BERTHOLD TECHNOLOGIES

RADIATION PROTECTION

Moving Filter Particulates Monitor
BAI 9100 D

With compensation for and optional measurement of Natural radioactivity

The **Moving Filter Monitor BAI9100D** measures **Alpha and Beta Particulates activity** in Stack or Environmental monitoring applications

Introduction

The Moving Filter monitor has following key features:

- The Filter transport can be continuous or stepwise. The filter tape is led over a slotted capstan drive through which the sampling air is drawn. This ensures a uniform dust collection with a continuous smooth filter advance without risk of rupturing the filter.

- The detector is mounted directly over the dust collection area and promptly measures the particulates radioactivity.

- The dust collection and detector assembly is shielded by an enveloping 4pi lead shield. This results in a low intrinsic background and small ambient radiation Sensitivity. Should this not be sufficient in strong to compensate the influence.

- The large collection area allows a high flow rate of 25 m^3/h hence low detection limits.

- As an Option a delayed measurement can be offered which measures the activity on the filter 120 h (5 days) after collection, virtually eliminating any Radon progeny influence from the result which results in Detection limits for artificial Beta activities lower than 1 mBq/m^3.

- If required an automatic measuring range extension can be achieved by fast advance of the filter tape.

- In the standard version a Beta plastic scintillator detector BAI9300B with high dynamic range is used, resulting in a wide measuring range. Optionally an Alpha-/Beta Scintillator Detector BAI9300AB can be used to detect simultaneously in separated counting channels Alpha and Beta activities.

- With the Alpha-Beta measurement the influence of natural radioactivity is compensated by the Alpha/Beta ratio method or optional with the Alpha-Beta pseudo coincidence method (ABPD).

- If required the Moving Filter monitor can be combined with an Iodine and/or Noble gas monitor in the same 19” cabinet.

- For data-logging and evaluation the 2/3 channel electronics LB5310 Multi-Logger, the 6 channel BAI9111 µ-logger or the flexible multi counting channel data-logger LB9000 can be used.

The **Monitor BAI 9100 D** consists of following building blocks:

- A dust collection unit BAI9100D. This collection unit allows installing a prompt Beta or Alpha-Beta measurement as well as a prompt Gamma measurement. The Beta or Alpha-Beta detector is mounted on top of the dust collection area which ensures measurement while collecting activity. The Beta or respectively the Alpha/Beta Detector measures directly on the dust collection area in order that no delay occurs in the evaluation. The sample air is drawn in via a flat nozzle through the glass fiber filter. Additionally a delayed Measurement position is available with up to 120 h delay, depending on the filter speed. Optionally this position may be equipped with a Beta- or Alpha/Beta-Detector.

- A Cassette in Aluminum (Option Stainless Steel) with IP68 protection degree and a transparent Plexiglas front door which envelopes the medium wetted parts. On the back side of the Cassette the Capstan drive mechanism and filter tape sensors are mounted. The Capstan drive mechanism ensures a virtually tension free filter advance and makes it less prone to filter rupture even with a humid filter tape. The Cassette is built to 19" Standard and is suited for mounting into a 19" enclosure. The front door is secured with 2 screw closures and an optional „Door Open" sensor.

- A PLC Unit to drive and monitor the Stepper motor filter advance mechanism.

- A Pump unit equipped with a maintenance free lateral blower pump, suited for temperatures up to 45°C and designed for a sample airflow of 25 m³/h with flow sensor or an optional flow meter (Vortex or Calorimetric measurement principle).

- A Beta-Detector BAI9300 B with Plastic Scintillator and integrated Preamplifier BAI9207-1. The Detector delivers digital Norm pulses that are fed to the Evaluation electronics.

  alternative

- An Alpha-/Beta-Detector BAI9300AB with ZnS coated Plastic Scintillator and Preamplifier unit LB2030 for simultaneous, separate Alpha and Beta activity measurement. The Analog signal from the Detector is converted into digital Norm pulses in the preamplifier LB2030 which are fed to the Evaluation electronics.

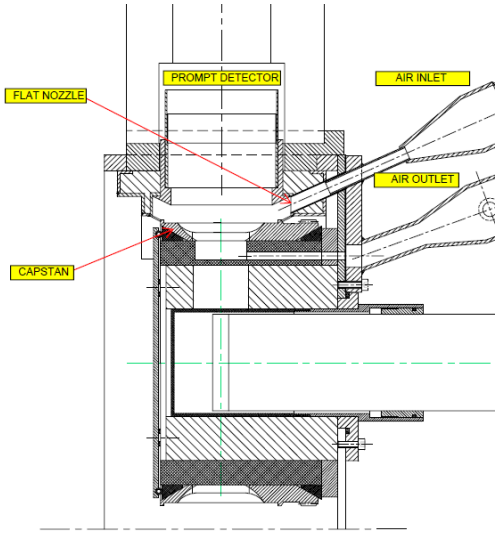
- Evaluation electronics depending on the application field (room or process gas, environmental or Stack monitoring): LB5310 Multi-Logger, BAI9111 Micro-Logger or LB 9000 Data- Logger.

- A 19"-Enclosure which contains the above Components.

Operating Principles

The sample air is drawn in the Cassette with a lateral blower pump unit via a flat nozzle and passed through a glass fiber filter tape which retains the particles on a 50 x 50 mm² strip. The filter tape is advanced in preprogrammed large steps or continuously in very small (0.3 mm) steps with a DC Stepper motor to ensure a homogenous particle distribution on the filter tape. Filter transport and End of tape is monitored with 2 inductive sensors. The filter rupture sensor is located on the left idler beside the Capstan whereas the filter end sensor is located on the filter feed spool.

Operating Principle Moving Filter



The sample air is drawn with the pump via the Inlet flange on the top side of the monitor and is brought to the dust collection area, located directly under the prompt Beta- or Alpha/Beta-detector, through a smooth inner surface stainless steel pipe. The aerosols are trapped in the filter tape en measured with the prompt detector. The filter tape is conducted from the feed spool over the Capstan and guide rolls to the filter take-up spool. The tape is advanced through the Capstan rotation by means of a stepper motor which ensures a steady rate of filter advance.

In Step Mode operation the monitor behaves like a fixed filter monitor (Activity Release Balance). Depending on the required cycle time the filter is advanced (changed) automatically in preset intervals (for instance daily).

To obtain a wider dynamic measuring range in Step mode the measuring and stepping intervals can be increased whereas in continuous mode the filter speed can be augmented. The cycle times or filter speeds can be preset through internal parameters or activated via an external trigger input.

As an option the airflow rate can be continuously measured with a flow meter. The calorimetric flow meter measures the Normalised sample volume flow (NTP volume flow to DIN ISO 2533 normalised to 1013 hPa, 15°C and 0% relative humidity). This type of flow measurement has no moving parts like a turbine and requires therefore little or no maintenance. The flow meter is installed after the Cassette and before the pump unit. The Analog output signal is connected to the Evaluation electronics for further processing, monitoring and registration.

The Detectors used for prompt and delayed measurement are scintillation-PMT types. The plastic scintillator detector BAI9300B is used for Beta only measurement, the ZnS coated plastic scintillator detector BAI9300AB is used for Alpha/Beta-measurements.

The separation between Alpha and Beta radiation in the Alpha/Beta- detector is obtained through pulse height discrimination inside the LB2030 preamplifier.
In the LB2030 the analog signal is presented to two pulse height window discriminators after amplification and pulse shaping in a first amplifier stage. The discriminators split the analog signal in two separate Alpha and Beta norm pulse outputs.
The norm pulse output signals from the LB2030 preamplifier or the direct output of the Beta detector are connected to the digital counter inputs of the Evaluation electronics.

Evaluation Electronics

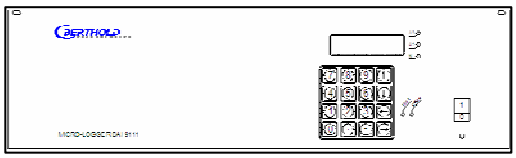
Several Electronics are available to interface & monitor the 9100D detector and sensor signals :

- 3 Channel counting electronics LB5310 Multi-Logger
- 5 dual counting channels electronics BAI9111 Micro-Logger
- Flexible Multi-counting channel Data logger LB9000 with up to 20 Channels

The application software in these electronics allows the free setting of System- and Measurement parameters.
For the LB5310 and the LB9000 additional service functions are available s.a. Background, Calibration, Radon compensation (pseudo coincidence factors), and Performance tests.

All data loggers are equipped with V24/RS232 serial interfaces for data transmission or logging of relevant measurement or operating parameters. The data are stored in a FIFO Data buffer.
Further details on each of the Evaluation electronics presented here can be found in the corresponding data sheets of each data logger.

LB 9000 Datenlogger



LB 9111 Micro-Logger

LB 5310 Multi-Logger

Detection Limits

- Continuous filter speed 10 mm/h
- Based on DIN 25482
- $k_{1-\alpha} = k_{1-\beta} = 1,96$ (false positive, false negative conf.level)

Prompt Measurement with Alpha/Beta-Detector without presence Nat. Activity

Alpha

Meas. time [s]	Det. limit [cps]	MDC [Bq/m³]
600	0,012	0,001
1800	0,007	0,001
3600	0,005	N/A
7200	0,004	N/A

Beta

Meas. time [s]	Det. limit [cps]	MDC [Bq/m³]
600	0,226	0,021
1800	0,131	0,012
3600	0,092	0,008
7200	0,065	0,006

Prompt Measurement with Alpha/Beta-Detector and ABPD-Compensation

And an assumed Radon daughter volumetric activity concentration of : 3,7 Bq/m³

Alpha

Meas. time [s]	Det. limit [cps]	MDC [Bq/m³]
600	1.506	0.143
1800	0.869	0.083
3600	0.615	0.058
7200	0.435	0.041

Beta

Meas. time [s]	Det. limit [cps]	MDC [Bq/m³]
600	2.921	0.266
1800	1.687	0.153
3600	1.193	0.109
7200	0.843	0.077

And an assumed Radon daughter volumetric activity concentration of: 37 Bq/m³

Alpha

Meas. time [s]	Det. limit [cps]	MDC [Bq/m³]
600	4.761	0.452
1800	2.749	0.261
3600	1.944	0.185
7200	1.374	0.131

Beta

Meas. time [s]	Det. limit [cps]	MDC [Bq/m³]
600	9.238	0.841
1800	5.334	0.485
3600	3.772	0.343
7200	2.667	0.243

Prompt Measurement with Alpha/Beta-Detector and Beta/Alpha Ratio -Compensation

And an assumed Radon daughter volumetric activity concentration of:

3,7 Bq/m³

Beta

Meas. time [s]	Det. limit [cps]	MDC [Bq/m³]
600	1.065	0.097
1800	0.615	0.056
3600	0.435	0.040
7200	0.307	0.028

37 Bq/m³

Beta

Meas. time [s]	Det. limit [cps]	MDC [Bq/m³]
600	3.367	0.306
1800	1.944	0.177
3600	1.375	0.125
7200	0.972	0.088

Delayed Measurement with Alpha-Beta Detector

Alpha

Meas. time [s]	Det. limit [cps]	MDC [Bq/m^3]
600	0.226	0.015
1800	0.131	0.009
3600	0.092	0.006
7200	0.065	0.004

Beta

Meas. time [s]	Det. limit [cps]	MDC [Bq/m3]
600	0.152	0.014
1800	0.088	0.008
3600	0.062	0.006
7200	0.044	0.004

Radon Progeny Compensation

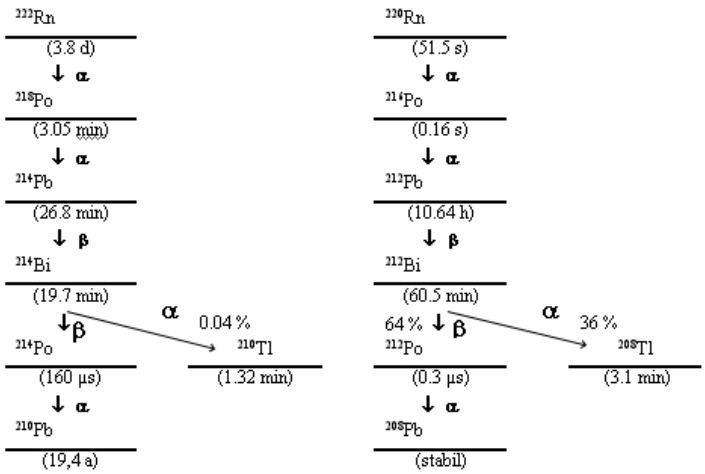
To detect the lowest levels of artificial radioactivity in the presence of natural activity (Radon/Thoron-progeny), which can fluctuate between 1 and several hundred Bq/m³ depending on the location, season of the year, time of day or night, weather conditions; a solid discrimination against natural activity is required. For a Beta only monitor this can be achieved using the Beta/Alpha ratio compensation method and the ABPD compensation method for an Alpha/Beta monitor.

Beta/Alpha ratio compensation

This compensation method relies on the assumption that all Alpha activity is resulting from Natural occurring isotopes. The Beta radiation is indicated as net artificial activity by correcting the gross activity for the natural component using the Beta/Alpha ratio formula: Beta art net = Kb*(B – aA), with A and B the background corrected count rates from Alpha and Beta channels, Kb the calibration factor for the Beta Channel and a the compensation factor derived from the Beta/Alpha count rate ratio measured *without presence* of artificial activity.

ABPD-Compensation and Measurement principle

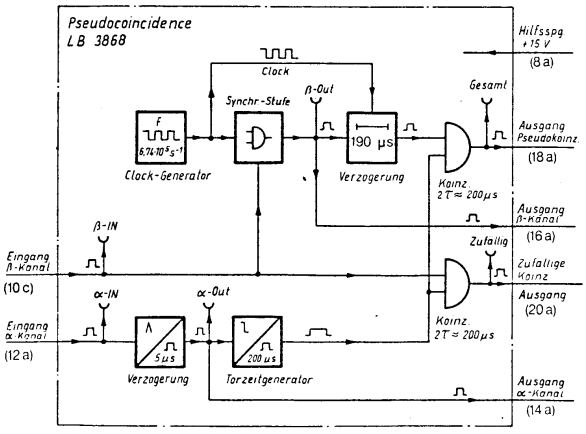
Alpha Beta Pseudo-coincidence Difference method



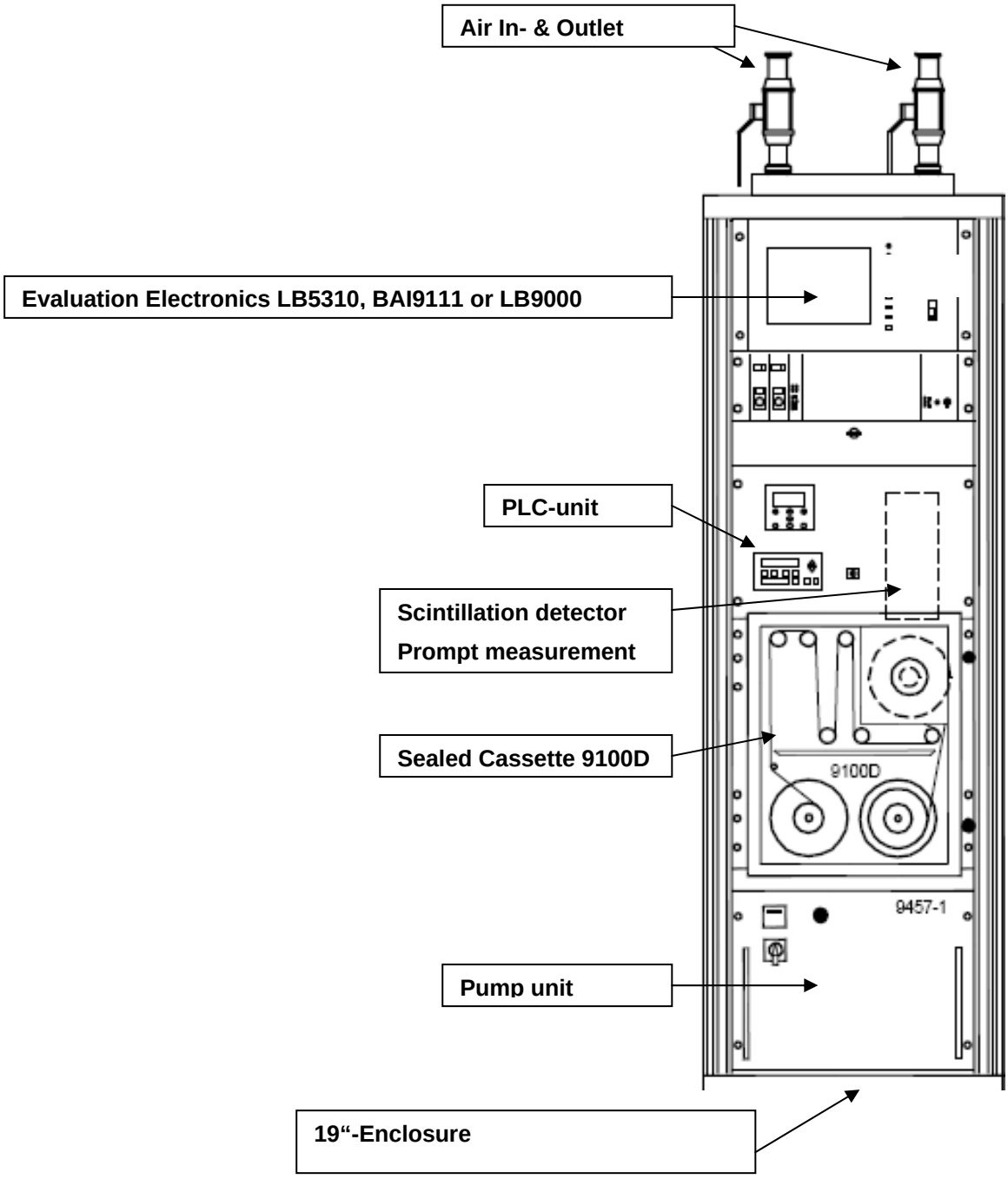
The ABPD method uses the specific measurement of the Bismut-214 decay into Polonium-214 and the Bismut-212 decay into Polonium-212 to compensate for natural activity.

Simplified we can say that the method is implemented in an electronics stage with a coincidence gate which is opened for a given time (>160µsec) as soon as a Beta decay is detected in the Detector. If during this gate time the Detector also 'sees' an Alpha decay a pseudo-coincidence pulse is generated which is a measure for the natural activity in the sample. In practice the electronics uses the Alpha counts to trigger the gate, whereby the Beta's are sent through a delay line. The reason for this is to obtain a wider dynamic range because in equilibrium the natural Alpha decays are about 1.6 times less than the natural Beta decays.

A good pseudo-coincidence stage should contain a second circuit to detect Random coincidences. These should be used to compensate the pseudo-coincidence stage for random coincidences at higher count rates to avoid overcompensation i.e. suppression of potential artificial radioactivity events. The ABPD module block diagram shown here has these 2 stages implemented the pseudo-coincidence stage (Bi-214/Po-214 and Bi-212/Po-212 decays) and the random (A/B) coincidence stage.



Components of the Moving Filter Particulates monitor BAI9100 D



Status Monitoring Functions of the System

The system is equipped with self-monitoring functions for the critical operating parameters which will report any Alarm threshold breaching or failure condition.

- Monitoring of Pump function
- Monitoring of Filter Tape status : filter end, filter ruptured or jammed
- Monitoring of the PLC unit
- Monitoring of the Collection Unit – door status (option)
- Monitoring for Detector failure of Alpha, Beta detector
- Breaching of pre-Alarm thresholds
- Breaching of Alarm thresholds for Alpha and Beta

Peripheral Interfaces

Depending on the selected Evaluation electronics a multifold of interfaces is available consisting of: Current Outputs (0/4-20 mA LIN/LOG), Current inputs (0/4-20 mA), serial printer and computer interfaces (RS232/V24 or other), Potential free relay outputs.

Brochure BAI 9100 D English Berthold Technologies GmbH & Co. KG
M. Madaric,/ LDM Rev01 10-12- 2010

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