DKS-02PN “CADMIUM”
SEARCH ALARM DOSIMETER

Operating Manual

CONTENTS

This Operating Manual (hereinafter called the OM) is intended to inform the user about the principles of operation and rules of application of DKS-02PN “CADMIUM” search alarm dosimeter. The manual contains all information necessary for full implementation of its technical capabilities and its proper use.

DKS-02PN “CADMIUM” search dosimeter-radiometer is made in the following models:

DKS-02PN “CADMIUM” with the installed detector of neutron radiation;

DKS-02PN “CADMIUM” with no installed detector of neutron radiation.

The OM contains the following abbreviations:

DER - ambient dose equivalent rate of gamma and X-ray radiation (further – photon-ionizing radiation);

DE - ambient dose equivalent of gamma and X-ray radiation (further – photon-ionizing radiation);

SGDU - scintillation detecting unit of photon-ionizing radiation;

GMC - Geiger-Muller counter;

SNDU - scintillation neutron detecting unit;

PC - personal computer.

1 DESCRIPTION AND OPERATION

1.1 Purpose of use

DKS-02PN “CADMIUM” search alarm dosimeter (hereinafter – device) is designed to:

- Search (detect and localize) for radioactive and nuclear materials by their external gamma and neutron radiation;
- Measure DER of photon-ionizing radiation;
- Measure DE of photon-ionizing radiation;
- Display DER of neutron radiation;
- Determine the intensity of photon-ionizing and neutron radiation.

The device is designed under ANSI N42.32-2006.

The device can be used to control illicit transfer of radioactive materials, search for the radioactive sources, and at enterprises and organizations that deal with sources of photon-ionzing and neutron radiation.

The device can be employed in the following areas:

- Customs and Border Services;
- Law enforcement agencies (MIA, Security Service of Ukraine, safeguard services);
- Metallurgy and scrap metal stocks;
- Vehicles monitoring, seaports, and airports;
- Environmental inspections;
- Radioactive waste disposals.

1.2 Technical specifications

1.2.1 Key specifications are presented in Table 1.1.

Table 1.1

Name	Measure-ment unit	Standardized value
Total measurement and display range of photon-ionizing DER: From built-in: -SGDU -GMC	μSv/h	$0.01…10^6$ 0.01 to 50 50 to 10^6
Measurement and display range of photon-ionizing DE from the GMC	μSv	$0.1…9.9·10^6$
Display range of neutron radiation DER	μSv/h	$0.01 … 10^4$
Display range of pulse count rate of photon-ionizing radiation	cps	1 … 25000
Display range of pulse count rate of neutron radiation from the SNDU	cps	0.01 … 25000
Main relative permissible error limit when measuring photon-ionizing radiation DER from the SGDU at 0.95 confidence probability (^{137}Cs)	%	15+1/H*(10), where H*(10) is a numeric value of measured DER in μSv/h

Table 1.1 (continued)

Name	Measure-ment unit	Standardized value
Main relative permissible error limit when measuring photon-ionizing radiation DER and DE from the GMC at 0.95 confidence probability (^{137}Cs)	%	15
Energy range of registered photon-ionizing radiation	MeV	0.02 … 3.00
Energy dependence of the device's readings when measuring photon-ionizing radiation DER and DE in the energy range from 0.05 MeV to 3.00 MeV relative to 0.662 MeV energy (^{137}Cs)	%	±25
Anisotropy of the detectors SGDU and GMC at incidence of gamma quanta at angles from +60° to – 60° horizontally and vertically relative to the main measurement direction, marked by "+": - for ^{137}Cs and ^{60}Co isotopes - for ^{241}Am isotopes	%	 ±30 ±75
Energy range of registered neutron radiation	eV	$0.025 – 14 \cdot 10^6$
Set-up time of the device operation, not more than	min	1
Calibration time by the level of gamma background	s	2 … 90

Table 1.1 (continued)

Name	Measure-ment unit	Standardized value
Response time to over 10 times change of photon-ionizing radiation DER	s	0.25
Operating supply voltage of the device from a lithium-polymer battery	V	3.7
Continuous operation of the device when powered from the freshly-charged battery under background of gamma radiation not more than 0.5 μSv/h: - a switched-off display backlight, with no alarm triggering and a switched-off GPS receiver, not less than - a switched-off display backlight, with no alarm triggering and a switched-on GPS receiver, not less than	h	200 55
Operating temperature range	°C	–20 … +50
Dimensions of the device with no clip (the clip included), not more than	mm	67×127×30 (45)
Weight of the device, not more than	kg	0.28

1.2.2 The photon-ionizing radiation sensitivity of (^{137}Cs) CsI(Tl) scintillation detector is at least 200 (cps)/(μSv/h).

Note. At the request of the user, the sensitivity can be changed to a value of not less than 450 (cps)/(μSv/h).

The neutron radiation sensitivity while using the LiI(Eu) scintillation detector is equal to:

- At least 1.2 ± 0.12 (pulse×cm^2)/n for thermal neutrons;
- At least 0.12 ± 0.012 (pulse×cm^2)/n for fast neutrons.

1.2.3 The device features a threshold alarm system with four independent threshold levels:

- Search threshold level or sigma-threshold (a threshold level of pulse count rate from the detector of photon-ionizing radiation);
- Safety threshold level (a threshold level of DER photon-ionizing radiation);
- Neutrons threshold level (a threshold level of count rate from the neutron detector);
- Accumulated dose threshold level (a threshold level of photon-ionizing DE).

1.2.4 The search threshold level is calculated automatically by the device in the mode of calibration by the gamma background intensity level and consists of the background counting rate and the preset number of rms deviations of background counting rate. Calibration time by the level of gamma background intensity ranges from 2 to 90 s.

The adjustable range of the number of rms deviations is from 1 to 9.9. Programming resolution – 0.1. The device notifies on exceeding of the search threshold level with light (red), vibration, or sound signals **"Sigma threshold exceeding"**. Any combination of alarms is possible, while at least one type must remain. On the screen of the device appears a corresponding icon that duplicates the alarm.

1.2.5 The safety threshold level is adjusted in the format XXX.YY in μSv/h or mSv/h. The minimum safety threshold level may not be less than 0.3 μSv/h.

The device notifies on exceeding of this threshold level with light (red), vibration, or sound signals **"Safety threshold exceeding"**. Any combination of alarms is possible, while at least one type must remain. On the screen of the device appears a corresponding icon that duplicates the alarm.

1.2.6 The conditional threshold alarm level by a neutron channel is set with the values from 1 to 9, where 1 is the highest sensitivity of the device to neutron radiation (but also the greatest probability of false positives), and 9 is the lowest sensitivity and lowest probability of false positives. Programming resolution – 1. The device notifies on exceeding of this threshold level with a light (blue), vibration, or sound signal "Neutron threshold exceeding".

Any combination of alarms is possible, while at least one type must remain. On the screen of the device appears a corresponding icon that duplicates the alarm.

1.2.7 The threshold level by the accumulated dose is adjusted in the XXX.Y format in μSv/h and mSv/h, and in the X.YYY format in Sv. While the DE threshold level can be set to 0, the alarm on exceeding the DE threshold level will be turned off. Otherwise, when the DE threshold level is surpassed, the device notifies by light (red), vibration, or sound signals “Accumulated dose threshold exceeding”. On the screen of the device appears a corresponding icon that duplicates the alarm.

1.2.8 The device’s threshold alarm on exceeding of the search threshold level triggers no later than in 2 s after the level of photon-ionizing radiation increases above the background value (with photon-ionizing DER level of 0.1 μSv/h) to the DER level of 0.5 μSv/h for a maximum time of 0.5 s.

1.2.9 The false alarm rate for photon-ionizing radiation and neutron rays is not more than 1 per 10 hours of operation in the stable background environment and at the following values of threshold levels:

- Search – 5;
- Safety – 1 μSv/h;
- Neutron – 5.

1.2.10 The device does not give false signals about the presence of neutron radiation when exposed to photon-ionizing radiation from ^{60}Co or ^{137}Cs source at DER value of up to 100 μSv/h.

1.2.11 The device can automatically record event log files in the nonvolatile memory, namely:

- Switch the device on;
- Switch the device off;
- Search threshold level being exceeded;
- Safety threshold level being exceeded;
- Conditional threshold level being exceeded in the detector of neutron radiation;
- Accumulated dose threshold level being exceeded;
- Save measurement by the user's command;
- Change settings by the administrator;
- Clear the device's flash memory.

1.2.12 The nonvolatile memory stores up to 65 000 records of registered event.

1.2.13 Data communication between the device and the PC is done via USB.

1.2.14 The device displays signs of the low battery.

1.2.15 The device remains operable under:

- Ambient temperature –20 to +50 °C;
- Relative humidity up to 100 % at 35 °C temperature, non-condensing;
- Atmospheric pressure from 84 to 106.7 kPa.

1.2.16 The device is tolerant to sinusoidal vibrations by N1 group according to recommendations of GOST 12997-84 standard.

1.2.17 The device is resistant to single shocks with the following parameters:

- Shock pulse duration – 6 ms
- Maximum shock acceleration – 50 m/s^2.

1.2.18 The device withstands falls on each of its six edges from a height of 0.75 m on the concrete floor.

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

1.2.20 The device is immune to gamma radiation of up to 1.0 Sv/h DER for 50 minutes.

1.2.21 According to GOST 14254-96 standard, the ingress protection rating of the device is IP67.

1.2.22 The device is resistant to electromagnetic fields of radio-frequency range in accordance with DSTU IEC 61000-4-3: 2007 in the frequency range from 80 to 1000 MHz at intensity of 10 V/m (test level 3).

1.2.23 The quasi-peak value of the radio-frequency field intensity at a distance of 3 m from the device does not surpass the values for class B equipment according to DSTU EN 55011:2014.

1.2.24 The mean time between failure is not less than 6000 h.

1.2.25 The mean time to full repair is not less than 10 000 h.

1.2.26 The mean service life of the device is at least 10 years (with the built-in battery being replaced every 5 years).

1.2.27 The average shelf life of the device is at least 10 years (with the built-in battery being replaced every 5 years).

1.2.28 The mean time to repair of the device, excluding the delivery time of spare parts, is not more than 3 hours.

1.3 Delivery kit of the device

1.3.1 The units and maintenance documentation are included with the device and presented in Table 1.2.

Table 1.2 – Delivery kit

Item	Type	Q-ty	Note
DKS-02PN "CADMIUM" search alarm dosimeter	BICT.412139.005-02	1	
Charging device		1	Model is not specified
Shielded USB cable		1	Model is not specified
Operating Manual	BICT. 412139.005-02 HE	1	
"Spectra Reader" software		1	On a mimi-CD
Case		1	Model is not specified

1.4 Design and principle of operation

1.4.1 General information, design overview

1.4.1.1 External view of the device is shown in Figure 1.

Figure 1 – External view of the device

The device is structurally designed as a shape derivative of rectangular parallelepiped with flat planes being replaced with surfaces of large radii of curvature with rounded edges. The body is dustproof, waterproof, made of plastic. The device has upright working position.

The ingress protection rating is IP67. The body consists of two covers (1) and (2) connected by screws. The front cover (1) contains the graphical color display (3), multifunctional manipulator (joystick) (4), indicators – GAMMA (7), NEUTRON (8), BATTERY (9) – and the light sensor ABC (10). In the upper part of the cover, there is a light display (5) for alarm triggering when radioactive sources are detected.

A spring clip retainer (11) is secured with one screw on the back cover, with the help of which the device is securely fastened onto the operator's clothes, and which can be easily removed, if necessary. The back cover and the clip are marked with "+" symbols (12), which stand for the mechanical centers of photon-ionizing and neutron radiation detectors.

On the right lateral surface of the device's body under the protective flexible plug (6) there is a USB connector to connect the peripheral devices and charge the built-in battery.

The device is powered from a lithium-polymer battery of 3.7 V rated voltage.

The device is sealed with a paste in the indention (13) of the bottom cover.

1.4.2 Operation of the device

The device consists of the following main parts: high-sensitivity detecting unit of gamma radiation (GDUh), low-sensitivity detecting unit of gamma radiation (GDUl), detecting unit of neutron radiation (NDU), supply voltage formers (SVF), bias voltage formers (BVF), GPS/GNSS receiver (NAV), display and processing module (DPM), graphical color display (GCD), battery (B), and thermal detector (TD).

GDUh consists of the detector of CsI(Tl) scintillator type with silicon photomultiplier and amplifier, while NDU – of the detector of LiI(Eu) scintillator type with the silicon photomultiplier and amplifier. GDUl is represented as a Geiger-Muller counter.

The principle of operation of the detecting unit is based on the transformation of scintillations caused by gamma or neutron radiation in the scintillator into the voltage pulses in the semiconductor photomultiplier. These pulses are emanated to the input of the amplifier where they are intensified and come to the output as pulses of positive polarity. The number of these pulses is proportional to gamma or neutron radiation DER, and the amplitude – to the energy.

For high temperature stability of the detectors with silicon photomultiplier, the DPM constantly compensates temperature by measuring exact values of temperature at the detectors, and precisely adjusting the bias voltage.

DPM processes the pulse flow coming from the outputs of GDUh, GDUl, NDU, and calculates the value of gamma radiation DER, which corresponds to this flow considering the multichannel amplitude analysis, and the pulse count rate from GDUh, GDUl, and NDU.

Depending on the operating mode of the device, the GCD shows the readings of DER, flux intensity, intensity flow histogram, statistical error for gamma and neutron channels.

If DER exceeds 50 μSv/h by gamma channel, GDUh is automatically turned off, and the DER value is calculated from GDUl that runs continuously.

The DPM consists of the nonvolatile memory, which stores the event log files.

1.5 Labeling and sealing

1.5.1 The upper cover and the panel of the device is inscribed with the name and a symbol of the device, the ingress protection rating and the manufacturer's trademark.

1.5.2 The lower cover of the device contains the factory serial number and the date of manufacture.

1.5.3 Sealing of the device is performed by the manufacturer.

1.5.4 Removal of seals and repeated sealing is performed by the company after repair and calibration of the device.

1.6 Packing

1.6.1 The device, the charger, and the operating manual are placed into a dustproof and waterproof case.

1.6.2 The case with the device's kit is put into a cardboard packing box, which is glued up on both sides with a plastic film with a sticky layer.

2 PROPER USE OF THE DEVICE

2.1 Operating limitations

Operating limitations are presented in Table 2.1.

Table 2.1 – Operating limitations

Operating limitation	Limitation parameters
1 Ambient air temperature	from –20 to 50 °C
2 Relative humidity	Up to 100 % at 35 °C temperature, non-condensing
3 Gamma radiation exposure	Exposure of photon-ionizing radiation DER is up to 10 Sv/h during 5 min

2.2 Preparation for operation

2.2.1 Scope and order of external examination

2.2.1.1 Before using the device, 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 Read this OM carefully before you start, examine the location, and find out the intended use of indicators and controls.

2.2.2.2 Charge the battery by connecting the charger to the USB-port of the device. However, if the device was on, it would automatically turn off and switch to the charging mode, and the display would show the battery charging process animation: 

Note 1. The device is equipped with a lithium-polymer battery with no "memory effect", which can be charged at any time.

Note 2. Fully charge the battery before the long-term storage of the device.

2.2.3 List of possible troubles and troubleshooting

2.2.3.1 The list of possible troubles and troubleshooting is presented in Table 2.2. Please record the possible troubles in the table of Appendix A of this Operating Manual.

Table 2.2 – Possible troubles and troubleshooting

Trouble, its manifestation and additional features	Probable trouble cause	Troubleshooting
The device does not switch on	The battery is discharged	Charge the battery
No communication between the device and the PC	Damaged USB cable	Replace the USB cable
The device's battery does not charge	1 Damaged USB cable 2 Charger is out of order	1 Replace the USB cable 2 Replace the charger

2.2.3.2 If you fail to eliminate the troubles listed in Table 2.2 or locate more complicated troubles, send the device for repair to the manufacturer.

2.3 Use of the device

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

2.3.1.1 All works on the device use should be carried out according to the requirements set out in the following documents:

"Radiation Safety Standards of Ukraine" (NRBU-97). State hygienic standards DHN 6.6.1-6.5.001-98,

"Basic Sanitary Rules of Radiation Safety of Ukraine" (OSPU-2005) DSP 6.177-2005-09-02.

2.3.1.2 The device's surface contains no voltages hazardous for life.

2.3.1.3 The device meets safety requirements of DSTU EN 61010-1:2014.

A special protective jacket is used in the device to prevent accidental contact with conductive parts.

Ingress protection rating is IP67 according to GOST 14254-96.

2.3.1.4 Under fire safety requirements, the device meets the applicable regulatory documents and guidance of fire safety.

2.3.1.5 Direct application of the device is not dangerous for attending personnel and is environmentally friendly.

2.3.1.6 In the event of contamination, the device is subject to decontamination by wiping its surfaces by a gauze swab moistened with a standard decontaminating agent.

2.3.1.7 Disposal of the device should be performed according to DSTU 4462.3.01:2006, DSTU 4462.3.02:2006, and to the Laws of Ukraine On Environmental Protection and On Waste.

2.3.2 **Operating modes of the device**

The device has the following modes to:

- Switch the device on/off (2.3.3.1 - 2.3.3.2);
- Measure and indicate DER for gamma and neutron channels (2.3.3.3);
- Display intensity histograms for gamma and neutron channels (2.3.3.4);
- Measure DE (2.3.3.5);
- Adjust the device (2.3.3.6);
- PC communication (2.3.3.7).

2.3.2.1 A joystick with a central button as shown in Figure 1 is used to manage the device's operation.

Use the joystick to change the operating modes of the device, its settings, and navigate the menu. The central button serves to save the settings, confirm the entered data, recalibration and switching on/off the device.

2.3.2.2 GCD is used to control the device's operation.

2.3.2.3 In the process of operation, the device generates vibration, sound, and light signals as described below.

2.3.2.3.1 Vibration and sound signals:

"Quantum", a sequence of short beeps that indicate the intensity of registered gamma quanta or neutrons. Signal frequency is proportional to the count rate of gamma quanta or neutrons. Signal **"Quantum"** can be enabled or disabled only when the intensity histograms of gamma and neutron channels are displayed.

"**Sigma threshold level exceeding"**, periodic light, sound, and/or vibration signals that indicate on exceeding of the preset intensity threshold of gamma quanta count or conventional neutrons threshold level.

"Safety threshold level exceeding", periodic light, sound, and/or vibration signals that are generated when the measured value of photon-ionizing radiation DER is higher than the safety threshold level.

"Accumulated dose threshold exceeding", periodic light, sound, and/or vibration signals generated when the measured value of photon-ionizing radiation DE is greater than the threshold level.

"Low battery", periodic light, sound, and/or vibration signals that indicate a significant discharge of the device's battery. These signals can be completely disabled.

"Turning the device on/off", polytonic sound, vibration, and light signals, which indicate that the device was switched on or off. These signals can be completely disabled.

"Key tone", audible and/or vibration signals generated when there was some manipulation with the device's controls. These signals can be completely disabled.

2.3.3 **Operation procedure of the device**

The general control algorithm of the device's operation is as described below.

As soon as switched on, the device enters the mode of DER measurement and indication by gamma and neutron channels, and starts calibration by gamma background level and testing gamma radiation detector efficiency. The duration of calibration is from 90 to 2 s, depending on the gamma background DER.

The 

icon that is totally green with no flashing "background" inside it indicates that the calibration is completed.

Note 1. Calibration by the level of gamma background is done automatically when switching the device on or as required by the user. Calculation of the search sigma threshold level of the alarm is performed regardless of the operating mode of the device.

Note 2. For manual recalibration, press and hold "OK" in the joystick for at least 2 seconds while still being in DER measurement mode. The background icon will start filling once again, and "**background**" will start flashing

The device has the mode of sound alarm of registered quanta of photon ionizing radiation or neutrons, which turns on and off only in the mode of intensity histogram display by gamma and neutron channels. To enable/disable this mode, press and hold "OK" on the joystick for at least 2 seconds. On the joystick, briefly press "OK" for recalibration in terms of the intensity of sounding.

Each short press of the joystick to the right switches the device between the modes in the following order:

- Mode of DER measurement and indication by gamma and neutron channels;
- Mode of intensity histograms display by gamma and neutron channels;
- Mode of DE measurement;
- Mode of adjusting the device, which incorporates:
    - Display
    - Sound
    - Vibro
    - Light
    - Language
    - Location
    - Measurement
    - Time and Date
    - Device info
    - Device off

By pressing the joystick to the left, the device switches between the modes in the reverse sequence.

Regardless of the operating mode of the device, the icons as shown below can be displayed in the top two lines of the display:

 – the current battery status

 – the current time

 – the GPS-receiver status

 – the device's internal memory overflow

 – the level of alarm threshold is exceeded

 – the gamma background calibration is in process

 – the alarm status of count rate of photon-ionizing quanta

 – the sound alarm status

 – the vibration alarm status

 – the light alarm status

When you connect the device via the USB-cable to the PC (if the device was switched on), the device automatically switches off and goes to the charging mode. Run the "Spectra Reader" software and enter the correct password to switch to the mode of data communication with the PC. Once you have fnished and closed the "Spectra Reader" software, the device automatically turns off and goes to the charging mode until disconnected from the PC.

2.3.3.1 Switching the device on and entering the measurement mode

To switch the device on, hold down the central joystick button for at least 3 seconds. A backlit graphical color display (further – the display) indicates that the device is on, and then it will show information about the device and the producer's trademark (Fig. 2).

If the  icon appears on the display when you try to turn on the device, it means that the battery is completely discharged and it should be charged.

Note.You can use the necessary options of the settings to turn on or turn off the sound, light, and/or vibration signals that enable the device.

When you switch the device on, a login screen will appear on the display (Fig. 3).

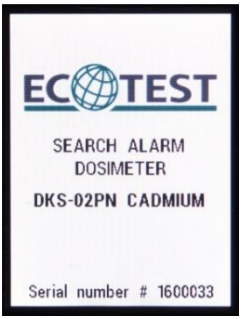

Figure 2 - Switching the device on

Figure 3 - Login screen

When you move the joystick up or down, select one of the login options – **"User"** or **"Administrator"** – and press the central joystick button.

Operation in the "**Administrator**" mode is different in that you can change those device settings that directly affect its operation (thresholds levels of alarm triggering by gamma and neutron channels coupled with the time and date of the device). To enter the "**Administrator**" mode, you must enter the password provided by the manufacturer of the device (Fig. 4).

Figure 4 - Entering the administrator password

By moving your joystick up or down, choose the required number for each section of the password, and press the central button. Press the joystick to the left or right to navigate through sections. After you press the central joystick button, the device goes to the mode of DER measurement and indication by gamma and neutron channels.

WARNING! Do not share the login password as "**Administrator**" with persons who will use the device as "**Users**". They should not be able to change settings that directly affect the device's operation.

2.3.3.2 Switching off the device

To switch the device off, go to settings, and select **Device off** on the second page of settings. The display will show the information about the manufacturer, and the dosimeter will switch off.

2.3.3.3 The mode of DER measurement and display by gamma and neutron channels

As you log in as a "**User**" or as an "**Administrator**", the device enters the mode of DER measurement and indication by gamma and neutron channels. The **"DER"** label in the upper left corner of the display indicates that the device is in this mode.

Figure 5 – Mode of DER measurement and indication

The window is divided into two independent display areas: the upper one captures DER and the pulse count rate of gamma radiation, while the lower one – DER and the pulse count rate of neutrons. The resolution of display of the pulse count rate of gamma radiation is 1 cps, that of neutrons – 0.01 cps. A unit of measurement is specified near each value, according to which the data is displayed at this point of time.

Also, each display area has an analogue scale of pulse count intensity, which automatically changes the gradation depending on the radiation intensity. A statistical error in percentage is displayed as well (Fig. 5).

If the set threshold level of alarm triggering by sigma threshold is exceeded, the σ and σ icons alternately appear in the corresponding area. If the threshold level of alarm triggering by neutrons count rate is surpassed, the σ and σ icons alternately appear in the relevant area, whereas actuation of both alarms makes σ and σ alternately appear. Light, sound, and/or vibration alarms also turn on according to the device's settings.

On exceeding of the set threshold level of alarm triggering by the safety level, the  icon appears, and light, sound, and/or vibration alarms also turn on according to the device's settings.

In exceeding the set threshold level of alarm triggering by accumulated dose, the  icon appears, and light, sound, and/or vibration alarms also turn on according to the device's settings.

Note. If you need to recalibrate the device by sigma-threshold for gamma radiation, you need to hold down the central joystick button for at least 2 seconds in the mode of DER measurement and indication by gamma and neutron channels.

IMPORTANT! If DER is over 50 μSv/h, only the alarm by the safety level would trigger and it would be impossible to recalibrate the device by sigma-threshold for gamma radiation.

IMPORTANT! The exposure of powerful electromagnetic radiation on the device may cause false readings and false alarms.

IMPORTANT! For neutron registration, the device uses a scintillation detector and amplitude analysis to isolate neutron responses at the existing gamma background. Since the neutron responses in the detector correspond to quite high energy values of equivalent photon radiation, high selective sensitivity particularly to neutron radiation is achieved. However, high energy single photons of cosmic origin can be registered as neutrons, which will make counts appear on the digital display.

The display of random DER counts or intensity count rate by the neutron channel for less than 24 seconds without actuation of the neutron alarm threshold is very common and should not be considered.

2.3.3.4 The mode that displays intensity histograms by gamma and neutron channels

To go to the mode of intensity histograms by gamma and neutron channels, move the device's joystick to the left or to the right (depending on the current operating mode of the device).

In the left upper corner of the display, you can find **"SM"** that shows the current operating mode (Fig. 6).

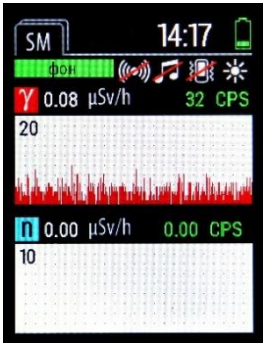

Figure 6 – Histograms display mode

The window is divided into two independent display areas. The upper one reflects DER, gamma radiation pulse count rate, and an intensity histogram of gamma radiation that represents pulses at each 100 ms during the last 24 s, and the bottom one – DER, neutrons pulse count rate, and an intensity histogram of neutron radiation that shows pulses at each 100 ms during the last 24 s. The resolution of display of the pulse count rate of gamma radiation is 1 cps, that of neutrons – 0.01 cps. A unit of measurement is found near each value according to which data is displayed at this point of time.

In the upper left corner of the histograms, there is a figure that demonstrates the current dimension of the histogram, and each point within its field on the vertical axis indicates the 1/10 of this value (Fig. 6).

Note. In the absence of a neutron radiation source in the environment, the intensity histogram of neutron radiation will not appear on the display since the common background radiation has no neutron component.

If sigma threshold for gamma radiation exceeds the set level of alarm triggering, the  and  icons alternately appear in the corresponding area. If the threshold level of alarm triggering by neutrons count rate is exceeded, the  and  icons alternately appear in that area. When both alarms are actuated, the  and  icons are shown one by one in the corresponding area. Light, sound, and/or vibration alarms also turn on according to the device's settings.

If the set threshold level of alarm triggering by the safety level is exceeded, the  icon appears, and light, sound, and/or vibration alarms are also enabled as specified in the device's settings.

In exceeding the set threshold level of alarm triggering by accumulated dose, the  icon appears, and the light, sound, and/or vibration alarms also turn on according to the device's settings.

To turn on/off a sound effect of pulse count rate, hold down the central joystick button for at least 2 s. The  icon indicates that pulse count rate is followed by sound, the  icon – that sound is absent. Short presses of the central joystick button, when sound of pulse count rate is enabled, initiates recalibration of the sounding rate relative to the current pulse count rate, which make it possible to distinguish sounds when the device approaches a radiation source and switch sound from the mode of continuous signal to a distinct periodic one.

2.3.3.5 Mode of DE measurement

To go to the mode of accumulated dose display, move the device's joystick to the right or to the left, depending on the current operating mode of the device.

In the left upper corner of the display, you can find **"AD"** that shows the current operating mode (Fig. 7).

Figure 7 – Mode of DE measurement

The accumulated dose and the time since when the device is switched on appear on the display.

If sigma threshold for gamma radiation exceeds the set level of alarm triggering, the σ and σ icons alternately appear in the corresponding area. If the threshold level of alarm triggering by neutrons count rate is exceeded, the σ and σ icons appear in a row in that area. When both alarms are actuated, the σ and σ icons are shown one by one in the corresponding area. Light, sound, and/or vibration alarms also turn on according to the device's settings.

If the set threshold level of alarm triggering by the safety level is exceeded, the  icon appears, and light, sound, and/or vibration alarm is also enabled as specified in the device's settings.

In exceeding the set threshold level of alarm actuation by accumulated dose, the  icon appears, and the light, sound, and/or vibration alarm also turns on according to the device's settings.

2.3.3.6 The mode of the device setup

To switch to the setup mode, move the device's joystick to the left or to the right (depending on the current operating mode of the device).

"SET" inscription in the left upper corner of the display indicates to operation in this mode.

Figure 8 – Device setup mode

The device setup mode includes the following items (Fig. 8):

- **Display** – backlight setup,
- **Sound** – setting sound notifications and alarms,
- **Vibro** – setting vibrating notifications and alarms,
- **Light** – setting light notifications and alarms,
- **Language** – choice of the language of data display on the device display,

• **Location** - setting the device's navigation receiver,

• **Measurements** – setting thresholds of the alarm triggering and tracks saving,

• **Time&Date** – setting time and date,

• **Device Info** – information about the device and the manufacturer.

• **Device off –** switching off the device

To switch to the required item of settings, move the device's joystick up or down until this item becomes highlighted by the cursor, then press the central joystick button to confirm switching to this item.

To change the settings in items **"Display"**, **"Sound"**, **"Vibro"**, **"Light"** and **"Location"**, move the device's joystick up or down until you select the desired option, then move the device's joystick leftwards or rightwards to select 

, 

or a different value depending on the selected parameter.

To change the settings in the **"Language"** item, move the device's joystick up or down until you select the desired language, then press the central joystick button to confirm your choice.

To change the settings in items **"Measurements"**, **"Time&Date"** and sub-item **"Change Password"** of the item **"Device Info"**, move the device's joystick up or down until you select the desired option, then press the central joystick button to confirm your choice.

Then, you should move the device's joystick leftwards or rightwards until you select the desired value or unit of measurement, and then move the joystick up or down until you select the desired value. Press the central joystick button to return to selection of other parameters of the respective item.

Each item of the setup menu contains icons 

, (but for **"Device Info"** item) and 

responsible for settings saving and returning to the previous menu without saving settings respectively. To select the desired icon, move the device's joystick up or down until this icon becomes highlighted with green cursor (for example, 

), then press the central joystick button to confirm.

2.3.3.6.1 Display

“Display” item contains the following settings (Fig. 9):

Figure 9 – Setting display parameters

• **Brightness** – makes it possible to set the display backlight intensity ranging from 10% to 100% in 10% increment, or "Auto". When selecting the display backlight intensity "Auto", its intensity is adjusted automatically, depending on the external lighting.

• **Backlight timeout** - makes it possible to set the following display backlight time: 15 s, 30 s, 60 s, 120 s, 300 s or continuous backlight.

2.3.3.6.2 Sound

“Sound” item contains the following settings (Fig. 10):

Figure 10 – Setting sound signals

• **ON Sound**– makes it possible to enable or disable the beeps when switching the device on and off;

• **Key Beep** – makes it possible to enable or disable sounding of manipulations with the device controls;

• **Alarm Sound** – makes it possible to enable or disable the audible alarm triggered by exceeding the threshold level of radiation;

• **Law bat Sound** – makes it possible to enable or disable the audible alarm when the device’s battery is law.

2.3.3.6.3 Vibration

“Vibration” item contains the following settings (Fig. 11):

Figure 11 – Setting vibration signals

• **ON Vibro** – makes it possible to enable or disable vibration signals when switching the device on and off;

• **Key Vibro** – makes it possible to enable or disable vibration during manipulations with the device controls;

• **Alarm Vibro** – makes it possible to enable or disable the vibration alarm triggered by exceeding the threshold level of radiation;

• **Law bat Vibro** – makes it possible to enable or disable the vibration alarm when the device’s battery is law.

2.3.3.6.4 Light

“Light” item contains the following settings (Fig. 12):

Figure 12 – Setting light signals

• **On Light** – makes it possible to enable or disable light signals when switching the device on and off;

• **Alarm Light**– makes it possible to enable or disable the light alarm triggered by exceeding the threshold level of radiation;

• **Law bat Light**– makes it possible to enable or disable the light alarm when the device’s battery is law.

2.3.3.6.5 Language

“Language” item makes it possible to change the data display language on the device display (Fig. 13):

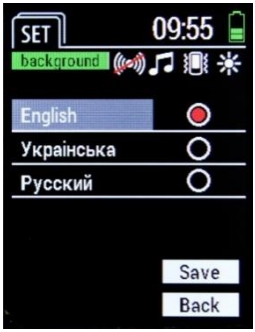

Figure 13 – Setting the language

2.3.3.6.6 Location

“Location” item contains the following settings (Fig. 14):

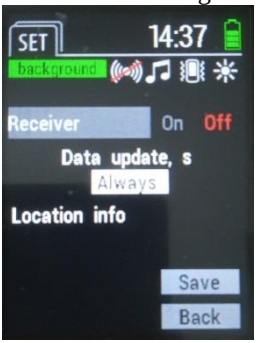

Figure 14 – Setting the parameters of navigation receiver

• **Receiver** – makes it possible to enable or disable power supply of the device navigation receiver;

• **Data update** – allows setting the following coordinates update interval: 15s, 30s, 60s, 120s, 300s, or continuous update;

• **Location info** - makes it possible to switch to viewing the current data of navigation receiver, namely, time, date, coordinates, number of satellites currently found by the device (SIU), as well as information on whether these coordinates are reliable (Fig. 15).

Figure 15 – Location information

2.3.3.6.7 Measurement

“Measurement” item contains the following settings (Fig. 16):

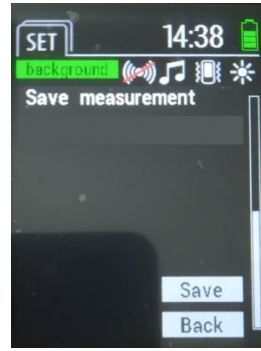

Figure 16 – Setting measurement parameters

• **Gamma sigma threshold -** allows setting the threshold of the alarm triggering by the number of exceedances of the mean square value of gamma pulse count rate;

• **Cond. neutron threshold** - allows setting the conditional threshold of the alarm triggering by neutrons;

• **Safety threshold -** allows setting the threshold of the alarm triggering by the DER value;

• **Accum. dose threshold** - allows setting the threshold by the accumulated dose;

• **Save measurements** - allows saving the events with current coordinates, time and DER in the device's memory during measurements. **If the navigation receiver is disabled at the time of saving, or there is no communication with satellites, information about current coordinates is not added to the event.**

IMPORTANT! The options to configure **"Sigma threshold Gamma"**, **"Conditional threshold Neutrons"** and **"Safety Threshold"** are available only after you enter the **"Administrator"** mode (2.3.3.1).

The device's memory allows storing about 65,000 events. If  and  icons alternatively appear in the top line of the display, it means that the device's memory is full and further saving of the events is impossible. To read and clear the events from the device's memory use the **"Spectra Reader"** software.

2.3.3.6.8 Time and Date

"Time and Date" item contains the following settings (Fig. 17):

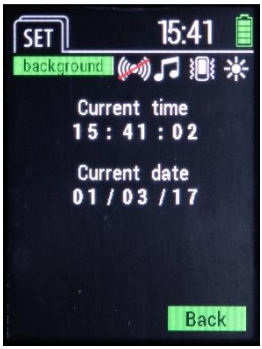

Figure 17 – Setting time and date parameters

- **Current time** – allows setting the current time;
- **Current date** – allows setting the current date.

IMPORTANT! The option to configure **"Current time"** and **"Current date"** parameters is available only after entering the **"Administrator"** mode.

2.3.3.6.9 About the device

"About the device" item contains information about the device model, version of its proprietary software, serial number, and information about the device's manufacturer (Fig.18).

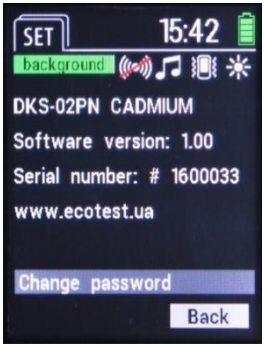

Figure 18 – About the device

This item also contains the **"Change password"** subitem that allows you to change the password to enter in the **"Administrator"** mode.

The **"Change Password"** subitem contains the following items (Fig. 19):

Figure 19 – Password change

• **Enter password** - enter the current password in this field;

• **Enter new password** - enter a new password in this field;

• **Repeat new password** - reenter the new password in this field.

2.3.3.7 Data communication with personal computer (PC)

2.3.3.7.1 Software installation

To read and view the events from the device and set its parameters use the **"Spectra Reader"** software (hereinafter **"Spectra Reader" SW**), which is supplied by the device's manufacturer.

IMPORTANT! You need to know the password to log in as **"Administrator"** to use the **"Spectra Reader" SW**. It is common for operation with the device and this SW.

To realize the option of data communication of the device and a personal computer (hereinafter, the PC) you first **need to install the driver** supplied by the device's manufacturer.

After installing the driver, you have to install the **"Spectra Reader" SW**.

Installation of the driver and **"Spectra Reader" SW** is similar to installing other applications and does not require any special skills.

IMPORTANT! Smooth operation of **"Spectra Reader" SW** requires installation of at least **OS Windows 7** on the PC. To install the **driver** and **"Spectra Reader" SW** you might need to login in the OS of your PC as the **"Administrator"**. In case of complications, please contact your system administrator who supports your PC.

2.3.3.7.2 Establishing data communication with PC

Connect the device via USB-cable to the PC. If the device is switched on, it automatically switches off and proceeds to charging mode. To switch to the mode of data communication with PC, you have to run **"Spectra Reader" SW** (through a link on the desktop or via "Start" menu), after which you see a login window into the **"Spectra Reader" SW** containing the following fields (Fig. 20):

• **Language** – selection of the desired language of interface display;

• **COM-port** - selection of a COM-port, which the device is connected to;

• **PIN code** - entering a PIN code to access the program.

Note. You may get to know the COM-port number by right-clicking on the icon "Computer" and selecting "Properties" in the popup window. Then in the left side of the window that appears, select "Device Manager" item, and in the "Ports (COM and LPT)" tab find "**ST Microelectronics Virtual COM Port**". COM-port (COM__) number specified opposite the device is used to select the login window to **"Spectra Reader" SW** in the "COM-port" field. If you connect the device to the same USB-port of the PC each time, the number of its COM-port does not change. An example of access to information about the COM-port number is provided for Windows 7 and may vary in other operating systems.

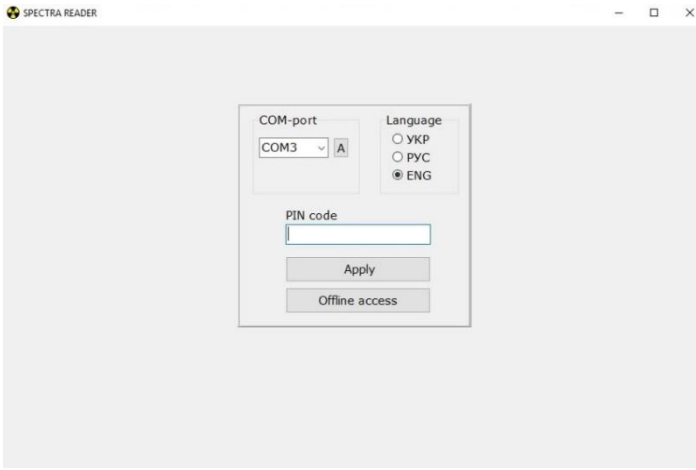

Figure 20 – Login window in **“Spectra Reader” SW**

Select the desired options, enter a PIN code and click "**Apply**" button. If all data is entered correctly, “Events” tab of the "**Spectra Reader**" SW opens. If a window appears with a warning that your data is incorrect, check the entered data and click "**Apply**" again.

2.3.3.7.3 Events reading

After starting the **"Spectra Reader" SW,** the "**Events**" tab of the main window opens (Fig.21).

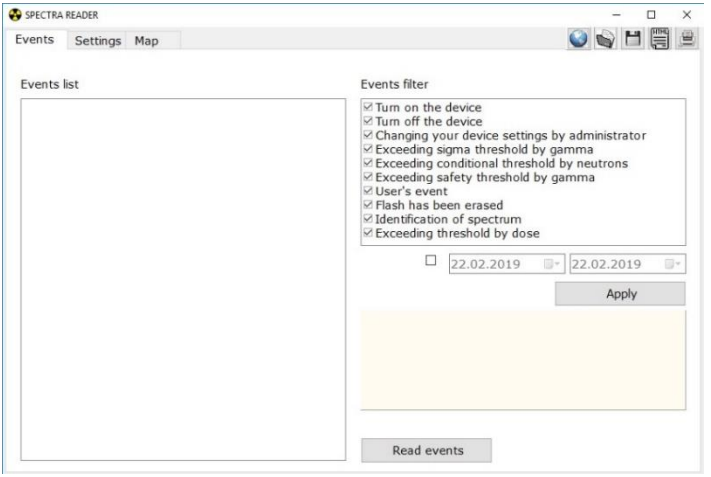

Figure 21 – **"Events"** tab

In the upper left corner of the **"Events"** tab a serial number of the connected device is highlighted in the format "Ser.number XXXXXXXX", where XXXXXXXX is a unique serial number of the currently connected device.

This tab has the following fields as well:

• **List of events** - this field displays the list of events downloaded from the device during the last readout session;

• **Events Filter** - you can select the type and the date of the events saving in this field that will be displayed in the list after reading from the device.

Click "**Read events**" to read all events saved in the device's memory.

IMPORTANT! Even if not all types of events were selected in the "**Events Filter**" field, they still would be read again each time until cleared from the device's memory.

2.3.3.7.4 Working with the readout events

After successful reading of the events from the device, they are displayed in the "**List of Events**" field of the "**Events**" tab (Fig. 22).

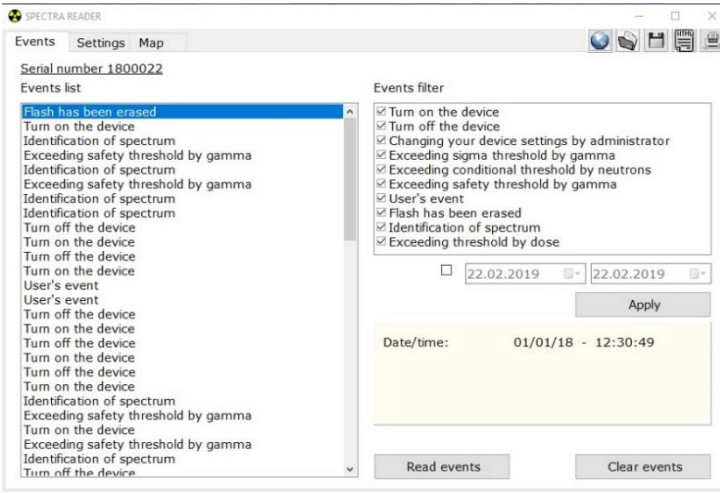

Figure 22 – Readout events

Select the required event in the "**List of events**" field. The information it contains is displayed rightwards below the "**Events Filter**" field.

If you need to sort the downloaded events, you can check the boxes in the "**Events Filter**" field opposite those types of events to be displayed in the "**List of Events**" field.

You can also set the time interval to display the events, the date of creation of which falls within this interval. To do this you have to check the box opposite the fields "from" and "to" and set the required time interval.

After selecting the types of events and/or the time interval, click "**Apply**" to display the events according to the specified parameters.

"Clear events" button is designed to delete all events from the device's memory.

IMPORTANT! If the events were not saved on the PC's hard drive (or removable disk), they are not subject to recovery after removal from the device's memory.

The upper right corner of the "**Events**" tab contains the following buttons of the events control:

 - saving all events to the PC's hard drive in the .dat format (including those that are not displayed according to filters);

 - download the saved events from the PC's hard drive;

- save all events to the PC's hard drive in .html format;

 - printout the report;

 - display the event on the map, according to the coordinates where it was saved (if the coordinates have been added) (Fig. 23).

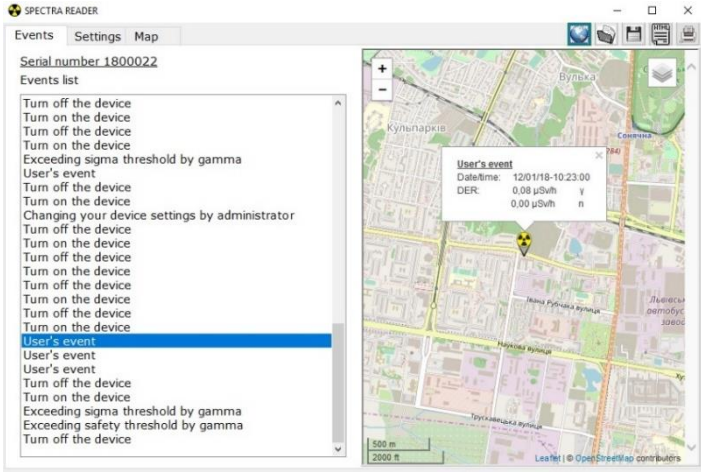

Figure 23 – Event display on the map

2.3.3.7.5 Settings

Go to the "**Settings**" tab of the main window of **"Spectra Reader" SW** (Figure 24) and click on the **"Read Settings"** button to read the current data from the device.

"Settings" tab includes the following fields:

• **Serial No.** - this field displays the unique serial number of the connected device;

• **Sigma threshold by gamma** – in this field you can set the threshold of alarm triggering by the number of rms deviations of gamma radiation pulse count rate;

• **Conditional threshold by neutrons** - in this field you can set the threshold of alarm triggering by the neutrons count rate;

• **Safety threshold by gamma** - in this field you can set the threshold of alarm triggering by gamma radiation DER level;

• **Date/Time** - in this field you can enter the current date and time or check the box in the "Synchronization" line and click "**Update**" to read the system time from the PC.

After entering the required data, click "**Save settings**" to record the updated data in the device's memory.

After entering the required data and checking the fields that are to be saved, click the **"Save settings"** button to record the updated data in the device's memory.

• **Dose threshold** - in this field you can set the threshold of alarm triggering by accumulated dose. After entering the desired value, click the **"Save"** button.

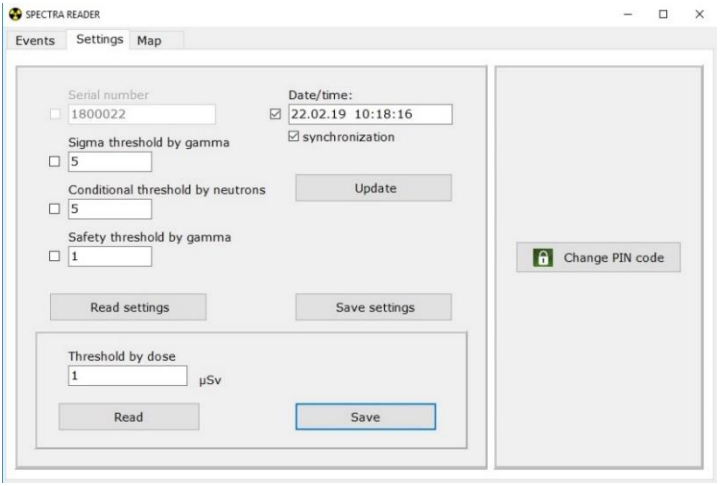

Figure 24 – Settings tab

2.3.3.7.6 PIN code change

To change the PIN code of access to **"Spectra Reader" SW** and login as the "Administrator" in the device, click on the **"Change PIN code"** button on the right side of the **"Settings"** tab.

A field of the PIN code change opens featuring the following fields (Fig. 25):

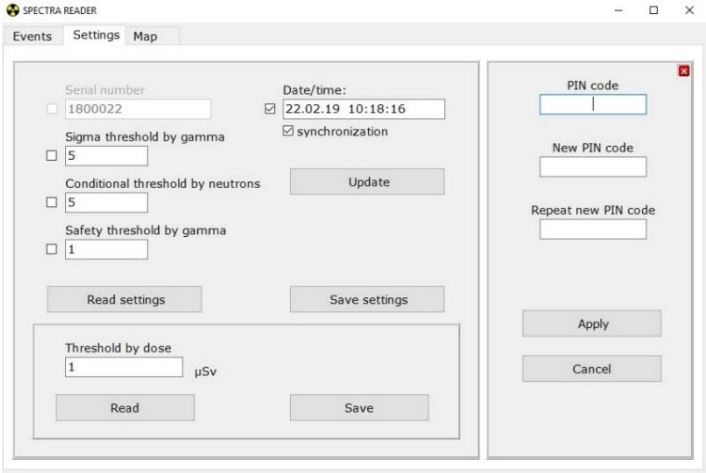

Figure 25 – PIN code change

- **PIN code** - enter the current access PIN code in this field;
- **New PIN code** - enter a new access PIN code in this field;
- **Repeat new PIN code** - renter the new access PIN code in this field.
- **Click "Apply"** to save the new PIN code or **"Cancel"** to keep the current PIN code unchanged.

2.3.3.7.7 Map

The **"Map"** tab of the **"Spectra Reader" SW** main window allows viewing all points on the map downloaded during the last reading according to the coordinates where they were saved (Fig. 26).

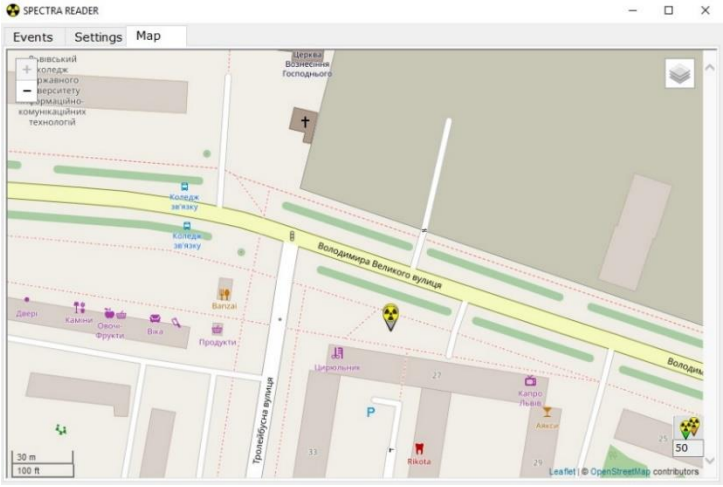

Figure 26 – "Map" tab

2.3.3.7.8 Completion of operation in the mode of data communication with PC

After completion of operation and exiting the **"Spectra Reader" SW,** the device automatically turns off and switches to the charging mode until it is disconnected from the PC.

3 TECHNICAL MAINTENANCE

3.1 Technical maintenance of the device

3.1.1 General guidelines

The list of operations during technical maintenance (hereinafter - TM) of the device, the order of priority and features at different stages of the device use is shown in Table 3.1.

Table 3.1 - List of operations during technical maintenance

Operations	Type of technical maintenance			OM item No.
	during		during long-term storage	
	everyday use	periodical use		
External examination	+	+	+	3.1.3.1
Delivery kit completeness check	-	+	+	3.1.3.2
Operability check	+	+	+	3.1.3.3
Storage battery status control	+	+	+	3.1.3.4
Verification of the device	-	+	+	3.2

Note 1. "+" means the operation is applicable at this type of TM; "-" means the operation is not applicable.

Note 2. The devices should be verified during use and after repair

3.1.2 Safety measures

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

3.1.3 TM procedure of the device

3.1.3.1 External examination

Examination of the device should be performed in the following order:

a) check the condition of the device's surfaces, the integrity of seals, absence of scratches, traces of corrosion, and surface damage of coating;

b) check the condition of the USB socket contacts.

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 device

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

3.1.3.4 Storage battery status control

The device's battery status control is performed during daily use, and before the long-term storage of the device. Follow the procedure below:

- Switch on the device;
- Monitor the battery status by the indicator on the display;
- If the battery is not full, charge it by plugging the charger in the USB connector.

3.2 Verification of the device

The devices should be verified during use (periodic verification at least annually), as well as after repair.

3.2.1 Verification operations

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

Table 3.2 - Verification operations

Operation	Verification technique No.
1 External examination	3.2.4.1
2 Testing	3.2.4.2
3 Calculation of the main relative permissible error limit during gamma radiation DER measurement	3.2.4.3
4 Determination of the main relative permissible error limit during gamma radiation DE measurement by the built in GMC	3.2.4.4

3.2.2 Verification instruments

The following instruments that should be used for verification are given in Table 3.3.

Table 3.3

Name	Regulatory documents or technical specifications
УПГД-3Б standard equipment	Ambient dose equivalent rate of gamma radiation in the range from 0.1 to 10^6 μSv/h. Energy range from 59 keV to 1.25 MeV. Main relative permissible error limit of gamma radiation DER and DE – 4 % with confidence probability of 0.95
УКПН-1М industrial standard unit of neutron radiation	Thermal neutron flux density in the range from 10 to 500 $cm^{-2} \cdot s^{-1}$. Main relative permissible error limit of thermal neutron flux density with confidence probability of 0.95 - 5 %
Aspiration psychrometer MB-4M	Л82.844.000 ПС. Temperature measurement range from –30 to +100 ^{0}C. Temperature measurement error ± 0.1 ^{0}C. Relative humidity measurement range from 10 to 100 %. Relative error of relative humidity measurement in the range from - to ± 12 % at t=–10 ^{0}C to ±2 % at t = +30 ^{0}C
Control aneroid baro-meter M-67	Л62.832.003 ПС. Pressure measurement range from 81.3 to 105.3 kPa (from 610 to 790 mmHg). Pressure measurement error limit is ± 0.107 kPa (0.8 mmHg)
RKS-01 “STORA” gamma, beta radiation radiometer-dosimeter	ТУ У 33.2-22362867-008-2004. 1. Gamma radiation DER measurement range from 0.1 to 1000 μSv/h. 2. Main relative permissible error limit of gamma radiation DER with 0.662 MeV energy is 15 % at P=0.95
Note 1. Measurement equipment shall be used according to the laws in the field of metrology and metrological activity. **Note 2.** The use of other measurement equipment that meets the prescribed accuracy is also applicable	

3.2.3 Verification conditions

3.2.3.1 Verification should be carried out under the following conditions:

- ambient air temperature within (20±5) °C;
- relative air humidity within (65±15) %;
- atmospheric pressure from 84 kPa to 106.7 kPa;
- natural gamma radiation background should not exceed 0.25 μSv/h;
- the device should be powered from the newly charged storage battery.

3.2.4 Verification procedure

3.2.4.1 External examination

During external examination the device should meet the following requirements:

- the delivery kit should be completed as described in OM 1.3;
- labeling should be accurate;
- Quality Control Department seals should not be violated;
- the device should be free from mechanical damage that may affect its performance.

Note. The delivery kit of the device is checked only at manufacture.

3.2.4.2 Testing

3.2.4.2.1 Switch on the device according to OM 2.3.3.1 and proceed to calibration relative to gamma background.

3.2.4.2.2 Place the ^{137}Cs gamma source near the device and observe the increase of pulse count rate from the gamma detector above the background level, and alarm triggering when an automatically set search threshold level is exceeded.

3.2.4.2.3 Place the device in the УКПН-1М carriage holder so that the mechanical center of neutron beam coincides with the one of the device's neutron detector. Place the УКПН-1М carriage holder with the device in the position, where neutron radiation from ^{239}Pu-Be ensures pulse count rate from the neutron detector within a 10 – 20 s^{-1} range. Make sure that the alarm of neutron radiation is triggered.

3.2.4.2.4 Switch off the device according to OM 2.3.3.2.

3.2.4.3 Calculation of the main relative permissible error limit during gamma radiation DER measurement.

3.2.4.3.1 Prepare the testing equipment УПГД-3Б (hereinfater – УПГД-3Б) according to its Operating Manual.

Place the device in the УПГД-3Б carriage holder so that the mechanical center of gamma beam coincides with the mechanical center of the device's gamma detector.

Note 1. The mechanical center of the gamma detector is labeled "+" on device's back cover.

Note 2. The distance between the mechanical center of the source and the mechanical center of the device's gamma 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 propagation, and passes through the mechanical center of the device's gamma detector in this plane.

Switch on the device. Turn off the sound and vibration alarms of threshold levels.

Make five measurements of gamma background DER $\dot{H}^{*}_{i}(10)$ in УПГД-3Б with an interval of 10 seconds. Register the obtained readings in the report.

Calculate the average value of $\overline{\dot{H}^*}(10)$, μSv/h, by the formula:

$$\overline{\dot{H}^*}(10) = \frac{\sum_{i=1}^{5} \dot{H}^*{}_i(10)}{5} \qquad (3.1)$$

3.2.4.3.2 Place the УПГД-3Б carriage holder with the device in the position, where gamma radiation DER from the ^{137}Cs source is $\dot{H}^*{}_0(10) = (10.0 \pm 0.1)$ μSv/h. After the device has been exposed to radiation, wait for 5 s and proceed to take five measurements of gamma radiation DER with a 10 s interval. Enter the results in the report. Calculate the average value of gamma radiation DER ($\overline{\dot{H}^*_\Sigma}(10)$) by the formula (3.1). The value of gamma radiation DER with gamma background DER in УПГД-3Б $\overline{\dot{H}^*}(10)$, μSv/h, is calculated as follows:

$$\overline{\dot{H}^*}(10) = \overline{\dot{H}^*_\Sigma}(10) - \overline{\dot{H}^*_\Phi}(10), \qquad (3.2)$$

where $\overline{\dot{H}^*_\Sigma}(10)$ - is an average value of the device readings from the source and gamma background in УПГД-3Б calculated by the formula (3.1), μSv/h;

$\overline{H^*_\Phi}(10)$ - is an average value of the device's readings during gamma background measurement in УПГД-3Б, μSv/h.

3.2.4.3.3 Determine the main relative permissible error of gamma radiation DER measurement in percentage by the following method.

3.2.4.3.3.1 Calculate the confidence limit of relative random error of measurement results as follows:

$$\varepsilon = t \cdot S, \qquad (3.3)$$

where t = 2.78 - a Student's coefficient at the confidence probability P = 0.95 and n = 5;

S - a relative root-mean-square deviation of measurement result calculated by the formula:

$$S = \frac{1}{\overline{\dot{H}^*}(10)} \sqrt{\frac{\sum_{i=1}^{n} \left(\dot{H}^*{}_i(10) - \overline{\dot{H}^*}(10)\right)^2}{n(n-1)}} \qquad (3.4)$$

3.2.4.3.3.2 Calculate the limit of residual systematic error of measurement results Θ by the formula

$$\Theta = 1.1 \sqrt{\left(\frac{\overline{\dot{H}^*}(10) - \dot{H}_0^*(10)}{\dot{H}_0^*(10)}\right)^2 + \left(\frac{\delta \dot{H}_0^*(10)}{2}\right)^2}, \qquad (3.5)$$

where $\delta \dot{H}_0^*(10)$ - is the main relative permissible error limit of gamma radiation DER of УПГД-3Б.

3.2.4.3.3.3 If $\frac{\Theta}{S} < 0.8$, then $\delta \overline{\dot{H}^*}(10) = \varepsilon \cdot 100 \cdot$

3.2.4.3.3.4 If $\frac{\Theta}{S} > 8$, then $\delta \overline{\dot{H}^*}(10) = \Theta \cdot 100.$

3.2.4.3.3.5 If $0.8 < \frac{\Theta}{S} < 8$, then $\delta \overline{\dot{H}^*}(10) = K \cdot S_\Sigma \cdot 100$,

where K - is the coefficient which depends on the ratio between the random and residual systematic errors, and is calculated by the formula:

$$K = \frac{\varepsilon + \Theta}{S + \frac{\Theta}{\sqrt{3}}}, \qquad (3.6)$$

S_Σ - is an evaluation of the total root-mean-square deviation of measurement result defined as follows:

$$S_\Sigma = \sqrt{S^2 + \left(\frac{\Theta}{\sqrt{3}}\right)^2} \qquad (3.7)$$

3.2.4.3.4 Perform operations 3.2.4.3.2, 3.2.4.3.3 for gamma radiation DER $\dot{H}^*_0(10)$ = (8.0 ± 0.8) mSv/h. Set the safety threshold equal to 6 mSv/h. Make measurements in 60 s after the beginning of irradiation at 60 s interval.

3.2.4.3.5 The device is acknowledged to have passed the verification test if the main relative permissible error at measurement for each level of gamma radiation DER does not exceed $(15+1/\dot{H}^*(10))$ %, where $\dot{H}^*(10)$ is a measured value of gamma radiation DER equivalent to μSv/h.

3.2.4.4 Determination of the main relative permissible error limit of gamma radiation DE measurement by the built-in GMC.

3.2.4.4.1 To determine the main relative permissible error limit of gamma radiation DE measurement by the built-in GMC, do the following:

3.2.4.4.2 Enable the device and log in in the **"Administrator"** mode.

3.2.4.4.3 Secure the device in the УПГД-3Б carriage so that the mechanical center of the УПГД-3Б collimator coincides with the mechanical center of the device, which is indicated on the back panel.

3.2.4.4.4 Place the УПГД-3Б carriage with the device in a position where gamma radiation DER from the sources with ^{137}Cs radionuclide is equal to $\dot{H}^*_0(10)$ =(1.0±0.1) mSv/h and at the same time record the readings of time from the exact time server and feed the source to the collimator.

3.2.4.4.5 In some time, which is calculated by the formula:

$$t = 3600 + t_\partial, \qquad (3.8)$$

where t_{∂}, s - time after which the source is fed into the collimator, read the result of gamma radiation DE measurement with time readings recording from the exact time server.

3.2.4.4.6 The main relative permissible error of photon-ionizing DE measurement in percentage shall be calculated by the formula:

$$\delta H^{*}(10) = 1{,}1\sqrt{\left(\frac{H^{*}(10) - H_0^{*}(10)}{H_0^{*}(10)}\right)^2 + \left(\frac{\delta H_0^{*}(10)}{2}\right)^2}, \qquad (3.9)$$

where

$H_0^{*}(10) = \dot{H}_0^{*}(10) \cdot t$ – gamma radiation DE of УПГД-3Б;

$\delta H_0^{*}(10)$ – main relative permissible error limit of gamma DE of УПГД-3Б, calculated by the formula:

$$\delta H_0^{*}(10) = \sqrt{\left(\delta \dot{H}_0^{*}(10)\right)^2 + \left(\delta t\right)^2}, \qquad (3.10)$$

where δt - the limit of the main relative permissible error of the measurement of the gamma DE exposure time, which must be not exceed 5%, is calculated by the formula:

$$\delta_t = \frac{1.1\sqrt{\left(\Delta t_c\right)^2 + \left(\Delta t_p\right)^2 + \left(\Delta t_{\partial}\right)^2}}{t}, \qquad (3.11)$$

where Δt_c – the limit of permissible error of stopwatch;

Δt_p = 1 s – the error caused by human reaction;

Δt_{∂} = 1 s - the error caused by the process during which the collimator opens.

Turn off the device.

3.2.4.4.7 The device is considered to pass the verification if the main relative error during gamma radiation DE measurement does not exceed 15%.

3.2.5 Presentation of verification results.

3.2.5.1 Positive results of periodic or after-repair verification are certified in the table of Appendix B or by issuing a verification certificate for the legislatively regulated measurement equipment.

3.2.5.2 If the device is acknowledged unfit for use after its verification, it gets the inadequacy certificate.

4 CERTIFICATE OF ACCEPTANCE

The DKS-02PN "CADMIUM" Search Alarm Dosimeter BICT.412139.005-02, with _____ serial number is verified and accepted for use.

Date of manufacture _____

QCD Representative: _____

Stamp here (signature)

5 PACKING CERTIFICATE

The DKS-02PN "CADMIUM" Search Alarm Dosimeter BICT.412139.005-02 with _____ serial number is packed by the PE "SPPE "Sparing-Vist Center" in accordance with the requirements outlined in the OM.

Date of packing _____

Stamp here

Packed by _____
(signature)

6 WARRANTY

6.1 The manufacturer guarantees the conformity of the device with the technical requirements if the customer observes the guidelines on its use, shipping and storage presented in the OM BICT.412139.005-02 HE.

6.2 The warranty period of use of the device shall terminate and be of no further effect in 24 months after the date of putting it into operation or after the warranty period of storage terminates.

6.3 The warranty period of storage of the device is 6 months after its manufacture date according to GOST 27451-87 standard.

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

6.5 When the warranty period of the device terminates, the repair is done according to separate agreements.

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

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

7 REPAIR

7.1 In case of failure or troubles during the warranty period of the device, the user should contact the supplier in his/her country. Warranty and post-warranty repair should be done only by the manufacturer at the following address:

PE "SPPE "Sparing-Vist Center"

79026, Ukraine, Lviv, 33 Volodymyra Velykoho St.

Tel.: (+38032) 242 15 15, fax: (+38032) 242 20 15

***E-mail:* sales@ecotest.ua.**

7.2 All claims are registered in Table 7.1.

Table 7.1

Date of failure	Claim summary	Action taken	Note

7.3 Warranty and post-warranty repair should be done only by the manufacturer. Information about repair of the device is recorded in the table of Appendix C of this OM.

8 STORAGE

8.1 The devices should be stored in the packing box under conditions 1 (Л) according to GOST 15150-69 standard in heated and ventilated storehouses with air-conditioning at the ambient air 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, alkalis and gases that may cause corrosion, and vapors of organic solvents.

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

8.3 The devices should be stored on the shelves.

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

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

8.6 Average shelf life is not less than six years.

8.7 Additional information on storage, check during storage and maintenance of the device is registered in Appendices D, E, F of this OM.

9 SHIPPING

9.1 Packed devices may be shipped by any kinds of closed transport vehicles under the conditions 4 (Ж2) (with temperature limitations in the range of – 25 °C to +50 °C) according to GOST 15150-69 and rules and standards effective for each means of transport.

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

9.3 The devices in shipping container endure:

- temperature from -25 to +50 ºC;
- relative humidity (95±3) % at 35 ºC temperature;
- shocks with 98 m/s^2 acceleration, shock pulse duration – 16 ms and the number of shocks not less than 1000.

9.4 Canting is forbidden.

10 DISPOSAL

Disposal of the device is performed in compliance with DSTU 4462.3.01:2006, DSTU 4462.3.02:2006 standards, Laws of Ukraine on Environmental Protection and on Waste and the general rules, i.e. metal is recycled or melted, and plastic parts are dumped.

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

APPENDIX A

TROUBLE RECORD DURING USE

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

APPENDIX B

PERIODIC VERIFICATION OF MAIN SPECIFICATIONS

Verified specification		Date of measurement					
		Year of 20		Year of 20		Year of 20	
Name	Standardized value	Actual value	Measured by (position, signature)	Actual value	Measured by (position, signature)	Actual value	Measured by (position, signature)
Main relative permissible error during gamma radiation DER measurement, %	$15+1/\dot{H}^{*}(10)$ where $\dot{H}^{*}(10)$ - is a measured value of gamma radiation DER, μSv/h						
Main relative permissible error during gamma radiation DE measurement with built-in GMC, %	15						

APPENDIX C

INFORMATION ABOUT DEVICE REPAIR

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

APPENDIX D

STORAGE

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

APPENDIX E

PUTTING IN PROLONGED STORAGE AND REMOVAL FROM STORAGE

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

APPENDIX F

VERIFICATION AND INSPECTION RESULTS

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