



DKG-21
PERSONAL GAMMA RADIATION DOSIMETER

Operating manual
BICT.412118.014-02 HE

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This operating manual is intended to inform the user about the principles of operation and rules of application of the DKG-21 personal gamma radiation dosimeter. The manual contains all information necessary for proper use of the DKG-21 dosimeter (hereinafter called the dosimeter) and full realization of its technical possibilities.

Before operating the dosimeter, the user should be instructed on safety regulations and radiation safety, and should study this operating manual.

1 GENERAL GUIDELINES

1.1 Carefully study the operating manual (hereinafter called the OM) before using the dosimeter.

1.2 The OM should always be kept with the dosimeter.

1.3 All records in the OM should be accurate and clear. Notes made in pencil, erasures and uncertified corrections are not allowed.

2 MAIN INFORMATION ABOUT THE DOSIMETER

The dosimeter meets the requirements of TY Y 33.2-22362867-010:2007 technical specifications, and is registered in the State Register for Measuring Instruments, accepted for application in Ukraine. The State Register No Y2514-07.

The dosimeter is a part of the automated system of personal dosimetry control ASPDC-21 registered in the State Register for Measuring Instruments, and is accepted for application in Ukraine under No. Y1816-07.

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3 DESCRIPTION AND OPERATION

3.1 Purpose of use

3.1.1 The dosimeter is designed to measure individual dose equivalent $H_p(10)$ of gamma and X-ray radiation (hereinafter – DE) and dose equivalent rate $\dot{H}_p(10)$ (hereinafter – DER) of gamma and X-ray radiation.

3.1.2 The dosimeter can be used in industrial enterprises and companies that deal with gamma and X-ray radiation sources.

3.2 Technical specifications

3.2.1 Measurement range of DER varies from 0.1 $\mu\text{Sv/h}$ to 1.0 Sv/h.

3.2.2 Main relative permissible error limit of DER measurement at 0.95 confidence probability is:

- 20 % - in the DER range of 1.0 to 10 $\mu\text{Sv/h}$;
- 15 % - in the DER range of 10 $\mu\text{Sv/h}$ to 1.0 Sv/h.

3.2.3 Measurement range of DE in the DER range of 0.1 $\mu\text{Sv/h}$ to 1.0 Sv/h varies from 0.001 to 9999 mSv.

3.2.4 Main relative permissible error limit of DE measurement in the DER range of 1.0 $\mu\text{Sv/h}$ to 1.0 Sv/h in the DE range of 0.01 to 9999 mSv at 0.95 confidence probability is 15 %.

3.2.5 Complementary relative permissible error limit of DER and DE measurement caused by ambient temperature change from - 10 to + 50 $^{\circ}\text{C}$ is 5 % per each 10 $^{\circ}\text{C}$ of deviation from + 20 $^{\circ}\text{C}$.

3.2.6 Energy range of registered gamma and X-ray radiation is from 0.05 to 6.00 MeV.

3.2.7 Energy dependence of DER and DE measurement in the energy range of 0.05 to 1.25 MeV is not more than ± 25 %.

3.2.8 Anisotropy at gamma quantum incidence at solid angle of $\pm 60^{\circ}$ relative to the main measurement direction (perpendicular to the front panel of the dosimeter), not more than:

- 15 % - for ^{137}Cs and ^{60}Co radionuclides;
- 70 % - for ^{241}Am radionuclide.

3.2.9 Time of operating mode setting at DER measurement, not more than:

- 8 min – in the DER range of 1.0 $\mu\text{Sv/h}$ to 10.0 $\mu\text{Sv/h}$;
- 2 min - in the DER range of 10.0 $\mu\text{Sv/h}$ to 1.0 Sv/h.

3.2.10 Time of DER measurement, not more than:

- 10 s – in the DER range of 1.0 $\mu\text{Sv/h}$ to 10.0 $\mu\text{Sv/h}$;
- 5 s – in the DER range of 10.0 $\mu\text{Sv/h}$ to 1.0 Sv/h.

3.2.11 Time of continuous operation, not less than:

- 2200 hrs – for DER values less than 1.0 $\mu\text{Sv/h}$
- 1400 hrs – in the DER range of 0.1 $\mu\text{Sv/h}$ to 100 $\mu\text{Sv/h}$;
- 560 hrs - in the DER range of 100 $\mu\text{Sv/h}$ to 1.0 mSv/h;
- 110 hrs - in the DER range of 1.0 mSv/h to 10 mSv/h;
- 35 hrs - in the DER range of 10 mSv/h to 1.0 Sv/h.

3.2.12 Unstable readings during 8 hours of continuous operation, not more than 5 %.

3.2.13 The dosimeter is powered from DC source of 2.4 to 3.2 V voltage and capacity of 560 mAh.

Note – Operating supply voltage – 3 V.

3.2.14 Maximum useful current at nominal voltage does not exceed:

- 0.4 mA – in the DER range of 0.1 $\mu\text{Sv/h}$ to 100 $\mu\text{Sv/h}$;
- mA - in the DER range of 100 $\mu\text{Sv/h}$ to 1.0 mSv/h;
- 5 mA - in the DER range of 1.0 mSv/h to 10 mSv/h;
- 15 mA - in the DER range of 10 mSv/h to 1.0 Sv/h.

3.2.15 Dimensions, not more than:

- length - 90 mm;
- height - 55 mm;
- width - 10 mm.

3.2.16 Weight, not more than 0.08 kg.

3.2.17 The dosimeter performs measurements under the following conditions:

- temperature – from - 10 to + 50 °C;
- relative humidity – up to (95±3) % at + 35 °C temperature;
- atmospheric pressure – from 84 to 106.7 kPa.

3.2.18 The dosimeter is resistant to sinusoidal vibrations of 10 to 55 Hz frequency, frequency bias 0.15 mm lower than the crossover frequency.

3.2.19 The dosimeter is resistant to shocks with the following parameters:

- shock pulse duration – 9.5 ms;
- number of shocks - 1000±10;
- maximum shock acceleration - 100 m/s².

3.2.20 The dosimeter in shipping container endure:

- ambient air temperature – from - 50 to + 50 °C;
- relative humidity – up to (95±3) % at + 35 °C temperature;

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

3.2.21 The dosimeter remains unaffected by constant and alternating magnetic field of (50 ± 1) Hz frequency and 400 A/m intensity.

3.2.22 The dosimeter is immune to gamma and X-ray radiation of up to 10 Sv/h DER for 50 minutes.

3.2.23 The dosimeter has “Clock” and “Alarm clock” operating modes.

3.2.23.1 The alarm clock rings during one minute or until any button is pressed.

3.2.24 DER and DE threshold level values with discreteness of a unit of a programmable digit in overall operating measurement range can be programmed in the dosimeter with the help of the control buttons.

3.2.25 The dosimeter sends audio and light signals if the programmed DER or DE threshold level is exceeded.

3.2.25.1 The dosimeter sends an interrupted audio signal when 90 % of the programmed threshold level of DE is reached. Press any button to switch this audio signaling off.

3.2.26 DER and DE values as well as DER and DE threshold level values alternately appear on the digital liquid crystal display (LCD), indicating the correspondence of information.

3.2.26.1 The dosimeter indicates the statistical error of the displayed DER measurement result. Indication is performed by a blinking or steady decimal point.

3.2.27 The LCD can be switched off automatically not later than in 5 min provided that the current gamma background is lower than the preset threshold level. The LCD may be instantly switched on by pressing any button or when gamma background exceeds the preset threshold level.

3.2.28 The dosimeter includes the mode of automatic power supply testing and battery status indication shown by a battery symbol. This symbol appears in the right upper corner of the LCD. The level of battery discharge is indicated by a number of blinking segments. Full discharge is indicated by all four segments blinking and by audio signaling.

3.2.29 Design of the dosimeter supports deactivation.

3.2.30 Reliability Requirements

3.2.30.1 Mean time to failure, not less than 6000 h. Failure criterion is nonconformity to the requirements stated in 3.2.2.

3.2.30.2 Average value of operational readiness, not less than 0.999.

3.2.30.3 Mean time to repair, not less than 10000 h, and average service life, not less than 10 years.

Limit state criterion is deviation of parameters from the values stated in 3.2.2 that can not be eliminated.

3.2.30.4 Average shelf life, not less than 10 years.

3.2.31 Service capabilities of the dosimeter being functionally compatible with the personal computer (hereinafter – the PC).

3.2.31.1 The dosimeter supports recording the history of dose accumulation during a working shift (8 h) in the nonvolatile memory with the discreteness of the record change of 1 min in the range from 5 to 255 min with reference to real time.

3.2.31.2 The dosimeter is able to transfer the history of dose accumulation to the PC via the infrared port. The distance of positive exchange is not more than 0.3 m between the dosimeter and the infrared port adapter (IRPA).

3.2.31.3 Coupled with the PC, the dosimeter enables:

- blocking the mode of power supply switch off before the start of the data reading procedure;

- blocking the modes of indication (DER, DER threshold, DE, DE threshold, clock and alarm clock); change (DER threshold, DE threshold) and correction of clock and alarm clock settings.

3.3 Delivery kit of the dosimeter

3.3.1 The delivery kit is presented in Table 3.1.

Table 3.1 – Delivery kit of the DKG-21 dosimeter

Item	Type	Quantity
Personal gamma radiation dosimeter DKG-21	BICT.412118.014-02	1
Battery *	CR 2450 (Panasonic)	1
Operating manual	BICT.412118.014-02 HE	1
Case with a clip	Model is not specified	1
Carton box	BICT.321342.014	1

* Other batteries similar in application, safety and reliability can be used

3.4 Design and principle of operation

3.4.1 General information

The dosimeter is presented as a mono block including a built-in detector of gamma and X-ray radiation, a printed circuit board equipped with a circuit of anode voltage formation, digital processing, control and indication, an infrared port of data exchange, and a battery.

Gamma and X-ray radiation detector transforms radiation into the sequence of voltage pulses; the number of pulses is proportional to the registered radiation intensity.

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

- scaling and linearization of the counting response of the detector;
- measurement of DER through measurement of the average pulse frequency of the detector output;

- measurement of DE through measurement of total amount of pulses of the detector output;
- measurement of real time;
- formation and stabilization of anode voltage of the detector;
- control of operating modes of the dosimeter;
- indication of measurement results.

Power for operation is supplied by a disk-shaped lithium battery of CR 2450 (Panasonic) type.

3.4.2 Design description

The dosimeter is designed as a flat square plastic body (Figure B.1, B.2), which consists of the upper (1) and the lower (2) covers, the battery compartment lid (3), the film front panel (4) and the metal ring (5) used to fasten the strap.

The transparent window (6), with the LCD (7) located behind it, is located in the left upper corner of the front panel. Two smaller windows (8, 9) for the optical system of the infrared port (10) and the light-emitting diode indicator (11) are located next to this window. Two membrane control keys (12) with corresponding inscriptions are located in the right lower corner of the front panel.

The printed circuit board (13) lies within the body, where all elements of the electric circuit, with an exception of the loudspeaker and the battery, are located. The loudspeaker (14) is located in a cylindrical sound chamber, done as a construct of the upper cover. The loudspeaker is mechanically fastened and electrically connected with the circuit by three spring contacts, located on the printed circuit board.

The components of the device and the printed circuit board are fastened with five screws.

The battery (15) is inserted into the battery compartment (16), and fastened to the circuit by two spring contacts. The inscriptions that specify type, voltage and polarity of the battery connection are placed at the bottom of the battery compartment.

3.5 Labeling and sealing

3.5.1 The front panel of the dosimeter is inscribed with the:

- name – “Personal gamma radiation dosimeter DKG-21”;
- trademark of the manufacturer;
- approval mark;

3.5.2 The rear panel of the dosimeter is inscribed with the markings:

- “Made in Ukraine”;
- name of the manufacturer;
- TY number;
- serial number of the dosimeter according to the numbering system of the producer-enterprise);

- ingress protection rating – “IP31”;
- mechanical center of the detector with the “+” symbol;
- month and year of manufacture.

3.5.3 Labeling quality is maintained during service life under all conditions and modes, except for labeling done on the individual package.

3.5.4 The dosimeter accepted by the Quality Control Department (QCD) and prepared for packing is sealed with a special film seal, covering the screw heads, which fasten together the upper and the lower covers, or a paste seal in the hollow above the head of the fastening screw.

3.6 Packing

3.6.1 Packing is performed in accordance with the requirements specified in BICT.412118.014.

3.6.2 The dosimeter is packed in a special cardboard box, which (together with the operating manual), in its turn, is placed in a transparent polyethylene package, welded after packing performed.

4 PROPER USE OF THE DOSIMETER

4.1 Operating limitations

4.1.1 Operating limitations are presented in 3.2.14, 3.2.18 - 3.2.1.23.

4.2 Preparation of the dosimeter for operation

4.2.1 Scope and order of external examination

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

4.2.2 Rules and order of examination for operational readiness

4.2.2.1 Examine the control buttons before switching the dosimeter on.

4.2.2.2 Open the battery compartment and make sure the battery is inserted, connections are reliable, and there is no leakage of salts after long-term storage of the dosimeter. In case of salt leakage, remove the battery. Clean it, if possible, or replace, if not. Insert the battery and close the battery compartment with the lid.

4.2.3 Guidelines on switching on and testing the dosimeter

4.2.3.1 Prepare the dosimeter for operation. Do the following:

- unpack the dosimeter;

- open the battery compartment and insert the battery of CR 2450 type observing the polarity. The dosimeter should enter the mode of DER measurement indicated by “ $\mu\text{Sv/h}$ ” measurement units, which are constantly displayed on the LCD.

4.2.3.2 Press shortly the MODE button and make sure the dosimeter has entered the mode of DE indication. DE units of measurement expressed in “mSv” should appear on the LCD.

4.2.3.3 Press shortly the MODE button and make sure the dosimeter has entered the mode of real time indication, which is shown by a one-second blinking colon between the two pairs of the LCD digits.

4.2.3.4 Press shortly the MODE button and make sure the dosimeter has entered the mode of the alarm clock setting, which is indicated by a nonblinking colon between the two pairs of digits on the LCD. After setting the alarm clock (4.3.3.7) press shortly the MODE button to switch it on, which should be indicated by a “)))” symbol on the LCD.

4.2.3.5 Hold the MODE button pressed for 4 s to switch the dosimeter off.

Note. The battery should be replaced if the low battery symbol appears on the LCD – gradual blinking of one to four segments of the battery symbol in the right top corner of the LCD, which depends on the increasing process of discharge, when the dosimeter is switched on irrespective of the selected mode. All four segments of the symbol are blinking and a short audio signal is generated each 4 s when the battery is fully discharged.

4.2.4 List of possible troubles and troubleshooting

4.2.4.1 The list of possible troubles and troubleshooting is presented in Table 4.1.

Table 4.1 - Possible troubles and troubleshooting

Trouble	Probable cause	Solution
1 The dosimeter does not switch on after the MODE button is pressed	1 The battery is discharged 2 Poor contact between the battery and the battery compartment clamps	1 Replace the battery 2 Restore the contact between the battery and the clamps
2 The "Err" symbol is displayed on the LCD after the battery has been replaced	Failure of the nonvolatile memory of the dosimeter	Send the dosimeter for repair to the manufacturer
3 The "Err1" symbol is displayed on the LCD during operation of the dosimeter	Failure of the anode voltage former or the ionizing radiation detector	Send the dosimeter for repair to the manufacturer

4.2.4.2 At failure to eliminate the troubles presented in Table 4.1, or at detection of more complicated troubles, the dosimeter should be sent for repair to the manufacturer.

4.3 Use of the dosimeter

4.3.1 Safety measures

4.3.1.1 The dosimeter meets the requirements of the valid standards with regard to people protection against electric-shock hazard.

4.3.1.2 The dosimeter contains electric circuits of voltage up to 400 V; demount the dosimeter when the power supply is switched off.

4.3.1.3 The dosimeter's design excludes any electric voltages on the outside of the dosimeter.

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

4.3.1.5 Ingress protection rating is IP31.

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

Note. If the dosimeter is contaminated by any liquid or dry radionuclides and it is impossible to completely decontaminate the device, the dosimeter should be buried as solid radioactive waste.

4.3.2 **Operating modes of the dosimeter**

4.3.2.1 The dosimeter operates within the following modes:

- switching the dosimeter on/off;
- DER measurement and indication;
- programming of audio and light alarm threshold levels of DER;
- DE measurement indication;
- programming of audio and light alarm threshold level of DE;
- indication and correction of real time;
- indication and correction of the alarm clock settings, switching the alarm clock on/off;

- power supply control;
- performance monitoring of the ionizing radiation detector.

4.3.3 Operation procedure of the dosimeter

4.3.3.1 Switching the dosimeter on/off

Press shortly the MODE button to switch the dosimeter on. The information displayed on the LCD shows that the dosimeter is on.

At the same time the infrared port of the dosimeter is activated for 15 s. While the infrared port is active, you can perform the procedure of data exchange with the PC, programme the threshold levels, intervals of dose history accumulation, and permit/prohibit certain operating modes of the dosimeter. The blinking digits on the LCD indicate that the infrared port is active. As soon as data exchange with the PC is finished, the dosimeter starts accumulating dose history with the preset interval. Otherwise, the dosimeter starts operating in the stand-alone mode with integral dose accumulation without dose history accumulation.

Press the MODE button once again and hold it pressed for 4 s to switch the dosimeter off. If the dosimeter is switched on in the stand-alone mode, e.i. no data exchange with the PC is done, the dosimeter will be switched off. If during switching it on data exchange between the dosimeter and the PC took place the effort to switch the dosimeter off would only activate the infrared port for 15 s.

4.3.3.2 Measurement of DER

The mode of DER measurement is entered automatically after the dosimeter is switched on. The units of measurement are expressed in $\mu\text{Sv/h}$. The process of DER measurement accumulation and averaging will start after the dosimeter is switched on. The process will continue up to 1600 s at DER values close to background. The data on the LCD will be updated each 10 s. However, wait 2-3 minutes to get close to true result. As the radiation intensity increases, the time of DER measurement averaging and the time of data updating on the LCD decreases to minimum 2 s. The units of measurement are expressed in $\mu\text{Sv/h}$, mSv/h , and Sv/h .

The statistical error of the displayed measurement result of DER is indicated by the blinking or steady decimal point. The blinking point indicates that the statistical error of the indicated DER measurement result exceeds maximum permissible error. Hence, the measurement result can be used only for rough evaluation of DER. The steady point informs that the statistical error of the DER measurement result is within the permissible range.

The main direction of the dosimeter during DER measurement is the direction perpendicular to the front (rear) panel of the dosimeter.

DER measurement result is considered the arithmetic mean of five last measurements in 8 min after the intensity of radiation is changed at DER levels in the range of 1.0 to 10.0 $\mu\text{Sv/h}$, or within 2 min to 2 s for the levels in the range of 10.0 $\mu\text{Sv/h}$ to 1.0 Sv/h .

Measurement intervals and subranges will be set automatically according to the intensity of registered radiation.

Note. The process of data averaging can be stopped forcedly for quick evaluation of DER. This is achieved by pressing shortly the THRESHOLD button. Rough evaluation of DER value will be performed within 1 min.

4.3.3.3 Programming of audio and light DER alarm threshold level

Audio and light alarm threshold levels of DER are programmed in the mode of DER measurement. Press the THRESHOLD button and hold it pressed for 4 s to start programming. The low-order digit will start blinking on the LCD.

Set an appropriate value of the low-order digit by pressing and releasing the THRESHOLD button. Press shortly the MODE button to proceed to the programming of another digit, the latter will start blinking. The necessary value of the digit is set with short pressing and releasing the THRESHOLD button.

After the last digit of the threshold level is set and next pressing of the MODE button, the LCD will blink four times, indicating that the value is fixed. The dosimeter will enter the mode of DER measurement.

Press the THRESHOLD button and hold it pressed not more than 4 s after a new threshold level value appears to check the value of the fixed DER threshold level.

When holding the THRESHOLD button pressed for more than 4 s the low-order digit starts blinking, indicating that a new threshold level value can be programmed.

Blinking of the red light-emitting diode and a two-tone audio alarm indicate that the programmed DER threshold level has been exceeded.

Notes

1 The DER threshold level value of 1.0 $\mu\text{Sv/h}$ is set automatically after the dosimeter is switched on.

2 A preset zero value of the DER threshold level sets off the alarm system when the threshold level is exceeded.

4.3.3.4 Indication of DE measurement

Press shortly the MODE button to enter the mode of DE measurement indication. This mode follows the mode of DER measurement (entered automatically after the dosimeter is switched on).

The “mSv” symbol that appears on the LCD indicates you have entered the appropriate mode. A comma after the first left digit will appear on the

LCD after the dosimeter is switched on. The comma will automatically shift to the right until full completion of the DE scale of the dosimeter as the DE measurement value increases. The units of DE measurement are expressed in mSv.

4.3.3.5 Programming of audio and light DER alarm threshold levels

Audio and light alarm threshold level of DE is programmed in the mode of DE measurement. Hold the THRESHOLD button down for more than 4 s to start programming. The low-order digit will start blinking on the LCD.

Set an appropriate value of the low-order digit by pressing and releasing the THRESHOLD button. Press shortly the MODE button to proceed to programming of another digit, the latter will start blinking. Set an appropriate value of the digit by pressing and releasing the THRESHOLD button.

After the last digit of the threshold level is set and at next pressing of the MODE button, the LCD will blink four times, indicating that the value is fixed, and the dosimeter will enter the mode of DE indication.

Press the THRESHOLD button and hold it pressed for maximum 4 s after the threshold level value appears to check the value of the fixed DE threshold level.

Hold the THRESHOLD button pressed for more than 4 s to set the threshold value to zero. The low-order digit will start blinking at that indicating that a new threshold level value can be programmed.

Blinking of the red light-emitting diode and a two-tone audio alarm indicate that the programmed DE threshold level has been exceeded.

To inform the user that the DE threshold level is likely to be quickly reached, the dosimeter sends an interrupted audio signal when 90 % of the programmed threshold level is achieved. Press any button to switch this audio alarm off.

Note. The DE threshold level value of 0.000 mSv is set automatically when the dosimeter is switched on indicating that the alarm is switched off.

4.3.3.6 **Indication and correction of real time**

Press shortly the MODE button to enter the mode of real time indication. This mode follows the mode of DE measurement.

It is indicated by a one-second blinking “:” symbol between the two pairs of the LCD digits.

The digits from the right to the left show the following: the first digit indicates minutes; the second one - tens of minutes; the third one - hours; the fourth one - tens of hours.

Press the THRESHOLD button and hold it down until two digits to the right from the “:” symbol start blinking to correct the value of real time. Release the button afterwards. The proper values of units and tens of minutes are fixed by further pressing and holding the THRESHOLD button. The minutes can also be corrected by short pressing of the THRESHOLD button. Each pressing will change the value per unit. Press shortly the MODE button to correct the value of hours. The two digits to the left from the “:” symbol start blinking at that. The hour value correction is performed likewise. Press shortly the MODE button once again to exit the mode of real time correction.

4.3.3.7 Indication and correction of alarm clock settings, switching alarm clock on/off

Press shortly the MODE button to enter the mode of indication of the alarm clock time. This mode follows the mode of real time indication. A non-blinking “:” symbol between the two pairs of digits on the LCD indicates you have entered the appropriate mode.

Press the THRESHOLD button and hold it down until the two digits to the right from the “:” symbol start blinking to correct the alarm clock settings. Release the button afterwards. Set the proper values of units and tens of minutes by further pressing and holding the THRESHOLD button. The minutes can also be corrected by short pressing of the THRESHOLD button. The value will change per unit each time in this case. Press shortly the MODE button to correct the value of hours. The two digits to the left from the “:” symbol start blinking at that. Hour values can be corrected likewise.

Press shortly the MODE button to switch the alarm clock on/off after correcting the hour values of the alarm clock. A blinking sound symbol “)))” should appear on the LCD. Press shortly the THRESHOLD button; make the non blinking sound symbol appear on the LCD to switch the alarm clock on.

Press shortly the THRESHOLD button to switch the alarm clock off. The sound symbol should extinct. Fix the alarm clock settings by further short pressing of the MODE button. If the alarm clock is on, the sound symbol will be displayed on the LCD irrespective of the selected operating mode.

Note. The alarm clock will continue working even after the power supply of the dosimeter is off (provided that the batteries are inserted). The dosimeter will automatically enter the mode of real time indication when the alarm clock goes off. Press any control button to switch off audio signal of the alarm clock. Otherwise, audio signal will be disabled automatically in a minute after the alarm clock rings.

4.3.3.8 Power supply control

The mode of power supply control is turned on immediately after the dosimeter is on. It is indicated by the four-segment battery symbol displayed in the right upper corner of the LCD. The number of segments blinking starting from the last right one shows the level of battery discharge. Blinking of three and more segments means that the battery should be replaced with a new one.

4.3.3.9 Operability check of the detector

The mode of detector's operability check is switched on as soon as the dosimeter is on. If the detector fails, the "Err1" symbol is displayed on the LCD, which means the dosimeter should be sent for repair.

5 TECHNICAL MAINTENANCE

5.1 Technical maintenance of the dosimeter

5.1.1 General instructions

The list of operations performed during technical maintenance (hereinafter called TM) of the dosimeter, the order and the peculiarities of operational phases are presented in Table 5.1.

Table 5.1 - List of operations during technical maintenance

Operations	TM type			OM item No.
	during		During long-term storage	
	everyday use	periodical use (annually)		
External examination	+	+	+	5.1.3.1
Delivery kit completeness check	-	+	+	5.1.3.2
Operability check	+	+	+	5.1.3.3
Power supply disconnection	-	+	+	5.1.3.4
Verification of the dosimeter	-	+	+	5.2
<p>Note. “+” means the operation is applicable for this type of TM; “-” means the operation is not applicable.</p>				

5.1.2 Safety measures

5.1.2.1 TM safety measures fully comply with safety measures stated in item 4.3.1 of the present OM.

5.1.3 Maintenance procedure of the dosimeter

5.1.3.1 External examination

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

- check the technical condition of surface, inspect for integrity of seals, absence of scratches, traces of corrosion, surface damage of the dosimeter;
- check the condition of clamps in the battery compartment.

5.1.3.2 Delivery kit completeness check

Check if the delivery kit is complete according to Table 3.1.

5.1.3.3 Operability check of the dosimeter.

Operability check of the dosimeter is performed according to item 4.2.3 of the present OM.

5.1.3.4 Power supply switch off

Power supply should be switched off each time the dosimeter is periodically used and before the long-term storage of it. Do this as follows:

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

5.2 Verification

5.2.1 The DKG-21 dosimeter should be verified after manufacture, repair or during use.

5.2.2 The interval between verifications should not exceed 12 months.

5.2.3 Verification operations are presented in Table 5.2.

Table 5.2 - Verification operations

Operation name	Verification technique No.
External examination	5.2.7.1
Testing	5.2.7.2
Calculation of main relative permissible error limit of DER measurement in the DER range of 1.0 μ Sv/h to 1.0 Sv/h	5.2.7.3, 5.2.7.4
Calculation of main relative permissible error limit of DE measurement in the DER range of 1.0 μ Sv/h to 1.0 Sv/h in the DE range of 0.01 to 9999 mSv	5.2.7.3, 5.2.7.5
Presentation of verification results	5.2.7.6

5.2.4 Verification facilities are presented in Table 5.3.

Table 5.3 - Verification facilities

Name	Regulatory Document or Main Technical Specifications
УПГД-3Б testing equipment	Gamma radiation DER range from 0.01 $\mu\text{Sv/h}$ to 1 Sv/h. Energy range from 59 KeV to 1.25 MeV. Main relative permissible error limit of gamma radiation DER and DE is 4 % at 0.95 confidence probability
Phantom	Dimensions: 30 \times 30 \times 15 cm; PMMA walls (polymethylmethacrylate, front wall thickness – 2.5 mm, other walls thickness – 10 mm); phantom is filled with distilled water

Table 5.3 (continued)

Name	Regulatory Document or Main Technical Specifications
Stopwatch	Measurement range from 1 s to 59 min
Aspiration psychrometer	Temperature measurement range from - 30 °C to + 50 °C. Temperature measurement error is ± 0.1 °C. Relative humidity measurement range from 10 to 100 %. Relative humidity measurement error from ± 12 % at $t = -10$ °C to ± 2 % at $t = 30$ °C
Control aneroid barometer	Pressure measurement range from 81.3 to 105.3 kPa (from 610 to 790 mm Hg). Pressure measurement error is ± 0.107 kPa (0.8 mm Hg)
<p>Notes</p> <p>1 All verification facilities should be certified, tested or calibrated.</p> <p>2 Use of other measuring instruments, tools and equipment with specifications similar to those outlined in Table 5.3 is allowed.</p>	

5.2.5 Verification should be performed in accordance with safety measures presented in item 4.3.1 of the OM.

5.2.6 Verification conditions

Verification should be performed under the following conditions:

- ambient air temperature range within (20 ± 5) °C;
- relative air humidity from 30 to 80 %;
- atmospheric pressure from 86 kPa to 106.7 kPa;
- natural background level of gamma radiation should not exceed $0.25 \mu\text{Sv/h}$;
- power supply voltage within (3.0 ± 0.2) V.

5.2.7 **Verification procedure**

5.2.7.1 External examination

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

- the delivery kit should be completed as stated in Table 3.1;

- labeling should be accurate;
- QCD seals should not be violated;
- the dosimeter should be free from mechanical damage that may affect its performance.

5.2.7.1.1.2 If the requirements in 5.2.7.1.1 are satisfied, proceed to the next verification operation.

5.2.7.1.1.3 If the delivery kit is not completed as stated in Table 3.1, verification should be stopped until the delivery kit is complete.

5.2.7.1.1.4 If labeling and sealing requirements are not satisfied, and the dosimeter has the signs of mechanical damages that affect its performance, it can not be verified and should be sent for repair.

5.2.7.2 Testing

5.2.7.2.1 Perform operations stated in item 4.2.3 of the present OM.

5.2.7.2.1.1 If all operations stated in 4.2.3 are performed, proceed to the next test operation.

5.2.7.2.1.2 Even if a single operation stated in 4.2.3 can not be performed, the dosimeter should not be verified and should be sent for repair.

5.2.7.3 DER and DE measurement should be performed on the phantom with 30x30x15cm dimensions, with PMMA walls (polymethylmethacrylate, front wall thickness - 2.5 mm, other walls thickness – 10 mm); the phantom should be filled with distilled water.

5.2.7.3.1 During measurement the dosimeter should be placed close to the phantom surface, directed to a gamma source. The indicator of the dosimeter should be directed towards the gamma source.

5.2.7.4 Calculation of main relative permissible error in DER measurement in the DER range of 1.0 $\mu\text{Sv/h}$ to 1.0 Sv/h is performed as follows.

5.2.7.4.1 Prepare the dosimeter for DER measurement and program zero value of DER threshold level.

5.2.7.4.2 Fix the dosimeter on the phantom according to item 5.2.7.3 in the УПГД-3Б carriage so that the mechanical center of the collimator coincides with the mechanical center of the detector. Take ten measurements of background DER ($\dot{H}_{p\phi i}(10)$) in УПГД-3Б with 10 s interval eight minutes after the dosimeter is switched on. Calculate the average DER value in $\mu\text{Sv/h}$ by the formula

$$\bar{\dot{H}}_{p\phi}(10) = \frac{\sum_{i=1}^{10} \dot{H}_{p\phi i}(10)}{10} \quad (5.1)$$

5.2.7.4.3 Place the carriage УПГД-3Б together with the phantom and the dosimeter in the position, where DER from the ^{137}Cs source with radionuclide is $\dot{H}_{p0}(10) = (1.15 \pm 0.15) \mu\text{Sv/h}$. Take ten measurements of DER with 10 s interval eight minutes after irradiation of the dosimeter was started. Calculate the average DER value ($\bar{\dot{H}}_{p\Sigma}(10)$) by the formula (5.1).

Calculate the DER value without gamma background DER of the УПГД-3Б by the formula

$$\bar{\dot{H}}_p(10) = \bar{\dot{H}}_{p\Sigma}(10) - \bar{\dot{H}}_{p\phi}(10) \quad (5.2)$$

Note - The distance between the mechanical center of the source and the mechanical center of the dosimeter's detector is considered to be the distance between the mechanical center of the source and the plane, which is perpendicular to the direction of gamma-quanta beam spreading, and passes through the mechanical center of the dosimeter in this plane.

5.2.7.4.4 Calculate the main relative permissible error limit of DER measurement in percentage.

5.2.7.4.5 Perform operations 5.2.7.4.3, 5.2.7.4.4 for DER $\dot{H}_{p0}(10) = (12 \pm 2) \mu\text{Sv/h}$ in 3 minutes after the dosimeter irradiation start provided that DER measurement time is 5 s.

5.2.7.4.6 Perform operations 5.2.7.4.5 for DER $\dot{H}_{p0}(10) = (1.2 \pm 0.2) \text{mSv/h}$.

5.2.7.4.7 Perform operations 5.2.7.4.5 for DER $\dot{H}_{p0}(10) = (12 \pm 2)$ mSv/h.

5.2.7.4.8 Perform operations 5.2.7.4.5 for DER $\dot{H}_{p0}(10) = (900 \pm 100)$ mSv/h.

5.2.7.4.9 Maximum value of all received errors is the limit of main relative permissible error of DER measurement.

5.2.7.4.10 If the main relative permissible error limit of DER measurement at 0.95 confidence probability does not exceed:

- 20 % in the DER range of 1.0 to 10 μ Sv/h;
 - 15 % in the DER range of 10 μ Sv/h to 1.0 Sv/h,
- proceed to the following verification operation.

5.2.7.4.11 If the main relative permissible error limit of DER measurement does not meet the requirements stated in 5.2.7.4.10, the dosimeter can not be verified and should be sent for repair.

5.2.7.5 Calculation of main relative permissible error limit of DE measurement in the DER range of 1.0 μ Sv/h to 1.0 Sv/h, in the DE range of 0.01 to 9999 mSv is performed as follows.

5.2.7.5.1 Prepare the dosimeter for DE measurement. The initial DE readings should be “0.000 mSv”.

5.2.7.5.2 Fix the dosimeter on the phantom as stated in 5.2.7.3 in the УПГД-3Б carriage so that the mechanical center of the collimator coincides with the mechanical center of the dosimeter's detector.

5.2.7.5.3 Prepare the dosimeter for DE measurement and place the УПГД-3Б carriage together with the phantom and the dosimeter in the position, where DER from ^{137}Cs source with radionuclide is $\dot{H}_{p0}(10) = (12 \pm 2) \mu\text{Sv/h}$ and at the same time switch on the stop-watch and place the source into the collimator.

5.2.7.5.4 In the period of time (according to the stop-watch) expressed in seconds and calculated by the formula $t = 3600 + t_{\partial}$, where t_{∂} is the period of time expressed in seconds used to place the source into the collimator, take DE measurement result. Switch the dosimeter off afterwards.

5.2.7.5.5 Calculate the limit of main relative permissible error of DE measurement in percentage by the formula

$$\delta H_p(10) = 1,1 \sqrt{\left(\frac{H_p(10) - H_{p0}(10)}{H_{p0}(10)}\right)^2 + \left(\frac{\delta H_{p0}(10)}{2}\right)^2}, \quad (5.3)$$

here $H_{p0}(10) = \dot{H}_{p0}(10) \cdot t$ - DE of the УПГД-3Б carriage;

$\delta H_{p0}(10) = \sqrt{(\delta \dot{H}_{p0}(10))^2 + (\delta t)^2}$ - main relative permissible error limit of DE of the УПГД-3Б carriage;

$$\delta t = \frac{1,1 \sqrt{(\Delta t_c)^2 + (\Delta t_p)^2 + (\Delta t_\delta)^2}}{t} \quad \text{- main relative permissible error limit}$$

of DE exposure time measurement that should not exceed 5 %;

Δt_c - permissible error limit of the stop-watch;

$\Delta t_p = 1 \text{ c}$ - error caused by response of a user;

$\Delta t_\delta = 1 \text{ c}$ - error caused by the process of placing the source into the collimator.

5.2.7.5.6 Perform operations 5.2.7.5.1-5.2.7.5.5 for DER
 $\dot{H}_{p0}(10) = (120 \pm 20) \mu\text{Sv/h}$.

5.2.7.5.7 Perform operations 5.2.7.5.1-5.2.7.5.5 for DER
 $\dot{H}_{p0}(10) = (12 \pm 2) \text{mSv/h}$.

5.2.7.5.8 Perform operations 5.2.7.5.1-5.2.7.5.5 for DER
 $\dot{H}_{p0}(10) = (120 \pm 20) \text{mSv/h}$.

5.2.7.5.9 Perform operations 5.2.7.5.1-5.2.7.5.3 for DER $\dot{H}_{p0}(10) = (900 \pm 100)$ mSv/h for the time period (according to the stopwatch), which is calculated by the formula $t = \left(60 + \frac{36000}{\dot{H}_p(10)} \right) + t_\delta$, where

$\dot{H}_p(10)$ is a numeric DER value, expressed in $\mu\text{Sv/h}$. Take the DE measurement results and perform operations 5.2.7.5.5. Switch the dosimeter off afterwards.

5.2.7.5.10 Maximum value of all received errors is the limit of main relative permissible error of DE measurement.

5.2.7.5.11 The result of the dosimeter verification is considered positive if the main relative permissible error limit of DE measurement in the DER range of 1.0 $\mu\text{Sv/h}$ to 1.0 Sv/h and the DE range of 0.01 mSv to 9999 mSv at 0.95 confidence probability does not exceed 15 %.

5.2.7.5.12 If the limit of main relative permissible error of DE measurement does not meet the requirements stated in 5.2.7.5.11, the dosimeter can not be verified and should be sent for repair.

5.2.7.6 Presentation of verification results

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

- primary verification is registered in the “CERTIFICATE OF ACCEPTANCE” section;
- periodic verification is registered in the issued Certificate of the established form.

5.2.7.6.2 If recognized inapplicable for use the dosimeter:

- should not be allowed to manufacture and use at primary verification;
- gets the certificate of inadequacy during use and after repair.

6 STORAGE

6.1 The dosimeters should be stored packed, safe from mechanical damage in dry, ventilated and clean storehouses at the ambient temperature from +5 to +40 °C and relative humidity up to 80 % at + 25 °C temperature. The storehouse should be free of dust, acids, gas, vapors of organic solvents, and alkali that may cause corrosion.

6.2 Maximum shelf life of the dosimeters in packing is 3 years.

7 SHIPPING

7.1 Packed dosimeters may be shipped at the ambient air temperature from - 50 to + 50 °C; relative humidity (95±3) % at + 35 °C temperature by railway, air, water or motor transport at any distances in conformance with the following rules:

- by railway transport – in a clean box car;
- by air transport – in pressurized compartments;

- by water transport – in a dry hold;
- by motor transport – in a closed car.

7.2 The dosimeters in shipping container should be placed and fixed in the vehicle to ensure their stable position and to avoid shocks.

7.4 Observe the inscriptions on the shipping container at loading and unloading the dosimeters.

7.5 The dosimeters must not be exposed to the influence of atmospheric precipitations during loading-unloading.

7.6 The dosimeters may be delivered in parcels in conformance with the international rules.

8 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.

Note. If the dosimeter is soiled by liquids or dry radionuclides, and it is impossible to completely decontaminate it, it should be buried as solid radioactive waste.

9 WARRANTY

9.1 The manufacturer guarantees the conformity of the dosimeter to the technical requirements provided that the customer observes the guidelines for its use, shipping and storage presented in the operating manual.

9.2 The warranty period of the dosimeter use shall terminate and be of no further effect in not less than 18 months after the date of putting it into operation, or after the end of the storage period.

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

9.4 The warranty period is prolonged for the time when the dosimeter has been under warranty repair.

9.5 Warranty is invalid in case of use, shipping and storage violations, any mechanical damages, or if the warranty seals are violated. In this case the repair is performed at the user's expense.

9.6 After the warranty period terminates, the repair of the dosimeter is performed under separate contracts (as further agreed).

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

10 PACKING CERTIFICATE

The DKG-21 personal gamma radiation dosimeter of BICT.412118.014-02 type with _____ serial number is packed by the Private Enterprise “SPPE “Sparing-Vist Center” in accordance with the requirements specified in TY Y 33.2-22362867-010:2007.

(position)

(signature / print full name)

(year, month, date)

11 CERTIFICATE OF ACCEPTANCE

The DKG-21 personal gamma radiation dosimeter of BICT.412118.014-02 type with _____ serial number is manufactured to meet the technical requirements specified in TY Y 33.2-22362867-010:2007, and is accepted for use.

QCD head

(signature / print full name)

Stamp here

State verification officer

(signature / print full name)

Verification mark here

(year, month, date)

12 REPAIR

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

PE “SPPE “Sparing-Vist Center”

Tel.: (+380 32) 242 15 15; Fax: (+380 32) 242 20 15

E-mail: sales @ ecotest.ua

13 ACCEPTANCE AND WARRANTY

The DKG-21 personal gamma radiation dosimeter of BICT.412118.014-02 type with _____ serial number, repair type _____ is accepted in accordance with the requirements specified in TY Y 33.2-22362867-010:2007, and is accepted for operation by the manufacturer PE "SEPP "Sparing-Vist Center".
Life till scheduled repair _____
during service life _____ years,
shelf life included _____

PE "SPPE "Sparing-Vist Center" guarantees the conformity of the dosimeter to the technical requirements specified in TY Y 33.2-22362867-010:2007 provided that the customer observes the requirements of the operating manual.

QCD head _____
(signature / print full name)

Stamp here _____
(year, month, date)

APPENDIX A

Anisotropy of
the dosimeter
DKG-21
(vertical plane)

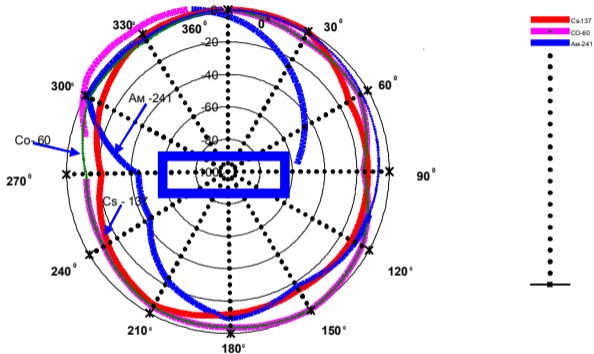


Figure A.1

Anisotropy
of the dosimeter
DKG - 21
(horizontal plane)

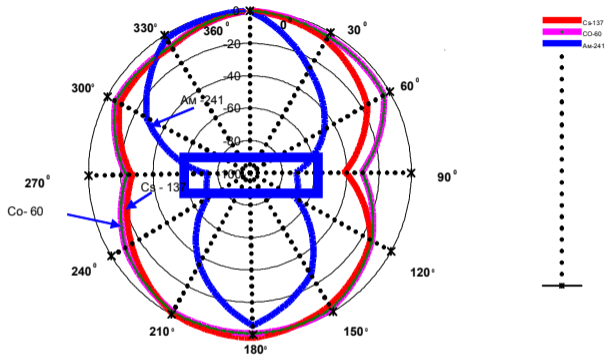


Figure A.2

APPENDIX B

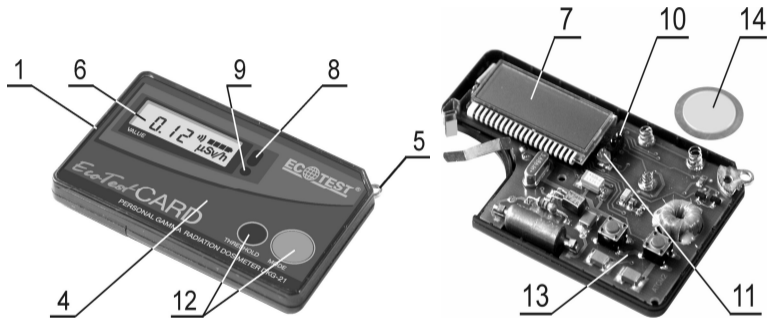


Figure B.1 – Front view of the dosimeter with the removed upper cover

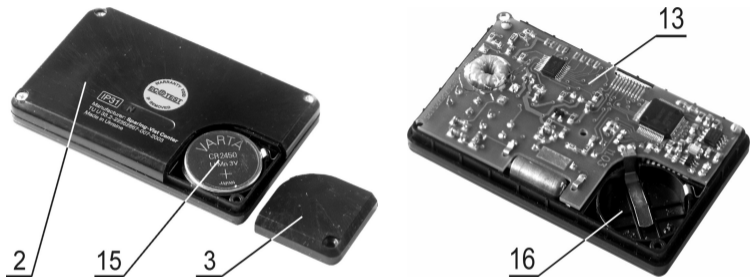


Figure B.2 - Rear view of the dosimeter with the removed lower cover

APPENDIX C

PRIMARY AND PERIODIC VERIFICATION OF KEY SPECIFICATIONS

Verified specification		Date of measurement			
Name	Value according to specification	year 20		year 20	
		Actual value	Measured by (position, signature)	Actual value	Measured by (position, signature)
1 Main relative error limit of the dosimeter of DER measurement with confidence probability of 0.95, % in the DER range:					
- from 1.0 $\mu\text{Sv/h}$ to 10 $\mu\text{Sv/h}$	20 %				
- from 10 $\mu\text{Sv/h}$ to 1.0 Sv/h	15 %				

APPENDIX C

C-1

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

APPENDIX C

PRIMARY AND PERIODIC VERIFICATION OF KEY SPECIFICATIONS

Verified specification		Date of measurement			
Name	Value according to specification	year 20		year 20	
		Actual value	Measured by (position, signature)	Actual value	Measured by (position, signature)
2 Main relative error limit of the dosimeter of DE measurement in the DER range from 1.0 μ Sv/h to 1 Sv/h with confidence probability of 0.95 in the DE range: - from 0.01 to 9999 mSv	15 %				

APPENDIX C

C-2

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

LIST OF ABBREVIATIONS

ASPDC	- automated system of personal dosimetry control
B	- battery
LS	- loudspeaker
IRD	- ionizing radiation detector
DE	- equivalent dose
NVM	- nonvolatile memory
DER	- equivalent dose rate
DCC	- detector control circuit
IPC	- infrared port circuit
DPCC	- digital processing and control circuit
AVF	- anode voltage former
LCD	- digital liquid crystal display