Thermo
ELECTRON CORPORATION

Operating Instructions DB-059-060324 E

SENTINEL RadEye G

Portable Dose- and Dose Rate Meter

REVISIONS SHEET:

Rev.	Rev. state	Dept. resp.	Name	Rev. page	Cat. *)	Explanation
	24.03.06	RM&P-E	Trost			

*) Category C: editorial correction
I: clearing improvement
A: substantial amendment

Explanations must be given, at least with Category A.

CONTENTS:

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SAFETY INSTRUCTIONS

Due to the rather high detector sensitivity the dose rate measuring range of the SENTINEL RadEye G is limited to 10 R/h.

A correct dose integration is performed only, if the instrument does not display over load “OVERLOAD”

The SENTINEL RadEye G is suited to perform highly accurate dose measurements at low to medium dose rates. It is however **not** intended for use as a legal personal dose meter.

Do not use the unit if error messages appear on the screen.

The earphone connector at the bottom side of the instrument must be exclusively used by equipment that is specified for use with SENTINEL RadEye G.

WEEE Compliance:

This product is required to comply with the European Union's Waste Electrical & Electronic Equipment (WEEE) Directive 2002/96/EC. It is marked with the following symbol:

Thermo Electron has contracted with one or more recycling/disposal companies in each EU Member State, and this product should be disposed of or recycled through them. Further information on Thermo Electron's compliance with these Directives, the recyclers in your country, and information on Thermo Electron products which may assist the detection of substances subject to the RoHS Directive are available at **www.thermo.com/WEEERoHS**

1. Introduction

The pocket sized SENTINEL RadEye G is a sensitive and rugged device to measure the photon exposure rate (R/h) of gamma and X-ray radiation.

The characteristic feature of the SENTINEL RadEye G is the use of sophisticated low power technology components and microprocessor based, fully automatic self checks. No maintenance is required.
The SENTINEL RadEye G incorporates a sensitive GM tube detector allowing the detection of low to medium radiation levels.

While in some of the pictures in this documentation the measuring unit "µR/h" is displayed, the measuring range of the SENTINEL Rad Eye G is restricted to 0.01 mR/h – 10 R/h.

The last 1600 mean and maximum values of the dose rate and count rate are recorded internally and can be read out via serial interface.

Additionally the SENTINEL RadEye G logs the last 250 alarms, errors and changes of the configuration. All events can be read out via serial interface.

A real time clock is provided to add a time stamp to all buffer data.

All or selected menu functions described in 3.1 can be configured to be invisible and inaccessible by the user.
Thus the instrument can be configured to both, an extremely simple mode allowing just LCD-illumination and alarm acknowledgment to a very versatile mode for the more experienced user.

Alarm LED, showing radiation exceeding thresholds. Visible from top if worn in a holster and from display side

Key on top side to acknowledge alarms if worn in a holster

Powerful graphical display

Easy to use, four key, menu driven user interface

Rugged plastic enclosure

Earphone connector

2. Installation and start-up

2.1 Scope of delivery

The SENTINEL RadEye G is delivered in a folding paper box together with two AAA cells and an operating manual.

A rubber protection sleeve, a holster and an earphone may be added optionally.

Ordering information for accessories:

Holster	Part No.:	42506/7046
Rubber sleeve	Part No.:	42506/7030-18
Earphone.....	Part No.:	42506/7037
Car holder.....	Part No.:	42506/7065

2.2 Inserting the battery

The two AAA-Alkaline cells as delivered with the instrument allow up to 600 h of normal operation.
AAA size rechargeable batteries can be used as well.

- Switch off the measuring instrument.
- If supplied, remove rubber sleeve.

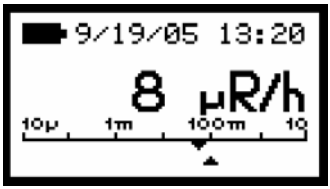
- Open the cover of the battery compartment.
  Use of a coin is recommended.



- Exchange the batteries according to the shown polarity.
- Close the compartment cover, hooks first, care for the rubber seal being in it's groove.
- Switch on the unit again. (see chapter 2.4)

The instrument continues working in the operating mode set last (see chapter 3.2).
The measured values in the history memory remain stored.
The real time clock for time stamp of history values and logbook continue operation, if batteries are exchanged without

delays. If Real Time Clock is set, actual time and date is displayed for 10 s.



If correct timing information of logbook and history is required, the Real Time Clock should be set by means of the PC-program.

To keep RTC running during battery exchange, batteries must be exchanged without delays.
RTC will always be reset, if instrument is stored without batteries for more than 10 seconds.
History data and measurement parameters are stored permanently, even if batteries are removed.

RTC information is only required, if the instrument is switched off and on during operation and if correct timing information for history and logbook entries is needed.
For the last power on interval, the relative time information of logbook and history is corrected to actual PC clock time during read out. In these cases the setting of the clock is not required.

2.3 Mounting of the protection sleeve

The rubber protection sleeve improves ruggedness to mechanical shocks.

For mounting of the sleeve first put the instrument into the top of the sleeve. Then pull lower edges of the sleeve, one after the other into it's right position.

First step

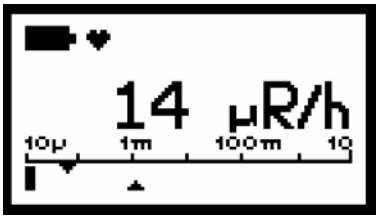
Second step

Front view

Rear view

2.4 Switching the unit on

To switch on the SENTINEL RadEye G, **keep** the ON button pressed for **at least one second**. The sound generator (beeper) is initiated.
After switching the unit on, the SENTINEL RadEye G starts working with the parameters previously selected (operation mode, calibration factor, alarm thresholds etc.).



Typical display after switch on.
Real Time Clock is only displayed if clock is set. See 2.2.

Unless otherwise specified by the customer when placing the order, the following values are set by the factory before delivery:

Alarm 1 for Dose Rate	0.5 µSv/h or 50 µR/h
Alarm 2 for Dose Rate	25.0 µSv/h or 2.5mR/h
Alarm 1 and 2 for the Dose	app. 16 Sv or 1600 R
Acoustic alarm (Sound)	active
LED alarm indication	active
Vibrator alarm indication	active
Acoustic count rate indication	Single Pulse
Autosend	off

History recording interval 120 s *)

*) These parameters can only be changed through the serial interface by means of the configuration software.

The first alarm thresholds for dose rate is around 200 - 500 % above the typical normal background and allow sensitive, but false alarm free dose rate monitoring with a reasonable fast response time. The alarm thresholds for the dose are set to the maximum possible values, thus being deactivated. With the setting of the history recording interval of 120 s , the last 52 hours of operation will be stored in the history memory.

These default values are reasonable for the majority of applications. For special applications the parameters (except calibration parameters) can be changed with the help of the optional PC-program „SENTINEL RadEye.EXE“ and the cable 42540/29. Furthermore, additional monitoring modes can be activated.

The calibration parameters can only be changed in the factory using special software tools.

3. Configuration

3.1 Menu functions

To enter the operating menu press the “Menu” key.
Scrolling through the single menu options is effected by the up / down arrow keys.
The display returns to its initial default setting in case no key has been activated for more than 10 seconds.
A j to be found behind some menu options means that the respective function is active.

The menu offers the following displays:

The above illustration depicts all menu options available or possible

Using the PC-Software and an interface adapter, any of the functions can be hidden. This allows the user to be given only the functions necessary to accomplish his measurement duties, thus simplifying the handling considerably.

The Up- and Down arrow key are used to scroll through the menu.

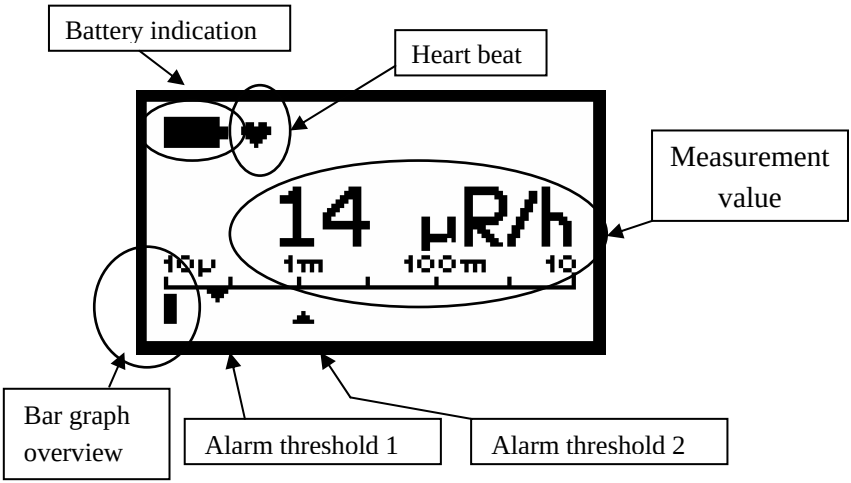
To select a menu option, release the left key as the respective menu option has been reached.

The meaning of the Menu key may change with the selected menu. The meaning is shown on the bottom of the display.
Change: Edit Alarm values
Off, **On**: Switching a function on and off
Select: Select a default display mode
Yes: Confirmation of an action
Exit: Exit menu
In Change menu the Up-/Down arrow keys are used to change a digit of an alarm value.

MENU DISPLAY	DESCRIPTION OF THE FUNCTION ACTIVATED BY THE LEFT KEY
Sound	Switching the acoustic alarm and the audible indication of keystrokes on/off
Switch off	SENTINEL RadEye is switched off. Time and stored data are maintained.
Single Pulse	Enabling and disabling of single pulse indication. Activation is done by audio keys (right button and top button).
Finder	Enabling and disabling of audible radiation intensity. Activation is done by audio keys (right button and top button).
Clear Dose	Clears accumulated dose
Alarm Dose	Allows setting of dose alarm 1 and 2
Alarm Dose Rate	Allows setting of dose rate Alarm1 and 2 (R/h or Sv/h).
LED	Switching the optical alarm on/off
Vibrator	Switching the vibration alarm on/off
Autosend	If activated, the instrument sends a data string periodically to the infrared port. This is used for radio transmission units.

3.2 Basic display

The standard display is indication of the actual dose rate .



Pressing the up arrow/dose – key shows upon the

- 1st click: the accumulated dose (R)
  Additionally the remaining time until the dose alarm 1 is reached, assuming the current dose rate will persist.
- 2nd click: the mean value and max value of the measured dose rate (R/h), together with the time indicated since the last reset..
- 3rd click: standard display

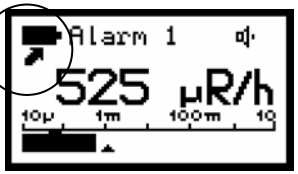
After 10 seconds or after 3rd click standard display with dose rate indication is activated again.

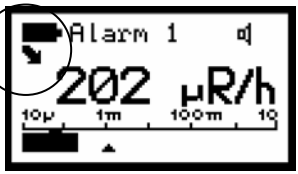
1st click

2nd click

3.2.1 Trend indication

A trend indication is given, if the measured dose rate is increasing or decreasing.





For accurate measurements, only readings without trend indication should be used.
A trend indication is not given at dose rates of less than 60 µR/h.

3.3 Alarm thresholds

There are two alarm thresholds each allocated to dose and dose rate.

In order to avoid dose alarms while using the instrument exclusively as a rate meter, the dose alarms can be set to the maximum level.

Configuration of the alarms is possible via infrared interface (chapter 6.2) or via the menu.
As to the alarm activation, please also read chapter 4.2.

3.4 Setting alarm thresholds

The menu options **Alarm Dose Rate** and **Alarm Dose** allow the alarm thresholds to be modified. For this setting, the user has 255 seconds time. Changing the value is effected by pressing the left (Change) button if the corresponding “Alarm” is selected:

To increment the number, press the up/down arrow keys. To go on to the next digit or to quit the edit mode, menu use right/left arrow keys.
Once the last number has been set, quit the editing mode by pressing the “Exit”-key. Then, the value set is saved and after 10s the unit returns to the basic display.

Example:

The dose rate alarm threshold must be changed.

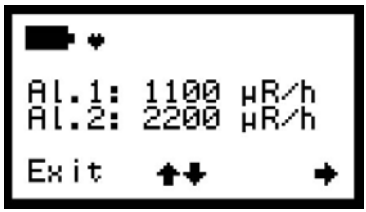
Press “Menu” key, and up/down arrow keys until **Alarm Dose Rate** is selected

Then enter change menu by pressing “Change” key.

Edit value by pressing up / down keys

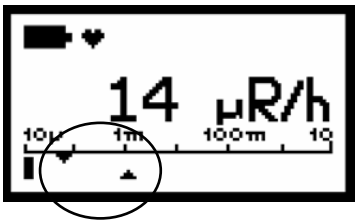
select digit by left / right keys

Pre unit “µ”, “m” may be chosen as well.



Leaving the last digit with the right arrow key:

Confirm storage of edited value pressing “yes”



The set points of the actual dose rate alarm thresholds is seen at the marks on the intensity bar scale. The upper mark shows alarm threshold 1, the lower mark shows alarm threshold 2

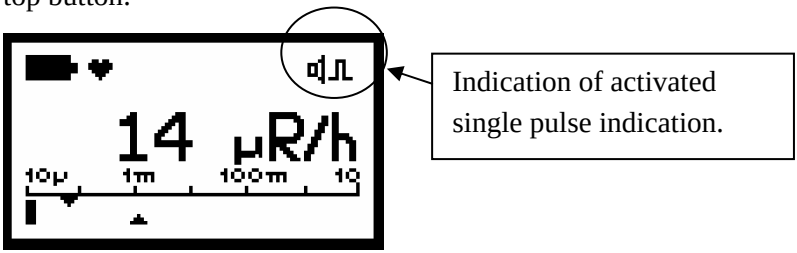
4. Operation

4.1 Audible single pulse indication and finder mode

With the single pulse indication being selected, each pulse of the detector generates a short audible signal emitted by the beeper.

An audible alarm signal caused by exceeding the alarm threshold is not given while single pulse indication or finder mode is active.

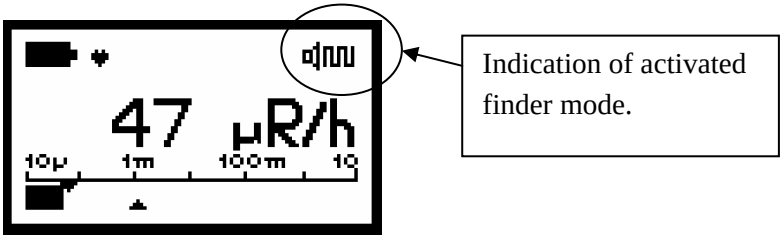
The single pulse indication must be enabled in the menu.
It is activated and deactivated by two times pressing the right or top button:



Finder mode:

In the Finder mode, the sound frequency depends on the pulse rate of the detector. The more detector pulses above the count rate that is present at the moment of the activation of the finder mode are captured by the detector, the higher the tone.

The finder mode must be enabled in the menu.
It is activated and deactivated by two times pressing the right or top button:



4.2 Alarm indication

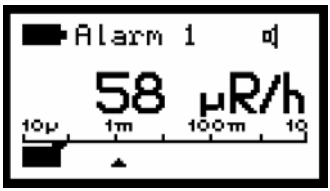
Each time the first alarm threshold is exceeded, the alarm devices beeper, LED and the vibrator become active, if they are enabled.

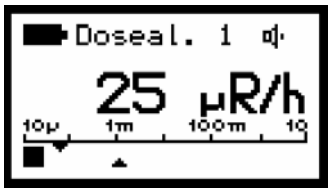
Alarm 1: LED slowly blinking, two frequency alarm tone

Alarm 2: LED quick blinking, continuous alarm tone

Dose Alarm: LED constantly on, continuous alarm tone, vibrator slow.

The alarm tone and vibrator are acknowledged by a short key depression, the LED remains pulsing. The alarm is extinguished, when the first alarm threshold is remained under. When the first **dose** alarm threshold is exceeded, the beeper and the LED together with the vibrator are active, each component signaling the alarm for 1s alternating. When the second dose alarm threshold is exceeded, the beeper emits a continuous tone, while the LED and the vibrator continue emitting pulsing signals.



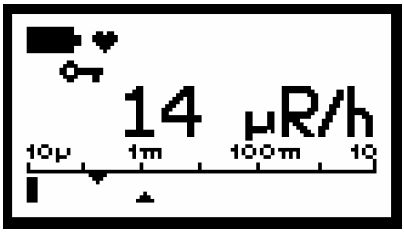


4.3 Additional information

In addition to the basic display, using the menu options, requests for further information can be started such as e.g. the setting of the enabling and disabling of the various alarm indicators.

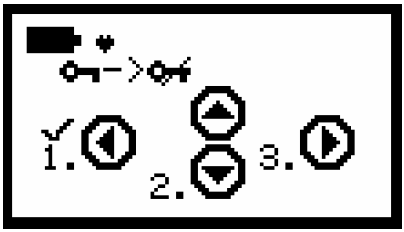
4.4 Key Lock

Pressing the “on/arrow down” key for at least 3 seconds, locks the key pad:



It is recommended to lock the keys when wearing the unit in the holster. Thus reduced battery time because of additional power consumption by illumination of the LCD or other unintended operations is avoided.

Unlocking is performed according to the LCD instructions upon pressing any key:



Press left key first, then lower key and then right key.

4.5 Process description for detection of radiation sources.

Direction of maximum response

To detect hidden radiation sources, the dose rate alarm threshold must be set to the lowest value, that does not produce fail alarms. This is typical a value of 30 µR/h to 50 µR/h.
Due to it's almost 100 times higher efficiency, the RadEye PRD is more suited for this task, than the SENTINEL RadEye G.
Subsequently, the operator passes the object while keeping thereby the distance between the monitor and the object to be checked as small as possible.
With an alarm occurring, the operator should move the instrument while observing the display in order to localize the position of the source. Please note, that the alarm can occur up to a few seconds after passing the nearest distance to the source.
If the alarm disappears after a few seconds, this alarm is to be considered as a statistically released false alarm.
In case a radiation source has been detected, the radiation intensity is indicated. (see chapter 3.2).

4.6 Earphone

For alarming in noisy environments or for undercover investigations an earphone is available. See ordering information page 2-1.

The earphone is connected at the bottom of the instrument after opening the rubber protection seal.

5. Functional test

The radiation meter performs continuous self-check routines. A complete failure of the detector will be detected in around 2 minutes and will be indicated on the LCD and be announced by the beeper. The same applies to the battery voltage.

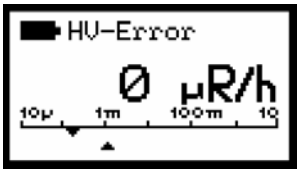
5.1 Functional test

To carry out a simple test, shortly press any key. A short audible pulse has to be released and the LC display is illuminated for some seconds.

The heart symbol next to the battery indicator must be “beating”. This indicates that the cyclic tasks as calculating measurement values, and checking for alarm thresholds are active.

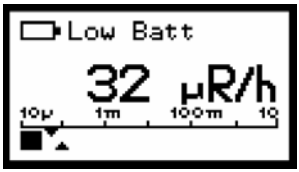
5.2 Failure indication

In case of a failure or if the battery voltage is low, the beeper generates a sharp single pulse every 32 s.
The corresponding failure message is displayed in the LCD:

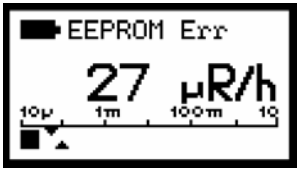


Error high voltage generation

No detector pulse within 128 seconds



Battery voltage below 2.1 V
The battery needs to be changed. However, the RadEye PRD can still be operated for several hours.



EEPROM with calibration data shows EEPROM Read or EEPROM Write error.

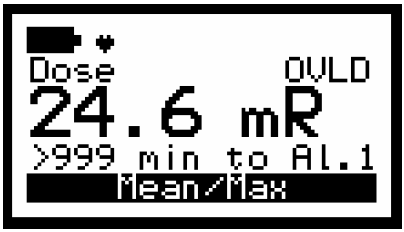
A Watchdog Error indicates, that the micro controller has problems to work on it's tasks in a given timeframe. Reasons are strong electromagnetic pulses, firmware errors or hardware issues.

5.3 Overload indication

On dose rates of more than 10 R/h an overload indication is given:

Overload indication in dose rate display

The dose value is marked with an overload indication, if a dose rate overload occurred since the last dose reset.



Overload indication in dose display

6. PC configuration

Communication between PC and SENTINEL RadEye G takes place via an optical adapter. (Infrared adapter 42540/29 plus desk top adapter 42506/7060) that is connected to a COM port of a PC.

If there is a faulty connection betwe
puter, the program shows the error message “Data transfer to instrument fails”
In this case, you must check whether:

- the unit has been connected;
- the unit has been switched on;
- the infrared transmission window at the unit and at the transmission unit are clean;
- the correct serial interface COM1 … COM4 has been selected.

Select the required interface, press OK to acknowledge the error message. In the window that is displayed now, select the **Configuration / Com settings...** menu.

6.1 Main menu

Once the SENTINELRadEye.EXE program has been started, device parameters are displayed on the screen.

6.1.1 SENTINEL RadEye G Device Parameters

The Frame "SENTINEL RadEye G" contains the unit's serial number and version number of the software. Click on the Read button, the Parameters of SENTINEL RadEye G will be read out from device and shown in the Frame.

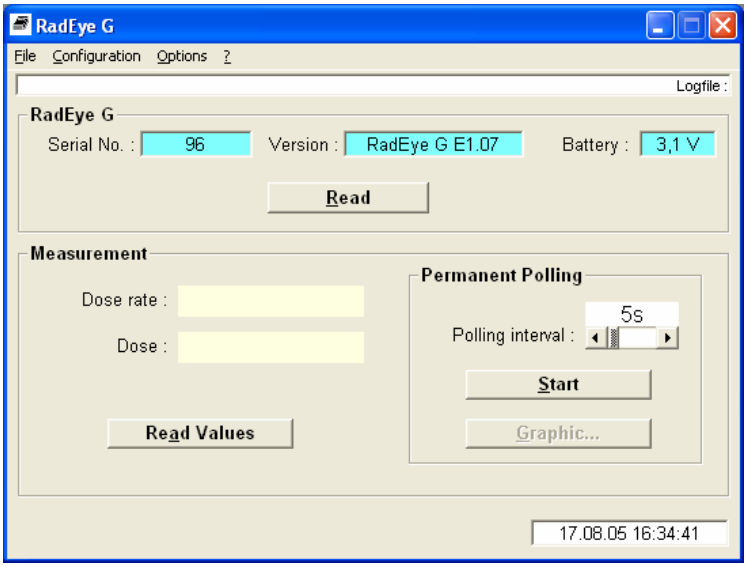


Figure 6-1: Main Window

6.1.2 Measurements

After pressing the button Read Values the current Count rate, dose rate and dose are displayed in this frame.
With button Start the measured value is read from the unit at a certain polling interval. Use the scroll bar to define the polling interval. You can select a value between 1 and 3600 seconds.
The dose rate can be displayed numerically and graphically. Click on the Graphics…. A diagram is displayed that gives a representation of the dose rate values versus the time.
The current measured value is added at the right-hand side, and the diagram is shifted to the left. Up to 100 measured values can be represented. The graduation of the ordinate is automatically adjusted to the measured values supplied by the unit.

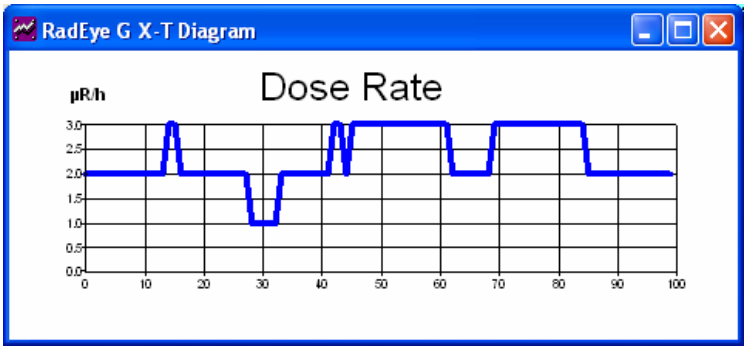


Figure 6-2: Measurement graphics

6.1.3 Creating a Measurement File

The actual measured values Count rate and Dose rate that are shown in the "Measurement" display field can be stored in a measurement file.

To do this, open the File menu, click on **Open Logfile...**, and enter path and name. The file is stored with the file name extension ".log".

If another file of the same name exists, the system asks whether that file shall be overwritten or the new measured data shall be appended to the existing data.

Once you have pressed OK to confirm the entries, the measurement logfile is created and the polling measured data is stored in the scan interval you have defined. An open measurement file is indicated by the name and the path of the measurement logfile that appears in the top right-hand corner of the window.

To terminate data storage, open the File menu and select the **Close Logfile** menu item. No further data is recorded.

Open the **File / View Logfile...** menu to view the measurement logfile.

For training and demonstration a prior recorded logfile can be replayed by opening **Replay logfile**.

With the buttons Start and Stop together with the polling interval the replay can be controlled.

Close Replay switches back to accessing measurement values via infrared interface.

The measurement logfile is an ANSI text file with columns that are separated by <TAB>. This enables this file to be read easily into other programs (such as Excel) where the data can be processed.

The first line of the measurement logfile contains the unit name, the file name, and the path. Serial number and Device identification are specified on the second line.

Date and time of the measurement are specified in the columns under the field names "mm.dd.yy" and "hh:mm:ss". The time setting corresponds to the PC system time.

The "Counter" column contains the numerical value of the counter measurement. The "Unit" column informs about the unit. The "Dose Rate" column contains the numerical value of the dose rate measurement. The "Unit" column informs about the unit (Sv/h or R/h).

6.1.4 Select serial interface

Via **Configuration / Com settings**... menu another window is opened from which you may select the corresponding interface. An error message is displayed if the interface is not available.

6.2 Configuration

On the **Configuration** / **SENTINEL RadEye G…** menu, the following parameters can be modified:

- Unit
- Time interval of the history
- Acoustic indication
- Alarm level for all basic displays
- Signalling types
- Additional surveillances
- active menu functions

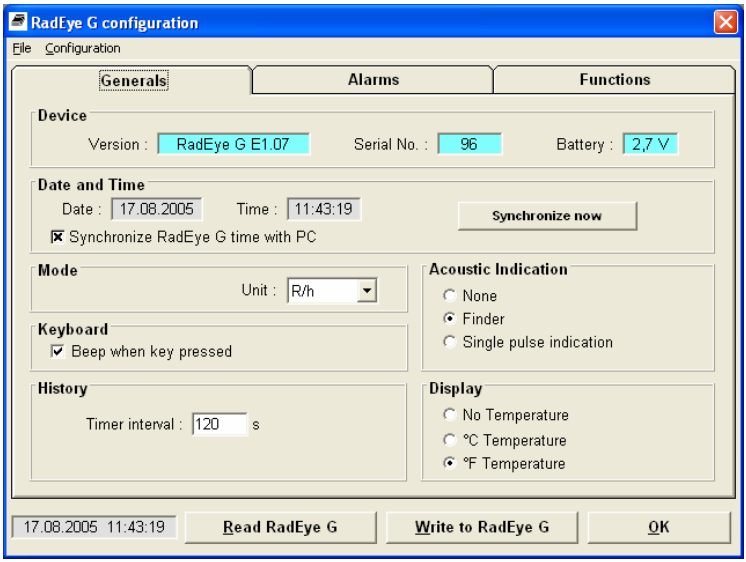


Figure 6-3: General configuration

On the „Generals“ tab, the user may set the physical unit (Roentgen or Sievert), the time interval for the history memory (1...43200s), the kind of the acoustic rate indication (single pulse, finder 4.1) and temperature.

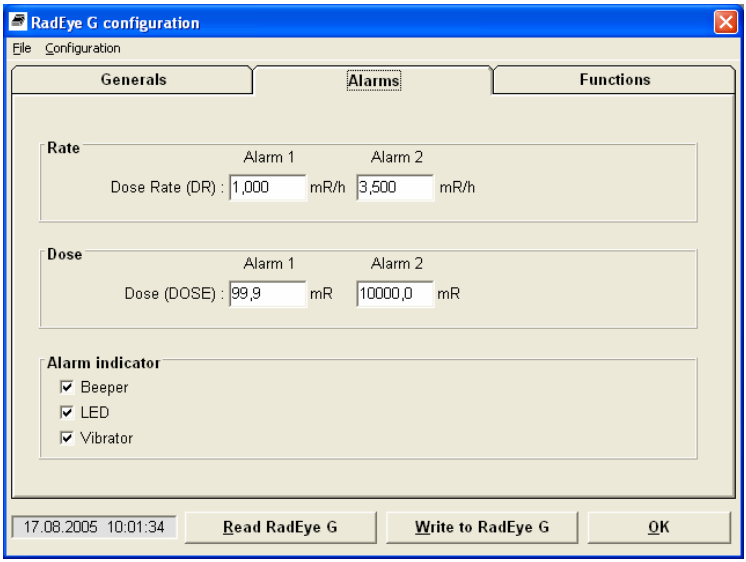


Figure 6-4: Alarm setting

The „Alarm“ tab offers the user the possibility of making the alarm settings for the single basic displays. Furthermore, the options on this tab allow beeper and additional alarm monitoring processes to be configured.

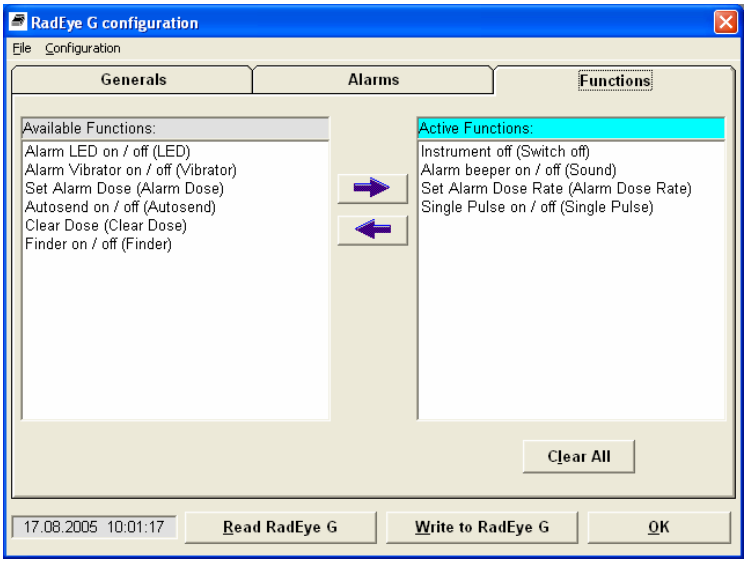


Figure 6-5: Menu selection

On the „Functions“ tab, the functions available to the user can be selected to speed up access to frequently needed functions. For example, if LED alarm is always active and rate level indication is never used, these functions can be hidden for the user.

Once the setting of the parameters is finished, these parameters have to be sent to the SENTINEL RadEye G by clicking on the Write to SENTINEL RadEye G button.

Parameters including the selected menu configuration can be saved with **File / Save as…** as parameter file (*.cfg). A saved configuration can be reloaded using the menu **File / Open…** and sent to SENTINEL RadEye G.

6.3 History

Via the **Options** / **History** menu, the values stored in the SENTINEL RadEye G data memory can be read out, represented in a x/t diagram and saved to the hard disk of the computer. These data subsequently can be read in and further processed in a spreadsheet program.

Time interval of History storing can be set from 1s to 43200 s (12 hours). 1600 measurement values can be stored.

The following figure depicts for example the curve of the dose rate over the last two days at a time resolution of 120 s. Clearly various levels resulting from different locations and points with high peaks can be recognized.

The blue line shows the mean values, the red line the maximum value within the time interval.
If batteries are removed, the time reference is lost. In the diagram time information is only provided for history values with valid timing entries.

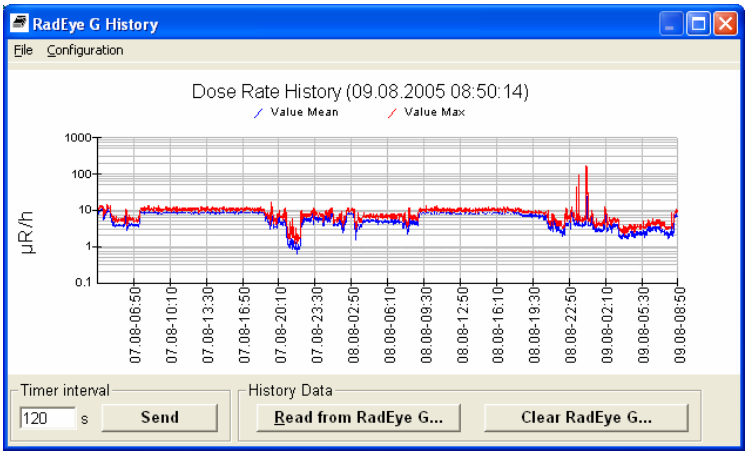


Figure 6-6: History read out

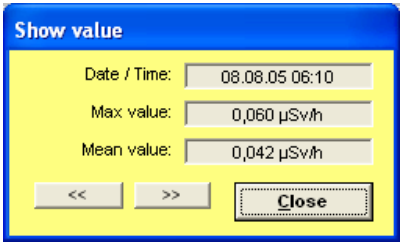


Figure 6-7: Single history value indication

Clicking at the graph, each individual, stored measured value can be displayed:

6.4 Logbook

Changes in configuration, occurring alarms and errors are logged in a buffer.

These saved events can be read out via **Options / Logbook…** .

The logbook is shown as a table, and can be saved to PC hard disc or printed.

The logbook has a maximum of 250 data sets. Several events at the same time are saved as one record. At the display every event is shown in one line for better overview. The date and time of the PC is used for time relation.

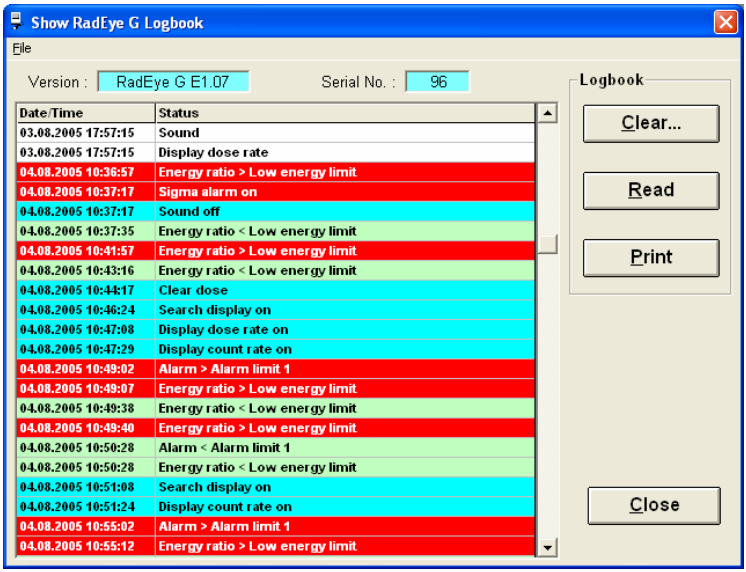


Figure 6-8: Logbook

6.4.1 Messages in the logbook-file

Error Message

No.	Message
0	Error high voltage generation
1	No detector pulse within 128 sec.
2	Battery voltage below 1,7 V
3	
4	Watchdog error
5	EEPROM checksum error
6	
7	

Alarm Message

No.	Message
0	Dose rate alarm
1	Dose alarm
2	Sigma alarm
3	Instrument switched off
4	Alarm > Alarm threshold 1
5	Alarm > Alarm threshold 2
6	Dose > Dose alarm threshold 1
7	Dose > Dose alarm threshold 2

Configuration

No.	Message
0	
1	
2	Display: 4=Dose rate
3	Sound
4	LED
5	Vibrator
6	Dose cleared
7	Alarm threshold changed

Configuration

No.	Message
0	
1	
2	
3	Power on
4	
5	
6	
7	

7. Technical data

Radiation type:	Gamma and X-ray radiation
Measured quantity:	Photon equivalent dose rate : $\dot{H}_X$ [R/h] and dose H_X [R]
Measuring range:	0.01 mR/h - 10 R/h
Overload display:	more than 10 R/h overload indication up to 1000 R/h
Linearity error:	max. ± 10 % in the measuring range
Sensitivity:	around 17 cps/mR/h photon radiation 660 keV (Cs-137)
Alarm threshold:	Two alarm thresholds for dose and dose rate each. Default setting: see chapter 2.4
Audible alarm intensity:	85 dB at a distance of 30 cm
Time to alarm:	typ.: 60s for background to 0.1 mR/h typ.: 20s for background to 0.3 mR/h typ.: 3s for background to 1mR/h

Energy range:	45 keV – 1.3 MeV:error less than ±30% for dose and dose rate measurement
Energy dependence:	see **Diagram 7-1**
Direction of max. response:	perpendicular to the device's longitudinal axis, on the reference mark on the back side of the unit
Reference point:	on the axis of the direction of max. response, 14 mm behind reference mark.
Angular dependence:	see Diagram 7-4 and 7-5

Working temperature:	-20°C ... + 50°C
Relative humidity:	10 ... 95 %
Operating voltage:	1,8 ... 4 V, Battery low voltage starting from 2.1 V
Degree of protection:	IP 65 according to EN 60 529
EMC:	Disturbance emission : EN 50081 – 1 Immunity : EN 61000-6-2
Mechanical shock:	Drop onto a concrete surface 0,5m without protection sleeve 1,5m with protection sleeve
Size:	96 mm x 61 mm x 31 mm Without rubber protection
Weight:	around 160 g including two Alkali Manganese AAA cells LR 3 around 190g including AAA cells and protection sleeve
Internal memory:	The last 1600 measured values are saved and can be read out via PC program. Max- and mean value of count rate and dose rate. The time interval is factory preset to 120s by default. Logbook with 250 entries for changes of configuration, occurring alarms and errors.

Averaging filters:	Dose Rate filter type: **A**dvanced **D**igital **F**ilter (ADF) Digital RC-Filter with time constant 1s.....180s, depending on dose rate and dose rate changing.
Power consumption:	≈ 2 mA: normal operation without alarm signals and LCD illumination ≈ 57 mA with illuminated LC display ≈ 16 mA LED alarm ≈ 80 mA acoustic alarm ≈ 30 mA vibrator alarm
Battery service life:	≈ 600h using two alkaline AAA cells depending on the operating mode ≈ 300h using 800mAh NiMH accu

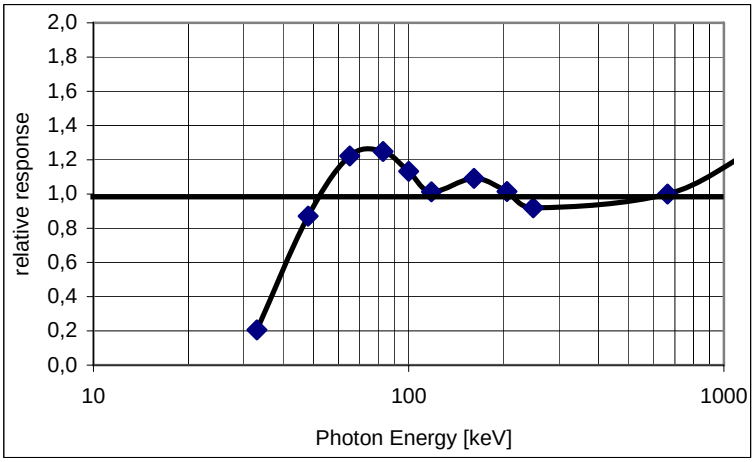


Diagram 7-1: Energy dependence in direction of max. response, perpendicular to ref. mark

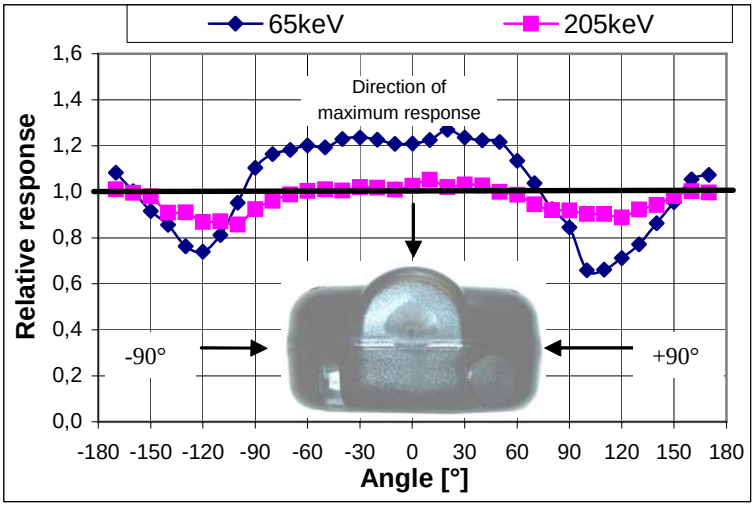


Diagram 7-2: Angular response, horizontal plane

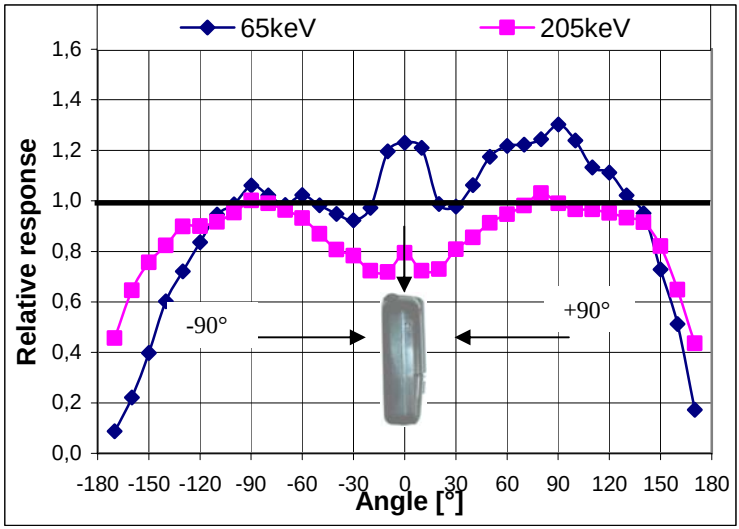


Diagram 7-3: Angular response, vertical plane A

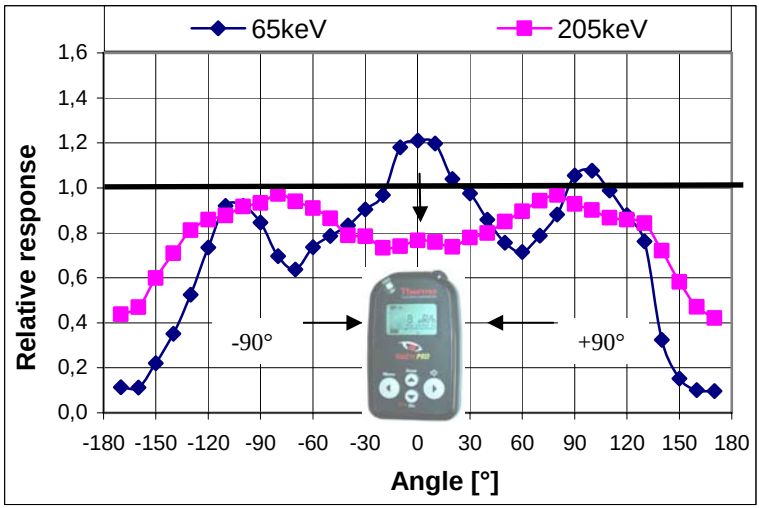


Diagram 7-4: Angular response, vertical plane B

7.1 Firmware revisions

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