BDBG-T
DETECTING UNIT OF GAMMA RADIATION

Operating Manual

BICT.418266.063-02 HE

CONTENTS

This operating manual (the OM) is intended to inform the user about the principle of operation of the BDBG-T detecting unit of gamma radiation (hereinafter - the detecting unit), its operation procedure and contains all the information necessary for the 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.

1 DESCRIPTION AND OPERATION

1.1 Purpose of use of the detecting unit

The detecting unit is designed to measure the ambient dose equivalent rate of gamma radiation in the environment. The detecting unit transmits the measurement results to the data collection and processing system, information panels or other display facilities via the RS485 digital interface.

The detecting unit is designed for installation on special purpose vehicles, including radiochemical reconnaissance units of the armed forces and civil defense.

1.2. Key technical data and specifications of the detecting unit

Key technical data and specifications of the detecting unit are given in Table 1.1.

Table 1.1 – Key technical data and specifications of the detecting units

Name	Unit of measurement	Standardized values
Measurement range of gamma radiation DER	μSv/h	0,05 – 2•10^7
Main relative permissible error limit of gamma radiation DER measurement at ^{137}Cs calibration with a confidence probability of 0.95	%	±(15+1/), where $\dot{H}^*(10)$ – is a numeric value of measured gamma radiation DER, μSv/h
Energy range of photon-ionizing radiation being registered	MeV	0.05 – 3.00
Energy dependence of readings of the detecting unit when measuring gamma radiation DER in the energy range from 0.05 to 1.25 MeV, not worse	%	±30

Table 1.1 (continued)

Name	Unit of measurement	Standardized values
Anisotropy of the detecting unit at gamma quanta incidence at angles from +60° to - 60° horizontally and vertically relative to the main measurement direction, marked by a "+" symbol , does not exceed: - for ^{241}Am isotope - for ^{137}Cs and ^{60}Co isotopes	%	 ± 60 ± 30
Operating supply voltage of the detecting unit from external regulated power supply	V	7 - 32
Current consumption of the detecting unit for the entire range of gamma radiation DER being measured, not more than	mA	30
Time of operating mode setting and measurement time of the detecting unit, not more than	min	2
Unstable readings of the detecting unit during 24-hour continuous operation, not more than	%	5
Complementary permissible error limit at measurement caused by ambient temperature change from - 40 to +70 °C	%	5 per each 10 °C of deviation from +20 °C
Interface	-	RS-485
Dimensions of the detecting unit, not more than	mm	50 ×116 × 50
Weight of the detecting unit, not more than	kg	0.3

1.2.1 The detecting unit is resistant to (when on) the following environmental influences:

- operating temperatures: from minus 40 to +70 °C;
- limit temperatures: from minus 40 to +75 °C;
- relative humidity up to 100 % at a temperature of +40 °C and lower temperatures with moisture condensation;
- salt spray for 48 hours;
- photon ionizing radiation with DER equal to 100 Sv/h for 5 minutes.

1.2.2 The detecting unit is resistant to (when off) sinusoidal vibration in the frequency range from 5 to 500 Hz with an acceleration amplitude of 59 m/s^2 (6 g).

1.2.3 The detecting unit is resistant (when off) to single-impact mechanical shocks with a shock acceleration duration from 1 to 5 ms and a shock acceleration peak value of 740 m/s^2 (75 g).

1.2.4 The detecting unit is resistant (when off) to multiple mechanical shocks with a shock acceleration duration from 5 to 15 ms and a shock acceleration peak value of 196 m/s^2 (20 g).

1.2.5 The detecting unit provides a function of monitoring the performance of built-in detectors with the generation of check information.

1.2.6 The ingress protection rating of the detecting unit's housing is IP67 in accordance with EN 60529.

1.3 Delivery kit

1.3.1 The system's delivery kit includes components and operating documentation listed in Table 1.2.

Table 1.2 – Delivery kit of the detecting unit

Designation of the component part	Component part name	Quan-tity, pcs.	Note
BICT.418266.063	BDBG-T detecting unit	1	
BICT.418266.063-02 HE	Operating manual	1	One per batch of detecting units
	Assembly parts kit	1	According to 1.3
	Package	1	
Note - The delivery kit can be changed depending on the Customer's requirements			

1.3.2 The assembly parts kit of the detecting unit is shown in Table 1.3.

Table 1.3 - Assembly parts kit of the detecting unit

Component part	Quantity, pcs.	Note
7 pin JCS "LTAVA" Socket	1	

Note - In agreement with the Customer, a cable of appropriate length may be included in the assembly parts kit used to produce the necessary connecting cable.

1.4 Design of the detecting unit and the principle of its operation

1.4.1 Design description

The detecting unit (according to Figure 1) consists of two interconnected rectangular parts: the base (1) and the cover (2). The design provides two through holes (3) for mounting the detecting unit 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.

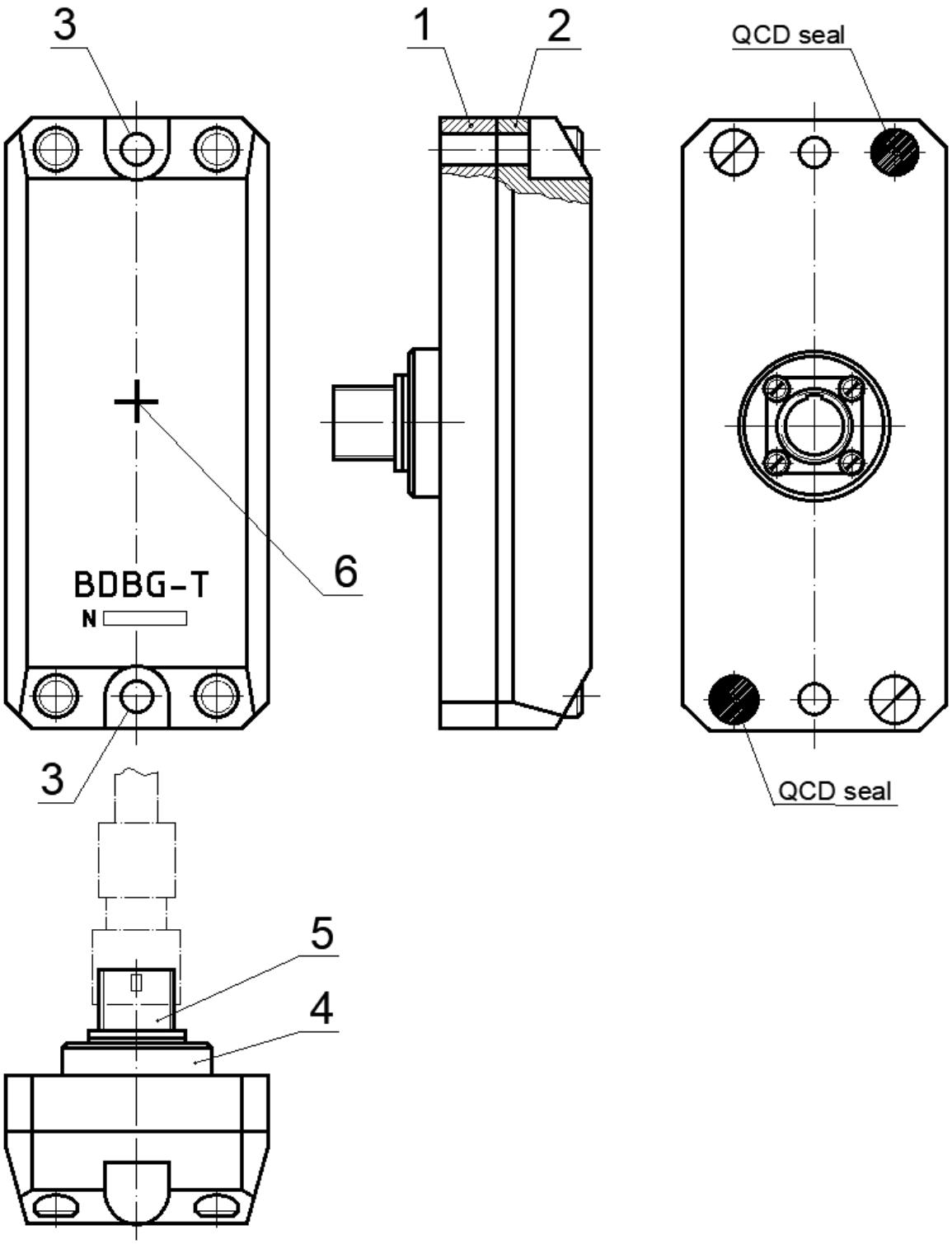


Figure 1 – Appearance of the detecting unit

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

The overall and connecting dimensions of the detecting unit are given in Annex A.

1.4.2 The principle of operation of the detecting unit

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

Operation of the detecting unit is based on the method of gamma radiation transformation into voltage pulse train at the detectors' outlet. The high sensitivity and the low sensitivity scintillation detectors with thermocompression silicon photomultipliers are used as detectors in the detecting unit

The microcontroller processes the pulse flow from the detectors and based on 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 of the detectors and continuously monitors their performance.

If requested by an external device, the microcontroller sends it 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 performance monitoring.

The supply voltage former converts the voltage of the external power source into a 3.3 V voltage to supply the low-voltage part of the detecting unit circuit, and generates bias voltages for the photomultipliers of high sensitivity and low sensitivity detectors.

1.5 Labeling and sealing

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

1.5.2 Contents of the labeling for the detecting unit – complies with Annex A.

1.5.3 Sealing is performed by a representative of the QC department. Removal of seals and repeated sealing is carried out by the organization in charge of repairs or verification.

1.6 Packing

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

2 PROPER USE

2.1 Operating limitations

2.1.1 The detecting unit shall operate under the conditions that do not fall outside the use requirements outlined in section 1.2.

2.2 Preparing the detecting unit for operation

2.2.1 Scope and sequence of external examination

2.2.1.1 Before using the detecting unit, unpack it and check if the delivery kit is complete. Examine its component parts for mechanical damage.

2.2.2 Installation rules of the detecting unit

2.2.2.1 Please read this OM carefully before starting operation.

2.2.2.2 Locate the detecting unit to estimate the length of the connecting cable to the data collection and processing system. Make the cable using the assembly parts kit. The addresses of the pins according to the wiring diagram are given in Annex B.

2.2.3 Installation of the detecting unit

2.2.3.1 The overall and connecting dimensions of the detecting unit are specified in Annex A.

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

2.2.4 Testing of the detecting unit

2.2.4.1 Switch on the data collection and processing system, to which the detecting unit is connected, and observe the measurement results of the background DER and the units of measurement on its display.

2.2.5 List of possible troubles and troubleshooting

2.2.5.1 The main troubles occur for the following reasons:

- No contact in the connectors;
- Damage to the connecting cable.

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

Table 2.1 - List of possible troubles and troubleshooting

Trouble, manifestation and additional features that may be present on the external display means	Probable cause	Troubleshooting
“Er1” message on the DER indicator (set bit D0 in the byte of the self-test results of the detecting unit)	Failure of the high sensitivity detector, which is a part of the detecting unit	Replace the appropriate detecting unit
“Er2” message on the DER indicator (set bit D1 in the byte of the self-test results of the detecting unit)	Failure of the low sensitivity detector, which is a part of the detecting unit	Replace the appropriate detecting unit
“Er3” message on the DER indicator (the detecting unit does not respond to data frames from the data collection and processing system)	1 The detecting unit is not connected to the data collection and processing system 2 The connecting cable between the data collection and processing system and the detecting unit is damaged	1 Connect the appropriate detecting unit to the data collection and processing system 2 Repair the cable breakage or replace the corresponding connecting cable

2.2.5.3 At failure to eliminate the troubles presented in the Table 2.2, or at detection of more complicated faults, the detecting unit should be sent for repair to the repair services or to the producer enterprise.

2.3 Use of the detecting unit

2.3.1 Safety measures during use of the detecting unit

2.3.1.2 There are no life-threatening voltages on the surfaces of the detecting unit components.

2.3.1.3 Direct use of the detecting unit is not dangerous for the maintenance personnel and is environmentally friendly.

2.3.1.4 In case of contamination with radiation substances, the detecting unit shall be decontaminated by wiping its outer surfaces with a cloth soaked in a solution of synthetic detergent.

2.3.1.5 Disposal of the detecting unit shall be carried out in accordance with the requirements of national regulations.

Note - In case of contamination of the detecting unit with liquid or bulk radionuclides and impossibility of its complete decontamination, the detecting unit shall be disposed of as solid radioactive waste at specialized enterprises.

3 MAINTENANCE

3.1 Technical maintenance of the detecting unit

3.1.1 General instructions

The list of operations during technical maintenance (hereinafter the TM) of the detecting unit, order and peculiarities of operational phases are given in the Table 3.1.

Table 3.1 – List of operations during maintenance

List of operations	Maintenance type			OM item No.
	during		during long-term storage	
	everyday use	periodical use		
External examination	+	+	+	3.1.3.1
Delivery kit completeness check	–	+	+	3.1.3.2
Operability check	+	+	+	3.1.3.3
Verification of the detecting units	–	+	+	3.2
Note – "+" symbol means the operation is applicable during this maintenance type, "-" symbol means the operation is not applicable.				

3.1.2 Safety measures

Safety measures during maintenance fully comply with safety measures presented in 2.3.1 of the OM.

3.1.3 Maintenance procedure of the detecting unit

3.1.3.1 External examination

3.1.3.1.1 External examination of the detecting unit should be performed in the following order:

а) check the condition of the surfaces, integrity of seals, absence of scratches, traces of corrosion, and surface damage;

б) check the condition of connectors in the cable connection points.

3.1.3.1.2 The case surface and component parts of the detecting unit are deactivated if required.

Deactivate the surfaces of the component parts of the detecting unit by cleaning them with the decontamination solution.

As a deactivating solution, it is recommended to use a washing liquid consisting of:

- synthetic detergent - from 7 to 10 g;
- water - 1 dm^3.

To deactivate, wipe thoroughly the contaminated areas with a cloth moistened with decontamination solution, then with a cloth moistened with warm water and wipe dry.

Notes

1 Before deactivating the detecting unit, put on cotton gloves and rubber gloves, observing safety requirements for operation with chemical solutions.

2 Deactivation of the detecting unit can be done according to the procedure established for measuring instruments of ionizing radiation at the object of use.

3.1.3.2 Delivery kit completeness check

Check if the delivery kit of the detecting unit is complete according to section 1.3.

3.1.3.3 Operability check of the detecting unit

3.1.3.3.1 Operability check of the detecting unit and the procedure for its implementation are carried out in accordance with 2.2.4 of this OM.

3.1.3.3.2 The procedure of pre-repair fault detection and rejection

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

- for mid-life repair:

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

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

- for major repair:

a) at least one non-operating measuring channel;

b) mechanical damages that affected the leak tightness of the detecting unit case or the cable.

3.2 Verification of the detecting units

The detecting units shall be verified according to the verification procedure below.

The detecting units should be verified after manufacture or during use (periodically, at least once a year).

3.2.1 Verification operations

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

Table 3.2 – Verification operations

Operation	Verification technique No.
1 External examination	3.2.4.1
2 Testing	3.2.4.2
3 Determination of the main relative error during 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 and equipment should be used for verification:

- standard equipment of gamma radiation with ^{137}Cs nuclide;
- stopwatch;
- aspiration psychrometer;
- control aneroid barometer;
- special high power metrological equipment (^{60}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±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 μSv/h;

3.2.4 Verification procedure

3.2.4.1 External examination

During external examination, the detecting units should meet the following requirements:

- labeling should be accurate;
- QCD seals should not be violated;
- the detecting units 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.

3.2.4.3 Determination of the main relative permissible error limit 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 detecting unit in the carriage holder of the standard equipment so that the mechanical center of gamma quanta beam coincides with the center of detectors. The center of the detectors is marked with a "+" symbol on the housing of the detecting unit. Turn on the system and set the carriage of the standard equipment in the position where gamma radiation DER from the source with ^{137}Cs radionuclide is $\dot{H}^*(10) = (800 \pm 80)$ μSv/h.

3.2.4.3.3 One min after the start of irradiation, perform five measurements of the gamma radiation DER value for each of the detecting units on 10 s intervals. Calculate the average DER $\overline{\dot{H}^*(10)}$ value by formula (3.1).

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

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

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

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

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

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

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

$\overline{\dot{H}^*(10)}$ - the average value of the measured DER.

Record the results in the report.

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

3.2.4.3.5 Secure the detecting unit in the carriage holder of special metrological equipment so that the mechanical center of gamma quanta beam coincides with the center of the gamma detectors marked with the "+" symbol.

Set the carriage of special metrological equipment with detecting units in the position where DER from ^{60}Co source is $\dot{H}_0^*(10)$= (18000±2000) 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 main relative permissible error limit of DER measurement does not exceed $(15+1/\dot{H}^*(10))$%, where $\dot{H}^*(10)$ is the numerical value of the measured gamma radiation DER, μSv/h.

3.2.4.4 Presentation of verification results

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

3.2.4.6.2. The detecting units that do not meet the requirements of the verification technique are not allowed to be used and get a certificate of inadequacy.

4 STORAGE

4.1 The detecting unit shall be stored in the packaging of the manufacturer in the premises (warehouses) under the following conditions:

- air temperature - from minus 30 to + 50 ºC;
- average annual relative humidity - 80% at a temperature of +6 ºC;
- 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 SERVICE LIFE AND LIFETIME

5.1 The mean time to failure - not less than 4,000 hours.

5.2 The average overhaul life - not less than 16,000 hours, mean time to repair - not less than 6 years.

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

5.4 Warranty period of storage - 6 months from the date of manufacture of the system. The warranty period 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 detecting unit in the manufacturer’s packaging can be shipped by rail, air, water and motor vehicles at any distance in compliance with the following rules:

- by rail- in closed clean cars;
- by air - in airtight heated compartments;
- by water - in a dry hold;
- by motor vehicles - in closed cars.

Note - In case of ordering a batch of detecting units, their transportation in a unitized container is allowed.

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

6.3 During transportation, observe the handling marks inscribed on the packaging (transport containers).

6.4 Canting of products is forbidden.

6.5 During loading and unloading operations, the detecting units shall not be exposed to precipitation.

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

6.7 Shipping for all modes of transport should be carried out under the following conditions:

- ambient temperature - in the range from minus 40 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 BDBG-T detecting unit (units) BICT.418266.063 with serial number _____
_____
_____
_____
_____
_____
meets (meet) the technical requirements of the operating manual BICT.418266.063-02 HE and is (are) accepted for use.

Date of issue _____

Seal here QCD representative: _____
(signature)

8 PACKING CERTIFICATE

The BDBG-T detecting unit (units) BICT.418266.063 with serial number _____
_____
_____
_____
_____
_____
is (are) packed by the Private Enterprise “SPPE “Sparing-Vist Center” in accordance with the requirements specified in the operating manual BICT.418266.063-02 HE.

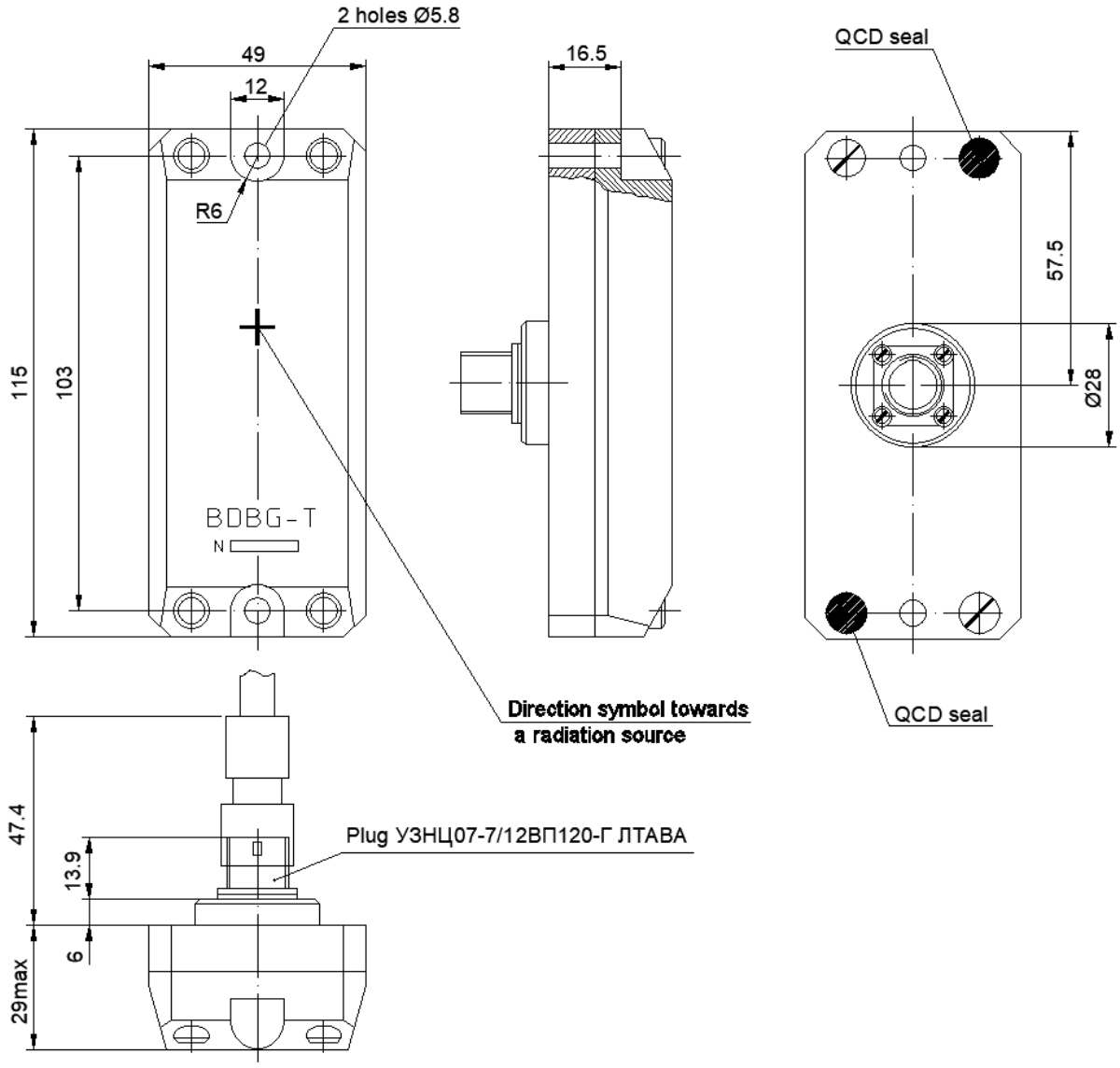
Date of packing _____

Seal here

Packed by: _____
(signature)

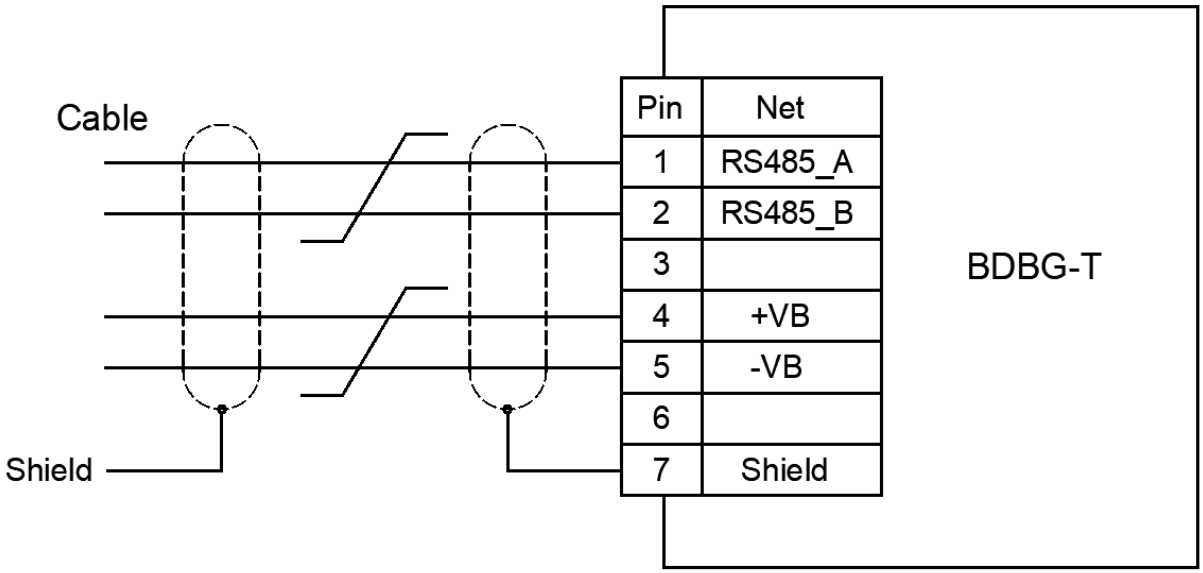
ANNEX A

OVERALL AND CONNECTING DIMENSIONS OF THE DETECTING UNIT



ANNEX B

WIRING DIAGRAM OF THE DETECTING UNIT



ANNEX C

COMMUNICATIONS PROTOCOL OF THE DATA COLLECTION AND PROCESSING SYSTEM WITH THE DETECTING UNIT

C.1 Data frames exchange between the detecting unit and the data collection and processing system is done via the RS-485 interface in a half-duplex mode.

Exchange parameters:
- rate: 19200 bps;
- data word length: 8 bit;
- parity bit: none;
- stop bits: 1.

The time interval between the bytes in one frame should not exceed 1 ms. The time interval between the frames should not be less than 5 ms.

C.2 After the supply voltage from the data collection and processing system is transmitted to the detecting unit, the latter not later than in 30 s automatically starts gamma radiation DER measurement and processing of data frames form the data display system.

C.3 This detecting unit supports data communications protocol version with both 4-digit field address (v1.2), and 8-digit field address (v1.3).

C.3.1 Communications protocol with the 4-digit field address (v1.2).

To receive the measured value of DER from the detecting unit, the data collection and processing system should transmit the "**DER query**" frame to the detecting unit. The detecting unit will respond in 5 ms to 15 ms with the "**Current DER**" frame, where current DER, maximum statistical error of its measurement, and self-testing results of the detecting unit will be displayed.

To receive the measured value of temperature from the detecting unit (with embedded temperature detector), the data collection and processing system should transmit the "**Temperature query**" frame to the detecting unit. The detecting unit will respond in 5 ms to 15 ms with the "**Current temperature**" frame, where current temperature and condition of the temperature detector will be given.

To receive the serial number of the detecting unit, the data collection and processing system should transmit the "**Serial # query**" frame to the detecting

unit. The detecting unit will respond in 5 ms to 15 ms with the "**Serial #**" frame with the displayed serial number.

To change the address of the detecting unit, the data collection and processing system should transmit the "**Address change**" frame to the detecting unit. In 5 ms to 500 ms the detecting unit will respond with the "**Confirmation**" frame.

Important! In the address field of the "**Confirmation**" frame the old value of the address will be recorded. In the event of successful reception of a new value, the detecting unit records it in the nonvolatile memory, and not later than in 5 s starts responding to the frames with the new address.

To make operation with several detecting units (up to 15 units) easier that are simultaneously connected to the data collection and processing system via single RS-485 interface, the **0Fh** broadcast address is provided. The use of broadcast address is permitted only in the "**DER query**", "**Temperature query**" and "**Serial # query**" frames. All detecting units respond to the query with such address (broadcast query).

When the detecting units respond to the broadcast query, each of them does it with delay T, which is calculated by the formula:

$$T = 5\ \text{ms} + \text{Adr} \times 8\ \text{ms}\ , \qquad \text{(C.1)}$$

where Adr - is the address of the detecting unit.

The broadcast query allows you to conveniently implement auto-detection of the detecting units that are connected/disconnected to the data collection and processing system during system operation.

"**DER query**" frame format – the data collection and processing system to the detecting unit

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h – start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
0	0	0	0	A3	A2	A1	A0	D7...D4 - "**DER query**" frame code D3...D0 - detecting unit address *

* - 0Fh address – broadcast address. All detecting units respond to the query with such address.

"**Current DER**" frame format –the detecting unit to the data collection and processing system

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h – start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
0	0	0	1	A3	A2	A1	A0	D7...D4 - "Current DER" frame code D3...D0 - detecting unit address
DER0 (low byte)								DER, fixed point number, Least significant bit (LSB) = 0.01 µSv/h
DER1								
DER2								
DER3 (high byte)								
Byte								Statistical error of measurement
D7	D6	0	0	0	D2	D1	D0	D0,D1 – self-testing results of the detecting unit D0=1 – failure of the high sensitivity detector D1=1 – failure of the low sensitivity detector Reliable measurement result character D2=0 – result is true D2=1 – result is false * D6=1 – exceeding by DER D7=0 – LSB DER = 0,01 µSv/h D7=1 – LSB DER = 0,1 µSv/h
control								arithmetical checksum with a carry

* - measurement result is accepted as false if the statistical error of measurement exceeds maximum permissible error of measurement.

"**Temperature query**" frame format – the data collection and processing system to the detecting unit (for the detecting units with embedded temperature detector)

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h – start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
1	0	0	0	A3	A2	A1	A0	D7...D4 – "**Temperature query**" frame code D3...D0 – detecting unit address *

* - 0Fh address – broadcast address. All detecting units respond to the query with such address.

"**Current temperature**" frame format – the detecting unit to the data display system

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h – start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
1	0	0	0	A3	A2	A1	A0	D7...D4 – "**Temperature**" frame code D3...D0 – detecting unit address
2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}	Temperature, binary number
D7	X	X	X	S	2^6	2^5	2^4	S=0-above-zero temperature S=1-below-zero temperature D7=0-normal operation of thermal detector D7=1-failure of thermal detector
control								arithmetical checksum with a carry

"**Serial # query**" frame format – the data collection and processing system to the detecting unit

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h – start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
0	1	0	1	A3	A2	A1	A0	D7...D4 – "**Serial # query**" frame code D3...D0 – detecting unit address*

* - 0Fh address – broadcast address. All detecting units respond to the query with such address.

"**Serial #**" frame format – the detecting unit to the data collection and processing system

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h – start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
0	1	0	1	A3	A2	A1	A0	D7...D4 – "**Serial #**" frame code D3...D0 – detecting unit address
Serial No._0 (low byte)								Serial No. of the detecting unit
Serial No._1								
Serial No._2								
Serial No._3 (high byte)								
control								arithmetical checksum with a carry

"**Address change**" frame format – the data collection and processing system to the detecting unit

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h – start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
0	1	1	0	A3	A2	A1	A0	D7...D4 - "**Address change**" frame code D3...D0 - current address of the detecting unit
0	0	0	0	NA3	NA2	NA1	NA0	D3…D0– new address of the detecting unit
control								arithmetical checksum with a carry

"**Confirmation**" frame format –the detecting unit to the data collection and processing system

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h – start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
1/0	0	1	1	A3	A2	A1	A0	D7 = 0 – normal operation D7 = 1 – error D6…D4 – "**Confirmation**" frame code D3…D0 – OLD address of the detecting unit

C.3.2 Communications protocol with the 8-digit field address (v1.3).

To receive the measured value of DER from the detecting unit, the data collection and processing system should transmit the "**DER1 query**" frame to the detecting unit. The detecting unit will respond in 5 ms to 15 ms with the "**Current DER1**" frame, where current DER, maximum statistical error of its measurement, and self-testing results of the detecting unit will be displayed.

To receive the measured value of temperature from the detecting unit (with embedded temperature detector), the data collection and processing system should transmit the "**Temperature1 query**" frame to the detecting unit. The detecting unit will respond in 5 ms to 15 ms with the "**Current temperature1**" frame, where current temperature and condition of the temperature detector will be given.

To receive a serial number and the delay coefficient of the response to the broadcast query from the detecting unit, the data collection and processing system should transmit the frame "**Serial #_1 query**" to the detecting unit. The detecting unit will respond in 5 ms to 15 ms with the "**Serial #_1**" frame with the displayed serial number and the response delay factor to the broadcast query.

To change the address of the detecting unit and the response delay factor to the broadcast query, the data collection and processing system should transmit the "**Address1 change**" frame to the detecting unit. In 5 ms to 500 ms the detecting unit will respond with the "**Confirmation1**" frame. *Important!* In the address field of the "**Confirmation1**" frame the old value of address will be recorded. In the event of successful reception of a new value and response delay factor to the broadcast query, the detecting unit records it in the nonvolatile memory, and not later than in 5 s starts responding to frames with the new address.

To make operation with several detecting units (up to 255 units) easier that are simultaneously connected to the data collection and processing system via single RS-485 interface, the 0FFh broadcast address is provided. The use of this address is permitted only in the "**DER1 query**", "**Temperature1 query**" and "**Serial #_1 query**" frames. All detecting units respond to the query with such address (broadcast query).

When the detecting units respond to the broadcast query, each of them does it with delay T, which is calculated by the formula:

$$T = 5\ \text{ms} + t \times 8\ \text{ms}, \qquad \text{(C.2.1)}$$

if the response delay factor to the broadcast query t is within the range from 0 to 15;

or by the formula:

$$T = (5\ \text{ms} + t \times 8\ \text{ms}) + 125\ \text{ms}, \qquad \text{(C.2.2)}$$

if the response delay factor to the broadcast query t is within the range from 16 to 255.

The broadcast query allows you to conveniently implement auto-detection of the detecting units that are connected/disconnected to the data display system during system operation.

"**DER1 query**" frame format –the data collection and processing system to the detecting unit

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h - start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
0	1	1	1	0	0	0	0	D7…D4– protocol v1.3 character
address								D7…D0– detecting unit address*
0	0	0	0	0	0	0	0	D7…D0–**"DER1 query"** frame code
control								arithmetical checksum with a carry

* - 0FFh address – broadcast address. All detecting units respond to the query with such address.

"Current DER1" frame format –the detecting unit to the data collection and processing system

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h - start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
0	1	1	1	0	0	0	0	D7…D4– protocol v1.3 character
address								D7…D0– detecting unit address
0	0	0	0	0	0	0	1	D7…D0–**"Current DER1"** frame code
DER0 (low byte)								DER, fixed point number, Least significant bit (LSB) = 0.01 µSv/h
DER1								
DER2								
DER3 (high byte)								
Byte								Statistical error of measurement
D7	D6	0	0	0	D2	D1	D0	D0,D1 - self-testing results of the detecting unit D0=1 - failure of the high sensitivity detector D1=1 - failure of the low sensitivity detector Reliable measurement result character D2=0 - result is true D2=1 – result is false * D6=1 – exceeding by DER D7=0 – LSB DER = 0,01 µSv/h D7=1 – LSB DER = 0,1 µSv/h
control								arithmetical checksum with a carry

* - measurement result is accepted as false if the statistical error of measurement exceeds the maximum permissible error of measurement

“Temperature1 query” frame format – the data collection and processing system to the detecting unit (for the detecting units with embedded temperature detector)

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h – start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
0	1	1	1	0	0	0	0	D7…D4– protocol v1.3 character
address								D7…D0– detecting unit address*
0	0	0	0	1	0	0	0	D7…D0–**“Temperature1 query”** frame code
control								arithmetical checksum with a carry

* - **0FFh** address – broadcast address. All detecting units respond to the query with such address.

“Current temperature1” frame format – the detecting unit to the data collection and processing system

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h – start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
0	1	1	1	0	0	0	0	D7…D4– protocol v1.3 character
address								D7…D0– detecting unit address
0	0	0	0	1	0	0	0	D7…D0–**“Temperature1 query”** frame code
2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}	Temperature, binary number
D7	X	X	X	S	2^6	2^5	2^4	S=0-above-zero temperature S=1-below-zero temperature D7=0-normal operation of thermal detector D7=1-failure of thermal detector
control								arithmetical checksum with a carry

“Serial #_1 query” frame format – the data collection and processing system to the detecting unit

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h – start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
0	1	1	1	0	0	0	0	D7…D4– protocol v1.3 character
address								D7…D0– detecting unit address*
0	0	0	0	0	1	0	1	D7…D0–**“Serial#_1 query”** frame code
control								arithmetical checksum with a carry

* - 0FFh address – broadcast address. All detecting units respond to the query with such address.

“Serial #_1” frame format – the detecting unit to the data collection and processing system

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h – start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
0	1	1	1	0	0	0	0	D7…D4– protocol v1.3 character
address								D7…D0– detecting unit address
0	0	0	0	0	1	0	1	D7…D0–**“Serial#_1”** frame code
Serial No._0 (low byte)								Serial No. of the detecting unit
Serial No._1								
Serial No._2								
Serial No._3 (high byte)								
current constant								D7…D0–current response delay factor to broadcast query
control								arithmetical checksum with a carry

“Address1 change” frame format – the data collection and processing system to the detecting unit

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h – start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
0	1	1	1	0	0	0	0	D7…D4– protocol v1.3 character
current address								D7…D0– current address of the detecting unit
0	0	0	0	0	1	1	0	D7…D0–**“Address1 change”** frame code
new address								D7…D0– new address of the detecting unit
new constant								D7…D0– new response delay factor to broadcast query
control								arithmetical checksum with a carry

“Confirmation1” frame format –the detecting unit to the data collection and processing system

D7	D6	D5	D4	D3	D2	D1	D0	
0	1	0	1	0	1	0	1	Byte 55h – start-of-frame character
1	0	1	0	1	0	1	0	Byte AAh
0	1	1	1	0	0	0	0	D7…D4– protocol v1.3 character
OLD address								D7…D0– OLD address of the detecting unit
1/0	0	0	0	0	0	1	1	D6…D0–**“Confirmation1”** frame code D7 = 0 - normal operation D7 = 1 - error
control								arithmetical checksum with a carry

C.4 Checksum for data communications using both v1.2 protocol, and v1.3 protocol is calculated according to Figure C.1.

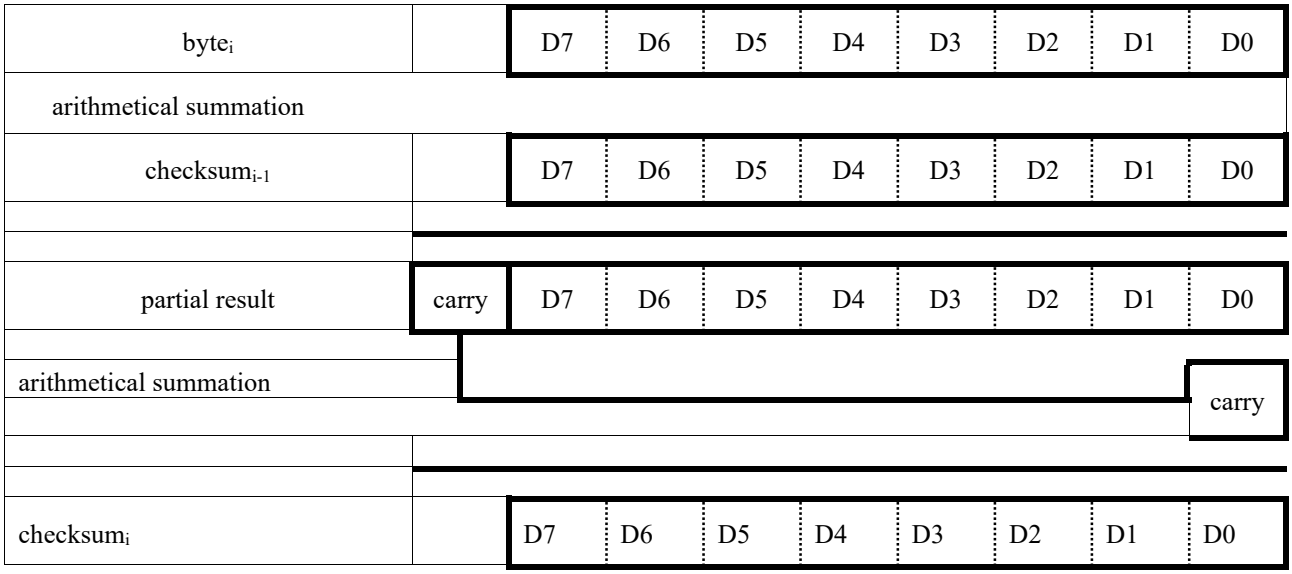


Figure C.1 – Checksum calculation algorithm

SPECIAL NOTES