

# Manual DOSEman PRO

Version 04/2009

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## CONTENT

THEORY OF OPERATION .....	2
OPERATION .....	2
Switching on the Instrument and Starting a Measurement.....	2
Stop Sample and switching off the Instrument.....	5
Special Dosimeter Function .....	6
Alert States .....	6
Instrument Set-up.....	6
Filter Replacement.....	7
Battery and Charger.....	7
Communication with the PC .....	8
TECHNICAL DATA .....	9

## Theory of Operation

The ambient air is sucked through a membrane filter by the internal pump. The Radon daughters within the sampled air are deposited on the surface of the filter. Depending on the decay constants of the single nuclides, an equilibrium between their activity concentration in the air and the collected filter activity will be obtained. In case of Po-214 as the last element of the short living Radon (Rn-222) daughters within the decay chain, this equilibrium is reached after about two hours resulting from the previous decay of the Beta emitters Pb-214 and Bi-214. This circumstance defines also the minimum response time of the instrument for the Rn-222 daughters. In practice it means a smoothing of the measured time distribution with a time period of approximately two hours. The concentration of the Thoron decay products is derived from the relative increase of the Po-212 activity within two sequential sampling intervals.

The semiconductor detector, placed directly above the filter and connected to an alpha spectroscopy, allows the independent determination of the filter activities of Po-218, Po-214 and Po-212.

The duration of the counting interval used for the activity is adjustable by software. The resulting time distribution created by those successive intervals is stored in the memory and will be available for further analysis.

The influence of the possibly present Thoron daughter products is compensated by the spectroscopy too.

## Operation

### Switching on the Instrument and Starting a Measurement

The instrument is switched on by pressing the front-side push button. On the display appears:

**WELCOME**  
Please push  
button!

If the button was locked in the set-up before, the display will show

**WELCOME**  
Please  
check in!

Changing user parameters and access to the instrument set-up is only possible during this state of operation (stand by). The measurement can be started by pressing the button once again. If the button is locked, the software has to be used to start the sample. During a running sample seven different display pages can be toggled by the push button.

### Info page

**USER**     603  
**ENTRY**     1  
16:34 > 60'

The upper line always shows the actual day time. Beside, different symbols can appear depending on the recent operation state:

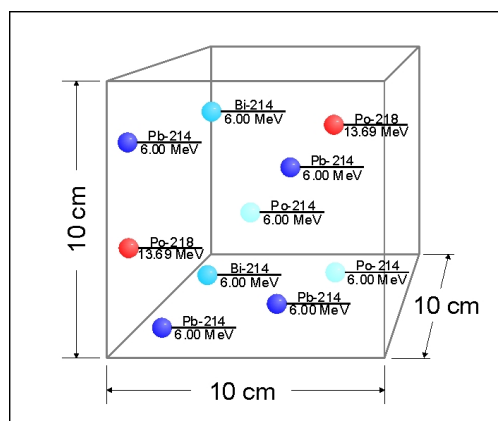
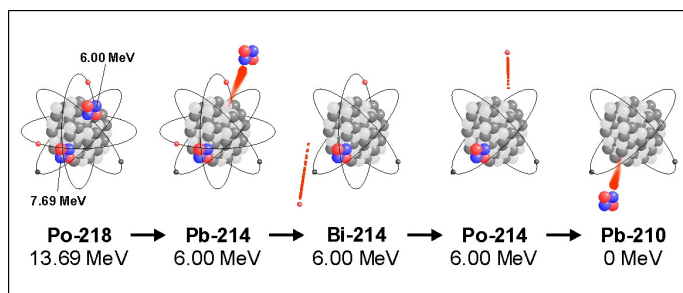
- Key symbol if the filter analysis is running after finishing the air sampling if the dosimeter-mode has been chosen (please look at the chapter „Special Dosimeter Function“).
- Battery symbol if the battery voltage drops below 3.2 Volts
- Bell symbol if an alert has been detected during the measurement
- Exclamation mark if an internal error has been detected

The lower line shows always the actual time and the number of remaining Minutes until finishing the recent interval.

### Potential Alpha Energy Concentration (PAEC)

<b>PAEC</b> <b>63nJ/m3</b> <b>16:34 &gt; 60'</b>
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The Potential Alpha Energy Concentration (PAEC) is the sum of the energy within a defined volume which will be emitted by all short living Radon daughters during the complete decay chain.



This energy amounts 7.68MeV in case of a Pb-214, Bi-214 or Po-214 atom while Po-218 will emit 13.68MeV (6MeV as Po-218 and additional 7.68MeV as Po-214 later on). Because the ratios between the particle concentrations of the several nuclides are dependent on the ambient conditions it is necessary to measure them independently by spectroscopy.

From the energetic point of view it is unimportant if the air contains more or less Pb-214 or Bi-214 because they will be present in the PAEC calculation only by their Po-214 decay. This explains that the beta radiation needs not to be measured in addition to the alpha decays of Po-218 and Po-214.

## Equilibrium Equivalent Concentration (EEC)

EEC
670Bq/m <sup>3</sup>
16 : 34 > 60'

For each real atmosphere with any mixture of the several Radon daughters a virtual atmosphere can be stated which undergoes the following two terms:

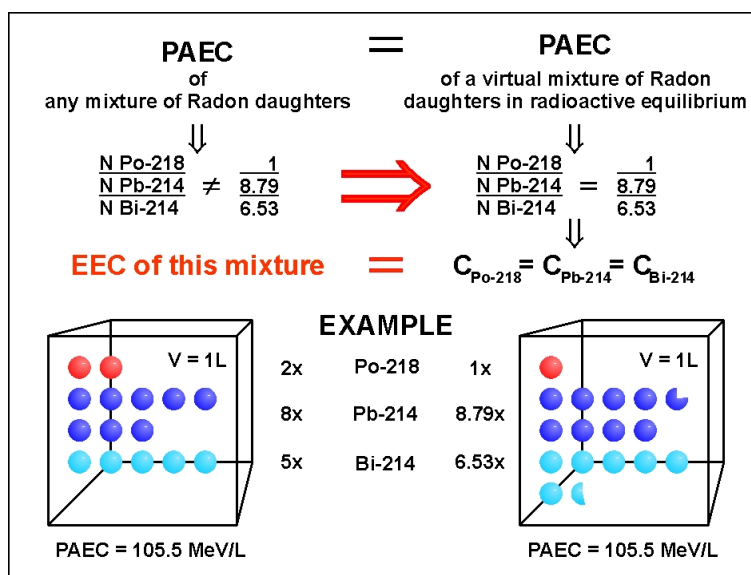
- The PAEC of both, real and virtual atmosphere is identically
- The activity concentrations of all single nuclides within the decay chain are identically (radioactive equilibrium)

The radioactive equilibrium will be reached only if the ratios between the particle concentrations are:

$$\text{Po-218} / \text{Pb-214} / \text{Bi-214} = 1 / 8.79 / 6.53$$

The ratios are defined by the various half life constant of the different daughters. Because of the short half life (few Microseconds) of Po-214 it is always in equilibrium with the Bi-214 and practical not available in the atmosphere. Therefore it is generally handled as one unique nuclide (Bi-214).

To fulfil also the first term, the available (measured) PAEC needs to be redistributed with respect to the required concentration ratios as shown in the graphic.



This causes a linear relationship between the measured PAEC and the resulting activity concentration which is called Equilibrium Equivalent Concentration (EEC).

The EEC is used to define the Equilibrium Factor  $F$  which describes the ratio between the Radon gas and the Radon daughter products within an given atmosphere:

$$F = \text{EEC} / \text{Radon-Concentration}$$

Because the Radon gas concentration in natural environments is always higher than the concentration of the decay products  $F$  is defined for a range from 0 to 1.

## Potential Alpha Energy Exposure (PAEE)

PAEE
nJh/m <sup>3</sup>
16:34 > 60'

The Potential Alpha Energy Exposure is the product of the PAEC and the exposure period and therefore an integral value of the whole measurement. The PAEE is the basic value to derive the equivalent dose.

## Equivalent Dose

DOSE
4μSv
16:34 > 60'

The Equivalent Dose is derived from the PAEE using the dose conversion coefficient g(pot). The dose conversion coefficient is user adjustable and can be set with respect to the valid local regulations.

## Po-218 Concentration

Po-218
4Bq/m <sup>3</sup>
16:34 > 60'

The display output of the Po-218 was implemented to detect increases of the activity concentration as fast as possible. Because of the short half life time of the Po-218, the final value is reached already after 12 to 15 Minutes. The Po-218 concentration is not directly related to the EEC but it gives the possibility for a first and soon estimation of the conditions at the measurement site.

## Stop Sample and switching off the Instrument

If the button has been locked, the measurement can be cancelled only by the PC software. The software also allows to switch off the instrument after the download of the acquired data. In case of an unlocked button the DOSEman-PRO can be switched off also by pressing the button for approx. five Seconds.

The acquired data remain in the memory and can be read after switching on the unit again. Please note that a repeated keystroke starts a new sample (if the button is unlocked) and the data of the last measurement series will be lost immediately.

If the battery voltage drops below the defined minimum level, the instrument switches off automatically. The data are stored non volatile, so that it is possible to read them after re-charging.

## Special Dosimeter Function

If a measurement has been cancelled, a number of collected daughter products are still on the filter which we have to take in account for an accurate exposure calculation. For this purpose, the DOSEman-PRO offers a special Dosimeter mode (selectable by the software)

After finishing the measurement, only the pump will be switched off while the filter analysis will be continued for 180 Minutes. Within this time span all remaining daughter products will decay and will be included in the exposure calculation.

During those 180 Minutes the instrument neither can be switched off nor the data can be read from the memory. After this period the unit will switch off automatically.

The push button should be locked if the DOSEman-PRO is set into the Dosimeter mode. This avoids an unintended restart of the unit causing the loss of data and three more hours without instrument access.

## Alert States

Alert states are indicated by an acoustic signal and a display output. Two alert states are implemented:

*Low Battery Alarm:* becomes active if the battery capacity drops below 10% of the nominal value. To prevent an automatic switch off in case of complete discharging, the battery should be recharged immediately.



Low Batt.

*Dose Alarm:* becomes active if the calculated dose value exceeds the pre-set limit.



DOSE ALARM

After confirming the alert message by pressing the button, the dosimeter turns back to the normal display mode. In the right upper edge of the display appears either a bell or a battery symbol dependent on the kind of alert.

## Instrument Set-up

All set-up parameters can be changed only by PC software. Beside the integration interval and the operation mode (monitor/dosimeter) also the dose conversion coefficient and the dose limit may be adjusted.

To assign the acquired data correctly to a person or location, some codes are programmable which appear later on within any data protocol or export file.

Unintended manipulations can be avoided by locking the push button. The activation of the internal buzzer forces the DOSEman to give a short audible signal at each keystroke.

Please refer to the software manual for detailed information.

## Filter Replacement

The filter of the DOSEman-PRO should be replaced at least after 500 hours of operation under normal ambient conditions. If the dust pollution is increased the time span has to be reduced according the requirements. The white filter paper becomes darker even in normal environments but you should take care that there is no thick dust layer on it.

Important note: Use only filters of the specified type. The filter material affects directly the quality of the alpha spectroscopy. Wrong filter materials causes malfunction.

To replace the filter loose the small screw on the back of the pivot mounted arm. Swivel



away the pivot arm backwards for free filter access. Unscrew the filter nut anti-clockwise and remove the old filter. The measurement head must not be turned around for several times because the connection wires could become damaged! Do not

touch the surface of the semiconductor detector! Start a sample to make the pump running. The new filter can be placed now very easily because the pump pressure fixes the filter on the air inlet. Take care for the filter material because it is very sensitive against bending. Do not use any sharp-edged tool. Fix the filter nut slightly by two fingers. Too strong fixing may damage the filter as well.

## Battery and Charger

The internal rechargeable battery allows an autonomous operation of approx. 48 hours. To ensure optimal performance two things should be attended:

The battery must not be stored over long times in the discharged state. Please recharge the instrument after each measurement.

From time to time the battery should be discharged and recharged by the maintenance function of the charger unit (button next to the LED).



To charge the battery, the charger has to be plugged to the mains power line firstly. After that, the cable can be connected to the charge receptacle of the DOSEman-PRO. The red LED lamp will blink for a few Seconds (battery check) and afterwards light permanently. At the end of the recharging process, the LED lamp switches from red to green light.

If the maintenance button of the charger was pressed, the battery will be discharged firstly (the LED lamp blinks during this process) and after that the charging process will be started automatically.

Please note: The charger is not a power supply for permanent operation of the DOSEman-PRO. The connection between the battery and charger is released by the charge controller if the full battery capacity has been reached.

If the DOSEman-PRO shall operated permanently, please contact the manufacturer to talk about the modifications required for your application.

**ATTENTION!** The poles of the battery are directly connected to the charge receptacle of the instrument. Do not connect any external power supply or shortcut the contacts. This will cause a heavy damage of the instrument and a strong heat emission.

## Communication with the PC

The data communication between PC and DOSEman-PRO is realised by a special infrared adapter. The usage of a possibly available IrDA interface integrated in the PC is not possible. The infrared adapter has to be connected to the USB port.

The PC software handles the adapter like a serial port (COM), similar like an USB/Serial converter. To link the adapter to any COM port, a driver is necessary which can be found on the program disc in the subdirectory "DRIVER". After plugging the connector into the USB port, Windows will automatically start the hardware installation assistant. The port number is commonly assigned by Windows during the installation. The port number has to be between COM1 and COM9, otherwise the software will not be able to access the adapter. Generally, the first available number following the last physical installed port (for example COM3 or COM5) is chosen. The Windows device manager within the Windows control panel can be used for reassignment, if it is necessary.

To read the data or to change the set-up, the DOSEman-PRO has to be placed on the top of the infrared adapter with the bottom panel down (IR transmitter window). This guarantees a safely connection and no other instrument in the surrounding will be affected.



## Technical Data

Theory of Operation	Collection of the Radon daughter products at the surface of a filter by a continuous air flow permanent alpha spectroscopic analysis of the filter
Filter	3 µm Membrane filter (PTFE) Diameter 17.5 mm 1 month replacement interval under normal conditions
Pump	Membrane pump 0.18 Lpm
Sensitivity	approx. 150 cpm @ 1000 Bq/m <sup>3</sup> (EEC)
Response time	2 hours (to 90% of the final value)
Integration interval	1 ... 255 Minutes, adjustable in 1 Minute steps
Operation	Single push button with „Lock“ function Display 3 x 12 characters, either US or SI units Acoustic alert
Memory	377 records and sum spectrum, non-volatile
Interface	Infrared data link with special adapter for the USB-Port of the PC
Power supply	internal rechargeable battery approx. 48 hours continuous operation Charging time approx. 2 hours
Housing	rough Aluminium enclosure with open sampling head Dimensions 138 x 57 x 32 mm Weight 300g
Software	Radon Vision