

SURVEY METER PM1405

Operation manual

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This Operating Manual is intended to describe the design, configuration and principle of operation of the survey meter PM1405 (hereinafter referred to as instrument). The Operating Manual includes the general description, specifications of the instrument, maintenance and verification technique instructions, as well as some other information necessary for the proper operation of the instrument and a full realization of its possibilities.

Instrument can be delivered in following modification:
«Survey meter PM1405 TU BY 100345122.055-2009».

During manufacturing of the instrument some changes may be introduced in its electrical diagram and construction that do not influence the specifications and metrological parameters and, therefore, may be not specified in this manual.

1 Description and operation of the instrument

1.1 Application of the instrument

1.1.1 Instrument is designed to provide:

- measurement of the ambient dose equivalent rate $\dot{H}^*_{(10)}$ (hereinafter DER) of gamma and X-ray (hereinafter photon) radiation;
- measurement of the ambient dose equivalent $H^*_{(10)}$ (hereinafter DE) of gamma and X-ray radiation**);
- measurement of the α - particles flux density (surface contamination level measuring)**);
- measurement of the β - particles flux density (surface contamination level measuring);
- search, detection and location of radioactive materials by their photon, α - and β - radiation registration;
- transmission of the measured data to the personal computer (PC).

Instrument can be used for measurement of the bank notes surface contamination level carried out by the bank personnel, measurement of the ionizing radiation by the radiology and isotopic laboratory staff, emergency, border patrol and customs services to prevent illicit trafficking of radioactive and nuclear materials, as well as by the other special industry, agriculture, transport, medicine services where the nuclear technical units and ionizing radiation sources are used.

Attention! Operation modes of the instrument are enabled/disabled by the manufacturer according to the customer's order in accordance with the order form.

All operation modes of the instrument are described in this operation manual ("Operating mode").

The operation modes and functions of your instrument are shown in Attachment C.

1.1.2 Operating conditions:

ambient air temperature.....from -10 to +50 °C
relative air humidity.....up to 95 % at 35 °C
atmospheric pressure.....from 84 to 106.7 kPa

**) hereinafter referred to as – special configuration, supplied only by individual order

1.2 Delivery kit

1.2.1 Delivery kit of the instrument corresponds to the table 1.1.

Table 1.1

Item	Quantity, pcs.
Survey meter PM1405	1
USB Cable	1
α- cover (plastic bag, film thickness 50 μm)	5
Battery Panasonic Xtreme POWER Alkaline AA - LR6 – Size M -1.5V ¹⁾	2
Operation manual ²⁾	1
Data storage (Software)	1
Package	1
¹⁾ Usage of other batteries with similar parameters is allowed; ²⁾ Verification method is included.	

1.3 Specifications

- 1.3.1** Operating mode:
- photon radiation DER measurement mode ("MEASUREMENT γ ");
 - photon radiation DE measurement mode ("DOSE")**);
 - alfa- particles flux density measurement mode (MEASUREMENT α)**);
 - beta- particles flux density measurement mode (MEASUREMENT β);
 - radiation sources search mode ("SEARCH β γ ");
 - menu indication mode ("MENU");
 - set mode ("SETTINGS");
 - PC data exchange mode (USB);
 - testing mode.
- 1.3.2** DER indication range
DER measurement range
- 0.01 $\mu\text{Sv/h}$ – 130 mSv/h;
0.1 $\mu\text{Sv/h}$ – 100 mSv/h.
- 1.3.3** Limits of permissible intrinsic relative DER measurement error in measurement range
- $\pm (20 + K/H) \%$,
- where H – DER value, $\mu\text{Sv/h}$;
K – coefficient 1.0 $\mu\text{Sv/h}$.
- 1.3.4** DE indication range
DE measurement range
- 0.01 μSv – 10.0 Sv
1.00 μSv – 10.0 Sv
- 1.3.5** Limits of permissible intrinsic relative DE measurement error in measurement range
- $\pm 20 \%$
- 1.3.6** Instrument provides input, storage in non-volatile memory and continuous monitoring of threshold levels by all kinds of radiations in all range of measurements, as well as audible and visual alarms at exceeding of the radiation threshold values. At exceeding of the first DER threshold ("THRSH ATTENT.") instrument gives a discrete signal. At exceeding of the second DER threshold ("THRSH DANGER") – a frequent discrete signal. At exceeding of the DE threshold (only one threshold) – a discrete signal
- 1.3.7** Instrument provides:
- testing of the early set values of two thresholds and setting of new threshold values of photon radiation dose rate. DER threshold range of photon radiation – from 0.1 $\mu\text{Sv/h}$ to 100 mSv/h;
 - testing of the early set threshold value and setting of new threshold value of photon radiation dose. DE threshold range of photon radiation – from 0.1 $\mu\text{Sv/h}$ to 10 Sv/h;
 - testing of the early set values of two thresholds and setting of new threshold values of β -particle flux. DER threshold range of β - particle flux – from 6.0 to 10^3 (10^4 **)) $\text{min}^{-1} \cdot \text{cm}^{-2}$ (cpm/cm²)
- Discreteness of the threshold level setting low – order significant digit
- 1.3.8** Photon radiation energy range
- from 0.05 to 3.0 MeV.
- 1.3.9** Energy response relative to 0.662 MeV (¹³⁷Cs) in the DER and DE measurement mode in the energy range from 0,05 to 3,0 MeV, no more than
- $\pm 30 \%$
- 1.3.10** β - particle flux measurement range (Appendix A)
- from 6.0 to 10^3 $\text{min}^{-1} \cdot \text{cm}^{-2}$ (cpm/cm²);
from 6.0 to 10^4 **)) $\text{min}^{-1} \cdot \text{cm}^{-2}$ (cpm/cm²)
- β -particle flux indication range
- from 0.1 to 10^4 $\text{min}^{-1} \cdot \text{cm}^{-2}$ (cpm/cm²)

- 1.3.11** Limits of permissible intrinsic relative β -particle ($^{90}\text{Sr}+^{90}\text{Y}$) measurement error $\pm(20 + A/\varphi) \%$,
where φ – measured β - flux density, $\text{min}^{-1}\cdot\text{cm}^{-2}$ (cpm/cm²);
A – coefficient, $60 \text{ min}^{-1}\cdot\text{cm}^{-2}$ (cpm/cm²)
- 1.3.12** Energy range by β -particle flux density measurement from 0.1 to 3.5 MeV
- 1.3.13** Energy response by β -particle flux density measurement (Appendix B, figure B.1), no more than $\pm 30 \%$.
- 1.3.14** Sensitivity for β -radiation ($^{90}\text{Sr}+^{90}\text{Y}$), no less than $3.5 \text{ counts}\cdot\text{cm}^2$
- 1.3.15** Coefficient of variation (deviation of the instrument's readings caused by statistic fluctuations) at DER measurement at a confidence probability 0.95, no more than $\pm 10 \%$
- 1.3.16** Count rate indication for β - γ radiation in the search mode from 0.00 to $3.5\cdot 10^5 \text{ s}^{-1}$ (cps)
- 1.3.17** α - particle flux density measurement range (Appendix A) from 90 to $10^4 \text{ min}^{-1}\cdot\text{cm}^{-2}$ (cpm/cm²)
 α - particle flux density indication range from 0.1 to $10^4 \text{ min}^{-1}\cdot\text{cm}^{-2}$ (cpm/cm²)
Limits of permissible intrinsic relative error of the α -particle flux density measurement in ^{239}Pu measurement range $\pm(30 + A/\varphi) \%$,
where φ – measured α - flux density, $\text{min}^{-1}\cdot\text{cm}^{-2}$ (cpm/cm²);
A – coefficient equal to the $900 \text{ min}^{-1}\cdot\text{cm}^{-2}$ (cpm/cm²)
- 1.3.18** In a measurement mode instrument automatically calculates and displays on liquid-crystal display (LCD) relative mean-square error of average value of measurement result (statistical accuracy) in percentage at a confidence probability 0.95.
- 1.3.19** Anisotropy of the instrument for each kind of energy does not exceed values given in Table 1.2 when the instrument is rotated in the horizontal plane, and values given in Table 1.3, when the instrument is rotated in the vertical plane.

Table 1.2

Angle of detection relative to the direction of graduation, °	Energy of gamma radiation, MeV		
	Anisotropy (δ_{α} , %)		
	0,059	0,662	1,25
0	0	0	0
30	± 10	± 10	± 10
60	± 20	0/-30	± 20
90	0/-40	-10/-40	0/-35
120	-10/-40	0/-30	0/-20
150	0/30	0/-20	± 10
180	5/45	± 15	± 10
-30	± 10	± 10	± 10
-60	± 15	0/-30	0/-15
-90	± 20	-10/-40	0/-35
-120	0/-40	0/-25	± 20
-150	0/20	± 15	± 10

Table 1.3

Angle of detection relative to the direction of graduation, °	Energy of gamma radiation, MeV		
	Anisotropy (δ_{α} , %)		
	0,059	0,662	1,25
0	0	0	0
30	±10	±20	±15
60	±15	±20	0/-25
90	±25	-15/-40	-10/-40
120	-10/-40	0/-25	0/-20
150	0/30	±15	±15
180	10/50	±10	±15
-30	±10	±10	±10
-60	±20	0/-20	0/-20
-90	-30/-80	-20/-60	-10/-50
-120	-10/-45	0/-25	0/-20
-150	0/40	±15	±10

1.3.20 Limits of permissible intrinsic relative error of DER, DE, α - and β -particle flux density measurements:

- at temperature variations from normal to minus 10 and from normal to 50 °C ± 10 %;
- at relative humidity of ambient air 95 % at 35 °C ± 10 %;
- at power voltage variations from nominal value to limiting voltage values at photon radiation DER measurement ± 10 %;
- at power voltage variations from nominal value to limiting voltage values at β - particle flux density measurement 5 % of the permissible intrinsic error;
- on exposure to magnetic field of 400 A/m ± 10 %;
- on exposure to radio frequency electromagnetic fields of 10 V/m ± 10 %

1.3.21 LCD backlight duration

20 s

1.3.22 Instability of readings during 24 hour continuous work, no more than

± 5 %

1.3.23 PC communication

USB interface

1.3.24 Instrument provides the following functions:

- 1) in the mode of data transmission to PC:
 - readout of the information from the instrument's memory:
 - indication of the instrument's number;
 - turn on/off the date and time;
 - time and value of thresholds exceeding as well as time and date of the of photon radiation DER and β - particles flux density measuring;
 - on/off turning of the audible alarm;

- 2) recording and storage in the non-volatile memory (with battery took-out) the following information:
- indication of the instrument's number;
 - date and time on/off turning;
 - time and value of thresholds exceeding as well as time and date of the of photon radiation DER and β - particles flux density measuring;
 - indication of the of audible alarm on/off turning
- 1.3.25** Maximum permissible complementary relative error of the β -particles flux density measurement at the exposure of the external gamma radiation field with the exposure dose to 0.1 mR/h, no more than 15 %
- 1.3.26** Instrument keeps availability and the intrinsic error within the mark, as specified in 1.3.11. after short-term (5 min) photon radiation with DER equal 1 Sv/h. During exposure instrument displays on LSD "OL" (overload) and gives an audible signal.
- 1.3.27** Operating mode setting time 60 s
- 1.3.28** Power supply
- from two AA batteries 3 (+ 0.2; -0.8) V;
 - from the external power supply (USB)
- 1.3.29** consumption current in a DER measurement mode with DER 0,3 μ R/h, voltage rating equal 3,0 V and temperature (20 \pm 5) $^{\circ}$ C:
- at the LCD backlight and alarm off, no more than 0.5 mA
 - at the LCD backlight on, no more than 6.0 mA
 - at the and alarm on, no more than 35.0 mA
- 1.3.30** Period of continuous operation of the instrument from one battery set by standard environment and by following nominal operating mode:
- at an average value of the measured DER up to 0.3 μ Sv/h;
 - using LCD backlight, audible and visual alarm not more than 5 m/day, no more than 6 months
- 1.3.31** Ingress protection IP30
- 1.3.32** The instrument is proof against:
- temperature of an ambient air from minus 10 $^{\circ}$ C up to plus 50 $^{\circ}$ C;
 - relative humidity of an ambient air up to 95 % at 35 $^{\circ}$ C;
 - atmosphere pressure from 84 up to 106.7 kPa
- 1.3.33** The instrument is proof against:
- sinusoidal vibration in the frequency range 5 – 35 Hz and bias amplitude for frequencies lower than the transition frequency 0.75 mm;
 - shocks with acceleration 100 m/s², duration of shock pulse 2-50 ms, shock rate is 60 - 180 shocks per minute.
- 1.3.34** The instrument meets drop test against the concrete surface from the height 0.7 m

1.3.35	The instrument is proof against the action of static and variable magnetic fields of strength	up to 400 A/m
1.3.36	The instrument is proof against the action of radio frequency electromagnetic fields	up to 10 V/m (rigidity degree 3) in the frequency range 80 – 1000 MHz and up to 30 V/m (rigidity degree 4) in the frequency range 800 – 960 MHz and 1.4 – 2.0 GHz (under conditions of noise emission from digital radio telephones), performance criterion A
1.3.37	The instrument is proof against the electrostatic discharges influence	8 kV (rigidity degree 3) performance criterion B
1.3.38	Dosimeter corresponds to ANSI 42.34, section 9.11 requirements by the level of emitted radio-noise	
1.3.39	The instrument in a transport package is proof against the action of	- ambient air temperature from -50 to +50 °C; - relative air humidity up to 100 % at 40 °C; - shocks with acceleration 98 m/s ² , duration 16 ms; - vibrations with frequency 10-55 Hz and bias amplitude 0.35 mm
1.3.40	Weight, no more than	0.29 kg
	Weight in package, no more than	0.5 kg
1.3.41	Overall dimensions, no more than	148 x 80 x 38 mm
1.3.42	Reliability parameters	
	- average full operating time, no less than	20000 h;
	- average service life, no less than	10 years;
	- average time of recovery, no more than	60 min.

1.4. Design and theory of operation

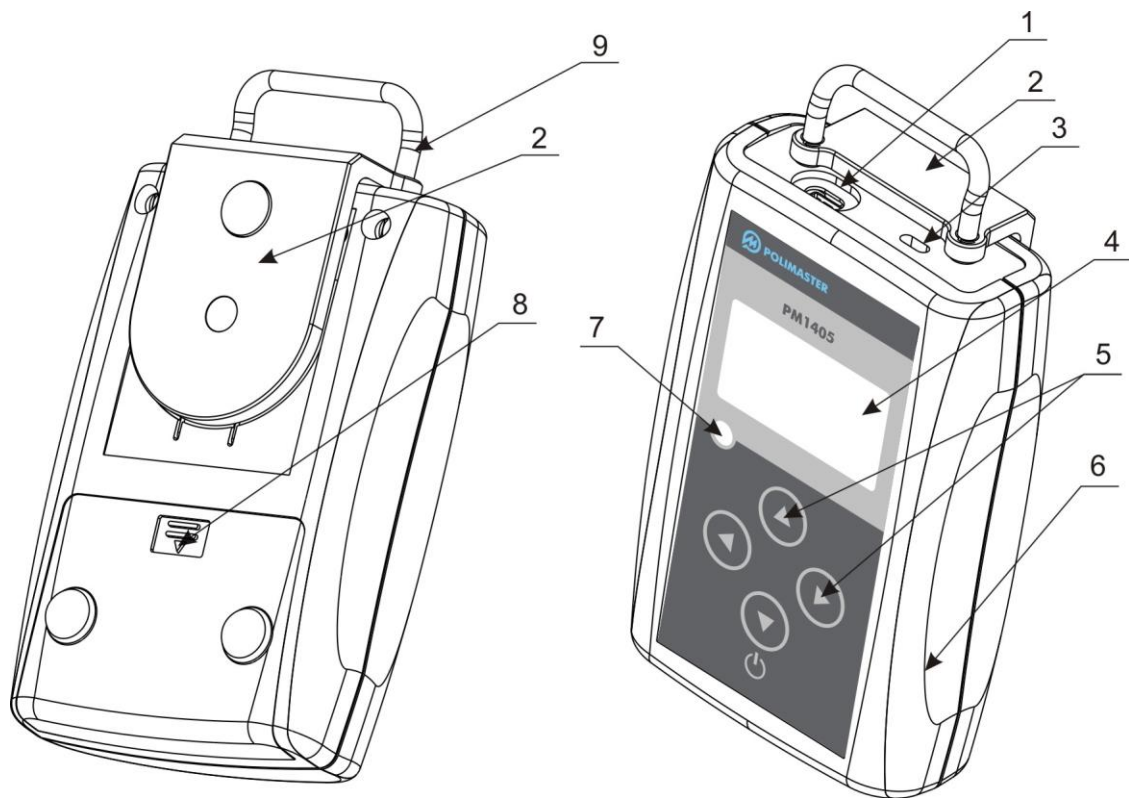
1.4.1 Design of the instrument

General overview of the instrument is shown in Figure 1.1. Instrument is designed as a unit housed in a plastic case (6). On the front panel of the instrument is located a matrix liquid crystal display (LCD) (4), four-button keyboard (5), visual alarm LED indicator (7) (“ALARM”). On the upper end there is a mini-USB (1) for the PC connection and the audible alarm outlet (3). At the backside of the instrument are located: cover of the battery compartment (8) and Geiger-Muller counter, closed by sliding screen-filter (2).

In the measurement mode filter acts as a power compensating element of the Geiger-Muller counter and should be closed. In the mode of superficial β -particle flux density measurement (“Measurement β ”) filter acts as a screen for the β -particles and could be open or closed (2.2.6).

Cable included in the delivery kit is meant for PC connection.

Overall dimensions, graduation direction and effective centre of the instrument are shown in Figure 1.2.



- 1 – USB port;
- 2 – screen-filter;
- 3 – audible alarm outlet;
- 4 – LCD;
- 5 – four-button keyboard;
- 6 – plastic case;
- 7 – LED indicator;
- 8 – cover of the battery compartment;
- 9 – filter handle.

Figure 1.1 – Physical configuration of the PM1405

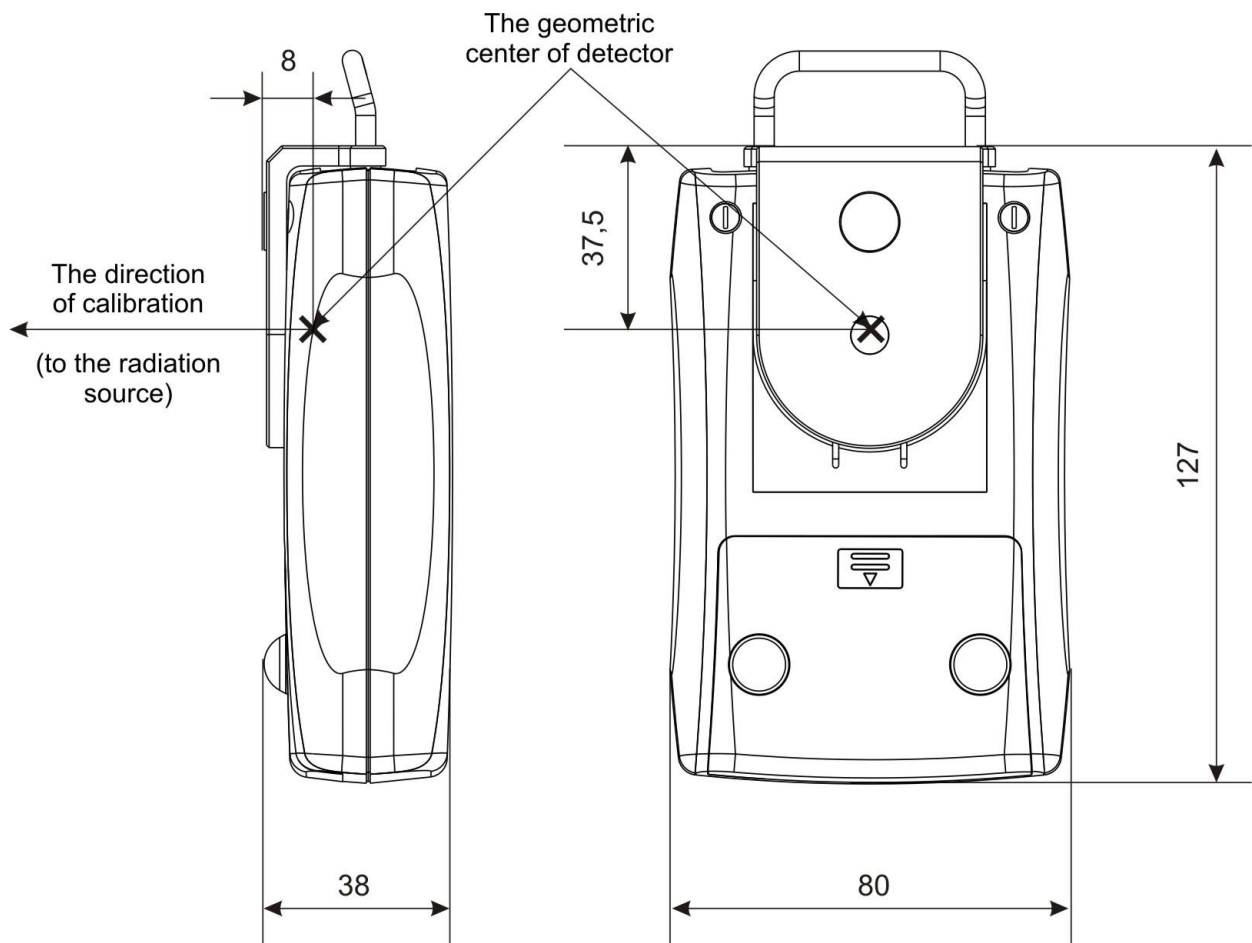


Figure 1.2 – Overall dimensions, graduation direction and geometric centre of the detector

1.4.2 Mode of functioning

DER, photon radiation, as well as α - and β - particles flux density measurements (surface contamination level control) are carried out by built-in universal detection block (DB) on basis of Geiger-Muller counter.

Control of the detection block is carried out by separate microprocessor controller, which sends the information to the main microprocessor controller.

The operation modes are chosen using the four-button keyboard on the screen menu. Results of measurement and operation modes are displayed on matrix LCD.

In the communication mode with PC SELECT of operation mode, as well as of data transmission mode are carried out using USB interface.

Instrument has built-in audible alarm.

The switching on of the instrument is carried out by pressing and holding the lower button on the key-board. (2.2.1).

As a power supply of the instrument could be used two AA galvanic batteries or USB.

The block diagram of the instrument is shown in Figure 1.3.

The instrument comprises the following main blocks and modules:

- Geiger-Muller detection bloc (GM);
- LCD;
- main microprocessor controller (Microprocessor);
- keyboard;
- audible alarm (AA);
- key;
- batteries set (BS);
- power supply (PS);
- USB interface unit (USB).

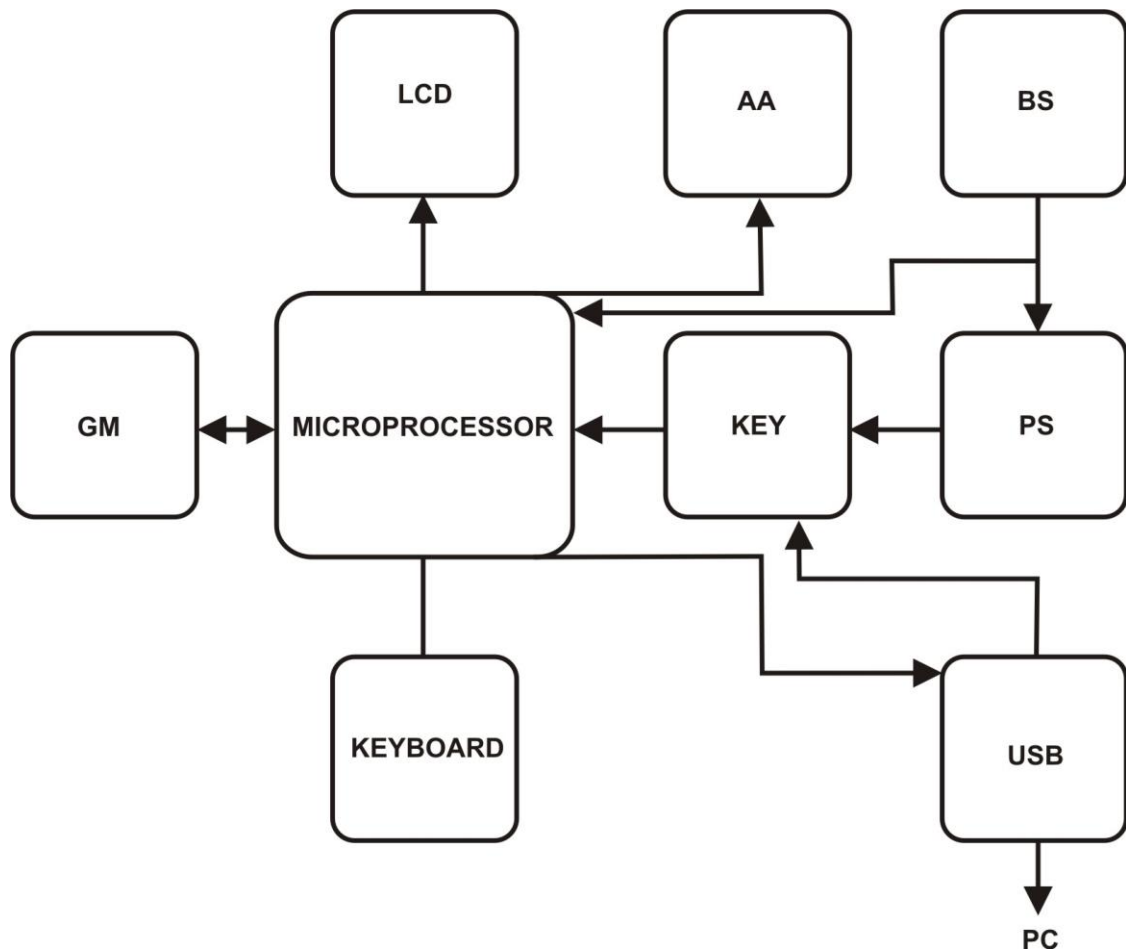


Figure 1.3 – Block scheme of the instrument

Detecting α -, γ - and β - radiations is carried out by detection bloc on the basis of Geiger-Muller counter by transformation of the photon and α - and β - radiation to the electropulses. Detection block controlling, transfer of the measured data to main microprocessor controller are carried out by the embedded microprocessor controller.

The instrument's operating algorithm ensures continuity of the measurement process, static handling of measurements results, fast adaptation to radiation rate changes (setting the time of measurement in inverse dependence on the dose rate) and effective output of the information obtained to the LCD. The data link (USB) provides an exchange of information with PC.

The instrument has an internal non-volatile memory that allows the information accumulation and storage.

The microprocessor controls the instrument's operating modes, backlight, USB interface, matrix LCD, non-volatile memory, keyboard, necessary calculations, self-diagnostics, as well as information gathering from the detection bloc.

Power supply provides transformation of the battery's voltage into a stable voltage 3.3 V necessary for the instrument's power supply.

In the PC communication mode the key automatically switches the power supply of the instrument. In this mode the power supply is provided from PC through USB.

1.4.3 Operating modes

The instrument operates in the following modes:

- DER measurement mode ("MEASUREMENT γ ");
- DE measurement mode ("DOSE")**);
- α - particles flux density measurement mode ("MEASUREMENT α ")**);
- β -particles flux density measurement mode ("MEASUREMENT β ");
- ionizing sources search mode ("SEARCH $\beta \gamma$ ");
- menu indication mode ("MENU");
- set mode ("SETTINGS");
- PC data exchange mode (USB);
- testing mode.

The operating procedure in all modes listed above is described in part 2.

In any operating mode the energy supply voltage is continuously controlled by the dosimeter (2.2.9). In any operating mode the turning on of the backlight is possible (2.2.9).

1.5 Marking and sealing

The logo, number and manufacturer name of the instrument are marked on the front panel.

The serial number of the instrument is marked under the cover of the battery compartment.

Under the cover of the battery compartment in the fastening screw pit is placed the seal, which protects the instrument from the unauthorized access.

1.6 Package

The instrument is packed into a waterproof polyethylene package and together with the operation manual is placed in a carton.

2 Use of the instrument

2.1 Preparation for use

2.1.1 General guidelines

When purchasing the instrument it is necessary to check the delivery kit and the proper operation of the device in all the operation modes according to the items 1.2.1 and 2.1.4.

Protect the instrument from shocks and mechanical damages. Avoid exposing the instrument to hostile environments, organic solvents and open fire.

When in use, don't keep the instrument in immediate proximity to radio emitting sources, such as cell phones, to avoid false positive alarms.

2.1.2 Safety instructions

2.1.2.1 During the device adjustment, checking, repair, maintenance and verification, if the radioactive sources are used, the regulations for work with radioactive materials and other radiation sources, as well as Standards of radiation safety should be followed.

2.1.2.2 Additional safety instructions

In case of radioactive contamination it is necessary to delete the radioactive substances from surfaces of the detector and the instrument with a fabric, wetted in ethyl alcohol. The ethyl alcohol consumption on deactivation of the instrument is about 50 ml.

2.1.2.3 If the batteries are not installed, it's necessary to install them according to the item 2.1.3.3.

2.1.3 Preparation for use

2.1.3.1 It is necessary to study all sections of the present operating manual before using the device.

2.1.3.2 Unpack the instrument.

2.1.3.3 Installation of the batteries:

- open the battery compartment's cover (shift toward himself) (Figure 1.1);
- insert the battery, observing the polarity;
- fix the battery compartment's cover in its place.

Right after inserting the battery the instrument switches on automatically. Switching on of the instrument with batteries installed is carried out according to the item 2.2.1.

2.1.4 Workability checking

For checking workability it's necessary to close the filter 2 (Figure 1.1). Switch the instrument on according to the item 2.2.1. After switching on and termination of the checking process the instrument should enter the DER measurement mode "measurement γ ". The information should be displayed on LCD (Figure 2.4).

At mean-square error value (hereinafter referred as "statistical accuracy") less than 20 % the DER value should be readout. DER value (at normal γ -radiation background) should be within the range of 0.05 – 0.2 $\mu\text{Sv/h}$. At pressing the buttons LCD backlight should be switched on. Approximately in 20 seconds if any button has not been pressed, backlight should be switched off automatically.

For checking the possibility of switching on and off all the operation modes it's necessary to enter the set mode by pressing the MENU button on the LCD.

Then enter the operation mode by pressing the upper or lower button and press the SELECT button. Before enter the next mode it's necessary to get back to MENU.

During the workability checking there shouldn't be any error messages.

Switch instrument off according to the item 2.2.4.

2.2 Usage of the instrument

2.2.1 Switching on. Testing.

For switching the instrument on a lower button on the keyboard is to be pressed and held till the backlight goes on. During the testing on LCD is indicated the analogue scale with the decreasing number of segments (Figure 2.1). In case of malfunction the LCD indicates corresponding message (according to the item 4). After calibration completion the instrument should enter the DER measurement mode. The instrument is ready for use in the DER measurement mode.

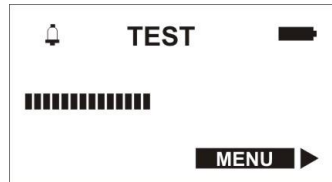


Figure 2.1

2.2.2 Operation of the instrument

The instrument maintains the user friendly interface. The operation is carried out by four buttons: left, right, upper and lower. The detector window could be opened by shifting the screen-filter (Figure 1.1 - position 2). Operating mode, current state of the instrument, as well as the key functions for changing the instrument state are indicated on the LCD. For example, on LCD near to the title designating forthcoming action, such as "BACK", "SELECT", "MEMORY" etc., is displayed the image of arrows.

The arrow points to the key, which is to be pressed to enter chosen operating mode. For example, if the arrow points to the left it is necessary to press the left button, if upwards – it is necessary to press the upper button.

2.2.3 Selecting the instrument operating mode

The operating mode selection is carried out from MENU indication mode (Figure 2.2).

It is possible to enter MENU mode from each mode by pressing the key pointed by the arrow, or by pressing and holding the lower button. In the MENU mode all possible operating modes are indicated. The required operating mode could be chosen by short pressing upper or lower button, placing the cursor opposite the needed mode and than pressing the right button "SELECT" (on the Figure 2.2 the cursor is placed opposite "MEASUREMENT β " line.)

If the buttons have not been pressed during 20 s the instrument returns to the DER measurement mode.



Figure 2.2

2.2.4 Switching the instrument off

For switching the instrument off it is necessary to enter the MENU mode, to choose the line "POWER OFF", to press the "SELECT" button, and than to confirm the switching off by pressing the "YES" button (Figure 2.3).

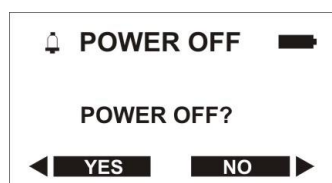


Figure 2.3

2.2.5 Operation in the photon radiation DER measurement mode ("MEASUREMENT γ ")

Attention! For carrying out the measurement in the mode DER "MEASUREMENT γ " it is necessary to close the detector window by sliding screen-filter up to the stop (Figure 1.1, position 2).

The instrument enters DER measurement mode automatically just after switching on, or purposely from "MENU". For that it is necessary to choose the "MEASUREMENT γ " line and press the "SELECT" button. Being in the DER mode the instrument displays on LCD continuously measured values the photon radiation DER in " $\mu\text{Sv/h}$ ", "mSv/h" and the statistical error of the measured DER in percentage, Figure 2.4.

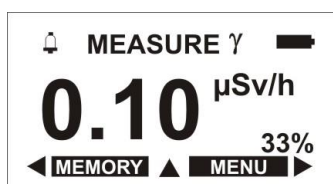


Figure 2.4

On reaching 15 % and less of statistical error DER could be readout. And the longer is the measurement time the smaller will be the statistical error. Measured DER value could be stored in the non-volatile memory after pressing the "MEMORY" button. At that if the statistical error is more than 10 % on the LCD is indicated the information according to the Figure 2.5 a, if the statistical error is less than 10 % (Figure 2.5 b) on the LCD are indicated the measurement results. To store the measurement results it is necessary to press the "YES" button (Figure 2.5 b).

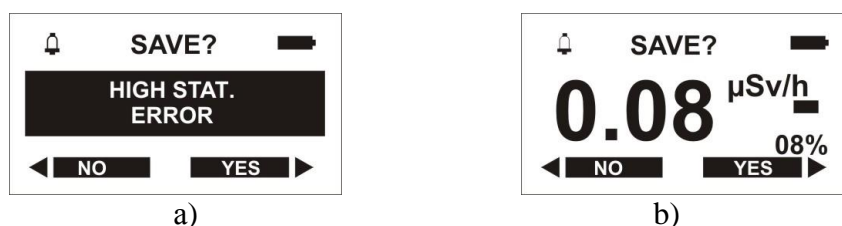


Figure 2.5

When pressing "NO" button the information will not be stored and the DER measurement will be continued.

Attention! It is important to remember that the smaller is the statistical error the reliable will be the measurement result.

After pressing the upper button the instrument will shift into the submenu of the "MEASURE γ " mode and on the LCD following information will be indicated (Figure 2.6):

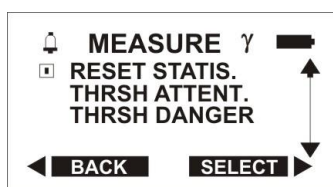


Figure 2.6

Information indicated in the submenu of the "MEASURE γ " mode has following functions:

- "RESET STATIS." (statistics reset) – after putting the cursor opposite this line and pressing the "SELECT" button (hereafter – line select) occurs the reset of collected statistics of the DER measurement and the measurement process can be reactivated;

- "THRSH ATTENT." (threshold attention), "THRSH DANGER" (threshold danger) – after choosing this option there is the possibility to set two DER threshold levels at which achievement or crossing the instrument begins to signal the danger through audible alarm of various tonality, as

well LED indicator is turned ON (Position 7, Figure 1.1). In case of crossing of the first DER threshold level ("THRSH ATTENT.") – it gives the intermittent audible signal; In case of crossing of the second DER threshold level ("THRSH DANGER") – it gives the frequent intermittent audible signal.

Attention! At pressing any instrument button (Position 5, Figure 1.1) audible and light alarms are turned OFF for about 60 s; "B" symbol being indicated in the upper left LCD corner.

After DER threshold level setting on the LCD will be indicated the information according to the Figure 2.7.

The LCD will indicate the blinking symbol of the DER measurement units. The required DER measurement units are chosen by pressing the upper or lower button. To choose the next symbol you have to press the left button – "←" After setting the threshold level the right button – "SELECT" – is to be pressed. The instrument will store the threshold level values and will shift to the DER measurement mode.



Figure 2.7

If no option was being chosen, you can quit the submenu of the "MEASUREMENT γ" (Figure 2.6) by pressing the "BACK" button. The instrument will shift to the "MEASUREMENT γ" mode.

At pressing the "MENU" button the instrument will shift from the "MEASUREMENT γ" mode to the "MENU" mode.

2.2.6 Operation in the γ- radiation DE measurement mode ("DOSE")

It is possible to enter DE measurement mode ("DOSE") from the MENU. For that it is necessary to choose the "DOSE" line and press the "SELECT" button.

Being in this mode, instrument displays on LCD continuously measured photon radiation DE value in "μSv", "mSv" and "Sv" as well as the DE accumulation time in hours (h). On the LCD following information is indicated, Figure 2.8.

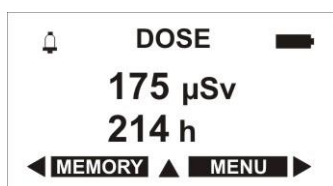


Figure 2.8

After pressing the upper button the instrument will shift into the submenu of the photon radiation DE measurement mode, and on the LCD following information will be indicated (Figure 2.9).

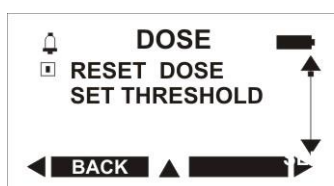


Figure 2.9

By choosing the “DOSE RESET” button the accumulated dose and dose accumulation time values will be reset. Herewith the accumulated dose, dose accumulation time values and the dose reset time will be stored in the non-volatile memory, and the Instrument will shift to the “DOSE” mode.

By choosing the “SET THRESHOLD” after pressing the “SELECT” button setting of the DE threshold level is carried out. In case of approaching or crossing the set threshold value the instrument gives the audible signals. DE and DER threshold setting procedures are similar (3.2.5).

If no option was being chosen, you can press the “BACK” button and the instrument will shift to the “DOSE” mode.

If reset of the accumulated dose was carried out before starting the DE measurement, then dose value displayed by the end of the measurement will be the accumulated dose value. If not – then it is necessary to fix the initial and final DE values. Difference between these DE values will be the accumulated dose value.

2.2.7 Operation in the α -particles flux density measurement mode ("MEASUREMENT α ")

It is possible to enter "MEASUREMENT α " mode from the MENU, Figure 2.10.

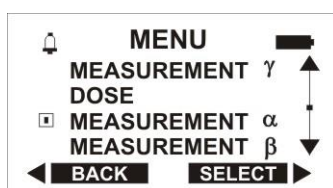


Figure 2.10

Attention! During the measurements with opened screen-filter it is important to be careful not to damage the detector window.

Distance between the controllable surface and the detector surface should be no more than 1 mm.

If the instrument is placed directly on a controlled surface, distance between the surface and the sensitive surface of the detector makes 8 mm. The sensitive surface area of the detector makes 7 cm².

α - particles flux density measurement (control of the surface contamination level) is carried out step by step (Figures 2.10 – 2.16). It is necessary to follow the instructions (tips) displayed on the LCD.

Short description of the measurement procedure:

1) instrument should be placed on the controlled surface, the screen-filter should be opened up to the stop and the measurement should be carried out on the contaminated (controlled) surface with the screen-filter opened. If the statistical error is 10 % or less, measurement results should be stored by pressing the “MEMORY” button;

2) put the α -cover (included in the delivery kit) on the instrument with opened filter and place on the same surface. Measurement is carried out with the α -cover on. Instrument indicates measurement results equal to the difference between readings with opened filter ($\alpha + \beta + \gamma$) and closed ($\beta + \gamma$) α -cover. With the statistical error is 15 % or less, measurement results should be read and stored by pressing the “MEMORY” button, if necessary. It is recommended to carry out 3 – 5 measurements and then use their mean value.

If the option "MEASUREMENT α " is chosen on the LCD is indicated the following information (Figure 2.11).

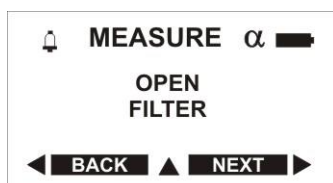


Figure 2.11

The screen-filter should be opened up to the stop and press the “NEXT” button. On the LCD is indicated the following information (Figure 2.12).

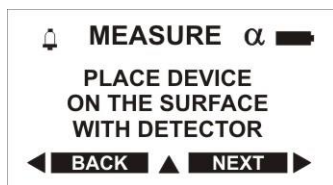


Figure 2.12

Then it is necessary to place the instrument in the controlled surface and press the “NEXT” button.

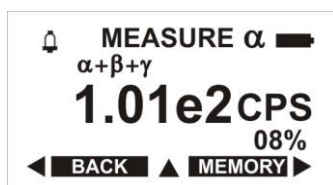


Figure 2.13

LCD will indicate the count rate value (Figure 2.13), determined by the joint α - β - γ - radiation during the α - particles flux density measurement.

If the statistical error is less than 10 % press “MEMORY” button. If the statistical error is more than 10 % LCD will indicate information according to the Figure 2.14 a). If the statistical error is less than 10 % (Figure 2.14 b) store the measured value by pressing the “YES” button.

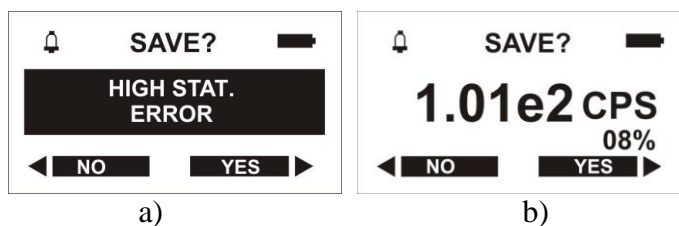


Figure 2.14

ATTENTION! It is important to remember that the smaller is the statistical error the reliable will be the measurement result.

Following the instructions on the LCD (Figure 2.15), it is necessary to put on the instrument α -cover with the filter opened. And then press the “NEXT” button.

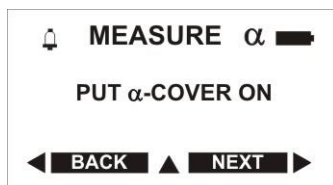


Figure 2.15

Place the instrument in the same point on the controlled surface and press the “NEXT” button.

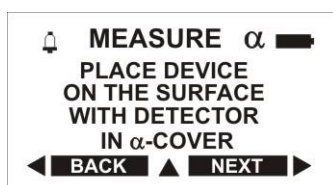


Figure 2.16

If the statistical error is less than 10 % on the LCD (Figure 2.17) could be read the results of the α -flux density measurement in the cpm/cm^2 . If necessary results of the α -flux density measurement could be stored. If the statistical error is more than 10 %, instrument will indicate the "HIGH STAT. ERROR" message.

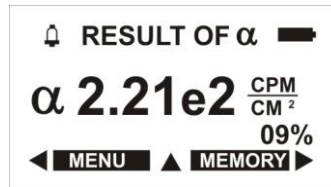


Figure 2.17

After pressing the upper button the instrument will shift into the submenu of the "MEASUREMENT α " mode (Figure 2.18).

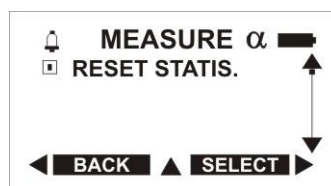


Figure 2.18

The instrument's operation in the submenu of the "MEASUREMENT α " mode at the "RESET STATIS." (Figure 2.18) option selection is similar to its operation in the "MEASUREMENT γ " submenu, described above (item 2.2.5).

It is to remember that the flux density measurement time depends on measured value of α -particles density. Dependence of measurement time on the measured α -flux density is given in the Attachment A.

Attention! During the measurements with opened screen-filter it is important to be careful not to damage the detector window.

Distance between the controllable surface and the instrument should be no more than 1 mm.

2.2.8 Operation in the β -flux density measurement mode ("MEASUREMENT β ")

The instrument enters "MEASUREMENT β " from "MENU" (Figure 2.19).



Figure 2.19

To enter the submenu of the "MEASUREMENT β " mode it is necessary to select in the "MENU" the "MEASUREMENT β " option and to press the "SELECT" button. On the LCD will be indicated the following information (Figure 2.20).



Figure 2.20

Then user can chose either the option "MEASUREMENT β " for β -flux density measurement, or the option "EXPRESS β " for express β -flux density measurement, or else the option "BACKGROUND" for background level measurement (measured and stored background level will be used in the express β -flux density measurement).

2.2.8.1 "MEASUREMENT β "

Attention! During the measurements with opened screen-filter it is important to be careful not to damage the detector window.

The distance between a controllable surface and the detector surface should be no more than 1 mm.

If the instrument is placed directly on a controlled surface the distance between the surface and the sensitive surface of the detector makes 8 mm. The sensitive surface area of the detector makes 7 cm².

β -flux density measurement (control of the surface contamination factor) is carried out step by step (Figures 2.21 – 2.27). It is necessary to follow the instructions (tips) displayed on the LCD.

Short description of the measurement procedure:

1) the instrument should be placed on the controlled surface, the screen-filter should be opened up to the stop and the measurement should be carried out on the contaminated (controlled) surface with the screen-filter opened. If the statistical error is 10 % or less the measurement results should be stored by pressing the "MEMORY" button;

2) then the screen-filter should be closed and the measurement should be carried out at the same place on the same surface. The instrument displays the measurement results equal to the difference between the indications with the open and closed screen-filter.

If the statistical error is 15 % or less the measurements results should be readout and stored by pressing the "MEMORY" button, if necessary.

If the option "MEASUREMENT β " is chosen on the LCD is indicated the following information (Figure 2.21).

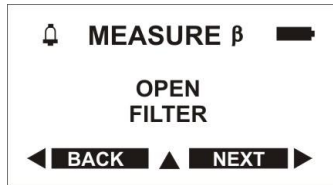


Figure 2.21

The screen-filter should be opened up to the stop and press the “NEXT” button. On the LCD is indicated the following information (Figure 2.22).

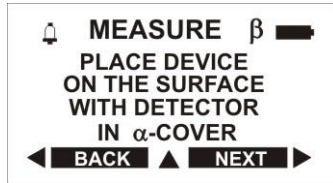


Figure 2.22

The instrument should be placed on the controlled surface and press the “NEXT” button.

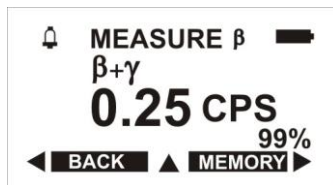
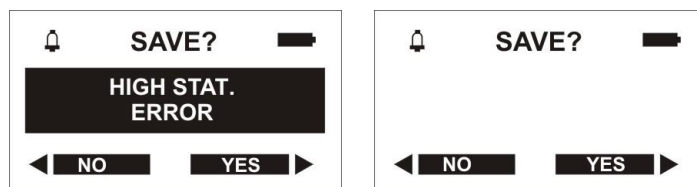


Figure 2.23

On the LCD is indicated the counting rate (Figure 2.23) resulting from joint β - γ -radiation by β -flux density modification. If the statistical error is less than 10 % it is necessary to press the “MEMORY” button. If the statistical error is more than 10 % on the LCD is indicated the following information (Figure 2.24 a)). If the statistical error is less than 10 % (Figure 2.24 b)) it is necessary to store the measurement results by pressing the “YES” button.



a)

b)

Figure 2.24

Attention! It is important to remember that the smaller is the statistical error the reliable will be the measurement result.

Following the instructions on the LCD (Figure 2.25), it is necessary to close the screen-filter up to the stop and press the “NEXT” button.

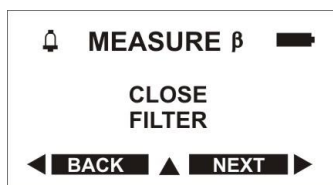


Figure 2.25

Then it is necessary to place the instrument in the same point on the controlled surface and press the "NEXT" button (Figure 2.26).

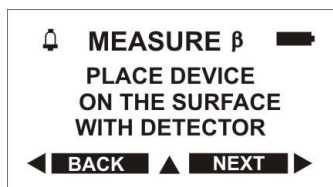


Figure 2.26

If the statistical error is less than 10 % on the LCD (Figure 2.27) could be readout the results of the β -flux density measurement in the cpm/cm^2 . If necessary the results of the β -flux density measurement could be stored. At that if the statistical error is more than 10 % the instrument will generate the message "HIGH STAT. ERROR".

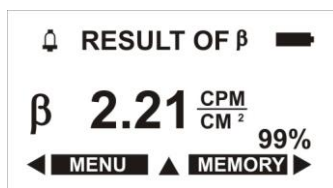


Figure 2.27

After pressing the upper button the instrument will shift into the submenu of of the "MEASURE β" mode (Figure 2.28).

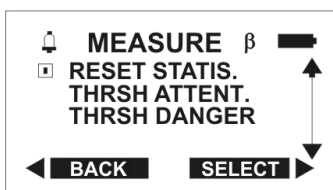


Figure 2.28

The instrument's operation in the submenu of the "MEASURE β" mode at the select of the options "RESET STATIS.", "THRSH ATTENT.", "THRSH. DANGER" (Figure 2.29) is similar to its operation in the submenu of the "measurement γ ", as described above according to the item 2.2.5. Recommended value of the "THRSH ATTENT." is 10 β - particles cpm/cm^2 (on LCD – "1.00 e1 CPM/CM²"). Recommended value of the "THRESH DANGER" is 100 β -particles in cpm/cm^2 (on LCD – "1.00 e2 CPM/CM²").



Figure 2.29

It is to remember that the flux density measurement time depends on measured value of β -particles density. Dependence of time of measurement on the measured density the β -flux density is given in the Attachment A.

2.2.8.2 Express measurement β ("EXPRESS β ")

Attention! During the measurements with opened screen-filter it is important to be careful not to damage the detector window.

The distance between a controllable surface and the detector surface should be no more than 10 mm.

This mode is recommended to be used by large quantity of examinations in equal conditions.

Starting to work in a mode "EXPRESS β " it is necessary to measure the background once and to store its value according to item 2.2.6.3.

If the user select the "EXPRESS β " option on the LCD is indicated the following information (Figure 2.30).

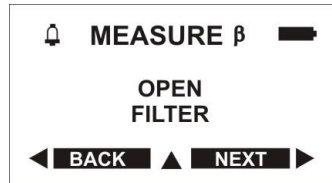


Figure 2.30

It is necessary to open the screen-filter up to the stop and press the "NEXT" button. On the LCD is indicated the following information (Figure 2.31).

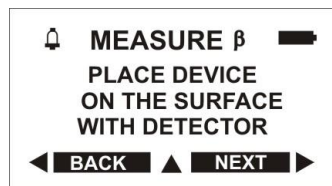


Figure 2.31

The instrument should be placed on the controlled surface and press the "NEXT" button.

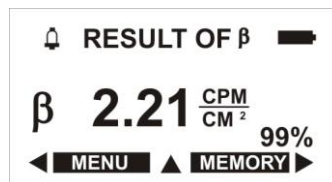


Figure 2.32

If the statistical error is less than 15 % on the LCD (Figure 2.32) could be readout the results of the β -flux density measurement in the cpm/cm². If necessary the results of the β -flux density measurement could be stored. At that if the statistical error is more than 10 % the instrument will generate the message "HIGH STAT. ERROR".

In the "EXPRESS β " mode (Figure 2.32) the statistic express evaluation of the β -flux density measurement results is carried out. The measurement results are compared with the value set for the threshold attention level "THRSH ATTENT.". Recommended value of the "THRSH ATTENT." is 10 β - particles cpm/cm² (on LCD – "1.00 e1 CPM/CM²").

If the measurements results of the controlled surface contamination level are lower than the set threshold value on the LCD is indicated the message "SAFE".

If the measurements results of the controlled surface contamination level are higher than the set threshold value on the LCD is indicated the message "CONTAMINATED".

If the measurements results of the controlled surface contamination level are close to the set threshold value on the LCD is indicated the message "UNCERTAIN RESULT".

After appearance of this message it is necessary to continue the measurements until the statistical error value will be (6-7) % and to decide to compare the measurement result with the set threshold level or with the standard contamination level.

To reactivate the measurement process in “EXPRESS β ” mode (Figure 2.32) it is necessary to enter the submenu by pressing the upper button and choose the "RESET STATIS." line.

Instrument's operation in submenu of the “MEASURE β ” mode by choosing the "RESET STATIS.", "THRSH ATTENT.", "THRSH DANGER" lines (Figure 2.29) is similar to the its operation in submenu of the “MEASURE γ ”, described in the issue 2.2.5.

2.2.8.3 “BACKGROUND” for the “EXPRESS β ” mode

The instrument should be placed on the controlled surface with the screen-filter closed up to the stop. Then in the submenu “MEASURE β ” mode the “Background” line should be chosen.

On the LCD is indicated the earlier measured (accumulated) and stored background level (Figure 2.33). To get back to the submenu “MEASURE β ” press the “BACK” button.

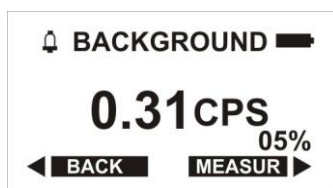


Figure 2.33

To renew the background level it is necessary to press the “MEASUR” button. The instrument should enter the “BACKGROUND” measurement mode (Figure 2.34). Then it is necessary to measure (accumulate) the background level with the statistical error not more than 10 % and store the measured background level by pressing the “MEMORY” button.

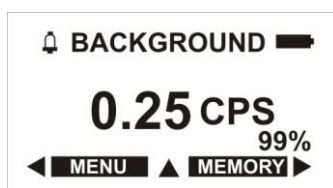


Figure 2.34

At pressing the upper button on the LCD will be indicated the following information (Figure 2.35). By choosing the "RESET STATIS." line the statistics can be reset and the process of measurement can be reactivated.



Figure 2.35

2.2.9 Operation in the radiation sources search mode (“SEARCH $\beta \gamma$ ”)

It is possible to enter the “SEARCH $\beta \gamma$ ” mode from the menu. You have to choose the “SEARCH $\beta \gamma$ ” line and press the “SELECT” button. In the “SEARCH $\beta \gamma$ ” mode is calculated the current total level of the average impulse counting rate, of the registered β - γ -radiation. On the LCD is indicated the total level of the average impulse counting rate in impulses pro second (cps). On the LCD is also indicated the statistical error of the average impulse counting rate (Figure 2.36). The average impulse counting rate, registered β - γ -radiation is accompanied by the audible and visible signals (visual alarm LED indicator).

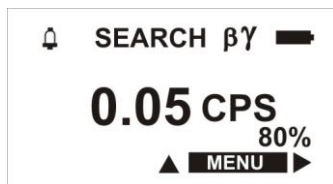


Figure 2.36

By pressing the upper button the instrument enters the submenut of the “SEARCH $\beta\gamma$ ” mode (Figure 2.37).



Figure 2.37

Information indicated in the submenut of the “SEARCH $\beta\gamma$ ” mode has following functions:

- "RESET STATIS." (statistics reset) – after choosing this line the reset of collected statistics of the average impulse counting rate occurs and process can be reactivated;
- "SET THRESHOLD" (threshold setting) – after choosing this option (Figure 2.38) there is the possibility to set the threshold level of the average impulse counting rate at which achievement or crossing the instrument gives the frequent intermittent audible and visual signal. The average impulse counting rate threshold level setting is similar to the DER threshold level setting (2.2.5.);



Figure 2.38

- “DISABLE BEEP” – after choosing this line (Figure 2.39.) the audible signal average impulse counting rate of the registered $\beta\text{-}\gamma$ -radiation will shut off in the “SEARCH $\beta\gamma$ ” mode;
- “ENABLE BEEP” – after choosing this line the audible signal of the average impulse counting rate of the registered $\beta\text{-}\gamma$ -radiation will switched on in the “SEARCH $\beta\gamma$ ” mode;
- “BACKGROUND β ” – background β measurement the same as in the item 2.2.6.3.

If no option was being chosen you can quit the submenut of the " SEARCH $\beta\gamma$ " mode by pressing the “BACK” button. The instrument will shift to the " SEARCH $\beta\gamma$ " mode.

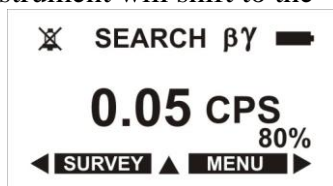


Figure 2.39

2.2.9.1 Detection and localization of the $\beta\text{-}\gamma$ -radiation sources

To achieve the maximum sensitivity by $\beta\text{-}\gamma$ -radiation sources searching (hereafter referred to as source) it is necessary to open the screen-filter and to keep the detector window at a distance no more than 10 cm from the scanned. The movement speed along the scanned object should not be more than 5.0 cm per second.

With the approach to the source the audible signal frequency will increase. After frequency limit achievement the audible signal will be continuous. After crossing of the set threshold level the instrument will give the frequent intermittent audible and visual signal.

During the detection and localization of the radiation sources it is necessary to carry out DER and β -flux density measurements.

ATTENTION! The detector window is made from the material with extremely low surface density (14 mcm mica). During the measurements with opened screen-filter it is important to be careful not to damage the detector window.

2.2.10 Operation in the setting mode (“SETTINGS”)

It is possible to enter the setting mode from the menu. To do this it is necessary to choose the “SETTINGS” line and to press the “SELECT” button. On the LCD will be indicated the following information (Figure 2.40).

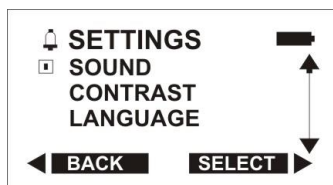


Figure 2.40

The "SETTINGS" mode has following functions:

- prohibition or permission of the audible alarm;
- LCD picture contrast setting;
- language select.

For audible alarm prohibition or permission it is necessary to choose the “SOUND” line and press the “SELECT” button. On the LCD will be indicated the following information (Figure 2.41).

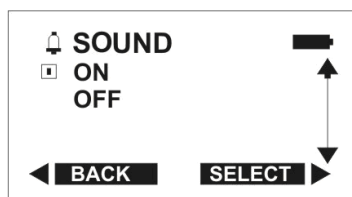


Figure 2.41

To turn on the audible alarm it is necessary to choose the "ON" line and press the “SELECT” button. The instrument will store the chosen setting and switch to the "SETTINGS" mode. At that in the upper left corner the bell icon will be indicated. At accompanying sound prohibition in the upper left corner the slashed bell icon will be indicated. After pressing the “BACK” button the instrument will shift to the menu.

To set the needed LCD picture contrast it is necessary to choose the "CONTRAST" line and press the “SELECT” button. On the LCD will be indicated the following information (Figure 2.42).

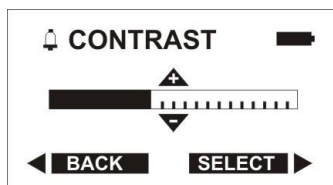


Figure 2.42

For contrast enhancement it is necessary to press repeatedly or to press and to hold the upper button, for contrast softening - the lower button. On reaching the needed contrast press the “SELECT” button. The instrument will store the chosen setting and switch to the "SETTINGS" mode. After pressing the “BACK” button the instrument will shift to the menu.

To choose the language it is necessary to choose the “LANGUAGE” line and to press the “SELECT” button. On the LCD will be indicated the following information (Figure 2.43).



Figure 2.43

It is necessary to choose the needed language “РУССКИЙ” (russian), “ENGLISH” or “日本語” (japanese) line and then press the “SELECT” button. The instrument will change the language and switch to the "SETTINGS" mode submenu.

After pressing the “BACK” button the instrument will store the chosen language and shift to the "SETTINGS" mode submenu.

2.2.10.1 Parameter settings

The instrument is delivered with following default parameters:

- consecutive time range to store the current DER value in non-volatile memory 60 min;
- audible alarm shut out.

2.2.10.2 Default parameters

User could change the following parameters from the front panel:

- to check the standard or choose the new audible alarm settings, if it is possible in the “Communication with PC” mode;
- to check the standard or choose the new threshold level settings for the DER measurement mode or threshold level settings for the β -flux density measurement mode.

2.2.11 Communication with PC

2.2.11.1 The instrument performs data transmission to the PC using WINDOWS 2000/NT/XP. Operation with the PC via USB is described in the Help file which are installed along with the user’s software. To operate in this mode is necessary:

- to connect the instrument to the PC via USB port;
- to install and then to run the program, supplied at the CD.

Instrument’s control switches to the PC.

2.2.11.2 During the operation in the communication mode with the user’s program it is possible to carry out the following actions:

- to read out the dosimetric information (DER);
- to indicate the dosimetric information on the PC monitor;
- to store the dosimetric information;
- to set up the information evaluation period;
- to set up the thresholds for the dosimetric information (at thresholds exceeding - visual ATTENTION);
- to read out the information from the instrument’s memory (history);
- to set up the operational characteristics of the instrument;
- to store and to transmit to PC the history of the photon radiation DER measurement, β -flux density measurement, events of exceeding the preset threshold values in the measurement and search mode;
- to program the instrument from the PC.

Operation with the user’s program is described in the Help file.

In order to provide correct record of event’s time after battery is installed, time should be synchronized. Synchronization may be performed by the application software when the instrument is connected to PC via IR Link. Please check and set the correct PC time prior to synchronization.

To synchronize time between instrument and PC after battery installation (or replacement) connect instrument to PC via IR Link and start the application software. Time would be synchronized after history reading. After that the event history will be saved with data stamps referred to your local PC time. If there's no possibility to synchronize time after battery replacement, we recommend to replace the battery as soon as possible. In this case instrument's real time clock will be slow for the duration of the battery absence.

2.2.12 Battery discharge control and the LCD backlight on/off turning

In all operating modes the instrument performs continuous control of the battery discharge. In the upper right corner of the LCD the filled battery icon will be indicated. In case of the battery partial discharge the filled part of the battery icon will shorten. Completely filled battery icon will be indicated only by the rated voltage. In case of the battery critical discharge the empty battery icon will be indicated. The battery is to be replaced.

After pressing any button on the keyboard the LCD backlight goes on. It is necessary to remember that only by pressing the lower button on the keyboard if in a current mode the button is not active (i.e. on the LCD the lower button cursor is not indicated) there is no change of the instrument's condition.

3 Maintenance

3.1 Maintenance involves preventive services, battery replacement and regular performance check according to 2.1.3.4.

3.2 Preventive services include external examination, dusting and decontamination in the case of radioactive contamination.

For decontamination wipe the case of the instrument using a cloth wetted with ethanol.

3.3 For battery replacement it is necessary:

- to turn off the instrument;
- to shift and remove the cover of the battery compartment;
- to remove the old battery, insert the new battery observing the polarity indicated on the label and inside the battery compartment;
- to fix the cover of the battery compartment in its place.

After the battery is replaced the instrument should turn on automatically.

4 Troubleshooting

4.1 The list of possible problems and their solutions are specified in the table 4.1.

Table 4.1

Problem	Possible cause	Solution
1 The instrument can not be switched on	the battery is absent, discharged or wrong installed	replace or install properly the battery
2 The audible alarm does not work	- the sound is turned out; - the indicator is defective	- to turn the sound on in the setting or in the communication with PC mode; - can be repaired by the manufacturer
3 The LCD displays the battery discharge ATTENTION sign	battery discharge	replace the battery (according to the item 3.3)
4 The LCD displays the sign “the the Geiger-Muller counter does not work”	the the Geiger-Muller counter is defective	- can be repaired by the manufacturer

5 Verification method

5.1 General

This procedure describes the calibration procedure for the PM1405 instrument. The calibration tests shall be performed by qualified calibration facilities. The instruments shall be calibrated during manufacture, after repair and periodically during operation and storage as required by national regulations.

5.2 Operations and measuring instruments

The operations that should be performed during the calibration procedure and measuring instruments that should be used are listed in the Table 5.1.

Table 5.1

Operations	Technique section No.	Names of reference and auxiliary measuring instruments and major performances
External examination	5.7.1	-
Testing	5.7.2	-
Determination of metrological characteristics	5.7.3.1	Instrument calibration assembly with a reference source ^{137}Cs in compliance with ISO 4037-1. Certified uncertainty of the assembly not more than 6 % at 0.95 confidence probability
	5.7.3.3	Standard radiometric β -radiation source of the category II from the $^{90}\text{Sr}+^{90}\text{Y}$, type 4CO, 5CO, 6CO
-	5.5	Barometer with the scale interval of 1kPa. Measurement range from 60 to 120 kPa.
-	5.5	Thermometer with the scale interval of 0.1°C. Measurement range from 10 to 30 °C.
-	5.5	Hygrometer with measurement range from 30 to 90%
-	5.7.3.1 – 5.7.3.4	Stopwatch with the scale interval 0,1 s
	5.7.3.4	PC Pentium with WINDOWS 98/2000/NT/XP and USB interfase
-	5.5	Dosimeter DBG-06T. Intrinsic error is $\pm 15\%$ (Other dosimeters providing the required accuracy of measurements may be used).

5.3 Expertise requirements to officers carrying out the verification

Persons certified as State Calibration Officers are allowed to carry out verification tests and/or to interpret the obtained results.

5.4 Safety requirements

The following safety requirements should be observed when verification tests are carried out by the officers:

- works involving the use of radioactive sources should be carried out in conformity with the requirements cited in "Major health rules for treating radioactive materials and other sources of ionizing radiation" and "Standards of radiation safety", as well as with the instructions for the accident prevention that are in force in the site where calibration tests are carried out;
- the calibration process should be considered as work under special conditions.

5.5 Verification conditions

The following conditions are required for carrying out calibration tests:

temperature of the environment.....	(20 ± 5) °C
relative air humidity.....	60 (+20; -30) %
atmospheric pressure.....	101.3 (+5.4; -15.3) kPa
background gamma radiation.....	not more than 0.20 μSv/h

5.6 Preparation for verification tests

Calibration officers should do the following preparatory work before the calibration tests:

- study the Operating Manual of the instrument;
- prepare the instrument for operation according to the section 3.1 of the Operating Manual.

5.7 Verification procedure

5.7.1 During the external examination the instrument should be tested against the following requirements:

- the delivery kit of the tested instrument should be the same as described in the manual;
- the initial or last calibration test should be recorded in the manual;
- the instrument should be marked with clear inscriptions;
- pollution and mechanical damages that may influence the work of the instrument should be eliminated.

5.7.2 During check-up it is necessary:

- to check the workability of the instrument as described in the section 2.1.3.4 of the manual;

5.7.3 Testing of metrological performance

5.7.3.1 To determine the intrinsic relative error of the DER measurements the following operations should be performed:

- 1) switch on the instrument;
- 2) after check up termination the instrument should enter the DER mode;
- 3) to fix the instrument on the calibration dosimetric unit with a ¹³⁷Cs gamma radiation source; the graduation direction should coincide with the direction of the radiation flow and the longitudinal axis of radiation flow should pass through the geometric center of the detector;

4) to determine the mean value of the DER of the γ-radiation external background (hereinafter γ-background), for that in no less than 600 s after placing the instrument on the calibration unit or at the intrinsic relative error value less than 10 % 5 times read the γ-background value and calculate

the mean DER value of the background $\overline{\dot{H}_b}$ by formula

$$\overline{\dot{H}_b} = \frac{1}{5} \sum_{i=1}^5 \dot{H}_{bi} . \quad (1)$$

where \dot{H}_{bi} – i-th value of instrument's readings in the j point, μSv/h;

5) create DER $\dot{H}_{oj} = 3.0 \mu\text{Sv/h}$ in the point coinciding with geometrical center of the detector and irradiate the instrument;

6) in no less than 100 s after the beginning of irradiation or at the intrinsic relative error value less than 10 % take 5 instrument's readings and calculate the mean DER value $\overline{\dot{H}_j}$, by formula

$$\overline{\dot{H}_j} = \frac{1}{5} \sum_{i=1}^5 \dot{H}_{ji} \quad (2)$$

7) repeat measurements for the points where reference DER is equal to 80.0; 800.0 μSv/h;

- 8) create DER $\dot{H}_{oj} = 8.0$ mSv/h in the point coinciding with geometrical center of the detector;
- 9) irradiate the instrument;
- 10) in no less than 60 s after the beginning of irradiation or after the determination of the intrinsic relative error value less than 10 % take the instrument's readings 5 times and calculate the mean DER value by formula (2);
- 11) repeat measurements for the point where DER is equal to 80 mSv/h;
- 12) calculate the intrinsic relative error for Q_j measurement in percents by formula

$$Q_j = \left| \frac{(\overline{\dot{H}_j} - \overline{\dot{H}_b}) - \dot{H}_{oj}}{\dot{H}_{oj}} \right| \cdot 100\% , \quad (3)$$

where \dot{H}_{oj} – reference DER value at check point;

- 13) calculate the intrinsic relative error confidence limit in % with the confidence probability 0,95 by formula

$$\delta = 1,1 \sqrt{(Q_o)^2 + (Q_{jmax})^2} \quad (4)$$

where Q_o – error (uncertainty) of the reference dosimetric assembly, %;
 Q_{jmax} – maximum relative measurement error Q_j , %.

- 14) compare the calculated error confidence limit value δ with an acceptable value of the permissible intrinsic relative error δ_{acc} calculated by formula

$$\delta_{acc} = \pm(20 + K/\dot{H}) \% , \quad (5)$$

where \dot{H} – DER value, $\mu\text{Sv/h}$;
 K – coefficient = 1,0 $\mu\text{Sv/h}$.

The instrument passes the test if $\delta \leq \delta_{acc}$.

5.7.3.2 To carry out determination of the intrinsic relative error of the β -flux measurement as follows:

- 1) to switch on the instrument and after the check up termination the instrument should enter the β -measurement mode. To choose β -measurement submenu of the β -measurement mode;
- 2) following the instructions indicated on the LCD, to remove the γ - β -filter from the detector. Then to place the detector surface against the standard radiometric β -radiation source of the category II type 4CO, 5CO or 6CO in parallel with the radiation source surface, so that the geometric center of the source surface was placed on the continuation of the perpendicular passing through the geometrical centre of a sensitive detector surface, and to press the "NEXT" button. On the LCD is indicated the counting rate resulting from joint γ - β -radiation by β -flux density measurement. If the statistical error is less than 10 % it is necessary to press the "MEMORY" button;
- 3) to store the measurement results by pressing the "YES" button.
- 4) to place the detector surface against the standard radiometric β -radiation source as stated in the previous item. Following the instructions indicated on the LCD, to place the γ - β -filter on the detector and to press the "NEXT" button. On the LCD is indicated the β -flux density and statistical error. If the statistical error is less than 10 % it is necessary to readout the measured β -flux density value. To store the measured value it is necessary to press the "MEMORY" button and than the "YES" button;
- 5) without changing the standard source to carry out the measurements according to the items 2 – 4 in four mutually perpendicular directions at shifting of the detector centre on 15 mm concerning the source centre.
- 6) to carry out the calibration from the items 2 – 5 in the points according to the Table 5.2;

Table 5.2

Verifiable point (standard source flux density), $\varphi_{oj}, \text{min}^{-1} \cdot \text{cm}^{-2}$	Number of the measurements, n	Radiation source	Approximate measurement time, s
20-40	5	4CO, 5CO or 6CO	1000
60-80	5	-	-
100-300	5	-	-
700-900	5	-	-
1000-3000 ^{**)}	5	-	-
4000-6000 ^{**)}	5	-	-
7000-9000 ^{**)}	5	-	-

^{**)} – for to supply on request.

7) to calculate the β -flux density mean value in each verifiable point $\bar{\varphi}_j, \text{min}^{-1} \cdot \text{cm}^{-2}$ by formula

$$\bar{\varphi}_j = \frac{1}{5} \sum_{i=1}^5 \varphi_{ji}, \quad (6)$$

where φ_{ij} – i-th measured value of the β -flux density in the verifiable point j, $\text{min}^{-1} \cdot \text{cm}^{-2}$.

To calculate the intrinsic relative error of the β -flux density measurement $\delta, \%$, for each verifiable point by formula

$$\delta = \frac{\bar{\varphi}_j - \varphi_{oj}}{\varphi_{oj}} \cdot 100, \quad (7)$$

where φ_{oj} – is the β -flux density from the active surface of the source j, $\text{min}^{-1} \cdot \text{cm}^{-2}$, taking into account the radioactive decay of the source.

To compare δ with the admissible value $\delta_{\text{acc}}, \%$, calculated by formula

$$\delta_{\text{acc}} = \pm (20 + A/\varphi), \quad (8)$$

where φ – measured value of the β -flux density, $\text{min}^{-1} \cdot \text{cm}^{-2}$,

A – coefficient equal to the $60 \text{min}^{-1} \cdot \text{cm}^{-2}$.

The instrument passes the test if $\delta \leq \delta_{\text{acc}}$.

5.7.3.3 Calculate permissible intrinsic relative error of α -radiation^{**)} flux density measurement in the following way:

1) switch Instruments on, and after termination of the testing select α -radiation flux density measurement mode;

2) following instructions indicated on the Instrument LCD, open filter (push it to the stop), covering window of the detector unit. Place detector very close to the reference source ^{239}Pu , second category, 5П9 (4П9, 6П9) type, so that the detector surface is parallel to the source surface. At that detector geometrical center must be perpendicular to geometric center of detector sensitive surface. Press the "NEXT" button. LCD indicates the count rate value, due to the joint γ -, α -, β -radiation during the α - radiation flux density measurement. When statistical error is less than 10 %, press the "MEMORY" button;

3) save the measured values by pressing the "YES" button;

4) following instructions indicated on the Instrument LCD, install the α -filter on the detector. Place the detector very close to the reference sources, as stated in item 2) and press "NEXT" button. LCD indicates the α -radiation flux density value. When statistical error is less than 10 % read the measured α -radiation flux density value, press the "MEMORY" button and then "YES" button;

5) test intrinsic relative error in the reference points according to the Table 5.3;

6) perform 5 measurements of the flux density, as stated in items 2) - 4), in every reference point. For every next measurement turn the reference source around the source geometric surface for 72° approximately (relative to the previous source position);

Table 5.3

Reference point (standard source flux density), φ_{oj} , $\text{min}^{-1}\cdot\text{cm}^{-2}$	Number of the measurements, n	Radiation source	Approximate measurement time, s
100-400**)	5	5П9 (4П9, 6П9)	1000
1000-4000**)	5	-	-
7000-9000**)	5	-	-

**)- for to supply on request.

7) to calculate the α -flux density mean value in each verifiable point $\bar{\varphi}_j$, $\text{min}^{-1}\cdot\text{cm}^{-2}$ by formula

$$\bar{\varphi}_j = \frac{1}{5} \sum_{i=1}^5 \varphi_{ji}, \quad (9)$$

where φ_{ji} – i-th α -radiation flux density value in the j-th reference point, $\text{min}^{-1}\cdot\text{cm}^{-2}$.

Calculate limits of the intrinsic relative measurement error δ of the α -radiation flux density, for every reference point, using the formula:

$$\delta = \frac{\varphi_j - \varphi_{oj}}{\varphi_{oj}} \cdot 100, \quad (10)$$

where φ_{oj} – is the α -flux density from the active surface of the source j, $\text{min}^{-1}\cdot\text{cm}^{-2}$, taking into account the radioactive decay of the source.

Compare δ with the permissible value $\delta_{\text{доп}}$, calculated using formula:

$$\delta_{\text{доп}} = \pm (30 + A/\varphi) \% \quad (11)$$

where φ – measured α -radiation flux density value, $\text{min}^{-1}\cdot\text{cm}^{-2}$;
A – coefficient equal to $900 \text{ min}^{-1}\cdot\text{cm}^{-2}$.

If $\delta > \delta_{\text{acc}}$, then instrument is rejected, if $\delta \leq \delta_{\text{acc}}$, than instrument is considered disposable for service.

5.7.3.4 Calculate range and permissible intrinsic relative error of the DE**) measurement in the following way:

- 1) switch instrument on;
- 2) after testing termination switch DE measurement mode on and set the maximum DE threshold value;
- 3) place instrument on the verification assembly with ^{137}Cs gamma source so that the line going through the geometrical center of the detector aligns with the irradiation flow axis. Graduation direction and location of the detector geometrical center;
- 4) place the instrument onto the dosimetric assembly so that geometrical center of the detector coincides with the reference point, where reference DER value equals $3.0 \mu\text{Sv/h}$;
- 5) irradiate the instrument during T time equal to 1 hour;
- 6) after irradiation termination take the final DE value;
- 7) calculate relative DER measurement error G_j , %, in every reference point, using formula:

$$G_j = \left(\frac{(H_{kj} - H_{Hj}) - \dot{H}_{oj} \cdot T - \bar{H}_b \cdot T}{\dot{H}_{oj} \cdot T} \right) \times 100, \quad (12)$$

where H_{kj} – final DE value, $\mu\text{Sv/h}$;

H_{Hj} – initial DE value, $\mu\text{Sv/h}$;

\dot{H}_{oj} – reference DER value in the test point, $\mu\text{Sv/h}$;

\bar{H}_b – mean background DER value, $\mu\text{Sv/h}$;

T – irradiation time, h;

8) repeat the measurement for the reference point where reference DER value equals 8; 800 mSv/h;

9) calculate confidence limits of permissible intrinsic relative error of DE measurement δ , %, at confidence probability 0.95 using formula:

$$\delta = 1,1\sqrt{(G_o)^2 + (G_j)^2}, \quad (13)$$

where G_o – reference dosimetric assembly error, %;

G_j – relative measurement error for each reference point.

If $\delta > \delta_{acc}$, then instrument is rejected, if $\delta \leq \delta_{acc}$, then instrument is considered disposable for service.

6 Storage and shipping

The instrument must be stored in the manufacturer's package without batteries installed at the air temperature between -15 to +50 °C and humidity less than 95 % at +35°C. The shelf life does not exceed the average service life of the instrument – 8 years. Instruments without its original packaging must be stored at 10 to 35°C and humidity less than 80 % at 25°C. The storage place must be free of dust and/or vapors from strong chemicals and other substances that may cause corrosion.

Instruments (switched off, in a package) may be shipped by any closed transport at air temperature from -50 to +50°C. The packaged instruments must be placed and fastened in a vehicle to exclude shocks against each other and against walls of the vehicle. When carried by sea, instruments in package must be packaged in hermetic plastic bags with silica gel. When carried by air, instruments in package must be placed in hermetic compartments.

7 Disposal

The instrument constitutes no danger to life, health and the environment, so disposal is performed in a regular way.

8 Warranty

8.1 The manufacturer warrants this instrument to meet specifications provided that the user follows the instructions for the operation of the instrument, shipping and storage described in the Operation manual.

8.2 Warranty operation period is 18 months since the date the instrument putting into operation. If there is no mark on instrument putting into operation, then the warranty period will be started from the date of warranty shelf-life end.

8.3 The warranty period is 6 months since the date of manufacturer QC department accepting the instrument.

8.4 Warranty and after-warranty repairs are performed by the manufacturer or by a company authorized by the manufacturer.

8.5 Warranty does not cover the instruments:

- subjected to the user's service (the instrument was tampered/opened by the user);
- with mechanical damages, if the requirements of operation and storage were not satisfied;
- without the operation manual;
- if their warranty period is expired.

8.6 The warranty period is extended for a period of warranty repair.

8.7 Warranty doesn't cover the batteries. The battery replacement is not considered as the warranty repair.

ATTACHMENT A
(reference)

Dependence of the measurement time from the measured β - particles flux density

Table A.1

β - particle flux measurement range $\text{min}^{-1}\cdot\text{cm}^{-2}$	Approximate measurement time of the β - particles flux density, s	Statistic intrinsic, %, no more
6 - 50	1000	20
50 - 100	1000	10
100 - 1000	1000	5

Dependence of the measurement time from the measured α - particles flux density

Table A.2

α - particle flux measurement range $\text{min}^{-1}\cdot\text{cm}^{-2}$	Approximate measurement time of the α - particles flux density, s	Statistic intrinsic, %, no more
90 -100	1000	15
100 - 1000	600	10
1000 –10000	180	5

ATTACHMENT B
(reference)

**Typical energy dependence of the instrument sensitivity on the β -radiation energy
(concerning energy of 2.27 MeV ($^{90}\text{Sr}+^{90}\text{Y}$))**

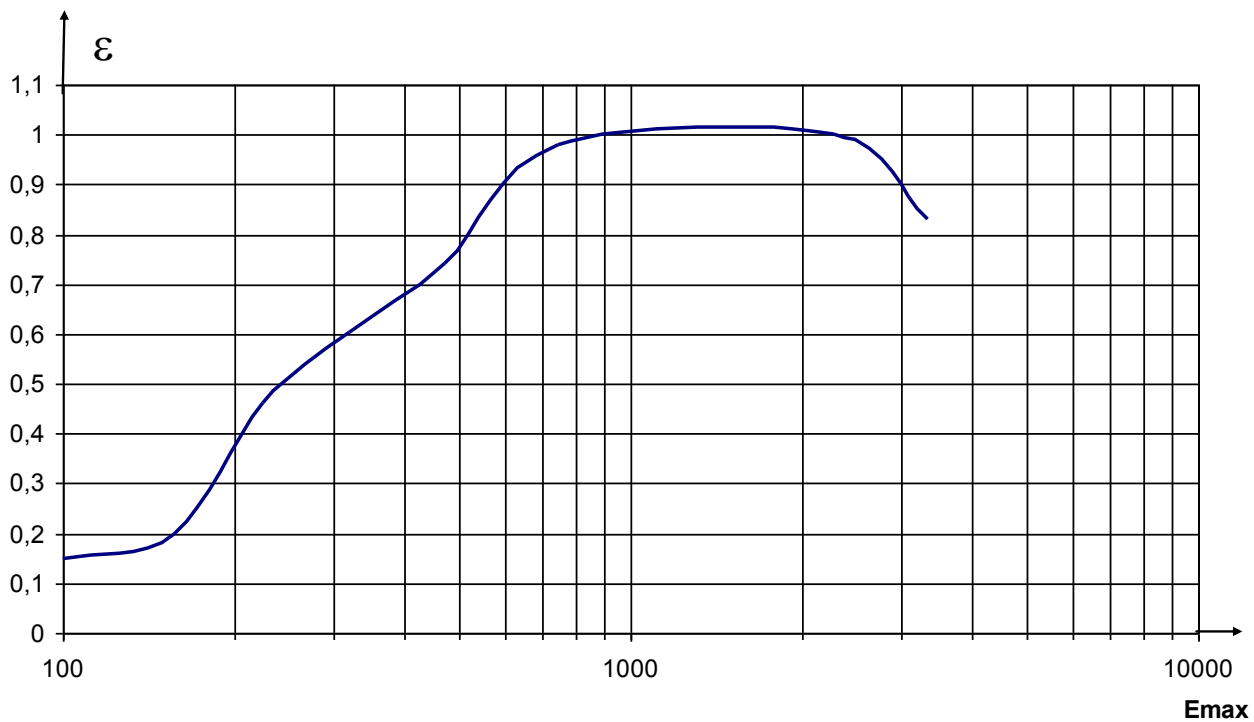


Figure B.1

ATTACHMENT C
(reference)

Order Form
Operation modes

Table C.1 (check box/write value, specify documents, contract, etc.)

Modes and functions	ON (+) OFF (-)	Note
1 Photon radiation DER measurement mode ("MEASUREMENT γ ");	+	
2 Beta- particles flux density measurement mode (MEASUREMENT β) from 6,0 to $10^3 \text{ min}^{-1} \cdot \text{cm}^{-2}$ (cpm/cm ²)	+	
3 Beta- particles flux density measurement mode (MEASUREMENT β) from 6,0 to $10^4 \text{ min}^{-1} \cdot \text{cm}^{-2}$ (cpm/cm ²)		
4 Radiation sources search mode ("SEARCH $\beta \gamma$ ")	+	
5 Alfa- particles flux density measurement mode (MEASUREMENT α)		
6 Photon radiation DE measurement mode ("DOSE")		