Manual

poCAMon

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Content

General information

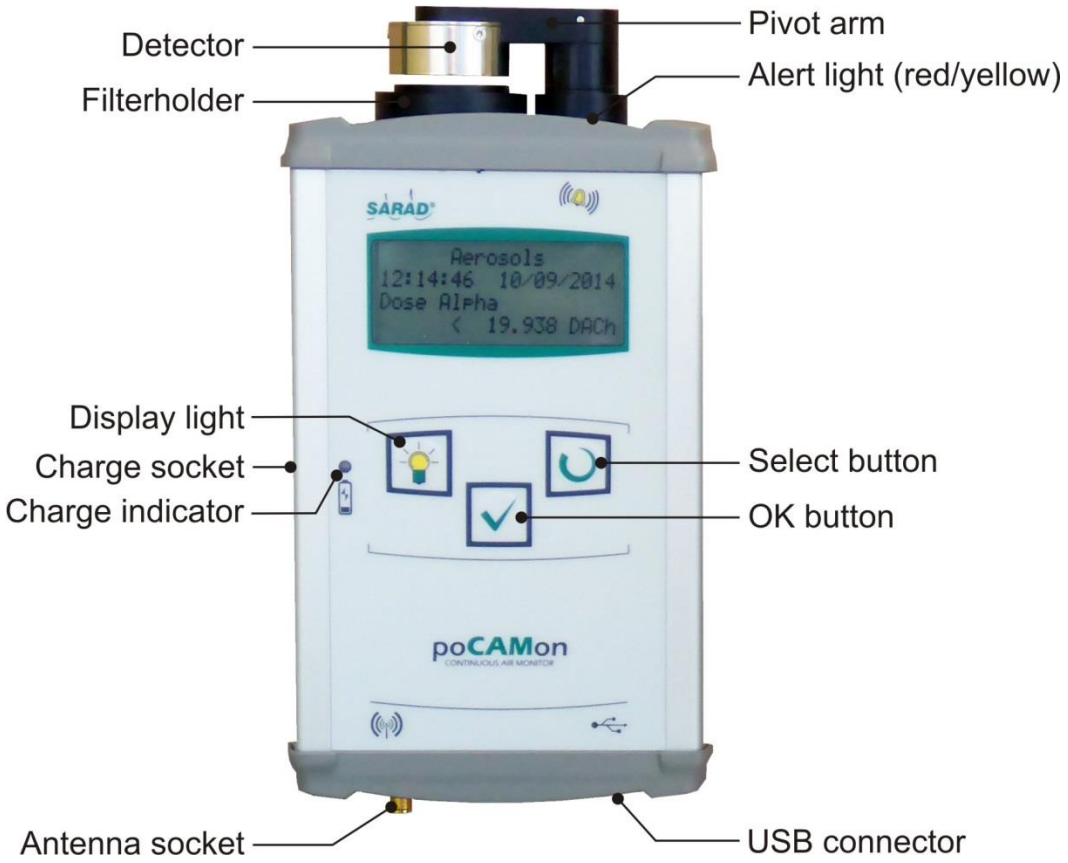
The personal online continuous air sampler poCAMon allows the measurement of the exposure of workers and first responders with respect to radioactive aerosols. The unit measures long lived radioactive dust (LLRD) as well as natural occurring Radon daughter products. Both values are presented separately. 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 spent 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 instrument offers various measurement cycles to fit for several applications. The configuration and operation software package dCONFIG/dVISION will be delivered with the unit.

An extended version especially for underground facilities contains a gas warn system including sensors for combustible gases (such as Methane) and the toxic Carbon Monoxide.

The picture below shows the main part and controls of the poCAMon



Power supply

The unit is powered by an internal 12V/3.8Ah rechargeable battery pack (standard cells). The battery allows more than 30 hours of autonomous operation. When the battery has been discharged, the instrument switches automatically to standby mode resulting in very low power consumption. If the battery remains without recharging of longer periods, a deep discharge prevention circuit disconnects the whole electronics. Then, the display switches completely off. After connecting the power supply it takes a few minutes to reach the battery voltage threshold which is required to turn on the unit again. The charging process takes about two hours and is indicated by a red light left beside the buttons. If the charging has been completed, the light turns off. The instrument warms up during charging process therefore it should not be covered as long as the charger is connected. Only 18VDC power adapters with a minimum rate of 60VA can be connected.

The instrument can be permanently connected to the adapter. The integrated charge controller forces a cyclic charge/discharge process to maintain the battery.

Important hints for battery maintenance

The instrument contains high quality NiMH battery packs of leading manufacturers. This technology provides a high power density, long life time a high transportation safety. Some hints should be noticed to maximize the battery performance.

Do not store the instrument with discharged battery even for short periods. NiMH batteries undergo a certain self-discharge which discharges the battery even if no load is connected. This may result in deep discharge and can damage the battery pack. Charge the battery to 50…75% of the capacity before longer storage. Recharge the battery at least every six month.

Switch off the instrument if it is not in use. This can be done by the implemented “Power off” cycle. The instrument consumes power even in standby modus resulting in continued discharging. If the battery is exhausted, the deep discharge protection circuit will disconnect the electronics, but cannot avoid self-discharge (see previous item)

Charge the battery within the temperature range from 10°C to 30°C. In case of higher or lower temperatures, the battery cannot reach its full capacity. To protect the battery, the charge process will be interrupted if the temperature exceeds approximately 43°C.

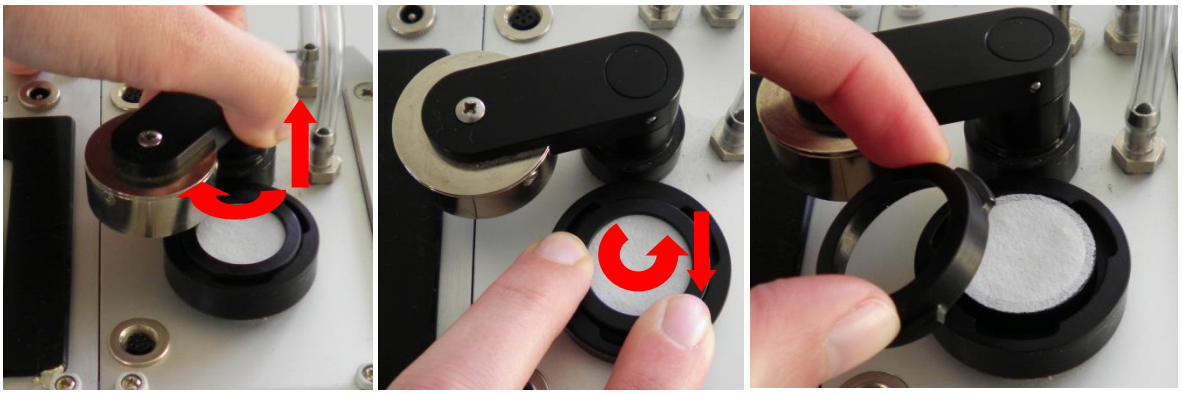
Recharge the battery even if it is not completely discharged. The capacity lost by the aging process can be minimized by operation between 20% and 80% of the capacity.

Remove the power adapter after charging. The integrated charge controller monitors the battery state continuously and provides a conservation charge. However, this cycle will accelerate the aging process of the battery.

Filter replacement and flow control

If the filter is heavily charged by particles and the pump cannot longer regulate the flow at the nominal rate, the yellow alarm light begins to blink. In this case the filter must be replaced. At first, the pivot mounted sampling head must be pulled out slightly and turned towards the display (pic. 1). After that, the filter cap (inner ring) must be pressed down and turned to lose the bayonet-catch (pic.

2). Now, the old filter can be removed and replaced by a new one. The smooth side of the filter must show in the direction of the sampling head. Only filters specified by SARAD should be used. This ensures a reliable sealing as well as the required spectroscopic performance.



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. As mentioned above, if the filter needs to be changed, the yellow signal starts to blink. This happens just before the contamination limit is reached. Thus, a running sampling can be finished before filter replacement. Flow rate as well as filter contamination are logged into the data file.

Important hint: The instrument must be switched off before filter replacement. Please see also chapter “Calculation of average activity concentration”.

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). If necessary, the SD card can be replaced by removing the bottom cap of the instrument’s enclosure (picture). After inserting a new card, the card needs to be initialized using the “RESET” button in the dVISIOn software.

Instrument operation by menus

If no measurement is in progress, the unit remains in a low power modus. The display shows the main menu containing the instrument name and configuration, the chosen sampling cycle and the selected menu command in the bottom line. The select button toggles between the following available commands:

- Start the chosen sampling cycle (Start cycle)
- Show the data of the last finished sampling interval after stopping the measurement (Show results)
- Select a pre-defined sampling cycle (Select cycle)

Command „Show results“

After selection of this menu command by the OK button, a list of available measurements appears on the display:

- “Filter check” contamination status of the filter
- “Battery” current battery voltage
- “Counter” Detector gross count rate (all detected disintegrations)
- “Aerosols” Activity and dose values derived from the energy spectrum
- “Pump” Flow rate

To select one of these items, the select button must be pressed several times until the arrow points to the desired measure. After pushing the OK button, the results including the time stamp are shown on the display. Because the “Aerosols” menu contains more than one result, the select button must be used to toggle between them. Press the OK button to return to main menu.

Command „Select cycle“

The selected sampling cycle determines the duration of a sampling interval as well as the kind of measurement. Up to 15 various cycles can be defined by the user. After delivery, six pre-defined cycles are available:

„Hazard alert“: Sampling with one minute interval time to detect dangerous exposures quickly as needed for first responders.

„Hazard alert ZB“: Same as cycle one but with enabled wireless interface (Net Monitors).

„Staff monitoring“: Sampling with 30 minutes interval time resulting in a low detection limit. This cycle is used to get the time dependent increase of exposure over the whole exposure period of a worker.

„Staff monit. ZB“ Same as cycle one but with enabled wireless interface (Net Monitors).

„Dose assessment“: Spectroscopic analysis of the filter after exposure period (for example once per month). The sample interval is eight hours and the pump is not working (spectrometer mode). The filter analysis starts three hours after starting the cycle. Possibly remaining activity of Radon daughters decays during that period. This procedure reduces the detection limit to a minimum which allows the exact determination of the exposure and related inhalation dose.

„MARKOV PAEC“: Fast procedure (15min) for grab sampling of Radon daughter products. Requires filter replacement before sampling.

„Alert test“: Test of all available alert signals.

„Power off“: Switches off the instrument.

Start of a measurement

A new measurement (using the previously selected cycle) can be started by the menu command "Start sampling". Then, the display shows the name of the cycle, interval time and the elapsed sampling time. The bottom line shows various menu commands which can be toggled by the Select button. The output of the results is implemented in the same manner as in standby mode. In addition to the interval values, the display shows also the recent reading of the selected measure. A blinking bar indicates recent readings while the time stamp indicates the interval results (time stamp is related to the end of the interval).

One more display command („GPS position“) informs of the remaining data memory and, if the unit is equipped with GPS receiver, of the geographic position.

Alert functions

Several types of alerts can arise while the unit is in operation. In parallel to the radiometric measures, battery voltage, 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 offers two different alert signals, a yellow blinking light on the one hand and a red light combined with a buzzer on the other hand. In the upper display line appears an alert message and in the lower line the menu option “Show alerts” is offered. Pressing the OK button leads to a list containing all pending alerts. The alert list has to be confirmed by pressing the OK button again. The behaviour of the signal devices can be configured by the user for each alert source independently. To 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 not more 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**	**Preset threshold**	**Displayed phrase**	**Reset**
Alpha dose	Red/Interval	> 10DACh	Aerosols	User
Beta dose	Red/Interval	> 10DACh	Aerosols	User
EEC Radon	Red/Interval	> 1000Bq/m³	Aerosols	User
EEC Thoron	Red/Interval	> 1000Bq/m³	Aerosols	User
Gros count ate	Red/Second	> 20 cpm	Count rate	Auto
Low battery	Yellow/Second	11,8 V	Battery	Auto
No filter inserted	Yellow/Second	< 0%	Filter check	Auto
Filter contaminated	Yellow/Second	> 90%	Filter check	Auto

The configuration procedure for alerts will be explained in the chapter “User specific settings“.

Gamma background

Increased background radiation results in an increased count rate for betas. The reason is the generation of conversion electrons by interaction of gamma quants with matter (e.g. detector housing). These conversion electrons cannot be separated 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 collect filter activity cannot decrease.

The 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:

Background count rate = 55cpm/(µSv/h) * Dose rate (µSv/h)

The preset background count rate will be subtracted from the beta gross count rate, taking the statistical fluctuations in consideration. If the unit with preset 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 chapter „user specific settings“.

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 in 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.

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. The user needs to make sure that filter activity and exposure period are always consistent. The instrument must be switched off (use cycle “Power off”) and on again to reset the exposure time in case of filter replacement. Now, a new averaging period starts. In the reverse conclusion, the instrument must not be switched off without filter replacement.

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

Operation conditions

The instrument has been designed as a robust unit for portable use in nuclear facilities 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. The unit should be worn on the body using the holster. The holster and the position close to the breathing tract offer a perfect shock protection as well as a good sampling procedure.
- Do not use any strong source of electro-magnetic fields in the immediate surroundings of the instrument (e.g. mobile phones, Wi-Fi adapter/router).
- The internal battery warms up during charging process. Therefore, the instrument must not be covered or operated in a box while the power supply is connected.
- The instrument should never be operated without filter. Particles in the air loop resulting in an increased abrasion of the pump.

Communication via USB and Net Monitors (ZigBee)

The instrument is equipped with both, a standard USB and a wireless interface. The USB interface has always the highest priority. That means, if the unit is connected to PC by the USB cable, the wireless connection will be interrupted. The USB port appears in the PC software as a virtual COM port. A driver must be installed before the communication can be established (see manual dVISION). After delivery, the wireless interface is only activated if one of the cycles “Hazard alert ZB” or “Staff monit. ZB” is in progress. If the wireless communication shall also be provided also in standby mode, the configuration needs to be changed (see chapter “user specific settings”). It should be taken in account that in this case the wireless interface draws still current from the battery, resulting in a faster discharge. It takes about 60 seconds after switching on the wireless interface (start of the cycle) until the connection has been established. Please mind the correct baud rate setting (9600) at the

Net Monitors coordinator. If the connection will be interrupted, the instrument automatically re-connects as soon as it is back in the range of the coordinator.

Integrated gas warn system (Carbon Monoxide & combustible gases)

Especially for underground facilities, the poCAMon comes with very sensitive internal gas sensors for combustible gases (such as Methane) and the toxic Carbon Monoxide. The gas concentration is measured continuously and will be presented as an additional result at the display and in the data file. Warn and alert levels for both sensors can be adjusted by the configuration software. As an important safety feature for areas exposed to explosion hazards, all electrical circuits will be disconnected (mechanical relay) from the battery if the gas concentration exceeds the alert level. The charger must be plugged in to the unit to switch on the instrument after such an event.

If any malfunction of the semiconductor gas sensors is detected, the sensor readings will show numbers below zero, coding the failure. Both sensors need approximately one minute to warm up before a valid result is presented. During that period, the display shows the number "-5 ppm" instead of the concentration and the yellow warn signal is blinking.

The specified measurement range for the Carbon Monoxide sensor is 50ppm to 1000ppm and for the combustible gas sensor 500 to 10000ppm. Outside this range, the sensors are still working but the accuracy decreases. If the concentration falls below 30ppm (CO) and 300ppm (Combustible Gases), the instrument will show zero.

Gas sensor alert function

The following table shows the various alerts generated by the gas sensors. See also chapter "Alert functions" for general information about the alert handling.

Alert source	Signal/check period	Preset threshold	Displayed phrase
CO concentration	Red/Second	> 50 ppm	CO (TGS2442)
Combustible gas Concentration	Red/Second	> 3000 ppm	CH4 (TGS2610)
Combustible gas Concentration	Total power Interruption	> 8000 ppm	Instrument turns off
Defective gas sensor Gas sensor warm-up period	Yellow/Second	< 0 ppm	CO (TGS2442) AND/OR CH4 (TGS2610)

The lower explosion level (LEL) for Methane (CH4) is 4.4% (40,000ppm). After delivery, the power interrupt level set to approximately 18% of the LEL while the warn level is set to approximately 7% LEL. For a maximum accuracy, the sensor is calibrated using these two concentrations.

The maximum allowed concentration (MAC) at workplaces for Carbon Monoxide is 30ppm. At levels of 200ppm, light headache come within 2…3 hours. Just a few hundred ppm will result in lethal effect. The sensor is calibrated at concentrations of 30ppm and 300ppm.

Gas sensor test

The user can test the gas warn system very easily. For combustible gases, a gas driven cigarette lighter provides the target gas after quenching the flame. Only a very short gas release in the

surrounding of the sampling had is sufficient to see the measured concentrations on the display and to activate the alert function. Release a little bit more gas to check the power interruption of the unit. A similar procedure is used for Carbon Monoxide. Light a rolled piece of paper and quench the flame that the paper still glows on. This incomplete burning process generates the target gas in sufficient high concentrations.

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.

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. The instrument offers two alert signals, which are controlled by the components DOUT3 (red light and buzzer) and DOUT4 (yellow light). After delivery, the component DOUT3 is chosen for radiometric alerts. To disable the alert function, select the item “inactive” from the list “Alarm output”.

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 appears 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 can be disabled in the same manner as described for the radiometric measures if the item “inactive” will be selected from the list box “Alarm index higher than”. After delivery, the red light and the buzzer (DOUT3) are activated in case of a pending alert. If only the yellow light shall signalize high count rates, select DOUT4 instead of DOUT3.

Adjusting the gamma background compensation

Configuration window of component SPEC1

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).

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/m³). The dose coefficient unit in case of SI unit scheme is µSv/(Bqh/m³). The values can be entered into the table “Calibration constants”. There, the parameters "Dose Coefficient Alpha", “Dose Coefficient Unat” and "Dose Coefficient Beta" 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/m³)		in µSv/(Bqh/m³)
	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

Enabling of the wireless interface in standby mode

Configuration window of component SPEC1

The power supply for the wireless interface can be switched on/off with the status of the switch output DOUT2. The output can be controlled during the measurement by the cycle definition chart (see dCONFIG). The configuration window offers the possibility to define the status of the output during standby. Use the list box “Reset status” either to turn on („active“) or turn off (“inactive”) the interface. After delivery, the reset status is set to „inactive“.

Changing the alert levels for the gas warn system

Configuration window of components TRMT1 and TRMT2

The transmitter configuration form offers two independent alert channels which can be interpreted as warn and alert levels. Each of them allows setting a “lower than” and “higher than” threshold. Different alert outputs can be chosen for all thresholds by the list boxes below the threshold edit lines. The “lower than” threshold of the warn channel is set to zero and is assigned to the DOUT4 (yellow light). The upper warn thresholds are related to the maximum allowable gas concentrations for CO and Methane (see table in chapter “Gas sensor alert functions”). If the concentrations exceed the threshold, DOUT3 (buzzer and red light) becomes activated. The alert channel for the combustible gas sensor (TRMT1) is used to disconnect the whole instrument from the battery in case of danger of explosion. This is done by using the DOUT7 as alert destination. Do not change this configuration to keep this safety function. The alert channel is not used for the CO sensor (TRMT2).

The warn levels may be changed with respect to the user requirements by entering the desired limits into the edit lines.

Appendix

Assignment of components in dCONFIG

Name	Function	Component type
DOUT1	Power supply for flow regulator	Switch outputs
DOUT2	Power supply for wireless interface (Net Monitors)	Switch outputs
DOUT3	Red Alert signal/buzzer	Switch outputs
DOUT4	Yellow alert signal	Switch outputs
CNT1	Gross count rate	16 bit counters
AIN8	Filter check (Pump voltage)	12 bit configurable analogous inputs
BATT	Battery voltage measurement	Internal sensors
SPEC1	Spectrometer for filter activity	Spectrometer
REG2	Flow rate regulator (set-point)	P-Regulator/analogous output
CMP1	Threshold for detector pulse signal	Voltage comparator input
TRM1 *)	Sensor for combustible gases	Transmitter
TRM2 *)	Sensor for carbon Monoxide	Transmitter
DOUT7 *)	Forces power interruption for all electronic circuits (see chapter gas warn system)	Swich outputs

*) only for instruments with integrated gas warn system