Scientific Production Company “Doza”

DOSIMETER/RADIOMETER DKS-96

User Manual
TE1.415313.003RE

Content

Appendices are included in a separate document TE1.415313.003RE1

This User Manual contains information on design and principle of operation of dosimeters/radiometers DKS-96. The User Manual contains basic specifications and features, as well as other information necessary for using the full range of technical possibilities of this product.

In the process of manufacturing dosimeters/radiometers DKS-96, their electric circuit, program of operation or design can be modified without affecting the technical and metrological characteristics; therefore such modifications may not be mentioned in this User Manual.

1 DESCRIPTION AND OPERATION OF DOSIMETER/RADIOMETER

1.1 Functionality of dosimeter/radiometer

1.1.1 Dosimeters/radiometers DKS-96 TE1.415313.003 (hereinafter – dosimeters/radiometers), depending on the type of detector unit connected, provide measurement:

- ambient dose equivalent rate $\dot{H}^*(10)$ of continuous and pulsed X-ray and gamma radiation (hereinafter – ADER);
- ambient dose equivalent $H^*(10)$ of continuous and pulsed X-ray and gamma radiation (hereinafter – ADE);
- ambient dose equivalent rate $\dot{H}^*(10)$ of neutron radiation (hereinafter – ADER);
- ambient dose equivalent $H^*(10)$ of neutron radiation (hereinafter – ADE);
- exposure dose rate $\dot{X}$ of gamma radiation (hereinafter – EDR);
- alpha particle flux density;
- beta particle flux density;
- gamma photon flux density;
- flux density of neutrons;
- flux of gamma photons.

1.1.2 Dosimeters/radiometers are used in dosimetry services at nuclear power industry facilities, at medical, scientific and other institutions, both standalone and as part of automated radiation monitoring systems for the following tasks:

- operation and periodic monitoring of the radiation environment;
- measurement of surface contamination with alpha-, beta-, gamma- and neutron-emitting substances;
- search and location of ionizing radiation sources;
- measurement of gamma photons flux and exposure dose rate of gamma radiation in wells and liquid media.
- measurement of radioactive contamination of scrap metal;
- radiation surveys at prospective construction sites;
- at customs check-point for the inspection of vehicles and cargo.

Dosimeters/radiometers can be connected to a personal computer via cable adapter PI-03 (RS-232 – USB) when using control units UIK-05/UIK-05-01, UIK-06 and interface RS-485/RS-422 when using control unit UIK-07.

Dosimeters/radiometers can be used for radiation surveys with georeferencing in conjunction with the global positioning system (GPS) sensor.

1.2 Technical characteristics

1.2.1 Basic metrological characteristics of dosimeters/radiometers for measurements of alpha particle flux density

1.2.1.1 Basic metrological characteristics of dosimeters/radiometers for measurements of alpha particle flux density are shown in Table 1.1.

Table 1.1

Detector unit	Measurement range, $min^{-1}\cdot cm^{-2}$	Maximum permissible basic relative error, %	Intrinsic background, $min^{-1}\cdot cm^{-2}$, not more than	detection efficiency of alpha radiation, not less than, %		
				^{239}Pu	^{234}U	^{238}U
BDZA-96	0.1 to $1\cdot10^4$	$\pm(20+5/A_x)$, where A_x – dimensionless quantity that is numerically equal to the measured value of flux density in $min^{-1}\cdot cm^{-2}$	0.3	42	25	15
BDZA-96b	0.1 to $2\cdot10^3$		1.0	42	31	21
BDZA-96m	0.1 to $1\cdot10^5$		0.2	50	30	18
BDZA-96s	0.1 to $5\cdot10^4$		0.2	45	25	15
BDZA-96t	0.1 to $1\cdot10^6$		0.1	45	32	30
BDPS-96	0.2 to $1\cdot10^4$		0.2	45	25	15

Notes
1 Maximum permissible basic relative errors are normalized values for sources with radionuclide ^{239}Pu.
2 According to customer's option, dosimeters/radiometers can be adapted to measure alpha particle flux density with the above metrological characteristics for sources with radionuclides ^{234}U and ^{238}U.
3 The level of intrinsic background is normalized for the level of external gamma background not exceeding 0,2 $\mu Sv\cdot h^{-1}$.

1.2.1.2 Dosimeters/radiometers are resistant to background gamma radiation with maximum ADER when using detector units:

- BDZA-96b …….. 0.01 $mSv\cdot h^{-1}$;
- BDZA-96, BDZA-96m, BDZA-96s, BDPS-96 …… 1.0 $mSv\cdot h^{-1}$;
- BDZA-96t ……. 100.0 $mSv\cdot h^{-1}$,

under the above conditions the measurement error of alpha particle flux density does not exceed the values of basic relative error specified in 1.2.1.1.

1.2.1.3 Dosimeters/radiometers with detector unit BDZA-96t are resistant to background neutron radiation with ADER up to 500 $\mu Sv\cdot h^{-1}$, under these conditions the measurement error of alpha particle flux density does not exceed the values of basic relative error specified in 1.2.1.1.

1.2.2 Basic metrological characteristics of dosimeters/radiometers for measurements of beta particle flux density

1.2.2.1 Basic metrological characteristics of dosimeters/radiometers for measurements of beta particle flux density are shown in Table 1.2.

Table 1.2

Detector unit	Measurement range, $min^{-1}\cdot cm^{-2}$	Maximum permissible basic relative error, %	Energy range of detected radiation, MeV	Intrinsic back-ground, $min^{-1}\cdot cm^{-2}$	Detection efficiency for beta radiation, not less than, %		
					$^{90}Sr+^{90}Y$	^{204}Tl	^{14}C
BDZB-96	10 to $1\cdot10^5$	$\pm(20+200/A_x)$, where A_x – dimensionless quantity that is numerically equal to the measured value of flux density in $min^{-1}\cdot cm^{-2}$	0.3 to 3.0	20.0	25	-	-
BDZB-96b	3 to $1\cdot10^4$		0.12 to 3.0	15.0	40	16	-
BDZB-96s	10 to $1\cdot10^5$		0.12 to 3.0	15.0	46	10	3
BDZB-99	20 to $1\cdot10^4$		0.12 to 3.0	30.0	45	20	3
BDKS-96s	10 to $3\cdot10^4$		0.12 to 3.0	-	48	10	3
BDPS-96	10 to $1\cdot10^5$		0.3 to 3.0	20	25	-	-

Notes
1 Maximum permissible basic relative errors are normalized values for sources with radionuclide $^{90}Sr + ^{90}Y$.
2 The level of intrinsic background is normalized for the level of external gamma background not exceeding 0,2 $\mu Sv\cdot h^{-1}$.

1.2.2.2 Dosimeters/radiometers with detector unit BDKS-96s are resistant to background gamma radiation with ADER up to 50 μSv·h^{-1}, under these conditions the measurement error beta particle flux density does not exceed the values of basic relative error specified in 1.2.2.1.

1.2.3 Basic metrological characteristics of dosimeters/radiometers for measurements of X-ray and gamma radiation

1.2.3.1 Basic metrological characteristics of dosimeters/radiometers for measurements of X-ray and gamma radiation are shown in Tables 1.3 and 1.4.

Table 1.3

Detector unit	Measurement range ADE	Measurement range ADER	Maximum permissible basic relative error, %	Anisotropy, %
BDKS-96, BDKS-96b	from 0.1 μSv to 10.0 Sv	from 0.1 μSv·h^{-1} to 1.0 Sv·h^{-1}	±(15+6/A_x), where A_x – dimensionless quantity that is numerically equal to the measured value of ADE in μSv or ADER in μSv·h^{-1} for low subrange and in mSv or mSv·h^{-1} for high subrange, accordingly	±25
BDKS-96s	from 0.1 μSv to 10.0 mSv	from 0.1 μSv·h^{-1} to 1.0 mSv·h^{-1}	±(20+2/A_x), where A_x – dimensionless quantity that is numerically equal to the measured value of ADE in μSv or ADER in μSv·h^{-1}	±35
BDMG-96	from 0.1 μSv to 10.0 Sv	from 0.1 μSv·h^{-1} to 10.0 Sv·h^{-1}	±(20+2/A_x), where A_x – dimensionless quantity that is numerically equal to the measured value of ADE in μSv or ADER in μSv·h^{-1} for low subrange and in mSv or mSv·h^{-1} for high subrange, accordingly	±25
BDVG-96	-	0.1 to 30,0 μSv·h^{-1}	±13	±35
BDPG-96	-	0.1 to 100 μSv·h^{-1}	±13	±35
BDPG-96m	-	0.1 to 300 μSv·h^{-1}	±13	±35

Notes

1 Maximum permissible basic relative errors of dosimeters/radiometers with detector units BDVG-96, BDPG-96 or BDPG-96m, are normalized values for sources with radionuclide ^{137}Cs.

2 Dosimeters/radiometers with detector units BDVG-96, BDPG-96 or BDPG-96m, are recommended for the monitoring of relative changes in the radiation environment only.

3 Anisotropy of detector units BDVG-96, BDKS-96, BDKS-96b, BDMG-96, BDPG-96 with reference to radionuclide ^{137}Cs is shown in the Appendix A.

4 Range of readings of dosimeters/radiometers with detector units:

- BDVG-96 ……..…… from 0.03 to 36,0 μSv·h^{-1};
- BDPG-96 …….. from 0.05 to 120 μSv·h^{-1};
- BDPG-96m ……..……... from 0.05 to 360 μSv·h^{-1}.

Table 1.4

Detector unit	Energy range of detected radiation	Energy dependence, %	Energy threshold of detection, keV
BDKS-96, BDKS-96b	from 15 to 25 keV	±45	-
	from 25 to 1250 keV	from +20 to minus 30	
	from 1.25 to 10 MeV	±15	
BDKS-96s	from 0.05 to 3,0 MeV	±30	-
BDMG-96	from 0.05 to 3,0 MeV	±30	-
BDVG-96	not standardized	not standardized	20
BDPG-96	not standardized	not standardized	50
BDPG-96m	not standardized	not standardized	50
Note – Typical energy dependence of detector units BDKS-96, BDVG-96, BDPG-96 and BDPG-96m with reference to radionuclide ^{137}Cs is shown in the Appendix B.			

1.2.3.2 Dosimeters/radiometers with detector units BDKS-96, BDKS-96b provide measurement of ADER and ADE of pulsed X-ray and gamma radiation with the parameters given in Table 1.5.

Table 1.5

Measurement subrange	Parameters of pulsed radiation		Limiting values of measurands	
	Frequency, s^{-1}	Pulse duration	ADER, $Sv \cdot s^{-1}$	ADE in a pulse, μSv
High	NMT 1	NLT0.3 ms	NMT 1.0	*
	1 to 10	from 0.3 ms to 0.01 μs	NMT 5.0	*
	more than 10	NMT 0.01μs	*	NMT 0,05
Low	NMT 1	NLT0.3 ms	NMT 0.01	*
	1 to 10	from 0.3 ms to 0.01μs	NMT 0,05	*
	more than 10	NMT 0.01μs	*	NMT 0,0005
* ADE in a pulse calculated as the product of ADER and pulse duration				

1.2.3.3 Dosimeters/radiometers provide measurement of gamma photon flux density in the range:
- with detector unit BDVG-96 …… 4 to 2000 $s^{-1} \cdot cm^{-2}$;
- with detector unit BDPG-96 …… 10 to 8000 $s^{-1} \cdot cm^{-2}$;
- with detector unit BDPG-96m …… 10 to 24000 $s^{-1} \cdot cm^{-2}$.

1.2.3.4 Maximum permissible basic relative error of gamma photons flux density measurements …….... ±13 %.

1.2.3.5 Dosimeters/radiometers with detector unit BDKG-96 provide measurement of EDR of gamma radiation with parameters listed in Table1.6.

Table 1.6

Detector unit	Measurement range exposure dose rate, $\mu R \cdot h^{-1}$	Maximum permissible basic relative error, %	Sensitivity, s^{-1} per 1 $\mu R \cdot h^{-1}$	Anisotropy, %	Energy threshold of gamma radiation detection, keV
BDKG-96	5 to $2 \cdot 10^4$	±30	2.0 ±0.4	±45	100
Notes 1 Maximum permissible basic relative errors are normalized values for sources with radionuclide ^{137}Cs. 2 Anisotropy of the detector unit BDKG-96 with reference to radionuclide ^{137}Cs is shown in the Appendix A.					

1.2.3.6 Dosimeters/radiometers with detector unit BDKG-96 provide measurement gamma photons flux in the range from 20 to 80000 photon·s^{-1} (sensitivity (0.5 ±0.15) s^{-1} per 1 photon·s^{-1}).

1.2.3.7 Maximum permissible basic relative error of gamma photons flux measurements …….…… ±30 %.

1.2.4 Basic metrological characteristics of dosimeters/radiometers for measurements of neutron radiation

1.2.4.1 Basic metrological characteristics of dosimeters/radiometers for measurements of neutron radiation are shown in Tables 1.7, 1.8.

Table 1.7

Detector unit	Measurement range ADE	Measurement range ADER	Limits of permissible basic relative error, %
BDMN-96	from 0.1 μSv to 1.0 Sv	from 0.1 μSv·h^{-1} to 0.1 Sv·h^{-1}	±(25+6/A_x), where A_x – dimensionless quantity that is numerically equal to the measured value of ADER in μSv·h^{-1} or ADE in μSv
BDKN-96	from 0.1 μSv to 1.0 Sv	from 0.1 μSv·h^{-1} to 0.1 Sv·h^{-1}	±(25+5/A_x), where A_x – dimensionless quantity that is numerically equal to the measured value of ADER in μSv·h^{-1} or ADE in μSv
Note - ADE and ADER measurement ranges, limits of basic relative error for neutron radiation measurements by dosimeters/radiometers with detector unit BDKN-96 are normalized for Pu-α-Be source.			

Table 1.8

Detector unit	Energy range of detected radiation	Energy dependence, %	Anisotropy, %
BDMN-96	from 0.025 eV to 10.0 MeV	±40	±30
BDKN-96	from 0.025 eV to 14.0 MeV	±40	±30
Note – The energy dependence of detector units BDMN-96, BDKN-96 is normalized for typical neutron spectra with reference to Pu-α-Be source.			

1.2.4.2 Dosimeters/radiometers with detector unit BDKN-96 provide measurement of flux density of neutrons from Pu-α-Be source in the range ……. 1 to 10^4 s^{-1}·cm^{-2}.

1.2.4.3 Maximum permissible basic relative error of Pu-α-Be source neutrons flux density measurements using dosimeters/radiometers with detector unit BDKN-96 …… ±(25 +5/A_x) %, where A_x – dimensionless quantity that is numerically equal to the measured value of flux density of neutrons in s^{-1}·cm^{-2}.

1.2.4.4 Dosimeters/radiometers with detector unit BDKN-96 are resistant to background gamma radiation with ADER up to 1.0 Sv·h^{-1}.

Limits of complementary error of ADER of neutron radiation measurements under conditions of background gamma radiation with ADER up to 1.0 Sv·h^{-1} relative to measurement results obtained at ADER of neutron radiation 1.0 mSv·h^{-1} ……..…… ±10 %.

1.2.5 Basic technical characteristics of dosimeters/radiometers

1.2.5.1 Warm-up time of dosimeters/radiometers with detector units of any type, except BDKS-96, is not more than ……..…… 1 min.

Warm-up time of dosimeters/radiometers with detector unit BDKS-96 ……15 min.

1.2.5.2 Continuous operation time of dosimeters/radiometers from a fully charged (fresh) batteries in normal conditions, depending on the type of control unit and the type of connected detector unit is shown in the Table 1.9.

Table 1.9 – Continuous operation time of dosimeters/radiometers

Type of detector unit	Continuous operation time, h			
	DKS-96-05 (UIK-05)	DKS-96-05-01 (UIK-05-01)	DKS-96-06 (UIK-06)	DKS-96-07 (UIK-07)
BDZA-96, BDZA-96b, BDZA-96s, BDZA-96m, BDZA-96t, BDZB-96, BDZB-96b, BDZB-99, BDZB-96s, BDPG-96, BDPG-96m, BDVG-96, BDMN-96	150.0	100.0	40.0	At least 2 hours when powered from built-in batteries in the absence of external power supply. Unlimited when powered from an external source.
BDKG-96, BDPS-96	120.0	80.0	30.0	
BDMG-96	200.0	140.0	50.0	
BDKS-96, BDKS-96b	50.0	35.0	10.0	
BDKS-96s	300.0	210.0	75.0	
BDKN-96	70.0	50.0	20.0	

1.2.5.3 Instability of dosimeters/radiometers readings during 10 hours of continous operation relative to the average value of readings during this interval does not exceed ……. ±10 %.

1.2.5.4 Power supply of dosimeters/radiometers is provided as follows:

- control unit UIK-05 with power module PNN-02-02: four C (R14) type cells with total nominal voltage ..... 6.0 V;
- control unit UIK-05-01 with power module PNN-02-03: four batteries of AA type with capacity not less than 2100 mA·h and total nominal voltage ..... 6.0 V;
- control unit UIK-06: three batteries of AA type with capacity not less than 1000 mA·h s and nominal voltage ..... 4.5 V;
- control unit UIK-07:
  1) mains power adapter BPS-06 with voltage ..... 9 – 12 V;
  2) DC source with nominal voltage ..... 24 V;
  3) four built-in batteries of AA type with capacity 2100 mA·h with nominal voltage 6 V - backup emergency power supply.

Note – Power supply from built-in batteries shall not be used as substitute of usual power supply, it supports operation of UIK-07 unit for not more than 2 hours.

1.2.5.5 Dosimeters/radiometers are resistant to changes in supply voltage:

- control units UIK-05, UIK-05-01 ..... +6.0 to +3.9 V;
- control unit UIK-06 ..... +4.5 to +2.9 V;
- control unit UIK-07 when powered by an external DC source ..... +9.0 to +36.0 V.

Limits of complementary measurement errors for all measurands due to supply voltage deviation from the nominal value ..... ±5 %.

1.2.5.6 Current consumed by dosimeter/radiometer DKS-96-07 from an external DC source with nominal voltage is not more than ..... 10 mA.

Power consumption of dosimeter/radiometer DKS-96-07 when powered from AC mains 220 V, 50 Hz, not more than ..... 20 VA.

1.2.5.7 Charging of batteries of UIK-05-01 and UIK-06 units is provided using charger ZU-02S/ZU-06S.

1.2.5.7.1 The built-in batteries of control unit UIK-07 are charged automatically when the unit is connected to power source.

1.2.5.7.2 Power supply of charger ZU-02S, power adapter BPS-06 and signalling device OSS-01 is provided from single-phase AC with voltage 220^{+22}_{-33} V and frequency $50^{+2,5}_{-2,5}$ Hz.

1.2.5.7.3 Power supply of charger ZU-06S is provided from the vehicle electrical system with voltage ..... 12 V or 24 V.

1.2.5.8 During operation dosimeters/radiometers automatically record measurements results in non-volatile memory.

The memory is capable to store information about 2000 measurement results and allows viewing of data on the display or transmission of data to personal computer using the "TETRA_Reporter" software (if this software is included in the purchase contract).

1.2.5.9 Alarm thresholds can be set by operator separately for each modification of the dosimeter/radiometer, each measuring channel and each measurement subrange.

1.2.5.10 Dosimeters/radiometers provide an audible alarm on exceeding the preset alarm threshold, audible signals accompanying pulses generated by ionizing particles or photons in the detector, and an audible signal after completion of the measuring process.

Dosimeters/radiometers DKS-96-07 generate light and audible signals when any of the alarm thresholds is exceeded and control signals for general purpose signalling device OSS-01.

1.2.5.11 The algorithm of dosimeters/radiometers performs the following functions:

- automatic identification of connected detector unit and displaying of the type of detector and corresponding measurement unit;
- automatic subtraction (compensation) of intrinsic or external background from the measurement result, only for detector units that can measure and compensate the background;
- automatic monitoring of supply voltage and display of current supply voltage: a fully charged battery is depicted as  , while a fully discharged battery as  ;
- automatic monitoring of supply voltage drop down to 3.9 V for UIK-05/UIK-05-01; 2.9 V - for UIK-06, 3.9 V for UIK-07; when this voltage drops to the above values the display will indicate a warning "Battery discharged" or generate a series of three beeps and then the dosimeter/radiometer turns off;
- automatic maintaining of current date and time starting from installation of batteries or cells into the control unit and until their removal or disconnecting of power supply module PNN-02-02/PNN-02-03 from the unit; when the control unit is turned on after replacing the batteries or cells or after power failure the unit asks the operator to input current date and time;
- automatic display of current date and time.
- auto-saving of measurements results in the archive if "Autosave" mode was selected or in manual mode.

1.2.5.12 Dosimeters/radiometers may be used as monitoring points in the automated radiation monitoring system supporting data transmission protocol DiBUS.

1.2.5.13 Dosimeters/radiometers may be used for radiation survey of the land territory with georeferencing in conjunction with the global positioning system (GPS) sensor.

For receiving information from GPS sensor RS-232 interface and software protocol NMEA 0183 (version 2.0) are used.

Note – For operating conditions of GPS sensors refer to the documentation supplied by the manufacturer.

1.2.5.14 Operating conditions of techical components of dosimeters/radiometers:

1) detector units of all types, control units of all types, interface device US-96, signalling device OSS-01, charger ZU-06S, unit BPS-06:

- temperature range:
  measurements with indication of results on the display ..... from minus 20 to +50 °C,
  measurements without indication of results on the display ..... from minus 40 to +50 °C,
- relative humidity limit ..... 98 % at +35 °C,
- atmospheric pressure ..... 84.0 to 106.7 kPa,
- content of corrosive agents in ambient air, atmosphere types ..... I, II, III;

2) interface converter PI-02 of charger ZU-02S:

- temperature range ..... 0 to +50 °C,

- relative humidity limit ..... 95 % at +35 °C, and lower temperatures without condensation,
- atmospheric pressure in the range ..... 84.0 to 106.7 kPa,
- content of corrosive agents in ambient air, atmosphere types .....I, II.

1.2.5.15 Limits of complementary measurement errors for all measurands:

- due to deviation of ambient air temperature from normal conditions, per each 10 °C – ±10 %;
- due to increasing of the ambient air humidity up to 98 % at +35 °C ..... ±10 %.

1.2.5.16 Dosimeters/radiometers are resistant to sinusoidal vibrations in the frequency range from 10 to 50 Hz with displacement amplitude 0.35 mm.

1.2.5.17 Dosimeters/radiometers DKS-96-05, DKS-96-05-01, DKS-96-06 are shockproof and withstand falling from height not more than 750 mm.

1.2.5.18 In terms of earthquake resistance dosimeters/radiometers DKS-96-07 are classified as category II devices according to Russian rules NP-031-01 "Design code for earthquake-resistant nuclear power plants" and meets the requirements of Russian regulations RD-25-818 "General requirements and testing procedures of the seismic stability of instruments and automation equipment supplied for the nuclear power plants": group A according to place of installation; version 2 according to functional purpose, for seismic load of up to 7 points by MSK-64 scale at the level from 70 m to 30 m relative to zero level.

After seismic impact with the above parameters dosimeter/radiometer DKS-96-07 meets the requirements of sections 1.2.1.1, 1.2.2.1, 1.2.3.1, 1.2.3.4, 1.2.3.7, 1.2.4.1, 1.2.4.3 during the entire service life under specified operating conditions.

1.2.5.19 The degree of protection provided by unit shells, against penetration of solid objects and water:

- interface converter PI-02 ……..…..…. IP30;
- charger ZU-02S, power adapter BPS-06 ……..…..…. IP40;
- control units UIK-05, UIK-05-01, UIK-06, units BDZA-96, BDZA-96b, BDZA-96m, BDZA-96s, BDZA-96t, BDZB-96, BDZB-96b, BDZB-96s, BDZB-99, BDKS-96s, BDPS-96, charger ZU-06S ……..…..... IP54;
- detector units BDVG-96, BDKS-96, BDKS-96b, BDMG-96, BDMN-96, BDPG-96, BDPG-96m, BDKN-96, control unit UIK-07, signalling device OSS-01, device US-96 ..…….… IP65;
- unit BDKG-96 ……..…….....…… IP68.

1.2.5.20 In term of importance for safety, dosimeters/radiometers are classified as normal operation elements, safety class 4N (classification as per the Russian standard OPB-88/97).

1.2.5.21 Dosimeters/radiometers are resistant to electromagnetic disturbances in compliance with IEC 1000-4-8-93, IEC 1000-4-9-93, IEC 61000-4-2-95, IEC 61000-4-3:2006, IEC 61000-4-4:2004, IEC 61000-4-5-95, IEC 61000-4-6-96, IEC 61000-4-11:2004, IEC 61000-4-12-95, IEC 61000-4-13:2002, IEC 61000-4-14-99 and IEC 61000-4-28-99 and conform to electromagnetic compatibility standards set by IEC 61000-3-2:2005, IEC 61000-3-3:2008, CISPR 22:2006 for Class A equipment.

Electromagnetic interference does not change the dosimeters/radiometers readings by more than ±10 %.

1.2.5.22 Dosimeters/radiometers with detector units BDVG-96, BDKG-96, BDKS-96, BDKS-96b, BDMG-96, BDPG-96, BDPG-96m in ADER/ADE of gamma radiation measurement mode or with detector unit BDKG-96 in EDR of gamma radiation measurement mode are resistant to background radiation of fast neutrons with energy up to 10 MeV and ADER numerically equal to the value of ADER/EDR of measured gamma radiation.

Limits of complementary measurement error due to exposure to background fast neutrons ±10 %.

1.2.5.23 Dosimeters/radiometers with detector units BDVG-96, BDKG-96, BDKS-96, BDKS-96b, BDMG-96, BDPG-96 in ADER/ADE of gamma radiation measurement mode or with detector unit BDKG-96 in EDR of gamma radiation measurement mode are resistant to background beta radiation from the $^{90}Sr+^{90}Y$ source with ADER numerically equal to the value of ADER/EDR of measured gamma radiation.

Limits of complementary measurement error due to exposure to background beta radiation ……..…….……..…… ±10 %.

1.2.5.24 Dosimeters/radiometers maintain operability after a short, less than 5 minutes, controlled exposure to ionizing radiation with the level 10-fold higher than the upper limit of measurement range.

After overload, dosimeters/radiometers maintain operability and are capable to work withing specified limits of basic relative measurement error.

1.2.5.25 Dosimeters/radiometers are protected against electric shock in compliance with IEC 61010-1:2001.

1.2.5.26 Dosimeters/radiometers are fire-safe devices with fire probability of causing fire not more than 10^{-6} $year^{-1}$.

1.2.5.27 Dosimeters/radiometers are resistant to exposure to 5 % citric acid solution in rectified ethyl alcohol.

1.2.5.28 Dimensions and weight of techical components of dosimeters/radiometers are listed in Table 1.10.

Table 1.10

Component	Dimensions, mm	Weight, kg
Control unit UIK-05	210×100×85	0.9
Control unit UIK-06	165×80×50	0.4
Control unit UIK-07	160×133×85	1.5
Detector unit BDZA-96	Ø130×240	0.9
Detector unit BDZA-96b	Ø230×290	4.0
Detector unit BDZA-96m	Ø65×240	0.9
Detector unit BDZA-96s	Ø90×240	1.0
Detector unit BDZA-96t	Ø50×60	0.15
Detector unit BDZB-96	Ø90×230	0.9
Detector unit BDZB-96b	150×200×110	1.5
Detector unit BDZB-96s	Ø65×65	0.3
Detector unit BDZB-99	Ø88×80	0.4
Detector unit BDPS-96	Ø88×280	1.2
Detector unit BDKS-96	Ø72×265	1.8
Detector unit BDKS-96b	Ø60×250	0.85
Detector unit BDKS-96s	Ø80×80	0.35
Detector unit BDMG-96	Ø40×250	0.5
Detector unit BDPG-96	50×190×480	1.0
Detector unit BDPG-96m	Ø35×320	0.5
Detector unit BDVG-96	Ø88×400	2.0
Detector unit BDKG-96	Ø38×535	3.6
Detector unit BDKN-96	295×142×100	2.25
Detector unit BDMN-96	Ø54×200	0.8
Spherical moderator	Ø245	7.3
Interface device US-96: interface assembly US-96-1, US-96-2	45×50×65	0.3
Signalling device OSS-01	77×77×387	2.8
AC mains adapter BPS-06	52×82×1000	0.3
Charger ZU-02S	80×80×50	0.3
Charger ZU-06S	Vehicle charger	0.1
Extension pole	Ø34×860	0.1
Pole for detector unit	Ø74×1600	0.3
Pole for detector unit	Ø74×3800	0.5

1.2.5.29 Mean time before failure ……..…….…… not less than 10 000 hours.
1.2.5.30 Mean life time ……..……..…….…. not less than 10 years.

1.3 Configuration

1.3.1 Dosimeter/radiometer represents an instrument that consists of control unit and includes one of the following detector units:

- **detector unit BDZA-96** (basic version) with light protective screen for measurements of alpha particle flux density;
- **detector unit BDZA-96b** (large) with light protective screen for measurements of alpha particle flux density;
- **detector unit BDZA-96s** (medium) with light protective screen for measurements of alpha particle flux density;
- **detector unit BDZA-96m** (small) with light protective screen for measurements of alpha particle flux density;
- **detector unit BDZA-96t** (solid state) with light protective screen for measurements of alpha particle flux density;
- **detector unit BDZB-96** (basic version) with light protective screen for measurements of beta particle flux density;
- **detector unit BDZB-96b** (large) for measurements of beta particle flux density;
- **detector unit BDZB-99** (GM counter) for measurements of beta particle flux density;
- **detector unit BDZB-96s** (medium) for measurements of beta particle flux density;
- **detector unit BDPS-96** with light protective screen for measurements of flux density of alpha- and beta-particles;
- **detector unit BDKS-96** for measurements of ambient dose equivalent and ambient dose equivalent rate of continuous and pulsed X-ray and gamma radiation;
- **detector unit BDKS-96b** for measurements of ambient dose equivalent and ambient dose equivalent rate of continuous and pulsed X-ray and gamma radiation;
- **detector unit BDKS-96s** for measurements of ambient dose equivalent and ambient dose equivalent rate of continuous X-ray and gamma radiation, beta particle flux density;
- **detector unit BDMG-96** for measurements of ambient dose equivalent and ambient dose equivalent rate of continuous X-ray and gamma radiation;
- **detector unit BDVG-96** (high sensitivity) for measurements of ambient dose equivalent rate of continuous X-ray and gamma radiation and gamma photon flux density;
- **detector unit BDPG-96** (survey) for measurements of ambient dose equivalent rate of continuous X-ray and gamma radiation and gamma photon flux density;
- **detector unit BDPG-96m** (survey small) for measurements of ambient dose equivalent rate of continuous X-ray and gamma radiation and gamma photon flux density;
- **detector unit BDKG-96** (logging) for measurements of exposure dose rate of gamma radiation and gamma photons flux;
- **detector unit BDMN-96** with spherical moderator for measurements of ambient dose equivalent and ambient dose equivalent rate of neutron radiation;
- **detector unit BDKN-96** with cylindrical polyethylene moderator for measurements of ambient dose equivalent, ambient dose equivalent rate of neutron radiation and flux density of neutrons.

Note - Letter designations of detector units contain information about the type of the detected radiation (the last letter in the unit name) and/or about the design features of the unit (capital letter after "96" in the unit name).

Detector units, except detector unit BDKG-96, are supplied with connecting cable with length 1.5 m.

Detector unit BDKG-96 is supplied with connecting cable with length 10 m and matching device. Customer can order connecting cable with length from 5 m to 1000 m supplied with matching device.

The number of detector units included in the delivery set, not more than one unit of each type, shall be determined by the consumer based on measurement tasks.

1.3.2 Dosimeters/radiometers can be equipped with the following control units:

- portable control unit UIK-05 with electric cell power supply module PNN-02-02;
- portable control unit UIK-05-01 with battery power supply module PNN-02-03;
- portable control unit UIK-06;
- stationary control unit UIK-07.

1.3.3 According to customer's order the delivery set may include:

- connecting cable with length 4 m (except detector units BDKS-96 and BDKS-96b);
- connecting cable with length up to 20 m (except detector units BDKS-96 and BDKS-96b);
- connecting cable with length from 20 to 500 m;
- interface device US-96 if the delivery includes connecting cable 20 to 500 m;
- cable-adapter PI-03 for connecting control units UIK-05/UIK-05-01/UIK-06 to PC;
- extension poles of various length, belts to hang the unit on operator's neck, wrist cuff for operator comfort;
- interface converter PI-02 for connecting of control unit UIK-07 to PC;
- communication cable "UIK-07-Atlant" for connecting of control unit UIK-07 to PI-02;
- AC mains adapter BPS-06 to supply power to UIK-07 from AC mains 220 V, 50 Hz;
- charger ZU-02S for charging batteries in the power module PNN-02-03 of the UIK-05-01 unit and in the UIK-06 unit;
- vehicle charger ZU-06S for charging batteries in the power module PNN-02-03 of the UIK-05-01 unit and in the UIK-06 unit;
- signalling device OSS-01 generating light and audible signals when connected to UIK-07;
- global positioning system sensor - for conducting geo-referenced radiation surveys;
- service software "TETRA_Checker" intended for output of measurement data to PC;
- service software "TETRA_Reporter" intended for reading data from the control unit's archive and generating reports based on these data in selected format (RTF, HTML, TXT), the software can also be used to delete measurement information from archive.

1.4 Design and operation of the dosimeter/radiometer

1.4.1 In the design of detector units well-known methods were used as for converting the energy of ionizing radiation into analog and digital electrical signals,as well as common circuit designs of power supply, amplification and discrimination units, etc. The detectors used are scintillators, gas-discharge counters or semiconductor detectors. Measurement data are processed using formula

$$P = K \cdot \frac{N}{1 - NM} \qquad (1.1)$$

where P – readings of the dosimeter/radiometer in appropriate units depending on the measurand;

$K = 1/\eta$ – conversion factor;

η – sensitivity factor of the detector unit;

N – pulse rate, s^{-1};

M – "dead time", s.

Matching of metrological parameters of the dosimeter/radiometer to the values specified in section 1.2 is ensured by determination and storing of sensitivity coefficients and dead time specific for each of the detector units in non-volatile memory of control unit during calibration. If the detector unit has two subranges (Low and High) or two measurement channels (gamma and beta), then the values of sensitivity factors and "dead time" is determined separately for each subrange/channel and each measured physical quantity (dose rate, flux density, count rate…).

1.4.2 Software of the dosimeter/radiometer is stored to processor's ROM, unauthorized modification is not possible (14-digit password protection). The mechanisms of protection of the flash memory data (sensitivity factors and constants) during read/write/erase operations and of separate information area in the flash memory which contain device ID and software versions are implemented by the manufacturer of control unit's processor (Renesas company).

1.4.3 The software of the dosimeter/radiometer implements three algorithms of continuous measurements of physical quantities characterizing ionizing radiation to be detected:

- "Fixed time";
- "Fixed tolerance";
- "Tracking".

1.4.3.1 Algorithm "Fixed time" provides a measurement resultequal to the current average value within given interval. The range of available intervals (measurement time) is 3 to 9999 seconds. Algorithm "Fixed time" starts automatically after turning on the dosimeter/radiometer; by default the "Measurement" time is set to values shown in Table 1.12.

1.4.3.2 Algorithm "Fixed tolerance" provides a measurement result with default value of uncertainty equal to 6 %. The uncertainty u (in percents) is calculated as follows:

$$u = \frac{2}{\sqrt{N}} \cdot 100 \qquad (1.2)$$

where N is the number counts detected at this point.

The measurement process is completed after the detection of such number of counts (1111), which provides an acceptable level of statistical error (uncertainty) or after expiration of user preset interval (measurement time), in case during this interval the required number of counts is not detected. If the interval is set to zero, then it is not limited in time.

The operator can stop the output of current measurement results at any time by pressing the button ⬇, without interrupting the measurement process. The output of measurement information resumes after pressing the button ⬇ again.

1.4.3.3 Algorithm "Tracking" provides a measurement result equal to the arithmetic mean calculated by the moving average method based on N measurement results with one second interval each. The number of measurements N is determined by averaging period during which the control unit detects the number of counts determined by the algorithm. The duration of averaging period depends only on the dynamics of radiation environment and in the absence of significant changes may reach 200 seconds. If the number of counts detected in the averaging period differ from that in the previous period by more than three sigma (standard deviations), than the measurement process automatically restarts and readings are updated. When calculating the updated readings, previous measurement result is not taken into account; that provides rapid response to changes in radiation environment. It is recommended to use this algorithm only with detector units BDPG-96, BDPG-96m or BDVG-96.

1.4.3.4 All algorithms of the dosimeter/radiometer has "Autosave" function which is used to automatically save measurements results in the archive which can be enabled or disabled.

Function "Stop after N meas" provides the possibility to perform a series of N measurements and save measurement results in memory.

Parameters of algorithms and "Autosave" and "Stop after N meas" functions can be selected in "Settings" mode under "Algorithm" menu item. Algorithms and "Settings" mode of the dosimeter/radiometer are described in section 3.5; regarding "Measurement" mode – in section 3.3.1.

1.4.4 Dosimeter/radiometer operates in two modes:

- "Measurement" (main mode);
- "Settings" (auxiliary mode).

To start any of the above modes, the dosimeter/radiometer must be turned off. Modes are started as follows:

- pressing ⓘ turns on the control unit in "Measurement" mode;
- pressing ⓘ after pressing and holding ▶ turns on the control unit in "Settings" mode.

In each mode measured values can be viewed in information windows described in sections 3.4 and 3.5.

1.4.5 Dosimeter/radiometer is delivered with default settings:

- mode and allowed windows for the mode used are listed in Table 1.11;
- measurement unit: the main unit for this detector unit type as per Table 1.12;
- measurement algorithm: "Fixed time";
- measurement time: as per Table 1.12; for each detector unit the corresponding preset time ensures that the measurement uncertainty is below 50 % at the lower limit of measurement range;
- alarm thresholds: zero;
- dynamic scale: OFF;
- work with archive of measurement results: not supported;
- autosave mode: disabled;
- parameter "N" of the "Stop after N meas." function: zero.

1.4.6 Default settings of the control unit allow measurements with optimal parameters. Types of detector units that provide the possibility of background radiation compensation are listed in Table 1.11.

Table 1.11

Type of detector unit	Background measurement	Background measurement time, s	Windows available in "Measurement" mode	Windows available in "Settings" mode
BDZA-96	+	60	"Primary measurement"	"Threshold", "Archive"
BDZA-96b	+	30	"Primary measurement"	
BDZA-96m	+	100	"Primary measurement"	
BDZA-96s	+	100	"Primary measurement"	
BDZA-96t	-	-	"Primary measurement"	
BDZB-96	+	30	"Primary measurement"	
BDZB-96b	+	30	"Primary measurement"	
BDZB-96s	+	30	"Primary measurement"	
BDZB-99	+	30	"Primary measurement"	
BDPS-96	+	100 α 30 β	"Primary measurement"; "Secondary measurement"	
BDMN-96	-	-	"Primary measurement"; "Dose"	
BDKN-96	-	-	"Primary measurement"; "Dose"	-
BDKS-96	+	30	"Primary measurement"; "Dose"	"Search", "Threshold", "Archive"
BDKS-96b	-	-	"Primary measurement"; "Dose"	
BDKS-96s	-	-	"Primary measurement"; "Dose"; "Secondary measurement"	
BDMG-96	-	-	"Primary measurement"; "Dose"	
BDPG-96	-	-	"Primary measurement"; "Detection"	
BDPG-96m	-	-	"Primary measurement"; "Detection"	
BDVG-96	-	-	"Primary measurement"; "Detection"	
BDKG-96	-	-	"Primary measurement"	

Typical values of sensitivity factors and "dead times" determined during manufacturing of the dosimeter/radiometer are listed in Table 1.12.

Table 1.12

Type of detector unit	Basic unit	Additional unit	Sensitiv. factor	"Dead time", μs	Algorithm	Meas. time, s	Note
BDZA-96	$min^{-1}·cm^{-2}$	-	2.20e-0	005.0	Fixed time	20	*
BDZA-96b	$min^{-1}·cm^{-2}$	-	5.00e-1	005.0		10	*
BDZA-96m	$min^{-1}·cm^{-2}$	-	1.50e+1	002.0		30	*
BDZA-96s	$min^{-1}·cm^{-2}$	-	5.0e-0	015.0		40	*
BDZA-96t	$min^{-1}·cm^{-2}$	-	2.50e-0	010.0		20	*
BDZB-96	$min^{-1}·cm^{-2}$	-	8.00e-0	002.0		10	*
BDZB-96b	$min^{-1}·cm^{-2}$	-	1.60e-0	055.0		10	*
BDZB-96s	$min^{-1}·cm^{-2}$	-	9.00-0	105.0		10	*
BDZB-99	$min^{-1}·cm^{-2}$	-	4.00e-0	110.0		10	*
BDPS-96 (alpha)	$min^{-1}·cm^{-2}$	-	5.0e-0	5.0		20	*
BDPS-96 (beta)	$min^{-1}·cm^{-2}$	-	7.0e-0	2.0		20	*
BDKS-96 (Low subr.)	Sv/h, Sv	-	1.00e-7	000.5		10	-
BDKS-96 (High subr.)	Sv/h, Sv	-	1.00e-5	000.5		10	-
BDKS-96b (Low subr.)	Sv/h, Sv		1.00e-7	001.0		10	-
BDKS-96b (High subr.)	Sv/h, Sv		2.00e-4	010.0		10	-
BDKS-96s-beta	$min^{-1}·cm^{-2}$	-	8.0e-0	100.0		20	-
BDKS-96s-gamma	Sv/h, Sv	-	2.00e-7	100.0		20	-
BDMG-96 (Low subr.)	Sv/h, Sv	-	2.00e-7	060.0		20	-
BDMG-96 (High subr.)	Sv/h, Sv	-	1.75e-4	040.0		20	-
BDPG-96	Sv/h	-	2.00e-9	002.5		10	-
	-	$s^{-1}·cm^{-2}$	1.50e-1	002.5		10	**
BDPG-96m	Sv/h	-	4.00e-9	005.0		10	-
	-	$s^{-1}·cm^{-2}$	0.30e-0	005.0		10	**
BDVG-96	Sv/h	-	4.00e-10	002.0		10	-
	-	$^{s-1}·cm^{-2}$	3.00e-2	002.0		10	**
BDKG-96	R/h	-	5.20e-7	015.0		10	-
	-	photon·s^{-1}	3.70e-0	015.0		10	**
BDMN-96	Sv/h, Sv	-	2.45e-6	023.0		20	-
BDKN-96	Sv/h, Sv	-	2.00e-7	025.0		20	-
	-	$s^{-1}·cm^{-2}$	1.56e-1	025.0			

* For detector units BDZA and BDZB the measurement unit "$Bq·cm^{-2}$" can be used after its selection in "Settings" mode and proper calibration of the dosimeter/radiometer.

** For detector units BDPG and BDVG the use of additional units is possible after their selection in "Settings" mode.

1.4.7 According to the results of subsequent calibrations of the dosimeter/radiometer equipped with supplied detector unit(s) the sensitivity factors and "dead times" can be corrected in the "Settings" mode.

1.5 Marking and sealing

1.5.1 The nameplate on the control unit contains the following information:

- trademark and name of the manufacturer (supplier);
- reference designation of the dosimeter/radiometer and control unit as per modification;
- works number according to the manufacturer's system of numeration;
- year of manufacture;
- approval mark of measurement instrument;
- ingress protection rating (IP).

1.5.2 The following markings are placed on the detector unit:

- trademark and name of the manufacturer (supplier);
- reference designation of the dosimeter/radiometer;
- reference designation of the detector unit;
- works number according to the manufacturer's system of numeration;
- year of manufacture;
- ingress protection rating (IP);
- made in Russia.

1.5.3 The location and method of fixing of the nameplate shall comply with the design documentation.

1.5.4 Components of dosimeters/radiometers are sealed in accordance with the design documentation.

1.6 Packing

1.6.1 Packing of dosimeters/radiometers shall comply with the design documentation and ensures protection against ingress of atmospheric precipitations and aerosols, splashes of water, dust, sand, solar ultra-violet radiation and also limits the ingress of water vapour and gases.

2 DESCRIPTION AND OPERATION OF DOSIMETER/RADIOMETER PARTS

2.1 General information

This section describes the structure and purpose of detector units, control units and devices of the dosimeter/radiometer.

2.2 Operation

2.2.1 Detector units

The dosimeter/radiometer set may include detector units of any type listed in section 1.3.1, but not more than one detector of each type. The reason is that the algorithm of dosimeter/radiometer automatically recognizes the type of connected detector unit and uses calibration factors stored in memory for detector units of particular type, but the units are not identified by their individual numbers (for example, by serial numbers).

Detectors used in the detector units and features of their design are listed in Table 2.1.

Table 2.1

Detector unit	Detector	Detector size and design	PMT type	Notes
BDZA-96	ZnS(Ag)	S = 70 cm^2	FEU-35-1	
BDZA-96b	ZnS(Ag)	S = 300 cm^2	FEU-139	
BDZA-96m	ZnS(Ag)	S = 10 cm^2	FEU-35-1	
BDZA-96s	ZnS(Ag)	S = 30 cm^2	FEU-35-1	
BDZA-96t	Semiconductor detector	S = 5 cm^2	-	
BDZB-96	Plastic scintillator	S = 28 cm^2	FEU-35-1	
BDZB-96b	Counters Beta-5×2 pcs	S = 80 cm^2	-	
BDZB-96s	Counter Beta-2	S = 15 cm^2	-	
BDZB-99	Counter SI-8B	S = 30 cm^2	-	
BDPS-96	Plastic scintillator + ZnS(Ag)	S = 28 cm^2	FEU-118	
BDKS-96	Tissue-equivalent plastic scintillator	Ø45×20 mm, light diaphragm with three fixed positions: "COMP", "mSv", "μSv"	FEU-118 (R980-A)	
BDKS-96b	Tissue-equivalent plastic scintillator	Ø30×15 mm	FEU R1294A	
BDKS-96s	Counters: Beta-2, Beta-2m	S = 15 cm^2	-	
BDMG-96	Counters: SBM-20×2 pcs, SI-34G×1 pcs	-	-	
BDPG-96	NaJ(Tl)	Ø25×40 mm	FEU-35-1	
BDPG-96m	NaJ(Tl)	Ø18×30 mm	FEU-67b	
BDVG-96	NaJ(Tl)	Ø63×63 mm	FEU-35-1	
BDKG-96	NaJ(Tl)	Ø18×30 mm	FEU-67B	Logging
BDKN-96	Proportional neutron counter	-	-	Placed inside moderator
BDMN-96	LiF with ^6Li content 85% + ZnS(Ag)	S = 5.0 cm^2	FEU-35-1	

Detector units for measurements of alpha- and beta-particles are equipped with protective plugs which are placed on the surface of detectors to provide full absorption of relevant particles when the background is measured and to protect the detector's window during transportation. Measurements of flux density of alpha- and beta-particles are carried out with protective plugs removed.

Detector units are connected to the control unit using connecting cable which is fixed in the back part of the detector unit, through the connector of RS7 type.

2.2.2 Control units

2.2.2.1 Control units UIK-05 and UIK-05-01 have a metal shockproof body to which power cell power supply module PNN-02-02 or battery power supply module PNN-02-03 is connected.

Connector for detector unit is located on the side of control units UIK-05 and UIK-05-01, the power supply module has jack connector for headphones or for charger (in case of battery power supply PNN-02-03).

The power supply module is connected to UIK-05/UIK-05-01 via connector (RS4TV type) and fixed by two screws.

The front panel of the control unit is equipped with graphic display and control buttons.

2.2.2.2 Control unit UIK-06 has a plastic shockproof body; batteries are located in the battery compartment on the rear side of the control unit body, under the cover.

The front panel of the control unit is equipped with graphic display and control buttons.

Portable control units are shown in Figure 2.1.

Control unit UIK-05/UIK-05-01

Control unit UIK-06

Figure 2.1 – Appearance of portable control units

2.2.2.3 Stationary control unit UIK-07 is intended to be mounted on a vertical or horizontal surface. This unit is functionally identical to units UIK-05, UIK-05-01 and UIK-06.

The front panel of the control unit is equipped with graphic display, control buttons, LED and acoustic radiator, which provide audible and light signals when the measurement result exceeds preset alarm threshold.

The four connectors on the side of the UIK-07 unit are the following:

- "BD" - for connection of detector unit;
- "LINE" - for connection of communication cable "UIK-07-Atlant" with information system or PC through interface converter PI-02 or equivalent;
- "9 – 36 V" - for connection of power adapter BPS-06 or another DC voltage source;
- "OSS" - for connection of signalling device OSS-01 if it is included in the delivery set.

The appearance of control unit UIK-07 is shown in Figure 2.2; overall and mounting dimensions are presented in Appendix C.

Figure 2.2 – Appearance of stationary control unit UIK-07

Power supply of UIK-07 unit when it is disconnected from external source is provided from built-in batteries. When power adapter BPS-06 or another power supply source is connected to the control unit, batteries are charged automatically and their charged condition is maintained. It takes approximately 12 hours to fully charge batteries.

2.2.2.4 All control units allow continuous monitoring of changes in the measured quantities by readings presented on the display and by sounds generated by the units in the process of radiation detection.

2.2.2.5 Description of the graphic display

The display can indicate letters, digits, signs and pictograms as shown in Figure 2.3.

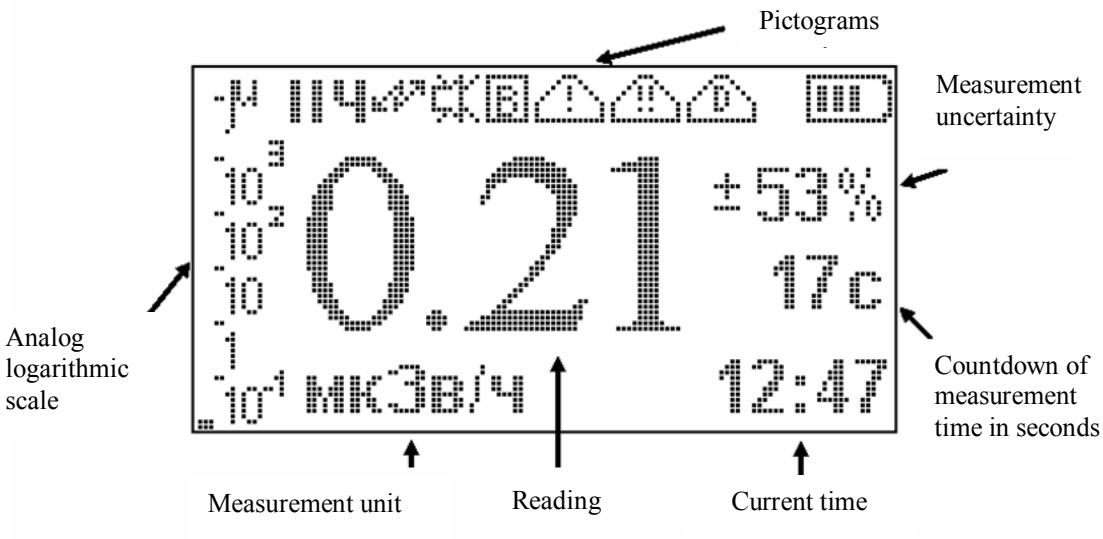


Figure 2.3

Pictograms are intended to indicate information about the dimension of measurement units, current events and modes of the dosimeter/radiometer:

- ► or ❚❚ - indicates the current state of the dosimeter/radiometer: measurement process or pause between the measuring cycles;
- **L** or **H** - indicates which Subrange is active: Low or High;
- **α** or **β** - indicates which type of radiation is measured by the detector unit BDPS-96;
- - indicates the presence of pulse disturbances; this is an advices to repeate measurement;
- - indicates that the sound is muted, if the sound is enabled, then in this place one of the following pictograms is displayed: ↑ or ↓, or ↕, indicating possible options to adjust the frequency of sound signals;
- B - indicates that measurement intrinsic and/or external background was not carried out (for detector units requiring such measurement for automatic background compensation); during background measurement this pictogram is blinking and after completion of such measurement it disappears;
- - indicates that current value of the main measurand exceeds the "Alarm" threshold;
- - indicates that current value of additional measurand measured by detector unit BDKS-96s (beta particle flux density) exceeds the "Beta" threshold;
- - indicates that the measured ADE exceeds the "Dose" threshold;
- - indicates charge condition of batteries or electric cell voltage.

2.2.2.6 Description of controls

The control unit has the following multifunction buttons:

ⓘ - button "ON";

▶ - button "SELECTION";

🕪 - button "SOUND";

☼ - button "LIGHT";

🡻/**II** - button "DOWN/PAUSE" (hereinafter – 🡻);

🡹/🗐 - button "UP/NEXT WINDOW" (hereinafter – 🡹).

In addition, combinations of button pressings start and cancel certain modes.

2.2.2.7 Hereinafter operator's actions with buttons are denoted as follows:

☼ (single button symbol) - **press the button for about 0.5 s**;

☼☼ (double button symbol) – **press and hold the button for about 1.5 s**;

🡹 🡹 (two identical symbols divided by space) – **successively press** this button twice;

🕪🡹 (two different symbols without space) - **simultaneous pressing**: press the second button while pressing and holding the first button);

▶🡻 🡻 (three symbols, with space between the second symbol and the third symbol) - **press and hold the first button then press the second button twice.**

Actions of the operator are accompanied by beeps or melody. Brief instructions for the operator for using the control unit is presented in Appendix D.

2.2.2.8 With factory settings, the following combunations of buttons can be used:

ⓘ - turn on, start measurement, cancel editing, go to the top-level menu (analog of Esc/Cancel on a computer keyboard);

☼🡹 - show help window;

ⓘⓘ - turn off;

☼ - turn on display backlight for 3 seconds / turn off display backlight;

☼☼ - turn on permanent backlight of display;

🕪 - turn the sound on/off;

🕪🕪 - set alarm thresholds for current measurement window;

🡻 - pause / resume measurement cycle;

🡻🡻 - set parameters of algorithm (for example, measurement time);

🕪🡹 - increase the frequency of audible signals;

🕪🡻 - decrease the frequency of audible signals;

▶▶ – enable background measurement mode when using detector units for which background measurements are possible for background compensation;

🡹 - switching between windows in which measurement results are displayed in operator selected modes;

▶🡹 - manual activation of "High" subrange for two-channel detector units BDMG-96, BDKS-96 and BDKS-96b;

▶🡻 - manual activation of "Low" subrange for two-channel detector units BDMG-96, BDKS-96 and BDKS-96b;

▶🡻 🡻 - enable automatic switching of subranges (for detector units BDKS-96b and BDMG-96 only).

Adjustment of numerical values (date, time, factors, alarm thresholds) is provided through the following actions: ▶ - move the cursor to the next character, 🡻 - decrement the digit above the cursor, 🡹 - increment the digit above the cursor.

2.2.2.9 Dosimeter/radiometer can be used as a measuring device for average count rate when in "Settings" mode the appropriate unit, s^{-1}, is selected in the "Coefficients" menu.

2.2.3 Chargers

Charger ZU-02S has a compact plastic housing combined with a standard AC mains plug. The two-wire cable with length 1 m ends with a plug. Operation mode of charger and test results are displayed by two-color LED:

- green – "Ready",
- red – "Charge",
- red and green – "Short circuit",
- blinking green – "Broken wire".

Color coding of modes is presented on the plate on the charger body as shown in Figure 2.4.

Charger ZU-02S

Charger ZU-06S

Figure 2.4 – The appearance of chargers

Charger ZU-06S designed to charge batteries from the vehicle electrical system. The algorithm of charger ZU-06S is the same as that of charger ZU-02S.

2.2.4 Interface device US-96

The interface device is designed for signal transmission from detector unit to control unit, if the length of the cable between the detector unit the control unit is in the range 20 to 500 m. The appearance of interface device is shown in Figure 2.5.

The device is manufactured in different modifications intended for relative detector unit types.

The device is comprised of interface module US-96-1 connected to the detector unit and interface module US-96-2N connected to the control unit (where N denotes modification index matching the index of the detector unit M, P, N, V and so on).

The device is powered with voltage 7 V from the control unit.

Figure 2.5 – The appearance of interface device US-96

2.2.5 Signalling device OSS-01

Signalling device provides audible and color-coded light signals depending on the monitored radiation environment when connected to the control unit UIK-07.

Power supply for signalling device is provided from AC mains 220 V, 50 Hz.

3 INTENDED USE

3.1 Operational limitations

3.1.1 Dosimeter/radiometer is a sophisticated complex electronic instrument. Before using it, the operator should read and understang this User Manual, design of the dosimeter/radiometer, the assignment of input and output connectors, and operation procedures.

The operator should strictly observe the requirements set forth in the documentation. Do not attempt to troubleshoot faults except as described in section 5. Address your inquiries for analysis of causes of faults and fixing them to the manufacturer.

3.1.2 Dosimeters/radiometers should be used only under operating conditions specified in section 1.2.

ATTENTION! MONOCRYSTALLINE DETECTORS USED IN DETECTOR UNITS BDVG-96, BDPG-96, BDPG-96m, BDKG-96 ARE SENSITIVE TO SHARP TEMPERATURE CHANGES AND CAN BE DAMAGED IF THE AMBIENT TEMPERATURE CHANGES WITH THE RATE MORE THAN 2 ºC/MIN.

3.1.3 The operator should observe safety measures of section 4.2 when using dosimeter/radiometer.

3.2 Preparation of the dosimeter/radiometer for use

3.2.1 Check that serial numbers on the control unit and detector units match numbers specified in the data sheet TE1.415313.003DS of the dosimeter/radiometer.

3.2.2 Inspect the control unit and detector units, connecting cable and accessories: extension poles, adapters, handles, case with "Filter Beta" for BDPS-96 unit, etc., for possible damages.

Remove protective caps and perfom visual check of the integrity of light barrier of detectors BDZA, BDZB-96 and BDZB-96b; replace light barrier in case of damage.

3.2.3 Install cells into power supply module PNN-02-02 or charge batteries of power supply module PNN-02-03 – for this purpose connect charger to power supply module PNN-02-03 of the control unit UIK-05 or to the control unit UIK-06 and then plug the charger to AC mains 220 V, 50 Hz. LED color will indicate the current operating mode of charger. When charging is complete, LED will change its color from red to green. Unplug the charger from AC mains and then disconnect it from the control unit.

3.2.4 Connect to the control unit UIK-07 external power source or AC mains adapter BPS-06, connect BPS-06 to AC mains 220 V, 50 Hz.

Connect signalling device OSS-01 (if included in the delivery set) to the control unit UIK-07 (connector "OSS" on the side of control unit).

3.3 Use of the dosimeter/radiometer

3.3.1 Turning on/off

3.3.1.1 Turn on the control unit by pressing ⓘ.

Set current date and time. This operation shall be performed every time when power supply module PNN-02-02 or PNN-02-03 is disconnected from the control unit or batteries are replaced.

The control unit UIK-07 is powered from the built-in battery when disconnected from main power supply; setting of date and time is needed only after switching the control unit for the first time.

Turn off the control unit by pressing ⓘⓘ.

3.3.1.2 Connect the selected detector unit to the control unit. Turn dosimeter/radiometer on by pressing ⓘ and make sure that the control unit correctly identified the detector unit (corresponding message will be displayed for about 2 seconds).

If the control unit is turned on when neither of detector units is connected to it, the message "BDZA-96 connected" is displayed.

3.3.1.3 If GPS sensor is connected and correctly identified along with detector unit, then the message "GPS sensor connected" is displayed for about 2 seconds.

3.3.1.4 After a warm-up time equal to 1 min for detector units of all types except BDKS-96, the dosimeter/radiometer is ready for operation; the warm-up time for detector unit BDKS-96 is 15 min.

3.3.1.5 By default preset by manufacturer, after turning on the dosimeter/radiometer automatically switches to "Measurement" mode, window – "Primary measurement", measurement algorithm – "Fixed time", algorithm parameter – measurement time (see Table 1.12). If during the previous use of the dosimeter/radiometer the operator entered "Settings" mode and selected windows and set parameters other than default ones, the dosimeter/radiometer stores them in nonvolatile memory and next time measurements will be carried out using these settings.

3.3.1.6 It is possible to select a different algorithm and adjust the corresponding parameter set "by default" as follows:

- press ⬇ ⬇ - algorithm selection window appears:

- press ⬇, move cursor → from one algorithm to another: "Fixed time", "Fixed tolerance", "Autosave", "Stop after N meas.", "Tracking" …;
- select optimal measurement algorithm by pressing ▶ when the cursor is next to this algorithm;

- press successively ⬇ or ⬆ and ▶, adjust parameter value, after adjustment of the last right digit press ▶;
- if necessary, set the number of measurement cycles that dosimeter/radiometer has to perfrom in automatic mode (when algorithm "Fixed time" or "Fixed tolerance" is set) sufficient to obtain acceptable statistics;
- press ⬇ until the cursor moves to the line "Stop after N meas";
- press successively ▶, ⬇ or ⬆ and ▶, adjust parameter value, after adjustment of the last right digit press ▶;
- press ⓘ to return to "Primary measurement" window.

3.3.1.7 If it is necessary to set the thresholds other than zero, follow this procedure:

- press 🔉 🔉 - alarm thresholds adjustment window appears:

- press ▶ when the cursor is next to threshold to be adjusted;
- press ⬇ to decrement or ⬆ to increment the digit; after all digits are changed as necessary press ▶, set the numerical value of threshold (threshold 25.0 $\mu Sv \cdot h^{-1}$ looks like "2.50e-05"), after adjustment of the last right digit press ▶.

3.3.1.8 Setting the "Alarm" threshold automatically enables the algorithm for comparing of the measured value with the threshold. When the measured value exceeds the threshold control units UIK-05, UIK-05-01 and UIK-06 generate audiovisual signal in the form of corresponding pictogram and audible signal and, in case of control unit UIK-07, color-coded signals when signalling device is connected.

If at the same time non-zero values are set for thresholds "Preliminary" and "Bottom" events of exceeding of "Preliminary" and falling below "Bottom" are recorded in the status register (DiBUS protocol, www.doza.ru). Information from the status register can be read using the "TETRA_Checker" software after connecting the control unit to PC.

3.3.1.9 Set the desired mode of backlight by pressing ☼ or ☼☼. Permanent backlight shortens leads to accelerated discharge of cells (batteries) in the control units UIK-05-01 and UIK-06.

3.3.1.10 Set the desired alarm signaling mode by pressing 🔊 .

3.3.2 Measuring the background level

3.3.2.1 The duration of intrinsic background measurement for different detector units is set by default as shown in the Table 1.11.

3.3.2.2 Subtraction of the background value from the total measured value is performed automatically, therefore, the measurement of background should be done before measurements and periodically during measurements, taking into account the changes of the environment and the possibility of external radioactive contamination of detector units.

The measured background value is not saved when the control unit is turned off.

3.3.2.3 Pictogram [B] in the information line of the display indicates the possibility and/or requirement to perform background measurement. This measurement is started by pressing ▶▶. The background measurement process begins with the display of message "Background measurement…". During the measurement the pictogram blinks. After the background measurement is complete, the pictogram disappears, the measurement result is shown on the display until the operator makes a decision how to use it:

- press ▶ to record the measurement result into memory for automatic background compensation and return to the primary measurement mode;
- press ⬇ to exit the background measurement mode and reject measurement result; the control unit will save previous background measurement result;
- press ⓘ to exit the background measurement mode and reject measurement result; the control unit will save zero background level;
- press ▶▶ to restart the background measurement.

3.4 Operation of the dosimeter/radiometer in "Measurement" mode

3.4.1 Using the control unit buttons in "Measurement" mode

3.4.1.1 General information about possible actions in "Measurement" mode:

ⓘ - enter the "Measurement" mode;

☼⬆ - call contextual help menu from current information window; the help menu describes all possible actions of the operator in this window;

☼ - turn on the display backlight for 3 seconds / turn off the display backlight;

☼☼ - turn on permanent backlight of display;

🔊 - turn the sound on/off; when the sound is muted, the pictogram 🔇 is displayed in the information line;

🔊⬆ - reduce 2-fold the frequency of audible signals accompanying the detection of particles or photons: the pictogram "↑" corresponds to the state when each detected particle or photon triggers one audible signal; the state when each audible signal is triggered only after detection of the maximum number (65535) of particles or photons is indicated by pictogram "↓"; all intermediate states are indicated by the pictogram "↕";

🔊⬇ - increase 2-fold the frequency of audible signals accompanying the detection of particles or photons (enable ½ multiplier);

▶ - record the measurement result, if the work in "Archive" window is allowed and start a new measurement – in the right part of the line with measurement result the serial number of the record in the archive is shown; if the work in "Archive" window is not allowed - start new measurement ("Measurement restarted" message will be displayed);

⬇ - pause / resume the measurement process - pause;

▶▶ - start background measurement, if pictogram B is shown in the information line, the measurement process will be accompanied by blinking pictogram B; upon completion of the background measurement the control unit will automatically switch to the measurement mode - pictogram B is not displayed;

⬇⬇ - select another measurement algorithm or adjust parameters of previously selected algorithm, return to "Measurement" mode - ⓘ;

🔊🔊 - adjust alarm thresholds, return to "Measurement" mode - ⓘ;

▶⬆ - switch to High subrange when using detector unit BDMG-96, BDKS-96 or BDKS-96b;

▶⬇ - switch to Low subrange when using detector unit BDMG-96, BDKS-96 or BDKS-96b;

▶⬇ ⬇ - enable automatic switching between subranges when using detector unit BDMG-96 or BDKS-96b; this mode is enabled by default when the control unit is turned on;

⬆ - switch to next operation and display mode corresponding to next window the display of which is allowed.

3.4.1.2 Actions performed for background measurement:

▶ - record the measured value of the background, enter the "Measurement" mode;

▶▶ - restart the background measurement;

ⓘ - exit the background measurement process and store zero background into memory;

⬆ or ⬇ - exit the background measurement process and store previous background measurement result into memory.

3.4.1.3 Actions performed when "Primary measurement" information window is active:

⬇⬇ - select measurement algorithm and adjust its parameters in accordance with 3.3.1.6 or perform setting-up in accordance with 3.5.6;

🔊🔊 - adjust alarm thresholds in the window "Primary measurement", steps to set alarm thresholds is described in 3.3.1.7 or perform setting-up in "Settings" mode as described in 3.5.5; setting of zero threshold disables automatic monitoring with reference to corresponding threshold.

3.4.1.4 Actions performed when "Dose" information window is active:

⬇ - turn on pause / resume displaying current dose measurement data; pause does not stop the process of measuring the dose, only updating of data on the control unit display is paused, pressing ⬇ once again resumes updating of data on the accumulated dose taking into account pause time;

🔉🔉 - adjust dose threshold;

ⓘ - restart dose measurement;

⬆ - move to the next information window.

3.4.1.5 Actions performed when "Secondary measurement" information window is active:

▶ - record the measurement result as described in 3.5.4.3 – the serial number of the record in the archive is shown on the right of the measured value; start new measurement;

ⓘ - start new measurement without recording the result of current measurement into archive (the control unit will display a message "Measurement restarted");

⬇ - pause – pause or resume displaying of current information about measurement process;

⬇⬇ - select another algorithm or adjust parameters of current algorithm;

🔉🔉 - adjust the threshold for additional measurand (threshold for beta);

⬆ - move to the next information window.

3.4.1.6 Actions performed when "Search" information window is active

The operator moves detector unit in different directions and visually (by readings on the display) and by audible signals determines the direction to the maximum radiation intensity. Then the operator moves in the direction of maximum intensity and in this way locates an object with increased radioactivity. If the intensity of the detected radiation becomes relatively high (the dynamic scale is overflowed, audible signals fade into a uniform stream) the operator can repeat the background measurement under the new conditions by pressing ▶.

3.4.1.7 Actions performed when "Threshold mode" information window is active:

▶▶ - start the background measurement;

▶ - start new measuring cycle;

🔉🔉 - adjust alarm thresholds values in the "Threshold mode" window (only possible during the pause between measurements);

⬆ - move to the next information window;

ⓘ - start new measuring cycle.

3.4.1.8 Actions performed when "Detection" information window is active:

▶ - start new measuring cycle;

⬆ - move to the next information window;

ⓘ - start new measuring cycle.

3.4.1.9 Actions performed when "Archive" information window is active:

▶ - next record;

▶▶ - dynamic scrolling forward;

☼ ▶ - 100 records forward;

⬇ - previous record;

⬇⬇ - dynamic scrolling backward;

☼ ⬇ - 100 records back;

🔉🔉 - move to "Service" menu;

⬆ - move to the next information window.

To access the "Service" menu from "Archive" window press 🔉🔉. The "Service" menu allows the following actions:

⬇ - move to the next menu item;

▶ - select menu item/subitem or character;

⬆ - increment digit of the edited character;

⬇ - decrement digit of the edited character;

ⓘ - move to "Archive" window.

3.4.2 Performing measurements in "Measurement" mode

3.4.2.1 Measurement of flux density of alpha- and beta-particles

1) measurement of flux density of alpha- and beta-particles by detector units BDZA and BDZB:

- turn the dosimeter/radiometer on by pressing ⓘ,
- position the unit with protective plug near the surface to be measured and perform background measurement by pressing ▶▶ (background measurement is not necessary when using the BDZA-96t detector unit),
- when the background measurement is complete, press ▶, the control unit will automatically switch to the "Primary measurement" window,
- remove the protective plug and position the detector unit near the surface to be measured,
- record the desired number of readings (see Table 1.12 for recommended measurement time);

2) measurement beta particle flux density by detector unit BDKS-96s:

- turn the dosimeter/radiometer on by pressing ⓘ,
- remove the transport cover from the detector unit BDKS-96s,
- move to "Secondary measurement" window by pressing ⬆, after that the unit "$\mu Sv \cdot h^{-1}$" displayed in the bottom line will change to "$min^{-1} \cdot cm^{-2}$",
- position the detector unit BDKS-96s near the surface to be measured,
- record the desired number of readings (see Table 1.12 for recommended measurement time);

3) measurement alpha particle flux density by detector unit BDPS-96:

- turn the dosimeter/radiometer on by pressing ⓘ,
- make sure that in the information line of the "Primary measurement" window **"α"** is displayed,
- replace the protective plug with "Beta filter";
- position the unit with "Beta filter" near the surface to be measured and perform background measurement by pressing ▶▶, save the measured value in memory by pressing ▶;
- remove "Beta filter" from the unit;
- position the unit near the surface to be measured and record the desired number of readings (see Table 1.12 for recommended measurement time);

4) measurement beta particle flux density by detector unit BDPS-96:

- turn the dosimeter/radiometer on by pressing ⓘ,
- move to window "Secondary measurement", by pressing ⬆, make sure that in the information line **"β"** is displayed,
- place the protective plug on the unit, position the detector unit near the surface to be measured and perform background measurement by pressing ▶▶, save the measured value in memory by pressing ▶,
- replace protective plug with "Beta filter";
- position the unit near the surface to be measured and record the desired number of readings (see Table 1.12 for recommended measurement time).

3.4.2.2 Measurement of ambient dose equivalent rate of X-ray and gamma radiation

1) measurement of ADER of X-ray and gamma radiation by detector unit BDKS-96:

- turn the dosimeter/radiometer on by pressing ⓘ,
- switch the light diaphragm to "COMP",
- make sure that in the information line "**L**" (Low subrange) is displayed,
- if pictogram "**H**" is displayed, select Low Subrange by pressing ▶⬇,
- perform intrinsic background measurement by pressing ▶▶,
- when the background measurement is complete, save measurement result of the control unit memory by pressing ▶; the control unit will automatically switch to "Primary measurement" window,
- switch the light diaphragm to "μSv" that corresponds to "Low" subrange from 0.1 $\mu Sv \cdot h^{-1}$ to 0.5 $mSv \cdot h^{-1}$ (make sure that pictogram "**L**" is shown in the information line),

- record the desired number of ADER readings,

- switch the light diaphragm to "mSv" that corresponds to “High” subrange from 0.5 $mSv \cdot h^{-1}$ to 1.0 $Sv \cdot h^{-1}$,

- switch the unit to High Subrange by pressing ▶⬆ (make sure that pictogram "**H**" is shown in the information line),

- record the desired number of ADER readings (see Table 1.12 for recommended measurement time);

2) measurement of ADER of X-ray and gamma radiation using BDKS-96b and BDMG-96 detector units:

- turn the dosimeter/radiometer on by pressing ⓘ,

- switch the unit to Low Subrange corresponding to ADER range from 0.1 $\mu Sv \cdot h^{-1}$ to 1.2 $mSv \cdot h^{-1}$ by pressing ▶⬇, on the display "Low Subrange" message will be shown for a short time, then pictogram "**L**" will appear in the information line,

- pressing ▶⬆ again will switch the dosimeter/radiometer to the automatic subrange switching mode: on the display "Automatic subrange switching" message will be shown for a short time, then pictogram "**L**" or "**H**" depending on the current values of ADER,

- record the desired number of ADER readings (see Table 1.12 for recommended measurement time),

- switch the unit to High Subrange corresponding to ADER range 1.0 $Sv \cdot h^{-1}$ to 0.8 $mSv \cdot h^{-1}$ for unit BDKS-96b or 0,8 $mSv \cdot h^{-1}$ to 10 $Sv \cdot h^{-1}$ for unit BDMG-96, by pressing ▶⬆; on the display "High subrange" message will be shown for a short time, then pictogram "**H**" will appear in the information line,

- record the desired number of ADER readings (see Table 1.12 for recommended measurement time);

3) measurement of ADER of X-ray and gamma radiation by detector unit BDKS-96s

- turn the dosimeter/radiometer on by pressing ⓘ,

- switch to gamma channel, if necessary, by pressing ⬆,

- make sure that in the information line of the "Primary measurement" window "γ" is displayed,

- record the desired number of ADER readings (see Table 1.12 for recommended measurement time);

4) measurement of ADER of X-ray and gamma radiation using BDVG-96, BDPG-96 and BDPG-96m detector units:

- turn the dosimeter/radiometer on by pressing ⓘ,

- record the desired number of readings (see Table 1.12 for recommended measurement time).

Taking into account significant energy dependence of detector units BDVG-96, BDPG-96 or BDPG-96m, with increased sensitivity in the energy range below 500 keV, it is incorrect to use the above units for measurements of ADER in the presence of radiation of specific radionuclides such as ^{241}Am, ^{57}Co, ^{133}Ba, etc. In this case conducting of relative measurements is possible in order to compare results and trending of ADER, to search and locate radiation sources as described in 3.4.2.9.

The dosimeter/radiometer is calibrated using gamma-radiation of ^{137}Cs so the result of ADER measurements are correct for this particular radionuclide or for the radiation which spectrum may be replaced by an effective radiation energy of ^{137}Cs, as well as the absence of certain man-made gamma-emitters. In practice, the range of natural background is in the range from 0.05 to 0.3 $\mu Sv \cdot h^{-1}$ and it is possible to measure it with permissible uncertainty by dosimeter/radiometer with units BDVG-96, BDPG-96 or BDPG-96m.

3.4.2.3 Measurement of ambient dose equivalent of X-ray and gamma radiation

Measurement of ADE of X-ray and gamma radiation by detector units BDKS-96, BDKS-96b, BDKS-96s or BDMG-96 is provided automatically from the moment when the dosimeter/radiometer is turned on. To view ADE values perform the following actions:

- press ⬆ to switch to "Dose" window; the displayed information about the current EDR value in "μSv/h"/"mSv/h" will be replaced by ED accumulated up to the moment in "μSv"/"mSv"/"Sv" and exposure time;
- press ⬇ (if necessary) to pause displaying the current dose, this will not interrupt the dose accumulation process;
- press ⓘ (if necessary) to reset the accumulated dose and restart the measurement process, the information about ADE accumulated until this action is erased and a new measuring cycle is started;
- press ⬆ to switch to "Primary measurement" window to view the current ADER value.

3.4.2.4 Measurement of gamma photon flux density

Measurement of gamma photon flux density using detector unit BDVG-96, BDPG-96 or BDPG-96m:

- turn the dosimeter/radiometer on in the "Settings" mode by pressing ▶▶ ⓘ;
- select "Units of measurement" item in the "Coefficients" menu, then select unit "$cm^{-2}·s^{-1}$" and switch to "Measurement" mode by pressing ⓘ ⓘ;
- record the desired number of readings (see Table 1.12 for recommended measurement time).

3.4.2.5 Measurement of exposure dose rate of gamma radiation

Measurement of EDR of gamma radiation by detector unit BDKG-96:

- turn the dosimeter/radiometer on by pressing ⓘ;
- record the desired number of readings (see Table 1.12 for recommended measurement time).

3.4.2.6 Measurement of gamma photons flux

Measurement of gamma photons flux by detector unit BDKG-96:

- turn the dosimeter/radiometer on in the "Settings" mode by pressing ▶▶ ⓘ;
- select "Units of measurement" item in the "Coefficients" menu, then select unit "s^{-1}" and switch to "Measurement" mode by pressing ⓘ ⓘ;
- press ⓘ to exit the "Settings" mode and switch to the "Measurement" mode, after that measurement unit "R/h" with the corresponding decimal prefix, which is displayed in the bottom line, will change to "s^{-1}";
- record the desired number of readings (see Table 1.12 for recommended measurement time).

3.4.2.7 Measurement of ADER and ADE of neutron radiation

1) measurement of ADER of neutron radiation detector unit BDMN-96 or BDKN-96:

- turn the dosimeter/radiometer on by pressing ⓘ,
- record the desired number of readings (see Table 1.12 for recommended measurement time),

Note - For the detector unit BDKN-96 in the menu "Coefficients" of the "Settings" mode the selected unit is neutrons/min·cm^2.

2) Measurement of ED of neutron radiation using detector unit BDMN-96 or BDKN-96

Measurement ED of neutron radiation using detector units BDMN-96 and BDKN-96 are carried out in accordance with 3.4.2.3.

3.4.2.8 Measurement of flux density of neutrons

Measurement of flux density of neutrons using detector unit BDKN-96:

- turn the dosimeter/radiometer on in the "Settings" mode by pressing ▶▶ ⓘ;
- select "Units of measurement" item in the "Coefficients" menu, then select unit "$cm^{-2}·s^{-1}$" and switch to "Measurement" mode by pressing ⓘ ⓘ;
- record the desired number of readings (see Table 1.12 for recommended measurement time).

3.4.2.9 Search and location of ionizing radiation sources

Search and location of ionizing radiation sources using detector units BDVG-96, BDPG-96 or BDPG-96m:

- turn the dosimeter/radiometer on by pressing ⓘ;
- press ⬆ to switch to "Detection" window;
- press ▶ to start background measurement, after a sufficient amount of information about the level of background is obtained, the control unit automatically switches to the mode of detection of abnormal point or distributed sources (contaminated areas);
- analyze the change in frequency of sound signals and the dynamics of change in the density of vertical segments on the time profile on the display while moving the detector unit along the surface to be surveyed;
- to assess the relative levels of radiation at the test point over the surface, use the count rate value displayed in the bottom line on the left;
- press ⬆ to switch to "Primary measurement" window in order to measure ADER in an area with an abnormal level of radiation.

3.5 Operation of the dosimeter/radiometer in "Settings" mode

3.5.1 Using the control unit buttons in "Settings" mode

ⓘ - turn on, start measurement, cancel editing, go to the top-level menu (analog of "ESC/CANCEL" on PC keyboard);

☼⬆ - show help window;

ⓘⓘ - turn off;

☼ - turn on display backlight for 3 seconds / turn off display backlight;

☼☼ - turn on permanent backlight of display;

🔊 - turn the sound on/off;

🔊🔊 - set alarm thresholds for current measurement window;

⬇ - pause / resume measurement cycle;

⬇⬇ - set parameters of algorithm (for example, measurement time);

🔊⬆ - increase the frequency of audible signals;

🔊⬇ - decrease the frequency of audible signals;

▶▶ - enable background measurement mode (only for detector units for which background measurements are possible for background compensation);

⬆ - switching between windows in which measurement results are displayed in operator selected modes;

▶⬆ - manual activation of "High" subrange for two-channel detector units BDMG-96, BDKS-96, BDKS-96b;

▶⬇ - manual activation of "Low" subrange for two-channel detector units BDMG-96, BDKS-96, BDKS-96b;

▶⬇ ⬇ - enable automatic switching of subranges (for detector units BDKS-96b and BDMG-96 only).

Adjustment of numerical values (date, time, factors, alarm thresholds) is provided through the following actions: ▶ - move the cursor to the next character, ⬇ - decrement the digit above the cursor, ⬆ - increment the digit above the cursor.

3.5.2 General information

3.5.2.1 For the implementation of basic functions of the dosimeter/radiometer the display is provided with information windows. Through these windows measurement results are presented for the operator, as well as additional visual and audible information about the dosimeter/radiometer current state and current measurement data.

3.5.2.2 To configure basic and advanced functions implemented in the "Measurement" mode of dosimeter/radiometer, such as date/time, audible signals, measurement units, measurement algorithms, image rotation on display by 90°, etc., "Settings" mode is used.

3.5.2.3 The number of information windows and the content of information presented is configured in the "Settings" mode for each type of detector units supplied with the dosimeter/radiometer.

3.5.3 Configuring basic and advanced functions of "Measurement" mode

3.5.3.1 For using the "Settings" menu perform the following steps:

- turn off the control unit by pressing ⓘⓘ (press and hold button ⓘ until you hear an audible signal and see a message):

- connect necessary detector unit to the control unit;
- turn the control unit on in "Settings" mode by pressing ▶▶ ⓘ (press and hold button ▶, then press button ⓘ): the "Settings" window will be displayed:

- make sure that the control unit correctly identified the type of connected detector unit (check the message that will appear for about 2 seconds).

3.5.3.2 The list of available menu items corresponds to the type of connected detector unit. When settings are to be changed, remember that changes apply only to detector unit connected (except the enabling of dynamic scale indication as described in 3.5.4.8), settings for other types of detector units remain unchanged.

The configuration of menu of the "Settings" mode (for BDVG and BDPG units) and "Configuration" menu (for BDZA, BDZB and BDKG units) are shown in Figures 3.1 and 3.2. The "Configuration" menu for BDKS and BDMG units includes an additional submenu "Dose".

3.5.3.3 To activate menu item highlighted by cursor press ▶, to move to the next or previous menu/submenu item press ⬆ or ⬇. To return to upper level menu press ⓘ, to exit "Settings" mode and return to "Measurement" mode ("Primary measurement" window) press ⓘ.

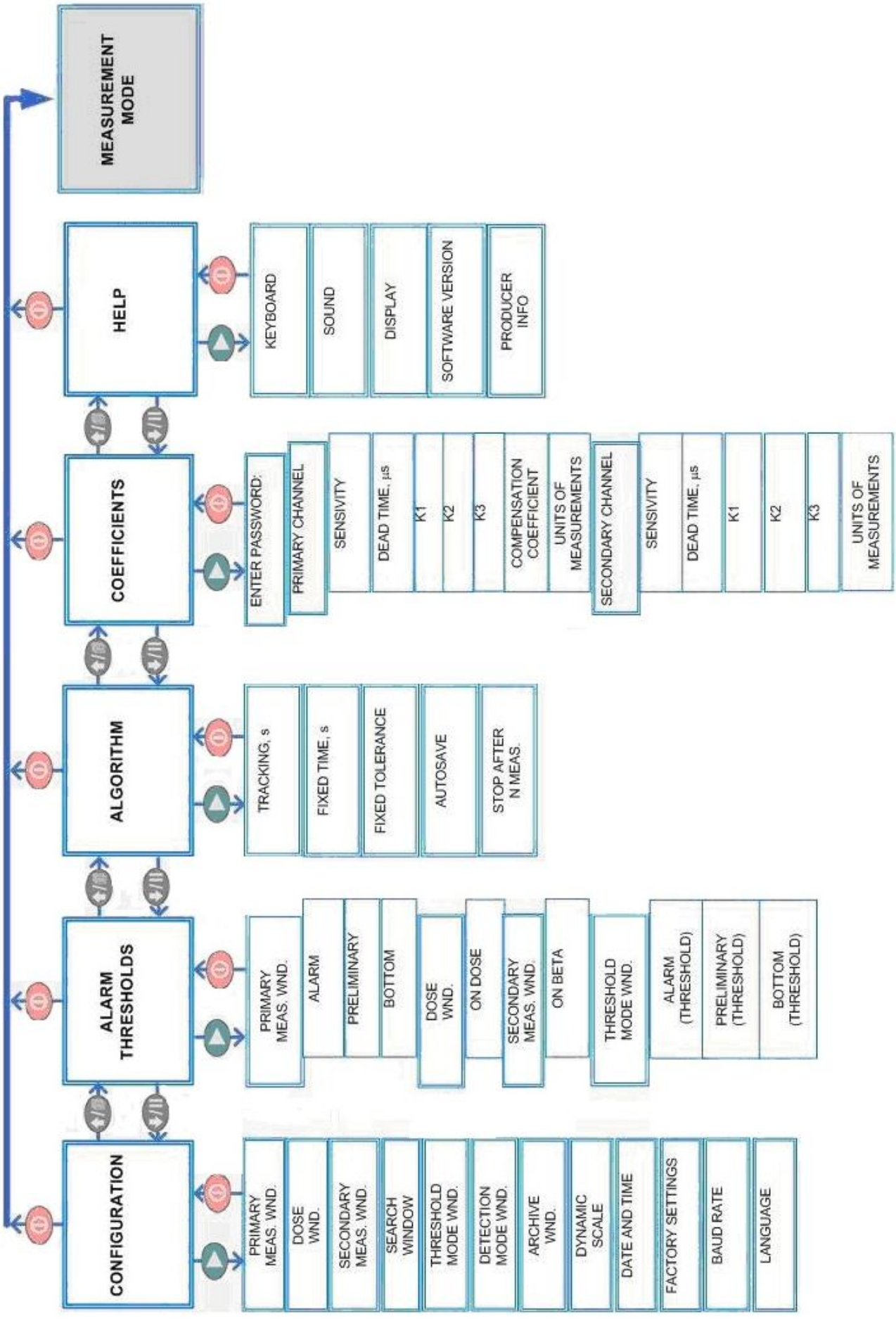


Figure 3.1 – Menu layout in "Settings" mode

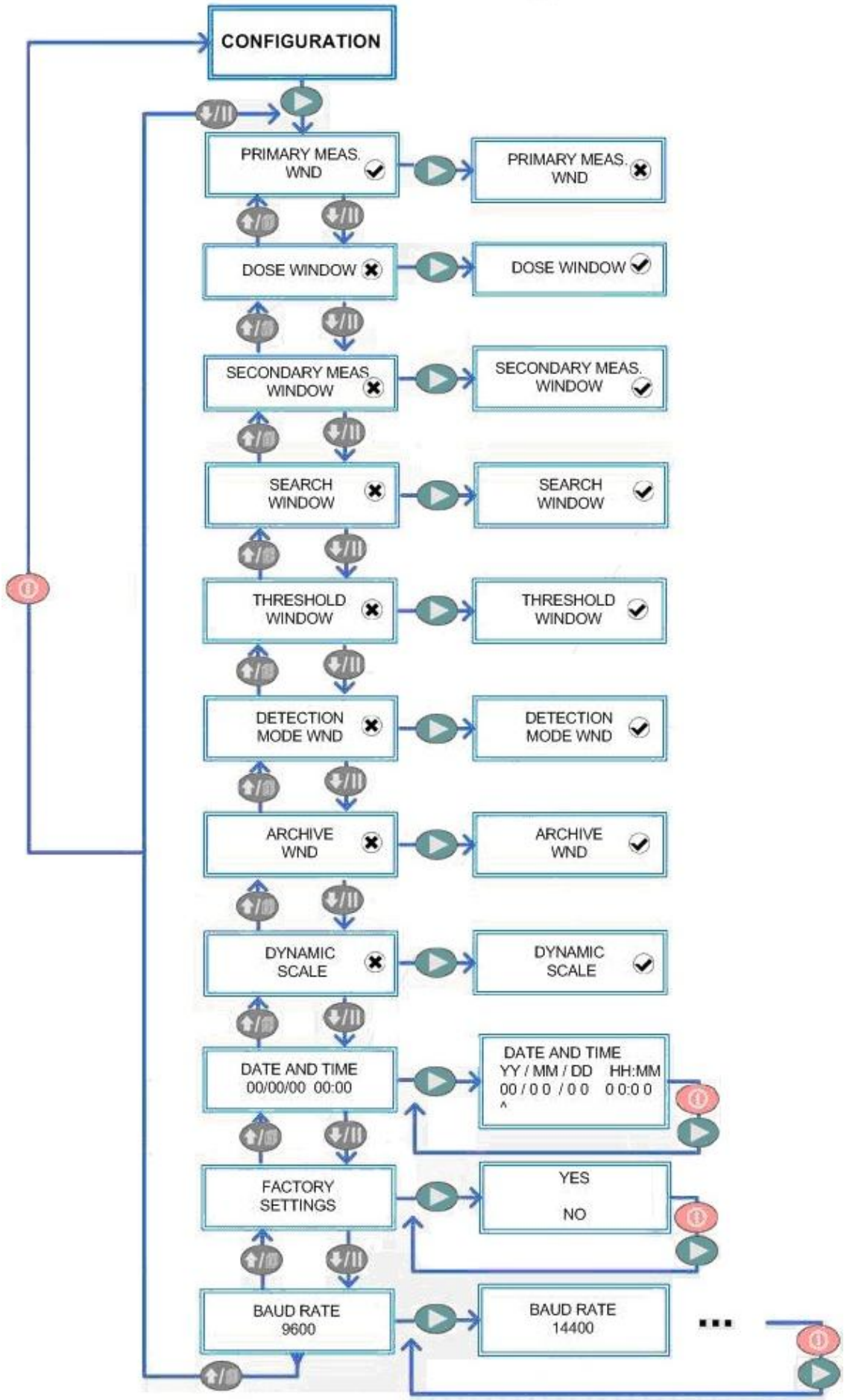


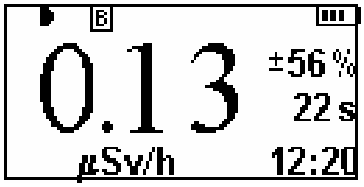
Figure 3.2 – "Configuration" menu

3.5.4 "Configuration" menu

Press ▶ to go to items of "Configuration" menu – these items match names of windows in which measurement results are displayed during operation of the dosimeter/radiometer. Enabling of dosimeter/radiometer operation in any of the windows is performed by pressing ▶ - it is confirmed by pictogram ⓥ; to disable operation in a window, press ▶ again; disabling is confirmed by pictogram ⓧ.

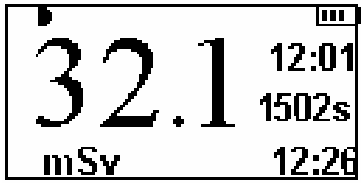
3.5.4.1 Menu item "Primary measurement" window"

When operation of the dosimeter/radiometer with displaying of results in this window is enabled, it makes it possibile to measure a physical quantity which is the main quantity for the connected detector unit and to obtain measurement information in units listed in Table 1.12. If all windows contained in the "Configuration" menu are disabled, than automatic enabling of the "Primary measurement" window is performed:



3.5.4.2 Menu item "Dose window"

This menu item is available when one of the following detector units is connected: BDKS-96, BDKS-96b, BDKS-96s, BDMG-96, BDMN-96 or BDKN-96. If presentation of results in "Dose" window is enabled, it makes it possibile to measure the effective dose of gamma or neutron radiation:



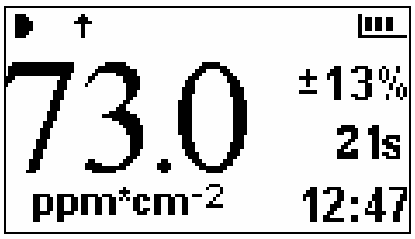
The "Dose window" menu item is absent when any other detector unit is connected.

Measurement of ADE is an independent function; measurement of ADE starts when dosimeter/radiometer (control unit) is turned on, accumulated ADE is not stored in memory when dosimeter/radiometer is turned off. "Dose" window can be distinguished by measurement unit - "Sv" with decimal prefix (µ or m) in the lower left corner of the display. On the right side of display the turn on time and the period of dose accumulation (in seconds) are shown.

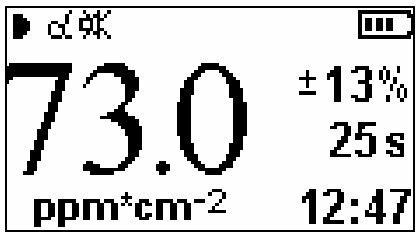
3.5.4.3 Menu item "Secondary measurement window"

This item is included in the "Configuration" menu only for BDKS-96s unit having two measuring channels: main channel (gamma) and additional channel (beta) and for BDPS-96 unit, which provides measurements of flux density alpha (main channel) and beta (additional channel).

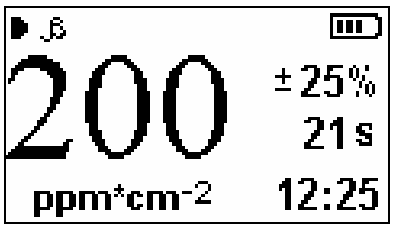
Enabling presentation of measurements results in this window makes it possibile to measure beta particle flux density with automatic subtraction of the background gamma radiation contribution to the readings. Thus, measurements using detector unit BDKS-96s can be carried out simultaneously in gamma and beta channels; results are displayed in the window "Primary measurement" (gamma-channel), or, after pressing ⬆, in the window "Secondary measurement" (beta-channel), according to operator's selection:



BDKS-96б (window «Secondary measurement»)



BDPS-96 (window «Primary measurement »)

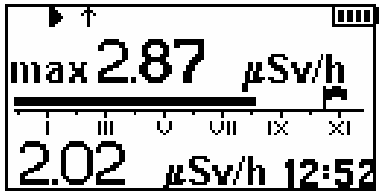


BDPS-96(window «Secondary measurement»))

3.5.4.4 Menu item "Search window"

Enabling presentation of measurements results in this window makes it possibile to search and locate sources of ionizing radiation using "Search" window. This algorithm provides automatic measurement of background radiation and subsequent comparison of current ADER readings in $Sv \cdot h^{-1}$ with the value of background level.

Current measurement results are shown in graphic form (dynamic scale: axis X – current reading / background ratio) and digitally – in the bottom line in units of measurand. In the top line (and as a flag on axis X) - the maximum radiation level detected in the current "Search" cycle:

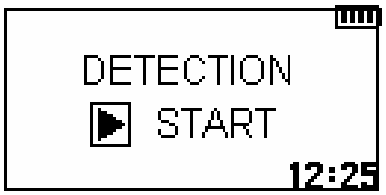


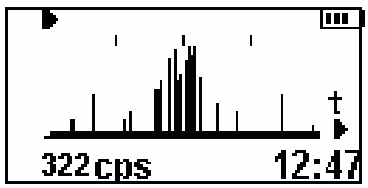
Upon detection of the local area with radiation levels exceeding the background level by more than 12-fold, the dosimeter/radiometer generates an audible alarm. To continue search in the area with elevated level of radiation (background), it is recommended to update the background values by pressing ▶▶.

3.5.4.5 Menu item "Detection window"

This menu item is available when one of the following detector units is connected: BDVG-96, BDPG-96 or BDPG-96m. If presentation of results in this window is enabled, it makes it possibile to obtain measurement information regarding presence or absence of sources (local areas) with elevated levels of radiation in the surveyed areas.

The information in the "Detection" window is presented in graphic form:





as well as in the form of audible signals. The audible signal generated at the time when the instantaneous value of radiation intensity exceeds the background level approximately two-fold. By pressing 🔊⬆ ⬆ the operator can increase the input-to-output frequency ratio for audible signals (corresponding to one or more detected photons) and to limit audible signals to signals of "Detection" mode only.

During the survey, occasional audible signals (approximately once every ten - twenty seconds) are considered normal. Increasing of the audible signals rate indicates the increase in the detected radiation intensity.

The diagram shows the current information about relative intensity of events of particles or photons detection. The X axis corresponds to current time (3 seconds per scale division), ticks are below information line. The X axis corresponds to count rate: solid line is the background level, vertical bars are instantaneous values of radiation intensity. The height of bars is proportional to the ratio of the instantaneous radiation intensity and the background level; the repetition interval is inversely proportional to the intensity of radiation.

3.5.4.6 Menu item "Threshold mode window"

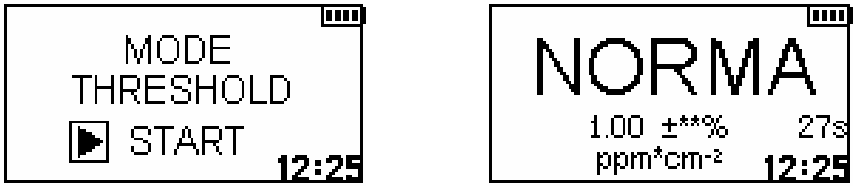
Enabling presentation of measurements results in this window makes it possibile to perform rapid assessment of the contamination level of tested object and to compare it with predetermined alarm thresholds – Alarm, Preliminary and Bottom in accordance with section 3.5.5 "Threshold" menu.

Any number of alarm thresholds can be used, but the order of their setting is important:

- one setting – Alarm;
- two settings – Alarm and Preliminary;
- three settings – Alarm, Preliminary and Bottom.

The Alarm threshold should be more than Preliminary threshold; the Preliminary threshold should be more than Bottom threshold.

The measurement result is a message on the display:

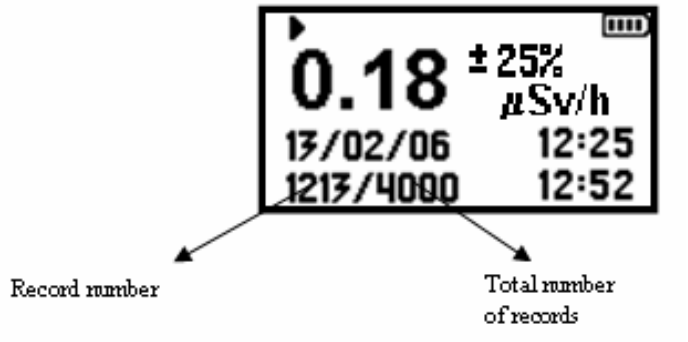


- "DIRTY" - the level of contamination is above the Alarm threshold;
- "NORMAL" - the level of contamination is below the Alarm threshold, but above the Preliminary threshold;
- "CLEAN" - the level of contamination is below the Preliminary threshold, but above the Bottom threshold;
- "CLEAN!" - the level of contamination is below the Bottom threshold.

The comparison with the threshold can be either absolute, without taking background level into account, or relative, taking into account the background level at the place where measurements are performed. The operator can initiate measurement of the background at any time when the window "Threshold" is active, by pressing ▶▶.

3.5.4.7 Menu item "Archive window"

Enabling presentation of measurements results in this window makes it possibile to store measurement data in archive for retrospective review; data are stored in nonvolatile memory. It is also possibile to perform statistical analysis measurement results within a given range of serial numbers of records.



Results of measurements may be saved into archive automatically, if "Autosave" is enabled in the menu item "Settings" – "Algorithm", or manually, by pressing ▶, but only if the "Archive" window was allowed for display in the Settings:

The maximum archive capacity is 2000 records.

When the "Archive" window is activated, it shows the last saved record. It provides the possibility to view the last saved measurement result.

The information can be read from archive to PC using the "TETRA_Reporter" software. Each record contains the following information:

- modification of the dosimeter/radiometer used to perform measurement;
- measurement result;
- measurement unit;
- measurement uncertainty;
- date and time of measurement;
- geographic coordinates of the measurement point (if GPS sensor is used).

To enter in the "Service" menu of the "Archive" window, press . The items of "Service" menu include:

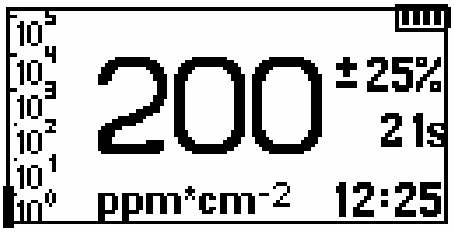
- "Start of interval" - indicates the number of the first record of interval to be analyzed;
- "End of interval" - indicates the number of the last record of interval to be analyzed;
- "Statistics" - indicates statistical analysis results of measurements data in the specified interval of archieve records (not more than 500 results):
  1) serial numbers of the first and the last records in the interval,
  2) minimum and maximum measurement results,
  3) mean value,
  4) standard deviation,

(if the specified interval contains records with measurement results obtained with detector units of different types, than the statistical analysis will take into account only results obtained with detector unit which was used in the first record measurement);

- "Clear archieve" - delete all archive records after confirming this operation by the operator.

3.5.4.8 Menu item "Dynamic scale"

Provides the possibility to display dynamic scale in enabled windows (see 3.5.4.1 – 3.5.4.6). The dynamic scale represent measurement information in analog form on a logarithmic scale:



The dynamic scale representation uses "Tracking" algorithm for data processing regardless of the algorithm selected by operator. This allows rapid visual tracking of the dynamics of detected radiation intensity.

The dynamic scale is the built-in function of the control unit, therefore enabling or disabling its is applicable to all types of detector units connected to the control unit.

3.5.4.9 Menu item "Date and time"

This menu item allows setting of the current date and time of the built-in clocks of the control unit. When the control unit is first turned on after replacing the electric cells, the window "Date and time" will appear automatically. To enter date and time, use ⬆ to increment the digit from 0 to 9, ⬇ to decrement the digit from 9 to 0, ▶ to move cursor to the next character and return to the measurement mode after entering (correction) of the last right digit.

3.5.4.10 Menu item "Factory settings"

Use this menu item to restore the default (factory) settings of the dosimeter/radiometer for all detector units simultaneously in accordance with Table 1.12.

3.5.4.11 Menu item "Baud rate"

Use this menu item to change the data exchange rate with external devices. Available values are listed by ▶. The default baud rate is 9600 baud.

3.5.4.12 Menu item "Baud rate GPS"

Use this menu item to change the data exchange rate with GPS sensor. Available values are listed by ▶. The default baud rate is 4800 baud.

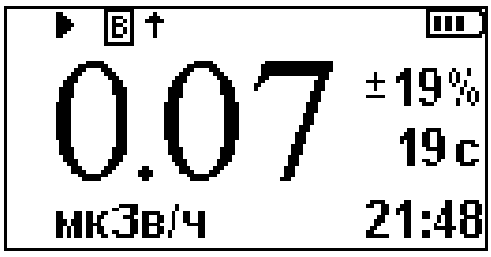
3.5.4.13 Menu item "Language"

Use this menu item to select the interface language: Russian or English.

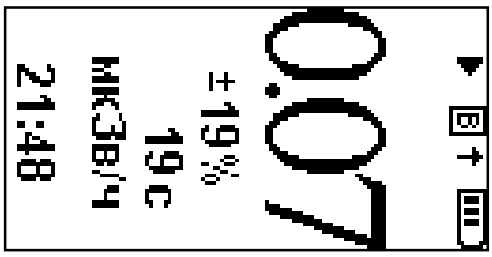
3.5.4.14 Menu item "Rotate 90°".

Use this menu item to rotate the display image. After pressing ⬆⬆ the image will rotate 90º clockwise:

Before rotation



After rotation by 90º



Orientation of the image is saved when the dosimeter is turned off.

3.5.5 "Alarm thresholds" menu

3.5.5.1 Press ▶, go to menu items "Alarm thresholds": "Primary measurement" window", "Dose window", "Secondary measurement window" or "Threshold window" for setting non-zero values of corresponding alarm thresholds according to the procedure described in 3.5.5.2 – 3.5.5.7.

3.5.5.2 Setting alarm threshold

Setting a non-zero alarm threshold using the menu item "Alarm" provides a continuous comparison of the current measurement result obtained using "Tracking" algorithm with the preset threshold. When the current measured value exceeds the alarm threshold, than in the measurement mode (in windows specified in sections 3.5.4.1 – 3.5.4.6) pictogram ⚠ is displayed and corresponding audible signal or (in case of UIK-07 unit) audible and light signal is generated.

Preliminary and Bottom thresholds are common for both subranges – Low and High. For the detector unit BDKS-96s the threshold is the setting for gamma-channel.

3.5.5.3 For two-channel detecting blocks (BDMG-96, BDKS-96), the alarm threshold setting (as well as «Preliminary» and «Bottom») is the same for both channels («low» and «high»). For the detecting block BDKS-96s, the threshold setting is the setting for gamma-channel.

3.5.5.4 Setting the Alarm threshold to zero disables the comparison algorithm; in this case the automatic monitoring with reference to this threshold is not performed.

3.5.5.5 Setting the non-zero Preliminary and/or Bottom threshold(s) in corresponding menu line(s) provides the same actions as the setting of Alarm threshold, but the pictogram ⚠ is not displayed.

3.5.5.6 "Beta" threshold is used to set the threshold for beta particle flux density and only possible when the detector unit BDKS-96s or BDPS-96 is connected. Setting the non-zero threshold enables the comparison algorithm. Current measurement result obtained by the algorithm chosen for beta-channel in the menu "Algorithm" is continuously compared with preset "Beta" threshold. When current measured value exceeds "Beta" threshold, the pictogram ⚠ is displayed in the measurement

mode in windows specified in 3.5.4.1 – 3.5.4.6 and corresponding audible signal or (in case of UIK-07 unit) audible and light signal is generated. Setting the "Beta" threshold to zero disables the comparison algorithm; in this case the automatic monitoring with reference to this threshold is not performed.

3.5.5.7 Setting the "Dose" threshold only possible when one of the following detector units is connected: BDKS-96, BDKS-96b, BDKS-96s, BDMG-96, BDMN-96 or BDKN-96. It is used to set threshold for ADE. Setting the non-zero threshold enables the comparison algorithm. Current measurement result for ADE is continuously compared with preset "Dose" threshold. When current measured value exceeds "Dose" threshold, the pictogram is displayed in the measurement mode in windows specified in 3.5.4.1 – 3.5.4.6 and corresponding audible signal or (in case of UIK-07 unit) audible and light signal is generated. Setting the "Dose" threshold to zero disables the comparison algorithm; in this case the automatic monitoring with reference to this threshold is not performed.

3.5.6 "Algorithm" menu

3.5.6.1 Press ▶ and go to items of "Algorithm" menu to select one of the algorithms of continuous measurements that will be applied during measurement process in the "Measurement" mode, and to set parameters for these algorithms. The choice of a particular algorithm is confirmed by pictograms ✓ in a line marked with cursor.

3.5.6.2 Selection of "Tracking, s" algorithm provides (in "Measurement" mode with detector units of BDPG-96, BDPG-96m or BDVG-96 type) continuous measurements with automatic restart of the measurement cycle as described in 1.4.4.3 in the case of abrupt changes in the radiation level. After automatic restart of measurement, the last measured value and time of restart are saved in archive, if archiving is enabled. The operator can change the following parameter of the algorithm: "period of time, after which the result of current measurement is saved into archive even if no restart of measurement was triggered." By default this parameter is set to 60 seconds.

3.5.6.3 Selection of "Fixed time, s" algorithm provides continuous measurements and averaging of results using moving average method with measurement interval "1 s" and averaging time corresponding to the parameter value. After the averaging time is over, the measurement cycle stops, the result of measurement is saved into archive (if "Autosave" is enabled) as described in 3.5.6.6 (if "Autosave" is disabled, press ▶ to save the result) and then a new measuring cycle starts automatically.

3.5.6.4 Selection of "Fixed tolerance" algorithm provides continuous of measurements and averaging of results using moving average method with interval "1 s". The averaging time is determined automatically: when the measurement uncertainty reaches 6 %, the measurement process stops, the result of measurement is saved into archive (if "Autosave" is enabled) as described in 3.5.6.6 (if "Autosave" is disabled, press ▶ to save the result) and then a new measuring cycle starts automatically (if ▶ is pressed, a new measuring cycle does not start). Parameter of the algorithm is the "maximum measurement interval". If non-zero measurement time is selected, the measurement process will stop:

- after reaching a preset value of measurement uncertainty; or
- after lapse of maximum measurement interval.

Setting algorithm parameter to zero disables the limit for measurement interval.

3.5.6.5 Regardless of the measurement algorithm selected by operator, measurement data are continuously processed using "Tracking" algorithm to provide representation on the dynamic scale in the "Primary measurement" window and to compare measured values with thresholds: Alarm, Preliminary and Bottom.

3.5.6.6 Enabling or disabling of "Autosave" function enables or disables automatic saving of measurement results in the archive of control unit. Results of measurements obtained using "Fixed time" and "Fixed tolerance" algorithms are saved at the end of measurement time; when "Tracking" algorithm is used, measurement data are saved with periodicity which was set when algorithm was selected or after each automatic restart of the measurement process.

3.5.6.7 Selection of "Stop after N meas" allows performing a series of *N* measurements and saving measurement results in memory.

3.5.7 "Coefficients" menu

3.5.7.1 Press ▶ and go to menu items "Coefficients" to adjust parameters used in the processing of measurement results and determining the metrological characteristics of the dosimeter/radiometer, and to store changed parameters in the control unit's memory. **The possibility to adjust these parameters is limited and password protected.**

3.5.7.2 Menu item "Enter password". Procedure for entering the password is described in 3.7.5.

3.5.7.3 Menu items "Primary channel" and "Secondary channel" are available when one of the following detector units is connected: BDKS-96, BDKS-96b, BDKS-96s, BDMG-96 or BDPS-96. The set of parameters is the same for both channels; values of parameters are determined during calibration.

3.5.7.4 Menu items "Coefficient K1", "Coefficient K2" and "Coefficient K3" are available in the menu for certain detector units only. If necessary, the non-zero values of these coefficients are determined and entered during calibration of the dosimeter/radiometer to ensure the possibility of measurements in the extended measuring range.

3.5.7.5 Menu item "Compensation coefficient" is available in the menu for detector units BDKS-96s and BDPS-96. The compensation coefficient is used for correlation of detector units' sensitivity to beta- and gamma-radiation. If necessary, the non-zero value of this coefficient is determined and entered during calibration of the dosimeter/radiometer.

3.5.7.6 Menu items "Sensitivity coefficient" and "Dead time" are intended to set the basic metrological characteristics of detector units.

3.5.7.7 Menu item "Units of measurement" provides the possibility to measure various physical quantities by detector unit of the same type (main and secondary measurement units). After selection of measurement unit values of coefficients are changed automatically. If measurement units "s^{-1}" is selected, the dosimeter/radiometer switches to measurement of mean count rate.

3.5.8 "Help" menu

Provides information about actions (item "Keypad") the operator needs to perform to switch the control unit to a certain mode, to select algorithm, to set a threshold, etc. in different windows; plays audible signals (item "Sound") which correspond to audible signals for various events during operation. The "Display" item contains information about the meaning of pictograms in the information line which may be displayed in "Measurement" mode. The "Software version" item displays the version of firmware. Item "Producer info" contains information about the manufacturer of the dosimeter/radiometer.

3.6 Connecting dosimeter/radiometer to PC

3.6.1 Connect UIK-05/-05-01/-06 unit to PC using the adapter cable PI-03 (UIK-USB), included in the delivery set (if ordered).

Connect UIK-07 unit to PC using cable "UIK-07-Atlant" and interface converter PI-02 then connect PI-02 to AC mains 220 V 50 Hz.

3.6.2 If necessary, install USB driver (the driver is available on the disc supplied with the dosimeter/radiometer and on the website www.doza.ru). After the driver is installed, the system will show the number of COM-port which can be used for data exchange between the control unit and PC.

The number of COM-port associated with the unit can be found in "Control panel/System/Equipment Manager/Device manager/Ports (COM and LPT) / Serial port (COM XX). Here XX is the number of port associated with the control unit connected to USB.

3.6.3 Install "TETRA_Checker" software from installation disk. Run the program. The general form of the program window is shown in Figure 3.3. Turn the dosimeter/radiometer on by pressing ⓘ; the name of the program will be displayed in the upper left corner and the version of sotware – in the "Device parameters" window.

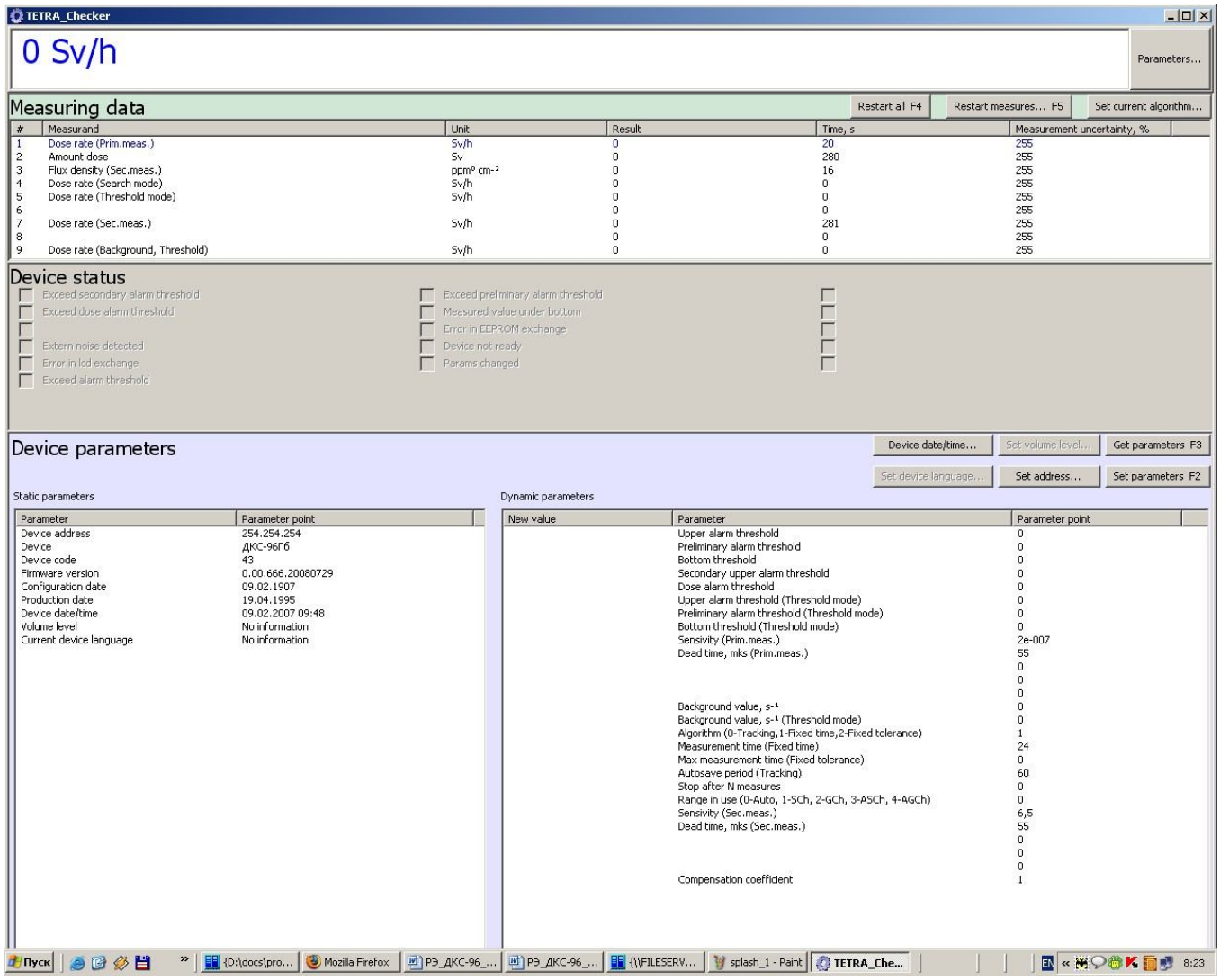


Figure 3.3

3.6.4 Click on button "Parameters" in the top information line of the program window and in the evoked "Parameters" window (see Figure 3.4) select the serial port number as determined according to 3.6.2 (for "Via broadcast address" mode). Click "OK".

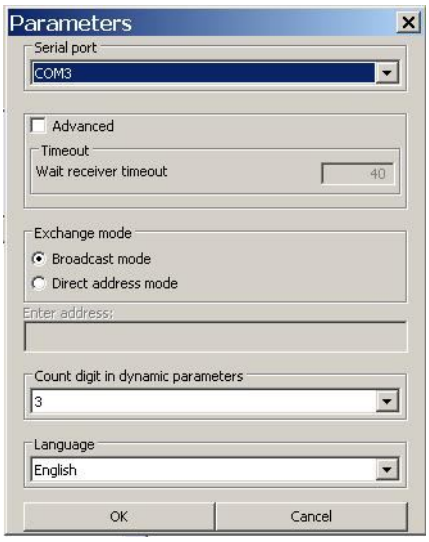


Figure 3.4

The information displayed on the PC monitor, duplicates the information displayed on the control unit. In addition the window "Dynamic parameters" contains information about modes selected in the control unit and their parameters.

3.6.5 "TETRA _Checker" software can be used to adjust dynamic parameters and operation modes of the dosimeter/radiometer. This is performed as follows:

- double click on "New value" column in the "Dynamic parameters" window in line with the parameter to be adjusted;
- enter the new "Current value" of parameter;
- click in the line with parameter that is not adjusted and then on the button "SET Parameters F2".

3.6.6 In the window "Device status" the information is displayed that reflects the state of the dosimeter/radiometer and the results of comparing the measured value and the Alarm thresholds.

3.6.7 Install the "TETRA_Reporter" software from installation disk; it is intended for generating reports about measurement results. Run the software. In the upper left corner of the window the software name is shown, in the window "About…" - the software version number.

3.6.8 Select the serial port number in the dropdown list "Serial port" as described in 3.6.2 (see Figure 3.5).

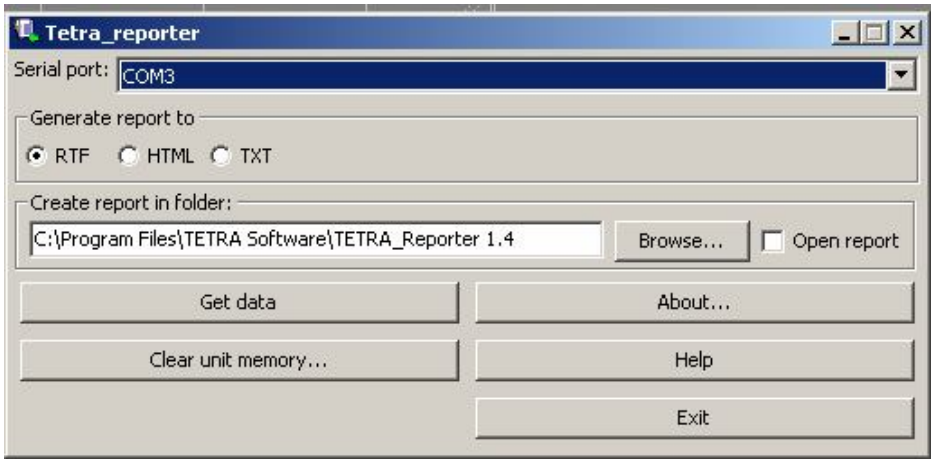


Figure 3.5

3.6.9 Select report format - HTML by clicking in the corresponding box. Select folder for saving the report about measurement results generated using data from control unit's archive (click on the button "Browse" if necessary).

3.6.10 Tick "Open report" if you want to view the report after it is created. Click on button "Get data". The report form is shown in Figure 3.6.

Report of 23.05.2008 15:48:47 - TETRA_Reporter							
No.	Detector unit	Value	Unit	Uncert. (%)	Date	Latitude	Longitude
0001	DKS-96A	0.00e-00	min^{-1} cm^{-2}	99	07/02/08 17:26	48°20.474N	33°30.515E
0002	DKS-96M	1.76e-07	Sv/h	02	07/02/08 17:36	48°20.473N	33°30.515E
0003	DKS-96M	1.77e-07	Sv/h	02	07/02/08 17:36	48°20.473N	33°30.515E

Figure 3.6

3.6.11 The firmware in the control unit supports DiBUS network protocol (www.doza.ru); thanks to this feature dosimeters/radiometers can be used as a monitoring points in radiation monitoring systems. Network address of a monitoring point is set by "TETRA _Checker" software in the "Device parameters" window of the "Statis parameters" section.

3.7 Adjustment of dosimeter/radiometer

3.7.1 Adjustment and setting of the dosimeter/radiometer are to be performed by **authorized user knowing password**: by the manufacturer in the manufacturing process, by service organization during repair, or during calibration based on its results. During settings of the dosimeter/radiometer the following operations are performed using sources of ionizing radiation:

- adjustment of sensitivity of detector units is carried out by rotating the tuning resistor located in the rear part of detector unit and closed with a screw-cap; if a detector unit has two subranges with different sensitivity, subranges have to be calibrated separately; for detector units equipped with scintillation detectors, the PMT voltage is set in the middle of plateau characteristic curve; if it is impossibile to adjust the sensitivity by adjusting the PMT voltage only, the value of sensitivity coefficient K shall be adjusted, see formula (1.1);
- adjustment of dead time of the detection channel of detector unit in order to linearize the counting response of the dosimeter/radiometer.

3.7.2 Typical values of sensitivity factors and "dead times" for all types of detector units that may be connected to dosimeter/radiometer are shown in Table 1.12.

3.7.3 Increasing the sensitivity coefficient during adjustment increases readings and vice versa. It is recommended to use it when it is necessary to adjust the lower part of measurement range.

3.7.4 Increasing the dead time during adjustment also increases readings, however, only when the count rate is relatively high, i.e. closer to the end of measurement range.

3.7.5 If necessary, adjustment of sensitivity coefficient and dead time is performed as follows:

- enter the "Settings" mode: press and hold ▶ and press ⓘ;
- go to "Coefficients" menu item by pressing ⬆ or ⬇;
- move cursor to the line "Enter password" by pressing ▶, and enter the password for access to adjustment (move cursor – ▶, increment the digit – ⬆, decrement the digit – ⬇);
- after adjustment of the last right digit press ▶ to exit the "Enter password" line;
- set cursor next to the menu line to be adjusted by pressing ⬇;
- press ▶ and enter the desired value of parameter;
- press ⓘ;
- after adjustment is complete, press ⓘ to return to "Measurement" mode.

3.7.6 Sensitivity coefficients and "dead times" for each detector unit included in the delivery set are determined during calibration.

4 MAINTENANCE

4.1 General notes

The purpose of maintenance is to ensure reliable, long-term operation of the dosimeter/radiometer. For maintenance no special qualification or workplace arrangement is required.

4.2 Safety precautions

4.2.1 Before beginning to work with dosimeter/radiometer familiarize yourself with this User Manual.

4.2.2 During all operations with dosimeter/radiometer follow occupational and radiation safety requirements of current safety instructions in the company (enterprise).

4.2.3 DANGEROUS HIGH VOLTAGE is generated in the dosimeter/radiometer. A person performing service operations must be familiar with rules for working with equipment with voltages up to 1000 V and be especially cautious during repair works.

4.3 Maintenance routine

Maintenance is divided into routine and periodic.

4.3.1 Routine maintenance

4.3.1.1 Routine maintenance is carried out during regular operation of the dosimeter/radiometer.

4.3.1.2 Routine maintenance includes periodic visual inspection for damage of the control unit and detector units, and testing of operability in accordance with section 3.2.

4.3.1.3 For possible faults and troubleshooting of the dosimeter/radiometer see section 5.

4.3.2 Periodic maintenance

4.3.2.1 Periodic maintenance includes calibration and decontamination of the dosimeter/radiometer.

4.3.2.2 Decontamination of dosimeter/radiometer shall be performed in accordance with work schedule at the company (facility), but at least once a year. Decontamination shall cover external surfaces of the control unit and of detector units, and cable connectors, 5% solution of citric acid in rectified ethyl alcohol shall be used.

5 CALIBRATION

5.1 Calibration of dosimeters/radiometers is performed in accordance with calibration procedure TE1.415313.003MP.

6 ROUTINE REPAIRS

6.1 Possible faults of the dosimeter/radiometer and troubleshooting are listed in Table 6.1.

Table 6.1 – Possible faults and troubleshooting

Symptom	Possible cause	Remedy
When the dosimeter/ radiometer is turned on, audible signal is not generated and the display shows nothing	Batteries discharged	Connect charger to the control unit and charge batteries
Intrinsic background exceeds permitted limit	Light protective screen of the detector is damaged	Replace light protective screen
In operation, measurement result is shown as "*****"	Number of digits in the indicated value exceeded the number of allocated characters. Perhaps incorrect sensitivity coefficient is set.	Restore sensitivity coefficient value with the value specified
Displayed information is not consistent with what is expected	The order of actions described in this Manual was not followed	Turn dosimeter/radiometer off. Refer the relevant section in the Manual and check the order of actions when using dosimeter/radiometer

If the fault is not listed in the above Table or if the suggested troubleshooting methods cannot solve the problem, please address your complaint to the manufacturer.

7 STORAGE

7.1 Prior to putting into operation dosimeters/radiometers shall be stored in a heated warehouse with natural ventilation:

- in manufacturer's package – at ambient temperatures from +5 to +40 °C and relative humidity up to 80 % at +25°C;
- unpacked – at ambient temperatures from +10 to +35 °C and relative humidity up to 80 % at +25 °C;

7.2 The storage location should be free of dust, chemical vapours, aggressive gases and other substances that may cause corrosion.

The storage location shall exclude exposure of dosimeters/radiometers to the direct rays of sunlight.

8 TRANSPORTATION

8.1 Dosimeters/radiometers in the original manufacturer's package can be transported by all means of transport at any distance:

- transportation by railway shall be carried out in clean boxcars;
- when transported by uncovered motor vehicles, boxes shall be covered by the water-proof material;
- when transported by air, boxes with dosimeters shall be placed in air-tight heated compartment;
- when transported by water and sea transport, boxes with dosimeters shall be placed in a special sealed packaging in the hold.

8.2 Arrangement and fastening of the boxes on transport means shall provide their steady position en route, prevent displacement and striking each other.

8.3 The shipment instructions on the transport packing shall be observed during loading and unloading. During loading and unloading dosimeter/radiometer should not be exposed to rain.

8.4 Transportation conditions:

- temperature ……..……..….. from minus 25 to +50 °C;
- humidity …….……...……....…..… up to 98 % at +35 °C;
- sinusoidal vibrations in the frequency range ……..…….. from 10 to 55 Hz with displacement amplitude 0.35 mm.

9 DISPOSAL

9.1 Upon the expiration of service life of the dosimeter/radiometer (or its parts) and also prior to dispatching it for repair or calibration, it shall be inspected for possible radioactive contamination of its surfaces. Criteria for decision making on decontamination and further use shall comply with obligatory requirements of national standards.

9.2 Decontamination shall be attempted in cases when the contamination of surfaces (including surfaces accessible during repair) can be reduced below allowable limits.

In case the radioactive contamination exceeds allowable limits, requirements set forth for the radioactive wastes shall become applicable to the detectors.

9.3 Dosimeters/radiometers accepted for operation after decontamination shall be repaired or replaced in case of failure. Dosimeters/radiometers not suitable for operation, with radioactive contamination levels below permissible limits, should be transferred to a special site for disposal of industrial wastes.

9.4 Dosimeter/radiometer with expired lifetime, accepted for use after decontamination, shall undergo technical inspection. If the technical condition of a dosimeter is satisfactory, an extended operation term of the product shall be determined.