# DKS-02PN “CADMIUM” SEARCH ALARM DOSIMETER

**Operating manual**
BICT.412129.002-04 HE

**CONTENTS**



This operating manual (hereinafter called the OM) is intended to inform the user about the theory of operation of the DKS-02PN "CADMIUM" search alarm dosimeter. The manual contains all information necessary for proper use of the dosimeter and full realization of its technical possibilities.

The OM contains the following abbreviations and symbols:

DER - ambient dose equivalent rate of gamma and X-ray radiation;

PC - personal computer.

## 1 DESCRIPTION AND OPERATION

### 1.1 Purpose of use

The DKS-02PN "CADMIUM" search alarm dosimeter (hereinafter called the dosimeter) is designed to search for (detect and localize) radioactive and nuclear materials relative to their external gamma and neutron radiation, as well as to measure ambient dose equivalent rate of gamma and X-ray radiation (hereinafter DER of photon-ionizing radiation).

The dosimeter is used to monitor the illicit transfer of radioactive materials and to search for radiation sources.

**1.2 Technical specifications**

1.2.1 Key specifications are presented in Table 1.1.

Table 1.1- Key specifications of the dosimeter

| Name | Unit of measurement | Standardized value |
|---|---|---|
| 1 Measurement range of gamma radiation DER | μSv/h | 0.1 – 100.00 |
| 2 Indication range of gamma radiation DER | μSv/h | 0.01 – 0.1 |

Table 1.1 (continued)

| Name | Unit of measurement | Standardized value |
|---|---|---|
| 3 Main relative permissible error limit of gamma radiation DER measurement in the range from 0.1 to 100.0 μSv/h with energy of 0.662 MeV at confidence probability of 0.95 | % | $(15+2/\dot{H}^*(10))$, where $\dot{H}^*(10)$ - is a measured value of DER in μSv/h |
| 4 Indication range of count rate from the gamma radiation detector | $s^{-1}$ | 1 – 9999 |
| 5 Energy dependence of the dosimeter readings at gamma radiation DER measurement in the energy range of 0.05 to 1.25 MeV | % | ±30 |
| 6 Indication range of count rate from the neutron radiation detector | $s^{-1}$ | 0.001 - 9999 |
| 7 Energy range of detected neutron radiation | eV | $0.025 – 14 \cdot 10^6$ |
| 8 Anisotropy of dosimeter:<br>- gamma radiation measurements for $^{137}Cs$ and $^{60}Co$ obtained from the SDUGR and GMC (at gamma quantum incidence at angle of ±60° relative to the plane of the detectors);<br>- for $^{241}Am$ (at gamma quantum incidence at angle of ±60°relative to the plane of the detectors) | % | ±30<br>±75 |
| 9 Calibration time relative to gamma background | s | 2 - 60 |
| 10 Response time to over 10 times change of photon-ionizing radiation DER | s | 0.25 |
| 11 Operating supply voltage of the control panel of the dosimeter from AA type nickel metal hydride battery | V | 1.2 |
| 12 Operating supply voltage of the wrist warning device from battery of two AAA type nickel metal hydride storage batteries | V | 2.4 |

Table 1.1 (continued)

| Name | Unit of measurement | Standardized value |
|---|---|---|
| 13 Complementary permissible error limit of photon-ionizing radiation DER measurement caused by supply voltage variations from standardized value within 1.4 to 1.0 V | % | ±5 |
| 14 Complementary permissible error limit of photon-ionizing radiation DER measurement caused by ambient air temperature variations from – 20 to + 40 °C | % per each 10 °C deviation from 20 °C | ±10 |
| 15 Storage battery life, 2500 mA×h, of the control panel at natural background and<br>- switched off display backlight and wrist warning device, not less than<br>- switched off display backlight and switched on wrist warning device, not less than | hour | <br>166<br>65 |
| 16 Storage battery life, 800 mA×h, of the wrist warning device at natural background, not less than | hour | 140 |
| 17 Dimensions of the control panel of the dosimeter, not more than | mm | 110×36×83 |
| 18 Weight of the control panel, not more than | kg | 0.4 |

Table 1.1 (continued)

| Name | Unit of measurement | Standardized value |
|---|---|---|
| 19 Dimensions of the wrist warning device, not more than | mm | 63×56×23 |
| 20 Weight of the wrist warning device, not more than | kg | 0.1 |
| 21 Dimensions of the split warning device, not more than | mm | 30×68×19 |
| 22 Weight of the split warning device with the cable, not more than | kg | 0.06 |

1.2.2 Threshold alarm system with three independent threshold levels is realized in the dosimeter:
- search threshold level (a threshold level of pulse count rate from the detector of photon-ionizing radiation), which is based on the relative root-mean-square deviation of pulse count rate ($\sigma$-threshold);
- safety threshold level (a threshold level of photon-ionizing radiation DER);
- threshold level of pulse count rate from the detector of neutron radiation.

1.2.3 Search threshold level is calculated by the dosimeter in the mode of calibration relative to gamma background depending on a programmed value of root-mean-square deviations quantity. Programming range of root-mean-square deviations quantity – 1 to 9.9. Programming resolution – 0.1. The dosimeter alerts the user when the search threshold level is exceeded with the help of light and vibration or audio alarm **"Search threshold level exceeded"** and **"Quantum"** signals. Simultaneous vibration and audio alarm is possible.

1.2.4 Safety threshold level is programmed in μSv/h in the range of 0.00 μSv/h to 99.99 μSv/h. Programming resolution – 0.01 μSv/h. The dosimeter alerts the user when the threshold level is exceeded with the help of light and vibration or audio alarm **"Safety threshold level exceeded"** signal. Simultaneous vibration and audio alarm is possible.

1.2.5 Threshold level of pulse count rate from the neutron radiation detector is programmed in pulse/s in the range of 0.00 pulse/s to 99.99 pulse/s. Programming resolution – 0.01 pulse/s. The dosimeter alerts the user when the threshold level is exceeded with the help of light and vibration or audio alarm **"Neutron threshold level exceeded"** signal. Simultaneous vibration and audio alarm is possible.

1.2.6 The dosimeter has the function of autocalibration, which ensures high sensitivity of the dosimeter when gamma background is slowly decreasing, and prevents from faulty alarms when it is slowly increasing.

1.2.7 The dosimeter can operate with both the split vibration-audible warning device and the additional wrist vibration-audible warning device (wrist warning device), which is connected with the control panel of the dosimeter via Bluetooth radio channel and does not require wire connection.

1.2.8 The dosimeter can automatically store the measured values of pulse count rate from the detector of photon-ionizing radiation, DER of photon-ionizing radiation and pulse count rate from the detector of neutron radiation in its nonvolatile memory. Storage interval is programmed in the range of 1 to 255 min with 1 min resolution.

1.2.9 The dosimeter provides automatic events logging in the nonvolatile memory. They are as follows:
- turning the dosimeter on;
- turning the dosimeter off;
- recalibration of the dosimeter;
- search threshold level exceeding start;
- search threshold level exceeding end and maximum value of pulse count rate during the period;
- safety threshold level exceeding start;
- safety threshold level exceeding end and maximum value of photon-ionizing radiation DER during the period;
- threshold level exceeding start of pulse count rate from the neutron radiation detector;
- threshold level exceeding end of pulse count rate from the neutron radiation detector and maximum value of pulse count rate during the period;
- loss of connection with the wrist warning device;
- reconnection with the wrist warning device;
- attempt to reconnect with the wrist warning device;
- failure to operate with the wrist warning device.

Each event logging (except for turning the dosimeter on) can be permitted or inhibited. Turning-dosimeter-on event should be obligatory logged.

1.2.10 The nonvolatile memory of 32 Kb enables storing up to 4000 values of measured photon-ionizing radiation DER and logged event records.

1.2.11 The dosimeter permits or inhibits the following operating modes via the PC:
- turning the dosimeter off;
- viewing alarm threshold levels;
- alarm threshold levels programming;
- calibration relative to gamma background;

- real time indication;
- real time correction.

1.2.12 Data reading from the nonvolatile memory of the dosimeter to the PC, selection of the events for logging, and permit/inhibit of the operating modes of the dosimeter is performed with the help of the “Computer-aided programming and operation logging of the dosimeter” custom-made software (“Cadmium-ECOMONITOR”). Synchronization of the PC and the dosimeter clocks is done during data communications with the PC.

1.2.13 Data communications between the dosimeter and the PC is done through Bluetooth wireless technology.

1.2.14 The dosimeter alerts about low storage battery of the control panel and the warning device.

1.2.15 The dosimeter operates in the following conditions:

- ambient air temperature from – 20 to +50 °C;
- relative humidity up to 95 % at 35 °C, non-condensing;
- atmospheric pressure from 84 Kpa to 106.7 Kpa.

**1.3 Delivery kit of the dosimeter**

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

Table 1.2 – Delivery kit

| Type | Item | Quantity | Note |
|---|---|---|---|
| BICT.468166.004 | Control panel | 1 | Case included |
| BICT.468239.003 | Split vibration-audible warning device | 1 | |
| | AA type NiMH storage battery, 2500 mA×hour (Varta) | 1 | Analogs permitted |
| | Purchased multipurpose charger for fast charging of AA and AAA type storage batteries | 1 | Model is not specified |
| 7810-0975 A0 H12X ГОСТ17199-88 | Screwdriver | 1 | |
| BICT.412129.002-04 HE | Operating manual | 1 | |
| BICT.412915.012 | Packing box | 1 | |
| BICT.468239.001 | Wrist vibration-audible warning device with Bluetooth wireless channel | 1 | |
| | AAA type NiMH storage battery, 800 mA×h (Varta) | 2 | Analogs permitted |
| | Bluetooth USB adapter | 1 | Model is not specified. Supplied in separate order |
| | “Cadmium - ECOMONITOR” SW | 1 | Supplied in separate order |

**1.4 Design and theory of operation**

1.4.1 Overview.

1.4.1.1 Appearance of the dosimeter is presented in Figures 1, 2 and 3. The dosimeter consists of the control panel and the vibration-audible warning device, which is connected to the control panel with the help of a short cable with a split (hereinafter – split warning device). The delivery kit also includes the additional vibration-audible wrist warning device with Bluetooth radio channel (hereinafter – wrist warning device) that provides wireless connection to the control panel.

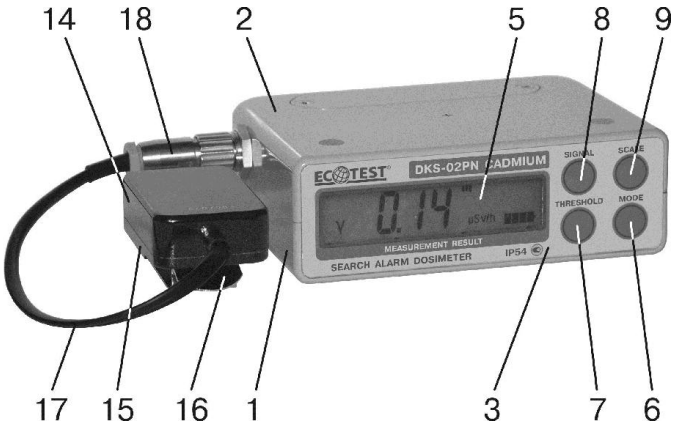


Figure 1 – Appearance of the control panel and the split warning device of the DKS-02PN “CADMIUM” dosimeter

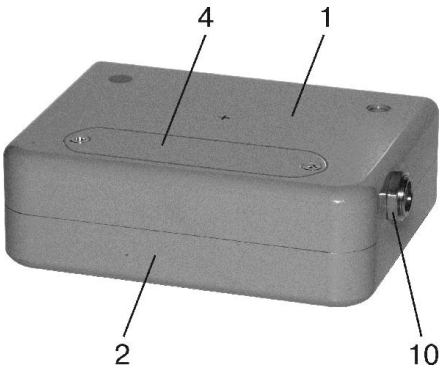


Figure 2 – Appearance of the control panel of the DKS-02PN "CADMIUM" dosimeter (bottom view)

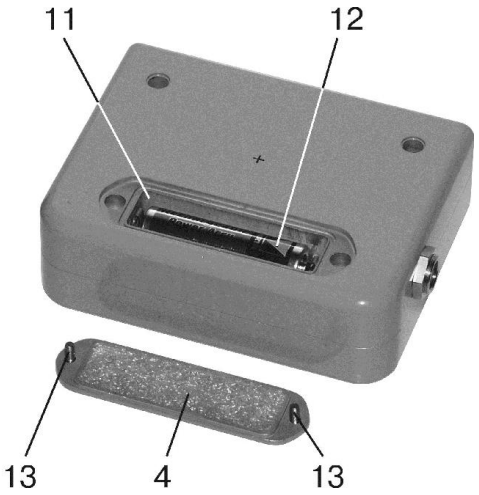


Figure 3 – Appearance of the control panel of the DKS-02PN "CADMIUM" dosimeter (front view with removed battery compartment lid)

Appearance of the wrist warning device is shown in Figure 4.

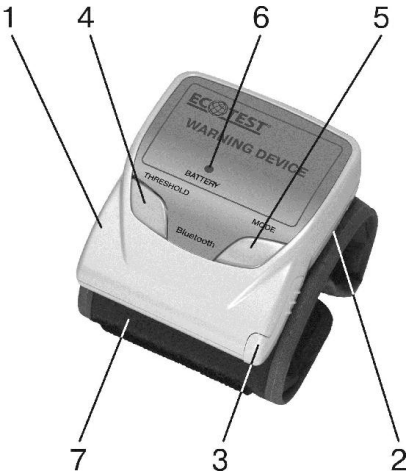


Figure 4 – Appearance of the wrist warning device of the DKS-02PN "CADMIUM" dosimeter

1.4.1.2 The control panel of the dosimeter performs the following functions:

- controlling the dosimeter operating modes;
- measurement and indication of pulse count rate from the detector of photon-ionizing radiation;
- measurement and indication of photon-ionizing radiation DER;
- measurement and indication of pulse count rate from the neutron radiation detector;
- light and audible or vibrating alarming when the threshold levels are exceeded;
- automatic storage of measurement results in the nonvolatile memory;
- automatic events logging in the nonvolatile memory;
- transmission of measurement results and event log via Bluetooth radio channel to PC;
- controlling the split warning device;
- data communications with the wrist warning device via Bluetooth radio channel.

The control panel of the dosimeter is powered from AA type nickel metal hydride storage battery.

The leather case, included in the delivery kit, is used to additionally protect the dosimeter from acoustic and mechanical damage.

1.4.1.3 The split warning device is intended to form audio and vibrating signals under control of the control panel. The split warning device is designed as a steel case with a clip for securing the warning device to a belt.

1.4.1.4 The wrist warning device is done as a wristlet (Figure 4) that consists of two basic parts – a plastic body and reinforced strap with the hook and loop fastener for securing the unit to an arm.

The wrist warning device is intended to form audio or vibrating signals under control of the control panel, as well as to transmit the commands to turn the dosimeter off or to perform calibration relative to gamma background to the control panel of the dosimeter. Data communications between the control panel and the wrist warning device is done via Bluetooth wireless technology. Maximum distance between the control panel of the dosimeter and the wrist warning device, at which stable data communications is maintained, is not more than 5 m.

1.4.2 Design of the dosimeter.

1.4.2.1 The control panel of the dosimeter is designed as a steel dust- and damp-proof housing. The operating position of the dosimeter is vertical (with indication and control elements upwards). The ingress protection rating is IP54. The housing of the control panel consists of (Figure 1, 2 and 3) the front (1) and the rear covers (2), the panel (3) and the battery compartment lid (4). The liquid crystal display (LCD) (5) and the MODE (6), THRESHOLD (7), SIGNAL (8), SCALE (9) buttons are located on the top panel. The split (10) for connecting the split warning device is adjusted on the left side wall. The compartment (11) for storage battery (12), which is closed with the lid (4) with the help of two captive screws (13), is located on the front cover. The leather case is used for fastening the control panel on a belt (not shown in figure).

1.4.2.2 The split warning device (Figure 1) is designed as a steel housing consisting of two covers (14 and 15) and a spring (16), which is intended for securing the warning device on a belt. To connect the warning device to the control panel, a cable (17) with a split (18) is provided.

1.4.2.3 The wrist warning device (Figure 4) is designed as a plastic housing consisting of the top (1), bottom (2) covers, and the battery compartment lid (3). In its top part the THRESHOLD (4), MODE (5) buttons and the BATTERY LED (6) are located. With the help of the strap (7) the warning device is fastened to a user's wrist. The wrist waning device is powered from a battery of two AAA type nickel metal hydride storage batteries.

1.4.3 Operation of the dosimeter.

1.4.3.1 The structure chart of the dosimeter is illustrated in Figure 5. It consists of the control panel and the split warning device. The split warning device is connected to the split on the side wall of the control panel of the dosimeter.

The wrist warning device, which is wirelessly connected to the control panel, can be included in the delivery kit at customer's request. Data communications between the control panel and the wrist warning device is done through Bluetooth radio channel.

1.4.3.2 The control panel consists of: the detecting units of photon-ionizing radiation (GDU1, GDU2), the detecting unit of neutron radiation (NDU), the digital processing circuit (DPC) with the Bluetooth RFC module, the liquid crystal display (LCD), the supply voltage former (SVF), the storage battery (B), and the MODE, THRESHOLD, SCALE and SIGNAL buttons.

The SVF controlled by the DPC forms the required supply voltages for all component parts of the control panel.

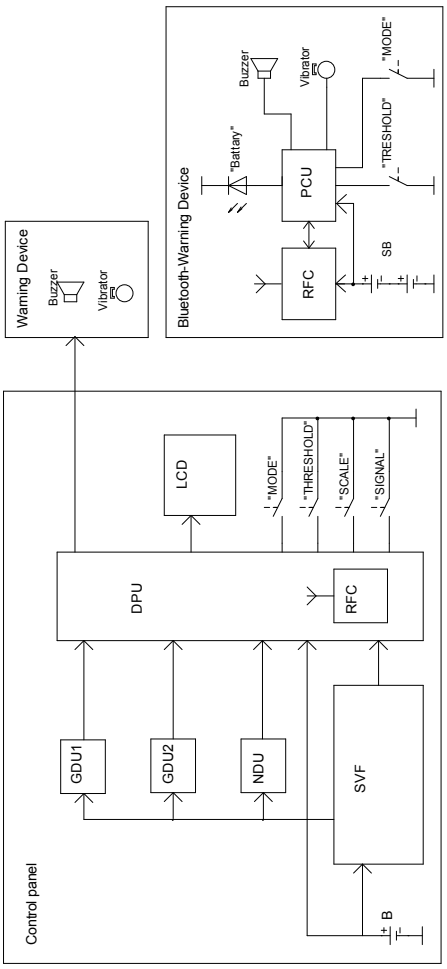


Figure 5 – Structure chart of the DKS-02PN "CADMIUM" search alarm dosimeter

The GDU1 and GDU2 consist of the detectors of CsJ(Tl) scintillator-photodiode type and the charge-sensitive amplifier, and the NDU consists of the detector of LiJ(Eu) scintillator-photodiode type and the charge-sensitive amplifier.

The detectors and charge-sensitive amplifiers are placed into the shared case-screens. The scintillator's volume of each photon-ionizing radiation detecting unit is 5 $cm^3$. The scintillator's volume of the neutron radiation detecting unit is 1.3 $cm^3$.

The operation principle of the detecting unit is based on transformation of scintillations in semi-conductive photodiode, caused by ionizing or neutron radiation in the scintillator, into current pulses. These input pulses of the charge-sensitive amplifier are intensified and become the output pulses of positive polarity. The number of these pulses is proportional to photon-ionizing radiation DER, and the amplitude – to its energy.

The DPC processes the pulse flow from the GDU1, GDU2 and NDU outputs, and forms the corresponding DER value as well as pulse count rate from the detecting units of ionizing and neutron radiation with the account of multichannel kicksorting. Depending on the operating mode of the dosimeter, one of the formed values is shown on the LCD.

The DPC also compares the measured DER value and the value of pulse count rate with the programmed threshold levels and starts light and audible or vibrating alarm when the value is exceeded.

The DPC also includes the nonvolatile memory, where the measured values of photon-ionizing radiation DER, pulse count rate from the detecting units of ionizing and neutron radiation, as well as the event log records are stored.

1.4.3.3 The split warning device consists of the piezo-acoustic buzzer and the vibrator. The split warning device is connected to the control panel of the dosimeter with the help of the 0.2 m cable.

1.4.3.4 The wrist warning device consists of: the Bluetooth radio frequency channel (RFC), the processing and control unit (PCU), the MODE and THRESHOLD buttons, the storage batteries (SB), and the alarm means such as the BATTERY LED, the buzzer and the vibrator.

The RFC is intended for wireless data communication between the control panel and the warning device. The PCU processes the received and transmitted data through the RFC, controls the RFC and the alarm means, as well as monitors the SB status, and inquires the MODE and THRESHOLD buttons.

The BATTERY LED is intended to indicate the SB discharge, and to inform about the active status of the wrist warning device with the help of the **“Wrist warning device on”** signal.

**1.5 Labeling and sealing**

1.5.1 The name and design letters of the dosimeter, the ingress protection rating and the manufacturer's trade mark are inscribed on the top panel of the control panel of the dosimeter.

The design letters and the manufacturer's trade mark are inscribed on the front cover of the split warning device.

1.5.2 The rear cover of the control panel of the dosimeter and the front cover of the split warning device are inscribed with the factory serial number and the manufacture date.

The bottom cover of the wrist warning device is inscribed with the factory serial number and the manufacture date.

1.5.3 Sealing is done by the manufacturer. Special sealing film is placed between the front and rear covers of the housing of the control panel.

The warning device is sealed with special sealing film between the covers of the housing.

1.5.4 Removal of seals and repeated sealing is performed by the enterprise after repair and verification.

**1.6 Packing**

1.6.1 The control panel of the dosimeter, the split warning device, the wrist warning device, the multipurpose charger and the operating manual are placed into a special packing box.

1.6.2 The packing box with the dosimeter kit is placed into the plastic sachet, which is soldered after packing performed.

## 2 PROPER USE

### 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 – 20 to + 50 $^{o}$C |
| 2 Relative humidity | up to 95 % at 35 $^{o}$C temperature, non-condensing |
| 3 Photon-ionizing radiation influence | DER up to 10.0 mSv/h during 5 min |

### 2.2 Preparation for operation

2.2.1 External examination procedure.

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

2.2.2 Preparation of the dosimeter for operation.

2.2.2.1 Study the operating manual, and examine the control buttons before putting the dosimeter into operation

2.2.2.2 With the help of the screwdriver remove the battery compartment lid of the dosimeter and make sure the storage battery is inserted, connections are reliable, and there is no leakage of salts on the contact surface after the long-term storage of the dosimeter. Remove the battery in case of salt leakage. Clean it if possible or replace if not.

2.2.2.3 In case the dosimeter is used with the wrist warning device, open the bottom cover of the battery compartment of the wrist warning device and make sure the storage batteries are inserted, connections are reliable, and there is no leakage of salts on the contact surface after the long-term storage of the warning device. Remove the batteries in case of salt leakage. Clean them if possible or replace if not.

2.2.2.4 Charge the storage batteries of the control panel and the wrist warning device according to the operating manual requirements of the charger. After that, insert the batteries into the control panel and the wrist warning device observing the polarity.

**Notes**

1 Repeated charging of the storage battery of the dosimeter should be done only after the low battery status appears (see 2.3.3.14).

2 Repeated charging of the storage batteries of the wrist warning device should be done only after the low battery status appears (see 2.3.3.14).

3 During the long-term storage of the dosimeter, the batteries should be removed from the control panel and the wrist warning device. They should be charged before being inserted back again if needed.

2.2.3 Troubleshooting.

2.2.3.1 Troubleshooting is presented in Table 2.2. Troubles during use are recorded in Appendix A of this OM.

Table 2.2 - Troubleshooting

| Trouble | Probable cause | Solution |
|---|---|---|
| Dosimeter will not turn on | 1. The storage battery of the control panel is discharged<br><br>2 No contact between the clamps and the storage battery of the control panel | 1 Charge or replace the battery<br><br>2 Remove the battery and clean out the contacts |
| “Er12” message on the LCD of the control panel | Gamma radiation detector is out of order | Send the dosimeter for repair to the manufacturer |
| No link between the control panel and the wrist warning device, which is indicated by the “Er02” or “Er05” symbols on the LCD and the “No link” signal | 1 The wrist warning device and the control panel belong to different kits<br><br>2 The control panel or the wrist warning device is damaged | 1 Use the control panel and the wrist warning device from one kit<br><br>2 Send the dosimeter for repair to the manufacturer. In case of absolute necessity, continue operation with the control panel of the dosimeter without linking it up to the wrist warning device (2.3.3.1) |

Table 2.2 (continued)

| Trouble | Probable cause | Solution |
|---|---|---|
| Link disconnection between the control panel and the wrist warning device indicated by the “Er02”, “Er05” or “Er07” on the LCD of the control panel and “No link” signal | The distance between the control panel and the wrist warning device is too big | Make the distance between the control panel and the wrist warning device smaller. Connection will be restored automatically, if disconnection lasted not longer than 20 s. Otherwise, to restore the connection between the control panel and the wrist warning device, press shortly the THRESHOLD button of the control panel |
| No link between the dosimeter and the PC indicated by the “Er08” or “Er09” on the LCD of the control panel | 1 The distance between the control panel and the PC is too big<br><br>2 The “Cadmium-ECOMONITOR” custom-made software is improperly launched or set | 1 Make the distance between the control panel and the PC smaller<br><br>2 Launch or set the “Cadmium-ECOMONITOR” custom-made software in line with the user guide |
| Mistakes during data communications with the PC indicated with “Er08” | The distance between the control panel and the PC is too big | Make the distance between the control panel and the PC smaller |

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

**2.3 Use of the dosimeter**

2.3.1 Safety measures.

2.3.1.1 The dosimeter should be used in line with the valid regulatory documents.

2.3.1.2 The dosimeter does not include any external parts exposed to voltages hazardous for life.

2.3.1.3 The dosimeter meets the requirements of ГОСТ 12.1.019-79 with regard to people protection against electric-shock hazard of III safety class according to ГОСТ 12.2.007.0-75.

The protective shielding is used in the dosimeter to provide protection from accidental contact with current-conducting parts.

The ingress protection rating is IP54.

2.3.1.4 The dosimeter meets the requirements of fire safety standards ГОСТ 12.1.004-91, ГОСТ 12.2.007.0-75.

2.3.1.5 The dosimeter is not dangerous for the maintenance personnel and is environmentally friendly.

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

2.3.17 The disposal of the dosimeter is performed in compliance with the general rules, i.e. metal is recycled or melted, and plastic parts are dumped.

2.3.2 Operating modes of the dosimeter.

The dosimeter operates within the following modes:

- calibration relative to gamma background and calculation of alarm search threshold level;
- measurement of pulse count rate from the detector of photon-ionizing radiation;
- measurement of photon-ionizing radiation DER;
- measurement of pulse count rate from the detector of neutron radiation;
- viewing and programming of root-mean-square deviations quantity for calculation of alarm search threshold level;
- safety threshold level viewing and programming;
- viewing and programming of alarm threshold level of pulse count rate from the neutron radiation detector;
- indication and correction of real time;
- control of data communications with the PC;
- storage battery status control.

The corresponding control buttons, liquid crystal display, as well as vibration-audio and light signals serve to control the operating modes and check for their execution.

2.3.2.1 To control the operating modes of the dosimeter the MODE (6), THRESHOLD (7), SIGNAL (8) and SCALE (9) buttons are used according to Figure 1.

The SCALE button turns on and off the backlight of the dosimeter LCD.

The SIGNAL button is used to select the operating mode of alarm: vibration, audible or vibration-audible mode.

The THRESHOLD button serves to view and input alarm threshold levels.

The MODE button turns the dosimeter on and off and changes its operating modes.

2.3.2.2 The character-symbolic liquid crystal display (LCD) of the control panel of the dosimeter is used to control the operating modes of the dosimeter.

The LCD of the control panel has the following data entries (Figure 1):

- four-digit indicator of the measured dimension;
- indicator of dimension of quantity;
- radiation type indicator;
- twenty-segment analog scale;
- storage battery status symbol.

2.3.2.3 The dosimeter generates the following vibration-audible and light signals.

2.3.2.3.1 Vibration and audible signals:

**„No link"** – short high-pitch beeps during audio alarm; short-time switching-ons of the vibrator during vibration alarm. Repetition rate is up to 3 Hz. Duration of pause and audio or vibration signal during alarm is the same. This signal shows that the control panel and the wrist warning device are disconnected.

Caution! If no actions are taken during 5 min after the "No link" signal appears (e.g., the wrist warning device turned off or connected to the control panel), the wrist warning device turns off automatically

"**Quantum**" - a short high-pitch beep of 10-15 ms during audio alarm; a short-time switching-on of the vibrator during vibration alarm. This signal shows the intensity of gamma quanta detection.

"**Search threshold level exceeded**" - a high-pitch beep of 1 s during audio alarm; a 1 s switching-on of the vibrator during vibration alarm. This signal is formed if the measured value of pulse count rate from the photon-ionizing radiation detector exceeds the alarm search threshold level that has been calculated during calibration relative to gamma background.

"**Safety threshold level exceeded**" - a two-tone continuous audio signal during audio alarm; switching of the vibrator on and off during vibration alarm. This signal is formed if the measured value of photon-ionizing radiation DER exceeds the alarm safety threshold level.

"**Neutron threshold level exceeded**" – a two-tone discontinuous audio signal during audio alarm; switching of the vibrator on and off during vibration alarm. This signal is formed if the measured value of pulse count rate from the neutron radiation detector exceeds the threshold level relative pulse count rate from the detector.

"**Low battery**" – a two-tone audio signal or switching-on of the vibrator for 0.6 s. This signal indicates a critical level of battery discharge of the control panel.

"**Wrist warning device switching-on signal**" consists of two parts. The first part is a short high-pitch beep of about 0.5 s irrespective of the mode. The second part is a short high-pitch beep of not less than 0.5 s during audio alarm; short switching-on of the vibrator for not less than 0.5 s during vibration alarm. This signal shows that the wrist warning device is on.

"**Warning device switching-off signal**" – a low-pitch beep of 1 s irrespective of the mode. This signal shows that the wrist warning device is off.

"**Temporary disconnection of the control panel**" – a short high-pitch beep of up to 1 s during audio alarm; a short-time switching-on of the vibrator during vibration alarm. This signal shows that the control panel is temporarily disconnected from the wrist warning device.

**"Connection of the control panel to the wrist warning device signal"** – a high-pitch beep of up to 3 s during audio alarm; switching-on of the vibrator for 3 s during vibration alarm. This signal shows that the control panel has been connected to the wrist warning device.

2.3.2.3.2 Light signals:

**"Wrist warning device on"** – short flashes of the "BATTERY" LED of **the wrist warning device** for 0.5 s with 5 s interval.

**"First stage of battery discharge"** – short flashes of the "BATTERY" LED of **the wrist warning device** for 1 s with repetition interval of about 2 s. This signal indicates a slight discharge of the storage batteries of the wrist warning device.

**"Second stage of battery discharge"** short flashes of the "BATTERY" LED of **the wrist warning device** of 2 s with repetition rate of about 0.3 s. This signal indicates a complete discharge of the storage batteries of the wrist warning device.

Caution! Light signals alert only about the discharge of the warning device storage batteries.

2.3.3 Operating procedure.

General operating procedure looks the following way.

After the dosimeter is turned on it is always in the mode of pulse count rate measurement from the detector of photon-ionizing radiation. Calibration relative to gamma background also starts with calculation of the alarm search threshold level and performance check of the photon-ionizing radiation detector. Blinking of digits on the LCD shows that calibration is taking place. Depending on the gamma background DER, calibration is performed from 60 s to 2 s. When calibration is completed, digits on the LCD stop blinking.

Each short press of the MODE button switches the dosimeter from one mode to another in the following sequence:

- measurement of pulse count rate from the detector of photon-ionizing radiation;
- measurement of photon-ionizing radiation DER;
- measurement of pulse count rate from the neutron radiation detector;
- real time indication;
- control of data communications with the PC.

When the dosimeter is in the mode of controlling data communications with the PC and the MODE button is pressed, it returns the device to the mode of pulse count rate from the photon-ionizing radiation detector.

You can switch to the mode of viewing and programming of the corresponding threshold level from each measurement mode by pressing the THRESHOLD button.

You can switch to the mode of real time correction from the mode of real time indication by pressing the THRESHOLD button.

A short press of the THRESHOLD button in the mode of controlling data communications with the PC, results in data communications start.

2.3.3.1 Turning the dosimeter on.

Press shortly the MODE button on the control panel of the dosimeter to turn it on. The backlight of the LCD and information displayed on it show that the dosimeter is on.

If the dosimeter is additionally equipped with the wrist warning device, the dosimeter (the wrist warning device and the control panel) should be turned on as follows:

- press shortly the MODE button of the wrist warning device. This is followed by the **“Wrist warning device turning-on”** signal. The **“Wrist warning device on”** light signal indicates that the warning device is active.
- press shortly the MODE button on the control panel (the cable of the split warning device should be disconnected from the control panel) to turn the dosimeter on. The backlight of the LCD and information displayed on it show that the control panel is on.

The control panel should be turned on during 30 s after the wrist warning device. Otherwise the **“No link”** signal is automatically actuated. The control panel can be connected to the wrist warning device even if there is the **“No link”** signal.

After both the control panel and the wrist warning device are turned on, they start linking up. It takes from 3 to 10 seconds. The „SiGn” message is displayed on the LCD by this. Successful connection is followed by the **“Connection of the control panel to the wrist warning device signal”**. Otherwise, “Er05” or “Er02” notifications appear on the LCD of the control panel.

Press shortly the THRESHOLD button on the control panel for another attempt to establish connection. Press shortly the MODE button to continue operation with the control panel without linking it to the wrist warning device. The buttons of the control panel are blocked and serve only to turn the control panel off until the control panel is connected to the warning device.

2.3.3.2 Turning the dosimeter off.

To turn off the dosimeter press and hold the MODE button of the control panel for about 4 s until the control panel is off.

If the dosimeter operates with the wrist warning device they are connected, and the dosimeter can be turned off with the help of the MODE button of both the control panel and the wrist warning device. If there is no connection, they should be turned off separately. Press and hold the MODE button to turn off the wrist warning device (c. 4 s). Turning the wrist warning device off is always followed by the **“Turning the wrist warning device off signal”**.

**Caution!** The option to turn the dosimeter off may be forbidden during data communications with the PC (see 2.3.3.13). In this case the dosimeter will not turn off till the next data communications session with the PC when turning the dosimeter off is permitted.

2.3.3.3 Switching between vibration/audio alarm.

The warning device provides three alarm modes: audio, vibration and vibration-audio alarm. To switch between the modes, shortly press the SIGNAL button of the control panel. Each press changes the alarm type. The “Aud” symbol is displayed on the LCD and a short audio signal is formed when audio alarm is selected. The “Vibr” symbol on the LCD and a short vibrating signal are formed when vibration alarm is selected. The “A V” symbols and a short vibration and audio signals are formed when vibration-audio alarm type is selected.

If the dosimeter is connected with the wrist warning device, switching between the alarm types can be performed with a short press of both the SIGNAL button of the control panel, and the MODE button of the wrist warning device.

2.3.3.4 Switching-on/off the LCD backlight of the control panel.

Press shortly the SCALE button to switch on the LCD backlight of the dosimeter for 8 s. The backlight will be switched off automatically in 8 s.

Press and hold the SCALE button (c. 2 s) until a short double blinking of the backlight occurs to switch on a continuous LCD backlight of the dosimeter.

Press shortly the SCALE button to switch off the LCD backlight.

2.3.3.5 Calibration relative to gamma background and calculation of the alarm search threshold level.

Calibration relative to gamma background and calculation of the alarm search threshold level is done independent of the operating mode of the dosimeter, and is launched automatically in the following cases:

- immediately after turning the dosimeter on;
- after a new value of root-mean-square deviations quantity has been programmed;
- after completion of data communications process with the PC.

Calibration relative to gamma background and calculation of the alarm search threshold level can also be started in the mode of pulse count rate measurement from the detector of photon-ionizing radiation (unless it has been forbidden during data communications with the PC (2.3.3.13)). Press shortly the THRESHOLD button of the control panel. The quantity of root-mean-square deviations will be displayed on the LCD. After that, shortly press the MODE button (c. 2 s) of the control panel (meanwhile the value of root-mean-square deviations quantity is indicated on the LCD).

Calibration relative to gamma background can also be started with a long press of the THRESHOLD button of the wrist warning device in the event the control panel and the wrist warning device are connected.

Calibration relative to gamma background is done independently of the operating mode of the dosimeter. Blinking of digits on the LCD of the control panel in the modes of measurement of pulse count rate from the detector of photon-ionizing radiation, photon-ionizing radiation DER and pulse count rate from the neutron detector shows that the dosimeter is in the process of calibration.

Calibration can last from 60 to 2 seconds, which depends on the gamma background DER. Average pulse count rate from the photon-ionizing radiation detector is measured in the process of calibration, and the following is calculated:

- alarm search threshold level (a threshold value of pulse count rate when alarm should be actuated):

$$Cnt_{п} = Cnt_{ф} + n\sqrt{Cnt_{ф}} \qquad (1)$$

where

$Cnt_{\phi}$ – is the average pulse count rate from the detector during calibration;

n - quantity of root-mean-square deviations.

- divider for formation of audio or vibration alarm of registered gamma quanta.

Digits stop blinking on the LCD to indicate that calibration relative to gamma background is finished.

In the mode of calibration relative to gamma background the photon-ionizing radiation detector is tested as well. If the number of pulses detected by the photon-ionizing radiation detector during calibration is less than 100, the detector is considered to have not passed the testing, and the "Er12" notification is displayed on the LCD of the control panel.

**Note.** Irrespective of the operating mode, the dosimeter executes the function of autocalibration relative to gamma background, which maintains high sensitivity of the dosimeter during slow decrease of gamma background, and prevents from false alarms when gamma background is slowly increasing. Autocalibration is performed continuously and is unavailable only when the threshold alarm is actuated.

2.3.3.6 Measurement of pulse count rate from photon-ionizing radiation detector.

The dosimeter enters the mode of pulse count rate measurement from the detector of photon-ionizing radiation as soon as it is turned on. This mode can also be entered from any other operating mode of the dosimeter with the help of a short press of the MODE button of the control panel.

**Caution!** This mode can be inhibited during data communications with the PC (2.3.3.13).

This mode is indicated with the „γ" symbol on the LCD and the absence of the measured dimension of quantity. Pulse count rate is displayed at LCD digits in pulses per second (pulse/s). The information is updated at LCD digits each 2 s. The information is also updated at LCD digits when pulse count rate rapidly changes.

Immediate value of pulse count rate is indicated in pseudo-logarithmic scale with the help of the twenty-segment analog scale. When the pulse count rate is lower than 13 pulse/s all segments of the scale are blackened. With pulse count rate increase scale segments start highlighting from left to right. The scale becomes fully highlighted when the pulse count rate reaches 7200 pulse/s. Information on the analog scale is updated each 250 ms.

If the measured value of pulse count rate from the photon-ionizing radiation detector exceeds the alarm search threshold, which was calculated in the mode of calibration relative to gamma background, the dosimeter forms and sends a short audible or vibration signal (**"Search threshold level exceeded**"), and audio or vibration, or vibration-audio alarm of the detected gamma quanta is actuated. The LCD backlight starts blinking as well, and a blinking „γ" symbol is displayed on it. The alarm signal repetition will increase with the pulse count rate increase, which can be used to search for radiation sources. As soon as the alarm signal repetition reaches its maximum (a continuous signal is formed), it will be impossible to continue searching without new calibration relative to gamma background.

Search relative to audio signal intensity can be continued after the second calibration is performed.

**Note**. Mechanical effect on the control panel of the dosimeter (shocks, vibration) may distort the measured value of pulse count rate, though it is not an indication of the dosimeter malfunction.

2.3.3.7 Viewing and programming of root-mean-square deviations quantity for calculation of alarm search threshold level.

The option to view and change the quantity of root-mean-square deviations is available in the mode of pulse count rate measurement from the detector of photon-ionizing radiation.

**Caution!** This mode can be inhibited during data communications with the PC (see 2.3.3.13).

Press shortly the THRESHOLD button of the control panel to view the quantity of root-mean-square deviations. The quantity will be displayed while the THRESHOLD button is pressed and during 2 s after it is released. If the THRESHOLD button is not released in 4 seconds, the fractional part of root-mean-square deviations (low-order digit of the LCD) starts blinking. This means that the value of the digit can be changed. After that, release the THRESHOLD button.

Successive short presses and releases of the THRESHOLD button of the control panel change this value per unit. Long press of the THRESHOLD button starts automatic change of this value, which is stopped after the button is released. A short press of the MODE button of the control panel fixes the value and allows presetting the value of the next digit (an integral part of root-mean-square deviations). At this, the low-order digit stops blinking on the LCD and the high-order digit starts blinking.

Preset the integral part (high-order digit) of the root-mean-square deviations with the help of the THRESHOLD button of the control panel in a similar way to fractional part value programming.

Next short press of the MODE button of the control panel fixes a new quantity of root-mean-square deviations, which is indicated with discontinuous blinking of the LCD digits. The dosimeter then starts calibration relative to gamma background level that will be indicated with the blinking LCD digits.

By presetting a zero value of root-mean-square deviations quantity, you switch off the search threshold level alarm.

**Caution!** If the process of root-mean-square deviations quantity change will be stopped for more than 30 s (the operator will not press any button of the control panel), the dosimeter will automatically switch to the mode of pulse count rate measurement from the detector of photon-ionizing radiation with the previous search threshold.

**Note.** Programming of root-mean-square deviations quantity (from 1 to 3.5) increases sensitivity of the dosimeter, but it can also trigger false alarms. With the quantity value increase the probability of false alarms decreases. Values starting from 4 (recommended) and up ensure operation with practically no false alarms.

2.3.3.8 Measurement of photon-ionizing radiation DER.

The mode can be entered from any other operating mode of the dosimeter by short pressing of the MODE button of the dosimeter control panel. This mode is the next one after the mode of pulse count rate measurement from the detector of photon-ionizing radiation.

**Caution!** This mode can be forbidden during data communications with the PC (see 2.3.3.13).

The mode of photon-ionizing radiation DER measurement is indicated by „γ" symbol and the "μSv/h" dimension of quantity that appear on the LCD. The value of photon-ionizing radiation DER is displayed with the help of the LCD digits. The device updates the LCD digits each 2 s. The LCD digits are also updated when photon-ionizing radiation DER sharply changes.

Immediate value of pulse count rate in this mode is indicated on the analog scale, the same way it is in the mode of pulse count rate measurement from the detector of photon-ionizing radiation.

If the measured value of photon-ionizing radiation DER exceeds the safety threshold level, the dosimeter forms and sends a short audio or vibration signal (**"Safety threshold level exceeded**"), and the LCD backlight starts blinking. The blinking „γ" symbol on the LCD is also an indication of threshold level exceeding.

**Note**. Mechanical effect on the control panel of the dosimeter (shocks, vibration) may distort the measured value of photon-ionizing radiation DER, though it is not an indication of the dosimeter malfunction.

2.3.3.9 Viewing and programming of safety threshold level.

The option to view and change the value of safety threshold level is available in the mode of photon-ionizing radiation DER measurement.

**Caution!** Viewing and/or change of safety threshold level value can be inhibited during data communications with the PC (2.3.3.13).

Press the THRESHOLD button of the control panel to view the value of safety threshold level. The value will be displayed while the THRESHOLD button is pressed and during 2 s after it is released. If the THRESHOLD button is not released in 4 seconds, the low-order digit of the LCD starts blinking. This means that the value of the digit can be changed. After that, release the THRESHOLD button.

The safety threshold level value is changed the same way as the value of root-mean-square deviations quantity with the help of the THRESHOLD and MODE buttons. The value of a blinking digit is changed with the help of the THRESHOLD button. You can switch to the next digit correction with the help of the MODE button. After the last digit value is changed, a new threshold level is fixed in the memory of the dosimeter. At this, all four digits of the LCD shortly blink and the dosimeter returns to the mode of photon-ionizing radiation DER measurement.

By presetting a zero value of safety threshold level, you switch off safety threshold level alarm.

**Caution!** If the process of safety threshold value change will be stopped for more than 30 s (the operator will not press any button of the control panel), the dosimeter will automatically switch to the mode of photon-ionizing radiation DER measurement with the previous safety threshold level.

2.3.3.10 Measurement of pulse count rate from neutron radiation detector.

This mode can be entered from any other operating mode of the dosimeter by short pressing of the MODE button on the control panel of the dosimeter. This mode is the next one after the mode of photon-ionizing radiation DER measurement.

**Caution!** This mode can be forbidden during data communications with the PC (see 2.3.3.13).

The mode of pulse count rate measurement from the neutron detector is indicated with the „n” symbol on the LCD and the absence of the measured dimension of quantity. The value of pulse count rate is displayed with the help of the LCD digits in pulses per second (pulse/s). The device updates the LCD digits each 2 s. The LCD digits are also updated when the pulse count rate sharply changes.

Immediate value of pulse count rate is indicated in pseudo-logarithmic scale with the help of the twenty-segment analog scale. When pulse count rate is lower than 13 pulse/s all segments of the scale are blackened. With pulse count rate increase scale segments start highlighting from left to right. The scale becomes fully highlighted when the pulse count rate reaches 7200 pulse/s. Information on the analog scale is updated each 250 ms.

If the measured value of pulse count rate exceeds the threshold level of pulse count rate from the detector of neutron radiation, the dosimeter forms and sends a short audible or vibration signal (**"Neutron threshold level exceeded**"), and the LCD backlight starts blinking. The blinking „n" symbol on the LCD is also an indication of the threshold level exceeding.

**Note**. Mechanical effect on the control panel of the dosimeter (shocks, vibration) may distort the measured value of pulse count rate from the detector of neutron radiation, though it is not an indication of the dosimeter malfunction.

2.3.3.11 Viewing and programming of threshold level of pulse count rate from neutron radiation detector.

The option to view and change the value of threshold level of pulse count rate from the neutron radiation detector is available in the mode of pulse count rate measurement from the detector of neutron radiation.

**Caution!** This mode can be inhibited during data communications with the PC (see 2.3.3.13).

Press the THRESHOLD button of the control panel to view the value of threshold level of pulse count rate from the neutron radiation detector. The threshold level will be displayed while the THRESHOLD button is pressed and during 2 s after it is released. If the THRESHOLD button is not released in 4 seconds, the low-order digit of the LCD starts blinking. This means that the value of the digit can be changed. After that, release the THRESHOLD button.

The value of threshold level of pulse count rate from the neutron radiation detector is changed the same way as the value of safety threshold level with the help of the THRESHOLD and MODE buttons. The value of a blinking digit is changed with the help of the THRESHOLD button. You can switch to the next digit correction with the help of the MODE button. After the last digit value correction, a new threshold level is fixed in the memory of the dosimeter. At this, all four digits of the LCD shortly blink and the dosimeter returns to the mode of pulse count rate measurement from the detector of neutron radiation.

By presetting a zero value of threshold level relative to pulse count rate from the neutron radiation detector, you switch off the threshold level alarm.

**Caution!** If the process of the threshold level value change will be stopped for more than 30 s (the operator will not press any button of the control panel), the dosimeter will automatically switch to the mode of pulse count rate measurement from the detector of neutron radiation with the previous threshold level value.

2.3.3.12 Indication and correction of real time.

Press shortly the MODE button of the control panel to switch to the mode of real time indication from any other mode. This mode follows the mode of pulse count rate measurement from the neutron radiation detector.

The time is displayed on the LCD in HH.MM format, where HH stands for hours and MM for minutes. Hours and minutes are divided by a "." symbol blinking with 1 s interval.

**Caution!** This mode can be inhibited during data communications with the PC (see 2.3.3.13).

In the mode of real time indication the option to correct the values of real time is available.

**Caution!** Real time correction can be forbidden during data communications with the PC (see 2.3.3.13).

To correct the real time value, press the THRESHOLD button of the control panel and hold it until the digits that stand for the minute values start blinking to the right from the "." symbol. This shows that the digit value can be changed. Then release the button.

Successive short presses and releases of the THRESHOLD button of the control panel change the value of minutes per unit. Long press of the THRESHOLD button starts automatic change of the minute value, which is ended after this button is released.

Press shortly the MODE button of the control panel to fix the value of minutes and enable hours change. The digits that stand for the hour values start blinking to the left from the "." symbol. The hour values are corrected in a similar way to minute correction. Press shortly the MODE button of the control panel once again to exit the mode of real time correction. The real time value is fixed in the memory of the dosimeter after that procedure, and all four digits of the LCD shortly blink.

**Caution!** If the process of real time correction will be stopped for more than 30 s (the operator will not press any button of the control panel), the dosimeter will automatically switch to the mode of real time indication.

2.3.3.13 Data communications with the PC.

Press shortly the MODE button of the control panel to enter the mode of data communications with the PC from any other operating mode. This mode follows the mode of real time indication.

A “PC” symbol should appear on the LCD of the control panel. To activate the data communications process with the PC, press shortly the THRESHOLD button of the control panel. The “PC” symbols start blinking at that.

If the dosimeter operates with the wrist warning device, the control panel of the dosimeter temporarily breaks the connection with the wrist warning device, which is indicated by the **“Temporary disconnection of the control panel”** signal, and links up to the PC. The “Computer-aided programming and operation logging of the dosimeter” (“Cadmium-ECOMONITOR”) custom-made software should be already installed and launched on the PC. Guidelines on use of the software are presented in the software documentation.

In case of successful completion of data communications process, the dosimeter will switch to the mode of pulse count rate measurement from the detector of photon-ionizing radiation. If the dosimeter operates with the wrist warning device, the control panel of the dosimeter will reconnect to it, which is indicated by the **“Connection between the control panel and the wrist warning device signal”.**

In case errors occur during data communications with the PC, the “Er08” or “Er09” symbols will appear on the LCD. A short press of the THRESHOLD button on the control panel allows repeating an attempt of data communications with the PC, and a short press of the MODE button on the control panel returns to pulse count rate measurement from the photon-ionizing radiation detector.

Press shortly the MODE button of the control panel to stop the process of linking up with the PC or data communications with the PC at any time. The “PC” symbols on the LCD will stop blinking at that, and maximum in 5 s the control panel switches to the mode of pulse count rate measurement from the detector of photon-ionizing radiation. If the dosimeter operates with the wrist warning device, the control panel will start reconnecting with it.

**Notes**

1. For successful data communications only one PC with Bluetooth-name that starts with “CHECKPOINT” should be located in the range of the Bluetooth-interface of the dosimeter (not more than 5 m).

2. If the control panel does not reconnect to the warning device during 5 minutes, the **“No link”** signal will be actuated.

2.3.3.14 Storage battery status control.

Storage battery status control starts automatically as soon as the dosimeter is on, and is continuously performed during its operation.

The condition of the battery is represented by the battery status symbol on the LCD of the control panel. The level of discharge is indicated by a number of blinking segments. Blinking of three or four segments is followed by the **"Battery discharge"** signal and means that the battery should be charged.

The condition of the storage batteries of the wrist warning device is not represented by the battery status symbol on the LCD of the control panel. It is indicated in the following way. The level of the battery discharge is divided into two stages:

– Slight discharge. **"First stage of battery discharge"** light alarm, which is followed by the **"Battery discharge"** signal every 30 s.

– Complete discharge. **"Second stage of battery discharge"** light alarm, which is followed by the **"Battery discharge"** signal every 5 s.

In case of complete battery discharge (second stage) the storage batteries should be immediately charged. Otherwise, with further discharge of the battery, the wrist warning device will **automatically turn off**.

**Caution! "First stage of battery discharge"** and **"Second stage of battery discharge"** light signals warn only about the discharge of the storage batteries of the wrist warning device.

2.3.3.15 Storage battery replacement.

2.3.3.15.1 To replace the storage battery of the control panel, open the battery compartment lid of the control panel with the help of the screwdriver and remove the battery. Insert the newly charged storage battery into the compartment observing the polarity shown on the label and close the lid.

2.3.3.15.2 To replace the storage batteries of the wrist warning device, open the battery compartment lid of the wrist warning device. Insert the newly charged storage batteries observing the polarity and close the lid.

## 3 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 the dosimeter use are given in Table 3.1

Table 3.1 - Operations at technical maintenance

| Operations | Type of technical maintenance | | | 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 |
| Operability check | + | + | + | 3.1.3.3 |
| Storage battery switching off and battery status control | - | + | + | 3.1.3.4 |
| Verification of the dosimeter | - | - | - | 3.2 |
| **Notes**<br>1 "+" means the operation is applicable at this type of TM, "-" means the operation is not applicable.<br>2 The dosimeter should be verified after manufacture, during use, and after repair. | | | | |

3.1.2 Safety measures.

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

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 component parts surface of the dosimeter, integrity of seals, absence of scratches, traces of corrosion, and surface damage of the dosimeter;

b) check the condition of battery clamps of the dosimeter.

3.1.3.2 Delivery kit completeness check.

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

3.1.3.3 Operability check.

3.1.3.3.1 Operability check of the dosimeter and its procedure are performed according to OM 2.3.3.

3.1.3.4 Storage battery switching off and battery status control.

The storage battery of the control panel is switched off each time before the long-term storage of the dosimeter. Do this as follows:

- turn the control panel of the dosimeter off;
- remove the lid of the battery compartment;
- remove the battery;
- examine the battery compartment, check the contact clamps, clean the battery compartment from dirtying and contact clamps from oxides;
- make sure there is no humidity, no salt spots on the battery surface, and the insulated coating is not damaged.

The same procedure should be applied to the storage batteries of the wrist warning device.

**3.2 Verification of the dosimeter**

The dosimeters should be verified after manufacture, during use (periodic verification at least once a year), and after repair.

3.2.1 Verification operations.

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

Table 3.2 - Verification operations

| Operation name | Verification technique No. | Operation required for: | | |
|---|---|---|---|---|
| | | initial verification | periodic verification | after repair |
| 1 External examination | 3.2.4.1 | Yes | Yes | Yes |
| 2 Testing | 3.2.4.2 | Yes | Yes | Yes |
| 3 Calculation of main relative permissible error limit at photon-ionizing radiation DER measurement | 3.2.4.3 | Yes | Yes | Yes |
| 4 Estimation of neutron radiation detector sensitivity | 3.2.4.4 | Yes | No | Yes |

3.2.2 Verification facilities.

3.2.2.1 The following facilities should be used for verification:

- УПГД-2 standard equipment with standard $^{137}$Cs gamma radiation sources;
- РЕТУ 12-03-01-03 standard equipment of neutron flux density unit;
- $^{137}$Cs reference spectroscopic gamma source.

All verification facilities should have valid verification certificate or state metrological certification.
**Note.** Other standard measuring equipment with the prescribed accuracy can be used.

3.2.3 Verification conditions
3.2.3.1 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 kPa to 106.7 kPa;
- natural photon-ionizing radiation background should not exceed 0.25 μSv/h;
- power supply voltage within (1.3±0.2) V.

3.2.4 Verification procedure.

3.2.4.1 External examination.
During external examination the dosimeter should meet the following requirements:
- the delivery kit should be completed as described in OM 1.3;
- labeling should be accurate;
- Quality Control Department seals should not be violated;
- the dosimeter should be free from mechanical damage that may affect its performance.
**Note.** The delivery kit completeness is checked only at manufacture.

3.2.4.2 Testing.

3.2.4.2.1 Turn on the dosimeter according to 2.3.3.1 and perform calibration relative to gamma background. Place the $^{137}$Cs reference spectroscopic gamma source near the control panel of the dosimeter. Observe readings increase of pulse count rate from the detector of photon-ionizing radiation above the background level, and alarm actuation when the automatically preset search threshold level is exceeded. After the test, turn off the dosimeter according to 2.3.3.2.

3.2.4.3 Calculation of main relative permissible error limit at photon-ionizing radiation DER measurement.
3.2.4.3.1 Prepare the standard equipment УПГД-2 for operation according to its operating manual.
Place the control panel of the dosimeter in the УПГД-2 carriage holder so that the mechanical center of gamma quanta beam coincides with the "+" label on the front cover of the control panel. Turn on the control panel of the dosimeter (without the warning device). After the "Er05" or "Er02" symbols appear on the LCD, press shortly the MODE button. Program zero values of threshold levels and root-mean-square deviations quantity according to 2.3.3.7, 2.3.3.9 and 2.3.3.11 of the OM and wait until calibration relative to gamma background is finished.
Perform five measurements of gamma background indoors without exposure of the dosimeter control panel to the standard source.
Register the received readings in the protocol.
Place the УПГД-2 carriage together with the control panel of the dosimeter in the position, where DER from $^{137}$Cs source is 0.8 μSv/h.
Wait for 8 s and fulfill five measurements of photon-ionizing radiation DER.
Register the received readings in the protocol, and calculate the photon-ionizing radiation DER by the formula (2) and the main relative error of measurement.

$$\dot{H}\gamma = \overline{\dot{H}\gamma_i\phi} - \overline{\dot{H}\phi} \qquad (2)$$

where: $\overline{\dot{H}\gamma_i\phi}$ - is an average value of the dosimeter readings from the source and external gamma background, μSv/h;

$\overline{\dot{H}\phi}$ - is an average value of the dosimeter readings at measurement of external gamma background, μSv/h.

3.2.4.3.2 Place the УПГД-2 carriage together with the control panel of the dosimeter in the position, where DER from $^{137}$Cs source is 8.0 μSv/h.
Wait for 8 s and fulfill five measurements of photon-ionizing radiation DER.
Register the received readings in the protocol, and calculate the photon-ionizing radiation DER value by the formula (2) and the main relative error of measurement.

3.2.4.3.3 Place the УПГД-2 carriage together with the control panel of the dosimeter in the position, where DER from $^{137}$Cs source is 80.0 μSv/h.
Wait for 8 s and fulfill five measurements of photon-ionizing radiation DER.
Register the received readings in the protocol, and calculate the average DER value and the main relative error of measurement.

3.2.4.3.4 The dosimeter is acknowledged to have passed the verification test if the main relative error of measurement for each DER level does not exceed $\pm(15 + 2 / \dot{H})$ %, where $\dot{H}$ - is the measured DER value in μSv/h.

3.2.4.4 Estimation of sensitivity of neutron radiation detector.

3.2.4.4.1 Prepare to operation the РЕТУ 12-03-01-03 standard equipment of neutron flux density unit for creation of thermal neutron flux according to its maintenance documentation.

3.2.4.4.2 Secure the control panel of the dosimeter in the УКПН-1М carriage holder, which is included in the РЕТУ 12-03-01-03 standard equipment, so that the mechanical center of thermal neutrons beam coincides with the "+" label on the front cover of the control panel.

3.2.4.4.3 Turn on the control panel of the dosimeter (without the warning device). As soon as the "Er05" or "Er02" symbols appear on the LCD, press shortly the MODE button. Program zero values of the threshold levels and root-mean-square deviations quantity according to 2.3.3.7, 2.3.3.9 and 2.3.3.11 of the OM and wait until calibration relative to gamma background is finished.

3.2.4.4.4 Place the neutron radiation source ИБН-8-7 No.025 in the УКПН-1М equipment collimator, and to create thermal neutrons flux fix the thermal header from the equipment kit. Move the carriage with the control panel to 2.0 m distance. Wait for 30 s and fulfill five measurements of pulse count rate from the neutron radiation detector.

Register the received readings in the protocol, and calculate the average value.

Calculate the neutron detector sensitivity to thermal neutrons $\varepsilon_{nTh}$ by the formula (3).

$$\varepsilon_{nTh} = \frac{\overline{N}_{Th}}{\varphi_{The}} \cdot 60 \qquad \left[\frac{pulse \cdot cm^2}{neutron}\right] \qquad (3)$$

where: $\overline{N}_{Th}$ is an average arithmetical value of five observations at measurements of pulse count rate from the neutron radiation detector, which was exposed to thermal neutrons, pulse/s;

$\varphi_{The}$ is a standard value of thermal neutrons flux density, 1/(cm$^2$·min)

3.2.4.4.5 Place the neutron radiation source ИБН-8-7 No.025 in the УКПН-1М equipment collimator, and to create fast neutrons flux remove the thermal header from the equipment collimator. Move the carriage with the control panel to 2.0 m distance. Wait for 30 s and fulfill five measurements of pulse count rate from the neutron radiation detector.

Register the received readings in the protocol, and calculate the average value.

Calculate the neutron detector sensitivity to fast neutrons $\varepsilon_{nF}$ by the formula (4).

$$\varepsilon_{nF} = \frac{\overline{N}_{F}}{\varphi_{Fe}} \cdot 60 \qquad \left[\frac{pulse \cdot cm^2}{neutron}\right] \qquad (4)$$

where: $\overline{N}_{F}$ is an average arithmetical value of five observations at measurements of pulse count rate from the neutron radiation detector, which was exposed to fast neutrons, pulse/s;

$\varphi_{Fe}$ is a standard value of fast neutrons flux density, 1/(cm$^2$·min).

3.2.4.4.6 The dosimeter is acknowledged to have passed the verification test if the neutron radiation detector sensitivity is not less, than:

- for thermal neutrons $\frac{pulse \cdot cm^2}{neutron}$;
- for fast neutrons $\frac{pulse \cdot cm^2}{neutron}$.

3.2.5 Presentation of verification results.

3.2.5.1 Positive results of primary, periodic or after-repair verification are presented as follows:

1) primary verification is registered in the "Certificate of acceptance" section. Primary verification results are recorded in Table 3.3;

2) periodic and after-repair verification is registered in the issued certificate of the established form.

3.2.5.2 The dosimeters that do not meet the requirements of verification are not allowed for manufacture and use, and get the certificate of inadequacy.

Table 3.3 – Primary verification of key specifications

| Tested specification | | Actual value |
|---|---|---|
| Name | Standardized value | |
| Main relative error at photon-ionizing radiation DER measurement within 0.1 to 100.00 μSv/h in the collimated beam from $^{137}$Cs with confidence probability of 0.95, % | $\pm(15 + 2 / \dot{H})$, where $\dot{H}$ is a numeric value of DER measurement in μSv/h | |

| | | |
|---|---|---|
| Sensitivity of the neutron radiation detector to:<br><br>- thermal neutrons<br>- fast neutrons | $\frac{pulse \cdot cm^2}{neutron}$<br>$\frac{pulse \cdot cm^2}{neutron}$ | |

## 4 CERTIFICATE OF ACCEPTANCE

The DKS-02PN “CADMIUM” search alarm dosimeter, with _____ serial number is verified and accepted for use.

Date of manufacture _____

QCD Representative: _____

(signature)

Stamp here

State Verification Officer: _____

(signature)

Mark here

## 5 PACKING CERTIFICATE

The DKS-02PN “CADMIUM” search alarm dosimeter with _____ serial number is packed by the PE “SPPE “Sparing-Vist Center” in accordance with the requirements outlined in the OM.

Date of packing _____

Stamp here

Packed by _____

(signature)

## 6 WARRANTY

6.1 The manufacturer guarantees the conformity of the dosimeter to the technical requirements provided that the customer observes the guidelines on its use, shipping and storage presented in the operating manual BICT.412129.002-04 HE.

6.2 The warranty period of the dosimeter shall terminate and be of no further effect in 18 months after the date of putting it into operation and 24 months after the manufacture date.

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

6.4 The warranty period of use of the dosimeter is prolonged for the warranty repair period.

6.5 When the warranty period of the dosimeter terminates, the repair of the dosimeter is performed according to separate contracts.

6.6 Warranty and post-warranty repair is done only by the manufacturer.

6.7 If the mechanical damage is detected or the seals are removed, the repair is done at customer’s cost.

## 7 REPAIR

7.1 In case of failure or troubles during the warranty period of the dosimeter, the customer should draw up a statement about the necessity of repair, and deliver the dosimeter to the producer-enterprise at the address:

***PE "SPPE "Sparing-Vist Center"***

***33 Volodymyr Velyky Str., Lviv 79026, Ukraine***

*Tel.: (+380 32) 242-1515, fax: (+380 32) 242-2015.*

7.2 All claims are registered in Table 7.1.

Table 7.1

| Date of failure | Claim summary | Action taken | Note |
|---|---|---|---|
| | | | |

7.3 Warranty and post-warranty repair should be done only by the producer-enterprise. Information on repair of the dosimeter is recorded in the table of Appendix B of this OM.

## 8 STORAGE

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

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

8.3 The dosimeters should be stored on the shelves.

8.4 The distance between the walls, the floor of the storehouse and dosimeters should be at least 1 m.

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

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

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

## 9 SHIPPING

9.1 Packed dosimeters may be shipped by any kinds of closed transport vehicles (with temperature limitations in the range from – 25 $^{o}$C to +50 $^{o}$C), in conformance with the rules and standards effective for each means of transport.

9.2 The dosimeters in shipping containers should be placed and fastened in the vehicle so that their stable position is ensured and shocks (with each other and the sidewalls of the transport) are avoided.

9.3 The dosimeters in shipping container endure:

- temperature from -25 to +50 $^{o}$C;
- relative humidity (95±3) % at 35 $^{o}$C temperature.

9.4 Canting is forbidden.

## 10 DISPOSAL

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

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

**APPENDIX A**

**TROUBLE RECORD DURING USE**

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

## APPENDIX B

**REPAIR**

| Name and type of the component part of the device | Reason for repair | Date | | Name of the repair organiza-tion | Number of hours worked before repair | Type of repair | Name of repair | Position, name and signature of the responsible person | |
|---|---|---|---|---|---|---|---|---|---|
| | | of arriving for repair | of repair completion | | | | | who performed repair | who accepted after repair |
| | | | | | | | | | |

**APPENDIX C**

**STORAGE**

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

**APPENDIX D**

**PUTTING IN PROLONGED STORAGE AND REMOVAL FROM STORAGE**

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

**APPENDIX E**

**VERIFICATION AND INSPECTION RESULTS**

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

NOTES