

# Manual

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# Aer 5000

Desktop Online Continuous Air Monitor

Version May 2023

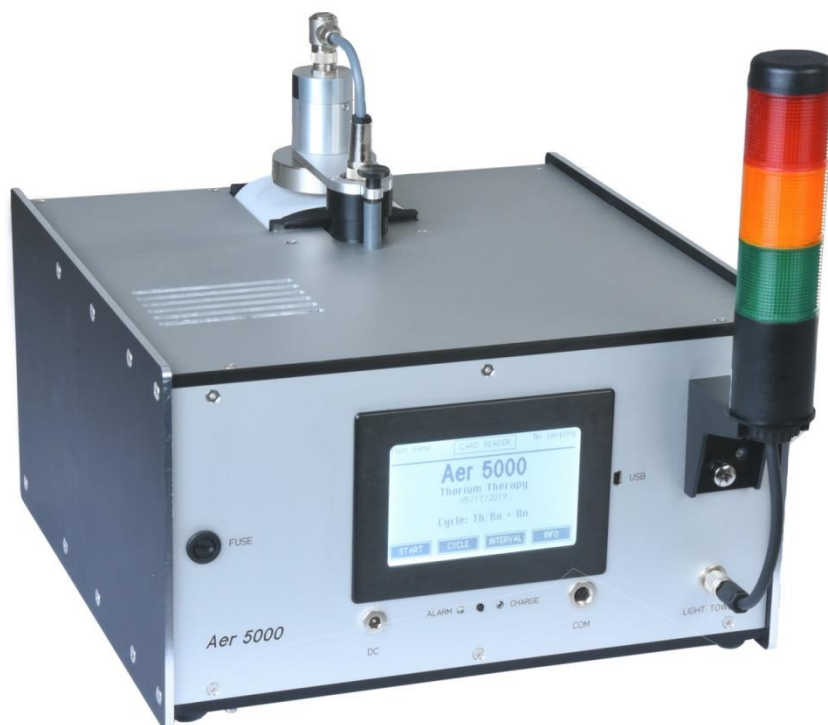
*Referenced documents*

*Software manual dVISION*

*Software manual dCONFIG*

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## Content

1. Applications and general information .....	4
2. Power supply .....	5
3. Filter replacement and flow control.....	5
3. 1. Filter sealing mechanism .....	6
3. 2. Replacing the filter tape .....	7
3. 3. Flow control .....	9
3. 4. End of filter and protection of the stepper drive .....	9
4. Tube connector (Option “S”) .....	10
5. Data storage .....	10
6. Instrument operation by menus .....	11
6. 1. Main page .....	11
6. 2. Module information and options .....	11
6. 3. Component configuration .....	12
6. 4. Selecting the cycle .....	12
6. 5. Recent readings display .....	12
6. 6. Displaying the data stored at the memory card.....	12
6. 7. Results shown on the display .....	13
7. Instrument set-up.....	13
7. 1. Clock switch .....	13
7. 2. Synchronized start of a measurement .....	13
7. 3. Display standby.....	14
8. Alert functions.....	14
9. Gamma background compensation for the beta channel .....	14
9. 1. Static gamma background compensation .....	15
9. 2. Dynamic gamma compensation, dose rate measurement .....	15
9. 2. 1. Dynamic gamma compensation .....	15
9. 2. 2. Measurement of local dose rate .....	16
10. Natural Uranium separation.....	16
11. Calculation of the average activity concentration .....	17
12. Operation conditions.....	17
13. Communication with a PC .....	17
14. User specific settings .....	18
14. 1. Changing the alert settings for radiometric measures.....	18
14. 2. Changing the threshold level for the count rate .....	18

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14. 3. Adjusting parameters for the gamma background compensation .....	18
14. 4. Changing units (US/SI) and dose coefficients .....	19
14. 5. Controlling the filter stepper drive .....	19
15. Test and maintenance .....	21
Appendix.....	22
Technical Data .....	23
Possible modifications of Air Monitor Aer 5X00-XXXX.....	26
Detection Limits.....	27

## 1. Applications and general information

The desktop online continuous air sampler Aer 5000 allows the measurement of the exposure of workers and first responders with respect to radioactive aerosols.

The Aer 5000 continuously monitors the ambient air to detect airborne radioactive aerosols (LLRD). Typical application fields are:

- **nuclear facilities**
- **the NORM industry**
- **mines**
- **nuclear medicine (e.g. ISO 16639)**

The unit is very suitable for limited space conditions due to its compact design.

The aerosols will be siphoned by the internal pump, deposited on the surface of a filter and analysed by spectroscopy. The natural background due to radon and gamma irradiation will be fully compensated.

The unit measures long lived radioactive dust (LLRD) as well as natural occurring Radon daughter products. Both values are presented separately. The influence of Radon daughters is dynamically compensated for LLRD detection. Following results are achieved from the acquired energy spectrum

- Alpha exposure, dose and average concentration for LLRD
- Beta exposure, dose and average concentration for LLRD
- Equilibrium equivalent concentration for Radon (Rn-222) daughters
- Equilibrium equivalent concentration for Thoron (Rn-220) daughters

If any of the user-adjustable thresholds is exceeded, audible and optical alerts are generated. Special attention has been paid on quality assurance. Air flow and filter status are logged in parallel with the radiation results. A complete energy spectrum is saved for each single sampling interval. The unit is equipped with an automatic filter stepper drive resulting in high reliability and low effort for maintenance. The instrument offers various measurement cycles to fit for several applications. The configuration and operation software package dCONFIG/dVISION will be delivered with the unit. The following picture shows the operational controls of the Aer 5000.



- a) Fuse
- b) Alert indicator (LED)
- c) Push button to exit display standby
- d) Charge indicator (LED)
- e) RS232 interface
- f) USB interface
- g) DC input (18...20V/60W)
- h) Connector for Signal light (alert outputs)

## 2. Power supply

The Aer 5000 is powered by a DC voltage of 18...20V which must be connected to DC input at the front panel. Please use only the original AC/DC adaptor with sufficient power rating, polarity and plug-size. The instrument is equipped with a battery to continue a measurement in case of power interruption. The pump is directly connected to the DC input voltage and therefore not buffered. If no measurement is running the electronic enters into sleep mode (display off) after a certain time. Remove the fuse to disconnect the power completely from the electronics if the instrument is not used over longer periods. Charge the battery before storage to avoid battery damages by deep discharging. The battery will be charged as soon as power is connected to the DC input.

## 3. Filter replacement and flow control

The aerosols are accumulated at a filter tape which will be positioned automatically above the air inlet of the instrument. The detector located above the filter measures simultaneously the decay of collected activity. The stepper drive ensures that exhausted filter pieces move in to the housing. Two optical sensors detect the end of the filter tape. A warn signal will be generated but it remains a piece of filter for one more step.

The filter drive can be controlled by several events which can be defined by the configuration of the instrument:

- Exhausted filter (flow rate cannot longer maintained by the flow controller)
- Collected activity exceeds a pre-set limit
- Fixed period (e.g. each interval, each day)

In delivery state, the filter only will step in case of exhaustion. Please read chapter “User specific settings” for more information regarding additional stepping conditions.

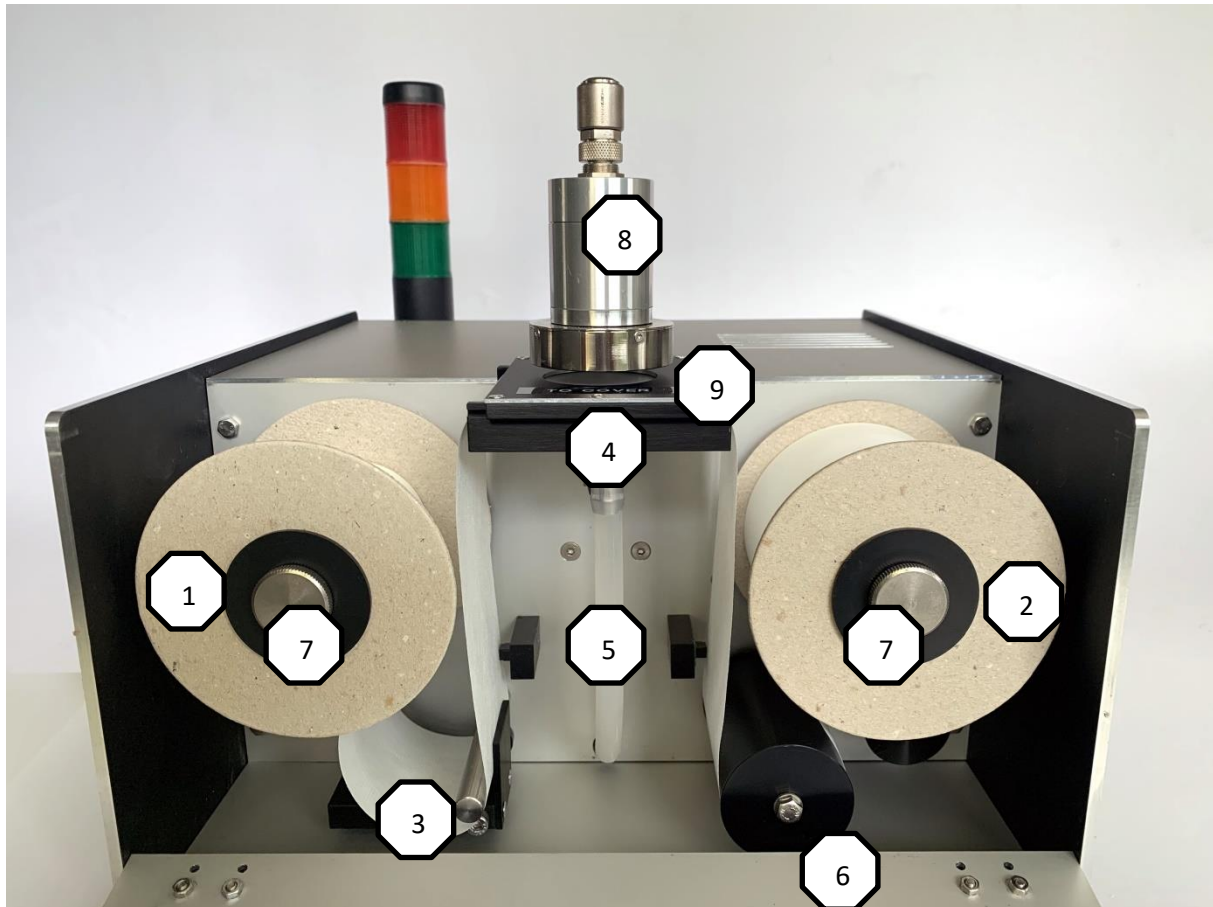
### **3. 1. Filter sealing mechanism**

The filter sealing mechanism avoids the partial bypass of the air stream through the filter. A soft rubber sealing will be pressed onto the backside of the filter while sampling. As soon as the pump stops, the filter sealing will be released (e.g. during automatic filter stepping). Please take care that the rubber sealing (O-Ring) is always placed correctly in the notch of the filter holder. The filter holder must be easily movable within the guide-way.

### 3. 2. Replacing the filter tape

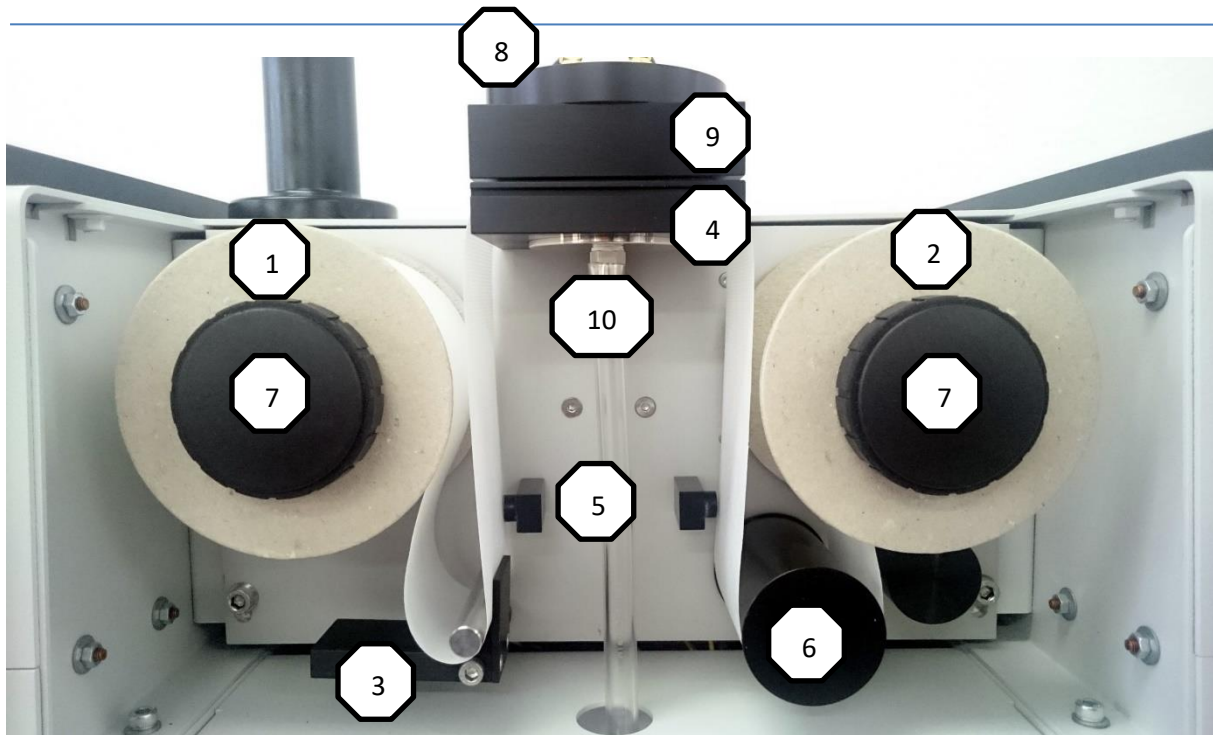
The measurement has to be stopped before changing the filter. The stepper drive can be accessed after hinge down the hatch at the rear side of the instrument.

The following pictures show the stepper drive with and without tube connector. Only manufacturer specified, 66mm wide filter tapes must be used.



Stepper unit of standard version with open face air inlet

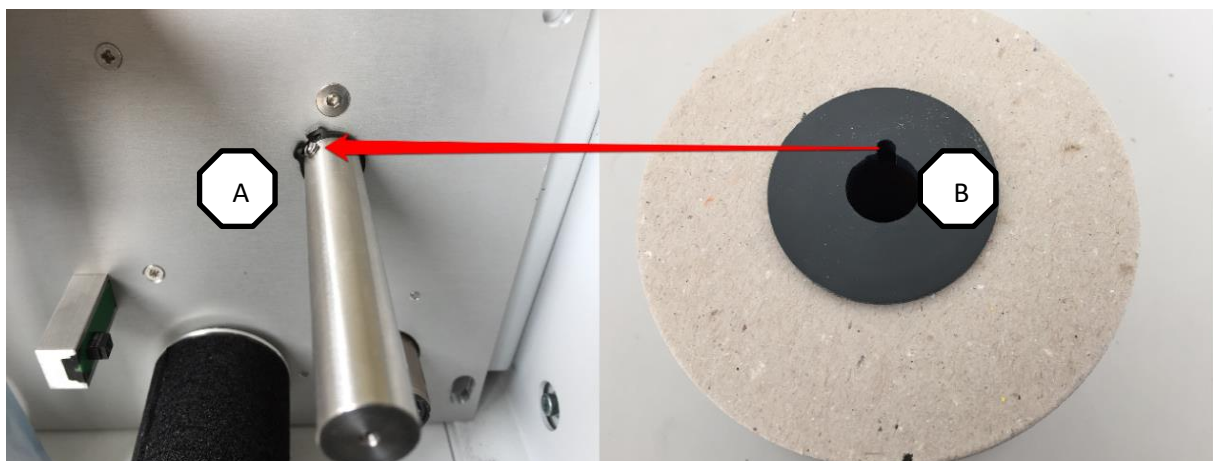
- 1) Coil with fresh filter
- 2) Coil with exhausted filter
- 3) Filter tension
- 4) Filter support
- 5) Optical sensors
- 6) Encoder for filter stepping distance
- 7) Locking screws
- 8) Detector head
- 9) Filter sealing plate (labelled side must point towards the hatch)



Stepper unit with tube connector

- 1) Coil with fresh filter
- 2) Coil with exhausted filter
- 3) Filter tension
- 4) Filter support
- 5) Optical sensors
- 6) Encoder for filter stepping distance
- 7) Locking screws
- 8) Detector cap
- 9) Filter sealing plate
- 10) Filter sealing mechanism

At first remove the both locking screws (7) from the axles. Now, both coils can be detached. The empty fresh filter coil acts as new coil for the exhausted part of the filter. When inserting the coil, take care for correct fitting of the tappet (A) at the axle and the slot (B) at the coil (picture below).





Attach the lock screws again after inserting the fresh filter coil too. Make sure that the fresh filter coil can be turned without strain.

Now, the filter tape can be inserted as shown in the picture. Please take care for the correct guidance. In case of a standard instrument with open face air inlet the access can be simplified by removing the filter sealing plate (the plate can be shifted to left). In addition, the detector head can be slewed sideward if the knurled screw to fix the swivel arm has been removed before. Feed the filter tape into the slot between filter support (4) and filter sealing plate (9) in case of an instrument with tube connector.

The filter has a smooth and a rough side. The smooth side must point towards the detector head. Make sure that the tape runs at the outer side of the both optical detectors (5). Check if the filter tape will be tightened between coil and filter support by the filter tension (3). Fix the end of the filter tape with a piece of duct tape at the empty coil (pic. right).



Insert the filter sealing plate (9) into the notches of the filter support (4) in case of a standard instrument. Shift it to the right to the final position (centred with the filter support). Take care that the mark on the filter sealing plate points in direction of the hatch.

Before starting an aerosol sampling use the cycle “Insert filter” to wrap the filter tape a few times around the coil. This procedure shows whether the tape runs correctly through the stepper drive or not. Finally, the front hatch can be closed.

### 3.3. Flow control

The air flow rate determines mainly the calibration factor of any aerosol monitor. A constant flow rate ensures reliable results because not only the sampled volume but also the collection characteristics do not underlie variations. For this reason, the pump of the instrument is regulated to the nominal flow rate set-point even if the filter becomes loaded. If the flow regulator cannot longer maintain the flow at the nominal rate, the filter will be stepped. This is always done synchronously with the beginning of a new sampling interval. Filter exhaustion and flow rate will appear later on in the stored data. There is also an indication when the filter was stepped.

The instrument uses a mass flow meter to measure and control the flow rate with respect to the set-point. As the result, the mass of sampled air remains stable even if the air pressure changes.

The filter movement is controlled by the upper alert limit of the analogous input AIN2. The input monitors continuously the control voltage of the pump regulator. If the control voltage reaches 80% of its maximum, the filter will be moved. Therefore, the analogous input AIN2 must be activated within any used sampling cycle. Take care for that when defining own sampling cycles.

**ATTENTION:** Do not change the set-point of the flow regulation without matching the aerosol calibration factor!

### 3.4. End of filter and protection of the stepper drive

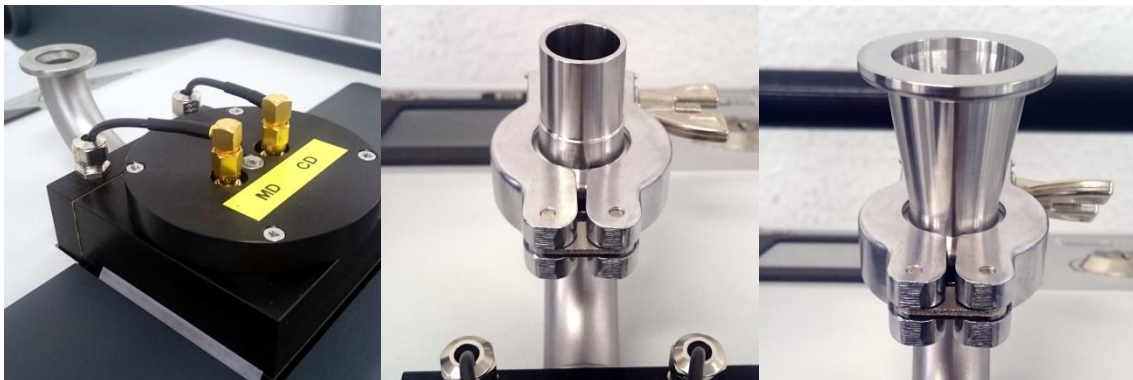
The end of the filter tape will be detected by optical sensors. The one located in front of the air inlet generates a warn signal (yellow light) as soon as the end of the filter has passed the sensor. A second

one is located in front of the encoder to stop the motor and the measurement. The warn signal is controlled by the alert of the digital status input DIN1. This input must be activated for any used cycle. Do not change the configuration of the DIN1.

A protection mechanism has been implemented which will protect the stepping motor against damages. If it takes more than two seconds to move the filter over the required distance, the system considers this condition as a serious error and stops the measurement. The motor signal is connected to the digital status input DIN2, which measures the time span of motor operation. The input will generate an alert if the pre-set period is exceeded. The alert results in the stopping of the whole measurement. Due to this implementation, the input DIN2 must be activated for any used cycle. Do not change the pre-set alert threshold (one second) in the configuration of DIN2.

#### 4. Tube connector (Option “S”)

Tubes, pipes or hoses must be elastically mounted at the connector. Do not transfer larger mechanical forces from the pipes/tubes to the connection flange of the instrument. The connection must be realised by a centring/sealing ring, a clamp and an adapter. The adapter must meet the dimensions of the standard small vacuum flange KF16 (16mm inner diameter). There are many options like hose adapter for hoses with 19mm inner diameter or tapered adapters for KF25 vacuum systems (see pictures below).



#### 5. Data storage

All acquired data is saved on an internal SD memory card (2GB). Data stored on the card can be read via PC either completely or for a selectable period (manual dVISION).

All measured values will be stored as a data record at the end of each sampling interval. Dependent on the type of sensor, the record will contain also the minimum and the maximum of a value within an interval in addition to the interval result. The instrument saves only raw data to guarantee traceability for quality assurance. This raw data includes also entire spectra for each sampling interval.

For online display as well as for later generation of time distributions in dVISION, the raw data will be interpreted with respect to the recent instrument configuration. This procedure allows a simple retrospective analysis of data, for example if dose coefficients needs to be changed by statutory regulations.

## 6. Instrument operation by menus

The RTM2200 is controlled by touch screen menus. The power consumption of the display as well as the backlight is very high compared with the other electronics. Therefore, the display will be switched off automatically after an adjustable period. The time span (max. 255 Seconds) can be set by the instrument set-up function of the operation software. To activate the display, press the small push button below the display. All other required inputs are realized by dynamic touch buttons on the screen. The screen will show always the display page which has been selected before the display was switched off. In case of a pending alert, the display turns on automatically.

### 6.1. Main page

If the display wakes up the main page appears on the screen. In standby mode, this page shows the instrument name, the name of the actual configuration (with the date of the last update) and the selected measurement cycle. Touch the **CYCLE** button to call a list containing all pre-defined cycles to select another cycle.

Now the measurement can be started by pressing the **START** button. It is necessary that a memory card is inserted and a valid cycle has been selected before. All information about the status of sampling is displayed during cycle execution:

- Date/time (with black background if the clock needs to be set)
- Name of the processed cycle
- Time span from the start of the whole sampling period (total sample time)
- Time span from the begin of the running interval
- Number of the executed step and step count of the running cycle
- Remaining data memory (number of data records which can be stored)

Several buttons are present at the main page to enable the access to various display pages. It is possible to show recent readings, data already stored on memory card, component configuration etc. The cycle execution can be stopped by the button **STOP**.

### 6.2. Module information and options

These pages show the module information as well as the actual setting of the module options. The menu can be called from the main menu by touching the **INFO** button. Use the **TOGGLE** button to toggle between the several pages.

Module information:

- Software version
- Serial number
- Date of manufacturing
- Date of the last software update

Options:

- Pre-set start time if the option "Synchronized start" is enabled
- Operation mode and time scheduling of the clock switch

Use the **BACK** button to return to the main menu or the **CONFIG** button to show the actual configuration of the various components.

### 6. 3. Component configuration

This menu shows the actual settings of the configuration parameters of each component. The user can check them for validity but it is not possible to make any changes. Components can be selected by the buttons **NEXT** and **LAST**. If not all parameters can be shown on one page, the others are accessible using the **TOGGLE** button.

### 6. 4. Selecting the cycle

This menu allows the selection of the sampling cycles which have been transferred to the instrument before. A touch sensitive list with the names of all available cycles appears after calling from main menu by the button **CYCLE**. If more than five cycles have been stored, the list can be scrolled by the **TOGGLE** button. A touch at the desired cycle name will select the cycle for execution. Touch the **BACK** button to return to the main menu without a new selection. There are a number pre-defined cycles available in delivery state:

*"1 min"/"5 min"/"15 min"/"1 hour":*

Measurement cycles with 1, 5, 15 or 60 minute sampling interval. Longer intervals resulting in lower detection limits while shorter intervals give faster response in case of detected activity. To optimize both parameters for your application use the table with the detection limits stated in the data sheet.

*"Alert test":* Test of all available alert signals.

*"Insert filter":* Steps the filter two times

*"Detector test":* Measurement cycle without pumping. Alpha/Beta calibration sources may be inserted for function test

### 6. 5. Recent readings display

This page is only available if a cycle is in progress. Use the button **RECENT** to call the recent readings page from the main menu. The results are updated once per second to show the actual sampling results. The display shows only data of components which are used and activated within the executed cycle. To select the different components for display, the buttons **NEXT** and **PREVIOUS** must be used. The order of components is defined by the order of component indexes (see appendix). The name of the selected component appears in the headline of the screen. Some components calculate more than one result from the acquired basic data. In that case, the **TOGGLE** button toggles between the various results. To return to the main page touch the **BACK** button.

### 6. 6. Displaying the data stored at the memory card

If available, all data stored data at the memory card can be displayed. This page can be called from the main page by the **INTERVAL** button even if the sample execution has been finished. The selection of the components and results is implemented in the same kind like in the recent data menu. If a component generates more than one result, an additional page with all results in parallel has been implemented.

Below the measurement result are shown two more lines indicated by "MIN" and "MAX". For analogous values (like temperature) the lines contain the smallest and largest result of a single sampling point within the sampling interval. In case of an interval based measurement (radioactivity) the lines show the limits of the  $1\sigma$  confidence interval. If no activity could be detected during a radioactivity measurement, the detection limit (prefaced by "<" sign) is displayed instead of the result.

There is an additional navigation menu directly above the control buttons. These buttons are used to select any data record within the card memory for display. The button in the middle selects the last acquired record while the other buttons scroll the data memory forward and backward by a factor of 1 or 10. If the current cycle has been finished, the new data appear immediately on the screen.

The headline of the display shows the time stamp and if available the GPS coordinates of the selected data record. To return to the main page touch the **BACK** button.

## 6. 7. Results shown on the display

Which results are presented on display depends on the definition of the used sampling cycle. In case of the pre-defined cycles "1 min" ... "1 hour" following results are available:

- Exposure, dose and average concentration for long lived Alpha emitters (only interval result)
- Exposure, dose and average concentration for long lived Beta emitters (only interval result)
- Radon (Rn-222) and Thoron (Rn-220) daughter product concentrations (EEC - only interval result)
- Accumulated number of counts within the running interval for Alphas and Betas (only recent results)
- Gross count rate of the detector (separate comparator/counter module)
- Measured air flow rate
- Filter exhaustion
- Filter movement
- Temperature, humidity and barometric pressure(internal sensors)
- Charge status of the internal battery

## 7. Instrument set-up

These options can be adjusted by the operation software dVISION (please refer software manual).

### 7. 1. Clock switch

The integrated clock switch is internally connected to the input of the filter stepper. Please read the chapter "User specific settings" how to use this feature for periodical filter movement. If the clock switch is not used, it should be deactivated.

### 7. 2. Synchronized start of a measurement

Sometimes it is required to synchronize the sampling points of several instruments at different locations. This can be done easily by the synchronized start capability of the instrument. Select the cycle which shall be executed from the cycle selection menu. Use dVISION to set the day time when the cycle shall start. Check out if all instruments which have to be synchronized are set to the same time base.

### 7. 3. Display standby

The display is switched off after a certain period to save power. The period counts from the moment of the last touch to any of the soft buttons and may be set to a value between 1 and 255 Seconds.

## 8. Alert functions

Several types of alerts can arise while the unit is in operation. In parallel to the radiometric measures, flow rate and filter contamination are monitored continuously. All alert thresholds are adjustable by the user. It is also possible to disable one or more alerts. These settings can be done with the PC configuration software dCONFIG.

The instrument is equipped with a signal tower (on top) with green, yellow and red lights. An acoustic alert generator (rear) will be activated always together with the red light. Additionally to the optical and acoustic signals, a touch button with an alert message appears at the screen. Touching the button leads to a list containing all pending alerts. The alert list has to be confirmed by pressing the **CONFIRM** button. The behaviour of the signal devices can be configured by the user for each alert source independently. Two options are available:

„Disable auto alert reset“	X	Signal devices will be switched off after the user confirms the alerts by the associated menu function.
	-	Signal devices will be switched off if the alert situation is no longer present.
„Alert confirmation“ *)	X	The alerts appear in the menu list for confirmation.
	-	The alerts do not appear in the menu list for alert confirmation.

\*) If “Disable auto alert reset” is activated, the alert always appears in the menu list independent on status of “Alert confirmation”.

After delivery, following alerts are pre-defined:

Alert source	Signal/check period	Pre-set threshold	Displayed phrase
Alpha dose	Red/Interval	> 2.5DACH	Aerosols
Beta dose	Red/Interval	> 2.5DACH	Aerosols
Flow rate	Yellow	< 15Lpm	Flowmeter
Filter stepping drive (optical sensor)	Yellow	> 5s	Filter status
Filter stepping drive (Motor signal)	Stop sampling	> 1s	Motor

The green light signalizes the proper operation of the instrument and will light only if sampling is started. The configuration procedure for alerts will be explained in the chapter “User specific settings”.

## 9. Gamma background compensation for the beta channel

Increased background radiation results in an increased count rate for betas. The reason is the generation of conversion electrons by interaction of photons with matter (e.g. detector housing). These conversion electrons cannot be distinguished physically from the electrons emitted by the collected aerosols. Thus, the instrument would show a beta exposure even if no air-born aerosols are

present. This “virtual” exposure disappears as soon as the instrument leaves the gamma radiation field while the real collected filter activity cannot decrease.

## 9. 1. Static gamma background compensation

The standard instrument offers the possibility of static background compensation if the gamma radiation field on site is known (work place). The best way is to measure the background count rate directly with the instrument (sampling without pump). Then, the achieved value can be set as one configuration parameter using the configuration software dCONFIG. The background count rate can also be estimated if the local dose on site is known. For a natural radiation field, the following formula may be used:

$$\text{Background count rate} = 250\text{cpm}/(\mu\text{Sv/h}) * \text{Dose rate } (\mu\text{Sv/h})$$

The pre-set background count rate will be subtracted from the beta gross count rate, taking the statistical fluctuations in consideration. If the unit with pre-set background is operated in areas without gamma radiation, the configuration needs to be changed again. Otherwise, the detection limit would be increased.

To set the background count rate see the chapter "User specific settings".

## 9. 2. Dynamic gamma compensation, dose rate measurement

### 9. 2. 1. Dynamic gamma compensation

Instrument versions with the option “G” are equipped with a second detector with identical geometry and orientation for dynamic compensation of the gamma background radiation. An aluminium absorber between the detectors avoids the detection of beta activity by the compensation detector which has been collected on the filter. The beta count rates generated by gamma background are expected to be similar for both detectors. Because the measurement detector counts the sum of real collected beta activity and gamma induced beta activity while the compensation detector counts only gamma related activity, the collected filter activity can be obtained by subtraction of both detector signals.

Directed or in-homogeneous radiation fields (e.g. sources very close to the detectors) result in differences between the gamma related count rates of both detectors. For incidence angles more than  $\pm 30^\circ$  related to the detector surface a significant over- or under-compensation will appear. This will result either in an increase of the detection limit or in the detection of a not really present beta activity. The configuration of the instrument allows the compensation of this difference by an additional factor:

$$R_{N\text{ beta}} = R_{MD} - K * R_{CD}$$

- $R_{N\text{ beta}}$  count rate of real beta activity collected on the filter
- $R_{MD}$  gross count rate of the measurement detector
- $R_{CD}$  count rate of the compensation detector
- $K$  correction factor

To check if such conditions are present and to determine the correction factor K, a test measurement without filter activity ( $R_{N\text{ beta}} = 0$ ; new filter, pump off by disconnected mains power plug) should be carried out. The count sums per interval are available in the spectrum view of dVISION after reading



them from the instrument (“Total Lo-E” = measurement detector, “Gamma background” = compensation detector). The correction factor K can be determined by the simple formula

$$K = N_{MD} / N_{CD}$$

To obtain a sufficient statistical uncertainty, the count sum of each detector should be more than 10,000 counts (can be achieved also by adding of a few intervals). The calculated correction factor (called as “Ratio Gamma Filter/Compensation” in the parameter table of the spectrometer configuration) can be transferred to the instrument (see chapter “User specific settings”).

After delivery this factor can be slightly different from one due to slight differences of the beta pulse threshold of both detectors.

### 9.2.2. Measurement of local dose rate

The count rate of the compensation detector is simultaneously used to determine the local dose rate. The counter channel (CNT1) is configured in the manner that an average dose rate will be calculated beginning at the start of the current interval. Thus, the statistical variance will be reduced with advancing interval.

## 10. Natural Uranium separation

From radiation protection point of view, it makes sense to distinguish between the isotopes of the natural U-238 decay chain ( $U_{nat}$ ) and others. The dose coefficient (respective DAC values) for  $U_{nat}$  is much lower than for Plutonium while the natural Thorium decay chain includes nuclides with dose coefficients similar to Plutonium. In many mines and Uranium facilities,  $U_{nat}$  is the single carrier of LLRD activity.

The separation algorithm uses the circumstance that the maximum emission energy of the whole  $U_{nat}$  decay chain is about 4.7MeV. All nuclides or decay chains with higher dose coefficients emit their alpha particles with energies above 4.7MeV. That means, if some LLRD activity appears in the energy region above 4.7MeV, we can assume that nuclides with high dose coefficients are present. In this case, the Plutonium dose coefficient will be applied to calculate the dose from the measured exposure - otherwise the instrument applies the one for  $U_{nat}$ . In both cases, the presented dose value covers the whole LLRD activity even if a mixture of  $U_{nat}$  and other nuclides has been collected. This implementation may result in a dose overestimation for such situations.

The configuration of the instrument allows the definition of two separate dose coefficients for  $U_{nat}$  and Plutonium. If a user knows that only  $U_{nat}$  or only Plutonium (or other) is present at the place of operation, both coefficients could be set either for  $U_{nat}$  or Plutonium.

If the instrument applies the  $U_{nat}$  dose coefficient, the phrase “\*Unat\*” appears on the display (if alpha dose value is shown). Please note: Due to statistical deviations and Radon background rejection, a misinterpretation of a single value (especially in the surrounding of the detection limit) is possible. Therefore, the user should always take care for the frequency of “ $U_{nat}$ ” appearances during sampling. Just one single “ $U_{nat}$ ” reading within a number of LLRD results indicates definitely a statistical fluctuation.



## 11. Calculation of the average activity concentration

The LLRD activity collected on the filter is proportional to the exposure and finally to the dose. Therefore, the exposure is the primary result for the calculation of the average activity concentration by division by the exposure time. The accumulated exposure time remains in the memory even if the measurement will be interrupted. The recently calculated result of the average concentration is always related to the whole exposure period. It is necessary to make sure that filter activity and exposure period are always consistent. Therefore, the exposure timer will be re-set after each filter step. That means, a new exposure period starts automatically with a filter movement. Triggering the filter movement by a fixed (short) interval allows to measure actual concentrations. Please note that the exposure time will be re-set also in case of power off/on using the key switch.

Please note that any presented result within the stored time distribution represents always the average concentration of the period from the last filter movement to the related time stamp. The result does not represent the actual concentration in that moment.

## 12. Operation conditions

The instrument has been designed as a robust unit for portable use in nuclear and mining facilities. Because of the sampling method, the detector head is directly exposed to the ambient conditions. Therefore, the user should mind a few limitations.

- The temperature range from 0°C to 50°C should not be exceeded. An extended range can be provided on request.
- Condensation of water must be avoided. After strong temperature changes (moving a cold unit in warm environment) the instrument should be tempered for a while before using.
- Avoid beats onto the enclosure or detector head. The microphonic (piezo-electric) effect generates electronic signals similar to decay events. The instrument is equipped with dynamic shock suppression (electronic pulse shape analyses). Frequently shocks or permanent vibration must still be avoided.
- Do not use any strong source of electro-magnetic fields in the immediate vicinity of the detector head (e.g. mobile phones, Wi-Fi adapter/router).
- The instrument should never be operated without filter. Particles in the air loop resulting in an increased abrasion of the pump.

## 13. Communication with a PC

The instrument is equipped with a RS232 as well as an USB interface. Optionally, the RS232 interface can be replaced by SARADs wireless network "Net Monitors - ZigBee". Both interfaces can be used for all required data transfer from and to the instrument. If the USB interface is connected, the RS232 interface will be disconnected (USB priority). The standard transfer rate is 9600 baud. If no sampling is in progress, the transfer speed can be increased significantly using the "Card Reader" function. Push simply the touch area at the top of the main menu to enter this mode. Please make sure that the card reader mode has been selected in dVISION too. Increased transfer speed is only available for the USB interface.

The instrument offers a simple proprietary communication protocol which allows the user to access the unit by own software solutions. For more detailed information please contact the manufacturer or your retailer.

## 14. User specific settings

The instrument is based on the DACM platform, which provides flexible tools for custom specific configurations. Each of the functional blocks, the so-called components, can be configured and controlled separately using the PC software dCONFIG. Changing the configuration requires caution and should be carried out by skilled persons only (administrator). Erroneous settings may result in a male function of the instrument. Before changing anything, the operator should read the recent configuration from the unit and save it on PC as configuration file. If necessary, this file can be written back to the unit in case of trouble. Each component offers a specific configuration window in dCONFIG for all available configuration parameter. The dCONFIG software manual informs of the procedures to access the various configuration windows.

### 14. 1. Changing the alert settings for radiometric measures

#### **Configuration window of component SPEC1**

It is possible to define two independent alert levels. The threshold values must be entered into the edit fields "Alarm 1 threshold" and "Alarm 2 threshold". Several measures can be assigned to each of the alert levels. These measures must be selected by marking the items within the list boxes "Alarm 1 source" and "Alarm 2 source". The threshold level is always related to the physical unit of the selected measure. For example, one could use the first threshold for the dose value and the other one for Radon and Thoron concentration. In delivery state the alert is routed to the red signal light (switch output DOUT4). To disable the alert function, select the item "inactive" from the list.

### 14. 2. Changing the threshold level for the count rate

#### **Configuration window of components CMP1 and CNT1**

Two components, a voltage comparator (CMP1) and a counter input (CNT1) are used for gross count rate measurements. The comparator output is internally connected to the counter input. A digital pulse will appear at the counter input if the detector signal exceeds the threshold level of the comparator. Because the height of the detector signal is related to the emission energy of the decay event, the count rate contains only events above the energy corresponding with the threshold. This allows the configuration of the counter either as gross alpha or total event counter. The threshold level can be adjusted in the component window of CMP1, edit field "Threshold voltage". To count alpha and beta decays, enter 100mV, for alphas only, enter 350mV.

The alert threshold for the count rate can be configured in the configuration window of component CNT1 ("Alarm if count rate becomes higher than"). The alert is disabled in delivery state ("inactive" selected from the list box "Alarm index higher than").

### 14. 3. Adjusting parameters for the gamma background compensation

#### **Configuration window of component SPEC1**

*Instruments without dynamic gamma compensation*

To enter the background count rate, the parameter "Fixed Background Count Rate" is available in the table "Calibration constants". The unit is cpm (counts per minute).

#### *Instruments with dynamic gamma compensation (double detector)*

The parameter table contains in that case the item "Ratio Gamm Filter/Compensation" instead of the "fixed background Count Rate". This parameter can be calculated according the chapter "Dynamic gamma compensation".

## 14. 4. Changing units (US/SI) and dose coefficients

### Configuration window of component SPEC1

The activity and dose results can be presented either in traditional US units or in international SI units, depending on the selection in the list box "Unit scheme". Changing the unit scheme requires always the changing of the dose coefficients. Dose coefficients must be stated in relation to the selected dose unit. That means for US unit scheme, the unit of dose coefficients is DACH/(Bqh/m<sup>3</sup>). The dose coefficient unit in case of SI unit scheme is  $\mu\text{Sv}/(\text{Bqh}/\text{m}^3)$ . The values can be entered into the table "Calibration constants". There, the parameters "Dose Coefficient Alpha", "Dose Coefficient Beta" and "Dose coefficient Unat" are available.

The factory-set coefficients are adjusted with respect to the normative 10CRF20 of the US-DOE. Because there are specific laws for various applications and countries, the user must change these constants in accordance with the local regulations.

Coefficient for	in DACH/(Bqh/m <sup>3</sup> )		in $\mu\text{Sv}/(\text{Bqh}/\text{m}^3)$
	10CRF20	10CRF835	German StrlSchV §§63 u. 63a Anlage 3
Plutonium	9,01	5,4	192
Natural Uranium	1,35	0,34	76,8
Strontium	0,014	0,0039	0,84

## 14. 5. Controlling the filter stepper drive

The stepper drive is controlled by three different signals. The meaning and origin of the signals is expressed in the following table:

Signal	DACM-Hardware	Meaning
SYNC	DOUT2	<ul style="list-style-type: none"> <li>Ensures synchronisation with the sampling cycle</li> <li>Will be activated for one second at the begin of each interval</li> </ul>
ALARM	DOUT1	<ul style="list-style-type: none"> <li>Allows the filter movement in case of any detected alert state of any component</li> <li>Will be controlled by the alert limits and thresholds defined in the component configuration</li> <li>Performs a logical AND with the SYNC signal to synchronize stepping if the alert arises asynchronously</li> </ul>
CLOCK	Clock Switch	<ul style="list-style-type: none"> <li>Clock switch can be configured as periodical timer</li> <li>Enables a time regime independent on cycle timing</li> <li>Performs a logical AND with the SYNC signal to synchronize stepping if the alert arises asynchronously</li> </ul>

The filter will be stepped under following conditions:

- SYNC signal AND ALARM signal

OR

- SYNC signal AND CLOCK signal

#### Filter movement in case of detected LLRD activity on the filter

Set the alert levels for exposure or dose to the desired values and mark them as source for alert generation (configuration window SPEC1). Select alert output DOUT2 instead of DOUT6 as destination for pending SPEC1 alerts. Please note that the redirection of the alert destination disables the optical/acoustical alert controlled by DOUT6.

#### Filter movement at the begin of each new sampling interval

DOUT2 needs to be activated in the cycle definition in parallel with DOUT1 (cycle definition in dCONFIG)

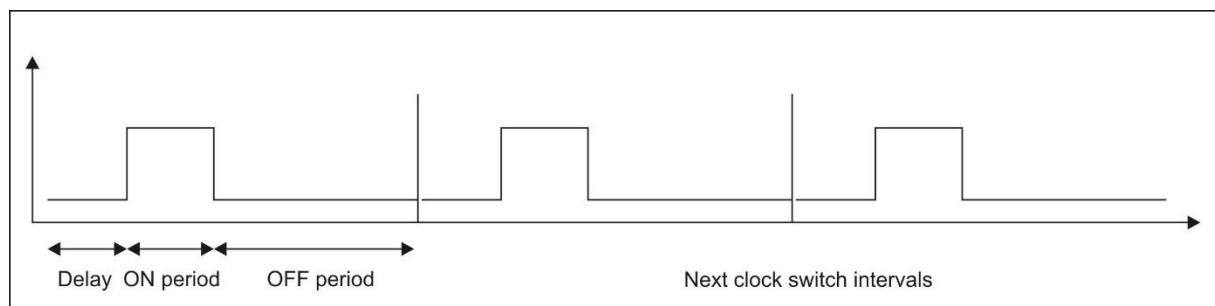
#### Filter movement after defined time periods

This function can be realized by the integrated clock switch (CLOCK signal). The configuration of the clock switch is done by dVISION (instrument setup). At first set the clock switch mode to “periodical” and after that enter the timing parameters:

Delay	0 seconds
ON period	1 second
OFF period	(Filter stepping interval* - 1) seconds

\*) The filter stepping interval must be an integer multiple of the length of the sampling interval (length of the cycle). This ensures that the clock switch signal arises simultaneously with the beginning of a new interval.

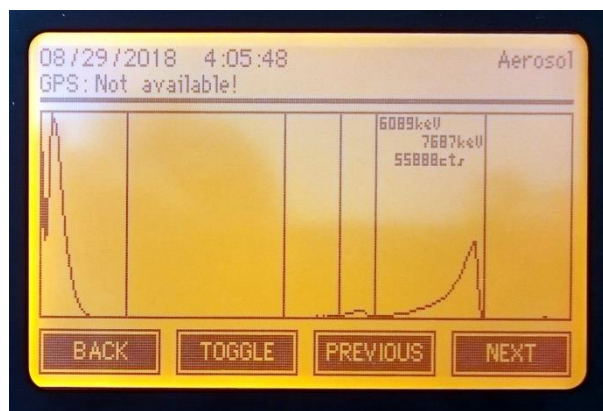
The graphic below points out the meaning of the clock switch setup timing parameters if used as periodical timer. The beginning of the clock switch's first interval is synchronised with the start of a measurement.



## 15. Test and maintenance

The instrument contains only reliable and durable quality parts. To ensure a trouble-free operation for a long time, periodical maintenance still needs to be carried out. This includes the maintenance of the pump (carbon shifter and filter), replacing the filter sealing (soft rubber O-Ring) and the check of the flow sensor. All necessary procedures are described in detail by the service manual.

All operational parameters are monitored continuously during the sampling process. Erroneous operation will be immediately signaled by the alert lights. Alert lights should be tested before any usage by starting the cycle "Alert test". In most cases a short view at the acquired spectrum during operation is sufficient to check the proper operation of the detector. Because you will find Radon daughter products everywhere in the air, the Polonium Peaks are always present in the spectrum. Especially if the 1 hour sampling interval has been selected, the spectrum shape appears clearly even at low Radon daughter product concentration.



The typical example of a Radon spectrum shown at the picture above contains four significant peaks as a maximum. The following table points out some criteria for the spectrum shape with respect to the peak area, peak shape and peak position:

Beta (gross counting)	Po-218 (Alpha)	Po-214 (Alpha)	Po-212 (Alpha)
peak area approximately two times that of Po-214	in most cases less peak area than the Po-214 peak; at most equal with Po-214	usually the greatest alpha peak within the spectrum	only present if the sampled air contains Rn220 (Thoron) too usually small peak area
significant tailing to right; steep sloop at left side minimum between left spectrum border and peak maximum	steep right slope; significant tailing to left	steep right slope; significant tailing to left	steep right slope in the upper part, small flat ramp to right at the bottom significant tailing to left
placed in the left region of the first window	peak maximum in the fourth window; right edge aligned with the upper border of the window about 35...40% of the peak area within the third window	nearly completely within the fifth window, right edge aligned with the upper border of the window	located in the middle of the sixth window

## Appendix

Assignment of components in dCONFIG

Name	Function	Component type
DOUT1	ALARM signal to control filter stepping drive	Switch outputs
DOUT2	SYNC signal to control filter stepping drive	Switch outputs
DOUT3	Pump ON/OFF	Switch outputs
DOUT4	Green signal light	Switch outputs
DOUT5	Yellow warn light	Switch outputs
DOUT6	Red alert light / buzzer	Switch outputs
DOUT7	Power supply for pump regulation and filter stepping drive	Switch outputs
AIN1	Not used	12 bit configurable analogous inputs
AIN2	Filter exhaustion (control voltage of the flow regulator, upper regulation limit)	12 bit configurable analogous inputs
AIN3	Flow rate monitoring	12 bit configurable analogous inputs
AIN4	Not used	12 bit configurable analogous inputs
AIN5	Not used	12 bit configurable analogous inputs
AIN6	Not used	12 bit configurable analogous inputs
AIN7	Not used	12 bit configurable analogous inputs
AIN8	Not used	12 bit configurable analogous inputs
DIN1	Signal optical sensor for end of filter detection	Digital status inputs
DIN2	Motor signal (time out for filter stepping)	Digital status inputs
CNT1	Motor speed (pump)	16 bit counters
CNT2	Gross count rate of aerosol sampling head	16 bit counters
CNT3	Motor signal (logs filter stepping into data record)	16 bit counters
SPEC1	Spectrometer for aerosol sampling head	Spectrometer
SPEC2	Spectrometer for Actinon measurement (only installed for option "Thorium-Therapy")	Spectrometer
REG1	Not used	PID-Regulator / analogous output
REG2	Flow rate regulator	PID-Regulator / analogous output
CMP1	Threshold for detector pulse signal (output tied to CNT1)	Voltage comparator input
BATT	Battery voltage measurement	Internal sensors
TEMP	Internal temperature sensor	Internal sensors
RHUM	Internal humidity sensor	Internal sensors
BARO	Not used (bar. Pressure sensor option)	Internal sensors

## Technical Data

<b>Detector</b>	<ul style="list-style-type: none"> <li>• 400 ... 1200mm<sup>2</sup> ion-implanted silicon detector</li> <li>• Option: Double detector for dynamic Gamma background compensation</li> <li>• Energy range 80keV...3MeV (Beta); 3...10MeV (Alpha) depending on detector size</li> <li>• Counting efficiency (<math>4\pi</math>) approx. 20%</li> <li>• Open face sampling for minimum collection losses</li> <li>• Option: Tube connector for air inlet (vacuum flange KF/DN16)</li> </ul>
<b>Filter/Stepper</b>	<ul style="list-style-type: none"> <li>• Membrane filter tape (PTFE); 5µm pore size; length 30m; width 65mm; good for 330 filter steps</li> <li>• Pneumatic filter sealing for minimum leakage rate</li> <li>• Deposition rate &gt;99,9%</li> <li>• Active filter test with respect to perforation and exhaustion</li> <li>• Tool-less replacement of filter coils</li> <li>• More than 12 month autonomous operation in "normal" environment</li> <li>• Configurable trigger for filter stepping (e.g. each sample interval, fixed period, filter exhaustion, activity detected)</li> <li>• Required period for filter replacement &lt;2s</li> </ul>
<b>Pump</b>	<ul style="list-style-type: none"> <li>• Brush-less, long-life, low noise quality membrane pump</li> <li>• Nominal air flow 8l/min (adjustable range 4 to 10l/min)</li> <li>• Processor controlled air flow for constant deposition conditions</li> <li>• Pressure drop across the filter 15...150mbar (at 10l/min)</li> <li>• Noise emission approx. 51dBA (in 1m distance)</li> </ul>
<b>Results</b>	<ul style="list-style-type: none"> <li>• Equilibrium Equivalent Concentration (EEC) for Radon and Thoron daughter products in Bq/m<sup>3</sup></li> <li>• Exposure for Alpha and Beta emitters (LLRD) in Bqh/m<sup>3</sup></li> <li>• Dose for Alpha and Beta emitters in µSv or DAC-hrs (dose coefficients adjustable by user)</li> <li>• Detection of Natural Uranium with automatic selection of the <math>U_{nat}</math> dose coefficient</li> <li>• Average activity concentration for Alpha and Beta emitters in Bq/m<sup>3</sup></li> <li>• Separate channel for Alpha gross counting in cps or Bq</li> <li>• Option: dose rate in µSv/h</li> <li>• Temperature, humidity, pressure, battery voltage</li> <li>• Flow rate, filter exhaustion, filter stepping, end of filter tape</li> </ul>

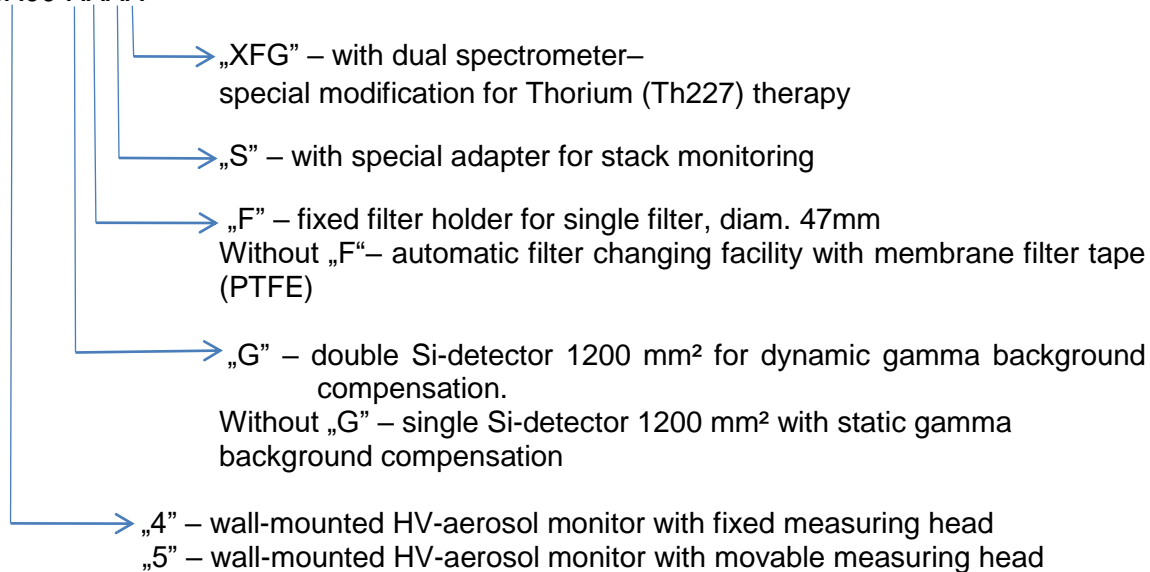
<b>Standards</b>	<ul style="list-style-type: none"><li>• IEC 60761-1</li><li>• IEC 60761-2</li><li>• IEC 61578</li><li>• IEC 61577-3</li><li>• IEC 1263</li><li>• CE, VDE</li><li>• DIN ISO 16639 (VDE 0493-1-6639)</li></ul>
<b>Compensation</b>	<ul style="list-style-type: none"><li>• Compensation of natural Radon background by Alpha spectroscopy with dynamic fitting of peak shape with respect to progressive filter exhaustion</li><li>• Upper Alpha energy threshold for LLRD = 5,6MeV</li><li>• Static compensation of Gamma background</li><li>• Option: dynamic compensation of Gamma background by double detector</li><li>• Dynamic shock rejection (mechanical shock) by pulse signal shape analysis</li></ul>
<b>LLRD Sensitivity</b>	<ul style="list-style-type: none"><li>• approx. 7cpm/(Bqh/m<sup>3</sup>)</li></ul>
<b>Measurement range</b>	<ul style="list-style-type: none"><li>• 35000Bqh/m<sup>3</sup> (175000DACH(Pu))</li><li>• 2MBq/m<sup>3</sup> over 1 minute</li></ul>
<b>Measurement</b>	<ul style="list-style-type: none"><li>• Up to 16 user definable sampling cycles (1s to 1year)</li><li>• Predefined sampling cycles 1, 5, 15, 60 minutes</li></ul>
<b>Detection limits</b>	<ul style="list-style-type: none"><li>• See tables below</li></ul>
<b>Alert indication</b>	<ul style="list-style-type: none"><li>• Configurable alert thresholds for all measured results</li><li>• Alert tower with green, yellow and red light, 360° visible</li><li>• 90dB signal buzzer (option)</li><li>• Alert indication at display</li><li>• Alert reset is configurable (either with confirmation by the user or automatic reset if the alert condition is no longer present)</li><li>• Pre-defined alerts for LLRD activity, low/high count rate, filter perforation, end of filter tape</li></ul>
<b>Data storage</b>	<ul style="list-style-type: none"><li>• 2GB SD card (&gt; 1,200,000 data records)</li><li>• Storage of all measured raw data incl. spectra</li></ul>
<b>Handling</b>	<ul style="list-style-type: none"><li>• Touch screen 6cm x 9cm (4.5"); Graphic 240 x128</li><li>• High contrast even in direct sunlight</li><li>• Backlight</li><li>• Intuitive, straight forward menu structure</li></ul>



<b>Interface</b>	<ul style="list-style-type: none"><li>• USB, RS232 (RS422/RS485 optionally)</li><li>• Option: Net Monitors wireless (ZigBee)</li><li>• Option: TCP/IP (Ethernet/WLAN)</li><li>• 6 additional configurable analogous sensor inputs</li><li>• 1 additional counter input (for models without GM-tube option only)</li><li>• Option: relay contacts instead alert light tower</li></ul>
<b>Power supply</b>	<ul style="list-style-type: none"><li>• Power adapter 18V/60VA</li><li>• Internal NiMH buffer battery 12V/1Ah for more than 6 hours operation in case of mains power interruption (without pump)</li></ul>
<b>Housing</b>	<ul style="list-style-type: none"><li>• Space saving desktop housing</li><li>• Ease of decontamination</li><li>• 308mm x 308mm x 175mm (12" x 12" x 7") plus detection head</li><li>• 8kg</li></ul>
<b>Ambient conditions</b>	<ul style="list-style-type: none"><li>• 0...50°C</li><li>• 5...95%rH, noncondensing</li></ul>
<b>Software dVISION</b>	<ul style="list-style-type: none"><li>• Remote control</li><li>• Data transfer, visualization</li><li>• Data management, export to text files</li><li>• System configuration</li><li>• Creating/Editing of measurement cycles</li><li>• Network management</li></ul>
<b>Additional options</b>	<ul style="list-style-type: none"><li>• Separate filter unit (connection by hose and cable)</li><li>• Sealed filter unit for connection to ventilation ducts</li><li>• Wall mounted housing</li><li>• Sodium Iodide gamma probe (2" x 2") with spectroscopy and nuclide identification</li><li>• GM tube for dose rate measurement</li><li>• CO and Methane sensors for usage in underground mines</li><li>• GPS receiver</li></ul>
<b>Calibration/Test</b>	<ul style="list-style-type: none"><li>• Factory calibration in a Radon daughter product atmosphere with aerosol generator</li><li>• Test sources Am-241 (Alpha) and Cs-137 (Beta); recommended are area sources with 25mm or 36mm diameter and 185Bq nominal activity such as Eckert &amp; Ziegler AMRB22757 and CDRB22758 (d 30 mm x 0.8 mm)</li><li>• Flow rate check on top of the filter using adapter dome and low differential pressure air flow meter (<math>\Delta p &lt; 15\text{mbar}</math> @10/min)</li></ul>

## Possible modifications of Air Monitor Aer 5X00-XXXX

Aer 5X00-XXXX



\*) options XFG and G cannot be combined

## Detection Limits

The detection limits stated in the tables below are valid for following operational conditions:

- Flow rate = 8l/min
- $k_{1-\alpha} = 3$  (99.8%)
- $k_{1-\beta} = 1.65$  (95%)
- 1DAC(Pu) = 0.2Bq/m<sup>3</sup> (10CRF835)
- 1DAC(Sr90) = 200Bq/m<sup>3</sup> (10CRF835)

Additionally for Beta measurement:

- F = 0.6
- Gamma background = 0.1μSv/h

The assumption for the detection limit of the concentration is a momentarily step-like increase of air activity concentration up to the detection limit at the beginning of a sampling interval. Furthermore it is presumed that there was no LLRD activity deposited on the filter.

Alpha LLRD									
Po-218 *)	Detection limit T = 1min			Detection limit T = 5min			Detection limit T = 15min		
Bq/m <sup>3</sup>	Bqh/m <sup>3</sup>	DACH	Bq/m <sup>3</sup>	Bqh/m <sup>3</sup>	DACH	Bq/m <sup>3</sup>	Bqh/m <sup>3</sup>	DACH	Bq/m <sup>3</sup>
10	2.7	13.3	160	0.74	3.7	8.8	0.4	2.0	1.6
20	2.7	13.3	160	1.0	5.0	12.0	0.57	2.8	2.3
50	3.7	18.3	220	1.54	7.7	18.5	0.95	3.7	3.7
100	5.0	24.9	285	2.21	11.1	26.6	1.41	5.7	5.6

Beta LLRD									
Po-218 *)	Detection limit T = 1min			Detection limit T = 5min			Detection limit T = 15min		
Bq/m <sup>3</sup>	Bqh/m <sup>3</sup>	DACH	Bq/m <sup>3</sup>	Bqh/m <sup>3</sup>	DACH	Bq/m <sup>3</sup>	Bqh/m <sup>3</sup>	DACH	Bq/m <sup>3</sup>
10	5.12	0.026	307	2.21	0.011	14.5	1.26	0.006	5.0
20	6.79	0.034	407	2.96	0.015	19.8	1.69	0.009	6.8
50	10.2	0.051	615	4.51	0.023	30.7	2.59	0.013	10.4
100	14.2	0.071	853	6.28	0.032	43.0	3.61	0.018	14.5

\*) The activity concentration of Po-218 is always less than the one of Rn-222