MKS-05 “TERRA”
DOSIMETER-RADIOMETER

OPERATING MANUAL

CONTENTS

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

The manual contains the following abbreviations and symbols:

DE - ambient dose equivalent;
DER - ambient dose equivalent rate;
MODE - on/off button and switch between the corresponding modes of measurement and indication (gamma radiation DER, gamma radiation DE, surface beta-particles flux density, DE accumulation time, and real time);
THRESHOLD - button of threshold level programming, time indication correction and backlight switching-on.

1 DESCRIPTION AND OPERATION OF THE DOSIMETER

1.1 Purpose of use

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

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

1.2 Technical specifications

1.2.1 Key specifications are presented in Table 1.1.

Table 1.1 – Key specifications

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

Table 1.1 (continued)

1	2	3
Measurement range of photon-ionizing radiation DE	mSv	0.001 - 9999
Main relative permissible error limit of photon-ionizing radiation DE measurement with 0.95 confidence probability	%	± 15
Energy range of registered photon-ionizing radiation	MeV	0.05 – 3.00
Energy dependence of the dosimeter readings at photon-ionizing radiation DER and DE measurement in the energy range of 0.05 MeV to 1.25 MeV	%	± 25

Table 1.1 (continued)

1	2	3
Anisotropy of the dosimeter at gamma quantum incidence at solid angle of 30^{o} to 150^{o} relative to the main axis of the detector and from the side of the main measurement direction for:	%	
- ^{137}Cs and ^{60}Co isotopes		± 25
- ^{241}Am isotopes		± 60
Note. Anisotropy charts are given in Appendix A		

Table 1.1 (continued)

1	2	3
Measurement range of surface beta-particles flux density	part./(cm^2·min)	10 - 10^5
Main relative permissible error limit of beta-particles flux density measurement with 0.95 confidence probability	%	$20+\frac{200}{\phi_\beta}$, φ_β is a numeric value of the measured surface flux density in part./(cm^2·min)
Energy range of registered beta-particles	MeV	0.5 – 3.0

Table 1.1 (continued)

1	2	3
Measurement range of DE accumulation time with measurement resolution of 1 min	h	100
Absolute permissible error limit at operator's DE accumulation time measurement during 24 hrs	min	± 1
Time of the dosimeter operating mode setting, not more than	min	1
Battery life (AAAx2 of 1280 mA·h capacity) under natural background radiation and switched off display backlight, not more than	h	2000

Table 1.1 (continued)

1	2	3
General operating supply voltage of the dosimeter from two batteries	V	3.0
Useful current of the dosimeter at operating supply voltage of 3.0 V under natural background radiation and switched off display backlight, not more than	mA	0.5
Additional permissible error limit at measurement caused by supply voltage deviation from nominal value in the range of 3.2 to 2.4 V for all measured physical values	%	± 10
Additional permissible error limit at measurement caused by ambient air temperature changes from - 20 to + 50 ^{o}C, per each 10 ^{o}C deviation from 20 ^{o}C for all measured physical values	%	± 5

Table 1.1 (continued)

1	2	3
Mean time to failure, not less than	h	6000
Average life of the dosimeter to the first major overhaul, not less than	h	10000
Average service life of the dosimeter, not less than	year	6
Average shelf life of the dosimeter, not less than	year	6
Dimensions, not more than	mm	52x26x120
Weight, not more than	kg	0.15

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

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

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

1.2.5 The dosimeter sends a one-tone audio signal if gamma quantum or beta-particle gets to the detector, and a two-tone audio signal if the programmed DER, DE or surface beta-particles flux density threshold levels have been exceeded.

1.2.6 Low battery status is indicated by the dosimeter.

1.2.7 DER, DE and surface beta-particles flux density values as well as DER, DE and surface beta-particles flux density threshold level values appear on the digital LCD indicating the correspondence of information. The values of DER and DER threshold level are expressed in μSv/h, the values of surface beta-particles flux density and surface beta-particles flux density threshold level are expressed in 10^3 part./($cm^2 \cdot min$), and the values of DE and DE threshold level are expressed in mSv.

1.2.8 The dosimeter performs measurements under the following conditions:

- temperature from - 20 to + 50 ^{O}C;

- relative humidity up to (95±3) % at + 35 ^{O}C;

- atmospheric pressure from 84 to 106.7 kPa.

1.2.9 The dosimeter is resistant to the following external factors:

- high frequency sinusoidal vibration in the range of 10 - 55 Hz;

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

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

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

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

1.3 Delivery kit

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

Table 1.2 - Delivery kit of the dosimeter

TYPE	Item	Quantity	Notes
BICT.412129.008-02	MKS-05 “TERRA” dosimeter-radiometer	1 pc.	
BICT.412129.006-04 HE	Operating manual	1 pc.	
BICT.412915.001	Package	1 pc.	
ENERGIZER	Battery of AAA 1.5 V type	2 pcs	Other AAA batteries of 1.5 V voltage are permissible. Supplied at customer’s request
	Leather case	1 pc.	

1.4 Design and theory of operation

1.4.1 General information

The dosimeter is a mono-block construction with a built-in detector of gamma and beta radiation, a printed-circuit board equipped with a circuit of the anode voltage formation, digital processing, control, and indication, and batteries.

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

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

- scaling and linear realization of the detector counting response;
- measurement of photon-ionizing radiation DER and surface beta-particles flux density by means of measurement of an average pulse frequency from the detector outlet;
- measurement of photon-ionizing radiation DE by means of measurement of a general number of pulses from the detector outlet;

- measurement of DE accumulation time and real time;
- generation and stabilization of the detector's anode voltage;
- operating modes control;
- measurement results indication.

The power for operation is supplied by two batteries of AAA type.

1.4.2 Design description

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

The housing (Figure B.1, B.2) consists of the upper (1) and lower (2) covers. The LCD (3) is located in the middle of the upper cover (1); two keys (4) of control are located to the left and to the right above the LCD, and a loudspeaker (5) in the upper part of the cover (1).

The battery compartment and the window (7) for surface beta-particles flux density measurement are located in the lower cover (2). The battery compartment (6) and the window (7) have covers (8) and (9) correspondingly, fastened due to the elastic capacities of the materials.

The circuit board (10) is located inside the unit, where all elements of the electric circuit, with an exception of a loudspeaker, are located (5). The loudspeaker is fixed to the upper cover (1) and electrically connected with the circuit board (10) by spring contacts. The latter (10) is screwed to the upper cover (1) of the housing.

The lower and the upper covers are connected with the help of a special coupling of the constructs and two screws. The screws are also used to fasten the contacts (11) for battery insertion.

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

1.5 Labeling and sealing

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

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

1.5.2 Sealing is performed by the producer.

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

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

1.6 Packing

The dosimeter kit (the device and the operating manual) is delivered in the cardboard box. Cardboard and polymer (blister) combination is permitted.

2 PROPER USE OF THE DOSIMETER

2.1 Operating limitations

Operating limitations are presented in Table 2.1.

Table 2.1 - Operating limitations

Operating limitations	Limitation parameters
Ambient air temperature	from - 25 to + 50 ^{o}C
Relative humidity	up to 95 % at + 35 ^{o}C, non-condensing
Photon-ionizing radiation influence	DER up to 1.0 Sv/h during 5 min

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

2.2 Preparation of the dosimeter for operation

2.2.1 Scope and order of external examination

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

2.2.2 Rules and order of examination for operational readiness

2.2.2.1 Examine the control buttons before switching the dosimeter on.

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

2.2.2.3 The batteries should be replaced if the dosimeter is switched on, and irrespective of the chosen mode the indication “PO3P” with a two-second interval is blinking on the LCD (the batteries are discharged).

2.2.3 Guidelines on switching on and testing the dosimeter

2.2.3.1 Prepare the dosimeter for operation by doing the following:

- unpack the dosimeter;

- open the battery compartment and insert two batteries of AAA type, observing the polarity.

2.2.3.2 Press shortly the MODE button to switch the dosimeter on. The dosimeter should enter the mode of photon-ionizing radiation DER measurement, which is shown by the blinking light-emitting diode opposite the appropriate mnemonic symbol below the LCD, and by audio signals following the detection of every gamma quantum.

2.2.3.3 Press shortly the MODE button and make sure the dosimeter has entered the mode of operator's DE indication, which is shown by the second blinking light-emitting diode below the LCD opposite the appropriate mnemonic symbol.

2.2.3.4 Press shortly the MODE button and make sure the dosimeter has entered the mode of surface beta-particles flux density measurement, which is indicated by the blinking light-emitting diode opposite the appropriate mnemonic symbol below the LCD, and by audio signals following the detection of every beta-particle or gamma quantum.

2.2.3.5 Press shortly the MODE button and make sure the dosimeter has entered the mode of operator's DE accumulation time indication, which is shown by blinking of all digits and a non-blinking comma between the two pairs of digits. The last right digit changes every minute per one unit.

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

2.2.3.7 Hold the MODE button pressed for six seconds to switch the dosimeter off.

2.2.4 List of possible troubles and troubleshooting

2.2.4.1 The list of possible troubles and troubleshooting is presented in Table 2.2.

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

Table 2.2 - List of possible troubles and troubleshooting

Trouble	Probable cause	Troubleshooting
1 The dosimeter is not switched on after the MODE button is pressed	1 The battery is discharged 2 No contact between the batteries and the battery compartment clamps 3 One of the batteries is out of order	1 Replace the batteries 2 Restore the contact between the batteries and the clamps 3 Replace the defected battery
2 A “PO3P” discharge symbol is displayed on the LCD after the batteries have been replaced when the dosimeter is switched on	Poor contact between the batteries and the battery compartment clamps	Clean out the contacts on the clamps and the batteries

2.3 Use of the dosimeter

2.3.1 Safety measures during use of the dosimeter

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

It is not dangerous for the service personnel, and is environmentally friendly.

A special protection jacket is used to prevent accidental contact with conductive parts. Ingress protection rating is IP20.

2.3.2 List of operating modes

The dosimeter uses the following indications and operates within the following modes:

- switching the dosimeter on/off;
- photon-ionizing radiation DER measurement;
- programming of audio alarm threshold levels of photon-ionizing radiation DER;
- photon-ionizing radiation DE measurement indication;

- programming of audio alarm threshold levels of photon-ionizing radiation DE;
- surface beta-particles flux density measurement;
- programming of audio alarm threshold levels of surface beta-particles flux density;
- indication of operator's DE accumulation time;
- indication and correction of real time;
- switching audio signaling of registered gamma quanta and beta-particles on/off;
- switching display backlight on/off.

2.3.3 Operation procedure of the dosimeter

2.3.3.1 **Switching the dosimeter on/off**

Press shortly the MODE button to switch the dosimeter on. The information displayed on the LCD, blinking of the light-emitting diode below the LCD and audio signaling of the registered gamma quanta show that the dosimeter is on. Press the MODE button once again and hold it pressed for six seconds to switch the dosimeter off.

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

The mode of photon-ionizing radiation DER measurement is entered automatically after the dosimeter is switched on. The mode is indicated by the blinking light-emitting diode opposite the appropriate mnemonic symbol below the LCD. The results of measurement will appear on the LCD during the first few seconds, enabling efficient evaluation of radiation level. The LCD will blink until the statistically processed reliable information is gained. The statistical processing period will depend on the radiation intensity. Units of measurement are expressed in μSv/h.

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

Consider the arithmetic mean of five last measurements after the LCD stops blinking as the DER measurement result. Every registered gamma quantum will be followed by an audio signal. Measurement intervals and subranges will be set automatically, depending on the measured radiation intensity.

Note. The statistical processing of data can be rerun forcibly to perform effective evaluation of the radiation level. To do this, press the THRESHOLD button and hold it pressed during two seconds. Rough evaluation of gamma background level can be performed within 10 s.

2.3.3.3 **Programming of audio alarm threshold levels of photon-ionizing radiation DER**

Programming of audio alarm threshold levels of DER is performed in the mode of photon-ionizing radiation DER measurement.

To start programming, press the THRESHOLD button and hold it pressed (circa six seconds) until the low-order digit starts blinking on the LCD. Set the necessary value of the low-order digit by successive pressing and releasing the THRESHOLD button. Press shortly the MODE button to program the next digit, which will start blinking at that. Other digits are programmed likewise.

The value of the preset threshold level is fixed after all digits are programmed by short pressing of the MODE button. To fix a new value of the threshold level, set all digits on the LCD by pressing the MODE button, even if the values of the high-order digits are not changed. Double extinction of the LCD will indicate that the programmed level is fixed.

Press the THRESHOLD button and hold it pressed to check the value of the fixed DER threshold level. The threshold level value will appear on the LCD in two seconds.

When the THRESHOLD button is pressed for more than four seconds, the low-order digit starts blinking, indicating that a new threshold level value can be programmed. A two-tone audio signal indicates that the programmed DER threshold level has been exceeded.

Note. The DER threshold level value of 0.30 μSv/h is set automatically when the dosimeter is switched on.

2.3.3.4 **Indication of photon-ionizing radiation DE measurement value**

Press shortly the MODE button to switch on the mode of DE measurement value indication. This mode follows the mode of photon-ionizing radiation DER measurement (switched on automatically as soon as the dosimeter is on). Photon-ionizing radiation DE measurement starts right after the dosimeter is switched on, and is performed in all operating modes, except for surface beta-particles flux density measurement.

A blinking light-emitting diode opposite the appropriate mnemonic symbol below the LCD indicates that the DE measurement indication mode has been entered. Measurement units are expressed in mSv. A comma after the first left digit will appear on the LCD when 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 photon-ionizing radiation DE value increases.

2.3.3.5 **Programming of audio alarm threshold level of photon-ionizing radiation DE**

Programming of audio alarm threshold level of photon-ionizing radiation DE is performed in the mode of photon-ionizing radiation DE measurement indication.

To start programming, press the THRESHOLD button and hold it pressed (circa six seconds) until the low-order digit starts blinking on the LCD. Set the appropriate value of the low-order digit by successive pressing and releasing the THRESHOLD button. Press shortly the MODE button to program the next digit, which will start blinking at that. Other digits are programmed likewise.

The value of the preset threshold level is fixed after all digits are programmed by short pressing of the MODE button. To fix a new value of the threshold level, set all digits on the LCD by pressing the MODE button, even if the values of the high-order digits are not changed. Double extinction of the LCD will indicate that the programmed level is fixed.

Press and hold the THRESHOLD button to check the value of the fixed DE threshold level. The threshold level value will appear on the LCD in two seconds. When the THRESHOLD button is pressed for more than four seconds, the low-order digit starts blinking, indicating that a new threshold level value can be programmed. A two-tone audio signal indicates that the programmed DE threshold level has been exceeded.

Note. A zero value of the threshold level is set automatically when the dosimeter is switched on indicating that the DE threshold alarm system is off.

2.3.3.6 **Surface beta-particles flux density measurement**

This mode follows the mode of photon-ionizing radiation DE measurement. It is indicated

by the blinking light-emitting diode opposite the appropriate mnemonic symbol below the LCD. Measurement units are expressed in part./(cm^2·min). At first measure gamma background (for further automatic subtraction), and then measure surface beta-particles flux density. To do this, wait until the digital LCD stops blinking in the mode of DER measurement (filter cover covers the window of the detector). Press shortly the MODE button twice. This will store the DER measurement value as gamma background and switch the dosimeter from DER measurement mode to surface beta-particles flux density measurement mode. Remove the filter cover from the window, located opposite the detector, direct the dosimeter with the window in parallel to the examined surface and place it as close as possible. Consider the arithmetic mean of five measurements after the LCD stops blinking as a result of the surface beta-particles flux density measurement. Every registered beta-particle and gamma-quantum will be followed by an audio signal.

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

2.3.3.7 **Programming of audio alarm threshold level of surface beta-particles flux density**

Programming of audio alarm threshold level of surface beta-particles flux density is performed in the mode of surface beta-particles flux density measurement and indication.

To start programming, press the THRESHOLD button and hold it pressed (circa six seconds) until the low-order digit starts blinking on the LCD. Set the appropriate value of the low-order digit by successive pressing and releasing the THRESHOLD button. Press shortly the MODE button to program the next digit, which will start blinking at that. Other digits are programmed likewise.

The value of the preset threshold level is fixed after all digits are programmed by short pressing of the MODE button. To fix a new value of the threshold level, set all digits on the LCD by pressing the MODE button, even if the values of the high-order digits are not changed. Double extinction of the LCD will indicate that the programmed level is fixed.

Press and hold the THRESHOLD button to check the value of the fixed threshold level of surface beta-particles flux density. The threshold level value will appear on the digital LCD in two seconds. When the THRESHOLD button is pressed for more than four seconds, the low-order digit starts blinking, indicating that a new threshold level value can be programmed. A two-tone audio signal indicates that the programmed threshold level during measurement has been exceeded.

Note. The threshold level value of surface beta-particles flux density of $0.04 \cdot 10^3$ part./(cm^2·min) is set automatically after the dosimeter is switched on.

2.3.3.8 **Indication of operator's DE accumulation time**

Press shortly the MODE button to initiate the mode of operator's DE accumulation time indication. This mode follows the mode of surface beta-particles flux density measurement and value indication.

It is indicated by blinking of all digits and a non-blinking comma between the two pairs of digits. The digits from the right to the left will indicate the following: the first digit indicates minutes; the second one - tens of minutes; the third one - hours; the fourth one - tens of hours.

2.3.3.9 **Indication and correction of real time**

Press shortly the MODE button to initiate the mode of real time indication. This mode follows the mode of indication of operator's DE accumulation time.

It is indicated by a one second blinking comma 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 pressed until two digits to the right from comma start blinking to correct the value of real time, and then release the button. The proper values of units and tens of minutes are fixed by further pressing and holding the THRESHOLD button. Press shortly the THRESHOLD button to correct the value of minutes. Each pressing will change the value per unit. Press shortly the MODE button to correct the

value of hours. Two digits on the left of comma 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.

2.3.3.10 **Switching audio signaling of registered gamma quanta and beta-particles on/off**

Simultaneously press and release the MODE and THRESHOLD buttons to switch audio signaling off. A "----" symbol that briefly appears on the digital LCD indicates that audio signaling is switched off.

Simultaneously press and release the MODE and THRESHOLD buttons once again to switch audio signaling on. An "Aud" symbol that briefly appears on the digital LCD indicates that audio signaling is switched on.

Audio signaling is switched on automatically along with the dosimeter.

Note. Audio alarm of exceeded programmed threshold levels is independent of the system condition of audio signaling of registered gamma quanta or beta-particles.

2.3.3.11 **Switching display backlight on/off**

At pressing any button of the dosimeter or changing the operating mode the display backlight is switched on for 5 seconds. Press shortly the THRESHOLD button to switch the dosimeter display backlight on without changing the operating mode. The display backlight will switch off automatically in 5 seconds.

3 TECHNICAL MAINTENANCE

3.1 Technical maintenance of the dosimeter

3.1.1 General instructions

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

Table 3.1 - List of operations during technical maintenance

List of operations	TM type			OM item No.
	During		During long-term storage	
	Everyday use	Periodical use (annually)		
External examination	+	+	+	3.1.3.1
Delivery kit completeness check	-	+	+	3.1.3.2
Operability check	+	+	+	3.1.3.3
Power supply switch off	-	-	+	3.1.3.4
Verification of the dosimeter	-	+	+	3.2
Notes. "+" means the operation is applicable for this type of TM; "-" means the operation is not applicable.				

3.1.2 Safety measures

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

3.1.3 Maintenance procedure of the dosimeter

3.1.3.1 External examination

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

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

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

3.1.3.2 Delivery kit completeness check

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

3.1.3.3 Operability check of the dosimeter

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

3.1.3.3.2 Order of pre-repair fault detection and rejection

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

- for mid-life repair:

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

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

c) no display backlight;

d) no audio signaling;

- for major repair:

a) at least one non-operating measurement channel;

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

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

3.1.3.4 Power supply switch off

Power supply should be switched off each time the dosimeter is not in use for a long time. Do the following:

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

3.2 Verification of the dosimeter

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

3.2.1 Verification operations

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

Table 3.2 – Verification operations

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

3.2.2 Verification facilities

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

- testing equipment with standard sources of gamma radiation ^{137}Cs;
- flat standard sources on a hard pad, containing $^{90}Sr + {}^{90}Y$ radionuclides;
- low-active gamma radiation source ^{137}Cs;
- standard stop-watch.

All verification facilities should obtain valid Control Certificate or State Metrological Qualification.

Note. Use of other standard measuring equipment that meets the specified accuracy is allowed.

3.2.3 Verification conditions

Verification should be performed in compliance with the following conditions:

- ambient air temperature range (20±5) °C;

- relative air humidity from 30 to 80 %;
- atmospheric pressure from 86 to 106.7 kPa;
- natural background level of gamma radiation not more than 0.30 μSv/h;
- power supply voltage of (3.0± 0.2) V.

3.2.4 Verification procedure

3.2.4.1 External examination

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

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

3.2.4.2 Testing

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

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

Prepare the verification equipment for operation according to its operating manual.

Prepare the dosimeter for photon-ionizing DER measurement according to item 2.3.3.2 of the OM.

Fix the dosimeter in the holder so that the mechanical center of gamma beam coincides with the center of the detector.

Perform five measurements of external background EDR and register the received readings in the protocol.

Place the holder together with the dosimeter in the position, where DER from ^{137}Cs source is 0.8 μSv/h. Perform five measurements of DER.

Register the received readings in the protocol.

Calculate the DER value $\dot{H}^*(10)$ in μSv/h according to the formula (1).

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

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

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

Calculate main relative error of measurement in percentage.

Place the holder and the dosimeter in the position, where DER from the ^{137}Cs source is 8.0 μSv/h.

Perform five measurements of DER, and register the received readings in the protocol.

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

Calculate main relative error of measurement in percentage.

Place the holder and the dosimeter in the position, where DER from the ^{137}Cs source is 80.0 μSv/h.

Perform five measurements of DER, and register the received readings in the protocol.

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

Calculate main relative error of measurement in percentage.

Place the holder and the dosimeter in the position, where DER from the ^{137}Cs source is $8 \cdot 10^2$ μSv/h.

Perform five measurements of DER. Register the received readings in the protocol, and calculate the average value of DER and main relative error of measurement in percentage.

Place the holder and the dosimeter in the position, where DER from the ^{137}Cs source is $8 \cdot 10^3$ μSv/h.

Perform five measurements of DER. Register the received readings in the protocol, and calculate the average value of DER and the main relative error of measurement in percentage.

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

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

Prepare the dosimeter for photon-ionizing radiation DE measurement according to item 3.3.3.4 of the OM.

Prepare the verification equipment for operation according to its operating manual.

Fix the dosimeter in the holder so that the mechanical center of gamma beam coincides with the center of the detector.

Place the holder and the dosimeter in the position, where DER from ^{137}Cs source is 80 μSv/h.

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

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

Place the holder and the dosimeter in the position, where DER from ^{137}Cs source is 800 μSv/h.

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

Register the DE measurement results after 30 minutes (according to the stop-watch) of irradiation, calculate the main relative error of measurement in percentage, and register the values in the protocol.

Place the holder and the dosimeter in the position, where ambient DER from ^{137}Cs source is 8000 μSv/h.

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

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

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

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

Calculate the main relative error at surface beta-particles flux density measurement according to item 2.3.3.6 of the OM.

Measure ambient gamma background with filter-covered window of the detector in the mode of photon-ionizing DER measurement. Gamma background measurement is completed when the LCD stops blinking.

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

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

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

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

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

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

The dosimeter is acknowledged to have passed the testing if the main relative error at measurement of each surface beta-particles flux density level does not exceed $20+\frac{200}{\phi_\beta}$,

where φ_β is a numeric value of the measured surface beta-particles flux density in part./(cm^2·min).

3.2.4.6 Presentation of verification results

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

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

2) periodic verification is registered in the issued Certificate of the established form.

Primary verification results are registered in Table 3.3.

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

Table 3.3 – Primary verification of main specifications

Tested specification		Actual value
Name	Standardized values according to the specifications	
Main relative error at measurement of photon-ionizing radiation dose equivalent rate, with 0.95 confidence probability, %	$15+2/\dot{H}^{*}(10)$, where $\dot{H}^{*}(10)$ is a numeric value of the measured DER in μSv/h	
Main relative error at measurement of photon-ionizing radiation dose equivalent, with 0.95 confidence probability, %	±15	
Main relative error at measurement of beta particles flux density, with 0.95 confidence probability, %	$20+200/\varphi_{\beta}$, where φ_{β} is a numeric value of the measured surface beta-particles flux density in part./(cm^2·min)	

4 CERTIFICATE OF ACCEPTANCE

The MKS-05 "TERRA" dosimeter-radiometer of BICT.412129.008-02 type with _____ serial number meets the ТУ У 33.2-22362867-006-2001 BICT.412129.006 ТУ technical requirements, is tested and accepted for use.

Date of issue _____

Stamp here Representative of Quality Control Department: _____
(signature)

Verification Mark here State Verification Officer: _____
(signature)

5 PACKING CERTIFICATE

The MKS-05 “TERRA” dosimeter-radiometer of BICT.412129.008-02 type with _____ serial number is packed by the PE “SPPE “Sparing-Vist Center” enterprise in accordance with the requirements specified in ТУ У 33.2-22362867-006-2001 BICT.412129.006 ТУ.

Date of packing _____

Stamp here

Packed by _____
(signature)

Packed product accepted by _____
(signature)

6 WARRANTY

6.1 The warranty period of the dosimeter use shall terminate and be of no further effect not less than 18 months after the date of putting it into operation, and not more than 24 months after the manufacture date.

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

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

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

6.5 The battery failure is not a reason for claim, after the warranty period of the battery is finished.

7 REPAIR

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

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

7.2 All claims are registered in Table 7.1.

Table 7.1

Date of failure	Claim summary	Action taken	Note

8 STORAGE

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

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

8.3 The dosimeters should be stored on the shelves.

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

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

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

9 SHIPPING

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

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

9.3 The dosimeters in shipping container endure:

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

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

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

9.4 Canting is forbidden.

10 DISPOSAL

Disposal of the dosimeter is performed in compliance with the general rules, i.e. metals are recycled or melted, and plastic parts are dumped. Disposal of the dosimeter is not hazardous for service personnel, and is environmentally friendly.

APPENDIX A

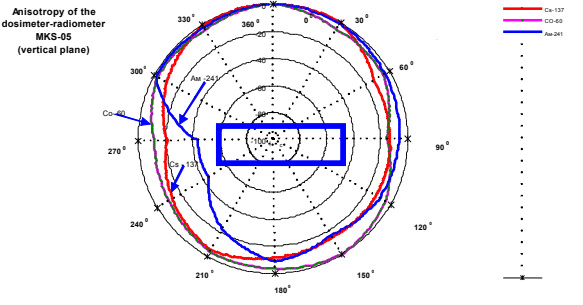

Figure A.1

APPENDIX A

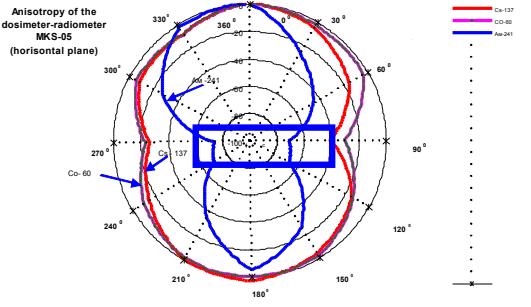

Figure A.2

APPENDIX B

Figure B.1 – Front view of the dosimeter

APPENDIX B

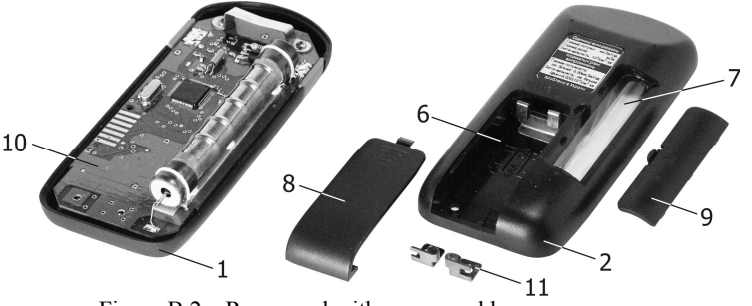

Figure B.2 – Rear panel with a removed lower cover

NOTES