PM1610

X-RAY AND GAMMA PERSONAL DOSIMETER

OPERATION MANUAL

CONTENTS

Thank you for purchasing a Polimaster Personal Electronic Dosimeter. Before operating this unit, please review this manual thoroughly and retain it for future reference.

This Operation Manual describes the design and operation of the PM1610, PM1610-01, PM1610A, PM1610A-01 X-Ray and Gamma Personal Dosimeter (hereinafter referred to as "the dosimeter"). It includes description and technical specifications of the dosimeter, calibration procedures, as well as other information necessary for proper operation of the dosimeter and understanding of its capabilities.

Detectors are manufactured in four versions:

- PM1610 X-Ray and Gamma Personal Dosimeter;
- PM1610-01 X-Ray and Gamma Personal Dosimeter. PM1610-01 differs from the PM1610 instrument due to presence of the data communication channel (ISO15693 standard);
- PM1610A X-Ray and Gamma Personal Dosimeter. PM1610A differs from PM1610 because of range of permissible main relative DER measurement error and increased DE measurement range;
- PM1610A-01 X-Ray and Gamma Personal Dosimeter. PM1610A-01 differs from PM1610 in the range of permissible main relative DER measurement error, enlarged DE measurement range and data transmission channel in accordance with the ISO15693 standard.

Some amendments may be introduced in the dosimeter's electrical circuit and design that do not influence the specifications and, therefore, may be not specified in this manual.

1 Description and Operation

1.1 Application

1.1.1 The dosimeter is designed to:

- measure personal dose equivalent rate $\dot{H}_{p(10)}$ (hereinafter - DER) of continuous and pulsed X-ray and gamma (hereinafter “photon”) radiation;

- measure personal dose equivalent $H_{p(10)}$ (hereinafter - DE) of continuous and pulsed photon radiation;

- measure DE accumulation time;

- alert the user with audible, light and vibration alarms when settable DE or DER alarm levels are exceeded;

- indicate current time in hours, minutes;

- transfer information stored in the dosimeter’s permanent memory to a personal computer (PC).

The dosimeter can be applied by customs and border guards, personnel of medical institutions, nuclear power plants, radiological and isotope laboratories, emergency services, civil defense, fire departments, police as well as by a variety of users involved in radiation measurements.

1.2 Delivery Kit

1.2.1 The dosimeter's delivery kit is shown in Table 1.1.

Table 1.1

Description	Quantity, pc.			
	PM1610	PM1610-01	PM1610A	PM1610A-01
PM1610 X-ray and Gamma Personal Dosimeter	1	-	-	-
PM1610-01 X-ray and Gamma Personal Dosimeter	-	1	-	-
PM1610A X-ray and Gamma Personal Dosimeter	-	-	1	-
PM1610A-01 X-ray and Gamma Personal Dosimeter	-	-	-	1
USB car charger Ritmix RM-002 [1), 2)]	1	1	1	1
RFID reader [1)] ID ISC.PR101-USB	-	1	-	1
Cable USB 2,0 type A(m)-B(m)[1)]	-	1	-	1
Cable USB A - USB mini B	1	1	1	1
Data storage (Software, Operation manual[3)])	1	1	1	1
Certificate	1	1	1	1
Holder	1	1	1	1
Package	1	1	1	1
Lace	1	1	1	1

[1)] Option, supplied on customer's request;
[2)] Other chargers with similar parameters are allowed;
[3)] Verification method is included.

1.3 Specifications

1.3.1 The dosimeter continuously measures DER, DE and DE accumulation time in all operation modes except for the computer communication mode.

1.3.2 Operation modes:
- DER measurement;
- DE measurement;
- settings;
- current time indication;
- battery status indication;
- communication with computer.

1.3.3 DER indication range: 0.01 μSv/h to 12.0 Sv/h.

1.3.4 DER measurement range: 0.1 μSv/h to 10.0 Sv/h.

Maximum permissible intrinsic relative error of DER measurement:

- PM1610 and PM1610-01: $\pm (15 + K/\dot{H})$ %,
  where $\dot{H}$ - DER value in mSv/h,
  K - coefficient 0.0015 mSv/h;
- PM1610A and PM1610A-01: $\pm (10 + K_1/\dot{H} + K_2 \cdot \dot{H})$ %,
  where $\dot{H}$ - DER value in mSv/h,
  K_1 - coefficient 0.0015 mSv/h,
  K_2 - coefficient 0.0015 $(mSv/h)^{-1}$.

In the DER measurement mode the dosimeter automatically calculates and indicates on LCD relative root-mean-square error of measurement result (statistic uncertainty) in percent at 0.95 confidence probability.

1.3.5 DE indication range:
- PM1610 and PM1610-01: 0.001 μSv to 12.0 Sv;
- PM1610A and PM1610A-01: 0.001 μSv to 24.0 Sv.

1.3.6 DE measurement range:

- continuous photon radiation (current):
  - PM1610 and PM1610-01: 0.05 μSv to 10.0 Sv;
  - PM1610A and PM1610A-01: 0.05 μSv to 20.0 Sv.
- pulsed photon radiation (pulse duration not less than 1 ms):
  - PM1610 and PM1610-01: 10 μSv to 10.0 Sv;
  - PM1610A and PM1610A-01: 10 μSv to 20.0 Sv.

Maximum permissible intrinsic relative error of DE measurement: ± 20 %.

1.3.7 The dosimeter measures DE accumulation time in hours and minutes and indicates it on LCD with 1 minute resolution

1.3.8 The dosimeter allows setting two DER alarm threshold levels and two DE alarm threshold levels. The dosimeter continuously controls the threshold levels and alerts the user with audible (intermittent signal for the fist threshold and fast intermittent for the second threshold), light (red color) and vibration alarms when the threshold level is exceeded.

DER thresholds setting range: 0.01 μSv/h to 10.0 Sv/h.

DE thresholds setting range: 1.0 μSv to 10.0 Sv (PM1610 and PM1610-01) and 1.0 μSv to 10.0 Sv (PM1610A and PM1610A-01).

Threshold setting resolution - low order digit.

1.3.9 Photon radiation energy range: 0.024 to 10.0 MeV.

Energy response relative to 0.662 MeV (^{137}Cs) in the DER and DE measurement mode, not more than:
- 60 % from 24 to 33 keV;
- 40 % 33 to 48 keV;
- ± 30 % 48 keV to 3 MeV;
- ± 50 % 3 to 10 MeV.

1.3.10 Anisotropy of the dosimeter δ_α for each energy does not exceed the values shown in Table 1.2 when the dosimeter is irradiated in the horizontal plane at indicated angles relative to the initial direction and does not exceed the values shown in Table 1.3 when the dosimeter is irradiated in the vertical plane at indicated angles relative the initial direction.

Table 1.2

Angle of detection relative to direction of calibration, deg	Gamma energy, MeV		
	Anisotropy (δ_α), %		
	0,059	0,662	1,25
0	0	0	0
15	±20	±5	±5
30	±25	±5	±5
45	±30	±10	±5
60	±20	±15	±10
- 15	±20	±5	±5
- 30	±25	±5	±5
- 45	±30	±10	±5
- 60	±20	±15	±10

Table 1.3

Angle of detection relative to direction of calibration, deg	Gamma energy, MeV		
	Anisotropy (δ_α), %		
	0,059	0,662	1,25
0	0	0	0
15	±5	±5	±5
30	±10	±5	±5
45	±15	±5	±5
60	±25	±10	±5
- 15	±5	±5	±5
- 30	±15	±5	±5
- 45	±15	±5	±5
- 60	±25	±10	±5

1.3.11 Variation coefficient (deviation of dosimeter readings caused by statistic fluctuations) of DER measurement at 0.95 confidence probability, not more than ± 10 %.

1.3.12 The dosimeter survives and retains its accuracy after a short-term 10 minute exposure to photon radiation DER 100 Sv/h. During the exposure the dosimeter indicates "OVERLOAD", value 12.0 Sv/h and audible, vibration and red light alarm.

1.3.13 Instability of readings for 24 hour continuous operation, not more than ± 5 %.

1.3.14 Maximum complementary permissible intrinsic relative error of DER and DE measurement:

- when measuring pulsed photon radiation $\pm 30\sqrt{\frac{k}{\tau}}$ %,

  where k - coefficient 1 ms;
  τ - pulse duration in ms;
- at temperature variations from normal to -20°C and from normal to +50°C ± 15 %;
- at relative humidity 98 % at 35°C ± 10 %;
- at supply voltage variations from nominal to extremes ± 5 %;
- in magnetic fields 800 A/m ± 10 %;

- in radio frequency electromagnetic fields ± 10 %.

1.3.15 The dosimeter displays current time in hours (24), minutes (60) and allows for setting and correction of current time in hours (24), minutes (60), as well as day, month and year.

1.3.16 LCD backlight setting 6 s, 20 s, 60 s, off.

1.3.17 Dosimeter automatically, in preset data logging intervals, records into its permanent memory and stores up to 7500 events (1 to 7500) of DER and DE measurement history. Depending on the type following events have to be stored in the instrument nonvolatile memory:
- current DER and DE value;
- current time (year, month, day, hour, minute);
- DER and DE value in case of alarm event;
- instrument status changes ("switching on", " switching off", etc.).

1.3.18 Communications

-USB interface;
- ISO15693 interface for PM1610-01 and PM1610A-01.

1.3.19 The dosimeter provides the following functions in computer communication mode:

1) enables or disables the setting of DER and DE alarm thresholds, DER and DE history parameters from the front panel using control buttons;
2) downloads the following information from the dosimeter to computer:
- dosimeter ID (serial number);
- DER and DE alarm threshold values;
- DER and DE data logging interval;
- time delay to record the first event of DER and DE history;
- DER and DE history (date, time, event, value) according to preset data logging interval;
- DER and DE history (date, time, event, value) of user-initiated recorded history;
- DER and DE history (date, time, event, value) at alarm events;
3) sets the following parameters in the dosimeter from the computer:
- current computer time and date;
- DER and DE alarm threshold values;
- DER and DE data logging intervals;
- time delay to record the first event of DER and DE history;
- reset accumulated DE and DE accumulation time;
4) sends readings from the dosimeter into PC: dosimeter number, current DE and DER values by the ISO15693 interface.

1.3.20 Setting time 60 s.

1.3.21 Power supply

- built-in rechargeable battery (502030 240mAh MOBILE STAR),
- charging via USB (USB charger or computer USB port).

1.3.22 Battery lifetime (full charge, 240 mAh) in normal operation (average DER not more than 0.3 μSv/h, backlight, audible, light and vibration alarms activated for not more than 20 s/24 hours)	1 month.
1.3.23 Ingress protection	IP65.
1.3.24 Environmental:	
- air temperature	-20 °C to + 50 °C;
- relative humidity	98 % at 35 °C;
- atmospheric pressure	84 to 106.7 kPa.
1.3.25 Dosimeter withstands:	- sine vibration in frequency range 5 - 35 Hz and bias amplitude for frequencies lower than transition frequency 0.75 mm; - shocks with peak acceleration of 100 m/s^2, duration of shock pulse 2-50 s, shock rate 60 - 180 shocks/min.
1.3.26 Drop test	1.5 m onto hard wooden surface.

1.3.27 Dosimeter withstands dc and ac magnetic fields of 800 A/m

1.3.28 Dosimeter withstands electrostatic discharges, IDT (air discharge 8 kV, contact discharge 6 kV)

1.3.29 Dosimeter complies with ANSI 42.34, section 9.11 requirements by the level of emitted radio-noise

1.3.30 Dosimeter is withstands the action of radio frequency electromagnetic fields up to 30 V/m (rigidity degree 4) in the frequency range 80 – 1000 MHz and 800 – 960 MHz and 1.4 – 2.5 GHz (under conditions of noise emission from digital radio telephones), performance criterion A

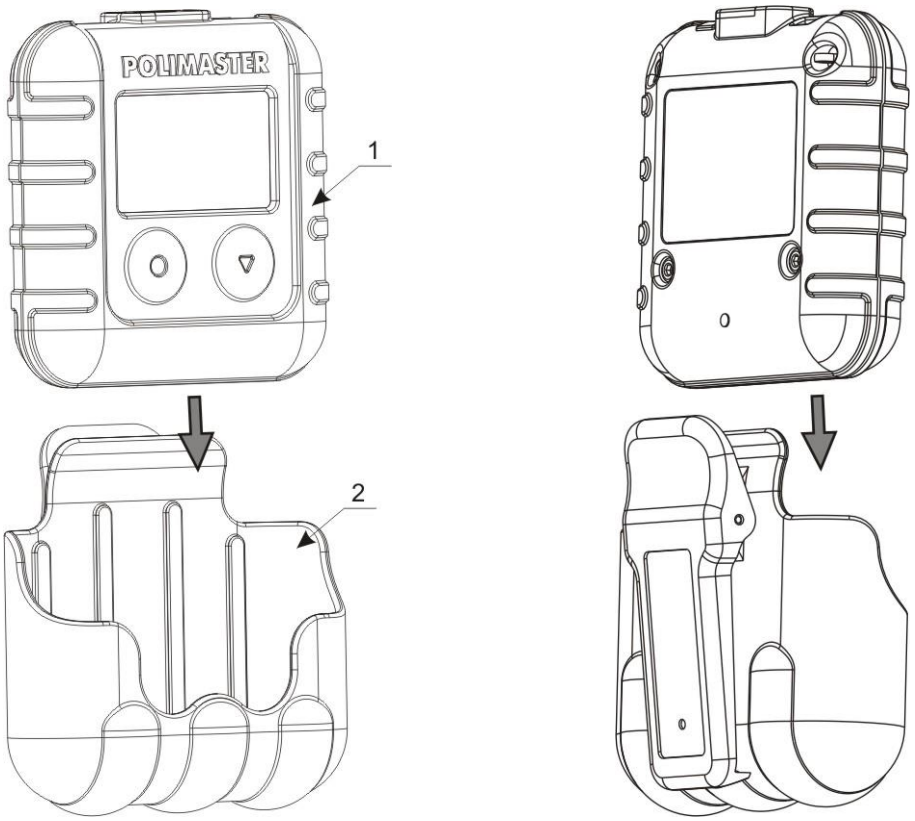
1.3.31 Weight, max	0.07 kg;
Weight in package, max	0.4 kg.
1.3.32 Overall dimensions, max	58 x 59 x 20 mm.
1.3.33 Reliability:	
- mean time between failures (MTBF), min	20000 h;
- average service life, min	10 years;
- mean time to recovery (MTTR), max	60 min.

N o t e – For more information please contact the manufacturer or visit www.polimaster.com.

1.4 Design and Principle of Operation

1.4.1 Design

The dosimeter external view is presented in Figure 1.1.



1 – dosimeter;
2 – holder with clip.

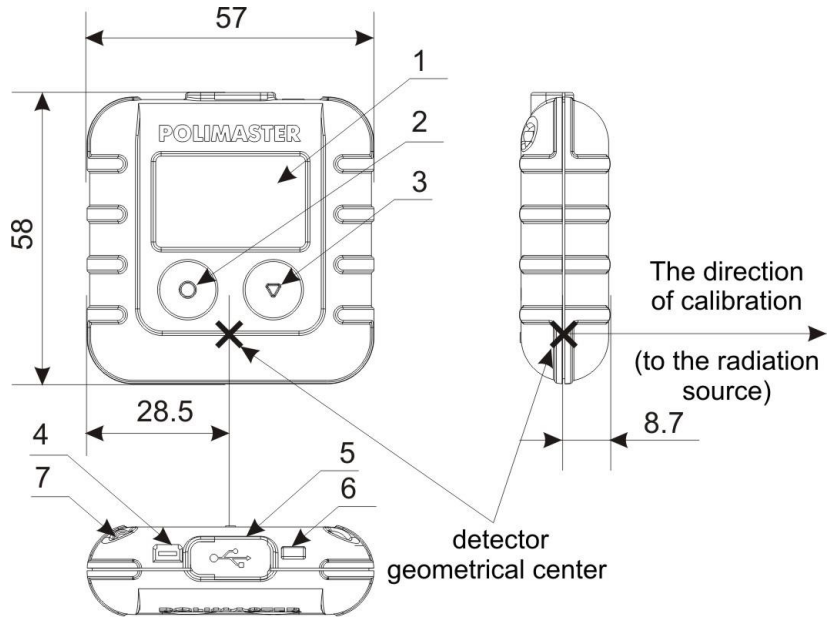
Figure 1.1 – External view of the dosimeter

The overall dimensions, direction of calibration and geometrical center of the dosimeter's detector are shown in Figure 1.2.

The body of the dosimeter is made of a shockproof plastic. The front panel of the dosimeter (Figure 1.2) contains a matrix LCD and two control buttons (2, 3).

Mini USB connector (5) (closed with plug), light emitting diode of visual alarm (6) and audible alarm outlet (4) are on the top of the dosimeter. The label with the model number and serial number are on the back side of the dosimeter.

The cable from the delivery kit of the dosimeter is used to connect the dosimeter to a personal computer.



1 – Liquid crystal display (LCD);
2, 3 – control buttons;
4 – sound buzzer;
5 – USB protective plug;
6 – red LED alarm;
7 – lanyard eyelet.

Figure 1.2 – Overall dimensions, geometrical center of the detector and direction of calibration

1.4.2 Principle of Operation

The dosimeter detector is the energy-compensated Geiger-Mueller counter, which converts photon radiation quanta into electric pulses to measure DER and DE of photon radiation.

Processing of detector pulses, control over the LCD, control buttons, audible and vibration alarms are performed by a built-in microcontroller.

The dosimeter's operating algorithm ensures continuous measurement process, statistical processing of measurement results, prompt adaptation to radiation intensity variations (measurement time is inverse to radiation intensity) and timely display of acquired data on the LCD.

The dosimeter's internal nonvolatile memory accumulates and stores dosimeter information, which can be further downloaded to personal computer. Data exchange is performed by means of USB interface provided in the dosimeter.

1.4.3 Operation Modes

The dosimeter performs in the following operation modes:
- DER measurement;
- DE measurement;
- settings;
- indication of current time;
- indication of battery status;
- re-start DER measurement;
- communication with computer.

Operation of the dosimeter in the above listed modes is described in Section 2.

The dosimeter continuously monitors it battery status in any operation mode (see 2.2.9). The LCD backlight can be activated in any operation mode (see 2.2.9).

1.5 Marking

The face panel of the dosimeter is marked with the manufacturer's logo.
The rear panel of the dosimeter is marked with:
- manufacturer's logo and name;
- dosimeter model;
- dosimeter serial number;
- ingress protection rating (IP);
- dosimeter's detector center.

1.6 Packing

The dosimeter is packed in a plastic bag and supplied in a cardboard box together with its Operation manual and delivery kit.

2 Operation

2.1 Pre-Operation

2.1.1 General

Check the dosimeter's delivery kit according to 1.2.1 and its functionality according to 2.1.4 paragraphs.

Avoid mechanical shocks and damages, corrosive media, organic solvents, open fire, and other adverse effects.

2.1.2 Safety Precautions

Observe radioactive materials handling and radiation safety standards and regulations during adjustment, repair, maintenance and calibration of the dosimeter, if radioactive sources are used.

In case of radioactive contamination, wipe the body of the dosimeter with and an ethyl alcohol-saturated tissue to decontaminate the dosimeter. Ethyl alcohol consumption for the dosimeter decontamination is 50 ml.

2.1.3 Preparation

Remove the instrument from its package.

Charge the built-in rechargeable battery of the dosimeter.

Charging the battery:

- remove the protective plug from the USB connector of the dosimeter (Figure 1.2);
- using USB A - USB mini B cable connect the dosimeter to USB port of a switched on personal computer or to a USB charger connected to power.

The dosimeter is automatically switched on when it is connected to computer or charger. The battery is charged until the battery icon (located at the upper left side of the screen) is completely filled up. While the battery is being charged green light alarm is switched on continually (see Fig.1.2, item 6).

N o t e – The dosimeter automatically enters the computer communication mode (USB) as soon as it is connected to computer. To reduce the battery charging time, exit the computer communication mode by pressing "BACK".

It takes around 3 hours to fully charge the dosimeters battery. When charging is over, disconnect the cable from the dosimeter and put the plug back.

2.1.4 Functional Check

Switch on the dosimeter according to 2.2.1. The dosimeter should enter the DER measurement mode. The LCD displays information (Figure 2.1). The dosimeter is ready for operation in approximately 60 seconds after switched on.

The DER value can be read when the relative root-mean-square uncertainty of the average reading (hereinafter referred to as "statistical uncertainty" is less than 15 %. The DER value (at normal radiation background) should be 0.05 to 0.2 μSv/h. The LCD backlight is activated upon pressing a button. If no button is pressed, the backlight is automatically switched off in approximately 6, 20 or 60 seconds (as set in the settings mode). If there is no backlight, switch it on in the settings mode.

Check the operation of each mode according to 2.2.3. There should be no error messages during the functional check.

Switch the dosimeter off according to 2.2.4.

2.2 Operation

2.2.1 Switching the Dosimeter ON

To switch on the dosimeter press and hold any button until the LCD is activated. The dosimeter will go through self-diagnostics and automatically enter the DER measurement mode (Figure 2.1). The dosimeter is ready for operation within 60 s after switched on.

2.2.2 Controls

The dosimeter is controlled by two multifunction buttons: ⊙ and ⊙.

The LCD displays the dosimeter operation mode, its current status as well as functions of the buttons for changing dosimeter status.

For example: being at screen control line inscriptions refer to the next action, such as "START", "SELECT", "NEXT", etc.

2.2.3 Selecting Operations Modes

Attention! The dosimeter continuously measures DE, DER and DE accumulation time in all operation modes except for the mode of PC communication via USB in the Settings.

Press "NEXT" button to select between operation modes of the dosimeter: DER (Figure 2.1) → ED (Figure 2.2) → SETTINGS (Figure 2.3).

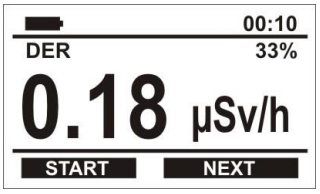


Figure 2.1

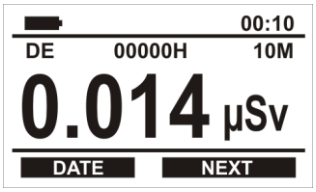


Figure 2.2

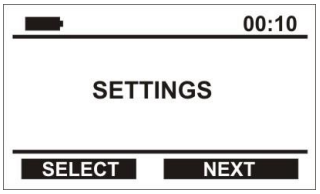


Figure 2.3

2.2.4 Switching the Dosimeter OFF

To switch off the dosimeter, enter "SETTINGS", press "NEXT" to go to "POWER OFF" and press "SELECT", then press "YES" to confirm (Figure 2.4).

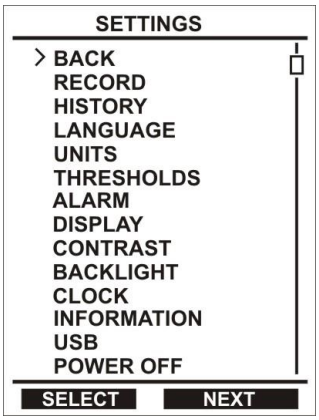


Figure 2.4

2.2.5 DER Measurement Mode

The dosimeter enters the DER measurement mode ("DER") automatically when switched on. In this mode, the dosimeter can measure:

- DER of continuous photon radiation;
- average DER of pulsed radiation.

2.2.5.1 Measurement of continuous photon radiation DER

While in the DER measurement mode ("DER"), the dosimeter's LCD indicates continuously measured DER values of photon radiation in "μSv/h", "mSv/h", "Sv/h", statistical uncertainty of DER indication in percent with 0.95 probability, status of the rechargeable battery (icon) and current time in hours and minutes (Figure 2.5).

Figure 2.5

The DER values can be read when the statistical uncertainty is 15 % and less.

Attention! Please remember that the lower the statistical uncertainty is, the more accurate the measurement result is.

It is possible to re-start DER measurement in this mode. Press "START", then "1" button (line "1 – DER") and the current DER value will be reset and the measurement will re-start.

The dosimeter monitors two alarm thresholds for the DER (2.2.7.5). When the DER alarm threshold (Threshold 1 or Threshold 2) is exceeded, the dosimeter goes to the DER measurement mode, indicates "THRESHOLD 1" or "THRESHOLD 2" on the upper line and triggers enabled audible (intermittent signal for threshold 1 and rapid intermittent signal for threshold 2), visual and vibration alarms (2.2.7.6). Press any key to switch off the alarms. The alarm is triggered again when the DER level becomes lower than one of the thresholds and threshold 1 or threshold 2 is exceeded again.

If the DER indication range is exceeded, the dosimeter triggers an alarm and the LCD indicates "OVERLOAD" and value 12.0 Sv/h.

2.2.5.2 Measurement of average DER of pulsed radiation

It becomes necessary to measure average DER of pulsed radiation when the user is exposed to pulsed photon radiation at pulse duration more than 1 ms.

Measurement of average DER of pulsed radiation can start from the DER measurement mode. Press "START", then press button "2" (line "2- AVERAGE DER OF IMP EXPOSURE"), the DER values will be reset and the dosimeters will start measurement of average DER of pulsed radiation ("AVERAGE DER") (Figure 2.6).

The average DER of pulsed radiation can be read when the statistical uncertainty is 15% or less. Measurement of the average DER may take some time to reduce statistical uncertainty for more accurate results. Press "BACK" to exit the average DER measurement mode.

When the dosimeter is moved to another place, re-start measurement of the average DER of pulsed radiation for more significant readings.

Attention! The dosimeter writes the values of average DER of pulsed radiation into its operating history. The dosimeter monitors two settable alarm thresholds for the average DER of pulsed radiation.

Press "BACK" to exit the mode of measuring average DER of pulsed radiation.

Figure 2.6

2.2.6 DE Measurement Mode

The DE measurement mode is used for the measurement of continuous and pulsed photon radiation (pulse duration not less than 1 ms).

Press "NEXT" in the DER measurement mode to enter the DE measurement mode ("DE") "NEXT", Figure 2.7.

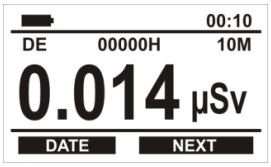


Figure 2.7

In this mode the dosimeter's LCD indicates measured DE values in "µSv", "mSv", "Sv", time of DE accumulation in hours (H) and minutes (M), status of the rechargeable battery (icon) and current time in hours and minutes (Figure 2.7).

It is possible to reset (zero) the DE and DE accumulation time values using the buttons in the "SETTINGS" mode. Enter "RESET DE": \"SETTINGS"\"THRESHOLDS"\"DE"\"RESET DE" and press "YES". The DE reset event and the reset DE value is recorded in the dosimeter's memory.

The dosimeter monitors two settable alarm thresholds for the DE (2.2.7.5). When the DE alarm threshold (Threshold 1 or Threshold 2) is exceeded, the dosimeter goes to the DE measurement mode, indicates "THRESHOLD 1" or "THRESHOLD 2" on the upper line and triggers enabled audible (intermittent signal for threshold 1 and rapid intermittent signal for threshold 2), light and vibration alarms (2.2.7.6). Press any key to switch off the alarms. The alarm is triggered again when the DE is reset or after setting higher threshold 1 or threshold 2 and DE threshold is exceeded again (threshold 1 or threshold 2).

If the DE indication range is exceeded, the dosimeter triggers an alarm and the LCD indicates "OVERLOAD" and value "12.0 Sv" (PM1610 and PM1610-01) or "24.0 Sv" (PM1610A and PM1610A-01).

When the "DATA" button is pressed, the dosimeter will display dose equivalent value and date (dd/mm/yyyy) when dose accumulation has started:

When the "TIME" button is pressed, the dosimeter will display the time (dd/hh/mm) left until the first dose equivalent threshold is exceeded as shown on the picture below:

If the time of warning alarm of the first dose equivalent threshold (ALARM1) is fixed, the dosimeter will produce three short signals every 10 minutes during this period until the alarm emits a signal informing that the first dose equivalent threshold is exceeded.

If "TOTAL" is pressed, the dosimeter will indicate the total dose of the dosimeter ("TOTAL DE"). The LCD indicates the value of photon radiation DE in "Sv" and DE accumulation time ("TOTAL TIME") in hours (H) and minutes (M) measured for the whole operating life of the dosimeter, status of the battery (icon) and current time in hours and minutes (Figure 2.7). It is impossible to reset values of DE and DE accumulation time in the "TOTAL DE" mode.

To return to the "DE" mode (Figure 2.7), press "CURRENT". To enter the next mode "SETTINGS", press "NEXT".

2.2.7 Settings

Press "NEXT" in the DE measurement mode to enter the settings mode (setting of parameters from the front panel). The LCD will display the following information, Figure 2.8.

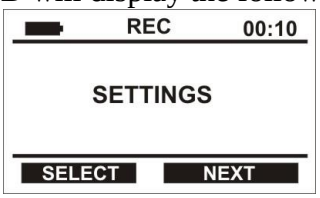


Figure 2.8

Press "SELECT" to enter the "SETTINGS" submenu. The LCD will display the following information, Figure 2.9.

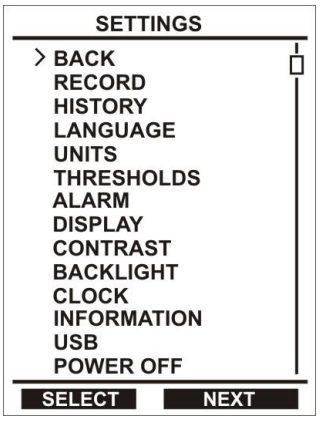


Figure 2.9

In the "SETTINGS" submenu the user can:

- write manually DER, DE, DE accumulation time values into the dosimeter's permanent memory ("RECORD");
- set and view parameters of data logging into the history ("HISTORY");
- select language of the dosimeter ("LANGUAGE");
- select units of indication of the dosimeter ("UNITS");
- set alarm threshold levels for DER and DE, reset DE ("THRESHOLDS");
- enable/disable light and vibration alarms, adjust volume of audible alarm ("ALARM");
- set active time of the LCD ("DISPLAY");
- set contrast of the LCD ("CONTRAST");
- set backlight duration or switch the backlight off ("BACKLIGHT");
- set current time of the dosimeter ("CLOCK");
- read serial number of the dosimeter ("INFORMATION");
- initiate communication with computer ("USB");
- switch off the dosimeter ("POWER OFF").

Note - Use "NEXT" button to move the cursor over the screen. Press "SELECT" to choose the control line pointed by the cursor. To exit an operating mode, press "BACK" or "DONE".

2.2.7.1 User-initiated writing of DER and DE history ("RECORD")

To write the DER and DE history (date, time, event, value) manually, enter the "SETTINGS", select "RECORD" and press "YES".

2.2.7.2 Setting and viewing the data logging parameters ("HISTORY").

"HISTORY" submenu:

- "MEMORY" – to view the status of the dosimeter's memory ("TOTAL", "FREE");
- "START" – to start writing DER and DE history into the dosimeter's memory;
- "STOP" – to stop writing history into the memory;
- "TYPE" – to select the type of data logging: linear or cyclic. If "linear" is selected, the DER and DE history will be written into the dosimeter until the memory is full, then the data writing stops. If "cyclic" is selected, the history writing continues after the memory is full (overwriting);
- "STEP" - to set the data logging interval in the format: hours-minutes-seconds (0:00:00);
- "DELAY" – to set time delay until the first event is written into the history;
- "ERASE" – to empty memory of the dosimeter.

The data logging parameters can be also set using the user software program supplied on CD.

Using the software program it is possible to disable changing of history parameters, so that the user can only view the dosimeter's history ("MEMORY").

Attention! While writing the history and available free memory, the "REC" message is displayed on the upper part of LCD - recording of the history is in progress. When writing is stopped or memory is full, the "REC" message disappears.

2.2.7.3 Selecting the language

To select the language of the dosimeter, select "LANGUAGE". The LCD will display the following information, Figure 2.10.

Figure 2.10

To change the language, select "РУССКИЙ" or "ENGLISH", and the dosimeter will change the language and exit to "SETTINGS" submenu. To return to "SETTINGS" submenu press "BACK".

2.2.7.4 Selecting the units of indication

To select the units of indication of the dosimeter, select "UNITS". The LCD will display the following information, Figure 2.11:

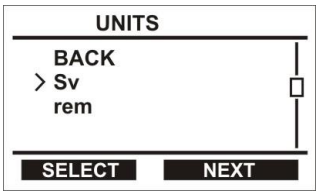


Figure 2.11

To change the units of indication, select "Sv" or "rem" and the dosimeter will change the units and exit to "SETTINGS" submenu. To return to "SETTINGS" submenu press "BACK".

2.2.7.5 Setting alarm threshold levels for DER and DE, resetting DE ("THRESHOLD")

Select "THRESHOLDS" to move to the settings of the alarm threshold levels for DER or DE . The LCD will display the following information, Figure 2.12.

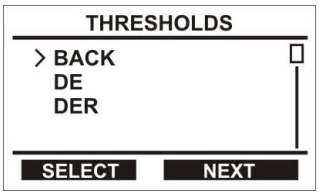


Figure 2.12

Select "DER" to set or check two DER thresholds ("THRESHOLD 1" and "THRESHOLD 2"). The LCD will display the following information, Figure 2.13.

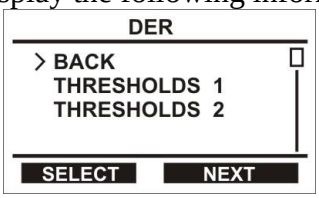


Figure 2.13

When "THRESHOLD 1" is selected, the LCD will display the following information, Figure 2.14.

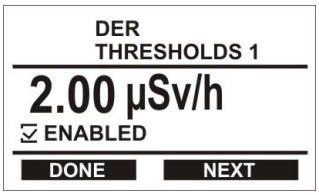


Figure 2.14

To change the threshold press "NEXT". Use "SELECT" to change an underlined symbol of the threshold. Use "NEXT" to move to the next symbol and press "DONE" to exit the threshold settings. The dosimeter will memorize the new value of the alarm threshold level.

Set the second DER threshold (line "THRESHOLD 2") in the same way as the first threshold.

Select "DE" to set or check two DE thresholds ("THRESHOLD 1" and "THRESHOLD 2") and to reset DE. The LCD will display the following information, Figure 2.15.

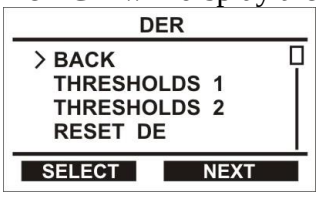


Figure 2.15

Set the DE thresholds ("THRESHOLD 1" and "THRESHOLD 2") in the same way as the DER thresholds.

To zero DE indication select “RESET DE” and press “YES”.

2.2.7.6 Selecting types of alarm ("ALARM")

Select "ALARM" in the "SETTINGS". The LCD will display the following information, Figure 2.16.

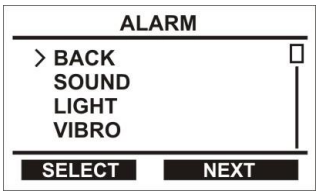


Figure 2.16

To change the level of volume of audible alarm, select "SOUND", then press "NEXT". Press "-" to reduce the sound volume. The audible alarm can be switched off using "-" button. Press "+" to increase the volume. You can set maximum volume of the audible alarm using "+" button. To exit the sound volume settings, press "DONE".

Select "LIGHT" or "VIBRO" to switch off/on the light and vibration alarms.

Attention! If all types of alarms are switched off, the dosimeter will automatically switch on the light alarm.

2.2.7.7 Setting the LCD active time ("DISPLAY")

Select "DISPLAY" to set active time of the LCD. The LCD will display the following information, Figure 2.17.

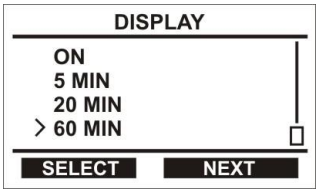


Figure 2.17

If "ON" is selected, the LCD is continuously on. If "5 MIN", "20 MIN" or "60 MIN" is selected, the LCD will switch off in around 5, 20 or 60 minutes, respectively. On switching off the display flashing green light alarm is switched on (see Fig. 1.2, item 6). To switch on the LCD, press any button.

2.2.7.8 Adjusting the LCD contrast ("CONTRAST")

Select "CONTRAST" in the "SETTINGS" to enter the contrast adjustment. The LCD will display the following information, Figure 2.18.

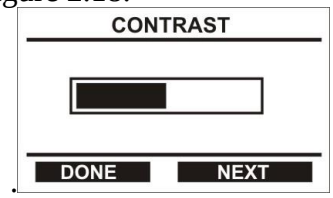


Figure 2.18

To change contrast of the screen, press "NEXT". Use "-" to reduce contrast and "+" to increase contrast. Press "DONE" to exit the contrast adjustment.

2.2.7.9 Setting the backlight time ("BACKLIGHT")

To adjust the backlight time, select "BACKLIGHT" in the "SETTINGS", then use "NEXT" and "SELECT" to set LCD backlight time – 5 , 20 or 60 seconds. To switch off the backlight, select "OFF".

2.2.7.10 Setting the dosimeter's time ("CLOCK")

To set the dosimeter current time, select "CLOCK" in the "SETTINGS", and press "NEXT". Use "SELECT" to change an underlined symbol. Press "NEXT" to move to the next symbol to be changed. Press "DONE" to exit the time settings.

2.2.8 Communication with Computer

2.2.8.1 The dosimeter performs data exchange with a computer with WINDOWS OS. Operation in the computer communication mode via USB is described in the HELP file of the user software. Please do the following for communication with computer:

- install the user software supplied on CD on your computer;
- connect the dosimeter to the computer with USB cable - the dosimeter will automatically establish communication with the computer;
- run the software program;
- the dosimeter is controlled by computer.

To disconnect computer communication, press "BACK" – the dosimeter will go into the DER measurement mode. To connect computer communication, enter the "SETTINGS" and select "USB".

When upon the connection of USB cable to the dosimeter the communication with computer isn't established automatically go into "SETTINGS", select line USB and shortly press "SELECT". After audio signal the dosimeter goes into communication with computer.

For a safe exit from communication with computer press "BACK" - the dosimeter goes into the DER measurement mode, only afterwards connect the USB cable off the dosimeter.

2.2.8.2 The following functions can be performed in the mode of communication with computer using the user software:

- read information (history) from the dosimeter's memory;
- write setup parameters into the dosimeter;
- process information read from the memory.

For detailed description of the user software please refer to the Help file.

2.2.8.3 PM1610-01 and PM1610A-01 instruments transfer information to the external reading device by the radio-channel according to ISO 15693.

Do the following to enable instrument-PC radio channel communication:

- install user software (supplied on the CD) onto the PC;
- connect a reading device to the PC USB-port (use a cable);
- start user software.

Reading procedure:

- press any key on the instrument;
- place the instrument's back surface close to the center of the reading device;
- the reading device will produce sound and light a red LED if the information exchange is successful.

The instrument registration dialogue window will appear at the first reading. Register the instrument as required.

During next readings a message displaying the instrument number and current accumulated dose value will be shown. The instrument serial number, current dose and dose rate values will be automatically sent into the software database simultaneously.

2.2.9 Low Battery Indication

In any operating mode the dosimeter continuously monitors the rechargeable battery voltage. The battery symbol is displayed on the left upper side of the screen. Completely filled symbol indicates nominal battery voltage. The filled portion of the battery symbol decreases as the battery voltage drops. When the battery voltage drops to its minimum, the battery symbol is empty. In case of critical battery discharge, the dosimeter produces audible and light warning signals and indicates "CHARGE THE BATTERY" message for one minute and then switches off indication on the LCD. The battery must be charged (2.1.3.3).

To activate indication on the LCD, press any button.

Avoid deep discharge of the battery!

Deep discharge of the battery reduces battery life and leads to the stop of internal clock of the dosimeter. When the battery is flat it charges to its minimum operating voltage after the dosimeter is connected to the charger during 1 – 20 minutes. At the same time while charging fist red indicator and then green indicator flashes. When the minimum operating voltage is attained the dosimeter goes into the DER measurement mode and continues charging. The battery is fully charged when the battery symbol doesn't move and it is completely filled. When the battery has been deeply discharged it's necessary to check the internal clock of the dosimeter and set it if needed.

3 Maintenance

3.1 Maintenance of the dosimeter involves preventive maintenance, battery charging and regular performance check according to 2.1.3.4.

3.2 Routinely examine the instrument body, remove any dust, and decontaminate the dosimeter in case of direct contact with radioactivity. Wipe the body with an ethyl alcohol-saturated soft tissue to decontaminate the dosimeter.

4 Troubleshooting

4.1 For common problems and their remedies, please refer to Table 4.1.

Table 4.1

Trouble	Possible cause	Remedy
1 Dosimeter cannot power on	Discharged battery	Charge the battery
2 No audible alarm	- Audible alarm is disabled (switched off) - Audible alarm failure	- Enable (switch on) the audible alarm in the settings mode or in computer communication mode - Contact the manufacturer for repair
3 "ERROR" message appears on screen	GM detector failure	Contact the manufacturer for repair
4 Upon the connection of USB cable to the dosimeter the communication with computer isn't established automatically	-	Go into "SETTINGS", select line USB and shortly press "SELECT". After audio signal the dosimeter goes into communication with computer

5 Verification method

5.1 Introduction

5.1.1 This verification procedure defines methods and tools of primary and periodic verification procedure of the X-Ray and Gamma Personal Dosimeters PM1610, PM1610A, PM1610B, PM1610-01, PM1610A-01, PM1610B-01 (further – instruments).

5.1.2 Produced instruments and instruments repaired because of non-compliance of metrological performance with specification requirements are subject to primary verification.

Instruments in operation are subject to periodic verification.

5.1.3 Exceptional verification is carried out before the verification period termination if:

- the instrument was repaired;
- it is necessary to validate the instrument operability;
- the instrument was put into operation, sold or rented after the half verification period termination.

Exceptional verification procedure for the instrument after repair is determined by the initial verification procedure.

5.1.4 Verification is carried out by local state metrological services according to current standards, or by authorized companies.

Verification frequency of instruments in use − 12 months.

5.2 Verification procedure operations

During the verification following operations specified in Table 5.1 should be carried out:

Table 5.1

Operation name	Verification procedure chapter number	Carrying out at	
		primary verification	primary verification
External examination	5.8.1	Yes	Yes
Testing	5.8.2	Yes	Yes
Metrological performance characterization: - estimation of the permissible intrinsic relative error of the photon radiation ambient dose equivalent rate measurement $\dot{H}^*(10)$ (further DER);	5.8.3.1	Yes	Yes
- estimation of the permissible intrinsic relative error of the photon radiation ambient dose equivalent measurement $\dot{H}^*(10)$ (further DE);	5.8.3.2	Yes	Yes

5.3 Verification tools

Verification has to be performed with the means of the tools with following characteristics as specified in the Table 5.2.

Table 5.2

Names of the reference and auxiliary verification tools	Main metrological and technical characteristics	Verification procedure chapter number at	
		primary verification	periodic verification
Reference verification assembly with ^{137}Cs sources set, according to local government standards	DER measurement range from 0.1 μSv/h to 10 Sv/h. Accuracy of the assembly calibration no more than ± 6 % at confidence probability 0.95	5.8.3.1, 5.8.3.2	5.8.3.1, 5.8.3.2
Reference gamma dosimeter	DER measurement range of the external gamma background from 0.1 μSv/h to 10 Sv/h. Accuracy of the assembly calibration no more than ± 3 % at confidence probability 0.95	5.8.3.1	5.8.3.1
Thermometer	Scale interval 1°C. Measurement range 10 °C - 40 °C	5.6.1	5.6.1
Barometer	Scale interval 1 kPa. Measurement range 60 - 120 kPa. Intrinsic error no more than 0.2 kPa	5.6.1	5.6.1
Hydrometer	Relative air humidity measurement range 30 % - 90 %. Measurement accuracy no more than ± 5 %	5.6.1	5.6.1
Gamma dosimeter	DER measurement range of the external gamma background from 0.1 to 10 μSv/h. Permissible intrinsic relative measurement error no more than ± 15 %	5.6.1	5.6.1
Seconds counter	Scale interval 0.1 s	5.8.3.1, 5.8.3.2	5.8.3.1, 5.8.3.2
Water phantom	30x30x15 cm*	5.8.3.1, 5.8.3.2	5.8.3.1, 5.8.3.2
*A plane-parallel PMMA phantom 30x30x15 cm can be used			

5.4 Verification Officers Qualification Requirements

5.4.1 Only persons certified as state verification officers in accordance with established procedure are allowed to conduct measurements during verification and (or) to analyze measurement results.

5.5 Safety Requirements

5.5.1 Any works with radioactive sources must be done according to state and local safety instructions for radioactive sources and other ionizing radiation sources valid at the verification site.

The verification process should be considered as work under special conditions.

5.6 Verification Conditions

5.6.1 Instrument verification is carried under normal environmental conditions:

- ambient air temperature (20 ± 5) °C;
- relative air humidity 60 (+20; -30) %;
- atmospheric pressure 101.3 (+5.4; -15.3) kPa;
- external gamma background radiation no more than 0.2 μSv/h.

5.7 Pre-verification procedure

5.7.1 Verification procedure of the instruments PM1610, PM1610A, PM1610-01 and PM1610A-01 is carried out with fully charged accumulator batteries. Verification procedure of the instruments PM1610B and PM1610B-01 is carried out with new batteries with guaranteed expiration date.

5.7.2 The following pre-verification procedures are required:

- study carefully Operation Manual before working with the Instruments to prevent errors and ensure safe operation.
- prepare Instrument for operation according to the item 2.1.3 of the Instrument Operation Manual.
- prepare auxiliary equipment for verification procedure in accordance with their technical documentation.

5.8 Verification Procedure

5.8.1 External examination

5.8.1.1 External examination must prove that instrument meets following requirements:

- delivery kit corresponds to Operation Manual requirements;
- there is a note in the Operation Manual about primary verification or certificate of recent verification;
- there are clear markings on the Instrument surface;
- there is no dirt or mechanical damage that can affect Instrument operation.

5.8.2 Testing

5.8.2.1 Check instrument operability according to according to the item 2.1.4 of the Instrument Operation Manual.

5.8.2.2 Set the maximum DER and DE alarm threshold values according to the item 2.2.7.5 of the Instrument Operation Manual.

5.8.3 Determination of the metrological characteristics

5.8.3.1 Calculate permissible intrinsic relative error of the DER measurement in the following way:

1) enter the DER measurement mode;

2) fix the instrument on the phantom, the backside facing the phantom. Place the dosimeter with the phantom on the dosimeter calibration assembly with ^{137}Cs gamma radiation source so that the calibration direction coincides with the direction of radiation flux axis and the radiation flux axis passes through the geometric center of the detector, Figure 5.1. The geometric center of the detector is marked with ”x”;

3) in not less than 600 s after placing the instrument with phantom on the dosimeter calibration assembly take five readings $\dot{H}_{bi}$ at intervals of not less than 150 s. Calculate the average background value $\dot{H}_b$, by formula

$$\overline{\dot{H}_b} = \frac{1}{5}\sum_{i=1}^{5}\dot{H}_{bi}, \qquad (5.1)$$

where $\dot{H}_{bi}$ – i-th value of the γ-background readings, μSv/h;

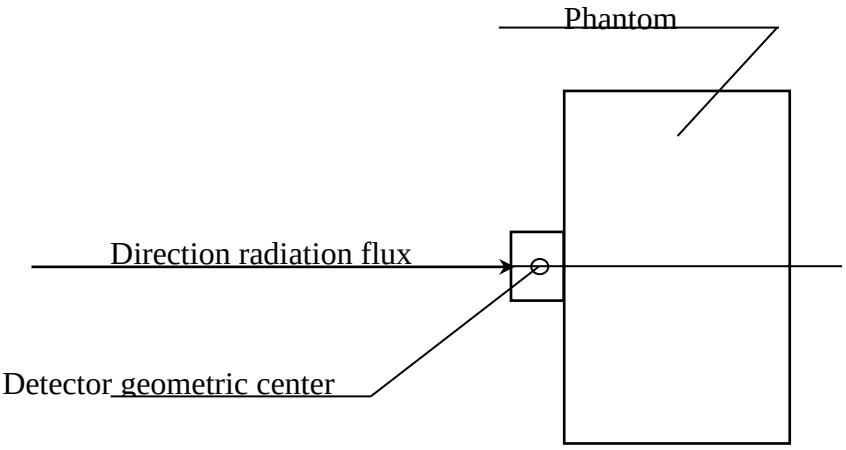


Figure 5.1 – The method of placing the dosimeter with phantom on the dosimeter calibration assembly

4) create reference DER $\dot{H}_{oj}$ = 3.0 μSv/h in the point coinciding with the geometric center of the detector and irradiate the instrument.

5) in 600 s after the beginning of irradiation take five the dosimeter's readings at intervals of not less than 60 s $\dot{H}_{ji}$ and calculate the average value $\dot{H}_j$, by formula

$$\overline{\dot{H}}_j = \frac{1}{5}\sum_{i=1}^{5}\dot{H}_{ji} \qquad (5.2)$$

6) repeat measurements for the points where DER $\dot{H}_{oj}$ is equal to 8.0 80.0; 800 μSv/h,

7) create DER $\dot{H}_{oj}$ equal to 8.0 mSv/h in the point coinciding with the detector geometric center;

8) irradiate the instrument;

9) in 120 s after the beginning of irradiation take five readings $\dot{H}_{ji}$ at intervals of 30 s. Calculate the average value by formula (5.2);

10) repeat measurements for the point where the DER $\dot{H}_{oj}$ is equal to 80.0, 800.0 mSv/h; 8.00 Sv/h;

11) calculate the measurement error Qj by formula

$$Q_j = \left|\frac{\left(\overline{\dot{H}}_j - \overline{\dot{H}}_b\right) - \dot{H}_{oj}}{\dot{H}_{oj}}\right| \cdot 100\%, \qquad (5.3)$$

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

$\overline{\dot{H}}_j$ – average DER value at the check point;

$\overline{\dot{H}}_b$ – average γ-background DER value;

12) calculate the error confidence limit of the dosimeter δ, %, with the confidence probability 0.95 under test by formula

$$\delta = 1.1\sqrt{(Q_o)^2 + (Q_{j\max})^2}, \qquad (5.4)$$

where Q_o – uncertainty of the reference dosimeter assembly, %;

Q_{jmax} – maximum measurement error of all Qj values, %;

13) compare the calculated value δ with an acceptable value δ_{acc} calculated by formula:

- for PM1610 and PM1610-01 instruments

$$\pm (15 + K/\dot{H}) \%, \qquad (5.5)$$

where $\dot{H}$ – DER value in mSv/h,

K – coefficient 0.0015 mSv/h;

- for PM1610A, PM1610A-01, PM1610B and PM1610B-01 instruments

$$\pm (10 + K_1/\dot{H} + K_2 \cdot \dot{H}) \%, \qquad (5.6)$$

where $\dot{H}$ – DER value in mSv/h,

K_1 – coefficient 0.0015 mSv/h,

K_2 – coefficient 0.0015 $(mSv/h)^{-1}$.

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

5.8.3.2 Calculate permissible intrinsic relative error of the DE measurement in the following way:

1) set the maximum values of DER threshold and DE threshold in the dosimeter and enter the DE measurement mode;

2) perform item 5.8.3.1 (2) of the present procedure;

3) read the initial DE $H_{нj}$ value from the dosimeter;

4) create from the reference source ^{137}Cs DER $\dot{H}_{oj}$ equal to 0.08 mSv/h in the point coinciding with the geometric center of the detector, irradiate the dosimeter during the time period T equal to 60 min;

5) read the final DE value after completion of irradiation;

6) calculate the intrinsic relative error of measurement Q_j, %, by formula

$$Q_j = \left| \frac{\left(H_{Kj} - H_{Hj}\right) - \dot{H}_{oj} \cdot T}{\dot{H}_{oj} \cdot T} \right| \cdot 100 , \qquad (5.7)$$

where $H_{кj}$ – finite DE value, mSv/h;

$H_{нj}$ – initial DE value, mSv/h;

$\dot{H}_{oj}$ – reference DER value at the check point, mSv/h;

T – time of the irradiation, h;

7) repeat measurements item 1) -6) for the point at reference DER equal to 8.0 mSv/h and 800.0 mSv/h during 30 min;

8) calculate dosimeter's intrinsic relative error confidence limit for each check point by formula (5.4), with the confidence probability 0.95, where Q_o – calibration installation's error, %; Q_j – relative error of the DE value measurement, calculated by formula (5.7), %. To compare the calculated value δ, calculated by formula (5.4) with an acceptable value δ_{acc} ± 20 %.

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

6 Disposal

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