

**MKS-UM VRS**  
**Vehicle Radiation Monitoring System**

**Operating Manual**  
BICT.412118.040 HE



## CONTENTS

1 DESCRIPTION AND OPERATION .....	3
1.1 Purpose of use.....	3
1.2 Technical Specifications .....	5
1.3 The system delivery kit.....	12
1.4 The system's design and the principle of its operation .....	13
1.5 Design of the MKS-UM control unit and the principle of its operation ....	13
1.6 Design of VRS Module and the principle of its operation .....	14
1.7 Design of the probe and the principle of its operation .....	17
1.8 Labeling and sealing .....	20
1.9 Packaging.....	20
2 PROPER USE.....	21
2.1 Operational limitations .....	21
2.2 Preparing the system for operation.....	21
2.3 Use of the system.....	24
3 TECHNICAL MAINTENANCE .....	26
3.1 Technical maintenance of the system.....	26
3.2 Verification of the probes .....	28
4 STORAGE .....	32
5 OPERATING AND SERVICE LIFE.....	33
6 SHIPPING.....	34
7 CERTIFICATE OF ACCEPTANCE .....	35
8 PACKING CERTIFICATE .....	36
ANNEX A Wiring diagram of the MKS-UM VRS system .....	37
ANNEX B Overall and connecting dimensions of VRS Module .....	38
ANNEX C Overall and connecting dimensions of the probe .....	40
ANNEX D Data communications protocol between VRS Module and the PC.....	41
SPECIAL NOTES.....	51

This operating manual (OM) is intended to inform the user about the principle of operation of MKS-UM VRS Vehicle Radiation Monitoring System (hereinafter referred to as the system), the procedure for working with it, and contains all the data necessary for full use of its technical capabilities and its proper operation.

The OM contains the following abbreviations:

- DER – ambient dose equivalent rate of gamma and X-ray radiation;
- DE – a ambient dose equivalent of gamma and X-ray radiation.

# 1 DESCRIPTION AND OPERATION

## 1.1 Purpose of use

The system is designed to collect, process, visualize information about the radiation state of the area in order to apply measures to protect personnel from ionizing radiation and radioactive contamination and maneuvering of the vehicle in the area affected by nuclear weapons, man-made disasters or other causes. The system provides light and sound alarms about dangerous levels of radiation background, as well as transfers measurement results to the data collection and processing system.

The system is designed for installation in special-purpose vehicles, including radiochemical reconnaissance units of the armed forces and civil defense.

The system consists of:

- control unit BICT.468166.040-02 from the kit of MKS-UM multipurpose dosimeter-radiometer BICT.412129.036-06 (hereinafter - MKS-UM control unit);
- control and indication module VRS Module BICT.468365.006 (hereinafter - VRS Module);
- two BDBG-T gamma radiation detecting units BICT.418266.063 (hereinafter - the probe);
- two cables to connect the probes;
- cable for connection to the data collection and processing system;
- cable for connection to the vehicle power supply system.

Note - Cables are manufactured by the customer using a mounting parts kit included in the delivery kit.

1.1.1 MKS-UM control unit as part of the system is designed for:

- measurement of gamma and X-ray radiation DER (hereinafter referred to as photon-ionizing radiation) inside the vehicle;
- measurement of photon-ionizing radiation DE inside the vehicle;
- measurement of photon-ionizing radiation DE accumulation time;
- archiving the results;
- transfer measurement results via the VRS Module to the data collection and processing system.

Note - The MKS-UM control unit can be used not only as part of the system, but also outside the vehicle with the use of standard remote probes from the kit of MKS-UM multipurpose dosimeter-radiometer if you order a complete kit of MKS-UM multipurpose dosimeter-radiometer.

1.1.2 VRS Module is designed to collect, process, visualize information about the radiation state of the area, received from two BDBG-T remote probes of gamma radiation, and provides light signaling of dangerous levels of radiation background, as well as transfers measurement results from two probes and MKS-UM control unit to the data collection and processing system (on-board computer).

1.1.3 The probes are designed to measure the gamma radiation DER outside the vehicle.

## 1.2 Technical Specifications

1.2.1 Key technical data and specifications of MKS-UM control unit are presented in Table 1.1.

Table 1.1 – Key technical data and specifications of MKS-UM control unit

Name	Measurement unit	Standardized value according to the specification
Measurement range of photon-ionizing radiation DER	μSv/h	$10^{-1} - 10^6$
Indication range of pulse count rate from gamma radiation detector	cps	0 – 9999
Measurement range of photon-ionizing radiation DE	mSv	0.001 to 9 999
Main relative permissible error limit during DER measurement at $^{137}\text{Cs}$ calibration with 0.95 confidence probability	%	$15 + 2/\dot{H}^*(10)$ , where $\dot{H}^*(10)$ – is a dimensionless quantity, numerically equal to DER value measured in μSv/h
Main relative permissible error limit during DE measurement at $^{137}\text{Cs}$ calibration with 0.95 confidence probability	%	15
Energy range of recorded photon-ionizing radiation	MeV	0.05 – 3.00
Change in sensitivity caused by energy (in the energy range from 50 keV to 1.5 MeV) and the angle of incidence (when gamma-quanta fall in the solid angle of $\pm 45^\circ$ relative to the main direction of measurement, marked by "+" symbol) of photon radiation	%	from - 25 to +50
Measurement range of DE accumulation time		1 min – 9999 hrs
Accuracy of DE accumulation time measurement for 100 hrs	min	$\pm 1$
Operating supply voltage - from Li-Ion battery - from VRS Module	V	3.7 from 9 to 32
Additional relative permissible error limit during measurement caused by supply voltage change from 4.2 to 3.0 V, for all physical quantities measured	%	$\pm 5$
Additional relative permissible error limit during measurement caused by deviation of environmental temperature from 20 °C in the temperature variation range from –30 °C to 55 °C	%	$\pm 10$
Operating mode setup time while the control unit is exposed to photon-ionizing radiation with DER equal to 5 μSv/h, not more than	min	5

Table 1.1 (end)

Name	Measurement unit	Standardized value according to the specification
Continuous operation time under normal climatic conditions when powered by a fully charged Li-Ion battery with a capacity of 4000 mAh in the absence of vehicle power supply, under gamma background conditions not exceeding 0.5 $\mu$ Sv/h and when the scale backlight is on	hrs	70
Unstable readings during DER measurement for an 8-hour continuous operation, not more than	%	5
Dimensions (in hard shell with solar panel), not more than	mm	166 $\times$ 70 $\times$ 132
Weight (in hard shell with solar panel), not more than	kg	1.3

1.2.1.1 The MKS-UM control unit allows storing up to 1500 measurement results in the non-volatile memory. For easier identification, each measurement result is recorded with information about measurement time, geographical coordinates of measurement (provided the MKS-UM control unit is used outside the vehicle) and a reference three-digit number of measurement object, which is entered during recording.

1.2.1.2 The MKS-UM control unit provides for automatic recording of photonizing radiation DE accumulation history in the nonvolatile memory of the dosimeter. The nonvolatile memory capacity ensures saving up to 2200 DE values. Saving frequency depends on DER and falls within 10 to 1 minute. DE is saved additionally when you turn the dosimeter on and off.

1.2.1.3 The MKS-UM control unit allows viewing measurement results earlier stored in the nonvolatile memory on its own LCD, as well as transferring this information to the data collection and processing system (on-board computer) via the VRS Module.

1.2.1.4 The MKS-UM control unit has an analog indicator of measured radiation intensity.

1.2.1.5 The MKS-UM control unit allows programming the values of threshold alarm levels for each measured radiation parameter.

1.2.1.6 The MKS-UM control unit sends a light and a sound signal when the programmed threshold levels are exceeded.

1.2.1.7 The MKS-UM control unit in a stand-alone mode is powered from lithium-ion battery of 26650 size with an integrated protection board against overcharging, prevention of discharge and short-circuit. Battery rated voltage – 3.7 V, capacity – at least 4000 mAh.

1.2.1.8 The MKS-UM control unit warns of the battery discharge.

1.2.1.9 The battery can be charged from:

- AC mains from of 100 V to 220 V voltage, frequency of 50 Hz to 60 Hz;
- vehicle network with DC voltage from 9 V to 32 V.

What is more, the battery can be charged from the solar panel (in the case of its stand-alone use).

1.2.1.10 The MKS-UM control unit ensures measurements if influenced by:

- ambient air temperature from – 30 °C to + 55 °C;
- relative humidity up to 95 % at 35 °C temperature, non-condensing;
- reduced atmospheric pressure of 57.2 kPa;
- salt spray for 48 h according to MIL-STD 810G Method 509.5;
- vibration according to MIL-STD 810G Method 514.6, Procedure I-General Vibration (Category 20);
- three single shocks with an acceleration of 20g lasting  $\pm 11$  ms on each axis according to MIL-STD 810G Method 516.6, Procedure I – Functional Shock.

1.2.1.11 The MKS-UM control unit remains operable after the influence of the following external factors:

- maximum low temperature –40 °C;
- maximum high temperature +60 °C;
- three temperature cycles in the temperature range from the extreme low of minus 40 °C to the extreme high of +60 °C;

- transportation under the impact of the maximum reduced atmospheric pressure of 57.2 kPa and reduced temperature of minus 40 °C;
  - Blowing dust (particle size less than 150 μm) according to MIL-STD 810G Method 510.5, Procedure I-Blowing Dust;
  - vibrations according to MIL-STD 810G Method 514.6, Procedure I-General Vibration (Category 4, 8, 11);
  - 26 drops (once on each plane, edge and corner) from a height of 122 cm in the package according to MIL-STD Method 516.6, Procedure IV-Transit drop;
  - photon-ionizing radiation with DER of 100 Sv/hour during 5 minutes.
- 1.2.1.12 Ingress protection rating is IP56 according to EN 60529:2018.

1.2.2 Key technical data and specifications of VRS Module are presented in Table 1.2.

Table 1.2 - Key technical data and specifications of VRS Module

Name	Measure-ment unit	Standardized values
1 Display range of gamma radiation DER values	μSv/h	0.01 – 2•10 <sup>7</sup>
2 Number of digits to display gamma radiation DER value in one channel	pcs	3
3 Number of channels for displaying the value of gamma radiation DER	pcs	2
4 Operating mode setup time, not more than	min	1
5 Maximum allowable cable length to BDBG-T probes (RS-485 interface)	m	200
6 Maximum allowable cable length from the unit to the PC (RS-485 interface)	m	200
7 Supply voltage Note - Rated supply voltage 24 V	V	from 9 to 32
8 Current consumption, not more than	A	1.0
9 Dimensions, not more than	mm	255×135×155
10 Weight: - without the MKS-UM control unit installed, maximum - with the MKS-UM control unit installed, maximum	kg	2.3 3.6

1.2.2.1 VRS Module (both independently and together with the installed MKS-UM control unit) can be used under the following conditions:

- operating temperature range: from minus 30 °C to +55 °C;
- limit temperatures range: from minus 30 °C to +60 °C;
- relative humidity: up to (95±3) % at a temperature of +35 °C and lower temperatures, non-condensing;
- atmospheric pressure - from 60 kPa to 106.7 kPa.

1.2.2.2 VRS Module (both independently and together with the installed MKS-UM control unit) is resistant to (when off) sinusoidal vibration in the frequency range from 5 Hz to 500 Hz with an acceleration amplitude of 59 m/s<sup>2</sup> (6 g).

1.2.2.3 VRS Module (both independently and together with the MKS-UM installed) is resistant to (when off) mechanical shocks of single action with a shock acceleration duration of 1 ms to 5 ms and a shock acceleration peak value of 740 m/s<sup>2</sup> (75 g).

1.2.2.4 VRS Module (both independently and together with the MKS-UM installed) is resistant to (when off) multiple mechanical shocks with a shock acceleration duration of 5 ms to 15 ms and a shock acceleration peak value of 196 m/s<sup>2</sup> (20 g).

1.2.2.5 VRS Module provides a light signaling (flashing of digital LED indicators) about exceeding the threshold levels of gamma radiation DER for each of the connected probes.

1.2.2.6 Ingress protection rating of VRS Module is IP54 in accordance with EN 60529:2018.

1.2.3 Key technical data and specifications of the probes are presented in Table 1.3.

Table 1.3 - Key technical data and specifications of the probes

Name	Measurement unit	Standardized values
Measurement range of gamma radiation DER	$\mu\text{Sv/h}$	$0.05 - 2 \cdot 10^7$
Main relative permissible error limit when measuring gamma radiation DER at $^{137}\text{Cs}$ calibration with a confidence probability of 0.95	%	$\pm(15 + 2/\dot{H}^*(10))$ , where $\dot{H}^*(10)$ – is a numerical value of gamma radiation DER, $\mu\text{Sv/h}$
Energy range of registered gamma radiation	MeV	0.05 – 3.00
Energy dependence of the measurement results of the probe when measuring gamma radiation DER in the energy range from 0.05 MeV to 1.25 MeV, at least	%	$\pm 30$
Change in sensitivity caused by energy (in the energy range from 50 keV to 1.5 MeV) and the angle of incidence (when gamma-quanta fall in the solid angle of $\pm 45^\circ$ relative to the main direction of measurement, marked by "+" symbol) of photon radiation	%	from - 25 to +50
Operating supply voltage range of the probe from an external stabilized power supply	V	7 - 32
Current consumption of the probe for the entire range of gamma radiation DER measured, not more than	mA	30
Operating mode setup time and measurement time of the probe, not more than	min	2
Unstable readings of the probe during continuous operation of 24 hours, not more than	%	5
Additional permissible error limit during measurement caused by the change in ambient temperature from minus 40 °C to +70 °C	%	5 per each 10 °C of deviation from +20 °C
Interface	-	RS-485
Dimensions of the probe, not more than	mm	$50 \times 116 \times 50$
Weight of the probe, not more than	kg	0.27

1.2.3.1 The probe is resistant to (when on) the following external influences:

- operating temperatures: from minus 40 °C to +70 °C;
- limit temperatures: from minus 40 °C to +75 °C;
- relative humidity up to 100 % at a temperature +40 °C and lower temperatures, non-condensing;
- salt spray for 48 h according to MIL-STD 810G Method 509.5;
- photon-ionizing radiation with DER equal to 100 Sv/h for 5 minutes.

1.2.3.2 The probe is resistant to (when off) sinusoidal vibration in the frequency range from 5 Hz to 500 Hz with an acceleration amplitude of  $59 \text{ m/s}^2$  (6 g).

1.2.3.3 The probe is resistant to (when off) to mechanical shocks of single action with a shock acceleration duration of 1 ms to 5 ms and a shock acceleration peak value of  $740 \text{ m/s}^2$  (75 g).

1.2.3.4 The probe is resistant to (when off) multiple mechanical shocks with a shock acceleration duration of 5 to 15 ms and a shock acceleration peak value of  $196 \text{ m/s}^2$  (20 g).

1.2.3.5 The probe provides a function of monitoring the performance of built-in detectors with the generation of check information.

1.2.3.6 The ingress protection rating of the probe is IP67 according to EN 60529:2018.

### 1.3 The system delivery kit

1.3.1 The system delivery kit includes components and operating documentation listed in Table 1.4.

Table 1.4 - Delivery kit of MKS-UM VRS system

Component identification	Component name	Quantity, pcs	Note
BICT.468166.040-02	MKS-UM control unit	1	
BICT.468365.006	VRS Module control and indication module	1	
BICT.418266.063	BDBG-T detecting unit	2	
	Mounting parts kit	1	According to Table 1.5
BICT.412118.040 HE	MKS-UM VRS Radiation Monitoring System. Operating Manual	1	
BICT.412129.036-02 HE	MKS-UM Multipurpose Dosimeter-Radiometer. Operating Manual	1	To work with the control unit of the MKS-UM multipurpose dosimeter-radiometer.
	Packaging	1	
Note - The delivery kit can be changed depending on the requirements of the Customer. At the request of the Customer, the complete kit of the MKS-UM multipurpose dosimeter-radiometer BICT.412129.036-06 can be delivered.			

1.3.2 The mounting parts kit of the system is presented in Table 1.5.

Table 1.5 - Mounting parts kit of the MKS-UM VRS system

Component	Quantity, pcs	Note
Connector Y3HIQ07-4/10PII121-B ЛТАБА	1	
Connector Y3HIQ07-7/12PII121-B ЛТАБА	4	
Connector Y3HIQ07-10/14PII121-B ЛТАБА	1	

Note - In agreement with the Customer, cables of appropriate lengths may be included in the mounting parts kit to produce the necessary connecting cables.

## 1.4 The system's design and the principle of its operation

### 1.4.1 The system's design

The system consists of the VRS Module, the MKS-UM control unit, two probes and cables according to the wiring diagram in Annex A.

### 1.4.2 System operation

The probes measure external gamma radiation DER. The measurement results are transmitted to the VRS Module and displayed on its digital indicators. When gamma radiation DER thresholds are exceeded, the DER values on the indicators of the VRS Module's front panel start flashing.

Gamma radiation DER as well as the dose of the crew in the vehicle is measured using the MKS-UM control unit.

The MKS-UM control unit as a part of the system is used in the following modes:

- display of DER measurement results from the built-in detector;
- display of the accumulated DE and DE accumulation time;
- viewing the measurement results recorded in non-volatile memory.

After switching on, the MKS-UM control unit always switches to the mode of display of DER measurement results received from the built-in detector.

VRS Module provides transmission of measurement results from two probes and the MKS-UM control unit to the data collection and processing system.

## 1.5 Design of the MKS-UM control unit and the principle of its operation

1.5.1 Design of the MKS-UM control unit and the principle of its operation are given in the Operating Manual BICT.412129.036-02 HE from the kit of MKS-UM multipurpose dosimeter-radiometer BICT.412129.036-06, which is included in the delivery kit of the system.

## 1.6 Design of VRS Module and the principle of its operation

### 1.6.1 Description of the design

1.6.2 The appearance of the VRS Module is shown in Figure 1.

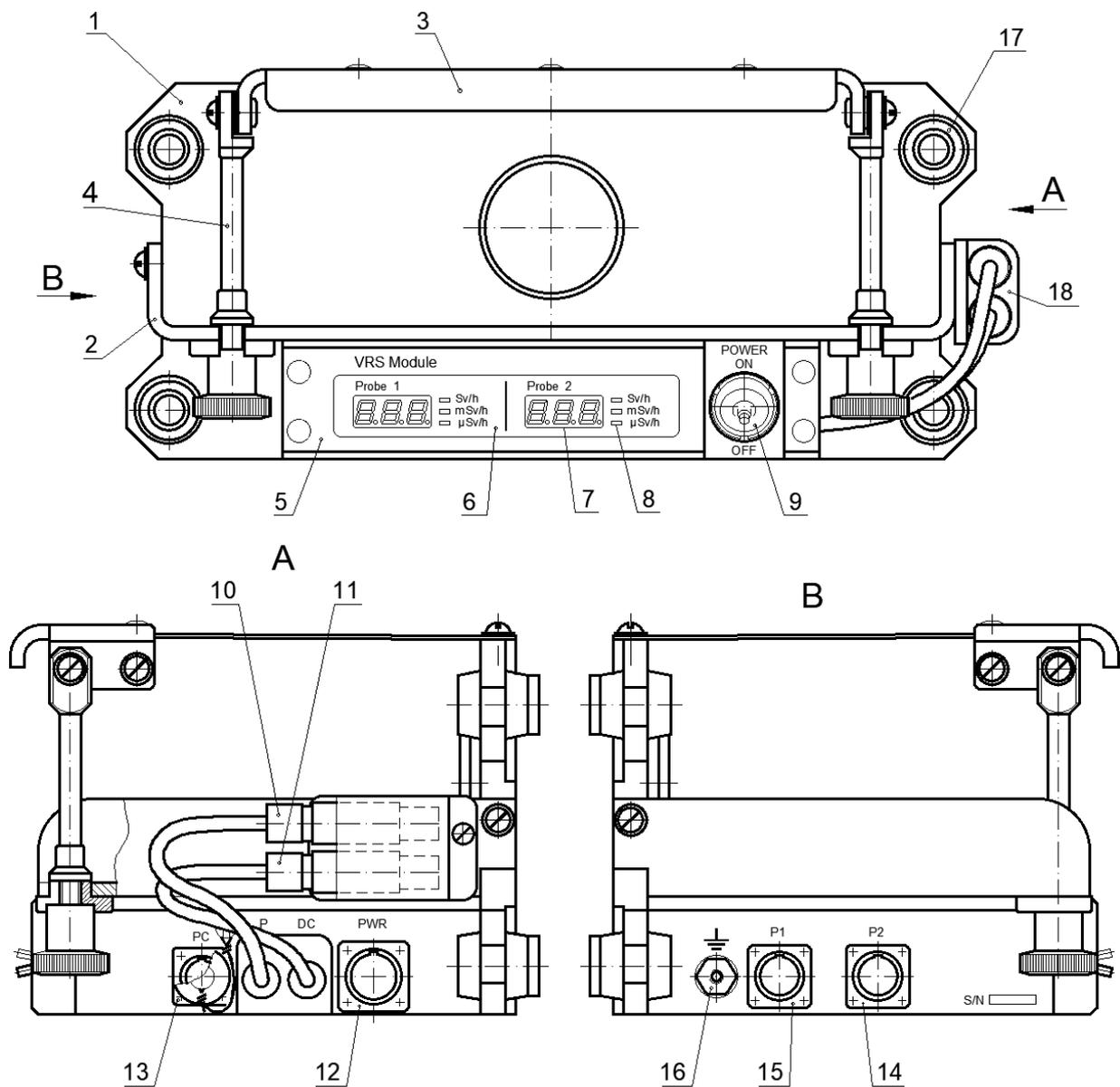


Figure 1, sheet 1 - Appearance of VRS Module

## View of VRS Module with MKS-UM control unit

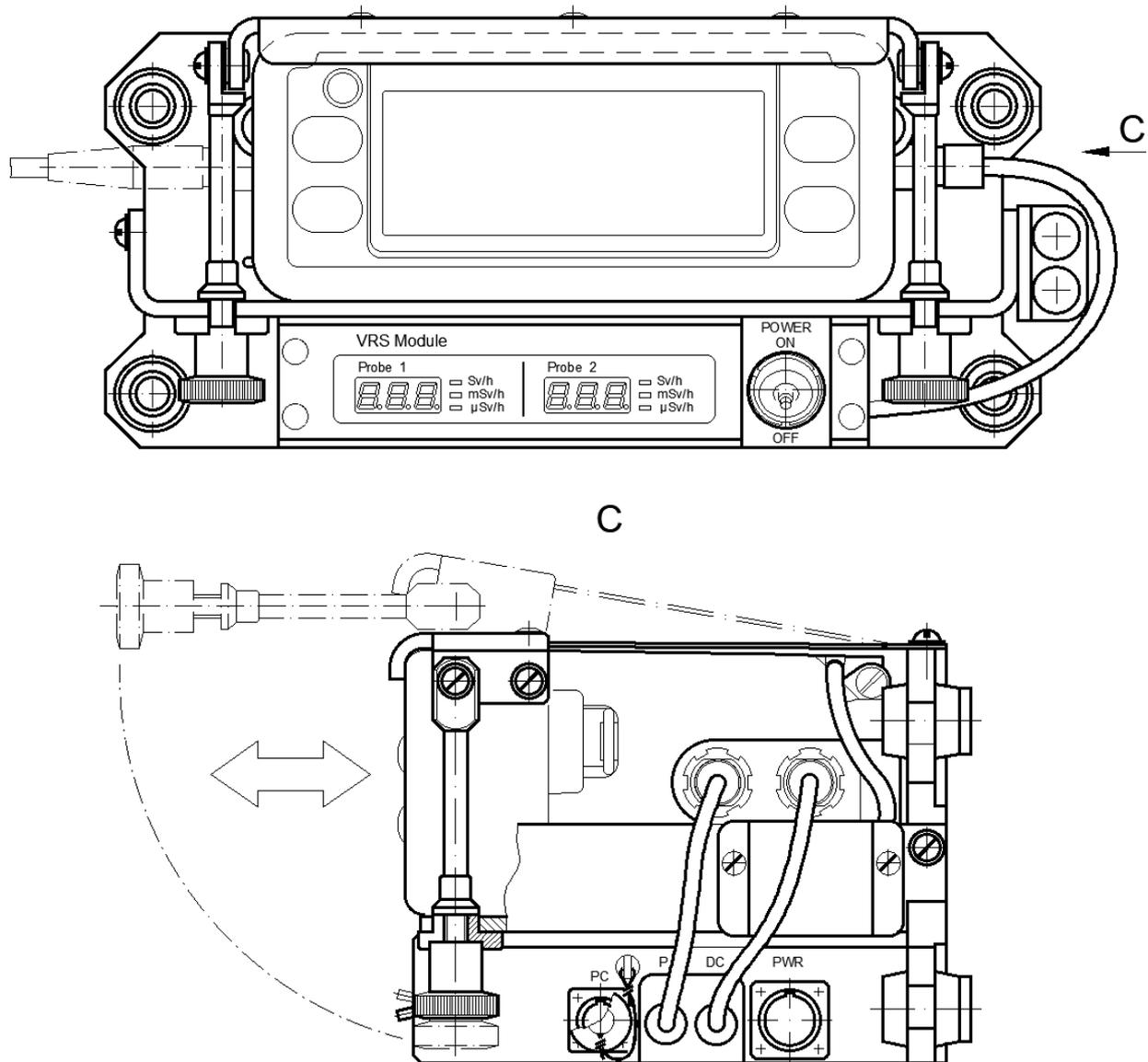


Figure 1, sheet 2

The VRS Module design is a frame consisting of a base (1) and a cantilever plate (2). The upper section of the frame is designed to accommodate the MKS-UM control unit. The MKS-UM control unit is fastened by means of an elastic overlay (3) with two folding threaded clips (4) connected to the base. This design allows quick installation/removal of the MKS-UM control unit for operation within the system or for a stand-alone operation. The electronic part of the VRS Module is located in the lower section of the frame. It is made in a metal housing (5).

The following is placed on the display (6) of its front panel:

- digital indicators of numerical DER value (7)
- LED indicators of DER units (8) (green -  $\mu\text{Sv/h}$ , yellow -  $\text{mSv/h}$ , red -  $\text{Sv/h}$ )
- toggle switch (9) for switching on/off power from the vehicle network.

On the side surfaces of the case there are:

- connectors (10), (11) on flexible cables for connection to the MKS-UM control unit;
- connector (12) for connection to the power supply;
- connector (13) with plug for connecting VRS Module to external devices;
- connectors (14), (15) for connection to the probes;
- ground terminal (16).

The design of the VRS Module provides for its fastening to vertical surfaces in the vehicle with four original rubber-metal shock absorbers in the corners of the plate (17). To place and fix the connectors (10), (11) on the ends of the flexible cables, with the MKS-UM control unit removed from the frame, a cassette (18) is provided on the side surface of the cantilever plate.

The color of the outer surfaces of VRS Module - RAL6014 (olive green).

The overall and connecting dimensions of the VRS Module are given in Annex B.

### 1.6.3 Operation principle of VRS Module

The electronic part consists of the supply voltage generator (SVG), digital processing circuit (DPC), digital indicators of the measured DER with LED indicator of units (DI DER), POWER toggle switch, receivers-transmitters (RT) RS-485 interface RS-485.

DPC is built on the basis of a microcontroller.

The VRS Module is powered from the vehicle DC network. Supply voltage range is from 9 V to 32 V.

Through RS-485 RT, the DPC generates queries and receives the results of DER measurements from the probes. The obtained measurement results are displayed on DI DER. The DPC also compares DER measurement results with the programmed threshold levels.

When the threshold levels of gamma radiation DER are exceeded, the DER value on the indicators of the front panel of the unit begins flashing.

Through RS-485 RT, the DPC also provides transmission of measurement results from two probes and the MKS-UM control unit to the data collection and processing system.

The supply voltage generator converts the voltage of the external power supply into a voltage of 3.3 V to power the circuits.

## 1.7 Design of the probe and the principle of its operation

### 1.7.1 Description of the design

The probe (according to Figure 2) consists of two interconnected rectangular parts: the base (1) and the cover (2). The design provides two through holes (3) for mounting the probe on the object. On the rear surface of the device, there is a washer (4) with an output connector (5). On the front surface of the device, there is a "+" symbol (6), which indicates the mechanical center of the gamma detector.

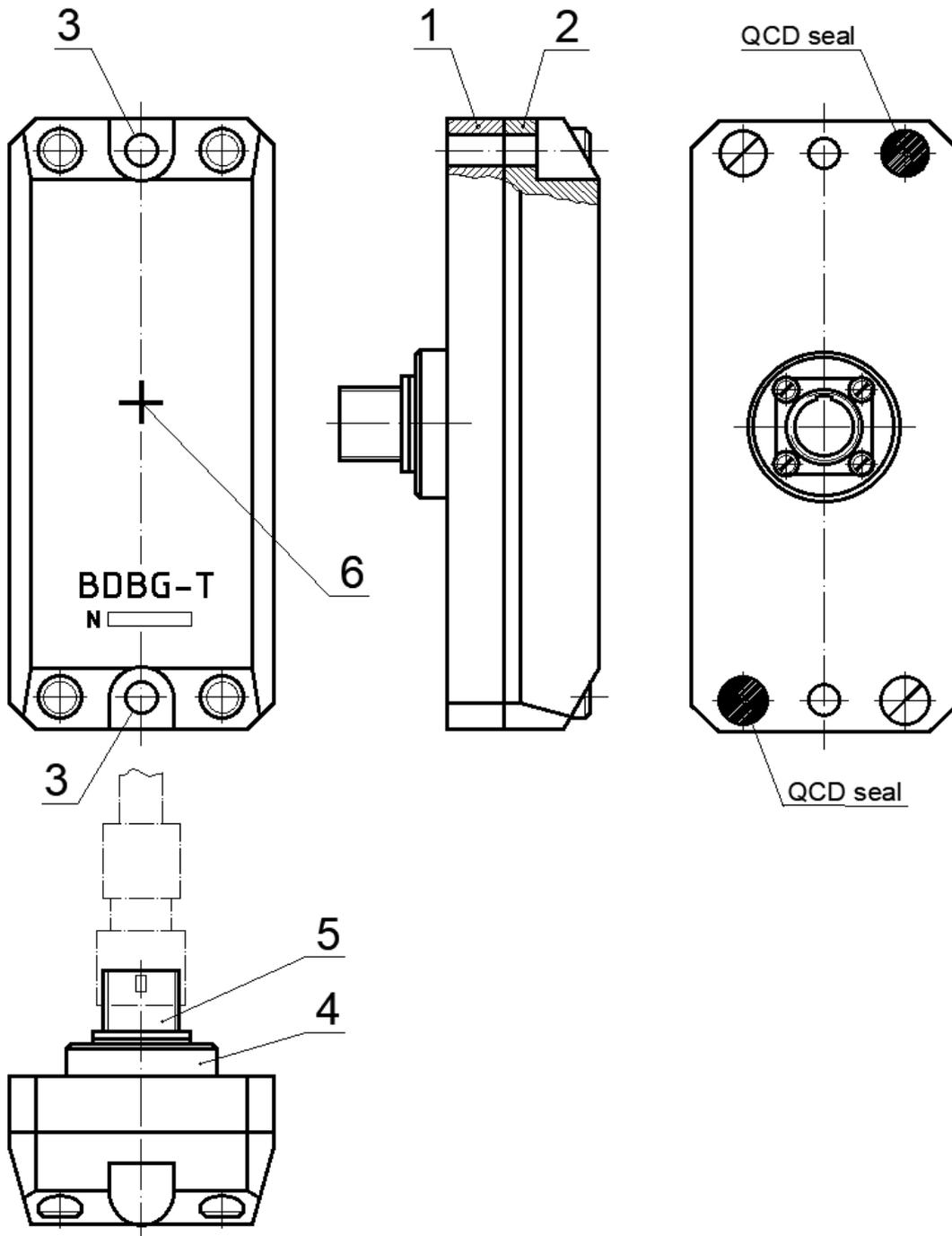


Figure 2 - Appearance of the probe

The color of the outer surfaces is RAL6014 (olive green).

The overall and connecting dimensions of the probe are provided in Annex C.

### 1.7.2 The principle of operation of the probe

The probe consists of a microcontroller, a high-sensitivity detector, a low-sensitivity detector, a supply voltage generator, and an RS-485 interface unit.

The operation of the probe is based on the principle of converting gamma radiation into a sequence of voltage pulses at the output of the detectors. High-sensitivity and low-sensitivity scintillation detectors with temperature-compensated silicon photomultipliers are used as the detectors in the probe.

The microcontroller processes the flow of pulses from the detectors and on the basis of the amplitude analysis of the pulses generates the value of gamma radiation DER. For each gamma radiation DER value, the microcontroller also determines the maximum value of the statistical measurement error of this DER. At the same time, the microcontroller controls the power supply of the detectors and continuously monitors their performance.

Upon query from the control and indication unit, the microcontroller transmits a data frame via the RS-485 interface node. The data frame contains information about the current gamma radiation DER, the maximum statistical error of its measurement, as well as the results of the detectors self-test monitoring.

The supply voltage generator converts the voltage of the external power supply into a voltage of 3.3 V to power the low-voltage part of the probe's circuit, and generates bias voltages for the photomultipliers of high-sensitivity and low-sensitivity detectors.

## 1.8 Labeling and sealing

1.8.1 Labeling meets the requirements of current regulatory and technical documentation and design documents of the manufacturer and is stored during service life in the conditions and modes specified in this manual.

1.8.2 Contents of the labeling for:

- VRS Module - in accordance with Annex B;
- probe - in accordance with Annex C.

1.8.3 Sealing is performed by a representative of the responsible organization. Removal of seals and repeated sealing is carried out by the organization making repairs or verification.

## 1.9 Packaging

1.9.1 Packaging meets the requirements of current regulatory and technical documentation and design documents of the manufacturer.

The MKS-UM multipurpose dosimeter-radiometer kit is packed in accordance with the packaging specifications BICT.412915.042-06.

The packaging of the system as a whole is performed in the packaging of the manufacturer in accordance with the terms of the Supply Agreement.

## **2 PROPER USE**

### 2.1 Operational limitations

2.1.1 The system is a complex electronic-physical device that requires qualified maintenance.

2.1.2 The requirements set out in the technical documentation shall be strictly observed.

2.1.3 The system shall operate in conditions that do not exceed the operating conditions specified in section 1.2.

### 2.2 Preparing the system for operation

#### 2.2.1 Scope and sequence of external examination

2.2.1.1 When the system is put into operation, unpack it and check if the delivery kit is complete, carry out an external examination of the components to determine the presence of mechanical damage.

2.2.2 Installation rules and procedure for checking the system's readiness for operation

2.2.2.1 Before starting work, you should carefully read this OM and the guidelines for the components that are part of the system, as well as familiarize yourself with the location and purpose of the controls and indication elements.

2.2.2.2 Install the system on the vehicle in accordance with the wiring diagram given in Annex A and at predetermined locations. Make cables using the mounting parts kit of the system.

#### 2.2.3 System installation

2.2.3.1 Overall and connecting dimensions of the VRS Module, the probe are specified in Annexes B, C.

2.2.3.2 The VRS Module shall be mounted inside the vehicle to a vertical surface and in a place that ensures no direct precipitation and direct sunlight.

To protect against the negative effects of external electromagnetic interference, it is necessary to ensure reliable grounding of the housing of the unit by connecting an external grounding conductor to the ground terminal.

2.2.3.3 The location and installation of the probes on the vehicle shall be such that the "+" symbol is oriented towards the probable source of gamma radiation.

#### 2.2.4 System testing

Turn on the VRS Module. During the self-test, all indicators and their individual segments should glow. The VRS Module shall turn on for 15 s, and the digital indicators shall display the gamma radiation DER values from the probes.

After switching on, the VRS Module starts operating in the mode of gamma radiation DER measurement. The first measurement results after switching the device on (or after a sharp change in the radiation situation) are statistically inaccurate (measurement error may exceed the permissible one), but these results allow the rapid assessment of gamma radiation DER. A sign of inaccuracy is the periodic illumination of the LEDs of the unit of measurement on the front panel of the device, which continues until the statistically reliable information is received, after which the illumination switches to continuous mode. The time of statistical processing depends on the intensity of radiation and can range from 2 s to 1 min.

Turn on the MKS-UM control unit. Press "ON/SAVE" and hold down for 4 seconds to do that. The activation of the dosimeter's control unit is evidenced by the testing of the display and alarm means (LCD, LEDs and buzzer), which lasts about 6 seconds. Upon completion of the test, the dosimeter starts measuring DE and DER of the photon-ionizing radiation and switches to the mode of DER measurement results display.

#### 2.2.5 List of possible failures and troubleshooting

##### 2.2.5.1 The main failures occur for the following reasons:

- no contact in the connectors;
- damage to the connecting cable;
- failure of system components.

2.2.5.2 The list of possible failures and troubleshooting are specified in Table 2.1.

Table 2.1 - List of possible failures and troubleshooting

Type of problem, external manifestation and additional signs	Probable cause	Troubleshooting
The control and display unit does not switch on	1 The unit is not connected to the mains 2 Power cord break	1 Connect power to the unit 2 Repair the break in power cord
“Er1” message on the DER indicator	The high-sensitivity detector of the probe of the corresponding channel failed	Replace the respective probe
“Er2” message on the DER indicator	The low-sensitivity detector of the probe of the corresponding channel failed	Replace the respective probe
“Er3” message on the DER indicator	1 The probe of the corresponding channel is not connected to the VRS Module  2 The connecting cable between the VRS Module and the probe of the corresponding channel is damaged  3 The probe of the corresponding channel failed	1 Connect the respective probe to the VRS Module  2 Repair the break in the cable or replace the corresponding connecting cable  3 Replace the respective probe
The MKS-UM control unit does not turn on	1 Low battery 2 Vehicle power supply is not switched on	1 Charge the battery 2 Switch on the vehicle power supply
Error codes "Er98" or "Er99" are displayed on the LCD of the MKS-UM control unit	Failure of the gamma radiation detector built into the dosimeter’s control unit. Error "Er98" – a communication error with the microcontroller of the gamma radiation detector. Error "Er99" - no pulses from the gamma counter	Replace the MKS-UM control unit

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

## 2.3 Use of the system

### 2.3.1 Safety measures when using the system

2.3.1.2 The surfaces of the system components are not exposed to voltages hazardous for life.

2.3.1.3 Direct use of the system is not dangerous for the service personnel and is environmentally friendly.

2.3.1.4 In the event of radiation contamination, the system shall be decontaminated by wiping the outer surfaces with a cloth dampened with a synthetic detergent solution.

2.3.1.5 Disposal of the system should be carried out in accordance with the requirements of national regulations.

Note - In case of contamination of the system with liquid or dry radionuclides and the impossibility of its complete decontamination, the system is subject to disposal as solid radioactive waste at specialized companies.

### 2.3.2 Operating modes

The VRS Module operates in the mode of continuous measurement, control and display of gamma radiation DER.

The MKS-UM control unit can operate both as part of the system and in a stand-alone mode, when the MKS-UM control unit is disconnected from the VRS Module and standard probes from the MKS-UM dosimeter-radiometer kit are used.

The operating modes of the MKS-UM dosimeter-radiometer are described in the Operating Manual BICT.412129.036-02 HE.

### 2.3.3 Operation procedure of the system

Move the POWER toggle switch on the front panel of the VRS Module to the ON position. During the self-test, the glow of all indicators and their individual segments should be observed. The VRS Module shall switch on for 15 s, and the digital indicators shall display the gamma radiation DER values from the probes.

After switching on, the VRS Module starts operating in the mode of gamma radiation DER measurement. The first measurement results after switching on the VRS Module (or after a sharp change in the radiation situation) are statistically inaccurate (measurement error may exceed the permissible one), but these results allow the rapid assessment of gamma radiation DER. A sign of inaccuracy is the periodic illumination of the LEDs of the unit of measurement on the front panel of the device, which continues until the statistically reliable information is received, after which the illumination switches to continuous mode. The time of statistical processing depends on the intensity of radiation and can range from 2 s to 1 min.

When the set threshold levels of gamma radiation DER are exceeded, for the probes, the DER value on the indicators of the front panel of the unit starts flashing.

The data exchange protocol between the VRS Module and the data collection and processing system is given in Annex D.

To turn on the MKS-UM control unit, press "ON/SAVE" and hold it down for 4 seconds. The activation is evidenced by the testing of display and alarm means (LCD, LEDs and buzzer), which lasts about 6 seconds. Upon completion of the test, the MKS-UM control unit starts measuring DE and DER of the photon-ionizing radiation and switches to the mode of DER measurement results display

The procedure for working with the MKS-UM dosimeter-radiometer is described in the Operating Manual BICT.412129.036-02 HE.

### 3 TECHNICAL MAINTENANCE

#### 3.1 Technical maintenance of the system

##### 3.1.1 General instructions

The list of works during technical maintenance (hereinafter - TM) of the system, their order and features at different stages of the system use are shown in Table 3.1.

Table 3.1 - List of maintenance works

Operations	TM type			OM item No.
	during		during long-term storage	
	everyday use	periodi-cal use		
External examination	+	+	+	3.1.3.1
Delivery kit completeness check	-	+	+	3.1.3.2
Operability check	+	+	+	3.1.3.3
Verification of the probes	-	+	+	3.2

Note. "+" means the operation is applicable for this type of TM; "-" means the operation is inapplicable

##### 3.1.2 Safety measures

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

##### 3.1.3 Maintenance procedure of the system

###### 3.1.3.1 External examination

3.1.3.1.1 Examination of the system should be performed in the following order:

- a) check the technical condition of surface of the system components, inspect for integrity of seals, absence of scratches, traces of corrosion, surface damage;
- b) check the condition of the connectors at the points of cable connections.

3.1.3.1.2 Decontamination of the surfaces of housings and components of the probes is carried out as needed.

The surfaces of the components of the probes are decontaminated by wiping them with a decontamination solution.

It is recommended to use a detergent solution of the following composition as a deactivating solution:

- synthetic detergent - from 7 g to 10 g;
- water - 1 dm<sup>3</sup>.

For decontamination, the contaminated areas of the surfaces of the probe housings must be thoroughly wiped with a cloth soaked in the decontamination solution, and then with a cloth soaked in warm water and wiped dry.

Notes

1 Carry out decontamination works in rubber gloves worn over cotton gloves in compliance with safety requirements for working with chemical solutions.

2 It is allowed to decontaminate the probes according to the method adopted at the site of operation for instruments of ionizing radiation measurement.

### 3.1.3.2 Delivery kit completeness check

Check if the delivery kit of the system is complete in accordance with section 1.3. At the same time, check the technical condition and correct placement of system components, as well as the availability of operating documentation.

### 3.1.3.3 Operability check of the system

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

#### 3.1.3.3.2 Procedure for pre-repair fault detection and rejection

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

- for mid-life repair:

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

b) minor defects of cables or connectors that do not affect their tightness and correctness of measurements;

- for major repair:

a) at least one non-operating measurement channel;

b) mechanical damage that has led to significant damage to the housings of system components or cables.

### 3.2 Verification of the probes

Verification of the probes is performed according to the verification procedure below.

The probes after repair and the probes that are in operation (periodic verification at least annually) are subject to verification.

The technique and frequency of verification of the control unit and probes supplied with the MKS-UM multipurpose dosimeter-radiometer are described in the Operating Manual BICT.412129.036-02 HE.

#### 3.2.1 Verification operations

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

Table 3.2 – Verification operations

Operation	Verification technique No.
1 External examination	3.2.4.1
2 Testing	3.2.4.2
3 Determination of the main relative error of gamma radiation DER measurement	3.2.4.3
4 Presentation of verification results	3.2.4.4

### 3.2.2 Verification facilities

The following measuring instruments (hereinafter - MI) and equipment should be used for verification:

- standard equipment of gamma radiation with  $^{137}\text{Cs}$  nuclide;
- stopwatch;
- aspiration psychrometer;
- control barometer-aneroid;
- special high-power metrological equipment ( $^{60}\text{Co}$  20, Sv/h).

### 3.2.3 Verification conditions

Verification should be performed in compliance with the following conditions:

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

### 3.2.4 Verification procedure

#### 3.2.4.1 External examination

During external examination, the probes should meet the following requirements:

- labeling should be accurate;
- Quality Control Department seals should not be violated;
- the probes should be free from mechanical damage that may affect their performance.

### 3.2.4.2 Testing

Carry out testing and prepare the system for gamma radiation DER measurement in accordance with section 2.2.4.

For each of the probes, follow these steps:

3.2.4.3 Determination of the main relative error when measuring gamma radiation DER.

3.2.4.3.1 Prepare the standard equipment of gamma radiation for operation.

3.2.4.3.2 Secure the probes in the carriage holder of the standard equipment so that the mechanical center of the gamma ray beam coincides with the center of the detectors. The center of the detectors is marked with a “+” symbol on the housing of the probe. Turn on the system and place the carriage of the standard equipment in the position where gamma radiation DER from the source with  $^{137}\text{Cs}$  radionuclide is equal to  $\dot{H}^*(10) = (800 \pm 80) \mu\text{Sv/h}$ .

3.2.4.3.3 One minute after the start of irradiation, perform five DER measurements for each of the probes at 10s intervals. Calculate the average DER value by the formula (3.1).

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

Calculate the limit of the main relative permissible error of gamma radiation DER measurement,%, by the formula:

$$\Delta = 1,1\sqrt{\delta\dot{H}^* (10)^2 + \delta\dot{H}_0^* (10)^2} , \quad (3.2)$$

where  $\delta\dot{H}_0^* (10)$  – the limit of the main relative permissible error of gamma radiation DER of the standard equipment;

where  $\delta\dot{H}^* (10)$  – the relative error of the measurement result, calculated by the formula:

$$\delta\dot{H}^*(10) = \frac{\dot{H}^*(10) - \dot{H}_0^*(10)}{\dot{H}_0^*(10)}, \quad (3.3)$$

$\dot{H}_0^*(10)$  – rated value of DER.

Record the results in the report.

3.2.4.3.4 Perform operations 3.2.4.3.3 for DER  $\dot{H}^*(10) = (80 \pm 8) \mu\text{Sv/h}$ .

3.2.4.3.5 Secure the probe in the carriage holder of special metrological equipment so that the mechanical center of the gamma-ray beam coincides with the center of the gamma detectors marked with a “+” symbol.

Place the carriage of special metrological equipment with the probes in the position where the DER from the  $^{60}\text{Co}$  source is equal to  $\dot{H}_0^*(10) = (18000 \pm 2000) \text{ mSv/h}$ . Turn on the system and follow the steps in 3.2.4.3.3.

3.2.4.3.6 The control result is considered satisfactory if the limit of the main relative permissible error of DER measurement does not exceed 15 %.

3.2.4.4 Presentation of verification results

3.2.4.4.1 Satisfactory results of verification are certified by issuing a certificate of verification.

3.2.4.4.2 The probes that do not meet the requirements of the verification technique shall not be allowed for use and shall get a certificate of inadequacy.

## 4 STORAGE

4.1 The system shall be stored in the manufacturer's packaging in the premises (warehouses) under the following conditions:

- air temperature - from minus 30 °C to + 50 °C;
- average annual relative humidity – 80 % at a temperature of +6 °C;
- the storage place must be protected from direct sunlight, rain, mold, dust.

Storage rooms must be free of acids, alkalis, corrosive gases and vapors of organic solvents.

4.2 The average shelf life is 10 years.

## **5 OPERATING AND SERVICE LIFE**

5.1 Mean time to failure - not less than 4000 hours.

5.2 Average first overhaul period- not less than 16,000 hours, average service life before the first overhaul - not less than 6 years.

5.3 Average service life - not less than 20 years with maintenance works in 10 years.

5.4 Warranty period of storage - 6 months from the date of manufacture of the system. Warranty period of operation is not less than 24 months from the date of commissioning, but not more than 30 months from the date of manufacture.

## 6 SHIPPING

6.1 The system in the manufacturer's packaging can be shipped by rail, air, water and road vehicles at any distance in compliance with the following rules:

- by railroad vehicle - in closed clean cars;
- by air transport - in airtight heating compartments;
- by waterborne craft - in a dry hold;
- by motor vehicle - in closed cars.

6.2 The placement and securing of boxes with the systems on vehicles shall ensure their stable position throughout the way, without displacement or shocks with each other.

6.3 During transportation follow the rules in accordance with the handling marks on the packaging (transport packaging).

6.4 Canting is forbidden.

6.5 During loading and unloading operations, the systems must not be exposed to precipitation.

6.6 It is allowed to send systems by postal parcels in compliance with the rules established by the carriers.

6.7 Transportation for all types of transport should be carried out under the following conditions:

- ambient temperature - in the range from minus 30 °C to + 50 °C;
- relative humidity - not more than 98 % at a temperature of +25 °C;
- atmospheric air pressure - not less than 12 kPa (90 mm Hg).

## 7 CERTIFICATE OF ACCEPTANCE

The control and indication module VRS Module with \_\_\_\_\_ serial number is manufactured and accepted in accordance with the mandatory requirements of state standards, a set of current technical documentation BICT.468365.006, is recognized as suitable for use.

QCD head

Seal here

\_\_\_\_\_  
(year, month, date)

BDBG-T detecting units of gamma radiation with \_\_\_\_\_ serial numbers are manufactured and accepted in accordance with the mandatory requirements of state standards, a set of current technical documentation BICT.418266.063, are recognized as suitable for use.

QCD head

Seal here

\_\_\_\_\_  
(year, month, date)

## 8 PACKING CERTIFICATE

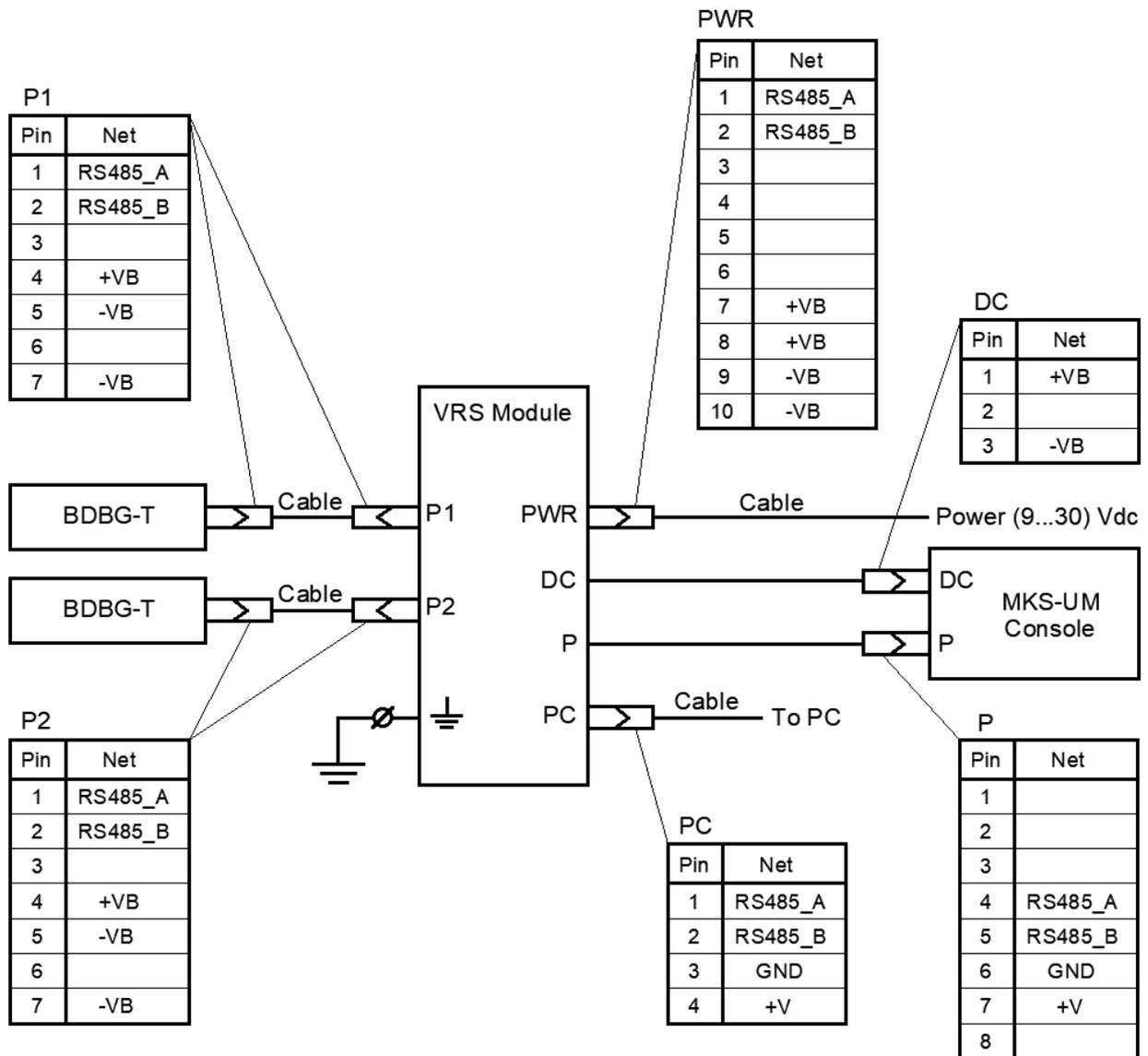
MKS-UM VRS Vehicle Radiation Monitoring System BICT.412118.040 according to the delivery kit is packed at the Private Enterprise "SPPE "Sparing-Vist Center".

\_\_\_\_\_

\_\_\_\_\_  
(year, month, date)

# ANNEX A

Wiring diagram of the MKS-UM VRS system



# ANNEX B

## Overall and connecting dimensions of VRS Module

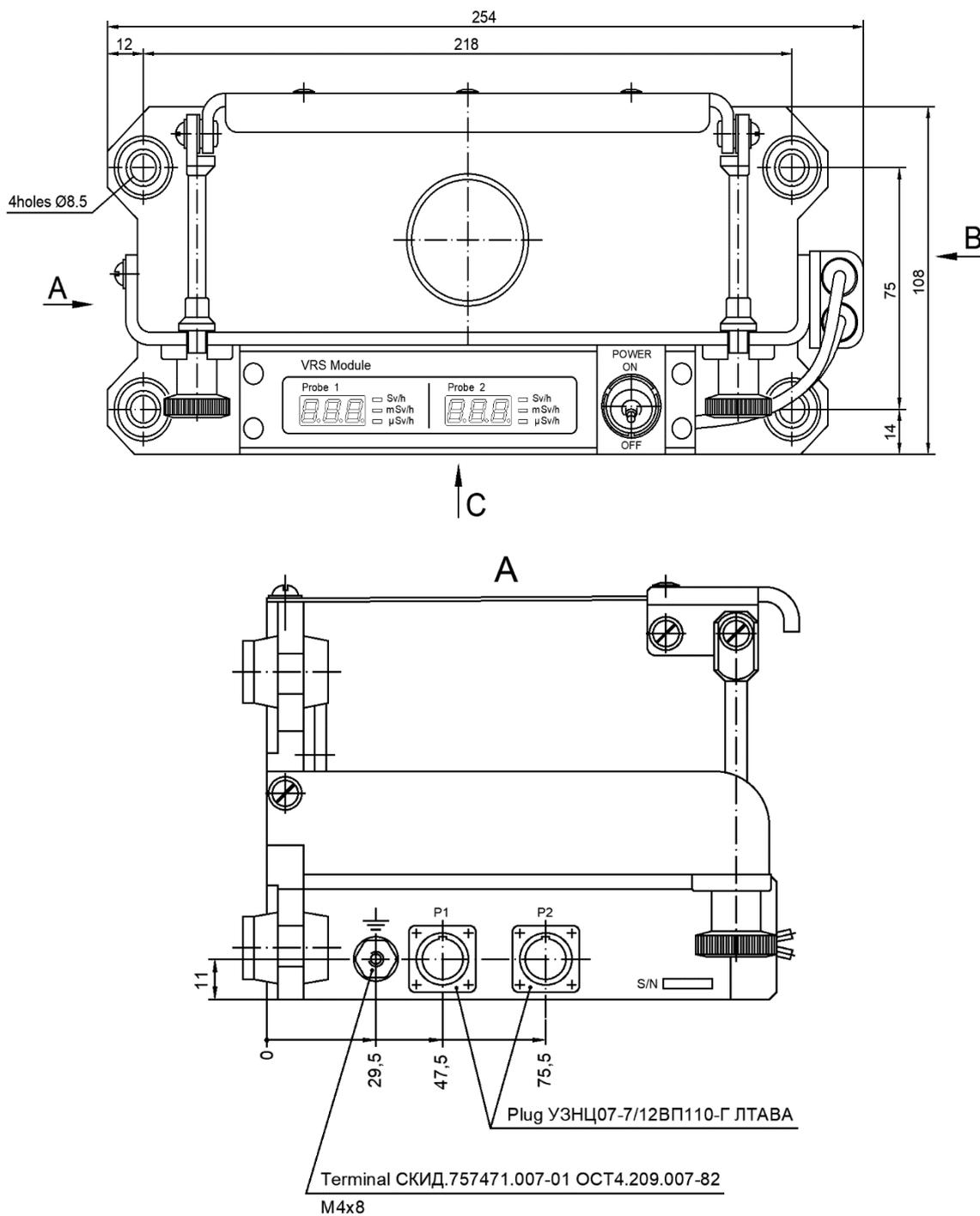
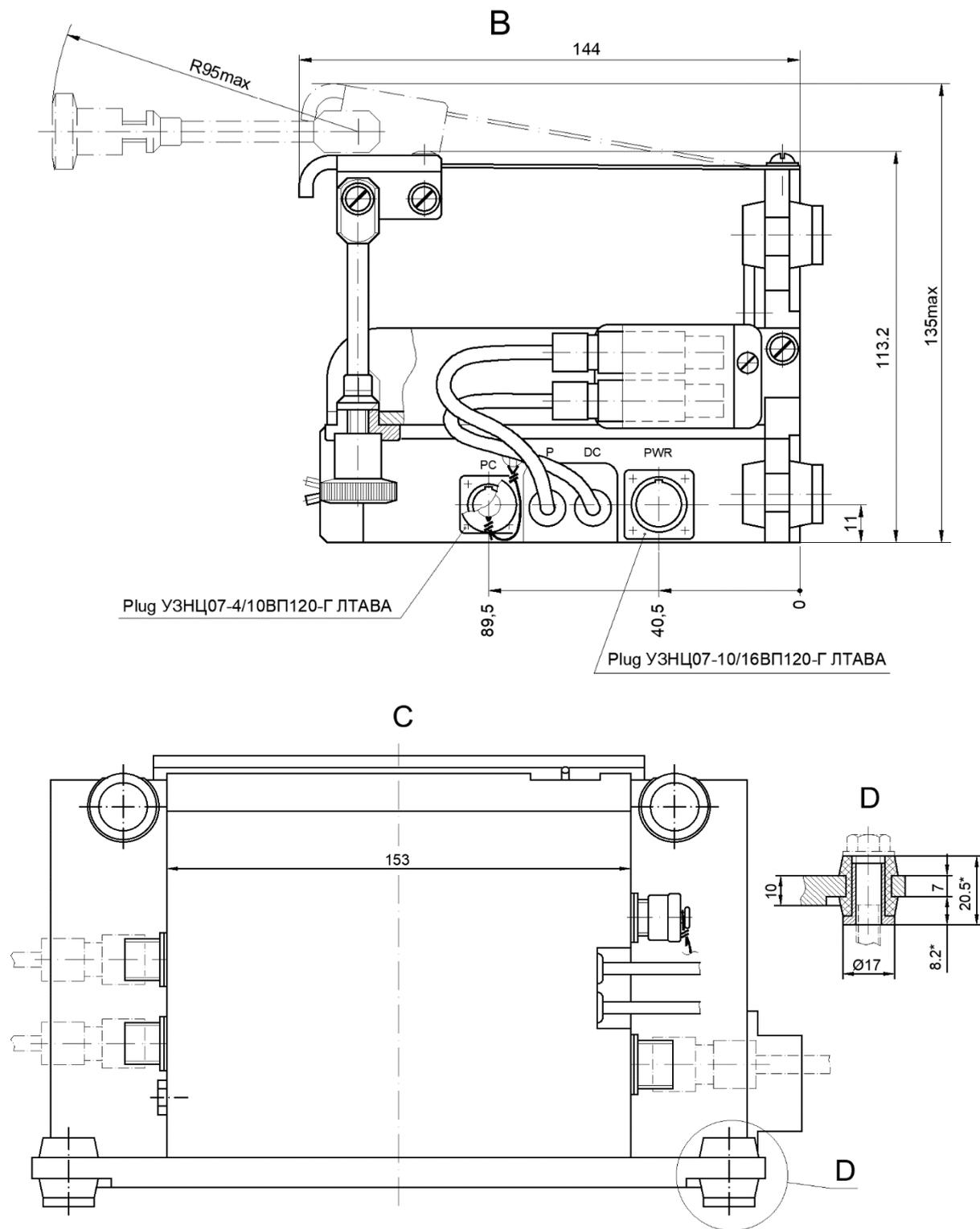


Figure B.1, sheet 1

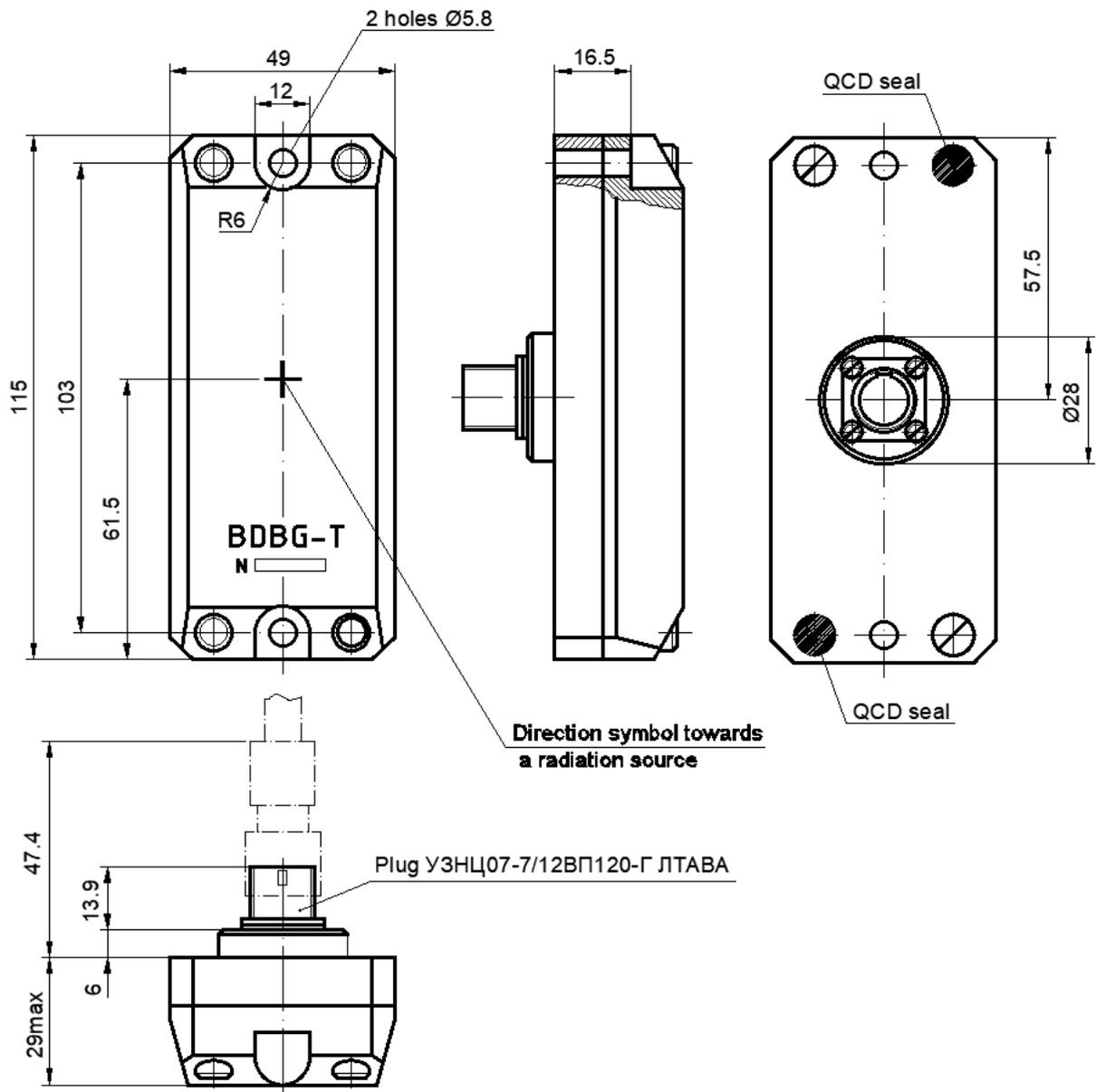


\* Dimensions with compressed shock absorbers.

Figure B.1, sheet 2

# ANNEX C

## Overall and connecting dimensions of the probe



## ANNEX D

### Data communications protocol between VRS Module and the PC

D.1 Data exchange between the product and the PC is carried out via the RS-485 interface in half-duplex mode.

Communications parameters:

- speed: 19200 bps;
- data word length: 8 bits;
- parity bit: N/A;
- stop bits: 1.

The time interval between bytes in one frame should not exceed 1 ms. The time interval between frames must be at least 500 ms.

#### Identification query

Query from PC to VRS Module.

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
0xF1	Command code
TIME0	TIME - seconds that have elapsed since the beginning of 2002 (computer time) If TIME0= TIME1= TIME2= TIME3=0, we do not synchronize time with the computer
TIME1	
TIME2	
TIME3	
byte	Checksum

Response from VRS Module to PC:

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
0xF1	Command code
AD0	If the address has, for example, the form 1234567.89613, then AD0=13, AD1=96, AD2=F8, AD3=67, AD4=45, AD5=23, AD6=B1 (\F' -\.'')
AD1	
AD2	
AD3	
AD4	
AD5	
AD6	
byte	Checksum

## MKS-UM data query

### Query from PC to VRS Module

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
0xF2	Command code
Byte	Reserve
Byte	Checksum

### Response from VRS Module to PC:

0x55	Byte 55h - start-of-frame character		
0xAA	Byte AAh - start-of-frame character		
0x01	D7...D0- detecting unit address		
0xF2	Command code		
0x18	The length of the information part		
Byte	Device status (first byte of inform. part) D0 = 1 dose threshold exceeded D1 = 1 pre-dose threshold exceeded D2 = 1 DER threshold exceeded D3 = 1 failure of the built-in detector D4 = 1 DER overflow when calculating DOSE		
Time0 (low)	seconds that have elapsed since 0:00:00		
Time1	January 1, 2002		
Time2	D7 - origin of time character:		
D7	D7 = 0 - time entered manually; D7 = 1 - time determined by GPS. Byte		
mantissa high byte	Dose(float MSP430)		
Exponent			
mantissa low byte			
mantissa middle byte			
DTime0 (low)	Dose accumulation time		
DTime1	D7 (DTime3 (high))=0 => $\mu$ Sv		
DTime2	D7 (DTime3 (high))=1 => $\mu$ Gy		
D7	D6	DTime3 (high)	D6 = 1 DER > 1 Sv/g during dose accumulation
mantissa high byte	DER (float MSP430)		
Exponent			
mantissa low byte			
mantissa middle byte			
Byte	Statistical measurement error		
Byte	Number of segments of the analog scale		
Byte	D3...D0 - unit of measurement: =0 - $\mu$ Sv/h; =1 - $\mu$ Gy/h; =6 - cps.		
Byte	D7=1 inaccurate information character		
Byte	reserve		
Byte	Self-testing result of the detecting unit D0=1 - failure of the HS gamma detector D1=1 - failure of the LS gamma detector D2=1 - beta detector failure D3=1 - alpha detector failure D6=1 - gamma background exceeding character when measuring beta		
Byte	Checksum		

## BDBG-T data query

### Data query from PC to VRS Module

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
0xE1	Command code
byte	Checksum

### Response from VRS Module to PC:

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
0xE1	Command code
Low byte	DER of BDBG-T (1) fixed point number, least significant bit (LSB) = D7 (see <u>Self-test 1</u> )
byte	
byte	
High byte	
byte	Stat. error (1)
byte	Self-test(1) D0=1 - HS failure D1=1 - LS failure D2=1 - data is inaccurate D3=1 - the device does not respond  D7=0 - LSB DER = 0.01 $\mu$ Sv/h D7 = 1 - LSB DER = 0.1 $\mu$ Sv/h
Low byte	DER of BDBG-T (2) fixed point number, least significant bit = D7 (see <u>Self-test 2</u> )
byte	
byte	
High byte	
byte	Stat. error (2)
byte	Self-test (2) D0=1 - HS failure D1=1 - LS failure D2=1 - data is inaccurate D3=1 - the device does not respond  D7=0 - LSB DER = 0.01 $\mu$ Sv/h D7 = 1 - LSB DER = 0.1 $\mu$ Sv/h
byte	Checksum

## MKS-UM threshold levels query

### Query from PC to VRS Module

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
0xF3	Command code
byte	reserve
byte	Checksum

### Response from VRS Module to PC (52 byte):

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
0xF3	Command code
mantissa high byte	GAMMA threshold ( $\mu\text{Sv/h}$ )
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	GAMMA threshold (cps)
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	GAMMA threshold ( $\mu\text{Gy/h}$ )
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	BETA threshold ( $\text{Bq/cm}^2$ )
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	BETA threshold (cps)
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	BETA threshold ( $\text{part./}(\text{cm}^2 \cdot \text{min})$ )
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	ALPHA threshold ( $\text{Bq/cm}^2$ )
Exponent	
mantissa low byte	
mantissa middle byte	

mantissa high byte	ALPHA threshold (cps)
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	ALPHA threshold (part./ (cm <sup>2</sup> *min))
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	DOSE threshold (μSv)
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	DOSE threshold (μGy)
Exponent	
mantissa low byte	
mantissa middle byte	
Byte	Gamma error
Byte	Beta error
Byte	Alpha error
byte	Checksum

## Sending new MKS-UM threshold levels

from PC to VRS Module (52 bytes)

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
0xF4	Command code
mantissa high byte	GAMMA threshold ( $\mu\text{Sv/h}$ )
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	GAMMA threshold (cps)
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	GAMMA threshold ( $\mu\text{Gy/h}$ )
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	BETA threshold ( $\text{Bq/cm}^2$ )
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	BETA threshold (cps)
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	BETA threshold ( $\text{part./}(\text{cm}^2 \cdot \text{min}))$ )
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	ALPHA threshold ( $\text{Bq/cm}^2$ )
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	ALPHA threshold (cps)
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	ALPHA threshold ( $\text{part./}(\text{cm}^2 \cdot \text{min}))$ )
Exponent	
mantissa low byte	
mantissa middle byte	

mantissa high byte	DOSE threshold ( $\mu\text{Sv}$ )
Exponent	
mantissa low byte	
mantissa middle byte	
mantissa high byte	DOSE threshold ( $\mu\text{Gy}$ )
Exponent	
mantissa low byte	
mantissa middle byte	
Byte	Gamma error
Byte	Beta error
Byte	Alpha error
Byte	Checksum

**Response from VRS Module to PC:**

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
byte	0xFD - normal, 0xFC -error
Byte	Checksum

## BDBG-T threshold levels query

### Query from PC to VRS Module

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
0xE2	Command code
byte	Checksum

### Response from VRS Module to PC:

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
0xE2	Command code
Low byte	BDBG-T threshold (1) LSB DER = 0.01 $\mu$ Sv/h
byte	
byte	
High byte	BDBG-T threshold (2) LSB DER = 0.01 $\mu$ Sv/h
Low byte	
byte	
byte	LSB DER = 0.01 $\mu$ Sv/h
High byte	
byte	Checksum

## Sending BDBG-T threshold levels

### From PC to VRS Module

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
0xE3	Command code
Low byte	BDBG-T threshold (1) LSB DER = 0.01 $\mu$ Sv/h
byte	
byte	
High byte	BDBG-T threshold (2) LSB DER = 0.01 $\mu$ Sv/h
Low byte	
byte	
byte	LSB DER = 0.01 $\mu$ Sv/h
High byte	
byte	Checksum

### Response from VRS Module to PC:

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
byte	0xFD - normal, 0xFC -error
byte	Checksum

## OPERATIONS MANAGEMENT

from PC to VRS Module

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
0xF5	Command code
byte	D0- clear accumulated dose D1- clear operations archive D2- turn off sound alarm until the next alarm event
byte	Checksum

Response from VRS Module to PC:

0x55	Byte 55h - start-of-frame character
0xAA	Byte AAh - start-of-frame character
0x01	D7...D0- detecting unit address
byte	0xFD - normal, 0xFC - error
byte	Checksum

D.2 The checksum is calculated according to Figure D.1.

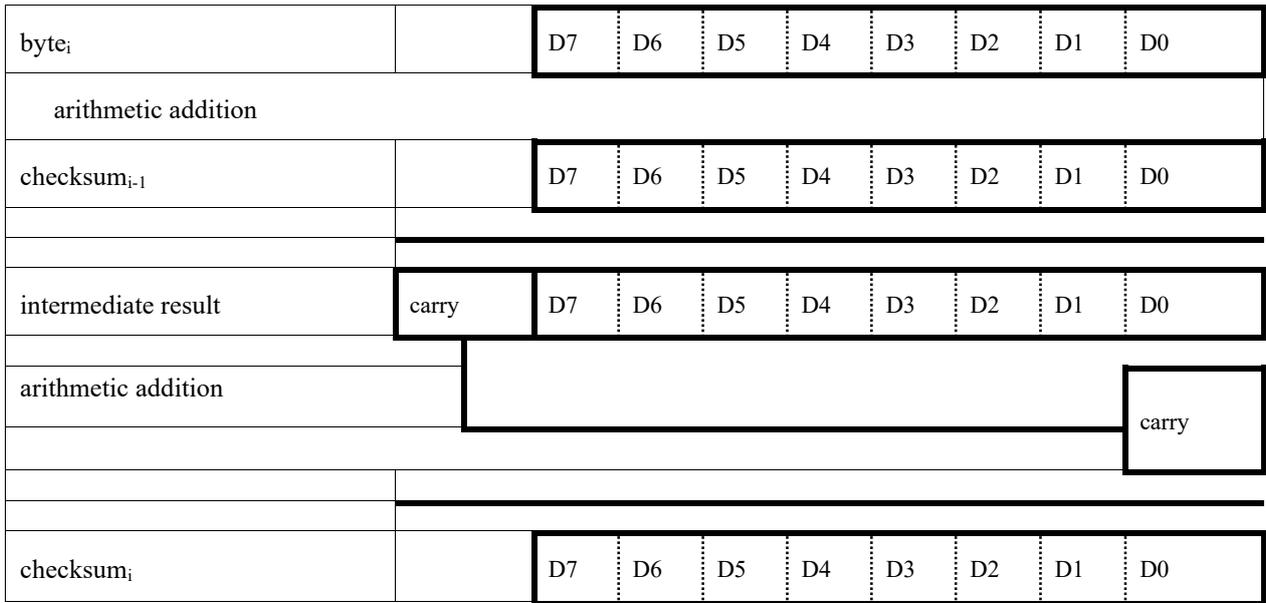


Figure D.1 - Algorithm for calculating the checksum

## SPECIAL NOTES