RKS-01 “STORA-TU”
GAMMA, BETA RADIOMETER-DOSIMETER

Operating manual

CONTENTS

This operating manual (hereinafter referred to as the OM) is intended to inform the user about the principles of operation and rules of application of the RKS 01 “STORA-TU” gamma, beta radiometer-dosimeter. The manual contains all information necessary for proper use of the radiometer and full realization of its technical possibilities

The manual contains the following abbreviations and symbols:

DER - ambient dose equivalent rate.

1 DESCRIPTION AND OPERATION

1.1 Purpose of use

The RKS-01 “STORA-TU” gamma, beta radiometer-dosimeter (hereinafter referred to as the radiometer) is designed to measure ambient dose equivalent rate (DER) of gamma and X-ray radiation (hereinafter called photon-ionizing radiation), and surface beta-particles flux density.

The radiometer 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 – 999.9
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

Table 1.1 (continued)

Name	Unit of measurement	Standardized values according to technical specifications
3 Energy range of registered photon-ionizing radiation	MeV	0.05 – 3.00
4 Energy dependence of the radiometer readings at photon-ionizing radiation DER measurement in the energy range of 0.05 to 3.00 MeV	%	from - 25 to +40
5 Anisotropy of the radiometer at gamma quantum incidence at solid angle of 30º to 150º 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	%	 ±25 ±60

Table 1.1 (continued)

Name	Unit of measurement	Standardized values according to technical specifications
6 Measurement range of surface beta-particles flux density	part./(cm^2·min)	5 - 10^5
7 Main relative permissible error limit of 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 surface beta-particles flux density in part./(cm^2·min)

Table 1.1 (continued)

Name	Unit of measure-ment	Standardized values according to technical specifications
8 Energy range of registered beta-particles	MeV	0.5 – 3.0
9 Time of the radiometer operating mode setting, not more than	s	10
10 Battery life (two AAA batteries of 1200 mA·h capacity) under + 20 ºC temperature, natural background radiation and switched off audio signaling of registered gamma quanta and no display backlight, not more than	h	1500
11 Unstable readings of the radiometer for 6 hours of continuous operation, not more than	%	5

Table 1.1 (continued)

Name	Unit of measurement	Standardized values according to technical specifications
12 Operating supply voltage of the radiometer from two AAA batteries	V	3.0
13 Additional permissible error limit at measurement of photon-ionizing radiation DER and surface beta-particles flux density in the supply voltage range of 3.2 to 2.4 V	%	±5
14 Additional permissible error limit at measurement of photon-ionizing radiation DER and surface beta-particles flux density in the ambient air temperature range of – 20 to + 50°C	%, per each 1 °C deviation from 20 °C	±0.5

Table 1.1 (continued)

Name	Unit of measure ment	Standardized values according to technical specifications
15 Average operating life of the radiometer till the first major repair, not less than	h	10000
16 Average service life of the radiometer, not less than	year	6
17 Mean time to failure, not less than	h	6000
18 Dimensions, not more than	mm	160×75×36
19 Weight of the radiometer, not more than	kg	0.5
20 Weight in package, not more than	kg	0.8 (with tube – 1.1)

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

1.2.3 The radiometer 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 radiometer depending on the radiation intensity.

1.2.4 For fast of photon-ionizing radiation DER and surface beta-particles flux density the radiometer provides a twelve-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 two independent threshold levels is realized in the radiometer:

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

1.2.5.1 Threshold level values of photon-ionizing radiation DER are programmed in the range of 0 to 999,9 μSv/h with discreteness of 0.01 μSv/h.

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

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

1.2.6 The radiometer provides light and audio alarm about the programmed threshold levels exceeding: a two-tone audio signal and a blinking red LED “ALARM”.

1.2.6.1 The radiometer also provides visual alarm of the exceeded threshold levels in the form of a measurement result that blinks on the LCD, and periodic and gradual highlighting (from left to right) of the sound symbol segments (4) according to Figure 3.

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

1.2.8 The radiometer 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 radiometer’s clock, while the object number is entered by the user during saving.

1.2.9 The radiometer 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 radiometer (hereinafter called the LCD).

1.2.10 The radiometer 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 radiometer has the mode of alarm clock.

1.2.12 The radiometer provides the possibility to work in the mode of intelligent detecting unit (hereinafter called the IDU). In this mode the radiometer 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 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 radiometer provides indication of low battery status.

1.2.14 The radiometer performs measurements under the following conditions:
- temperature from – 20 to + 50 °C;
- relative humidity up to (95±3) % at + 35 °C temperature;
- atmospheric pressure from 84 to 106.7 kPa.

1.2.15 The radiometer 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 °C and relative humidity up to (95±3) % at + 35 °C;
- photon-ionizing radiation with exposure dose rate that corresponds to ambient DER up to 0.1 Sv/h during 5 minutes.

1.3 Delivery kit

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

Table 1.2 - Delivery kit of the radiometer

Type	Item	Quantity	Note
BICT.412129.015-02.02	RKS-01 “STORA-TU” gamma, beta radiometer-dosimeter		Bluetooth radio channel included
BICT.412129.015-02.02 HE	Operating manual	1 copy	
BICT.412915.002-02	Package	1 pc.	
ENERGIZER	Battery of AAA 1,5 V type	2 pcs.	Analogs permitted

Table 1.2 (continued)

Type	Item	Quantity	Note
BICT.323382.002-02	Packing bag	1 pc.	
BICT.304592.004	Telescopic tube	1 pc.	Supplied in a separate order
BICT.301524.005	Holder	1 pc.	
BICT.758156.004	Screw	2 pcs.	
	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 radiometer**

The radiometer (according to Figure 1) is designed as a rectangular parallelepiped rounded on each side. The plastic damp and dustproof body of the radiometer (ingress protection rating IP54) consists of two parts – upper (1) and lower (2) covers. The LCD (3), “ALARM” light-emitting diode (4) and two key of control MODE (5) and THRESHOLD (6) are located on the panel of the upper cover. The printed-circuit board with the electric circuit of the device is screwed with four screws to the upper cover of the radiometer. All inscriptions of the upper cover are serigraphy applied.

Figure 1 - External view of the radiometer (top view)

The lower cover (2) of the body (Figure 2) contains the battery compartment (7) with two batteries and the detector of gamma and beta radiation (9), which consists of four Geiger-Muller counters СБМ-20-1. The counters are fixed to the lower cover and closed from the inside of the body with the metal energy compensated screen, fixed with two screws. From the outside the detector is closed with a transparent for beta particles polyethylene theraphthalate film and a metal beta-filter cover (10) fixed with an original screw. Beta-filter cover is removed when beta-particles flux density is measured.

The battery compartment is closed with a cover (8), fixed with the original screw. The polarity signs are indicated at the bottom of the battery compartment for proper insertion of batteries.

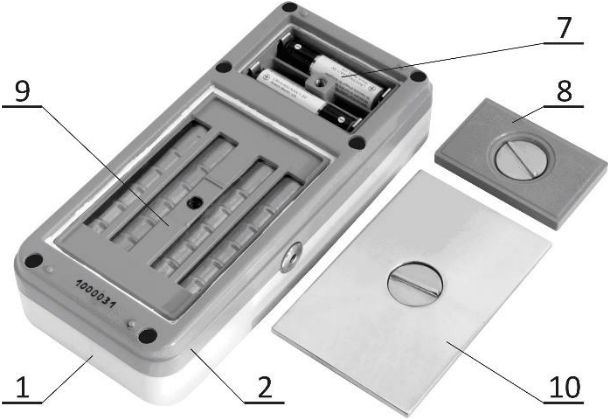

Figure 2 - External view of the radiometer (bottom view)

1.4.2 **Basic operation of the radiometer**

The radiometer 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;
- real time measurement;

- operating modes control;
- measurement results indication.

The Bluetooth radio channel module ensures interaction of the radiometer 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 radiometer is inscribed with the trademark, the name and the symbol of the device, the ingress protection rating of the radiometer, and the pattern approval mark of measuring instruments.

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

1.5.3 Sealing is performed by the producer enterprise. The device is sealed with mastic in the recesses of the lower cover or with special film seal on the side surfaces of the device at the junctions of the upper and the lower covers.

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

1.6 Packing

1.6.1 The radiometer kit (the device, accessories, and the operating manual) is delivered in the cardboard box.

1.6.2 The packing box with the radiometer’s kit is placed in a plastic sachet, which is welded after packing performed.

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 ºC
2 Relative humidity	up to 95 % at + 35 ºC temperature, non-condensing
3 Photon-ionizing radiation influence	DER up to 0.1 Sv/h during 5 min

2.2 Preparation of the radiometer for operation

2.2.1 Scope and order of external examination

2.2.1.1 Before using the radiometer, 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 radiometer 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 radiometer. 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 radiometer

2.2.3.1 Press shortly the MODE button to switch the radiometer on. The radiometer sends a short audio signal. The radiometer 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 radiometer 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 radiometer is operating in this mode.

2.2.3.3 Press and hold (circa 6 seconds) the MODE button until the radiometer 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 D 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 radiometer should be sent for repair to the manufacturer.

Table 2.2 – Possible troubles and troubleshooting

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

Table 2.2 (continued)

Trouble	Probable cause	Troubleshooting
"Er01" message on the LCD of the radiometer	Gamma and beta radiation detector is out of order	Send the radiometer for repair to the manufacturer
No connection between the radiometer and the PC, which is testified by the messages "Er03", "Er04", "Er05", "Er06" or "Er07" on the LCD of the radiometer	1 The distance between the radiometer 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 radiometer 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 radiometer

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

2.3.1.1 The radiometer 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 IP54.

2.3.1.4 The radiometer belongs to fire safety equipment.

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

2.3.1.6 Disposal of the radiometer 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 and submodes of the radiometer**

2.3.2.1 **Operating modes of the radiometer**

The radiometer operates within the following modes:

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

2.3.2.2 **Operating submodes of the radiometer**

Every operating mode of the radiometer 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 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 radiometer**

2.3.3.1 **Radiometer's buttons**

The MODE (5) and the THRESHOLD (6) buttons are used to operate the radiometer (Figure 1).

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

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

2.3.3.2 **Switching the radiometer on/off**

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

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

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

The radiometer's operation is controlled in the following way.

After the radiometer 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 radiometer 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 radiometer is switched on);
- 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 radiometer 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 radiometer is in the mode of measurement results viewing, you switch the radiometer 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 radiometer 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 radiometer changes the submodes of this operating mode. A detailed description of each operating mode of the radiometer with its submodes is given below.

2.3.3.4 **LCD backlight control**

Each press of any button of the radiometer activates the LCD backlight for circa 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.

2.3.3.5 **Batteries status control**

Irrespective of the chosen operating mode, the radiometer 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 signals. This means that the batteries should be replaced.

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

The mode of photon-ionizing radiation DER measurement is entered automatically after the radiometer 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 radiometer with its gamma and beta detector (9) (Figure 2) towards an examined object. The beta-filter cover (10) should cover the detector.

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

- statistical error (1) of the measurement result (7);
- "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);
- battery status symbol (6);
- measurement result (7);
- dimension of measurement result (8);
- current time (9);
- threshold level of alarm actuation (10).

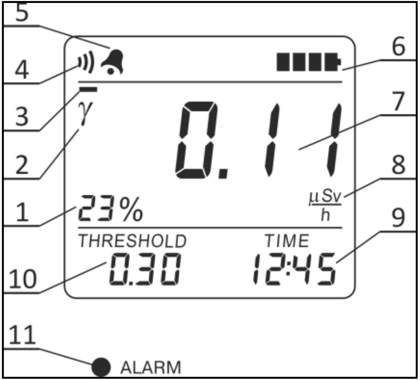

Figure 3 – LCD of the radiometer
(the mode of photon-ionizing radiation DER measurement)

As soon as the measurement is started the measurement results of photon-ionizing radiation DER (7) 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 (10), the radiometer sends a two-tone audio signal and starts blinking with the red LED "ALARM" (11). Measurement results start blinking on the LCD of the radiometer. 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 twelve-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 gamma and beta detector. 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 3100 pulse/s pulse count rate from the gamma and beta detector. DER is about 400 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 signal.

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 radiometer 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 radiometer can automatically determine the specified statistical error depending on the radiation intensity (Appendix A). 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 radiometer determined the specified statistical error automatically depending on the radiation intensity.

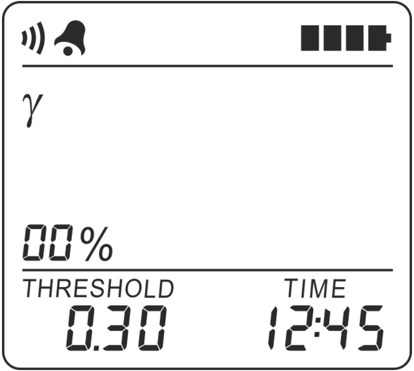

Figure 4 – LCD of the radiometer
(viewing the value of specified statistical error)

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.

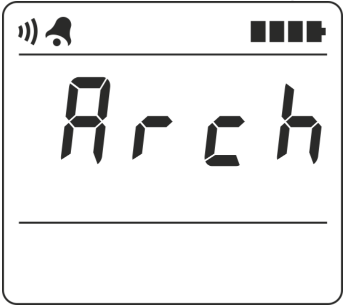

Figure 5 – LCD of the radiometer (start of the submode of measurement result saving in the nonvolatile memory)

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).

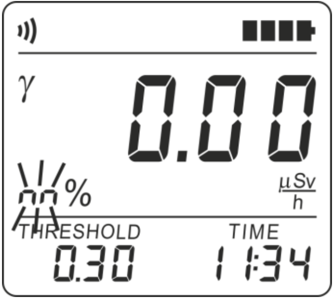

Figure 6 – LCD of the radiometer (measurement restart)

If you keep holding the THRESHOLD button, then during the next two seconds the radiometer 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.

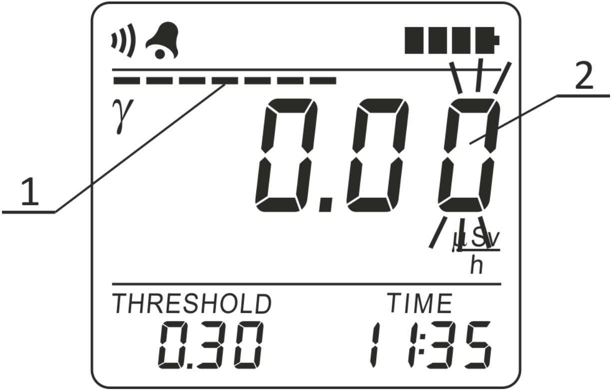

Figure 7 – LCD of the radiometer
(the submode of alarm threshold level programming)

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 radiometer 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 radiometer depending on the radiation intensity.

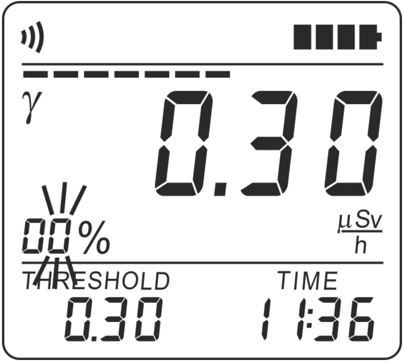

Figure 8 – LCD of the radiometer
(the submode of alarm threshold level programming:
specified statistical error programming)

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 radiometer (Figure 9). Thus it becomes possible to switch on/off audio 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.

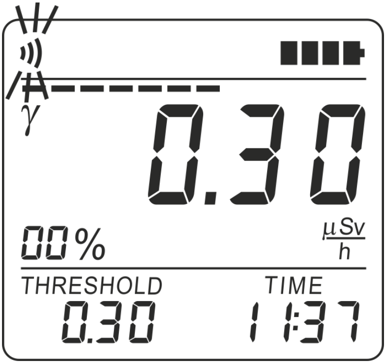

Figure 9 – LCD of the radiometer
(the submode of alarm threshold level programming: switching on/off audio signaling of every registered gamma quantum)

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 radiometer. 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 radiometer 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 radiometer), the radiometer 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 radiometer automatically returns to the mode of photon-ionizing radiation DER measurement.

If the “FULL” symbols are displayed on the LCD of the radiometer instead of the “Arch” symbols (Figure 10), there is no free space in the nonvolatile memory of the radiometer, and, correspondingly, the next measurement results cannot be saved.

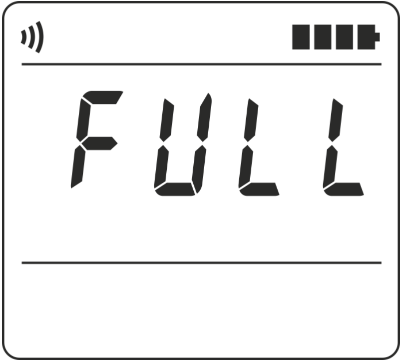

Figure 10 – LCD of the radiometer
(start of the submode of measurement result saving – no free space in the nonvolatile memory)

To clear the space in the nonvolatile memory, delete its saved measurement results. Measurement results can be cleared during data communications with the PC (2.3.3.10) or in the viewing mode (2.3.3.11).

The “Arch” symbols (2) on the LCD of the radiometer are an indication of the submode of measurement result saving (Figure 11). 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.

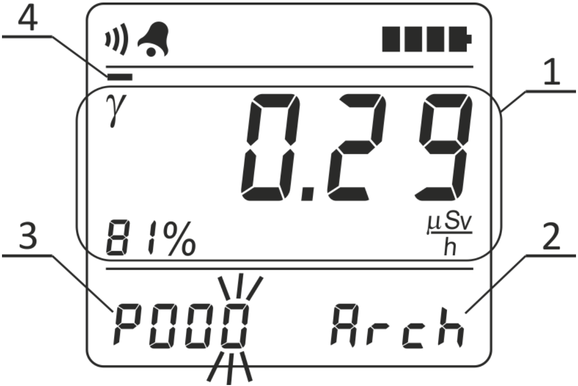

Figure 11 – LCD of the radiometer
(the submode of measurement result saving of photon-ionizing radiation DER)

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 radiometer, 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 radiometer), the radiometer will automatically return to the mode of photon-ionizing radiation DER measurement without saving the measurement result.

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

This mode can be entered from any other operating mode of the radiometer with the help of a short press of the MODE button. This mode follows the mode of photon-ionizing radiation DER measurement.

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 radiometer in the mode of DER measurement (beta-filter cover covers the detector of gamma and beta radiation) 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. This will store the measured value of gamma background DER and switch the radiometer from photon-ionizing radiation DER measurement mode to surface beta-particles flux density measurement mode.

To measure surface beta-particles flux density, remove the beta-filter cover from the detector of gamma and beta radiation, direct the radiometer with the detector in parallel to the examined surface and place it as close as possible.

In the mode of surface beta-particles flux density measurement the radiometer's LCD displays the following information (Figure 12):

- statistical error (1) of the measurement result (7);
- "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);
- battery status symbol (6);
- measurement result (7);
- dimension of measurement result (8);
- current time (9);
- threshold level of alarm actuation (10).

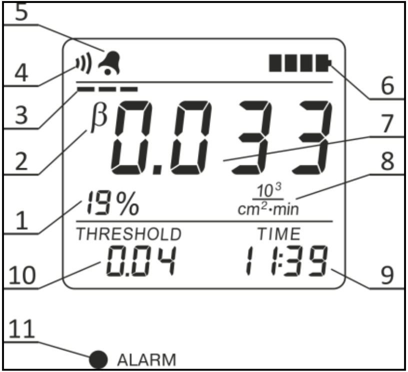

Figure 12 – LCD of the radiometer
(the mode of surface beta-particles flux density measurement)

As soon as the measurement is started the surface beta-particles flux density measurement results (7) 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 (10), the radiometer sends a two-tone audio signal and starts blinking with the “ALARM” LED (11). Measurement results start blinking on the LCD of the radiometer. 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 twelve-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 gamma and beta radiation detector. 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 3400 pulse/s pulse rate from the gamma and beta radiation detector. Beta-particles flux density is about $40 \cdot 10^3$ part./($cm^2 \cdot$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 signal.

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 radiometer 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 will have the statistical error, which is equal to or less than the specified one.

The radiometer can automatically determine the specified statistical error depending on the radiation intensity (Appendix A). 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 radiometer, 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 13) while the THRESHOLD button is being pressed and held down (but not longer than 3 s). A zero value display means that the radiometer determined the specified statistical error automatically depending on the radiation intensity.

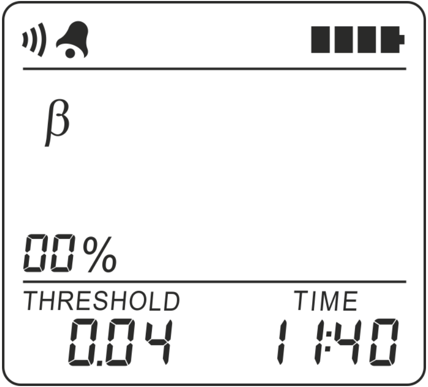

Figure 13 – LCD of the radiometer
(viewing the value of specified statistical error)

If the THRESHOLD button is being held down for more than three seconds, the LCD displays the “Arch” symbols (Figure 14). Thus, it becomes possible to proceed to the submode of measurement result saving in the nonvolatile memory.

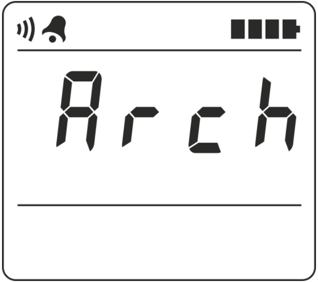

Figure 14 – LCD of the radiometer (start of the submode of measurement result saving in the nonvolatile memory)

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 15).

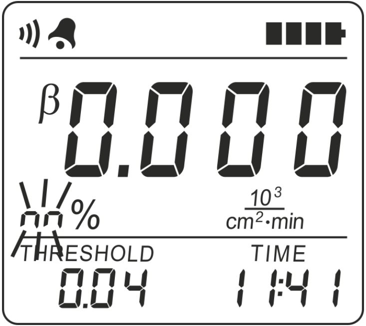

Figure 15 – LCD of the radiometer (measurement restart)

If you keep holding the THRESHOLD button, then during the next two seconds the radiometer 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 16). 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 radiometer 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 14). Then release the THRESHOLD button.

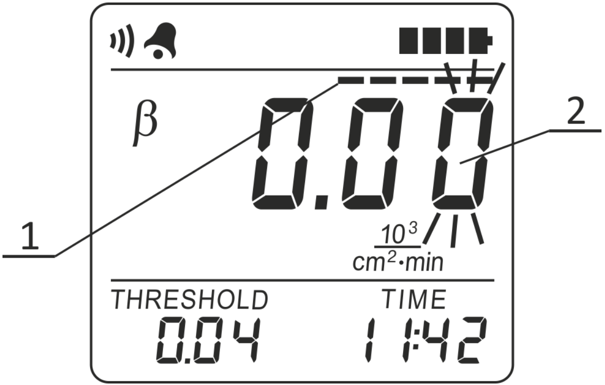

Figure 16 – LCD of the radiometer
(the submode of alarm threshold level programming)

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 radiometer automatically returns to the mode of surface beta-particles flux density measurement.

If the “FULL” symbols are displayed on the LCD of the radiometer (Figure 17) instead of the “Arch” symbols, there is no free space in the nonvolatile memory of the radiometer, 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 (2.3.3.10) or in the viewing mode (2.3.3.11).

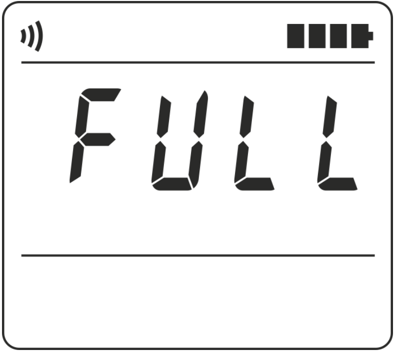

Figure 17 – LCD of the radiometer
(start of the submode of measurement result saving – no free space in the nonvolatile memory)

The “Arch” symbols (2) on the LCD of the radiometer are an indication of the submode of measurement result saving (Figure 18). 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 radiometer in this submode fully complies with the operation in a similar submode of the photon-ionizing radiation DER measurement mode.

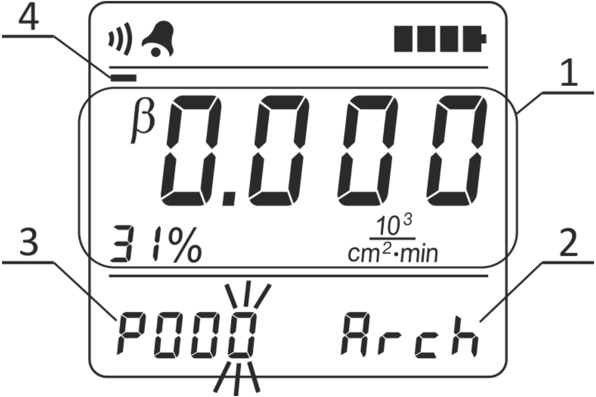

Figure 18 – LCD of the radiometer
(the submode of measurement result saving of surface beta-particles flux density)

2.3.3.8 **The clock mode**

This mode can be entered from any other operating mode of the radiometer 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 radiometer's LCD displays the following information (Figure 19):

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

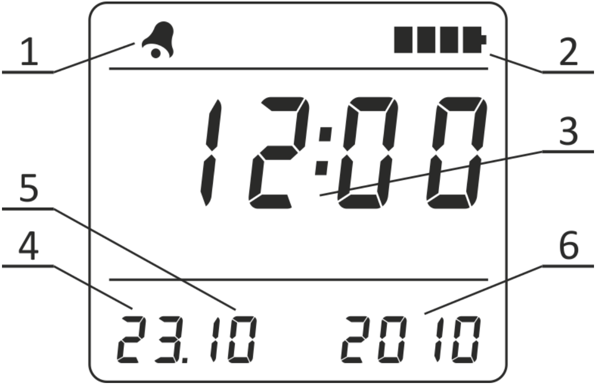

Figure 19 – LCD of the radiometer
(the clock mode)

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 20).

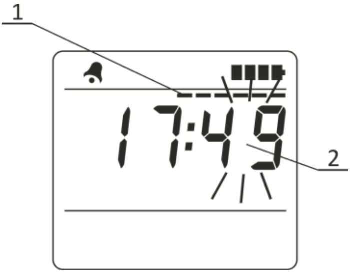

Figure 20 – LCD of the radiometer
(the submode of time and date correction – time programming)

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 radiometer’s memory. The new time value blinks three times on the LCD of the radiometer to show that it has been fixed. A year is then displayed on the LCD (Figure 21).

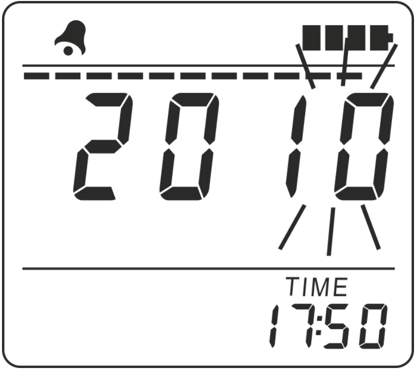

Figure 21 – LCD of the radiometer
(the submode of time and date correction – year programming)

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 radiometer's memory. The new value of year blinks three times on the LCD of the radiometer to show that it has been fixed. The date (1) and month (2) are then displayed on the LCD (Figure 22). 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.

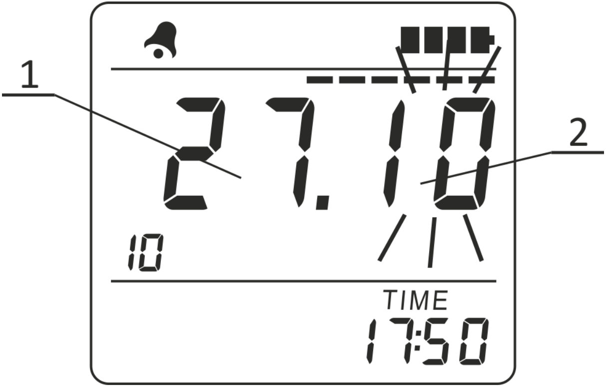

Figure 22 – LCD of the radiometer
(the submode of time and date correction – date programming)

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 radiometer’s memory. The new value blinks three times on the LCD, and the radiometer 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 radiometer), the radiometer will automatically return to the mode clock. All changes made and not fixed in the radiometer’s memory will be cancelled.

2.3.3.9 **The mode of alarm clock**

This mode can be entered from any other operating mode of the radiometer 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 radiometer's LCD displays the following information (Figure 23):

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

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 (2) start blinking (Figure 24).

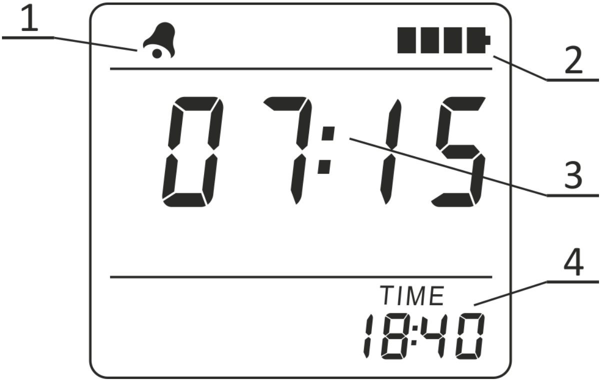

Figure 23 – LCD of the radiometer
(the alarm clock mode)

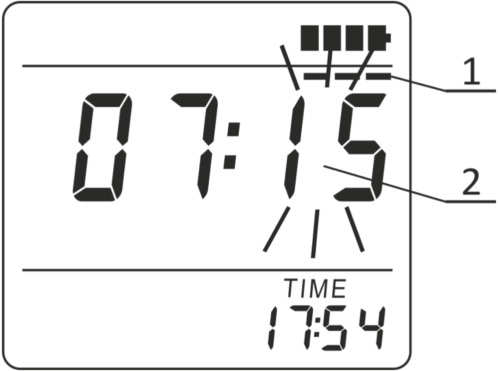

Figure 24 – LCD of the radiometer
(the submode of alarm clock activation time programming)

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 (1) starts blinking on the LCD of the radiometer (Figure 25).

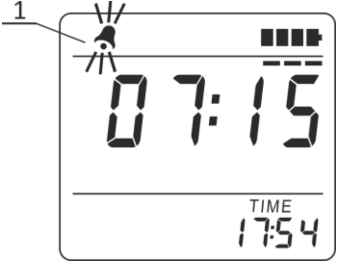

Figure 25 – LCD of the radiometer
(the submode of alarm clock activation time programming)

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 radiometer), the radiometer 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 radiometer will start generating the alarm clock signal in all operating modes and submodes of the radiometer, 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 radiometer 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 radiometer, 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 radiometer was off before the alarm clock goes off, the radiometer enters the clock mode. The radiometer 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 radiometer remains on.

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

2.3.3.10.1 This mode can be entered from any other operating mode of the radiometer 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 radiometer's LCD displays the following information (Figure 26):

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

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

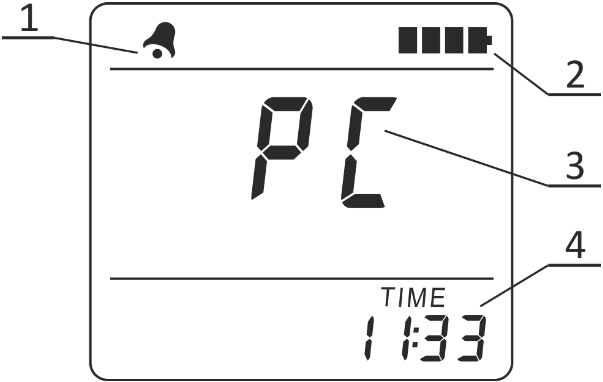

Figure 26 – LCD of the radiometer
(the mode of data communications control with the PC)

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-interface of the radiometer, or the custom-made software is not launched on this PC), the radiometer 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 radiometer displays a stripe (1) (Figure 27) “moving” across the instantaneous value indicator.

During the data communications the radiometer sends to the PC the measurement results that have been saved in the nonvolatile memory. During the data communications you can also clear the measurement results saved in the nonvolatile memory. After that the radiometer’s clock will be set according to the PC clock.

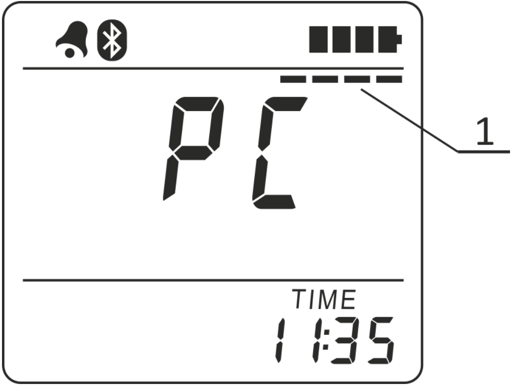

Figure 27 – LCD of the radiometer
(the mode of data communications control with the PC)

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

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

as well as receives the commands 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 radiometer to the mode of control of data communications with the PC.

Press shortly the MODE button of the radiometer 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”).

2.3.3.11 The mode of measurement results viewing stored in the nonvolatile memory

2.3.3.11.1 If the nonvolatile memory of the radiometer contains measurement results, this mode can be entered from any other operating mode of the radiometer 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 radiometer's LCD displays the following information (Figure 28):

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

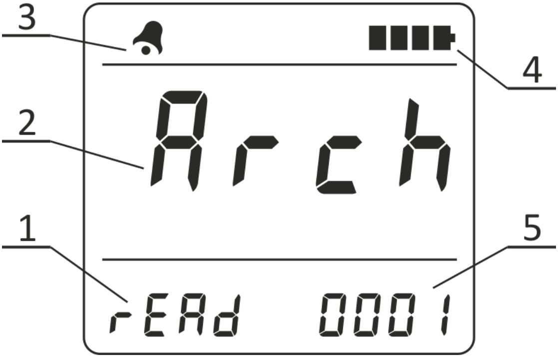

Figure 28 – LCD of the radiometer
(the mode of measurement results viewing stored in the nonvolatile memory)

Press shortly the THRESHOLD button to view the measurement results stored in the nonvolatile memory. The LCD of the radiometer displays the following information (Figure 29):

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

During viewing, if the user presses no buttons of the radiometer, zones (5) and (6) of the LCD alternatively display the measurement object number and the measurement time, or the date and year of measurement.

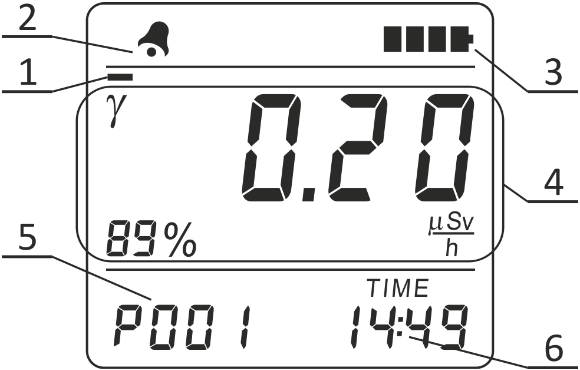

Figure 29 – LCD of the radiometer
(measurement results viewing)

The indicator of location (1) shows a place of the measurement result (4) 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 radiometer 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 radiometer 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 radiometer (Figure 30).

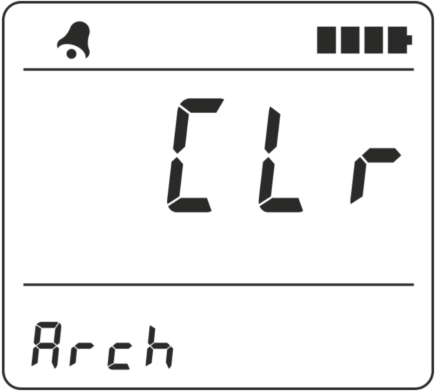

Figure 30 – LCD of the radiometer
(the submode of measurement results clearing stored in the nonvolatile memory)

To cancel clearing, shortly press the THRESHOLD button or do not press the buttons during 30 s (the radiometer 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 radiometer, and return of the radiometer 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 radiometer), the radiometer will automatically return to the mode of measurement results viewing without measurement results clearing.

3 TECHNICAL MAINTENANCE

3.1 Technical maintenance of the radiometer

3.1.1 **General instructions**

The list of operations performed during technical maintenance (hereinafter called TM) of the radiometer, 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 radiometer	-	+	+	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 radiometer**

3.1.3.1 External examination

External examination of the radiometer 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 radiometer;

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 radiometer

3.1.3.3.1 Operability check of the radiometer 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 radiometer for repair and the type of repair:

- for mid-life repair:

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

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 radiometer 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 radiometer. Do this as follows:

- switch the radiometer 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 radiometer

The radiometers 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 beta particles flux density measurement	3.2.4.4

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 radiometer 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 radiometer 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 radiometer 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 radiometer 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 radiometer for photon-ionizing radiation DER measurement (hereinafter called DER) and program 5 % value of the specified statistical error according to item 2.3.3.6 of the OM.

Fix the radiometer in the УПГД-3В carriage holder so that the mechanical center of gamma beam coincides with the center of the gamma and beta 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 radiometer 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:

$$\overline{\dot{H}^*}(10) = \overline{\dot{H}^*_{\Sigma}}(10) - \overline{\dot{H}^*_{\Phi}}(10)\,, \qquad (3.1)$$

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

$\overline{\dot{H}^{*}_{\Phi}}(10)$ - is an average value of the radiometer 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 radiometer 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 (3.1).

Calculate the main relative error of measurement in percentage according to ДСТУ ГОСТ 8.207:2008.

Place the УПГД-3В carriage together with the radiometer 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 (3.1).

Calculate the main relative error of measurement in percentage.

Place the УПГД-3В carriage together with the radiometer 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.

The radiometer 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 surface beta-particles flux density measurement**

Prepare the radiometer for photon-ionizing radiation DER measurement and program 5 % value of the specified statistical error according to item 2.3.3.6 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 radiometer to the mode of surface beta-particles flux density measurement, and set 10 % value of the specified statistical error according to item 2.3.3.7 of the OM.

Remove the beta-filter cover from the gamma and beta radiation detector. Place the radiometer above the 4CO source surface, providing surface beta-particles flux density from 50 to 150 part./($cm^2 \cdot min$), 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 radiometer above the 4CO source surface, providing surface beta-particles flux density from 1000 to 10000 part./($cm^2 \cdot min$), 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 radiometer above the 4CO source surface, providing surface beta-particles flux density from 50000 to 100000 part./($cm^2 \cdot min$), 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 radiometer 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).

3.2.4.5 **Presentation of verification results**

3.2.4.5.1 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 E 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, %	$\delta\dot{H}^*(10) = 15 + 2/\ \dot{H}^*(10)$, where $\dot{H}^*(10)$ is a numeric value of the measured DER in μSv/h	
Main relative error at measurement of beta particles flux density, with confidence probability of 0.95, %	$\delta\phi_\beta = 20 + 200/\ \phi_\beta$, where φ_β is a numeric value of the measured surface beta-particles flux density in part./(cm^2·min)	

3.2.4.5.2 The radiometers 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 RKS-01 “STORA-TU” radiometer-dosimeter of BICT.412129.015-02.02 type with ________________ serial number meets the ТУ У 33.2-22362867-008-2004 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 RKS-01 “STORA-TU” radiometer-dosimeter of BICT.412129.015-02.02 type with __________________ serial number is packed by the Private Enterprise “SPPE “Sparing-Vist Center” in accordance with the requirements specified in ТУ У 33.2-22362867-008-2004.

Date of packing ______________________

Stamp here

Packed by: ____________
(signature)

Packed product accepted by: ____________
(signature)

6 WARRANTY

6.1 The manufacturer guarantees the conformity of the radiometer to the technical requirements provided that the customer observes the guidelines for its use, shipping and storage presented in the operating manual BICT.412129.015-02.02 HE.

6.2 The warranty period of the radiometer 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 radiometer 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 radiometer 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 radiometer, the user should contact the enterprise producer 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 radiometer is recorded in the table of Appendix F of this OM.

8 STORAGE

8.1 The radiometers 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 radiometers in storehouses should ensure their free movement and access to them.

8.3 The radiometers 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 radiometers 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 radiometer is recorded in Appendices B, C, and G of this OM.

9 SHIPPING

9.1 Packed radiometers 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 radiometers 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 radiometers 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 radiometer is performed in compliance with the general rules, i.e. metals are recycled or melted, and plastic parts are dumped.

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

APPENDIX A

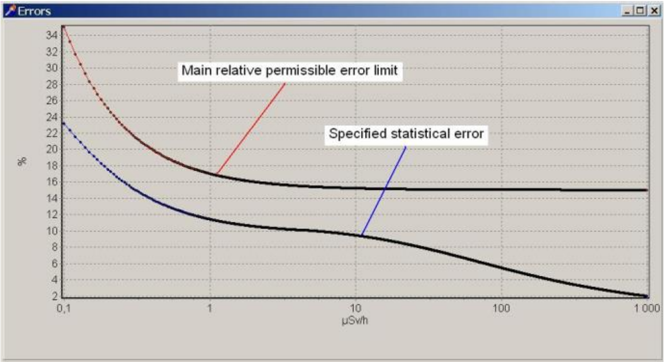

Figure A.1 – Plot of specified statistical error versus photon-ionizing radiation DER

APPENDIX A

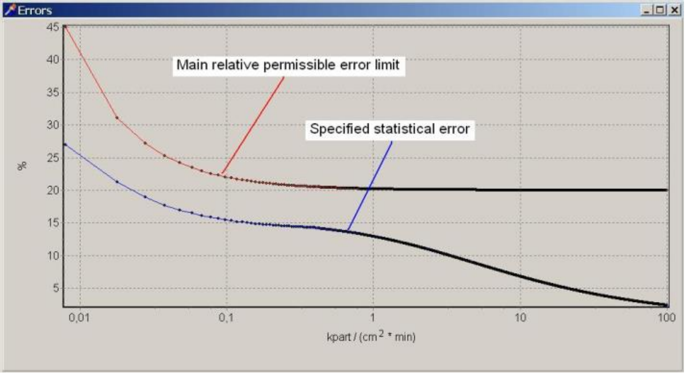

Figure A.2 – Plot of specified statistical error versus surface beta-particles flux density

APPENDIX B

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 C

STORAGE

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

APPENDIX D
TROUBLE RECORD DURING USE

Date and time of failure. Operating mode	Type (manifesta-tion) 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 E
PERIODIC VERIFICATION OF KEY SPECIFICATIONS

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)
1 Main relative error of the radiometer at photon-ionizing radiation DER measurement with confidence probability of 0.95, %	$15 + \frac{2}{\dot{H}^*(10)}$, where $\dot{H}^*(10)$ is the measured DER value, μSv/h				

APPENDIX E

E-1

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 E

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)
2 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 E

E-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

REPAIR

Name and type of the component part of the radiometer	Reason for repair	Date		Name of the repair organization	Number of operation hours before repair
		of arriving for repair	of repair completion		

APPENDIX F

REPAIR

Type of repair (mid-life, major, etc.)	Name of repair	Position, name and signature of the responsible person	
		who performed repair	who accepted after repair

APPENDIX G

VERIFICATION AND INSPECTION RESULTS

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