencies, their backgrounds and their maximum possible rates are given in Table 1.

detector VALVO 1441	efficiency	background	maximal possible rate
		pulses per second	
D1	0.13	0.1	10^4
D2	0.20	0.1	10^4
D3	0.20	0.1	10^4

Table 1 MEASURED SPECIFICATIONS OF THE DETECTORS

THE FUNCTION OF DETECTOR D1

During normal operation detector D1 measures, as a rule, only the natural radioactivity, which is not constant. In Fig. 2 the measured values of a stepwise moved filter tape (curve S1) and of the stepwise rotated filter system (curve D1) are compared. The measurements are carried out during the same contamination period. The differences are caused by the different types of filter paper (S1: charcoal contaminated filter paper; D1: glass-fiber filter) and the amount of air pumped through the filter spots. The air flow of the stepwise moved filter tape is higher by a factor of 10, which is also the reason for the reduced air flow after about 10 hours contamination time. If the curves are normalized they are identical. From the shape of a "mean curve" and its errors a signal is to be derived, if artificial radioactivity is in the air. But this is still under development.

In the case of an accident the detector D1 must be able to measure every possible high concentration. From the pump rate, the detector efficiency, the maximal possible pulse rate and a contamination period of 3 min the maximum measurable concentration of 1.5 10^6 Bq/m^3 is calculated. If we also operate the tube in the non-linear part of the tube characteristic the sampling time or the measurable concentration can be greater by a factor of about 6. Taking into account all possible filter spots (2 x 41), this device is able to operate for about one day without changing the filters. Moreover, the development of the air contamination is documented by the sequence of the contaminated filter spots, which may be later measured by gamma spektrometry in the laboratory. In the case of an accident the rotation of the filter is controlled by the software and a given maximum pulse number.

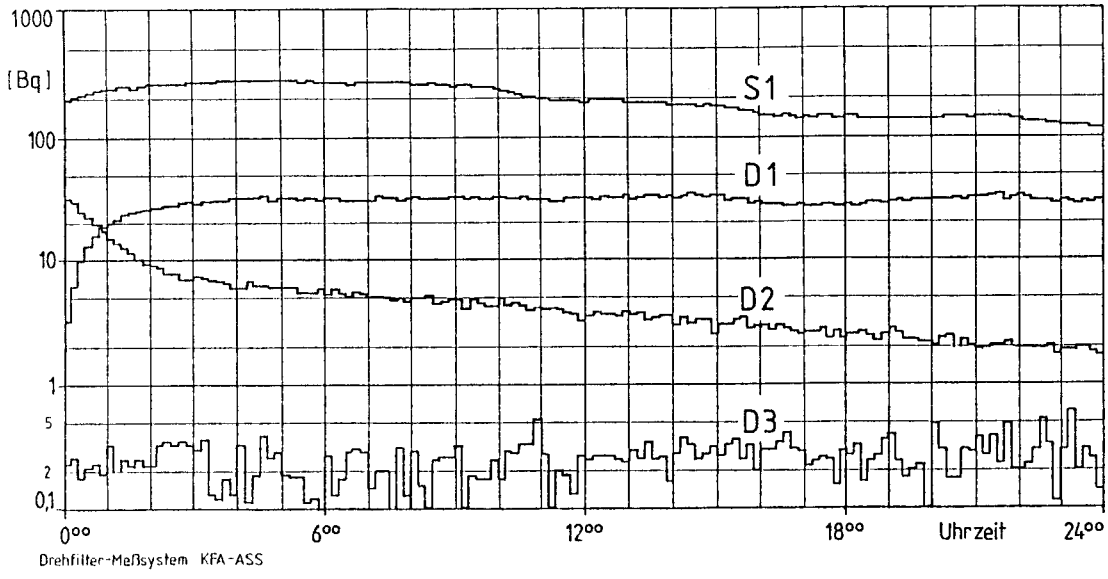

Fig. 2 MEASURED CURVES OF THE STEPWISE MOVED FILTER TAPE (S1), THE STEPWISE ROTATED FILTER SYSTEM (D1), THE DECAY CURVE (D2), AND THE LONG-LIVED RADIOACTIVITY (D3)

THE ANALYSIS OF DETECTOR D2

In accordance with national requirements, in environmental surveillance a filter is normally contaminated over a 14-day period. After the decay of the short-lived natural nuclides the filter is measured in the laboratory. The results are available about 20 days after the beginning of contamination. In our new device, the detector D2 starts the analysis about 3 hours after the end of the contamination period (Fig. 2). The results are available at the end of the second day after the beginning of contamination. By this procedure a contamination of a long-lived nuclide with a concentration of about 0.05 Bq/m^3 can be analyzed. An example of such an analysis in shown in Fig. 3.

Analyse Aerosole - Abklingverhalten
(Analysis of aerosol radioactivity decay)

Gerechnet bis 1421 Minuten = 23.69 Stunden		calculated up to 1421 min = 142 measurements
Ausgewertete Datensätze = 142		
Pb 214 (Ra B)=	3.36 Bq ± 7 %	
Pb 212 (Th B) =	1.12 Bq ± 23 %	
Langl.Anteil =	0.61 Bq ± 19 %	long-lived activity

Fig. 3 NUMERICAL RESULTS OF A DECAY ANALYSIS WITH DETECTOR D2

This analysis gives the first indication of artificial air contamination within 2 days. This result has to be confirmed by the measurements of detector D3.

MEASUREMENT OF THE LONG-LIVED RADIOACTIVITY BY DETECTOR D3

The long-lived radioactivity deposited on the filter is measured by detector D3 after a decay period of 5 days for natural short-lived radioactivity (Fig. 2). The detection limit of about 10^{-4} Bq/m^3 is determined by the detector efficiency, the well-known background, and the measuring time of 24 hours. Our tests have shown that it is necessary to pump off the air of the volume around the detectors to get a low and constant background which if possible is not influenced by the concentration of radon and its daughters. The detection limit achieved is more than one order of magnitude lower than the requirements of our national regulations.

CONCLUSION

The reported results have been obtained by one prototype of a stepwise rotated filter system, which has been in operation under realistic conditions for more than six months. For the interpretation of the data a simplified software was used. The tests have shown that calculated detection limits and a measuring range of eight orders of magnitude are achieved. This means that the stepwise rotated filter system is a good monitor for environmental surveillance, both for normal operation and in the case of an accident.

The analysis of the measurements of detector D2 indicates an artificial air contamination at the end of the second day. This is much faster than the results of the environmental surveillance procedure normally used, which are available about 20 days after the beginning of the contamination of the filter.

In 1988 seven such units are to be built to replace the old stations of the inner surveillance ring of the Nuclear Research Center Jülich, which is now equipped with stepwise moved filter tapes. Operation of these new stations with the central processor and a sophisticated software has still to be tested.

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