MKS-05 “TERRA”
DOSIMETER-RADIOMETER

Operating manual

CONTENTS

This operating manual (hereinafter called the OM) is intended to inform the user about the principles of operation and rules of application of the MKS-05 “TERRA” dosimeter-radiometer. The manual contains all information necessary for proper use of the dosimeter and full realization of its technical possibilities.

The manual contains the following abbreviations and symbols:

DE	- ambient dose equivalent;
DER	- ambient dose equivalent rate.

1 DESCRIPTION AND OPERATION

1.1 Purpose of use

The MKS-05 “TERRA” dosimeter-radiometer (hereinafter called the dosimeter) is designed to measure ambient dose equivalent (DE) and ambient dose equivalent rate (DER) of gamma and X-ray radiation (hereinafter called photon-ionizing radiation), and surface beta-particles flux density.

The dosimeter is used in ecology research; as visual aids for educational establishments, for dosimetry and radiometry control at industrial enterprises; apartment, building, and construction control, ground surface of infields and vehicles control, personal radiation safety.

1.2 Technical specifications

1.2.1 Key specifications are presented in Table 1.1.

Table 1.1 – Key specifications

Name	Unit of measurement	Standardized values according to technical specifications
1 Measurement range of photon-ionizing radiation DER	μSv/h	0.1 – 9999
2 Main relative permissible error limit of photon-ionizing radiation DER measurement with confidence probability of 0.95	%	$15 + \frac{2}{\dot{H}^*(10)}$, where $\dot{H}^*(10)$ is a numeric value of the measured DER in μSv/h
3 Measurement range of photon-ionizing radiation DE	mSv	0.001 - 9999

Table 1.1 (continued)

Name	Unit of measurement	Standardized values according to technical specifications
4 Main relative permissible error limit of photon-ionizing radiation DE measurement with confidence probability of 0.95	%	±15
5 Energy range of registered photon-ionizing radiation	MeV	0.05 – 3.00
6 Energy dependence of the dosimeter readings at photon-ionizing radiation DER and DE measurement in the energy range of 0.05 to 1.25 MeV	%	±25

Table 1.1 (continued)

Name	Unit of measurement	Standardized values according to technical specifications
7 Anisotropy of the dosimeter at gamma quantum incidence at solid angle of 30^o to 150^o relative to the main axis of the detector and from the side of the main measurement direction for: - ^{137}Cs and ^{60}Co isotopes - ^{241}Am isotopes **Note.** Anisotropy charts are given in Appendix A	%	 ±25 ±60
8 Measurement range of surface beta-particles flux density	part./(cm^2·min)	10 - 10^5

Table 1.1 (continued)

Name	Unit of measurement	Standardized values according to technical specifications
9 Main relative permissible error limit of beta-particles flux density measurement with confidence probability of 0.95	%	$20+\dfrac{200}{\phi_{\beta}}$, where φ_{β} is a numeric value of the measured surface flux density in part./(cm^2·min)
10 Energy range of registered beta-particles	MeV	0.5 – 3.0
11 Measurement range of DE accumulation time	h	9999

Table 1.1 (continued)

Name	Unit of measurement	Standardized values according to technical specifications
12 Resolution of DE accumulation time display in the range of 0 h to 100 hrs of 100 hrs to 9999 hrs	-	 1 min 1 h
13 Absolute permissible error limit at DE accumulation time measurement during 24 hrs	min	±1
14 Time of the dosimeter operating mode setting, not more than	min	1

Table 1.1 (continued)

Name	Unit of measurement	Standardized values according to technical specifications
15 Battery life (AAAx2 of 1280 mA·h capacity) under + 20 ^{o}C temperature, natural background radiation and switched off display backlight, not more than	h	1500
16 Unstable readings of the dosimeter for 6 hours of continuous operation, not more than	%	5
17 Operating supply voltage of the dosimeter	V	3.0
18 Additional permissible error limit at measurement of photon-ionizing radiation DE and DER and surface beta-particles flux density in the supply voltage range of 3.2 to 2.4 V	%	±10

Table 1.1 (continued)

Name	Unit of measurement	Standardized values according to technical specifications
19 Additional permissible error limit at measurement of photon-ionizing radiation DE and DER and surface beta-particles flux density in the ambient air temperature range of – 20 to + 50 °C	%	±5
20 Mean time to failure, not less than	h	6000
21 Average value of availability factor, not less than	-	0.999
22 Average operating life of the dosimeter till the first major repair, not less than	h	10000
23 Average service life of the dosimeter, not less than	year	6

Table 1.1 (continued)

Name	Unit of measurement	Standardized values according to technical specifications
24 Average shelf life of the dosimeter, not less than	year	6
25 Dimensions, not more than	mm	55×26×120
26 Weight, not more than	kg	0.2

1.2.2 The dosimeter displays the statistical error value of measurement result of photon-ionizing radiation DER and surface beta-particles flux density.

1.2.3 The dosimeter measures photon-ionizing radiation DER and surface beta-particles flux density until the specified statistical error is gained.

1.2.3.1 The specified statistical error can be programmed by the user or automatically determined by the dosimeter depending on the radiation intensity.

1.2.4 For fast evaluation of photon-ionizing radiation DER and surface beta-particles flux density the dosimeter provides a ten-segment indicator of instantaneous value. The information is updated on the indicator of instantaneous value each 500 ms.

1.2.5 Threshold alarm system with three independent threshold levels is realized in the dosimeter:

- photon-ionizing radiation DER;
- photon-ionizing radiation DE;
- surface beta-particles flux density.

1.2.5.1 Threshold level values of photon-ionizing radiation DER in the range of 0 to 9999 μSv/h with discreteness of 0.01 μSv/h are programmed in the dosimeter.

1.2.5.2 Threshold level values of photon-ionizing radiation DE in the range of 0 to 9999 mSv with discreteness of 0.001 mSv are programmed in the dosimeter.

1.2.5.3 Threshold level values of surface beta-particles flux density in the range of 0 to $9999 \cdot 10^3$ part./(cm^2·min) with discreteness of $0.01 \cdot 10^3$ part./(cm^2·min) are programmed in the dosimeter.

1.2.5.4 The programmed values of the threshold levels are saved in the nonvolatile memory of the dosimeter, and are not changed when the dosimeter is turned on/off or the batteries are replaced.

1.2.6 The dosimeter provides four alarm types about the programmed threshold levels exceeding: audio, vibration, vibration and audio, and visual.

1.2.6.1 The dosimeter sends a two-tone audio signal and/or an intermittent vibration signal when the programmed threshold levels are exceeded.

1.2.6.2 If the programmed threshold levels are exceeded the dosimeter provides visual alarm in the form of a measurement result blinking on the liquid crystal display, and periodic and subsequent (from left to right) highlighting of segments of a sound symbol (4) according to Figure 3.

1.2.7 The dosimeter sends a short one-tone audio signal and/or a short vibration signal if gamma quantum or beta-particle gets to the detector.

1.2.8 The dosimeter stores up to 1200 measurement results of photon-ionizing radiation DER or surface beta-particles flux density in its nonvolatile memory. For more convenient identification every measurement result is stored along with a three-digit number of measurement object, as well as with time and date of measurement. Time and date of measurement is received from the dosimeter's clock, while the object number is entered by the user during saving.

1.2.9 The dosimeter sends the measurement results, which have been saved in the nonvolatile memory, to the personal computer (hereinafter called the PC) through Bluetooth radio channel. There is also a possibility to view this information on the liquid crystal display of the dosimeter (hereinafter called the LCD).

1.2.10 The dosimeter has the mode of clock when the current time in hours and minutes, as well as the current date, month and year are displayed on the LCD.

1.2.11 The dosimeter has the mode of alarm clock.

1.2.12 The dosimeter provides the possibility to work in the mode of intelligent detecting unit (hereinafter called the IDU). In this mode the dosimeter sends to the PC via the Bluetooth radio channel:

- current measurement results of photon-ionizing radiation DER or surface beta-particles flux density;
- current value of accumulated photon-ionizing radiation DE, as well as DE accumulation time;
- current value of supply voltage, and receives from the PC the commands to change the measurement modes and to synchronize the time based on the PC clock.

1.2.13 The dosimeter provides indication of low battery status.

1.2.14 The dosimeter performs measurements under the following conditions:

- temperature from – 20 to + 50 ^{o}C;
- relative humidity up to (95±3) % at + 35 ^{o}C temperature;
- atmospheric pressure from 84 to 106.7 kPa.

1.2.15 The dosimeter is resistant to the following external factors:

- high frequency sinusoidal vibrations (with crossover frequency from 57 to 62 Hz) in the range of 10 to 55 Hz, 0.15 mm bias for frequency lower than the crossover frequency;

- shocks with a shock pulse duration of 5 ms, a total number of shocks 1000±10 and maximum acceleration of 100 m/s^2;

- shocks in shipping container with an acceleration of 98 m/s^2, with a shock pulse duration of 16 ms (number of shocks - 1000±10 in each direction), or equivalent shake tests;

- exposure in shipping container to ambient air temperature from - 25 to + 55 ^{O}C and relative humidity up to (95±3) % at + 35 ^{O}C;

- photon-ionizing radiation with exposure dose rate that corresponds to ambient DER up to 1.0 Sv/h during 5 minutes.

1.3 Delivery kit

1.3.1 The delivery kit of the dosimeter consists of the items and the maintenance documentation presented in Table 1.2.

Table 1.2 - Delivery kit of the dosimeter

Type	Item	Quantity	Note
BICT.412129.006-09	MKS-05 “TERRA” dosimeter-radiometer		Bluetooth radio channel included
BICT.412129.006-09 HE	Operating manual	1 copy	
BICT.412915.015-02	Package	1 pc.	
ENERGIZER	Battery of AAA 1.5 V type	2 pcs.	Analogs permitted

Table 1.2 (continued)

Type	Item	Quantity	Note
Art. 80311 ТУ У 31111166.001-2001	Leather case	1 pc.	
	Custom-made software “Computer-aided programming and operation logging of the dosimeter ” (“Cadmium-ECOMONITOR”)	1	Supplied with the devices equipped with Bluetooth channel

1.4 Design and principle of operation

1.4.1 **Design of the dosimeter**

The dosimeter is designed as a flat square plastic body with rounded corners.

The body (Figure 1) consists of the upper (1) and the lower (2) covers. The LCD (3) is located in the middle of the upper cover (2); two keys of control – THRESHOLD (4) and MODE (5) are located to the left and to the right above the LCD.

Figure 1 – External view of the dosimeter (top view)

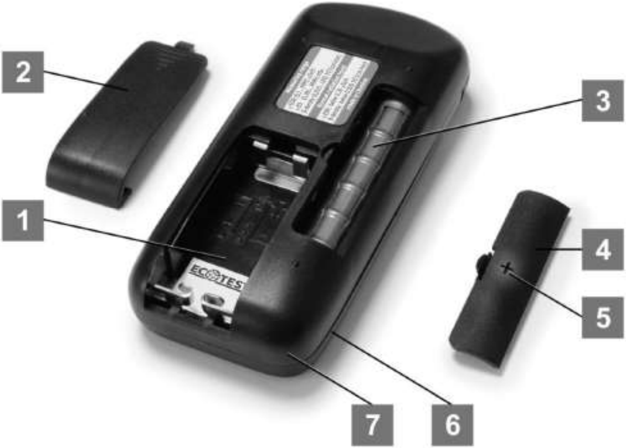

Figure 2 - External view of the dosimeter (bottom view)

The battery compartment (1) and the window (3) for surface beta-particles flux density measurement are located in the lower cover (7) (Figure 2). The battery compartment (1) is closed with the cover (2) whereas the window of the detector (3) is closed with the filter cover, both of which are fastened due to the elastic capacities of the material. The filter cover (4) contains the metrological mark (5) showing the mechanical center of the detector.

The control and indication keys of the dosimeter contain the corresponding inscriptions. The information table is drawn on the lower cover (7) of the device. (Figure 2) The polarity signs are indicated at the bottom of the battery compartment (1) for proper insertion of batteries.

1.4.2 **Basic operation of the dosimeter**

The dosimeter is a mono-block construction with:

- the detector of gamma and beta radiation;
- the printed-circuit board with the circuit of the anode voltage formation, the circuit of digital processing, control, and indication and the module of Bluetooth radio channel;
- the batteries.

The gamma and beta radiation detector built on the basis of СБМ-20-1 Geiger-Muller counter, transforms radiation into the sequence of voltage pulses; the number of pulses per unit of time is proportional to the registered radiation intensity.

The circuit of the anode voltage formation and the circuit of digital processing, control and indication provide:

- generation and regulation of the detector anode voltage;
- scaling and linearization of the detector counting response;
- measurement of photon-ionizing radiation DER and surface beta-particles flux density by means of measurement of an average pulse frequency from the detector outlet;
- measurement of photon-ionizing radiation DE by means of measurement of a general number of pulses from the detector outlet;
- measurement of DE accumulation time and real time;
- operating modes control;
- measurement results indication.

The Bluetooth radio channel module ensures interaction of the dosimeter and the personal computer.

The power for operation is supplied by two AAA batteries.

1.5 Labeling and sealing

1.5.1 The upper cover of the dosimeter is inscribed with the name, the symbol of the device, the trademark of the producer enterprise, the ingress protection rating of the dosimeter, and the pattern approval mark of measuring instruments

A serial number and a manufacture date are inscribed on the lower cover.

1.5.2 Sealing is performed by the producer enterprise.

The device is sealed with a special film seal located in the battery compartment. It covers the screw heads, whereas the screws fasten the lower cover.

Removal of seals and repeated sealing is performed by the company in charge of repair and verification of the dosimeter.

1.6 Packing

The dosimeter kit (the device, the operating manual and the leather case) is delivered in the cardboard box.

2 PROPER USE

2.1 Operating limitations

Operating limitations are presented in Table 2.1.

Table 2.1 – Operating limitations

Operating limitations	Limitation parameters
1 Ambient air temperature	from - 25 to +55 ^{o}C
2 Relative humidity	up to 95 % at + 35 ^{o}C temperature, non-condensing
3 Photon-ionizing radiation influence	DER up to 1.0 Sv/h during 5 min

Note. If operating in dusty environment or during atmospheric precipitations the dosimeter should be placed into a special case.

2.2 Preparation of the dosimeter for operation

2.2.1 **Scope and order of external examination**

2.2.1.1 Before using the dosimeter, unpack it and check if the delivery kit is complete. Examine for mechanical damages.

2.2.2 Rules and order of examination for operational readiness.

2.2.2.1 Study the operating manual before putting the dosimeter into operation.

2.2.2.2 Open the battery compartment and make sure the two batteries are inserted, connections are reliable, and there is no leakage of salts after durable storage of the dosimeter. In case there is a salt leakage, remove the batteries. Clean them, if possible, or replace, if not. Insert the batteries and close the battery compartment.

2.2.3 **Guidelines on switching on and testing the dosimeter**

2.2.3.1 Press shortly the MODE button to switch the dosimeter on. The dosimeter sends a short vibration-audio signal. The dosimeter enters the mode of photon-ionizing radiation DER measurement, which is shown by "γ" symbol and "μSv/h" dimension of the measured quantity.

Note. If the low battery indication appears on the LCD (see 2.3.3.6), replace the batteries.

2.2.3.2 Press shortly the MODE button and make sure the dosimeter has entered the mode of indication of photon-ionizing radiation DE accumulated value. "γ" symbol and "mSv" dimension of the measured quantity show that the dosimeter is operating in this mode.

2.2.3.3 Press shortly the MODE button and make sure the dosimeter enters the mode of surface beta-particles flux density measurement. "β" symbol and "$\frac{10^3}{(cm^2 \cdot \min)}$" dimension of the measured quantity show that the dosimeter is operating in this mode.

2.2.3.4 Press and hold (circa 6 seconds) the MODE button until the dosimeter turns off.

2.2.4 **List of possible troubles and troubleshooting**

2.2.4.1 The list of possible troubles and troubleshooting is presented in Table 2.2. Troubles during use are recorded in Appendix E of this OM.

2.2.4.2 At failure to eliminate the troubles presented in Table 2.2, or at detection of more complicated troubles, the dosimeter should be sent for repair to the manufacturer.

Table 2.2 – Possible troubles and troubleshooting

Trouble	Probable cause	Troubleshooting
The dosimeter does not switch on after the MODE button is pressed	1 The batteries are discharged	1 Replace the batteries
	2 No contact between the batteries and the battery compartment clamps	2 Restore the contact between the batteries and the clamps
	3 One of the batteries is out of order	3 Replace the defected battery

Table 2.2 (continued)

Trouble	Probable cause	Troubleshooting
Low battery indication is displayed on the LCD after the batteries have been replaced	1 Poor contact between the batteries and the battery compartment clamps 2 One of the batteries is out of order	1 Clean out the contacts on the clamps and the batteries 2 Replace the defected battery
“Er01” message on the LCD of the dosimeter	Gamma and beta radiation detector is out of order	Send the dosimeter for repair to the manufacturer

Table 2.2 (continued)

Trouble	Probable cause	Troubleshooting
No connection between the dosimeter and the PC, which is testified by the messages “Er03”, “Er04”, “Er05”, “Er06” or “Er07” on the LCD of the dosimeter	1 The distance between the dosimeter and the PC is too big 2 The “Cadmium-ECOMONITOR” custom-made software is not launched or improperly set on the PC	1 Make the distance between the dosimeter and the PC smaller 2 Launch or set the “Cadmium-ECOMONITOR” custom-made software in line with the user guide

2.3 Use of the dosimeter

2.3.1 **Safety measures during use of the dosimeter**

2.3.1.1 The dosimeter contains no external parts exposed to voltages hazardous for life.

2.3.1.2 Direct use of the device is not dangerous for the service personnel and is environmentally friendly.

2.3.1.3 A special protective jacket is used to prevent accidental contact with conductive parts.

Ingress protection rating is IP20.

2.3.1.4 The dosimeter belongs to fire safety equipment.

2.3.1.5 In case of contamination, the dosimeter should be deactivated. Wipe its surface by a gauze tampon moistened by standard decontaminating agent.

2.3.1.6 Disposal of the dosimeter should be performed in compliance with the general rules, i.e. metal is recycled or melted, and plastic parts are dumped.

2.3.2 **Operating modes of the dosimeter**

2.3.2.1 **Operating modes of the dosimeter**

The dosimeter operates within the following modes:

- photon-ionizing radiation DER measurement;
- indication of accumulated value of photon-ionizing radiation DE;
- surface beta-particles flux density measurement;
- clock;
- alarm clock;
- control of data communications with the PC;
- viewing of measurement results stored in the nonvolatile memory.

2.3.2.2 **Operating submodes of the dosimeter**

Every operating mode of the dosimeter has its submodes.

The mode of photon-ionizing radiation DER measurement consists of the following submodes:

- viewing of specified statistical error;
- saving of measurement results in the nonvolatile memory;
- measurement restart;

- programming of new values of audio alarm threshold level and specified statistical error, and switching on/off audio signaling of registered gamma-quanta.

The mode of accumulated value indication of photon-ionizing radiation DE consists of the following submodes:

- programming of a new value of audio alarm threshold level;
- resetting the values of DE and DE accumulation time.

The mode of surface beta-particles flux density measurement has the following submodes:

- viewing of specified statistical error;
- saving measurement results in the nonvolatile memory;
- measurement restart;
- programming of new values of audio alarm threshold level and specified statistical error, and switching on/off audio signaling of registered gamma-quanta and beta-particles.

The mode of clock has the submode of time and date correction.

The mode of alarm clock has the submode of programming the time of alarm activation.

The mode of measurement results viewing stored in the nonvolatile memory has the submode of measurement results clearing.

2.3.3 **Operation procedure of the dosimeter**

2.3.3.1 **Dosimeter's buttons**

The THRESHOLD (4) and the MODE (5) buttons are used to operate the dosimeter (Figure 1).

The MODE button is used to switch on/off the dosimeter and change its operating modes.

The THRESHOLD button is used to change the operating submodes of the dosimeter within one operating mode, as well as to correct the numeric values of the threshold levels and other parameters of the dosimeter operation.

2.3.3.2 **Switching the dosimeter on/off**

Press shortly the MODE button to switch the dosimeter on. A short vibration-audio signal and symbols displayed on the LCD show that the dosimeter is on.

Press the MODE button once again and hold it pressed for circa six seconds to switch the dosimeter off.

2.3.3.3 **General algorithm of the dosimeter operation control**

The general algorithm of the dosimeter operation control is carried out in the following way.

After the dosimeter is switched on, it enters the mode of photon-ionizing radiation DER measurement, which is shown by "γ" symbol and "μSv/h" dimension of the measured quantity. Each short press of the MODE button switches the dosimeter from one mode to another in the following order:

- the mode of photon-ionizing radiation DER measurement (it is set as the first one when the dosimeter is switched on);

- the mode of accumulated value indication of photon-ionizing radiation DE;
- the mode surface beta-particles flux density measurement;
- the mode of clock;
- the mode of alarm clock;
- the mode of data communications control with the PC;
- the mode of measurement results viewing stored in the nonvolatile memory (if such results exist).

If the nonvolatile memory contains any measurement result, a short press of the MODE button switches the dosimeter from the mode of data communications control with the PC to the mode of measurement results viewing stored in the nonvolatile memory. By pressing the MODE button when the dosimeter is in the mode of measurement results viewing, you switch the dosimeter to its initial mode – photon-ionizing radiation DER measurement.

If the nonvolatile memory has no saved measurement results, a short press of the MODE button switches the dosimeter from the mode of data communications control with the PC directly to the mode of photon-ionizing radiation DER measurement.

A short or a long press of the THRESHOLD button in any operating mode of the dosimeter changes the submodes of this operating mode. A detailed description of each operating mode of the dosimeter with its submodes is given below.

2.3.3.4 **Alarm type change**

The dosimeter provides the option to choose between three alarm types: audio, vibration and vibration-audio. Irrespective of the operating mode of the dosimeter a short press of the two buttons at a time (MODE and THRESHOLD) changes the alarm type and activates it for a short time. The alarm type is displayed on the LCD with “AUD” and/or “VIBR” symbols (6) (Figure 3).

Figure 3 – LCD of the dosimeter
(the mode of photon-ionizing radiation DER measurement)

2.3.3.5 **LCD backlight control**

Each press of any button of the dosimeter activates the LCD backlight for 6 seconds. Press the THRESHOLD button twice (time between presses should not exceed 0.5 s) to turn on a continuous LCD backlight. Press the THRESHOLD button twice once again to turn off a continuous LCD backlight.

2.3.3.6 **Batteries status control**

Irrespective of the chosen operating mode, the dosimeter carries out a non-stop control of batteries status. The control results are displayed on the LCD with a battery status symbol (7) (Figure 3), which consists of four segments. The number of blinking segments shows the level of batteries discharge. Blinking of three or four segments is accompanied by short audio and/or vibration signals. This means that the batteries should be replaced.

2.3.3.7 **The mode of photon-ionizing radiation DER measurement**

The mode of photon-ionizing radiation DER measurement is entered automatically after the dosimeter is switched on. With a short press on the MODE button you can proceed to this mode from any other operating mode.

To measure photon-ionizing radiation DER, direct the dosimeter with its metrological mark "+" (5) (Figure 2) towards an examined object. The filter cover (4) should cover the window with the detector located behind it (hereinafter called the window of the detector).

In this mode the dosimeter's LCD displays the following information (Figure 3):

- statistical error (1) of the measurement result (8);
- "γ" symbol (2) – an indication of the measured radiation type;
- instantaneous value indicator of radiation intensity (3);
- sound symbol (4) (if audio signaling of registered gamma quanta is switched on);
- alarm clock symbol (5) (if the alarm clock is on);
- alarm type symbol (6);

- battery status symbol (7);
- measurement result (8);
- dimension of measurement result (9);
- current time (10);
- threshold level of alarm actuation (11).

As soon as the measurement is started the measurement results of photon-ionizing radiation DER (8) and the statistical error values (1) that correspond to these results begin to be formed on the LCD.

If the DER measurement results exceed the alarm threshold level (11), the dosimeter sends a two-tone audio signal and/or an intermittent vibration signal, which depends on the chosen alarm type. Measurement results start blinking on the LCD of the dosimeter. Periodic and gradual (from left to right) highlighting of the sound symbol segments (4) serves as an indication of the threshold level exceeding as well (Figure 3).

The ten-segment indicator of instantaneous value (3) is used for fast evaluation of photon-ionizing radiation intensity. The integration time during measurement of the instantaneous intensity value and the time of information update on the instantaneous value indicator are equal to 500 ms.

The instantaneous intensity value is displayed in pseudo-logarithmic scale. The first segment of the indicator becomes highlighted when the intensity corresponds to 2 pulse/s pulse rate from the Geiger-Muller counter. The greater photon-ionizing DER becomes the more scale segments start to be highlighted from left to right. The scale becomes fully highlighted when the intensity equals to 2900 pulse/s pulse count rate from the Geiger-Muller counter. DER is about 1000 μSv/h in this case.

The sound symbol (4) means that audio signaling of registered gamma quanta is on. If signaling is on, the sound symbol is displayed on the LCD and each registered gamma quantum is followed by a short audio and/or vibration signal, which depends on the chosen alarm type.

Audio signaling of registered gamma quanta is switched on and off in the submode of alarm threshold level programming.

Photon-ionizing radiation DER is measured in the following way. As soon as the measurement is started the LCD of the dosimeter begins to display the measurement results and the statistical error values that correspond to these results. In the process of measurement the statistical error of each next measurement result becomes smaller, and in some time it reaches the specified statistical error. If this error is reached, a part of statistical information starts to be rejected while the measurement process continues. Therefore, all the following measurement results have the statistical error, which is equal to or less than the specified one.

The dosimeter can automatically determine the specified statistical error depending on the radiation intensity (Appendix B). The user can also do that in the submode of alarm threshold level programming. A blinking "%" symbol means that the user determined the statistical error.

If the specified statistical error is determined automatically by the device, its value is blinking on the LCD until it remains greater than the value of main relative permissible error limit of photon-ionizing radiation DER measurement (Table 1.1). If the specified statistical error is determined by the user, its value is blinking on the LCD until it remains greater than the value of the specified statistical error.

While the statistical error value keeps exceeding 99 %, the LCD displays the “пп%” symbols.

Press the THRESHOLD button in the mode of photon-ionizing radiation DER measurement to view the value of the specified statistical error. The value of the specified statistical error is displayed on the LCD (Figure 4) while the THRESHOLD button is being pressed and held down (but not longer than 3 s). A zero value display means that the dosimeter determined the specified statistical error automatically depending on the radiation intensity.

Figure 4 – LCD of the dosimeter
(viewing the value of specified statistical error)

If the THRESHOLD button is being held down for more than three seconds, the LCD displays the “Arch” symbols (Figure 5). Thus it becomes possible to proceed to the submode of measurement result saving in the nonvolatile memory.

Figure 5 – LCD of the dosimeter (start of the submode of measurement result saving in the nonvolatile memory)

If you keep holding the THRESHOLD button, the “Arch” symbols will disappear from the LCD, and the measurement will be restarted during the next two seconds (Figure 6).

Figure 6 – LCD of the dosimeter (measurement restart)

If you keep holding the THRESHOLD button, then during the next two seconds the dosimeter will proceed to the submode of programming of new values of alarm threshold level and specified statistical error, and switching on/off audio signaling of registered gamma-quanta (Figure 7). A stripe (1) “moving” across the instantaneous value indicator and blinking of the low-order digit (2) of a new threshold level serve as an indication of this submode. Then release the THRESHOLD button.

When a digit is blinking, it means that its value can be programmed. Use the THRESHOLD button to set the required value of the blinking digit. Successive short presses and releases of the THRESHOLD button change this value per unit. A long press of the THRESHOLD button starts automatic change of this value, which is stopped after the button is released.

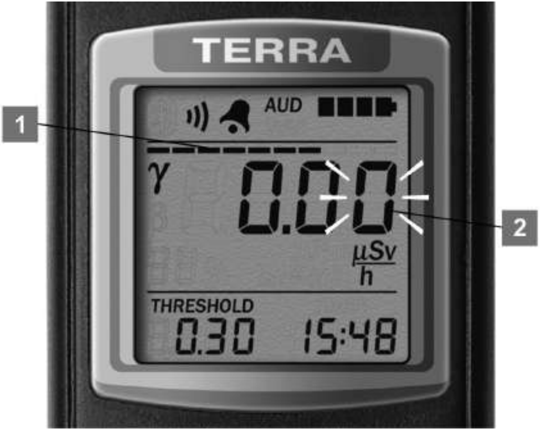

Figure 7 – LCD of the dosimeter
(the submode of alarm threshold level programming)

A short press of the MODE button fixes the value of the digit (it stops blinking) and allows presetting the value of the next digit, which starts blinking at that. Other digits are programmed likewise.

As soon as all digits of the new threshold level are programmed, the LCD of the dosimeter displays the specified statistical error (Figure 8). Its low-order digit is blinking, which means that its value can be programmed. Program the new value of the specified statistical error in a similar way to programming of the new value of alarm threshold level. By presetting a zero value, you switch on automatic determination of the specified statistical error by the dosimeter depending on the radiation intensity.

Figure 8 – LCD of the dosimeter
(the submode of alarm threshold level programming)

As soon as all digits of the new value of the specified statistical error are programmed, the sound symbol starts blinking on the LCD of the dosimeter. Thus it becomes possible to switch on/off audio and/or vibration signaling of every registered gamma quantum. Successive short presses of the THRESHOLD button switches the alarm on/off. Each press of the THRESHOLD button changes the sound symbol status, and, correspondingly, switches the alarm on or off. The highlighted unblinking sound symbol shows that signaling is on, and the dark one shows that it is off.

A short press of the MODE button after audio signaling of every registered gamma quantum has been switched on or off, fixes all programmed values in the nonvolatile memory of the dosimeter. It also finishes the submode of new values programming of alarm threshold level and specified statistical error, as well as switching on/off audio signaling of registered gamma-quanta.

If the programmed values are fixed, a new value of the threshold level blinks three times on the LCD, and the dosimeter returns to the mode of photon-ionizing radiation DER measurement.

Caution! If the submode of new values programming of alarm threshold level and specified statistical error, as well as switching on/off audio signaling of registered gamma-quanta is paused for more than 30 s (the user presses no buttons of the dosimeter), the dosimeter will automatically return to the mode of photon-ionizing radiation DER measurement. All changes made in the submode of new values programming will be cancelled.

Note. A zero value of the threshold level makes the alarm inactive.

To save the measurement result of photon-ionizing radiation DER in the nonvolatile memory, press and hold the THRESHOLD button in the measurement mode until the “Arch” symbols are displayed on the LCD (Figure 5). Then release the THRESHOLD button. Switching to the submode of measurement result saving should be confirmed by a short press of the MODE button. Press shortly the THRESHOLD button to cancel the action. If the buttons are not pressed for 30 s, the dosimeter automatically returns to the mode of photon-ionizing radiation DER measurement.

If the “FULL” symbols are displayed on the LCD of the dosimeter instead of the “Arch” symbols (Figure 9), there is no free space in the nonvolatile memory of the dosimeter, and, correspondingly, the next measurement results cannot be saved.

Figure 9 – LCD of the dosimeter
(start of the submode of measurement result saving – no free space in the nonvolatile memory)

To clear the space in the nonvolatile memory, delete its saved measurement results. Measurement results can be cleared during data communications with the PC (2.3.3.12 of the OM) or in the viewing mode (2.3.3.13 of the OM).

The “Arch” symbols (1) on the LCD of the dosimeter are an indication of the submode of measurement result saving (Figure 10). In this submode the LCD displays the measurement result (1) and the measurement object number (3) that will be saved in the nonvolatile memory. The nonvolatile memory status is displayed on the instantaneous value indicator (4). If the nonvolatile memory contains no data, only the first segment is highlighted on the indicator. If the memory is full, all segments are highlighted.

Figure 10 – LCD of the dosimeter
(the submode of measurement result saving of photon-ionizing radiation DER)

The low-order digit of the object number is blinking and shows that its value can be programmed. Use the THRESHOLD button to set the required value of the blinking digit. Successive short presses and releases of the THRESHOLD button change this value per unit. A long press of the THRESHOLD button starts automatic change of this value, which is stopped after the button is released.

A short press of the MODE button fixes the value of the digit (it stops blinking) and allows presetting the value of the next digit, which starts blinking at that. Other digits are programmed likewise.

As soon as the third (last) digit is programmed, the DER measurement result, the measurement object number, and the date and time of measurement are saved in the nonvolatile memory. If the information is saved, the measurement value under saving blinks three times on the LCD of the dosimeter, and it returns to the mode of photon-ionizing radiation DER measurement.

Caution! If the submode of measurement result saving is paused for more than 30 s (the user presses no buttons of the dosimeter), the dosimeter will automatically return to the mode of photon-ionizing radiation DER measurement without saving the measurement result.

2.3.3.8 **The mode of indication of photon-ionizing radiation DE accumulated value**

This mode can be entered from any other operating mode of the dosimeter with the help of a short press of the MODE button.

This mode follows the mode of photon-ionizing radiation DER measurement.

The LCD of the dosimeter displays the following information in the mode of indication of photon-ionizing radiation DE accumulated value (Figure 11):

- "γ" symbol (1) – an indication of the measured radiation type;
- DE current value (5);
- dimension (6);
- threshold level of alarm actuation (7);
- DE accumulation time (8);
- alarm clock symbol (2) (if the alarm clock is on);
- alarm type symbol (3);
- battery status symbol (4).

Figure 11 – LCD of the dosimeter
(the mode of indication of photon-ionizing radiation DE accumulated value)

The accumulated value of photon-ionizing radiation DE, DE accumulation time and DE threshold level are displayed in this mode. The process of photon-ionizing radiation DE accumulation starts right after the dosimeter is switched on, and is performed in all operating modes, except for surface beta-particles flux density measurement. When the dosimeter is turned off photon-ionizing radiation DE value and DE accumulation time are saved in the nonvolatile memory of the dosimeter. DE value and DE accumulation time can be set to zero in the corresponding mode, which is described below.

DE accumulation time can be displayed on the LCD in two formats. As long as DE accumulation time does not exceed 100 hours, it is displayed in the "HH:MM" format, where HH stands for hours, and MM stands for the value of minutes of DE accumulation time. The values of hours and minutes are separated with the unblinking ":" symbol.

As soon as DE accumulation time exceeds 100 hours, it is displayed in the “HHHH” format, where HHHH stands for the value of hours of DE accumulation time. The “:” symbol is absent.

The dosimeter sends a two-tone audio signal and/or an intermittent vibration signal when the measured DE value of alarm threshold level is exceeded, depending on the chosen alarm type. The DE value starts blinking on the LCD of the dosimeter. A periodic and subsequent (from left to right) highlighting of segments of the sound symbol also show that the threshold level has been exceeded.

To proceed to the submode of a new value programming of alarm threshold level, press and hold the THRESHOLD button until a stripe (1) is displayed on the LCD (Figure 12) that is “moving” across the instantaneous value indicator. The new threshold level with a blinking low-order digit (2) should also appear on the LCD.

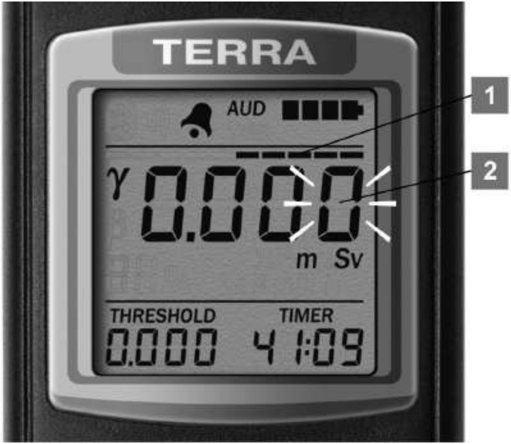

Figure 12 – LCD of the dosimeter
(the submode of a new value programming of alarm threshold level)

When a digit is blinking, it means that its value can be programmed. Use the THRESHOLD button to set the required value of the blinking digit. Successive short presses and releases of the THRESHOLD button change this value per unit. A long press of the THRESHOLD button starts automatic change of this value, which is stopped after the button is released.

A short press of the MODE button fixes the value of the digit (it stops blinking) and allows presetting the value of the next digit, which starts blinking at that. All other digits are programmed likewise.

A short press of the MODE button after the last digit has been programmed, fixes a new value of the alarm threshold level in the nonvolatile memory of the dosimeter. If it has been fixed, a new value of the threshold level blinks three times on the LCD, and the dosimeter returns to the mode of indication of photon-ionizing radiation DE accumulated value and DE accumulation time.

Caution! If the submode of a new value programming of alarm threshold level is paused for more than 30 s (the user presses no buttons of the dosimeter), the dosimeter will automatically return to the mode of indication of photon-ionizing radiation DE accumulated value. All changes made in the submode of a new value programming will be cancelled.

Note. A zero value of the threshold level makes the alarm inactive.

In order to proceed to the submode of DE and DE accumulation time values resetting, simultaneously press and hold the THRESHOLD and the MODE buttons until “CLr” and “dOSE” symbols appear on the LCD of the dosimeter (Figure 13).

Figure 13 – LCD of the dosimeter
(the sumbode of DE and DE accumulation time values resetting)

To cancel resetting, shortly press the THRESHOLD button once again or do not press the buttons during 30 s (the dosimeter will automatically enter the mode of indication of photon-ionizing radiation DE accumulated value and DE accumulation time).

To confirm resetting of DE and DE accumulation time values, shortly press the MODE button. The “CLr” symbols that blink three times on the LCD of the dosimeter, and return of the dosimeter to the mode of accumulated value indication of photon-ionizing radiation DE mean that the values have been set to zero.

Caution! If the submode of DE value and DE accumulation time resetting is paused for more than 30 s (the user presses no buttons of the dosimeter), the dosimeter will automatically return to the mode of indication of photon-ionizing radiation DE accumulated value without resetting.

2.3.3.9 **The mode surface beta-particles flux density measurement**

This mode can be entered from any other operating mode of the dosimeter with the help of a short press of the MODE button. This mode follows the mode of measured value indication of photon-ionizing radiation DE and DE accumulation time.

At first measure gamma background DER (to enable its further automatic subtraction), and then measure surface beta-particles flux density. To do this, place the dosimeter in the mode of DER measurement (filter cover covers the window of the detector) over the surface that should be examined for beta-particles flux density, and wait for the measurement result of gamma background DER with the required statistical error. Press shortly the MODE button twice. This will store the measured value of gamma background DER and switch the dosimeter from photon-ionizing radiation DER measurement mode to surface beta-particles flux density measurement mode.

To measure surface beta-particles flux density, remove the filter cover from the window, located opposite the detector, direct the dosimeter with the window in parallel to the examined surface and place it as close as possible.

In the mode of surface beta-particles flux density measurement the dosimeter's LCD displays the following information (Figure 14):

- statistical error (1) of the measurement result (8);
- "β" symbol (2) – an indication of the measured radiation type;
- indicator of instantaneous value (3);
- sound symbol (4) (if audio signaling of registered gamma quanta and beta-particles is switched on);
- alarm clock symbol (5) (if the alarm clock is on);
- alarm type symbol (6);
- battery status symbol (7);
- measurement result (8);
- dimension of measurement result (9);
- current time (10);
- threshold level of alarm actuation (11).

Figure 14 – LCD of the dosimeter
(the mode of surface beta-particles flux density measurement)

As soon as the measurement is started the surface beta-particles flux density measurement results (8) and the statistical error values (1) that correspond to these results begin to be formed on the LCD.

If the flux density measurement results exceed the alarm threshold level (11), the dosimeter sends a two-tone audio signal and/or an intermittent vibration signal, which depends on the chosen alarm type. Measurement results start blinking on the LCD of the dosimeter. Periodic and gradual (from left to right) highlighting of the sound symbol segments (4) serves as an indication of the threshold level exceeding as well.

The ten-segment indicator of instantaneous value (3) is used for fast evaluation of intensity of photon-ionizing radiation and beta-particles flux. The integration time during measurement of the instantaneous intensity value and the time of information update on the instantaneous value indicator are equal to 500 ms.

The instantaneous intensity value is displayed in pseudo-logarithmic scale. The first segment of the indicator becomes highlighted when the intensity corresponds to 2 pulse/s pulse rate from the Geiger-Muller counter.

The greater the intensity becomes the more scale segments start to be highlighted from left to right. The scale becomes fully highlighted when the intensity equals to 740 pulse/s pulse rate from the Geiger-Muller counter. Beta-particles flux density is about $45 \cdot 10^3$ part./(cm^2·min) in this case if gamma background is not increased.

The sound symbol (4) means that audio signaling of registered gamma quanta and beta-particles is on. If signaling is on, this symbol is displayed on the LCD, and each registered gamma quantum or beta-particle is followed by a short audio and/or vibration signal, which depends on the chosen alarm type.

Audio signaling of registered gamma quanta and beta-particles is switched on and off in the submode of alarm threshold level programming.

Surface beta-particles flux density is measured in a similar way to photon-ionizing radiation DER measurement. As soon as the measurement is started the LCD of the dosimeter begins to display the measurement results and the statistical error values that correspond to these results. In the process of measurement the statistical error of each next measurement result becomes smaller, and in some time it reaches the specified statistical error.

If this error is reached, a part of statistical information starts to be rejected while the measurement process continues. Therefore, all following measurement results will have the statistical error, which is equal to or less than the specified one.

The dosimeter can automatically determine the specified statistical error depending on the radiation intensity (Appendix C). The user can also do that in the submode of alarm threshold level programming. A blinking “%” symbol means that the user determined the statistical error.

If the specified statistical error is determined automatically by the device, its value is blinking on the LCD until it remains greater than the value of main relative permissible error limit of surface beta-particles flux density measurement (Table 1.1). If the specified statistical error is determined by the user, its value is blinking on the LCD until it remains greater than the value of the specified statistical error.

While the statistical error value keeps exceeding 99 %, the LCD displays the “ПП%” symbols.

Press the THRESHOLD button in the mode of surface beta-particles flux density measurement to view the value of the specified statistical error. The value of the specified statistical error is displayed on the LCD (Figure 15) while the

THRESHOLD button is being pressed and held down (but not longer than 3 s). A zero value display means that the dosimeter determined the specified statistical error automatically depending on the radiation intensity.

Figure 15 – LCD of the dosimeter
(viewing the value of specified statistical error)

If the THRESHOLD button is being held down for more than three seconds, the LCD displays the “Arch” symbols (Figure 16). Thus, it becomes possible to proceed to the submode of measurement result saving in the nonvolatile memory.

Figure 16 – LCD of the dosimeter (start of the submode of measurement result saving in the nonvolatile memory)

If you keep holding the THRESHOLD button, the “Arch” symbols will disappear from the LCD, and the measurement will be restarted during the next two seconds (Figure 17).

Figure 17 – LCD of the dosimeter (measurement restart)

If you keep holding the THRESHOLD button, then during the next two seconds the dosimeter will proceed to the submode of new values programming of alarm threshold level and specified statistical error, and switching on/off audio signaling of registered gamma-quanta and beta-particles (Figure 18). A stripe (1) “moving” across the instantaneous value indicator and blinking of the low-order digit (2) of a new threshold level serve as an indication of this submode.

Operation with the dosimeter in this submode fully complies with the operation in a similar submode of the photon-ionizing radiation DER measurement mode.

To save the measurement result of surface beta-particles flux density in the nonvolatile memory, press and hold the THRESHOLD button in the measurement mode until the “Arch” symbols are displayed on the LCD (Figure 16). Then release the THRESHOLD button.

Figure 18 – LCD of the dosimeter
(the submode of alarm threshold level programming)

Proceeding to the submode of measurement result saving should be confirmed by a short press of the MODE button. Press shortly the THRESHOLD button to cancel the action. If the buttons are not pressed for 30 s, the dosimeter automatically returns to the mode of surface beta-particles flux density measurement.

If the “FULL” symbols are displayed on the LCD of the dosimeter (Figure 19) instead of the “Arch” symbols, there is no free space in the nonvolatile memory of the dosimeter, and, correspondingly, the next measurement results cannot be saved. To clear the space in the nonvolatile memory, delete its saved measurement results. Measurement results can be cleared during data communications with the PC (2.3.3.12 of the OM) or in the viewing mode (2.3.3.13 of the OM).

Figure 19 – LCD of the dosimeter
(start of the submode of measurement result saving – no free space in the nonvolatile memory)

The “Arch” symbols (2) on the LCD of the dosimeter are an indication of the submode of measurement result saving (Figure 20). In this submode the LCD displays the measurement result (1) and the measurement object number (3) that will be saved in the nonvolatile memory. The nonvolatile memory status is displayed on the instantaneous value indicator (4). If the nonvolatile memory contains no data, only the first segment is highlighted on the indicator. If the memory is full, all segments are highlighted.

Operation with the dosimeter in this submode fully complies with the operation in a similar submode of the photon-ionizing radiation DER measurement mode.

Figure 20 – LCD of the dosimeter
(the submode of measurement result saving of surface beta-particles flux density)

2.3.3.10 **The clock mode**

This mode can be entered from any other operating mode of the dosimeter with the help of a short press of the MODE button. This mode follows the mode of surface beta-particles flux density measurement.

In the mode of clock the dosimeter's LCD displays the following information (Figure 21):

- alarm clock symbol (1) (if the alarm clock is on);
- alarm type symbol (2);
- battery status symbol (3);
- time (4);
- day (5);
- month (6);
- year (7).

Figure 21 – LCD of the dosimeter
(the clock mode)

To proceed to the submode of time and date correction, press and hold the THRESHOLD button until a stripe (1) “moving” across the instantaneous value indicator appears on the LCD, and the digits of minutes (2) start blinking (Figure 22).

Figure 22 – LCD of the dosimeter
(the submode of time and date correction – time programming)

When digits are blinking, it means that their values can be programmed. Use the THRESHOLD button to set the required value of the digit. Successive short presses and releases of the THRESHOLD button change this value per unit. A long press of the THRESHOLD button starts automatic change of this value, which is stopped after the THRESHOLD button is released.

A short press of the MODE button fixes the values of the minute digits (they stop blinking) and allows presetting the values of the hour digits, which start blinking at that. The hour digits are programmed with the help of the THRESHOLD button in a similar way to the minute digits programming.

A short press of the MODE button fixes a new time value in the dosimeter's memory. The new time value blinks three times on the LCD of the dosimeter to show that it has been fixed. A year is then displayed on the LCD (Figure 23).

Figure 23 – LCD of the dosimeter
(the submode of time and date correction – year programming)

When the low-order digits of the year are blinking, it means that their values can be programmed. They are programmed with the help of the THRESHOLD button in a similar way to the minute digits programming. The year value can be set within the limits from 2010 to 2099.

A short press of the MODE button fixes a new value of year in the dosimeter's memory. The new value of year blinks three times on the LCD of the dosimeter to show that it has been fixed. The date (1) and month (2) are then displayed on the LCD (Figure 24). When the month digits are blinking, it means that their values can be programmed. They are programmed with the help of the THRESHOLD button in a similar way to the minute digits programming.

Figure 24 – LCD of the dosimeter
(the submode of time and date correction – date programming)

A short press of the MODE button fixes the values of the month digits (they stop blinking) and allows presetting the values of the date digits, which start blinking at that. The date digits are programmed with the help of the THRESHOLD button in a similar way to the hour digits programming.

A short press of the MODE button fixes a new value of date and month in the dosimeter's memory. The new value blinks three times on the LCD, and the dosimeter returns to the mode of clock.

Caution! If the submode of date and time correction is paused for more than 30 s (the user presses no buttons of the dosimeter), the dosimeter will automatically return to the mode clock. All changes made and not fixed in the dosimeter's memory will be cancelled.

2.3.3.11 **The mode of alarm clock**

This mode can be entered from any other operating mode of the dosimeter with the help of a short press of the MODE button. This mode follows the mode of clock.

In the mode of alarm clock the dosimeter's LCD displays the following information (Figure 25):

- alarm clock symbol (1) (if the alarm clock is on);
- alarm type symbol (2);
- battery status symbol (3);
- time of the alarm clock activation (4);
- current time (5).

To proceed to the submode of alarm clock activation time programming, press and hold the THRESHOLD button until a stripe (1) "moving" across the instantaneous value indicator appears on the LCD, and the minute digits of alarm clock activation (3) start blinking (Figure 26).

Figure 25 – LCD of the dosimeter
(the alarm clock mode)

Figure 26 – LCD of the dosimeter
(the submode of alarm clock activation time programming)

Minutes and hours of the alarm clock activation are programmed in a similar way to time correction in the clock mode.

As soon as the alarm clock activation time is programmed, the alarm clock symbol (2) starts blinking on the LCD of the dosimeter. Thus it becomes possible to turn on/off the alarm clock ringing at a time set in advance. Successive short presses of the THRESHOLD button turn the alarm clock on/off. Each press of the THRESHOLD button changes the alarm clock symbol status. The highlighted unblinking alarm clock symbol shows that the alarm clock is on, and the dark one shows that it is off.

Caution! If the submode of alarm clock activation time programming is paused for more than 30 s (the user presses no buttons of the dosimeter), the dosimeter will automatically return to the alarm clock mode. All changes made in the submode of alarm clock activation time programming will be cancelled.

If the alarm clock is on, and the current time coincides with the alarm clock activation time, the alarm clock will be activated and the dosimeter will start generating the alarm clock signal – typical audio and/or vibration signals, in all operating modes and submodes of the dosimeter, except for the submode of time and date correction. The alarm clock symbol will be blinking at that. The alarm clock goes off even if the dosimeter is off.

The alarm clock signal can be switched off with a short press of the MODE or the THRESHOLD button in any operating mode or submode of the dosimeter, but for the submodes of threshold level new values input and the mode of measurement results viewing. If the alarm clock signal is not disabled using the buttons, it turns off automatically in 1 minute after activation.

If the dosimeter was off before the alarm clock goes off, the dosimeter enters the clock mode. The dosimeter automatically turns off as soon as the alarm clock signal stops ringing (in 1 min). If the user turns off the alarm clock signal before it stops ringing, the dosimeter remains on.

2.3.3.12 **The mode of data communications control with the PC**

2.3.3.12.1 This mode can be entered from any other operating mode of the dosimeter with the help of a short press of the MODE button. This mode follows the alarm clock mode.

In the mode of data communications control with the PC the dosimeter's LCD displays the following information (Figure 27):

- alarm clock symbol (1) (if the alarm clock is on);
- alarm type symbol (2);
- battery status symbol (3);
- "PC" symbol (4);
- current time (5).

2.3.3.12.2 Press shortly the THRESHOLD button to activate data communications with the PC. The LCD of the dosimeter displays the Bluetooth symbol, the "PC" symbols start blinking and the dosimeter starts establishing the connection with the PC, with which a successful data communications has already been performed. The custom-made software should be then launched on the PC.

Figure 27 – LCD of the dosimeter
(the mode of data communications control with the PC)

If the connection failed to be established or data communications failed to be performed with the PC (for instance, the PC is off, located beyond the reach of the Bluetooth radio channel of the dosimeter, or the custom-made software is not launched on this PC), the dosimeter is searching for the PC with a Bluetooth name starting with the "CHECKPOINT" symbols. If such PC is found, an attempt is made to establish connection and perform data communications with the PC.

In case of a successful connection with the PC and data communications start, the LCD of the dosimeter displays a stripe (1) (Figure 28) "moving" across the instantaneous value indicator.

During the data communications the dosimeter sends to the PC the measured value of photon-ionizing radiation DE and DE accumulation time; the measurement results that have been saved in the nonvolatile memory. During the data communications you can also reset the DE value and DE accumulation time; clear the measurement results saved in the nonvolatile memory; set the dosimeter's clock according to the PC clock.

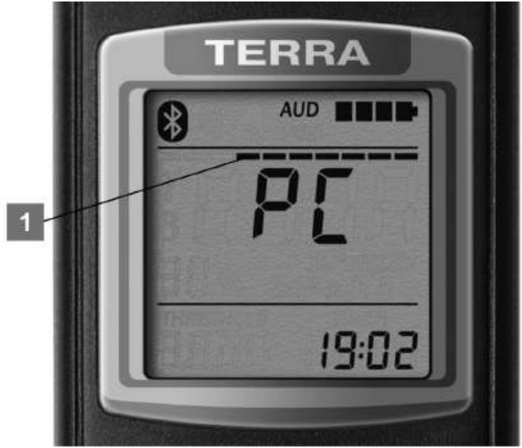

Figure 28 – LCD of the dosimeter
(the mode of data communications control with the PC)

During the data communications the dosimeter can operate in the mode of IDU. The dosimeter sends to the PC:

- current measurement results of photon-ionizing radiation DER or surface beta-particles flux density;
- current value of accumulated photon-ionizing radiation DE, and DE accumulation time;
- current value of supply voltage,

as well as receives the command from the PC to change the measurement modes and to synchronize the time according to the PC clock.

Should errors occur during data communications with the PC, the “Er03”, “Er04”, “Er05”, “Er06” or “Er07” symbols appear on the LCD. A short press of the MODE button returns the dosimeter to the mode of control of data communications with the PC.

Press shortly the MODE button of the dosimeter to stop the process of connection establishment with the PC. The “PC” symbols on the LCD stop blinking at that. If the connection with the PC is established, the data communications with the PC can be stopped only with the help of the controls of the custom-made software „Computer-aided programming and operation logging of the dosimeter” („Cadmium-ECOMONITOR”).

2.3.3.13 **The mode of measurement results viewing stored in the nonvolatile memory**

2.3.3.13.1 If the nonvolatile memory of the dosimeter contains measurement results, this mode can be entered from any other operating mode of the dosimeter with the help of a short press of the MODE button. This mode follows the mode of data communications control with the PC.

In the mode of measurement results viewing stored in the nonvolatile memory the dosimeter’s LCD displays the following information (Figure 29):

- “rEAd” (1) and “Arch” (2) symbols (an indication of this mode);
- alarm clock symbol (3) (if the alarm clock is on);
- alarm type symbol (4);
- battery status symbol (5);
- number of measurement results stored in the nonvolatile memory (6).

Figure 29 – LCD of the dosimeter
(the mode of measurement results viewing stored in the nonvolatile memory)

Press shortly the THRESHOLD button to view the measurement results stored in the nonvolatile memory. The LCD of the dosimeter displays the following information (Figure 30):

- indicator of measurement results location in the nonvolatile memory (1);
- alarm clock symbol (2) (if the alarm clock is on);
- alarm type symbol (3);
- battery status symbol (4);
- measurement result (5);
- measurement object number (6);
- measurement time (7).

During viewing, if the user presses no buttons of the dosimeter, zones (6) and (7) of the LCD alternatively display the measurement object number and the measurement time, or the date and year of measurement.

Figure 30 – LCD of the dosimeter
(measurement results viewing)

The indicator of location (1) shows a place of the measurement result (5) in the nonvolatile memory. The leftmost position of the location indicator corresponds to the start of the nonvolatile memory, i.e. the oldest measurement result (the measurement result that was first saved). The rightmost position corresponds the end of the nonvolatile memory, i.e. the newest measurement result (the measurement result that was last saved). If the nonvolatile memory contains only one measurement result, all ten segments are highlighted on the location indicator.

Shortly press the MODE and the THRESHOLD buttons to manage measurement results viewing. A short press on the MODE button makes it possible to view the next measurement result that has been saved after the measurement result, which is displayed on the LCD now.

A short press on the THRESHOLD button makes it possible to view the previous measurement result that has been saved before the measurement result, which is displayed on the LCD now. The LCD of the dosimeter displays the measurement object number and the time of measurement performance along with each measurement result.

To exit the mode of measurement results viewing stored in the nonvolatile memory, press and hold the THRESHOLD button (circa 6 seconds) until the dosimeter enters the mode of photon-ionizing radiation DER measurement.

To clear the measurement results stored in the nonvolatile memory, simultaneously press and hold the MODE and the THRESHOLD buttons until the “CLr” and the “Arch” symbols appear on the LCD of the dosimeter (Figure 31).

Figure 31 – LCD of the dosimeter
(the submode of measurement results clearing
stored in the nonvolatile memory)

To cancel clearing, shortly press the THRESHOLD button or do not press the buttons during 30 s (the dosimeter will automatically enter the mode of measurement results viewing stored in the nonvolatile memory).

To confirm clearing of the measurement results stored in the nonvolatile memory, shortly press the MODE button. The “CLr” symbols that blink three times on the LCD of the dosimeter, and return of the dosimeter to the mode of photon-ionizing radiation DER measurement mean that the values have been cleared.

Caution! If the submode of clearing of measurement results stored in the nonvolatile memory is paused for more than 30 s (the user presses no buttons of the dosimeter), the dosimeter will automatically return to the mode of measurement results viewing without measurement results clearing.

3 TECHNICAL MAINTENANCE

3.1 Technical maintenance of the dosimeter

3.1.1 **General instructions**

The list of operations performed during technical maintenance (hereinafter called TM) of the dosimeter, the order and the peculiarities of operational phases are presented in Table 3.1.

Table 3.1 – List of operations during technical maintenance

Operations	TM type			OM item No.
	during		During long-term storage	
	everyday use	periodical use (annually)		
External examination	+	+	+	3.1.3.1
Delivery kit completeness check	-	+	+	3.1.3.2
Operability check	+	+	+	3.1.3.3
Batteries switching off and their status control	-	-	+	3.1.3.4
Verification of the dosimeter	-	+	+	3.2

Note. "+" means the operation is applicable for this type of TM; "-" means the operation is not applicable.

3.1.2 **Safety measures**

TM safety measures fully comply with safety measures stated in item 2.3.1 of the present OM.

3.1.3 **Maintenance procedure of the dosimeter**

3.1.3.1 External examination

External examination of the dosimeter should be performed in the following order:

a) check the technical condition of surface, inspect for integrity of seals, absence of scratches, traces of corrosion, surface damage of the dosimeter;

b) check the condition of clamps in the battery compartment.

3.1.3.2 Delivery kit completeness check

Check if the delivery kit is complete according to Table 1.2.

3.1.3.3 Operability check of the dosimeter

3.1.3.3.1 Operability check of the dosimeter is performed according to item 2.2.3 of the present OM.

3.1.3.3.2 Order of pre-repair fault detection and rejection

Use the following criteria to evaluate the necessity of sending the dosimeter for repair and the type of repair:

- for mid-life repair:

a) deviation of parameters from reference values during the periodical verification of the dosimeter;

b) minor defects of the LCD that do not affect the correct readings of measurement results;

c) no scale backlight;

d) no audio alarm;

- for major repair:

a) at least one non-operating measurement channel;

b) defects of the LCD that affect the correct readings of measurement results;

c) serious mechanical damages of the component parts that affect the security access to the dosimeter circuit.

3.1.3.4 Batteries switching off and their status control

The batteries should be switched off each time before the long-term storage of the dosimeter. Do this as follows:

- switch the dosimeter off;
- open the lid of the battery compartment;
- remove the batteries;
- examine the battery compartment, check the contact clamps accuracy, clean the battery compartment from contamination and contact clamps from oxides;
- make sure there is no humidity, no salt spots on the surface of the batteries, and no damages of the insulated coating.

3.2 Verification of the dosimeter

The dosimeters should be verified after manufacture, repair or during use (periodically, at least once a year).

3.2.1 **Verification operations**

During verification, the operations presented in Table 3.2 should be performed.

Table 3.2 – Verification operations

Operation name	Verification technique No.
External examination	3.2.4.1
Testing	3.2.4.2
Calculation of main relative error of photon-ionizing radiation DER measurement	3.2.4.3
Calculation of main relative error of photon-ionizing radiation DE measurement	3.2.4.4
Calculation of main relative error of beta particles flux density measurement	3.2.4.5

3.2.2 **Verification facilities**

The following measuring instruments and equipment should be used for verification:

- УПГД-3В testing equipment with standard ^{137}Cs gamma radiation sources;
- standard sources of 4CO type on a hard pad, containing ^{90}Sr + ^{90}Y radionuclides;

- low-active gamma radiation source ^{137}Cs;
- standard stop-watch.

All verification facilities should obtain valid Verification Certificates or State Metrological Certification.

Note. Use of other standard measuring equipment with the accuracy prescribed in 3.2.2 is allowed.

3.2.3 **Verification conditions**

Verification should be performed in compliance with the following conditions:

- ambient air temperature range within (20±5) °C;
- relative air humidity from 30 to 80 %;
- atmospheric pressure from 86 kPa to 106.7 kPa;
- natural background level of gamma radiation should not exceed 0.30 μSv/h;
- power supply voltage within (3.0± 0.2) V.

3.2.4 **Verification procedure**

3.2.4.1 **External examination**

During external examination the dosimeter should meet the following requirements:

- the delivery kit should be completed as stated in item 1.3.1 of the present OM;
- labeling should be accurate;
- Quality Control Department seals should not be violated;
- the dosimeter should be free from mechanical damage that may affect its performance.

Note. The delivery kit completeness is checked only at manufacture.

3.2.4.2 **Testing**

Switch on the dosimeter and program zero values of audio alarm threshold levels of each measuring channel. Afterwards switch on the mode of photon-ionizing radiation DER measurement and place the dosimeter near the low-active ^{137}Cs gamma radiation source. Observe an increase of DER readings on the LCD upon the background level and audio signaling at registration of gamma-quanta by the detector.

3.2.4.3 **Calculation of main relative error of photon-ionizing radiation DER measurement**

Prepare the УПГД-3В testing equipment for operation according to its operating manual.

Prepare the dosimeter for photon-ionizing radiation DER measurement (hereinafter called DER) and program 5 % value of the specified statistical error according to item 2.3.3.7 of the OM.

Fix the dosimeter in the УПГД-3В carriage holder so that the mechanical center of gamma beam coincides with the center of the detector, and wait until the statistical error of external background DER measurement results goes down to the value of not more than 15 %. Then register five measurement results of external background DER in the protocol with 5 s interval.

Place the УПГД-3В carriage together with the dosimeter in the position, where DER from ^{137}Cs source is 0.8 μSv/h, and wait until the statistical error of DER measurement results goes down to the value of not more than 10 %. Then register five DER measurement results in the protocol with 5 s interval.

Calculate the DER value $\overline{\dot{H}^*}(10)$, in µSv/h by the formula:

$$\overline{\dot{H}^*}(10) = \overline{\dot{H}^*_{\Sigma}}(10) - \overline{\dot{H}^*_{\Phi}}(10), \qquad (1)$$

where $\overline{\dot{H}^*_{\Sigma}}(10)$ - is an average value of the dosimeter readings of source and external gamma background in µSv/h;

$\overline{\dot{H}^*_{\Phi}}(10)$ - is an average value of the dosimeter readings during external gamma background measurement in µSv/h.

Calculate the main relative error of measurement in percentage.

Place the УПГД-3В carriage together with the dosimeter in the position, where DER from ^{137}Cs source is 8.0 µSv/h, and wait until the statistical error of DER measurement results goes down to the value of not more than 10 %. Then register five DER measurement results in the protocol with 5 s interval.

Calculate the DER value in µSv/h by the formula (1).

Calculate the main relative error of measurement in percentage.

Place the УПГД-3В carriage together with the dosimeter in the position, where DER from ^{137}Cs source is 80.0 μSv/h, and wait until the statistical error of DER measurement results goes down to the value of not more than 10 %. Then register five DER measurement results in the protocol with 5 s interval.

Calculate the DER value in μSv/h by the formula (1).

Calculate the main relative error of measurement in percentage.

Place the УПГД-3В carriage together with the dosimeter in the position, where DER from ^{137}Cs source is 800 μSv/h, and wait until the statistical error of DER measurement results goes down to the value of not more than 10 %. Then register five DER measurement results in the protocol with 5 s interval.

Calculate the average DER value and the main relative error of measurement in percentage.

Place the УПГД-3В carriage together with the dosimeter in the position, where DER from ^{137}Cs source is 8000 μSv/h, and wait until the statistical error of DER measurement results goes down to the value of not more than 10 %. Then register five DER measurement results in the protocol with 5 s interval.

Calculate the average DER value and the main relative error of measurement in percentage.

The dosimeter is acknowledged to have passed the verification if the main relative error in percentage during measurement of each DER level does not exceed $15+\frac{2}{\dot{H}^*(10)}$, where $\dot{H}^*(10)$ is a numeric value of the measured DER in μSv/h.

3.2.4.4 **Calculation of main relative error of photon-ionizing radiation DE measurement**

Prepare the dosimeter for photon-ionizing radiation DE measurement according to item 2.3.3.8 of the OM.

Prepare the УПГД-3В testing equipment for operation according to its operating manual.

Fix the dosimeter in the УПГД-3В carriage holder so that the mechanical center of gamma beam coincides with the center of the detector.

Place the УПГД-3В carriage together with the dosimeter in the position, where DER from ^{137}Cs source is 80 μSv/h.

Record the initial DE value and simultaneously switch on the stop-watch.

Read the DE measurement result after 60 minutes (according to the stop-watch) of irradiation, subtract the DE initial value, calculate the main relative error of measurement in percentage, and register these values in the protocol.

Place the УПГД-3В carriage together with the dosimeter in the position, where DER from ^{137}Cs source is 800 μSv/h.

Record the initial DE value and simultaneously switch on the stop-watch. Read the DE measurement result after 30 minutes (according to the stop-watch) of irradiation, subtract the DE initial value, calculate the main relative error of measurement in percentage, and register these values in the protocol.

Place the УПГД-3В carriage together with the dosimeter in the position, where DER from ^{137}Cs source is 8000 μSv/h.

Record the initial DE value and simultaneously switch on the stop-watch.

Read the DE measurement result after 10 minutes (according to the stop-watch) of irradiation, subtract the DE initial value, calculate the main relative error of measurement in percentage, and register these values in the protocol.

The dosimeter is acknowledged to have passed the verification if the main relative error during DE measurement does not exceed ±15 %.

3.2.4.5 **Calculation of main relative error of surface beta-particles flux density measurement**

Prepare the dosimeter for photon-ionizing radiation DER measurement and program 5 % value of the specified statistical error according to item 2.3.3.7 of the OM.

Wait until the statistical error of external background DER measurement results goes down to the value of not more than 15 %.

Then switch the dosimeter to the mode of surface beta-particles flux density measurement, and set 10 % value of the specified statistical error according to item 2.3.3.9 of the OM.

Place the dosimeter with the open window above the 4CO source surface, providing surface beta-particles flux density from 50 to 150 part./(cm^2·min), so that the work surface of the detector is placed completely over the active surface of the source.

Wait until the statistical error of surface beta-particles flux density measurement results goes down to the value of not more than 15 %.

Then register five measurement results with 5 s interval, calculate the average value of surface beta-particles flux density and the main relative error of measurement.

Place the dosimeter with the open window above the 4CO source surface, providing surface beta-particles flux density from 1000 to 10000 part./(cm^2·min), so that the work surface of the detector is placed completely over the active surface of the source.

Wait until the statistical error of surface beta-particles flux density measurement results goes down to the value of not more than 10 %. Then register five measurement results in the protocol with 5 s interval.

Calculate the average value of surface beta-particles flux density and the main relative error of measurement.

Place the dosimeter with the open window above the 4CO source surface, providing surface beta-particles flux density from 50000 to 100000 part./(cm^2·min), so that the work surface of the detector is placed completely over the active surface of the source.

Wait until the statistical error of surface beta-particles flux density measurement results goes down to the value of not more than 10 %. Then register five measurement results in the protocol with 5 s interval.

Calculate the average value of surface beta-particles flux density and the main relative error of measurement.

The dosimeter is acknowledged to have passed the verification if the main relative error in percentage during measurement of each surface beta-particles flux density level does not exceed $20+\frac{200}{\phi_\beta}$, where φ_β is a numeric value of the measured surface beta-particles flux density in part./(cm^2·min).

3.2.4.6 **Presentation of verification results**

3.2.4.6.1 Positive results of primary or periodic verification are registered as follows:

1) primary verification is registered in the “CERTIFICATE OF ACCEPTANCE” section;

2) periodic verification is registered in the issued Certificate of the established form, or in the table of the Appendix F of the OM.

Primary verification results are registered in Table 3.3.

Table 3.3 – Primary verification of main specifications

Tested specification		Actual value
Name	Standardized values according to technical specifications	
Main relative error at measurement of photon-ionizing radiation DER, with confidence probability of 0.95, %	$\delta\dot{H}^*(10) = 15 + \frac{2}{\dot{H}^*(10)}$, where $\dot{H}^*(10)$ is a numeric value of the measured DER in μSv/h	
Main relative error at measurement of photon-ionizing radiation DE, with confidence probability of 0.95, %	±15	

Table 3.3 (continued)

Tested specification		Actual value
Name	Standardized values according to technical specifications	
Main relative error at measurement of beta particles flux density, with confidence probability of 0.95, %	$\delta\varphi_\beta = 20 + \frac{200}{\varphi_\beta}$, where φ_β is a numeric value of the measured surface beta-particles flux density in part./(cm^2·min)	

3.2.4.6.2 The dosimeters that do not meet the requirements of the verification technique are not allowed for manufacture and use, and get the Certificate of Inadequacy.

4 CERTIFICATE OF ACCEPTANCE

The MKS-05 "TERRA" dosimeter-radiometer of ВІСТ.412129.006-09 type with ________________________ serial number meets the ТУ У 33.2-22362867-006-2001 ВІСТ.412129.006 ТУ technical requirements, is verified and accepted for use.

Date of issue ________________________

Stamp here QCD representative: _______________
(signature)

Verification Mark here State Verification Officer: __________
(signature)

5 PACKING CERTIFICATE

The MKS-05 “TERRA” dosimeter-radiometer of BICT.412129.006-09 type with ________________________ serial number is packed by the Private Enterprise “SPPE “Sparing-Vist Center” in accordance with the requirements specified in ТУ У 33.2-22362867-006-2001 BICT.412129.006 ТУ.

Date of packing ________________________

Stamp here

Packed by: __________________
(signature)

Packed product accepted by: ______________
(signature)

6 WARRANTY

6.1 The manufacturer guarantees the conformity of the dosimeter to the technical requirements provided that the customer observes the guidelines for its use, shipping and storage presented in the operating manual BICT.412129.006-09 HE.

6.2 The warranty period of the dosimeter use shall terminate and be of no further effect in 24 months after the date of putting it into operation or after the warranty period of storage terminates.

6.3 The warranty period of storage of the dosimeter is 6 months after its manufacture date.

6.4 Free of charge repair or replacement during the warranty period of use is performed by the producer enterprise provided that the customer observes the guidelines for its use, shipping and storage.

6.5 If the defect (according to the claim) is eliminated, the warranty period is prolonged for the time when the dosimeter was not used because of the detected defects.

6.6 The batteries failure is not a reason for claim after their warranty period is finished.

7 REPAIR

7.1 In case of failure or troubles during the warranty period of the dosimeter, the user should contact the producer enterprise by e-mail (see below) to receive the address of the nearest service center:

PE "SPPE "Sparing-Vist Center"
Tel.: (+380 32) 242-15-15; Fax: (+380 32) 242-20-15;
E-mail: sales@ecotest.ua.

7.2 All claims are registered in Table 7.1.

Table 7.1

Date of failure	Claim summary	Action taken	Note

7.3 Information about repair of the dosimeter is recorded in the table of Appendix G of this OM.

8 STORAGE

8.1 The dosimeters should be stored in a packing box in heated and ventilated storehouses with air-conditioning at the ambient temperature from + 5 to + 40 °C and relative humidity up to 80 % at + 25 °C temperature, non-condensing. The storehouse should be free of acids, gas, vapors of organic solvents, and alkali that may cause corrosion.

8.2 The location of the devices in storehouses should ensure their free movement and access to them.

8.3 The dosimeters should be stored on the shelves.

8.4 The distance between the walls, the floor and the devices should not be less than 100 mm.

8.5 The distance between the heating gadgets of the storehouse and the devices should not be less than 0.5 m.

8.6 The average shelf life is not less than 6 years.

8.7 Additional information on storage, check during storage and maintenance of the dosimeter is recorded in Appendices C, D, and H of this OM.

9 SHIPPING

9.1 Packed dosimeters may be shipped by any kinds of closed transport vehicles under the conditions with temperature limitation in the range of - 25 to + 55 ^{o}C, and according to rules and standards effective for each means of transport.

9.2 The dosimeters in shipping container should be placed and fixed in the vehicle to ensure their stable position and to avoid shocks (with each other and the sidewalls of the transport).

9.3 The dosimeters in shipping container endure:

- temperature from - 25 to + 55 ^{o}C;

- relative humidity (95±3) % at + 35 ^{o}C temperature;

- shocks with acceleration of 98 m/s^2, a shock pulse duration of 16 ms (number of shocks - 1000 ± 10 in each direction).

9.4 Canting is forbidden.

10 DISPOSAL

Disposal of the dosimeter is performed in compliance with the general rules, i.e. metals are recycled or melted, and plastic parts are dumped.

Disposal of the dosimeter is not dangerous for service personnel, and is environmentally friendly.

APPENDIX A

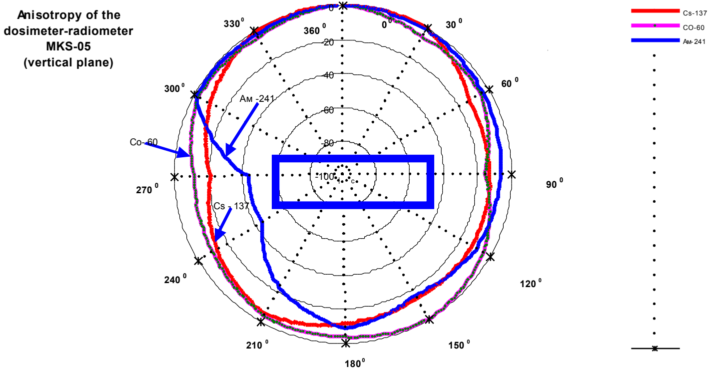

Figure A. 1

APPENDIX A

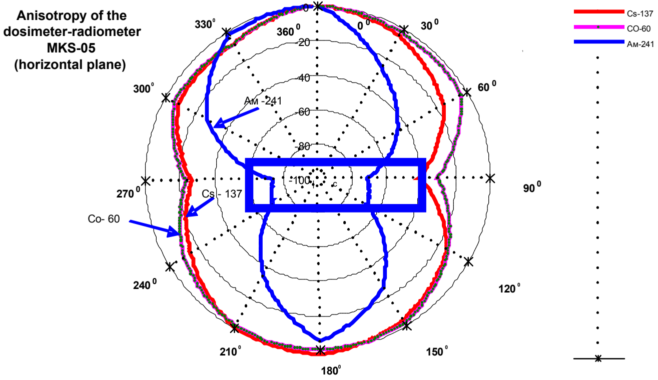

Figure A.2

APPENDIX B

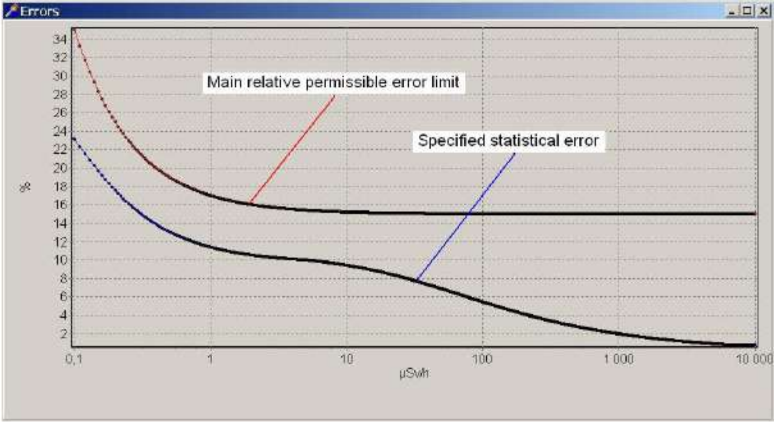

Figure B.1 – Plot of specified statistical error versus photon-ionizing radiation DER

APPENDIX B

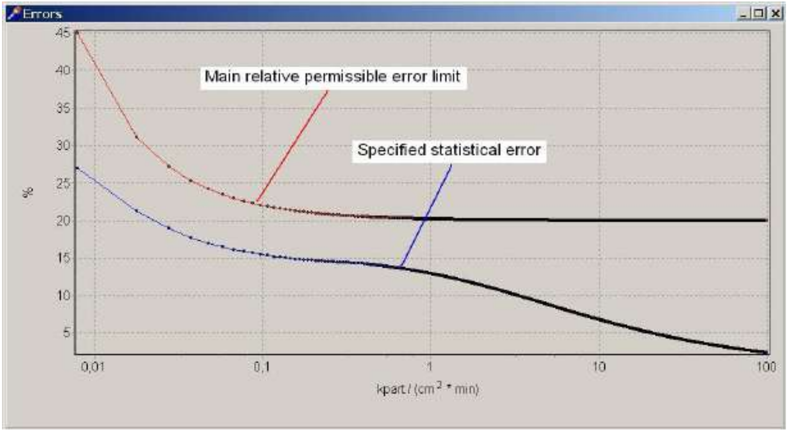

Figure B.2 – Plot of specified statistical error versus surface beta-particles flux density

APPENDIX C

PUTTING IN PROLOGED STORAGE AND REMOVAL FROM STORAGE

Date of putting in prolonged storage	Storage method	Date of removal from prolonged storage	Name of the enterprise in charge of putting or removing from prolonged storage	Date, position and signature of the responsible person

APPENDIX D

STORAGE

Date		Storage conditions	Position, name and signature of the responsible person
of placing in storage	of removing from storage		

APPENDIX E
TROUBLE RECORD DURING USE

Date and time of failure. Operating mode	Type (manifestation) of trouble	Cause of trouble, number of operation hours of the failed element	Action taken and claim note	Position, name and signature of the person responsible for solving the problem	Note

APPENDIX F

PERIODIC VERIFICATION OF KEY SPECIFICATIONS

<table>
<tr><th colspan="2">Tested specification</th><th colspan="4">Date of measurement</th></tr>
<tr><th rowspan="2">Name</th><th rowspan="2">Value according to technical specifications</th><th colspan="2">year 20</th><th colspan="2">year 20</th></tr>
<tr><th>Actual value</th><th>Measured by (position, signature)</th><th>Actual value</th><th>Measured by (position, signature)</th></tr>
<tr><td>1 Main relative error of the dosimeter at photon-ionizing radiation DER measurement with confidence probability of 0.95, %</td><td>$15+\frac{2}{\dot{H}^{*}(10)}$, where $\dot{H}^{*}(10)$ is the measured DER value, μSv/h</td><td></td><td></td><td></td><td></td></tr>
</table>

APPENDIX F

F-1

<table>
<tr><td colspan="6">Date of measurement</td></tr>
<tr><td colspan="2">year 20</td><td colspan="2">year 20</td><td colspan="2">year 20</td></tr>
<tr><td>Actual value</td><td>Measured by (position, signature)</td><td>Actual value</td><td>Measured by (position, signature)</td><td>Actual value</td><td>Measured by (position, signature)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

APPENDIX F

Tested specification		Date of measurement			
Name	Value according to technical specifications	year 20		year 20	
		Actual value	Measured by (position, signature)	Actual value	Measured by (position, signature)
2 Main relative error of the dosimeter at photon-ionizing radiation DE measurement with confidence probability of 0.95, %	±15				

APPENDIX F

F-2

Date of measurement					
year 20		year 20		year 20	
Actual value	Measured by (position, signature)	Actual value	Measured by (position, signature)	Actual value	Measured by (position, signature)

APPENDIX F

Tested specification		Date of measurement			
		year 20		year 20	
Name	Value according to technical specifications	Actual value	Measured by (position, signature)	Actual value	Measured by (position, signature)
3. Main relative error at surface beta-particles flux density measurement with confidence probability of 0.95, %	$20+\frac{200}{\phi_\beta}$, where φ_β is a numeric value of the measured beta-particles flux density, part./(cm^2·min)				

APPENDIX F

F-3

Date of measurement					
year 20		year 20		year 20	
Actual value	Measured by (position, signature)	Actual value	Measured by (position, signature)	Actual value	Measured by (position, signature)

APPENDIX G

REPAIR

Name and type of the component part of the device	Reason for repair	Date		Name of the repair organiza-tion	Number of operation hours before repair
		of arriving for repair	of repair completion		

APPENDIX G

<table>
<tr><th colspan="4">REPAIR</th></tr>
<tr><th rowspan="2">Type of repair (mid-life, major, etc.)</th><th rowspan="2">Name of repair</th><th colspan="2">Position, name and signature of the responsible person</th></tr>
<tr><th>who performed repair</th><th>who accepted after repair</th></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

APPENDIX H

VERIFICATION AND INSPECTION RESULTS

Date	Verification or inspection type	Verification or inspection result	Position, name and signature of the person responsible for inspection	Note