# MKS-U
# MULTIPURPOSE DOSIMETER-RADIOMETER

## Operating manual
BICT.412129.004-03 HE

CONTENTS

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

The OM contains the following abbreviations:

| | |
|---|---|
| DE | - ambient dose equivalent; |
| DER | - ambient dose equivalent rate; |
| CDU | - combined detecting unit; |
| BDD | - built-in detector of operator's dose; |
| RD | - remote detector of gamma radiation; |
| PC | - personal computer; |
| ON | - power button; |
| LIGHT | - display backlight button; |
| MODE | - button of the corresponding modes of measurement and indication (gamma radiation DER measurement by the CDU, gamma radiation DE measurement by the BDD, DE accumulation time); |
| γ/β | - switch button between the mode of gamma radiation DER measurement by the CDU and beta-particles flux density measurement, and vice versa. |

## 1 DESCRIPTION AND OPERATION

1.1 Purpose of use of the dosimeter

The MKS-U multipurpose dosimeter-radiometer (hereinafter referred to as the dosimeter) is designed to measure ambient dose equivalent (DE) and ambient dose equivalent rate (DER) of gamma and X-ray radiation (hereinafter referred to as photon-ionizing radiation), and surface beta-particles flux density.

The dosimeter is used as a part of radiation monitoring system of Ukraine, including: radiochemical reconnaissance units of civil defense, armed forces,
dosimetry services of the atomic power engineering, in medicine, and nuclear physics.

**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 the specifications |
|---|---|---|
| Measurement range of photon-ionizing radiation DER by the CDU | µSv/h | $10^{-1}$ - $10^{7}$ |
| Main relative permissible error limits of DER measurement by the CDU at $^{137}Cs$ calibration with 0.95 confidence probability | % | $15 + \frac{2}{\dot{H}^{*}(10)}$, where $\dot{H}^{*}(10)$ is a numeric value of measured DER in µSv/h |
| Measurement range of photon-ionizing radiation DER by the RD | Sv/h | $10^{-2}$ - $10^{2}$ |
| Main relative permissible error limits of DER measurement by the RD at $^{137}Cs$ calibration with 0.95 confidence probability | % | $15 + \frac{200}{\dot{H}^{*}(10)}$, where $\dot{H}^{*}(10)$ is a numeric value of measured DER in mSv/h |
| Measurement range of photon-ionizing radiation DE by the BDD | mSv | 0.001 - 9999 |
| Main relative permissible error limits of DE measurement by the BDD at $^{137}Cs$ calibration with 0.95 confidence probability | % | ±15 |
| Energy range of detected photon-ionizing radiation | MeV | 0.05 – 3.00 |
| Energy dependence of the dosimeter readings at photon-ionizing radiation measurement for:<br>- the CDU and BDD in the energy range of 0.05 to 1.25 MeV<br>- the RD in the energy rage of 0.662 to 1.25 MeV | % | <br>±25<br>from –25 to +30 |

Table 1.1 (continued)

| 1 | 2 | 3 |
|---|---|---|
| Anisotropy of gamma radiation CDU, BDD and RD for:<br>- $^{137}Cs$ and $^{60}Co$ (at gamma quantum incidence at ±150° solid angle relative to the reference direction of measurement marked by the "+" symbol)<br>- $^{241}Am$ (at gamma quantum incidence at ±60° solid angle relative to the reference direction of measurement marked by the "+" symbol)<br>**Note.** Anisotropy charts are presented in the Appendix A | % | ±30<br><br>±75 |
| Measurement range of beta-particles flux density by the CDU | part./(cm$^2$·min) | $10 - 2\cdot10^5$ |
| Main relative permissible error limits of surface beta-particles flux density measurement by the CDU at $^{90}Sr+^{90}Y$ calibration with 0.95 confidence probability | % | $20 + \frac{200}{\phi_\beta}$, where $\phi_\beta$ is a numeric value of measured surface flux density in part./(cm$^2$·min) |
| Energy range of detected beta-particles | MeV | 0.3 – 3.0 |
| Measurement range of operator's DE accumulation time with measurement resolution of 1 min | h | 100 |
| Absolute permissible error limits of operator's DE accumulation time measurement during 100 hrs | min | ±1 |
| Power supply voltage of the dosimeter from the storage battery of 5 nickel-cadmium AA cells | V | 6.0 |
| Additional relative permissible error limits of measurement caused by power supply variations from 5.4 to 6.6 V, for all measured physical quantities | % | ±5 |

Table 1.1 (continued)

| 1 | 2 | 3 |
|---|---|---|
| Additional relative permissible error limit of measurement caused by the environment temperature changes, per each 10 °C deviation from 20 °C, for all measured physical quantities within:<br>- temperature range from + 20 to + 50 °C<br>- temperature range from + 20 to – 40 °C | % | <br><br><br><br>±10<br>±5 |
| Time of operating mode setting, not more than | min | 1 |
| Time of continuous service of the dosimeter operated by a set of charged AA cells of 750 mA·h capacity and disconnected photo battery when:<br>- gamma background does not exceed 0.5 μSv/h, the remote detector is disconnected, and display backlight is switched off, not less than<br>- the RD is connected and display backlight is switched on, not less than | h | <br><br><br><br>100<br><br>10 |
| Unstable readings of the dosimeter at DER measurement during 8 hrs of continuous operation, not more than | % | 10 |
| Dimensions of the control panel of the dosimeter without the connecting cable, not more than | mm | 82x124x163 |
| Dimensions of the CDU without the connecting cable, not more than | mm | ∅50x167 |
| Length of the connecting cable of the CDU, not less than | m | 1.0 |
| Dimensions of the RD without the connecting cable, not more than | mm | ∅34x50 |
| Length of the connecting cable of the RD, not less than | m | 30 |
| Weight of the control panel of the dosimeter with the CDU, not more than | kg | 1.8 |
| Weight of the RD with the connecting cable, tube and cover, not more than | kg | 3 |
| Weight of the dosimeter's kit in packing case, not more than<br>**Note.** The delivery kit is completed at the customer's request | kg | 8 |

1.2.2 Measurement intervals and subranges for all operating modes of the dosimeter are preset automatically.

1.2.2.1 The dosimeter allows automatic subtraction of gamma background at surface beta-particles flux density measurement.

1.2.2.2 The dosimeter allows storing up to 4096 measurement results of photon-ionizing radiation DER or beta-particles flux density in the non-volatile memory. For easier identification, each measurement result is recorded with a reference three-digit number, which is entered during recording.

1.2.2.3 The dosimeter provides automatic recording of radiation-absorbed dose with 5 min recording resolution of photon-ionizing radiation DE.

1.2.3 The dosimeter beeps at each gamma quantum or beta-particle detected by the CDU.

1.2.4 The values of DE, DE accumulation time, DER, and surface beta-particles flux density are by turns indicated on the single digital liquid crystal display together with the corresponding symbols.

1.2.4.1 The dosimeter allows viewing measurement results earlier stored in the nonvolatile memory on the personal liquid crystal display, and PC communications through infrared port.

1.2.4.2 The dosimeter has an analog indicator of measured radiation intensity.

1.2.4.3 The dosimeter warns of the storage battery discharge.

1.2.5 The dosimeter allows recharging the standard storage battery and power supply from the photoelectric battery, the ~220 V / =12 V power supply unit or the automobile storage battery.

1.2.6 The dosimeter is proof against (when on) static or alternating magnetic fields of 400 A/m.

1.2.7 The dosimeter is proof against photon-ionizing radiation with exposure dose rate, corresponding to dose equivalent rate, up to 1.0 Sv/hour during 50 min influencing on the control panel, and 100 Sv/hour during 500 min on the gamma radiation remote detector.

1.2.8 The dosimeter is resistant to (when off) sinusoidal vibrations within energy range from 1 to 80 Hz with acceleration amplitude of 39 $m/s^2$ (4g).

1.2.9 The dosimeter is proof against sinusoidal vibrations within energy range from 1 to 80 Hz with acceleration amplitude of 39 $m/s^2$ (4g).

1.2.10 The packed dosimeter is resistant to mechanical shocks of single action with shock pulse duration from 1 to 5 ms, and shock acceleration peak value of 490 $m/s^2$ (50 g).

1.2.11 The packed dosimeter is resistant to mechanical shocks of repeated action with shock pulse duration from 5 to 10 ms, and shock acceleration peak value 147 $m/s^2$ (15 g).

1.2.12 The dosimeter is proof against acoustic noise in the frequency range of 50 to 10000 Hz with sound pressure level (relative to $2 \cdot 10^5$ Pa) 100 dB.

1.2.13 The dosimeter remains operable after low operating temperature influence – 40 ºC and after maximum low temperature – 60 ºC.

**Note.** At the temperature from– 21 ºC to – 40 ºC, the dosimeter should be powered from the external source (the ~220 V / = 12 V power supply unit, or the automobile storage battery).

1.2.14 The dosimeter remains operable after high operating temperature influence + 50 ºC and after maximum high temperature + 55 ºC.

1.2.15 The dosimeter remains operable after three temperature cycles in the temperature interval from maximum low temperature –60 ºC to maximum high temperature +55 ºC.

1.2.16 The dosimeter remains operable after the influence of high humidity level of (95 ± 3) % at +35 ºC temperature.

1.2.17 The dosimeter ensures measurement after the influence of working low atmospheric pressure 60 kPa (450 mm Hg).

1.2.18 The dosimeter remains operable after shipping when influenced by maximum low atmospheric pressure 23 kPa (170 mm Hg).

1.2.19 The dosimeter remains operable after the influence of condensed atmospheric precipitations (hoarfrost, dew) within the temperature range from – 20 ºC to +20 ºC.

1.2.20 The remote detector remains operable after being submerged at the depth of 1 m.

1.2.21 The control panel in casing remains operable after being dropped in ON position from 0.75 m height.

1.2.22 The control panel in casing functions after:

- atmospheric precipitations with (5±2) mm/min intensity;
- integral solar radiation with flux density of 1125 W/m$^2$;
- solar UV radiation 68 W/m$^2$;
- dynamic dust (send) with concentration of (5±2) g/m$^3$.

### 1.3 Delivery kit of the dosimeter

1.3.1 The delivery kit of the dosimeter includes units and maintenance documentation presented in Table 1.2.

Table 1.2 – Delivery kit of the dosimeter

| Type | Item | Q-ty | Note |
|---|---|---|---|
| ВІСТ.468382.003 | Control panel of the MKS-U multipurpose dosimeter-radiometer | 1 pc. | |
| ВІСТ.467979.009 | Remote detector of gamma radiation | 1 pc. | Supplied at the customer's request |
| | Silicon photoelectric battery БФК-1,1-6 ААЕИ.564113.021 ТУ | 1 pc. | Included in the case. Supplied at the customer's request |
| | NiCd (Storage battery) AA 750mAh VARTA | 5 pcs. | Inserted in the battery compartment. (Analog options allowed) |
| ВІСТ.468626.001 | Headphone | 1 pc. | |
| | Packing box | 1 pc. | |
| ЕЯ6.366.019 | Extension tube | 1 pc. | |
| ВІСТ.323368.003 | Case | 1 pc. | |
| ЕЯ6.834.013 Сп | Strap | 2 pcs. | |
| ВІСТ.685661.001 | Cable | 1 pc. | |
| | Power supply unit ~220 V / =12 V | 1 pc. | Model is not specified |
| | Telescopic tube | 1 pc. | |
| | Case | 1 pc. | For the remote detector of gamma radiation |
| | Screwdriver | 1 pc. | |
| ВІСТ.754152.002 | Gasket | 1 pc. | |
| ВІСТ.754152.002-01 | Gasket | 1 pc. | |
| ВІСТ.754152.002-02 | Gasket | 1 pc. | |
| ВІСТ.753161.001 | Button | 2 pc. | |
| ВІСТ.412129.004-03 НЕ | Operating manual | 1 copy | |
| ВІСТ.412129.004-03 ФО | Logbook | 1 copy | |

### 1.4 Design and theory of operation

1.4.1 Overview

The dosimeter kit includes the control panel, the remote combined detecting unit (of gamma radiation and beta-particles) – the CDU, and the remote detector of gamma radiation – the RD. The control panel has the built-in detector of the operator's dose – the BDD.

The control panel serves to:

- control the operating modes of the dosimeter;
- indicate measurement results on the liquid crystal display;
- provide audio alarm;
- save measurement results in the nonvolatile memory;
- PC communications through infrared port;
- generate and regulate power voltages for electronic component parts of the dosimeter;
- automatically charge the storage battery.

The CDU measures gamma radiation DER and beta-particles surface flux density, and transmits measurement results to the control panel through the RS-485 interface.

The RD remote detector of gamma radiation converts gamma radiation into the current. Current magnitude is proportional to the radiation intensity. The control panel converts output current of the RD into pulse frequency, and measures gamma radiation DER by calculating medium pulse frequency.

The BDD converts gamma radiation into the sequence of voltage pulses. The number of pulses is proportional to radiation DE. Gamma radiation DE is measured by calculating the general number of pulses coming from the BDD output in the control panel.

1.4.2 Structure chart of the dosimeter and component parts

1.4.2.1 As shown on the structure chart (Figure 1), the dosimeter consists of the control panel, the photo battery (PB), the remote detector of gamma radiation (RD), the power unit (PU) and the headphones (H).

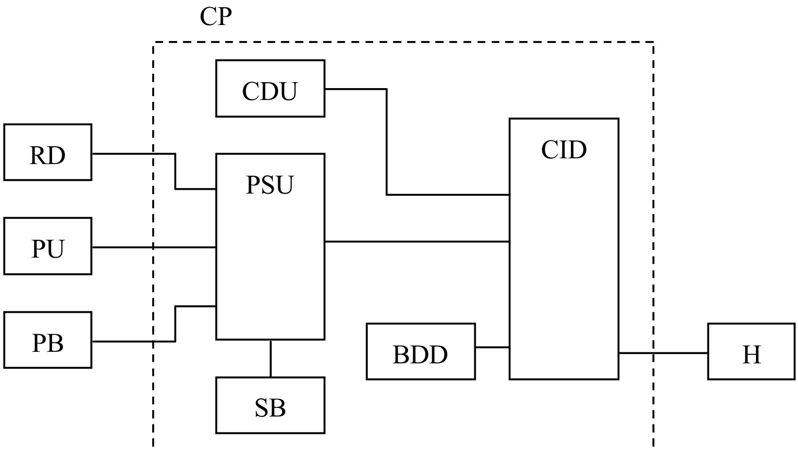


Figure 1 – Structure chart of the MKS-U dosimeter

1.4.2.2 Control panel

1.4.2.2.1 The control panel is designed to control the operating modes of the dosimeter, to process data received from detectors and detecting units, to display received measurement results, to provide audio alarm and power supply.

The control panel consists of the control and indication device (CID), the built-in detector of operator's dose (BDD), the power supply unit (PSU), the combined detecting unit (CDU), and the storage battery (SB).

1.4.2.2.2 The structure chart of the control and indication device (CID) is presented in Figure 2. The CID consists of the digital processing circuit (DPC), the liquid crystal display (LCD), the buzzer (BZ) and the ON, MODE, "γ/β", and LIGHT buttons.

The DPC is designed on the basis of the 16-digit RISC microcontroller (MC) and provides:

- operating mode control with the help of the ON, MODE, "γ/β", and LIGHT buttons;
- scaling and linearization of the counting response of the BDD;
- measurement of X-ray radiation DE, by measuring the general number of pulses coming from the BDD output;
- measurement of X-ray radiation DER, by measuring medium frequency of pulses from the "Current-Frequency" converter output of the RD;
- reading of gamma radiation DER or beta-particles flux density measurement results from the CDU;
- displaying measurement results on the liquid crystal display;
- audio alarm;
- saving measurement results and calibration coefficients in the non volatile memory;
- transmission of measurement results through infrared port to the personal computer (PC);
- storage battery charging control.

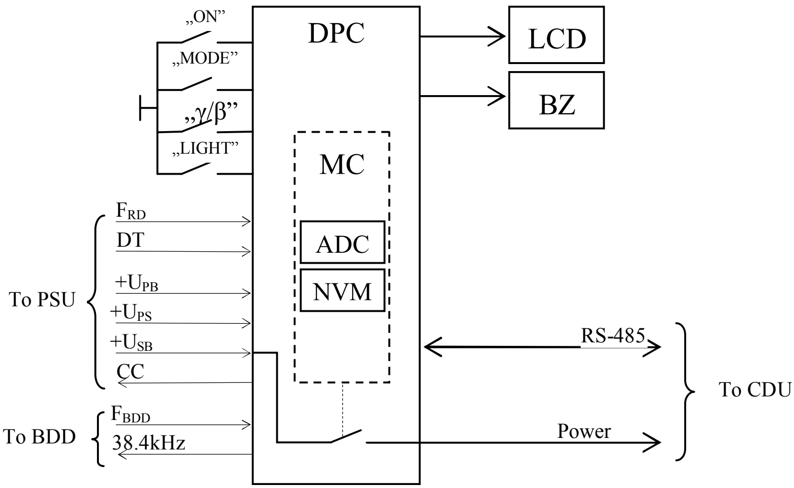


Figure 2 – Structure chart of the control and indication device

1.4.2.2.3 The power supply unit (Figure 3) is designed to charge the storage battery, to convert the RD current into frequency, and to generate the necessary power voltages.

The power supply unit consists of the charger (CH), the current-frequency converter (CFC) and the pulse voltage generator (PVG). The CFC is designed to convert the RD current into pulse frequency proportional to the current, for further measurement of gamma radiation DER. The PVG generates voltages necessary for the CFC power supply.

The CH recharges the storage battery with the help of the photo battery or the power supply unit. The CH consists of the voltage limiter of the photo battery and two current sources operated by the DPS.

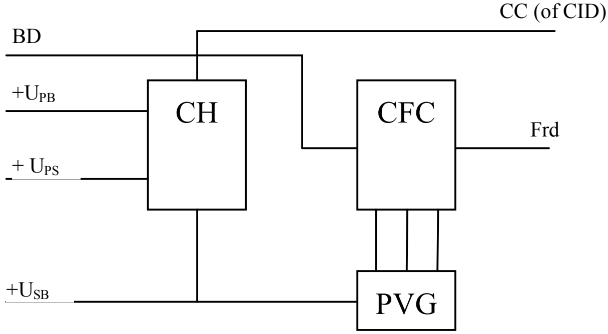


Figure 3 – Structure chart of the power supply unit

1.4.2.2.4 The built-in detector of operator's dose (BDD) is designed to measure operator's DE. The structure chart of the BDD is presented in Figure 4. The BDD consists of the anode voltage generator (AVG), the gamma radiation detector (D), and the detector control circuit (DCC). A gas-discharge counter of СБМ-21 type is used as the detector D. IR port (IRP) is also located on the BDD card.

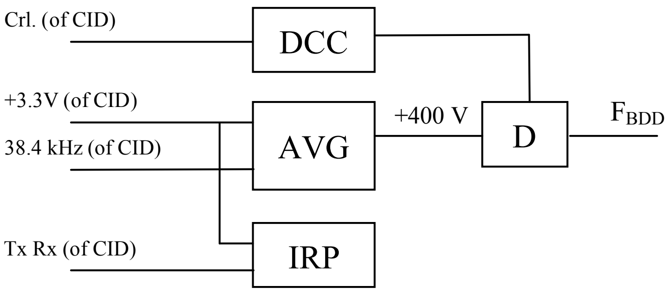


Figure 4 – Structure chart of the built-in detector of operator's dose

1.4.2.2.5 Combined detecting unit

1.4.2.2.5.1 The combined detecting unit (CDU) is designed to measure gamma radiation DER and beta-particles flux density. The CDU performs the final measurement process. From the CDU, measurement results are transmitted through the RS-485 interface to the control panel.

The CDU in return receives the commands and calibration coefficients from the control panel through the same interface.

1.4.2.2.5.2 The CDU (Figure 5) includes the detector of gamma radiation, the detector of beta-particles, and the digital processing circuit (DPC). The DPC is built on the 16-digit RISC microcontroller, and controls the two detecting devices. Structurally, the DPC elements are located on the printed circuit board of the gamma radiation detecting unit.

The detecting device of gamma radiation consists of the high-sensitivity detector (HD), the low-sensitivity detector (LD), the detector control circuits (DCC1, DCC2) and the anode voltage generators (AVG1, AVG2) for power supply of the detectors. A gas-discharge counter of СБМ-20-1 type is used as a high-sensitivity detector, a СИ 3БГ one – as a low-sensitivity detector. The detector control circuits are designed to standardize the “dead time” of the counters, what allows linearizing its counting response.

The detecting device of beta-particles consists of the voltage generator (VG), the amplifier (A) and the detector of beta-particles (DBP). The VG includes the linear stabilizer of voltage (+5 V) for power supply of the amplifier, and the pulse former of bias voltage of the detector (+25 V). The amplifier is built according to the pulse amplifier circuit with FET at the input. A planar silicon detector with work surface area of 1 sq.cm functions as a detector.

If one detector is in operation, another is always inactive (micro consumption mode). This helps to reduce general consumption current of the CDU.

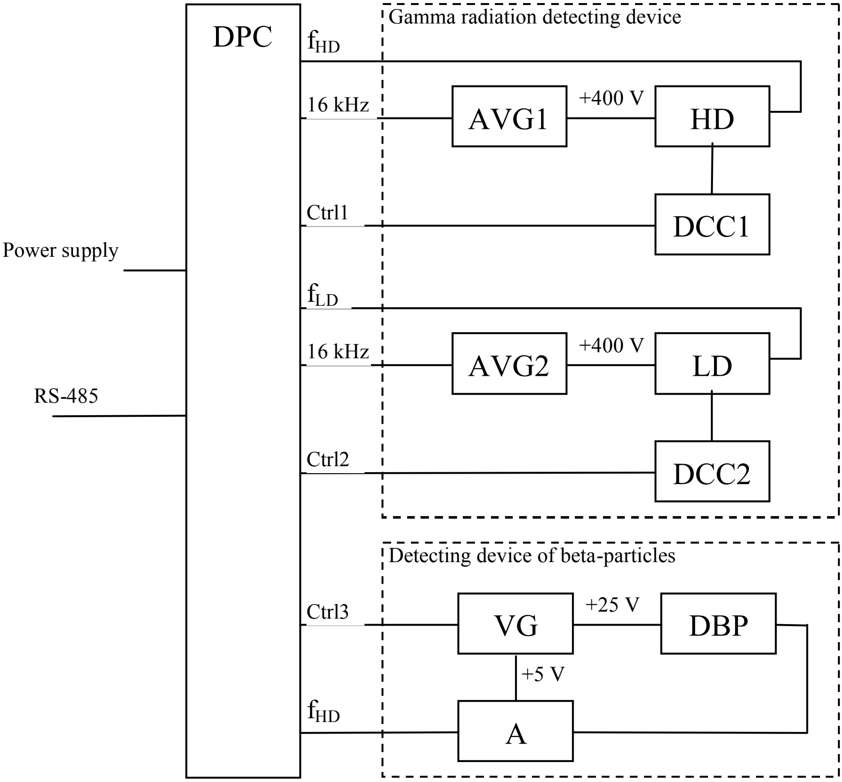


Figure 5 – Structure chart of the combined detecting unit

1.4.2.3 Remote detector of gamma radiation

1.4.2.3.1 The remote detector of gamma radiation is designed to measure medium and high levels of gamma radiation DER.

The remote detector of gamma radiation of scintillation electronic type (“SELDI” detector) is built on the basis of CsJ scintillation crystal and semiconductor photodiode. An optical contact is provided between the photo diode and the scintillator. The principle of operation of the detector lies in generating photocurrent by the photodiode as a result of scintillations in CsJ crystal at its irradiation. The output current of the detector is proportional to the intensity and energy of gamma radiation that hits the detector.

1.4.2.4 Photo battery

1.4.2.4.1 The photo battery is designed to charge the storage battery and power supply of the dosimeter in field conditions.

The photo battery is a battery of sequentially and concurrently connected silicon photo elements, located on the general substrate, and placed in hermetic enclosure with transparent window.

The photo battery generates photocurrent of photo elements under sunlight. Sequential connection of photo elements provides necessary level of voltage at load, and concurrent one – the required current strength.

Under direct sunlight (spectral conditions AM 1.5), the photo battery provides current not lower than 75 mA under 7.5 V voltage, which allows charging the storage battery and supplying the dosimeter.

1.4.2.5 Power supply unit

1.4.2.5.1 The power supply unit is designed to charge the storage battery, and to supply the dosimeter with power during operation in the temperature range from – 21 to – 40 $^{O}$C. The power supply unit is designed according to the classical circuit of the transformer 220 V voltage reduction of the industrial network of alternating current with 50 Hz frequency up to 15 V with further rectification, filtration and stabilization of the output +12 V voltage. The power supply unit model in the delivery kit of the dosimeter is not specified, as it is a part of the purchase component parts, where you can choose among the options. General electric parameters: output voltage (12±1.2) V; output current is not less 500 mA.

1.4.2.6 Headphone

1.4.2.6.1 The headphone is designed to provide audio alarm of radiation intensity at high acoustic noises level. Audio signaling in the headphone is formed by the control and indication device of the control panel of the dosimeter.

1.4.3 Operation of the dosimeter

1.4.3.1 After the storage battery is inserted into the battery compartment of the control panel, the dosimeter is switched on in the waiting mode. The current consumption in this mode is several tens of microamperes.

1.4.3.2 Shortly press the ON button to turn the dosimeter on. The DPC of the control and indication device (CID) is activated, checking if the RD is connected. The checking process continues up to 1 s. If the RD is not connected, the DPC of the CID supplies the CDU with power and gives the CDU a command to enter the mode of gamma radiation DER measurement. DER measurement results are formed directly in the CDU (1.4.4.2), and transmitted to the control panel with 0.5 Hz frequency. These results are received by the DPC of the control panel and indicated on the liquid crystal display.

After pressing the γ/β button on the control panel, the DPC of the CID gives the CDU a command to enter the mode of beta-particles flux density measurement. Beta-particles flux density measurement results are formed directly in the CDU (1.4.4.3) and transmitted to the control panel with 0.5 Hz frequency.

1.4.3.3 After the remote detector (RD) is connected, the DPC of the CID stops supplying the CDU with power, and launches the PVG, which is a part of the power supply unit (Figure 3). The CFC is activated converting output current of the RD into pulse frequency. The DPC of the CID measures average frequency of pulses, and converts it with the help of the calibration coefficients into gamma radiation DER in Sv/h.

1.4.3.4 After the dosimeter is switched on and irrespective of the selected operating mode, the dosimeter starts gamma radiation DE measurement, which is stopped only after the dosimeter is switched off. DE measurement is performed with the help of the built in the control panel detector of operator's dose (BDD) (Figure 4). The 400 V voltage applied to the Geiger-Muller counter anode is formed in the BDD under the CID DPC control. As a result of counter irradiation, the pulse flow is formed on the BDD output.

The DPC of the CID uninterruptedly registers pulses and normalizes the "dead time" of the BDD compensating the lost number of pulses. The DPC of the CID converts the general number of pulses with the help of the calibration coefficients into gamma radiation DE in Sv.

1.4.3.5 Both, when the DPC of the CID is active and when it operates in the mode of micro consumption, it uninterruptedly checks the +12 V voltage of the power supply (PS) or the photo battery (PB) on the input of the charger (CH). The CH is a part of the power supply unit (PSU) (Figure 3).

At +12 V voltage, the DPC of the CID is activated, and starts charging the storage battery (SB). The charging is controlled by the DPC of the CID with the help of two current sources included in the CH. The SB voltage is constantly checked during charging. The SB voltage is controlled by the 12-digit ADC, which is a part of the DPC of the CID. The charging process is indicated by two light emitting diodes - „Charging" and „End of charging".

The SB charging from the PB is done by the photo battery voltage limiter, which is a part of the CH. With the help of the light emitting diodes "Charging" and "End of charging", the DPC of the CID indicates if any charging is performed.

1.4.4 Operation of the CDU

1.4.4.1 After the supply voltage is applied, the CDU (Figure 5) switches to the micro consumption mode. In this mode, the CDU is waiting for the command from the control panel to switch to the mode of gamma radiation DER measurement or to the mode of beta-particles flux density measurement.

1.4.4.2 In response to a command from the control panel to switch to the mode of gamma radiation DER, the DPC generates the anode voltage of 400 V for the LD with the help of the AVG2. As a result of the LD irradiation, the pulse flow with frequency proportional to gamma radiation DER registered by the LD is formed on the output of the LD. With the help of the DCC2, the DPC standardizes the "dead time" of the LD, compensates for losses of the number of pulses, and measures
medium frequency of the pulse flow. With the help of the calibration coefficients the DPC converts frequency into gamma radiation DER expressed in Sv/h. Integration time, sufficient to provide the statistical error of measurement less than the basic relative permissible error given in Table 1.1, is chosen automatically according to DER. Simultaneously, the DPC measures medium frequency of pulses from the LD each second, and, accordingly, makes a decision whether further use of the LD is possible, or whether it is necessary to use the RD. Such analysis is made uninterruptedly each second.

If the RD use is necessary, the DPC quits generating the anode voltage for the LD and processing the pulse flow, and starts operating with the LD. Now the decision to switch to operation with the LD is made according to medium pulse frequency from the RD measured each 0.25 s per 0.25 s time interval.

1.4.4.3 In the mode of beta-particles flux density measurement, the DPC gives the command to switch on the beta-particles detecting device. The VG is activated generating +5 V voltage for power supply of the amplifier, and +25 V voltage – the DBP bias voltage.

Consequently, at the DBP irradiation, on the output of the amplifier A, a flow of pulses with frequency proportional to beta-particles flux density, registered by the DBP, is formed. The DPC measures medium pulse frequency of the flow and with the help of the calibration coefficients converts it into flux density expressed in $10^3$ part./(cm$^2$·min). Integration time, sufficient to provide the statistical error of measurement less than the main relative permissible error given in Table 1.1, is chosen automatically according to flux density.

1.4.5 Design description

1.4.5.1 General information

The dosimeter consists of:

- control panel;
- remote detector of gamma radiation;
- case with the photo battery and straps;
- headphone;
- power supply unit and power cable;
- packing box;
- other equipment, instruments and spare parts.

1.4.5.1.1 The control panel of the dosimeter (see Figure 6) consists of the control panel (1) and the combined detecting unit (2) interconnected by the cable (3).


Figure 6 – The control panel of the dosimeter

1.4.5.1.2 The control panel consists of the following component parts (Figure 7): the indication and control panel (1), the base (2) and the case (3).

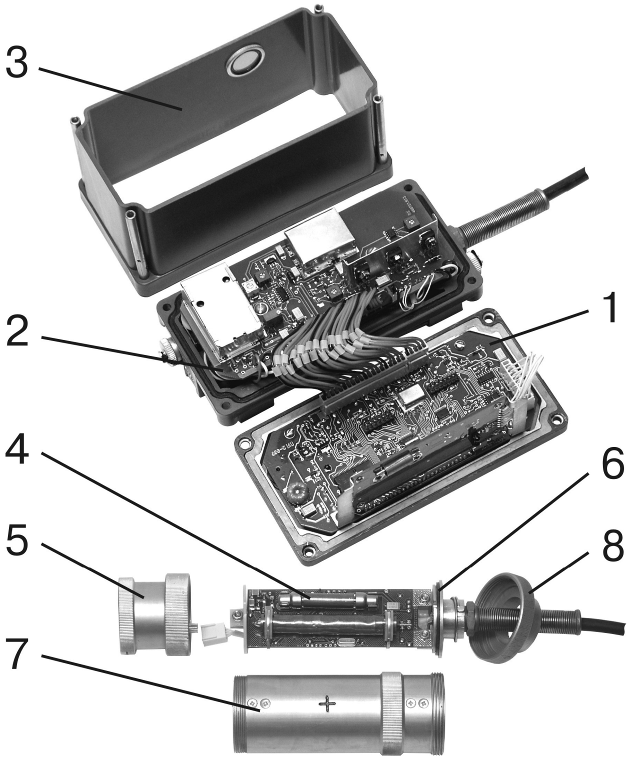


Figure 7 – Design of the control panel of the dosimeter

The top part of the panel is a protruding rectangular bent with an attached indication panel of the transparent plastic. The digital liquid crystal display and two light emitting diode indicators are located behind the panel. The four control buttons are located in the bottom of the panel.

All inscriptions that refer to the control and indication devices are raised and done on the inside of the indication panel. Inscriptions and the liquid crystal display screen can be backlit with the help of the built-in light emitting diode illumination system if outdoor illumination is insufficient. The printed circuit board of control and indication is located on the inside of the control panel. The printed circuit board of the built-in detector of operator’s dose is fastened to the control panel with the help of the brackets.

The printed circuit board of the energy supply device is located on the base of the control panel.

The battery compartment (Figure 8) with five AA size batteries (1) fixed with the help of the terminal block is located in the bottom of the base.

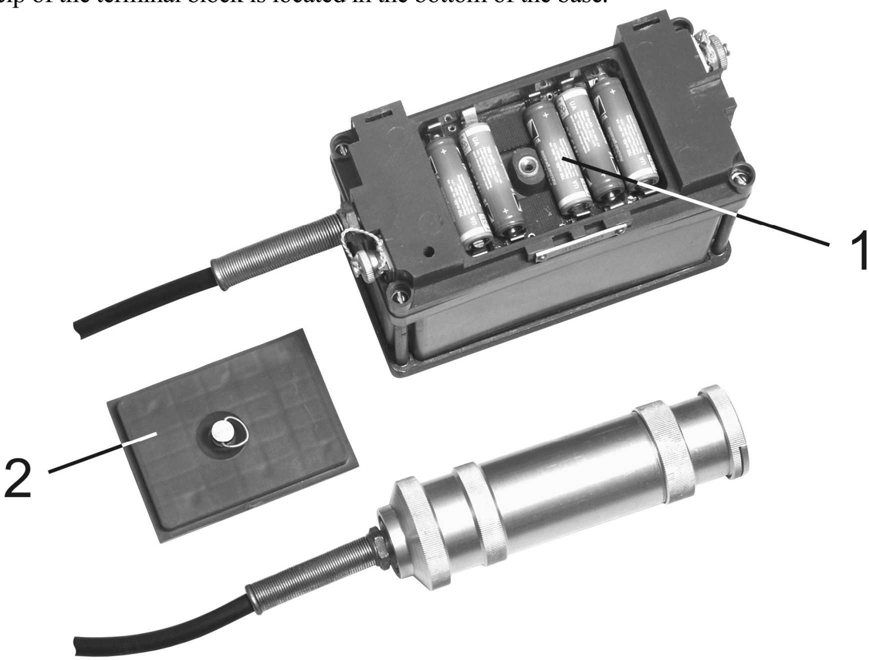


Figure 8 – Battery compartment of the control panel

The battery compartment is closed with the cover (2) that is firmly screwed. The connectors used for the connection of the remote detector of gamma radiation, for charging of the storage battery from the photo electric battery (this connector is also used for the cable connection of the vehicle battery or the power supply unit that operates from the industrial network), and a socket for the headphone connection is located on the right and the left side walls of the base.

The cable that connects the control panel with the combined detecting unit is fixed on the right side wall of the base. Electric contact between the energy supply board and the control and indication card is done with the help of the connector and the flat bunch.

The control panel and the base are screwed to the case. To prevent dust and humidity in the control panel and the battery compartment, elastic gaskets are used.

1.4.5.1.3 The combined detecting unit (Figure 7) consists of two detecting devices: a detecting device of gamma radiation (4) and a detecting device of beta-particles (5).

The case of the gamma radiation detecting device consists of the base (6) and the cylinder (7) interconnected by a coupling nut (8). Circuit elements of the gamma radiation detecting device are located on the rectangular printed circuit board that is cantilevered to the base. The free end of the circuit board is fixed in the case with the help of the spreader insulator. The digital processing circuit common for both detectors is also based on the circuit board.

The beta-particles detecting device is connected by the connector to the front part of the gamma radiation detecting device, mechanically connected by a coupling nut. Circuit elements of the beta-particles detecting device are located on three printed round circuit boards combined into a cylindrical module with the help of a special holder. The module is set in the case on the shock-absorbing gaskets.

To seal the combined detecting unit, the positions of joints of the case elements and the connection point of the connecting cable are gasketed with the help of elastic gaskets.

An extension tube of the length that may be modified within 450 to 750 mm is designed to be used with the detecting unit.

1.4.5.1.4 The remote detector of gamma radiation (Figure 9) is placed in a metal hermetic cylindrical case (1) and connected to the control panel with the help of the cable (2) with the connector (3). The 30 m long cable allows the operator to operate staying away from the radioactive source of high intensity at a significant distance.

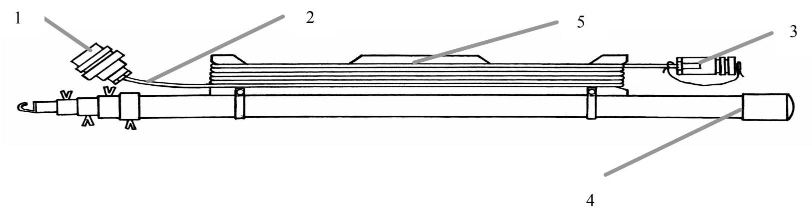


Figure 9 – Remote detector of gamma radiation

To study the radioactive sources of average power, a 5 m long telescopic tube (4) at extension is used. The case of the detector is hooked to the tube end, the cable is hung along the tube on special rings, with its inactive part wound around the tube frame (5) fastened to the main part of the tube (4). This frame also serves for the maintenance of the remote detector when inactive.

During shipping and storage, the folded telescopic tube together with the tube frame and the remote detector of gamma radiation is kept in the cover of close cloth (Figure 10).

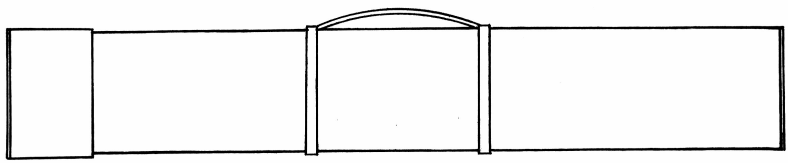

Figure 10 – Cover of the remote detector of gamma radiation

1.4.5.1.5 The casing (1) (Figure 11) ensures convenience when using the dosimeter on-site, or during storage and shipping of the dosimeter in the packing box. The inactive detecting unit is placed in a special cabinet and closed by a valve. The photo battery is fixed on the inside of the cover of the casing (2).

A U-shape rotary handle used for transportation is located on the outside of the cover. The transportation handle can be freely fixed, which allows using the handle as an adjustable stop for the photo battery insertion at an optimal angle to the source of light. The belts (3) fastened to the casing enable the user to carry the dosimeter in two positions: operating (on the breast) and mobile (on the shoulder).

1.4.5.1.6 The headphone (4) (Figure 11) consists of two small headphones and the cable with a plug for the control panel connection. The small headphones are fixed on the soft material handle.

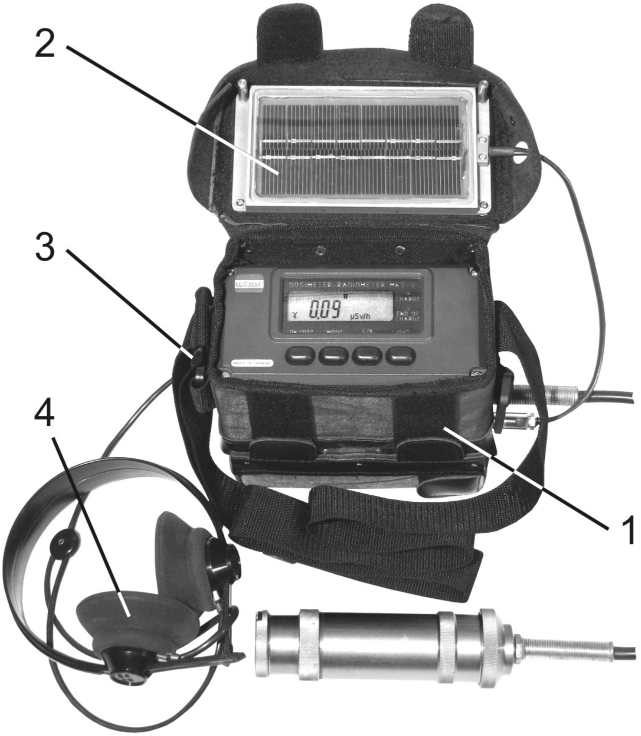


Figure11 – Dosimeter in casing

1.4.5.1.7 The power supply unit (1) (Figure 12) is connected to the dosimeter with the help of 1 m cable with a cable header. The power supply unit model in the delivery kit is not specified.


Figure 12 – Power supply unit and cable

The power cable (2) (Figure 12) serves to connect the dosimeter with the vehicle battery of 12 V power voltage. The 10 m cable is connected to the dosimeter through the cable header. Another cable end is equipped with two battery clips: positive - red and negative - black. The dosimeter is secured against incorrect connection of the power supply source with reverse polarity. To prevent contamination or oxidation of the contacts, all unit and cable headers of the dosimeter have end-caps, which are used in-between operation, during storage and shipping of the dosimeter.

1.4.5.1.8 A packing box (Figure 13) is used for storage and shipping of the main delivery kit of the dosimeter. The box is made of khaki enameled veneer and has a hinged cover with stops. The cover is closed with two stretching screws. A U-shape handle serves to carry the box. The box and the inner side wall of the cover contains the compartment, chambers, sockets, and clips for the accommodation of the dosimeter and its component parts, as well as equipment, tools, spare parts and maintenance documentation.

Figure 13 – Packing box

1.4.5.1.9 In addition to items described in 1.4.5.1.1 – 1.4.5.1.8, the delivery kit of the dosimeter includes spare parts, equipment and tools presented in Table 1.2 used during maintenance, repair and verification of the dosimeter.

1.5 Measuring tools, instruments and equipment

1.5.1 The list of measuring instruments, tools and equipment necessary for control, regulation and maintenance of the dosimeter and its component parts, is presented in Table 1.3.

Table 1.3 – List of measuring instruments, tools and equipment

| Item | Standards or basic specifications |
|---|---|
| 1 Special-purpose control device with $^{137}Cs$ source | Gamma radiation DER from the source at measurement point – from 10 to 30 µSv/h |
| 2 Stop-watch | Error – ± 1 s/day |
| 3 Digital universal voltmeter | B7-35,<br>Measurement range of direct current voltage – $10^{-4}$ to 1000 V;<br>Measurement range of direct current intensity– $10^{-7}$ to 1 A |
| 4 Universal power supply | ИПУ-12У2,<br>Voltage output – 0 to 30 V;<br>Current output – 0 to 2.5 A |
| 5 Standard equipment of gamma radiation | Gamma radiation exposure dose rate range – 100 µR/h to 100 R/h |
| 6 Special-purpose metrological equipment | Gamma radiation exposure dose rate range – 1.0 to 10000 R/h |
| 7 Beta radiation source | 2CO, surface flux density – 50 to 150 part./($cm^2$·min) |
| 8 Beta radiation source | 2CO, surface flux density – 750 to 1500 part./($cm^2$·min) |
| 9 Beta radiation source | 2CO, surface flux density – 50000 to 150000 part./($cm^2$·min) |
| 10 Screwdriver | Screwdriver (in packing box) |
| 11 Gasket | BICT.754152.002 (in packing box) |
| 12 Gasket | BICT.754152.002-01 (in packing box) |
| 13 Gasket | BICT.754152.002-02 (in packing box) |
| 14 Button | BICT.753161.001 (in packing box) |

1.6 Labeling and sealing

1.6.1 The name and the design letters of measurement instruments are inscribed on the upper part of the display panel of the dosimeter. The metal nameplate with the factory serial number and the date of manufacture of the dosimeter is fixed on the back wall of the control panel.

1.6.2 The left side wall of the packing box has the inscribed code of the dosimeter.

1.6.3 Sealing of the dosimeter is done by the manufacturer. The control panel of the dosimeter is sealed in the pockets for the fastening screw heads on the base and the display panel.

1.6.4 The main delivery kit of the dosimeter is placed into the packing box. Before shipping to the customer, the box is sealed with two seals near the stretching screws.

1.6.5 Removal of seals and repeated sealing of the dosimeter is done by the organization in charge of maintenance or verification of the dosimeters.

1.7 Packing

1.7.1 The MKS-U dosimeters-radiometers are designed on the basis of the DP-5V roentgen meters modernized by the manufacturer and supplied by the sponsoring agency. Industrial packaging (boxes, containers) are also supplied by the sponsoring agency. For lack of them, the dosimeters may be shipped in the packing boxes secured against damages with the help of such packing materials as polymer film, carton, wrapping paper folded several times etc.

1.7.2 Packing of the remote detector of gamma radiation

The remote detector of gamma radiation is placed on the telescopic tube frame and packed into the cover of close cloth. The latter, in turns, is packed in another cover made of polyethylene film, which is afterwards sealed. A box from corrugated cardboard is used for secondary package. Box flaps are taped. Box labeling is done according to the design documentation.

## 2 USE OF THE DOSIMETER

2.1 Operating limitations

Operating limitations are presented in Table 2.1.

Table 2.1 – Operating limitations

| Operating limitation | Parameters |
|---|---|
| 1 Ambient air temperature | From – 40 to +50 $^{o}$C |
| 2 Relative humidity | Up to (95±3) % at 35 $^{o}$C temperature |
| 3 Rain | Intensity not more than (5±2) mm/min |
| 4 Submergence of the remote detector of gamma radiation | Depth of 0.5 m |
| 5 Photon-ionizing radiation effect on:<br>- the control panel of the dosimeter<br>- the remote detector of gamma radiation | <br>DER up to 1.0 Sv/h during 50 min<br>DER up to 100 Sv/h during 500 min |

**Note – At operation in the temperature range from minus 21 to minus 40 $^{o}$C the dosimeter should operate from the external power supply source (~220 V / =12 V power supply unit or automobile storage battery).**

2.2 Preparation for operation

2.2.1 Safety measures

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

2.2.1.2 Radiation safety requirements should be met while using ionizing radiation sources.

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

2.2.2 External examination procedure

2.2.2.1 Unpack the dosimeter, and check if the delivery kit is complete. Inspect for mechanical damage.

2.2.2.2 Before using the dosimeter that was put in prolonged storage, remove it from storage and check its operability.

2.2.2.3 Register the removal from storage and putting the dosimeter into operation in the logbook.

2.2.3 Rules and order of examination for operational readiness

2.2.3.1 Examine the control buttons before switching the dosimeter on.

2.2.3.2 Open the battery compartment of the control panel of the dosimeter and make sure the five batteries are inserted, the connections are reliable, and there is no leakage of salts after the long-term storage of the dosimeter. In case there is salt leakage, remove the batteries. Clean them if possible, or replace if not. Afterwards, insert the cassette of batteries and close the lid of the battery compartment.

2.2.3.3 If necessary (minimum three battery symbol segments that are blinking on the LCD when the dosimeter is turned on irrespective of the selected mode indicate the discharge), recharge the storage battery according to OM 2.3.4.11.

2.2.3.4 If necessary to measure the emergency levels of photon-ionizing radiation DER, connect the remote detector of gamma radiation to the dosimeter with the help of the connecting cable through the corresponding connector in the bottom side part of the control panel of the dosimeter.

2.2.4 Guidelines on switching on and testing the dosimeter with the description of the checking procedure of the dosimeter when in use

2.2.4.1 Prepare the dosimeter for operation by doing the following:

- unpack the control panel of the dosimeter, and the remote detector of gamma radiation with the telescopic tube and the tube frame;
- unpack the detecting unit (CDU) from of the control panel case, and attach it to the tube, inserting the end clearance of the tube into the connecting jack of the CDU. Press until bumping and turn to fix it.
- fasten the waist and shoulder belts to the case.

2.2.4.2 Switch the dosimeter on by shortly pressing the ON button. The dosimeter should immediately enter the mode of photon-ionizing radiation DER measurement. A "γ" symbol and "μSv/h" measurement units should appear on the liquid crystal display at that, and every gamma quantum should be followed by an audio signal.

Rough gamma background value will be indicated on the liquid crystal display within 5 s. The digits will keep blinking on the liquid crystal display until the process of measurement results averaging is finished.

Unscrew the cover from the control source holder mounted on the inside of the packing box cover.

Put the CDU with the "+" metrological mark as close as possible to the control source, and perform control measurement of photon-ionizing radiation DER. The result received after the digits stop blinking on the liquid crystal display should be equal to _______±______ μSv/h.

2.2.4.3 Press the "γ/β" button and hold it pressed until the dosimeter switches to the mode of beta-particles flux density measurement. A "β" symbol and the "$10^3/(cm^2·min)$" measurement units should appear on the digital liquid crystal display. Every detected beta-particle is followed by an audio signal. Put the end of the CDU as close as possible to the control source, after opening the beta detector window, and perform control measurement of beta-particles flux density.

The result received after the digits stop blinking on the liquid crystal display should be equal to _______±_______ $10^3/(cm^2·min)$.

Close the cover of the control source holder.

**Note. Control values of $^{137}Cs$ source should be corrected according to the half-life of the radionuclide.**

2.2.4.4 Press shortly the MODE button and make sure the dosimeter switched to the mode of operator's DE indication. A "γ" symbol and "mSv" measurement units and a comma after the first left digit should appear on the liquid crystal display at that.

2.2.4.5 Press shortly the MODE button and make sure the dosimeter switched to the mode of indication of DE accumulation time by the operator. A comma blinking with an interval of a second separates two pairs of digits on the liquid crystal display. The last right digit should change every minute per unit.

2.2.4.6 Press shortly the LIGHT button and make sure the display backlight is switched on. It should switch off in 8 s.

2.2.4.7 Press shortly the MODE button and make sure the dosimeter switched to the mode of viewing of the measurement results stored in the nonvolatile memory. This mode is indicated by an "Arch" symbol that appears on the liquid crystal display flashing in turns with the last measurement result stored in the nonvolatile memory.

If there are no earlier stored measurement results of photon-ionizing radiation DER or beta-particles flux density in the nonvolatile memory, the dosimeter switches to the mode of photon-ionizing radiation DER measurement.

2.2.4.8 Press shortly the MODE button to switch the dosimeter from the view mode of measurement results stored in the nonvolatile memory to the mode of photon-ionizing radiation DER measurement. Connect the remote detector of gamma radiation to the control panel of the dosimeter and observe a "γ" symbol and "mSv/h" measurement units on the liquid crystal display. In the mode of photon-ionizing radiation DER measurement by the remote detector, the detected gamma quanta are not followed by audio signaling.

2.2.4.9 In the mode of photon-ionizing radiation DER measurement, disconnect the remote detector of gamma radiation from the control panel of the dosimeter and connect the headphone to the corresponding plug socket in the left lower part of the control panel. By audio signaling that should be heard at detecting gamma quanta, make sure the headphone is operable.

2.2.5 Troubleshooting

2.2.5.1 Troubleshooting is presented in Table 2.2.

Table 2.2 – Troubleshooting

| Trouble | Probable cause | Troubleshooting |
|---|---|---|
| 1 The dosimeter is not turned on at pressing the ON button | 1 Storage battery discharged<br>2 No contact between the batteries and the battery compartment clamps<br>3 Storage battery is out of order | 1 Charge the storage battery<br>2 Restore the contact between the batteries and the battery compartment clamps<br>3 Replace the batteries |

Table 2.2 (continued)

| Trouble | Probable cause | Troubleshooting |
|---|---|---|
| 2 A discharge symbol appears on the LCD after the battery has been charged (minimum three segments of the power supply unit are blinking on the LCD) | 1 Poor contact between the batteries and battery compartment clamps<br>2 Storage battery is out of order | 1 Clean out the contacts and charge the storage battery<br>2 Replace the batteries and repeat charging the storage battery |
| 3 The dosimeter is not turned on when operated by or when the storage battery is charged by the power supply unit, automobile battery or photo battery | Conductor break of the connecting cable | Remove the conductor break of the connecting cable |
| 4 No audio signaling in the headphone at detection of ionizing parts by the detecting units | Conductor break of the connecting cable | Remove the conductor break of the connecting cable |

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

2.3 Use of the dosimeter

2.3.1 Safety measures during use of the dosimeter.

2.3.1.1 Note that to check the operability of the dosimeter during its use a $^{137}Cs$ radioactive control source is used. The source is put into a special holder designed in such a way that it is completely safe to use the source during the check-up. The holder is mounted on the inside of the packing box cover. When the operability of the dosimeter is checked, the holder with the control source should be closed with the protective cover.

2.3.1.2 Radiation safety requirements should be met while using the ionizing radiation sources.

2.3.1.3 Note that the power supply unit of ~220 V / =12 V used for the storage battery charging should be used only indoors or under the shelter that protects the device from atmospheric precipitations.

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

2.3.2 **Operating modes of the dosimeter**

The dosimeter operates within the following modes:

- photon-ionizing radiation DER measurement by the CDU or RD;
- beta-particles flux density measurement by the CDU;
- indication of photon-ionizing radiation DE measurement;
- indication of photon-ionizing radiation DE accumulation time;
- viewing of measurement results stored in the nonvolatile memory;

2.3.3 **Control buttons of the dosimeter**

The dosimeter is operated with the help of the ON, MODE, "γ/β", and LIGHT buttons located on the front panel of the control panel.

The ON button serves to switch the dosimeter on/off, and to store measurement results in the nonvolatile memory.

The LIGHT button serves to switch the display backlight of the dosimeter on/off.

The MODE button serves to switch between the operating modes of the dosimeter.

Generally, the control algorithm of the dosimeter with the help of the control buttons is performed as follows.

After the dosimeter is switched on, it always enters the photon-ionizing radiation DER measurement mode. Short pressing of the MODE button switches the dosimeter between the modes in the following order:

- photon-ionizing radiation DER or beta-particles flux density measurement;
- photon-ionizing radiation DE measurement indication;
- DE accumulation time indication;
- viewing of measurement results stored in the nonvolatile memory;

From the mode of measurement results viewing, the dosimeter switches again to the mode of photon-ionizing radiation DER or beta-particles flux density measurement by pressing the MODE button.

If no measurement results of photon-ionizing radiation DER or beta-particles flux density are stored in the nonvolatile memory, the dosimeter returns from the mode of DE accumulation time indication directly to the mode of photon-ionizing radiation or beta-particles flux density measurement after the MODE button is pressed.

Switch the dosimeter from photon-ionizing radiation DER measurement to beta-particles flux density measurement and vice versa by the "γ/β" button. To switch, press this button and hold it pressed not less than 2 s.

2.3.4 **Operating procedure**

2.3.4.1 **Switching the dosimeter on/off**

Press shortly the ON button to switch the dosimeter on. Information displayed on the LCD and audio signaling of the detected gamma quanta indicate that the dosimeter is switched on. Press the ON button once again and hold it pressed for 6 s to switch the dosimeter off.

2.3.4.2 **Switching display backlight on/off**

Press shortly the LIGHT button to switch the display backlight on for 8 s. The display backlight is switched off automatically in 8 s.

Press the LIGHT button (c. 6 s) until short double backlight blinking to switch continuous backlight of the dosimeter display. Press shortly the LIGHT button to switch the backlight of the display off.

2.3.4.3 **Measurement of photon-ionizing radiation DER**

The dosimeter enters the mode of photon-ionizing radiation DER measurement after being switched on. It is indicated by a "γ" symbol and "μSv/h", “mSv/h” or “Sv/h” units of measurement that appear on the digital liquid crystal display.

Photon-ionizing radiation DER can be measured by the combined detecting unit (CDU) or the remote detector (RD). If the RD cable is not attached to the connector of the control panel of the dosimeter, measurement is done by the CDU. As soon as the RD cable is connected, the dosimeter automatically starts measuring photon-ionizing radiation DER by the RD. After the RD cable is disconnected from the control panel of the dosimeter, DER is again measured by the CDU.

To measure photon-ionizing radiation DER by the CDU, direct the dosimeter with the “+” metrological mark towards the examined object. At DER measurement by the CDU, every detected gamma quantum is followed by a short audio signal.

Measurement results are displayed on the digital display each 2 s after measurement started. Until the statistical error of DER measurement results remains bigger than the main permissible error given in Table 1.1, the digits keep blinking on the liquid crystal display. Initial results may be used for prompt evaluation of DER measurement.

In the process of integration, the statistical error of measurement will decrease. As it becomes smaller than the main relative permissible error, the digits stop blinking on the liquid crystal display.

If DER of measurement does not change essentially, the integration process will continue, and, accordingly, the statistical error will decrease. The substantial change (more than in 10 times) of measured radiation DER will automatically restart the integration process, making fast evaluation of new DER possible. The integration process can be forced to restart by shortly pressing the "γ/β" button.

Every DER value received after the digits stop blinking on the liquid crystal display should be considered as the DER measurement result.

Instantaneous value of radiation intensity should be evaluated according to the analog indicator located in the right upper field of the liquid crystal display. The analog indicator consists of twenty segments that cover the whole range of measurement channel in pseudo logarithmic scale.

To measure photon-ionizing radiation DER by the RD, connect the RD cable to the connector on the control panel of the dosimeter, and place the RD near the examined object. At DER measurement by the RD, the detected gamma quanta are not followed by audio signals.

Arithmetic mean of five last measurements received in 15 s after the beginning of measurement should be considered as DER measurement result.

Instantaneous value of radiation intensity can be evaluated according to the analog indicator much as while using the CDU.

The dosimeter provides storing up to 4096 measurement results in the nonvolatile memory. Press shortly the ON button to store measurement results in the nonvolatile memory. This will make a “P” symbol and three decimal digits to the right, identifying the number of the object that is under measurement, appear on the liquid crystal display. The number of the object can be set within 000 to 999 range.

The number of the object can be set with the help of the "γ/β" and MODE buttons. Short pressing of the "γ/β" button changes the blinking decimal digit value per unit. By pressing the "γ/β" button and holding it pressed, the blinking decimal digit value will automatically shift. After releasing the "γ/β" button, shifting will be stopped. Short pressing of the MODE button allows changing the next decimal digit. The latter starts blinking at that.

The DER measurement result and the object number are stored in the nonvolatile memory by short pressing of the ON button, which is followed by typical blinking of the analog display. Concurrently, time and date of storing are also automatically saved in the nonvolatile memory.

Time and date information is provided by the time and date meter of the dosimeter. The meter keeps working constantly after the batteries are inserted into the battery compartment of the dosimeter. Real time and date reference of the meter is done during communication with the personal computer (PC) through infrared port.

After the information is saved, the dosimeter automatically returns to photon-ionizing radiation DER measurement.

If no information saved during 16 s, the dosimeter automatically returns to photon-ionizing radiation DER measurement mode.

The dosimeter provides programming of photon-ionizing radiation DER threshold level. When the latter exceeded, the dosimeter sends light and two-tone audio signals. A separate threshold level is programmed for each detecting unit. When zero value is programmed, the exceeding of the threshold level is not checked. All threshold levels are zeroed each time when the dosimeter is switched on.

At DER measurement by the CDU, the threshold level is programmed in the range of 0 to 9.999 Sv/h with 0.1 μSv/h resolution; at measurement by the RD – in the range of 0 to 99.99 Sv/h with 10 mSv/h resolution.

To view the programmed threshold level, press the ON button, and while holding it down press the “γ/β” button. The threshold level will be displayed on the LCD until the “γ/β” button released.

At holding the “γ/β” button longer than 6 seconds, the earlier programmed threshold level can be zeroed and a new one programmed. A low order digit that can be corrected starts blinking indicating that a new threshold level can be programmed. Programming is done with the help of the “γ/β” and MODE buttons, much like the object number is entered when working with the nonvolatile memory.

The “γ/β” button changes the value of the blinking digit, while the MODE button proceeds to correcting the next digit. After the last digit is corrected, the new threshold level is saved in the memory of the dosimeter, which is indicated by short blinking of all four digits of the liquid crystal display and the returning of the dosimeter to photon-ionizing radiation DER measurement mode.

If during new threshold level programming a pause of over 16 s occurs, that is neither “γ/β” nor MODE buttons are pressed, the dosimeter will automatically return to the mode of photon-ionizing radiation DER measurement with previously preset threshold level.

2.3.4.4 **Beta-particles flux density measurement**

To switch from the mode of photon-ionizing radiation DER measurement to the mode of beta-particles flux density, press shortly and hold pressed the "γ/β" button for 2 s. The RD cable should be disconnected from the connector on the control panel of the dosimeter. The mode of beta-particles flux density measurement is indicated by a "β" symbol and "$10^3/(cm^2 \cdot min)$" units of measurement on the liquid crystal display.

Beta-particles flux density can be measured only by the CDU. To do this, open the window of the beta detector of the CDU, direct its edge parallel to the examined surface, placing it as close as possible. Every detected beta-particle is followed by a short audio signal.

Measurement results will be displayed on the digital display each 2 s after the beginning of measurement. Until the statistical error of beta-particles flux density measurement results is bigger than the main permissible error given in Table 1.1, the digits will keep blinking on the liquid crystal display. Initial results may be used for prompt evaluation of flux density measurement. In the process of integration the statistical error of measurement will decrease. When it becomes smaller than the main relative permissible error, the digits on the liquid crystal display will stop blinking.

If beta-particles flux density measurement is not changed essentially, the integration process will continue, and, accordingly, the statistical error will decrease. The substantial change (more than in 10 times) of surface flux density measurement will automatically restart the integration process making fast evaluation of new DER possible. The integration process can be forced to restart by shortly pressing the "γ/β" button.

Each flux density measurement received after the digits stop blinking on the liquid crystal display should be considered as the beta-particles flux density measurement result.

Instantaneous value of beta-particles flux intensity can be also evaluated according to the analog indicator located in the right upper field of the liquid crystal display.

The analog indicator consists of twenty segments covering the whole range of the measurement channel in pseudo logarithmic scale.

The dosimeter provides measurement and storage of the cumulative value of inherent gamma background of the detector and the examined object for its further subtraction from beta-particles flux density measurement result. After the dosimeter switches to the mode of beta-particles flux density measurement, a blinking „γ" symbol appears on the liquid crystal display indicating that gamma background value is not included in beta-particles flux density measurement result.

To measure gamma background, close the window of the beta detector by the filter, and place it near the examined object. Then by shortly pressing the "γ/β" button restart the integration process and wait until digits on the liquid crystal display stop blinking. The process may be time-consuming and may need up to 10 min for the levels close to background. Press shortly the MODE button to store measured gamma background after the digits stop blinking on the liquid crystal display. No "γ" symbol and close to zero value on the liquid crystal display indicate that gamma background is stored and subtracted from beta-particles measurement results. Open the window of beta detector afterwards.

The further measurement will be done with automatic subtraction of the stored gamma background.

Before measuring beta-particles flux density of another examined object, delete the previous value of gamma background, and perform a new gamma background measurement and storage.

For this purpose do the following:

- press the "γ/β" button and hold it pressed until a "γ" symbol and "μSv/h" units of measurement appear on the liquid crystal display. This will switch the dosimeter from the beta-particles flux density measurement mode to the mode of photon-ionizing radiation DER measurement;

- press the "γ/β" button again and hold it pressed until a "β" symbol, a flashing "γ" symbol and "$10^3/(cm^2 \cdot min)$" units of measurement appear on the liquid crystal display. This will switch the dosimeter from the photon-ionizing radiation DER measurement mode to the mode of beta-particles flux density;

- perform measurement and store gamma background according to the above procedure.

Beta-particles flux density measurement result can not be stored in the nonvolatile memory until gamma background is measured and stored. A blinking "γ" symbol on the digital display will indicate the above. After gamma background is measured and stored, the flux density measurement result can be stored in the nonvolatile memory much as storing the photon-ionizing radiation DER.

The dosimeter provides programming of beta-particles surface flux density threshold level. When the latter exceeded, the dosimeter sends light and two-tone audio signals. The threshold level can be programmed in the range of 0 to $99.99 \cdot 10^3$ part./$(cm^2 \cdot min)$ with $0.01 \cdot 10^3$ part./$(cm^2 \cdot min)$ resolution. When zero value is programmed, the exceeding of the threshold level is not checked. All threshold levels are zeroed each time when the dosimeter is switched on.

Viewing of the programmed beta-particles threshold levels and programming of the new ones is done much as the DER threshold level viewing and programming, which is described in 2.3.4.3.

2.3.4.5 **Indication of photon-ionizing radiation DE measurement**

DE is measured by the BDD built-in the control panel. Measurement is started immediately after the dosimeter is switched on, and continues irrespective of the mode. At switching the dosimeter on, the preset DE equals 0.000 mSv. If gamma background is close to natural, the lower digit of the DE scale on the LCD will change per unit approximately in 10 hrs. Measured DE values are automatically stored in the nonvolatile memory with 5 min interval.

The dosimeter can be switched to the mode of photon-ionizing radiation DE measurement indication from any other operating mode by shortly pressing the MODE button. This mode follows the mode of photon-ionizing radiation DER or beta-particles flux density measurement mode. In the mode of DE measurement a "γ" symbol and "mSv" units of measurement appear on the liquid crystal display.

2.3.4.6 **Indication of photon-ionizing radiation DE accumulation time**

The dosimeter can be switched to the mode of indication of photon-ionizing radiation DE accumulation time from any other operating mode by short pressing of the MODE button. It follows the photon-ionizing radiation DE measurement indication mode.

In this mode, time is displayed on the LCD in the following format:

HH.MM,

where HH stands for hours, and MM for minutes of DE accumulation.

Hours and minutes are separated by a comma that is blinking with 1 Hz frequency.

2.3.4.7 **Viewing of measurement results stored in the nonvolatile memory**

The dosimeter can be switched to the viewing mode of measurement results from any other operating mode by short pressing of the MODE button, if photon-ionizing radiation DER or beta-particles flux density measurement results are stored in the nonvolatile memory.

This mode follows the mode of photon-ionizing radiation DE accumulation time indication. If no photon-ionizing radiation DER or beta-particles flux density measurement results are stored in the nonvolatile memory, the dosimeter is switched from the mode of DE accumulation time indication to the mode of photon-ionizing radiation DER measurement mode at pressing the MODE button.

In the mode of measurement results viewing an "Arch" symbol appears on the digital display blinking in turns with the fetched from the memory measurement result. Both photon-ionizing radiation DER, or beta-particles flux density measurement result, and the number of the measurement referred object can be displayed on the liquid crystal display. Shortly press the "γ/β" button for either a measurement result or a number of the measurement referred object to be displayed.

Shortly press the ON button to view the next measurement result or the object number.

Photon-ionizing radiation DE measurement results that are automatically saved in the nonvolatile memory can be viewed only from the PC. To do this, the information from the nonvolatile memory should be transmitted to the PC through infrared port.

2.3.4.8 **PC communications**

To transmit information from the nonvolatile memory to the PC, place the active dosimeter opposite the infrared port adapter. The infrared port window of the dosimeter, located on the front of the control panel, should not be farther than 30 cm from the adapter window. The software that accepts and processes information from the dosimeter should be already launched on the PC, and the infrared port adapter connected to the PC.

Time of PC communications depends on the number or the results stored in the nonvolatile memory, and can continue from 5 to 45 s. An audio signal and the appropriate message popping up on the PC monitor indicate that the transmission procedure is finished.

After correctly transmitted to the PC, the information is deleted from the nonvolatile memory.

In the process of information transmission, time and date meter of the dosimeter is programmed by the PC real time and date. This meter continues to work uninterruptedly, irrespective of the selected operating mode, and whether the dosimeter is on or off, from the moment when the batteries are inserted into the battery compartment of the dosimeter.

2.3.4.9 **Deletion of information from the nonvolatile memory**

Information can be deleted from the nonvolatile memory in the mode of photon-ionizing radiation DER or beta-particles flux density measurement. To delete information from the nonvolatile memory, do the following:

- press shortly the MODE button holding pressed the ON button. An “Arch” symbol should appear on the digital display;
- release the ON button and press shortly the MODE button again. This will delete the information from the nonvolatile memory, which will be indicated by double blinking of the “Arch” symbol.

2.3.4.10 **Storage battery discharge warning**

Irrespective of the operating mode, the storage battery discharge is uninterruptedly controlled. The discharge of the storage battery is displayed with the help of the battery symbol that is located in the right lower part of the liquid crystal display. The battery symbol consists of four segments showing full capacity of the storage battery. When the battery is about 25 % discharged, the first of four segments is blinking, at 50 % discharge – two segments, at 75 % discharge – three segments. When the storage battery is completely discharged, all four segments are blinking.

2.3.4.11 **Storage battery charging**

Blinking of three or four segments of the battery indicates that the storage battery should be charged. The storage battery is charged with the help of the charging device built-in the control panel. The power supply of ~220 V / =12 V, the automobile battery (+12 V) or the photo battery (in field conditions under direct solar illumination) may serve as the external power sources for charging. To charge, connect the external power source to the connector on the control panel of the dosimeter. The automobile battery is connected with the help of the power cable that is included in the dosimeter kit.

The storage battery charging from the power supply unit of ~220 V / =12 V should be done only indoors or under shelter to protect the power supply from atmospheric precipitations.

The storage battery charging from the power supply unit or automobile battery should be done at ambient air temperature from +5 to +40 $^{o}$C. Charging at the temperature that is not within this range will increase the time of charging and decrease the resource of the storage battery.

The charging process of the storage battery is done automatically, which is indicated by the light-emitting diodes CHARGING and END OF CHARGING, located on the indication and control panel of the dosimeter. Uninterrupted CHARGING lighting indicates that the charging process is normal. Interrupted lighting of this diode shows that charging is done in the environment that is not within the recommended temperature range. Uninterrupted END OF CHARGING lighting informs that charging was finished correctly, while interrupted lighting - of the incorrect end of charging. In case of incorrect end of charging, check the storage battery and external power supply sources.

Time of the storage battery charging in the recommended temperature range is about 2.5 hrs. If the charging process is done under the temperature that is beyond the recommended range, time of charging increases from 5 to 7 hrs. Time of charging depends also on the residual capacitance of the storage battery.

Repeated charging of the battery is recommended only when it is completely discharged. Otherwise it may reduce its resources.

2.3.5 Operability control of the dosimeter during its use is presented in item 2.2.4 of this OM.

2.3.6 List of possible troubles during use of the dosimeter and recommendations on the solution is presented in OM 2.2.5.

# 3 TECHNICAL MAINTENANCE

3.1 Technical maintenance of the dosimeter

3.1.1 General instructions.

The list of operations at technical maintenance (hereinafter the TM) of the dosimeter, the order and peculiarities on different stages of use of the dosimeter are given in Table 3.1.

Table 3.1 – List of operations at technical maintenance

| List of operations | TM type | | | OM item No. |
|---|---|---|---|---|
| | during | | during long-term storage | |
| | everyday use | periodical use | | |
| External examination | + | + | + | 3.1.3.1 |
| Delivery kit completeness check | - | + | + | 3.1.3.2 |
| Performance check | + | + | + | 3.1.3.3 |
| Switching the dosimeter off | + | + | + | 2.3.4.1 |
| Storage battery disconnection and its elements condition control | - | - | + | 3.1.3.4 |
| Damaged covering repair | - | + | + | 3.1.3.5 |
| Verification of the dosimeter | - | + | + | 3.2 |
| Operations register | + | - | - | 3.1.3.6 |
| **Note.** "+" means the operation is applicable at this type of TM, "-" means the operation is not applicable. | | | | |

3.1.2 Safety measures.

TM safety measures fully comply with the safety measures presented in OM 2.3.1.

The dosimeter is blast-proof and fire-safe.

3.1.3 TM 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 condition of the packing box: check the transportation handle and locks, the availability and reliability of the shock-absorbing gaskets, and the covering condition;

b) examine the case, check for breakings, check the accuracy of the belt fastenings, and the reliability of the covers fixed with the help of the buttons;

c) check the technical condition of the surface, the integrity of seals, the absence of scratches, traces of corrosion, and the surface damages of the dosimeter;

d) check the technical condition of the remote detector, the combined detecting unit and the connecting cable – check for damages, dents, corrosion traces, thin places of the cable;

e) check the connectors in the points of connection with the photo battery, and the connectors of the remote detector and the headphone.

Clean the packing box inside and outside from dirtying.

Wipe metal unpainted parts of the dosimeter and its component parts with the oiled cloth after use in the rain or after special treatment.

3.1.3.2 Delivery kit completeness check

Check if the delivery kit is complete according to the Table 1.2. Check also the technical condition and the order of the component parts of the dosimeter, and the availability of the maintenance documentation.

3.1.3.3 Performance check of the dosimeter

3.1.3.3.1 Performance check of the dosimeter and its procedure is done according to 2.2.4 OM and the Table 3.2.

Table 3.2 – Performance check of the dosimeter

| Name | Checked by | Measuring instruments, supporting equipment | Control points |
|---|---|---|---|
| 1 Operability test of the channel of photon-ionizing radiation DER measured by the CDU | operator | control source $^{137}Cs$ | ____ ± ____ μSv/h |
| 2 Operability test of the channel of beta-particles flux density measured by the CDU | operator | control source $^{137}Cs$ | ____ ± ____ $10^3$ part./(cm$^2$·min) |

3.1.3.3.2 Order of pre-repair fault detection and rejection

Use the following criteria to determine the necessity of repairing the dosimeter, and the adequate type of repair:

- for mid-life repair:

a) deviation of parameters from control points during daily operability test of the dosimeter;

b) deviation of parameters from control points during periodical test of the dosimeter;

c) minor defects of the digital liquid crystal display that do not affect the correct readings of measurement results;

d) no display backlight;

e) no audio signaling;

- for major repairs:

a) at least one non-operating measurement channel;

b) operation defects of the digital liquid crystal display that affect the correct readings of measurement results;

c) serious mechanical damages of the details that affect the dust and humidity protection.

3.1.3.4 Storage battery switching off and its elements condition control

The storage battery is switched off each time after the dosimeter is turned off without removing the batteries from the battery compartment. Before the long-term storage of the dosimeter, the dosimeter should be switched off and the batteries removed from the battery compartment.

In this case do the following:

- switch the dosimeter off;
- remove the lid of the battery compartment;
- remove the batteries;
- examine the battery compartment, check the innerseals and contact springs, clean the battery compartment from dirtying and contact springs from oxides;
- make sure there is no humidity, no salt spots on the surface of the batteries, and the insulated coating is not damaged;
- pack the batteries in the plastic bag and put it in a special compartment of the packing case.

3.1.3.5 Damaged covering repair

The damaged covering of the packing case should be enameled.

Choose carefully the proper tint to try to match the color of the lacquered covering (to avoid significant difference in color). Clean the area that should be enameled. The paint should be smoothly applied to the surface with the help of the brush.

3.1.3.6 Operation register

Register the time of actual use of the dosimeter in section 11 of the logbook.

3.2 Verification of the dosimeter

The verification of the dosimeter should be performed after manufacture and repair or during maintenance (periodically, at least once a year).

3.2.1 Verification operations

During verification, the operations presented in Table 3.3 should be performed.

Table 3.3 – Verification operations

| Name of operation | Verification procedure No. |
|---|---|
| 1 External examination | 3.2.4.1 |
| 2 Testing | 3.2.4.2 |
| 3 Calculation of main relative error of photon-ionizing radiation DER measured by the combined detecting unit | 3.2.4.3 |
| 4 Calculation of main relative error of photon-ionizing radiation DER measured by the remote detecting unit | 3.2.4.4 |
| 5 Calculation of main relative error of photon-ionizing radiation DE measured by the built-in detector of operator's dose | 3.2.4.5 |
| 6 Calculation of main relative error of beta-particles flux density measured by the combined detecting unit | 3.2.4.6 |

3.2.2 Verification facilities

The following measuring instruments should be used for verification:

- УПГД-2 standard equipment of gamma radiation with $^{137}Cs$ gamma radiation sources;
- standard beta radiation sources of 2CO type containing $^{90}Sr$+$^{90}Y$ radionuclides on a hard pad;
- $^{137}Cs$ source of gamma radiation;
- special metrological equipment;
- electronic stop-watch.

All verification facilities should have a valid verification certificate or state metrological qualification.

**Note**. Other standard measuring instruments with like specifications to those presented in item 3.2.2 can be used.

3.2.3 Verification conditions

The verification test should be carried out under the following conditions:

- ambient air temperature within (20±5) °C;
- relative air humidity within (65±15) %;
- atmospheric pressure from 84 to 106.7 kPa;
- natural background level of gamma radiation not more than 0.25 μSv/h;
- power supply voltage of (6.00±0.25) V.

3.2.4 Verification procedure

3.2.4.1 External examination

During the external examination, the dosimeter should meet the following requirements:

- the delivery kit should be completed as described in section 3 of the logbook;

- labeling should be accurate;
- Quality Control Department seals should not be violated;
- the dosimeter should be free from mechanical damages that may affect its work.

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

3.2.4.2 Testing

Switch the dosimeter on and place the CDU near the source of $^{137}Cs$ gamma radiation. Observe DER count increasing above the background level on the liquid crystal display of the control panel, and audio signaling at gamma quanta detection by the detecting unit.

Switch the dosimeter to the mode of beta-particles flux density measurement. Place the CDU with the window of the beta detector above the source surface of 2CO type, and observe the beta-particles flux density count increasing above the background level on the liquid-crystal display, and audio signaling at beta-particles detection by the detecting unit.

3.2.4.3 Calculation of the main relative error of photon-ionizing radiation DER measurement by the CDU

Prepare the standard equipment of gamma radiation УПГД-2 (hereinafter УПГД-2) for operation according to its operating manual.

Prepare the dosimeter for photon-ionizing radiation DER measurement (hereinafter DER) according to OM 2.3.4.

Fix the CDU in the УПГД-2 holder so that the mechanical center of gamma beam coincides with the center of the gamma detector.

Perform five measurements of DER background indoors, after the liquid crystal display digits stop blinking, and register the received readings in the protocol.

Place the УПГД-2 with the CDU in the position, where DER from $^{137}Cs$ source is 0.8 μSv/h.

Perform five measurement of DER after the digits stop blinking on the liquid crystal display.

Register the received readings in the protocol.

Calculate the average DER value according to the formula (1), and the main relative error of measurement.

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

where:

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

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

Place the УПГД-2 with the CDU in the position, where DER from $^{137}Cs$ source is 8.0 μSv/h.

Perform five measurements of DER after the digits stop blinking on the liquid crystal display.

Register the received readings in the protocol.

Calculate the average DER value according to the formula (1), and the main relative error of measurement.

Place the УПГД-2 with the CDU in the position, where DER from $^{137}Cs$ source is 80.0 μSv/h.

Perform five measurements of DER after the digits stop blinking on the liquid crystal display.

Register the received readings in the protocol.

Calculate the average DER value according to the formula (1), and the main relative error of measurement.

Place the УПГД-2 with the CDU in the position, where DER from $^{137}Cs$ source is $8 \cdot 10^2$ μSv/h.

Perform five measurements of DER after the digits stop blinking on the liquid crystal display.

Register the received readings in the protocol.

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

Place the УПГД-2 with the CDU in the position, where DER from $^{137}Cs$ source is $8 \cdot 10^3$ μSv/h.

Perform five measurements of DER after the digits stop blinking on the liquid crystal display.

Register the received readings in the protocol.

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

Place the УПГД-2 with the CDU in the position, where DER from $^{137}Cs$ source is $8 \cdot 10^4$ μSv/h.

Perform five measurements of DER after the digits stop blinking on the liquid crystal display.

Register the received readings in the protocol.

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

Place the УПГД-2 with the CDU in the position, where DER from $^{137}Cs$ source is $8 \cdot 10^6$ μSv/h.

Perform five measurements of DER after the digits stop blinking on the liquid crystal display.

Register the received readings in the protocol.

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

The dosimeter is acknowledged to have passed the verification test if the main relative error of measurement by the CDU for each DER level does not exceed the value, which is calculated according to the formula $\delta\dot{H}^*(10) = 15 + \frac{2}{\dot{H}^*(10)}$, where $\dot{H}^*(10)$ is a numeric value of measured DER in μSv/h.

3.2.4.4 Calculation of the main relative error of photon-ionizing radiation DER measurement by the RD

Prepare the special metrological equipment for operation according to its operating manual.

Prepare the dosimeter for photon-ionizing radiation DER measurement by the RD according to OM 2.3.4.

Fix the RD in the holder of the special metrological equipment so that the mechanical center of gamma beam coincides with the center of the gamma detector.

Place the holder of the equipment with the RD in the position, where DER from $^{137}Cs$ source is 100 mSv/h.

Perform five measurements of DER in 20 s after the irradiation of the detector.

Register the received readings in the protocol. Calculate the average DER and the main relative error of measurement.

Place the holder of the equipment with the RD in the position, where DER from $^{137}Cs$ source is 1.0 Sv/h.

Perform five measurements of DER in 20 s after the irradiation of the detector.

Register the received readings in the protocol. Calculate the average DER and the main relative error of measurement.

Place the holder of the equipment with the RD in the position, where DER from $^{137}Cs$ source is in the range of 10 to 100 Sv/h.

Perform five measurements of DER in 20 s after the irradiation of the detector.

Register the received readings in the protocol. Calculate the average DER and the main relative error of measurement.

The dosimeter is acknowledged to have passed the verification test if the main relative error of measurement by the RD for each DER level does not exceed the value, which is calculated according to the formula $\delta\dot{H}^*(10) = 15 + \frac{200}{\dot{H}^*(10)}$, where $\dot{H}^*(10)$ is a numeric value of measured DER in mSv/h.

**Note.** Verification test can be done with the $^{60}Co$ gamma radiation source used by comparing the test results with the reference dosimeter with maximum main relative error of DER measurement not exceeding ±10 % and with consideration of energy response of the dosimeter.

3.2.4.5 Calculation of the main relative error at photon-ionizing radiation DE measurement by the built-in detector of the operator's dose (hereinafter the BDD)

Prepare the dosimeter for photon-ionizing radiation DE measurement according to OM 2.3.4.

Prepare the УПГД-2 equipment for operation according to its operating manual.

Fix the control panel of the dosimeter in the УПГД-2 so that the mechanical center of gamma beam coincides with the center of gamma detector.

Place the УПГД-2 with the control panel of the dosimeter in the position, where DER from $^{137}Cs$ source is 80 μSv/h.

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

Register the DE measurement result after 60 minutes (according to the stop-watch) of irradiation, calculate the main relative error of measurement, and register the values in the protocol.

Place the УПГД-2 with the control panel of the dosimeter in the position, where DER from $^{137}Cs$ source $8 \cdot 10^2$ μSv/h.

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

Register the DE measurement result after 20 minutes (according to the stop-watch) of irradiation, calculate the main relative error of measurement, and register the values in the protocol.

Place the УПГД-2 with the control panel of the dosimeter in the position, where DER from $^{137}Cs$ source $8 \cdot 10^3$ μSv/h.

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

Register the DE measurement result after 10 minutes (according to the stop-watch) of irradiation, calculate the main relative error of measurement, and register the values in the protocol.

Place the УПГД-2 with the control panel of the dosimeter in the position, where DER from $^{137}Cs$ source $8 \cdot 10^4$ μSv/h.

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

Register the DE measurement result after 10 minutes (according to the stop-watch) of irradiation, calculate the main relative error of measurement, and register the values in the protocol.

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

3.2.4.6 Calculation of the main relative error at surface beta-particles flux density measurement by the CDU

Prepare the dosimeter for beta-particles flux density measurement by the CDU according to OM 2.3.4.

Close the window of the beta detector with the filter, measure gamma background outdoors, and store the reading in the memory of the dosimeter after the digits stop blinking on the liquid crystal display.

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

Perform five measurements of surface beta-particles flux density after the digits stop blinking on the liquid crystal display, displacing the source of beta-particles relative to the beta detector after each measurement, revolving it 15$^o$ on the main axis. Register the received results in the protocol.

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

Place the CDU with the open window above the 2CO source surface, providing surface beta-particles flux density from 750 to 1500 part./(cm$^2$·min), so that the work surface of the beta detector is in the center of the active surface of the source.

Perform five measurements of surface beta-particles flux density after the digits stop blinking on the liquid crystal display, displacing the source of beta-particles relative to the beta detector after each measurement, revolving it 15$^o$ on the main axis. Register the received results in the protocol.

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

Place the CDU with the open window above the 2CO source surface, providing surface beta-particles flux density from 50000 to 150000 part./(cm$^2$·min), so that the work surface of the beta detector is in the center of the active surface of the source.

Perform five measurements of surface beta-particles flux density after the digits stop blinking on the liquid crystal display, displacing the source of beta-particles relative to the beta detector after each measurement, revolving it 15$^o$ on the main axis. Register the received results in the protocol.

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

The dosimeter is acknowledged to have passed the test if the main relative error of measurement by the CDU for each beta-particles flux density level does not exceed the value, which is calculated according to the formula $\delta\phi_\beta = 20 + \frac{200}{\phi_\beta}$, where $\phi_\beta$ is a numeric value of measured surface flux density in part./(cm$^2$·min).

3.2.4.7 Presentation of the verification results

3.2.4.7.1 Positive results of the initial or periodic verification test are presented as follows:

1) initial verification is registered in the “Certificate of acceptance” section of the logbook ;

2) periodic verification is registered in the issued certificate of the established form or in the “Periodic verification of key specifications” section of the logbook.

3.2.4.7.2 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.

3.3 Putting the dosimeter in prolonged storage

3.3.1 The dosimeter is put in prolonged storage in order to be protected from the influence of high air moisture at storage. Only the operable dosimeter and the remote detector of gamma radiation (RD), with the complete delivery kit (with the telescopic tube and the case), can be put in prolonged storage.

The dosimeter and the RD can be put in prolonged storage (repeated storage) in shelters or special room at environment temperature from +5 to +40 $^{o}$C and relative humidity of 80 % at +25 $^{o}$C temperature.

3.3.2 During short-term storage (up to 12 months), putting in prolonged storage should be done in the following order: wipe all unpainted metal details of the dosimeter in the packing box and the metal parts of the RD with a cotton cloth wetted by petrol and lubricate them.

Wrap the dosimeter and the RD after lubrication in the parchment paper and tie with threads.

3.3.3 During long-term storage, the dosimeter and the RD should be put in prolonged storage by being placed in the hermetic cover of polyethylene film 200 mc thick with the desiccant (silica gel).

Wrap the dosimeter in the packing box with the wrapping paper, and put it in the polyethylene cover. Together with the box put 3 bags with silica gel (200 g each). One bag should be the test one (with letter K on it), and with exact weight of (200±1) g. Place the test-paper in plain view. Seal the cover, making the packing hermetic.

Put the remote detector (on the telescopic tube and in the canvas bag) into the polyethylene cover. Put the bag with 200 g silica gel in the polyethylene cover together with the detector. Seal the cover, making the packing hermetic.

The humidity of the silica gel should not exceed 2 %. Dry the silica gel on the metal plate not more than 5 mm thick under the temperature of 200 to 250 $^{o}$C in the drying boxes or special dryers for 3 to 5 hrs.

Time of the prolonged storage - 2 years.

Check the supplying with water of the silica gel after 1-year storage. For this, do the following: open the 5 % of the lot of covers that are checked, and weigh the test bags. If the supplying with water of the silica gel does not exceed 18 %, put the test bags in the covers and seal them; if it equals or exceeds 18 %, the whole lot of the dosimeters should be repeatedly put in prolonged storage.

3.3.4 The removal of the dosimeters from prolonged storage after short-term storage should be done as follows: unpack the dosimeter from the packing box, carefully remove the lubricant from the outer unpainted component parts of the dosimeter with the help of the cloth wetted by petrol, and wipe it with a dry and clean cloth afterwards.

To remove the RD from the prolonged storage after short-term storage, unwrap the detector from the parchment paper and wipe its component parts with a dry and clean cloth.

The removal of the dosimeter and the RD from the prolonged storage after long-term storage should be done by unpacking the dosimeter and the RD from the polyethylene covers.

**4 REPAIR**

4.1 In case of failure or troubles during the warranty period of the dosimeter, 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.***

**5 STORAGE**

5.1 The dosimeter should be stored in the packing box, and the remote detector of gamma radiation in the cover in heated and ventilated storehouses with air-conditioning at the environment temperature of +5 to +40 °C and relative humidity up to 80 % at +25 °C temperature, without humidity condensation if the temperature is lower. The storehouse should be free of dust, acids, gas and alkali that may cause corrosion, and vapors of organic solvents.

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

5.3 Dosimeters and remote detectors of gamma radiation should be stored on the shelves.

5.4 The distance between the walls, the floor of the storehouse and dosimeters should be at least 100 mm.

5.5 The distance between the heating gadgets of the storehouse and the dosimeters should be at least 0.5 m.

5.6 Average shelf life is not less than 10 years.

5.7 Provided that the dosimeter and the remote detector of gamma radiation are properly stored, periodically put in prolonged storage, and that no defects found at quality inspection according to item 3.1.3.3.2, the storage of the dosimeter and the RD can be extended for the next 5 years.

## 6 SHIPPING

6.1 Packed dosimeters and remote detectors of gamma radiation may be shipped by any kinds of closed transport vehicles in conformance with the rules and standards effective for each means of transport.

When shipped by railway, air, sea, or motor transport at any distances in the packing of the producer enterprise the following rules should be met:

- by railway: in clean closed cars;
- by air: in pressurized compartments;
- by sea: in dry holds;
- by car: in sedan cars;

6.2 Dosimeters and remote detectors of gamma radiation in shipping container should be placed and fastened in the transport so that their stable position is ensured and shocks are avoided.

6.3 The dosimeter and the remote detector of gamma radiation in shipping container endure:

- influence of temperature from minus 60 to +55 $^{o}$C;
- influence of relative humidity (95±3) % at 35 $^{o}$C temperature;
- influence of low atmospheric pressure of 23 kPa (170 mercury.)

6.4 Canting is forbidden.

## 7 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 hazardous for service personnel, and is environmentally friendly.

**APPENDIX A**

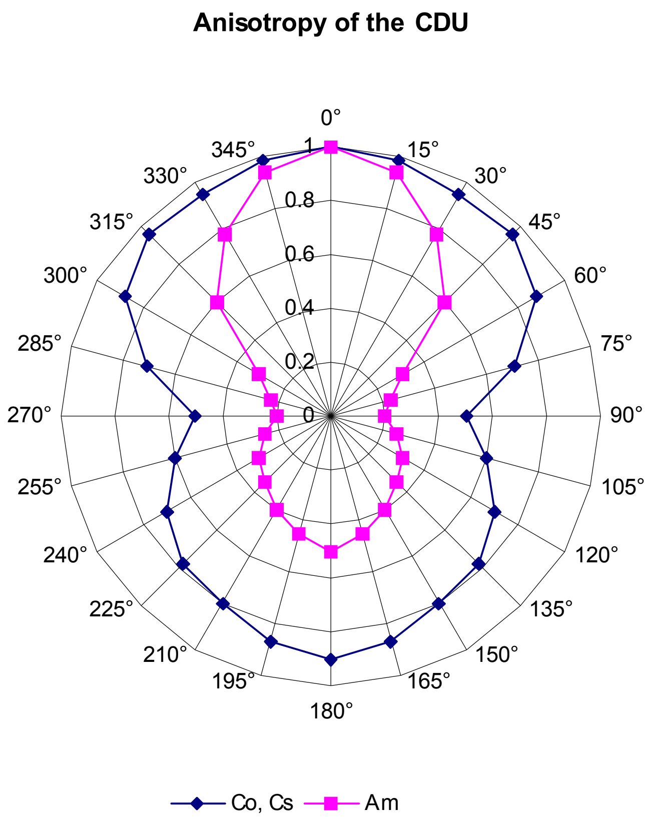


Figure A.1

## APPENDIX A

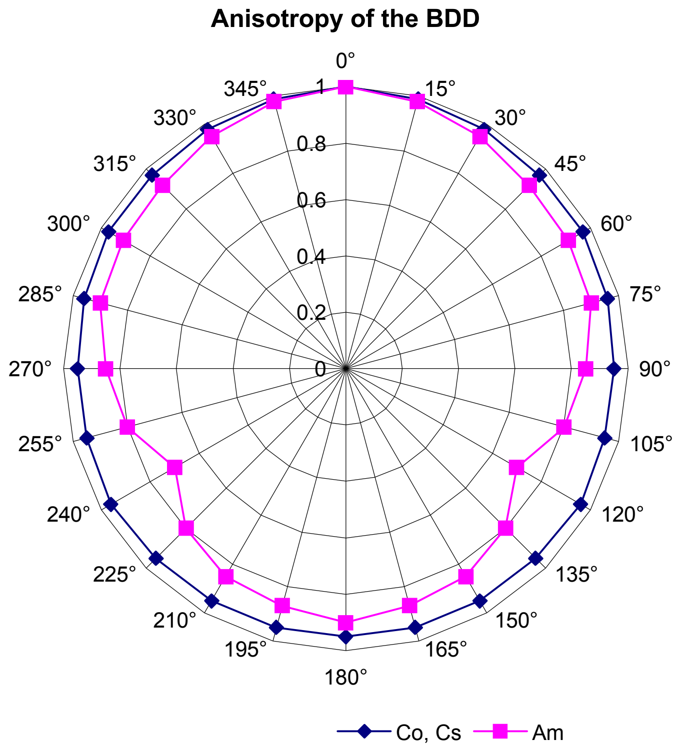


Figure A.2

**APPENDIX A**

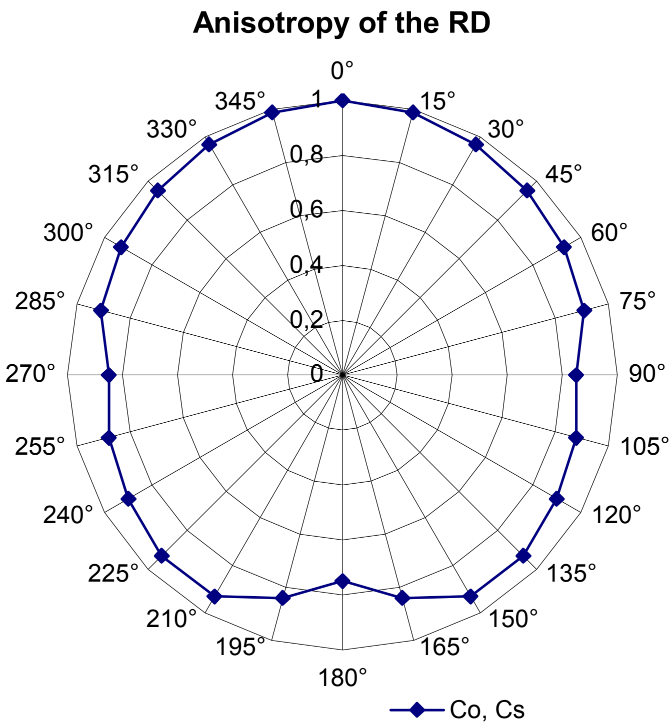


Figure A.3