RADON RADIOMETER

RRA-01M-03

OPERATION MANUAL

BVEK.431110.04 RE

Moscow, 2009

CONTENTS

1. INTRODUCTION

This operation manual is intended to describe the design, operation, specifications and other information needed for the proper use of the radon radiometer RRA-01M-03 BVEK.431110.04.

2. APPLICATION

2.1. The Radon Radiometer RRA-01M-03 BVEK.431110.04 (hereafter "radiometer") is designed for measurement of radon-222 (volumetric activity of radon) and the number of decays of ^{216}Po (ThA) in the indoor air of living quarters and dwellings, at workplaces and also in the outdoor air within the specifications of the radon monitor.

2.2. In addition the radiometer can control the following parameters of the environment: temperature, relative humidity and pressure.

3. SPECIFICATIONS

3.1. Measurement range of radon concentration, $Bq \cdot m^{-3}$, …….from 20 up to$2.0 \cdot 10^4$

3.2. Measurement range of ^{216}Po (ThA), decays, ……from 0 up to 10^3

3.3. Maximum permissible limit for intrinsic relative error of measured radon-222 concentration within measurement range less than ±30% (at confidence probability of 0.95)

3.4. Sensitivity to radon-222, $s^{-1} \cdot Bq^{-1} \cdot m^3$ …..…..…….. $1.4 \cdot 10^{-4}$

3.5. Measurement range of temperature within ±5% accuracy, °C ……5÷50

3.6. Measurement range of atmospheric pressure within ±5% accuracy, kPa (mmHg) ….…..…….…..…..……. 93÷109 (700÷820)

3.7. Measurement range of humidity within ±5% accuracy, % …… 30÷90

3.8. Self-background level, not more than, $Bq \cdot m^{-3}$……..……..……..... 7.0

3.9. Operating time with autonomous power supply under normal conditions, no less than 10 hours

3.10. Duration of measurement cycle, min, ……..…… 20, 60, 120

3.11. Interval between measurement cycles, hours …….…….. 0, 1, 4, 8

3.12. Nominal value of high voltage on electrode inside the measuring chamber, V, …… 1400±140

3.13. Volume capacity of built-in air-blower, not less than, $l \cdot min^{-1}$, ….……. 0.8

3.14. Warm-up time before operation is not more than 3 min.

3.15. Instability of readings during 24 hours of continuous operation not more than ±10%

3.16. Measuring chamber volume is not less than 1.6 liters.
3.17. Test code value of the ADC, relative units, ……200±5
3.18. Number of complex measurement results[1], not less than ……1500
3.19. Power consumption, no more than, VA
- with AC mains, ……..... 8.0;
- with battery, ……...1.0.
3.20. Operating conditions:
- ambient temperature, °C, ……..... from +5 to +35;
- relative humidity at +25 °C, % ……. up to 80;
- atmospheric pressure …… from 93 to 109 kPa (from 700 to 820 mmHg)

3.21. Maximum permissible limit for auxiliary relative error of measured radon-222 concentration within temperature range from +5°C to +35°C does not exceed ±10%
3.22. Weight with battery, no more than, kg,…… 4.0
3.23. Dimensions, mm, ……..... 290×200×155
3.24 Radiometer can be supplied from AC mains with nominal voltage 220^{+22}_{-33} V, frequency 50 Hz, harmonics content up to ±5% and/or from autonomous DC source batteries of GP160CK type.
3.25. The type of detector used in the radon radiometer RRA-01M-03 – passivated surface barrier semiconductor detector DKPS-100.

[1] - *Each complex measurement result includes the following data: measurement date, measurement number, series number, radon-222 concentration, number of detected α-particles of RaA (^{218}Po), temperature, relative air humidity, atmospheric pressure.*

4. Delivery packaging

4.1. Items included in the delivery kit are listed in table 1.

Table 1

Item	Qty	Comment
Measuring chamber	1	
Built-in air-blower	1	
Climatic chamber with temperature, humidity and pressure sensors	1	
High-voltage supply unit	1	
Battery	4	Battery type GP160CK
Charge-sensitive preamplifier	1	
Control unit	1	
Mains adapter BPT-01	1	Intended for power supply from AC mains and for charging the built-in battery

5. Design and principle of operation

5.1. The radiometer is designed as a hand-held device with a dual power supply (autonomous from battery and from AC mains). The radiometer is comprised of (see Figure 1):

- measuring chamber with detector DKPS-100 inside and a filter at the entrance;
- built-in air-blower;
- climatic chamber with temperature, air humidity and pressure sensors;
- charge-sensitive preamplifier;
- high-voltage supply unit;
- autonomous power supply unit (battery);
- micro-processor based control unit with control and indication elements;
- mains adapter (to be enclosed separately).

5.2. A measuring chamber with volume 1.6 liters is a hollow plastic cylinder sealed hermetically with flanges at both ends. Aerosol filter is positioned on the front (inlet) flange. The semiconductor detector is positioned at the centre of the back (outlet) flange. Climatic chamber, batteries for autonomous power supply and air-blower are secured close to the measuring chamber. The climatic chamber registers climatic parameters of the ambient air. The radiometer analyzes the air sampled into the measuring chamber by built-in air-blower. The air sample is cleaned from aerosol particles with attached radon and thoron decay products by the aerosol filter. Transparent fixing flange allows visual inspection of the filter. Replace the filter in case of mechanical damage, tears or high dust load. When air samples are taken at increased humidity, a dehydrating filter (dehumidifier) is arranged at the inlet of the measuring chamber under the decorative lid. The dehumidifier selectively absorbs water vapors from the analyzed air sample.

5.3. Measurement of radon and thoron concentration is based on electrostatic deposition of positively charged ions ^{218}Po (RaA) и ^{216}Po (ThA) contained in the sampled air onto the surface of detector. The electrostatic field is produced by high positive potential applied to the electrode (grid) inside the measuring chamber. Concentrations are calculated from the alpha-particles of RaA and ThA count rates measured using alpha-spectrometry.

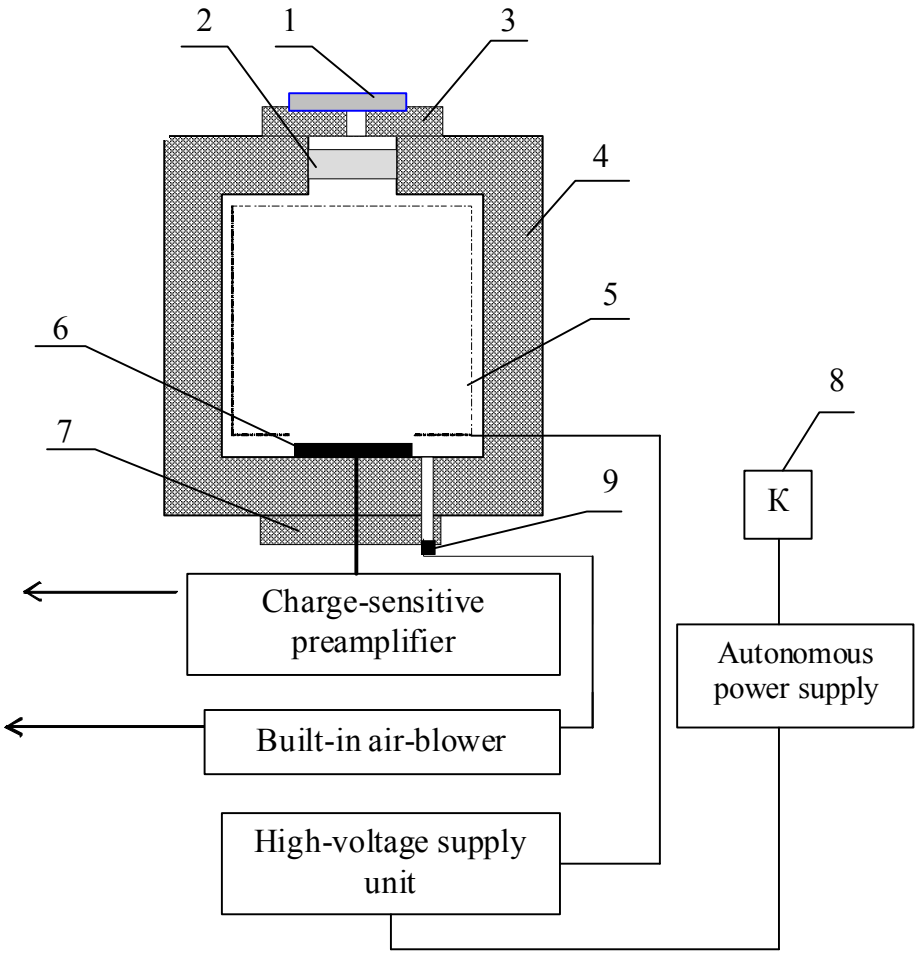


Figure 1. Schematic diagram of the radiometer

1 – dehumidifier;
2 – aerosol filter;
3 – inlet flange;
4 – measuring chamber body;
5 – electrode of measuring chamber;
6 – detecting unit with detector;
7 – outlet flange;
8 – climatic chamber;
9 – outlet adapter.

Electric pulses produced in the detector by α-particles, are amplified by the charge-sensitive preamplifier and their amplitudes are then converted to digital codes by the ADC for further processing (see Fig. 2.).

Pulses corresponding to α-particles of RaA, following the amplitude selection, are registered; their number and the calculated radon concentration are indicated on the LCD indicator of the radiometer.

RaA and ThA deposition on the detector surface doesn't compromise results of subsequent measurements due to RaA and ThA short half-lives.

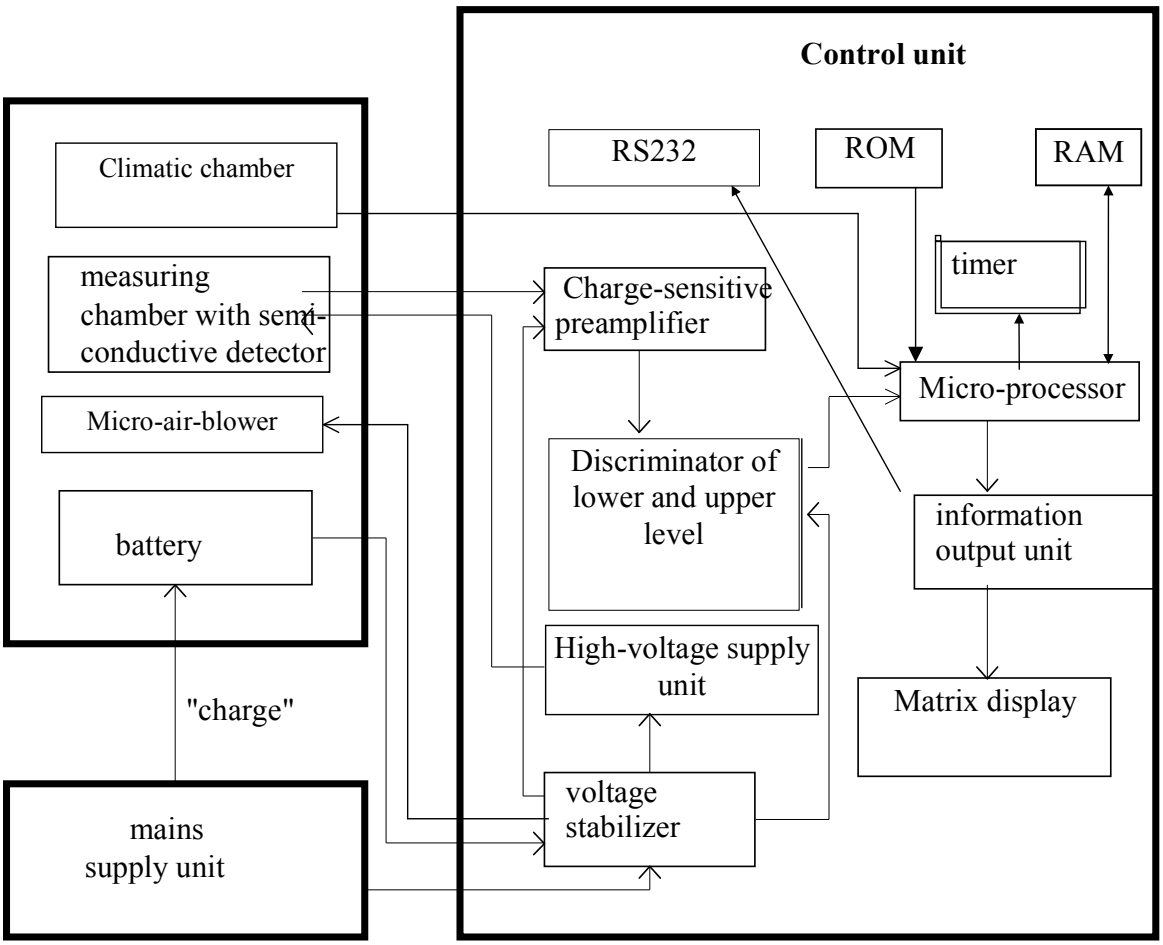


Figure 2. Functional diagram of the radiometer.

5.4. Control unit configuration and operation

5.4.1. The control unit is assembled on one board and includes ADC, micro-processor, RAM, ROM and RS 232 connector intended for connection with personal computer.

5.4.2. "**START**", "**VIEW**", "**RESET**" buttons, three "**MODE**" buttons and **LCD illumination** button are available on the front panel for controlling the radiometer operation. Radiometer appearance is shown in Figure 3.

5.4.2.1. LCD is intended for watching the status of the radiometer and viewing the measured data.

5.4.2.2. The radiometer is controlled via membrane keyboard containing "**START**", "**VIEW**", "**RESET**", "**LCD illumination**", "**MODE**" (with three settings corresponding to 1,2,3).

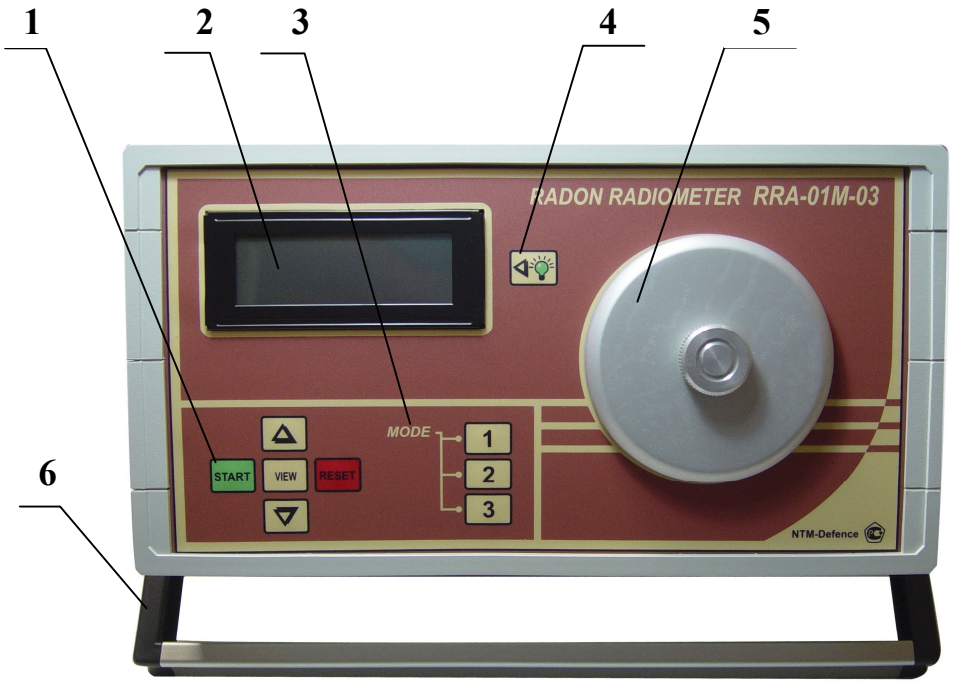


Figure 3a. Front panel of the radiometer

1 – Membrane keyboard with control buttons;
2 – LCD indicator;
3 – MODE buttons;
4 – LCD illumination button;
5 – Decorative lid of measuring chamber;
6 – Carrying/install handle.

5.4.2.3. Under the decorative lid the inlet for air sampling and for attaching (if of use) the dehumidifier are situated.

5.4.2.4. LCD illumination button facilitates the use of radiometer under conditions of dimmed light or in darkness. LCD illumination is enabled automatically when the radiometer is powered from the mains adapter. The illumination is switched on by pressing the **LCD illumination** button when the radiometer is supplied from battery.

5.4.3. A power connector (4, Fig. 3b) on the back panel of the radiometer is intended for connection of the mains adapter BPT-01. The radiometer can be powered from AC mains or from built-in battery. The radiometer is switched on/off by "POWER ON/OFF" switch (3, Fig. 3b).

5.4.4. LED indication of the battery charging process is situated on the back panel of the radiometer (1, Fig.3b).

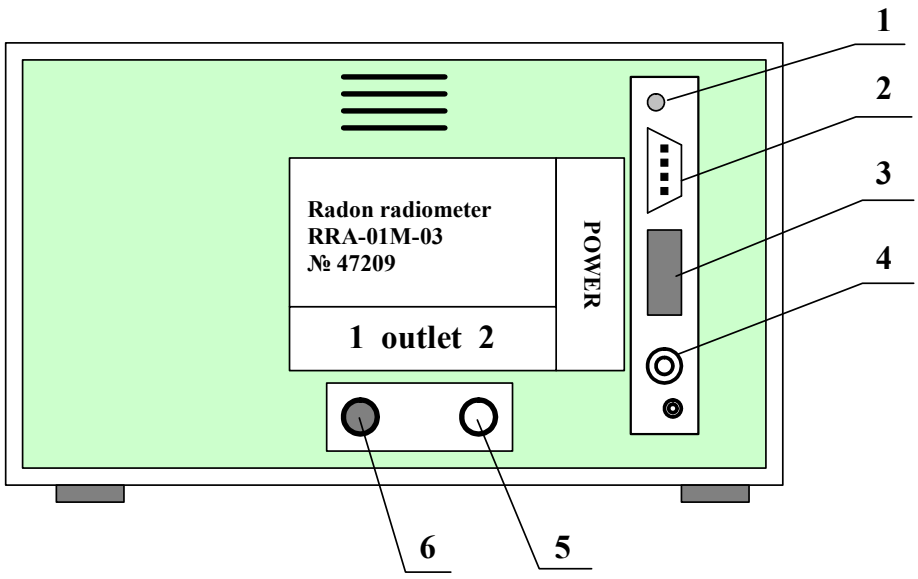


Figure 3b. Back panel of the radiometer

1 – LED indication of the battery charging;
2 – 9-pin connector for communication with personal computer;
3 –**«POWER ON/OFF»** switch;
4 – Connector for mains adapter;
5 – Built-in air-blower outlet;
6 – Measuring chamber outlet.

5.4.5. Connector for communication between the radiometer and personal computer (2, Fig. 3b) provides additional capabilities for work with the radiometer using accompanying software and for transferring measurement data to the computer.

5.4.6. In the course of measurements an outlet **1** (6, Fig. 3b) is always sealed with a rubber cap and connected with the measuring chamber outlet; an outlet 2 (5, Fig. 3b) is connected to the built-in air-blower and is intended for discharging the air out of the measuring chamber.

5.5. Accessories

5.5.1. BPT-01 mains adapter is intended for power supply and charging the battery of the radiometer from AC mains 220^{+22}_{-33} V/ 50 Hz with harmonics content of ±5%.

5.5.2. Filter-dehydrator kR18446736.30 is intended to dehumidify sampled air in case of sampling at relative humidity up to 60%. The filter contains water absorber material – silica gel[2].

5.5.3. Additional dehydrator-cartridge kR18446736.31 is intended for drying the air inside the measuring chamber and is used when relative humidity exceeds 60% (usually when summer). The cartridge represents a piece of plastic tube filled with drying agent and covered with flanges at both ends. Each flange has unions hermetically sealed with caps. A dehydrator-cartridge is connected using adapter kR 18446736.10.19 and PVC tubes included in the radiometer delivery kit.

If you need to use a dehydrator-cartridge, remove decorative lid from the radiometer, remove rubber caps and screw the cartridge into a threaded inlet thus replacing the decorative lid with cartridge.

Dehydrator-cartridge volume 50 cm^3 is filled with water absorber – granulated anhydrous calcium chloride ($CaCl_2$) – in accordance with the State Standard GOST 4460-87. This drying agent allows 100 samplings and cannot be reused. Reduction of granule size from initial 1-4 mm to 0.1 - 0.3 mm (powder state) or transformation into solution indicates that the $CaCl_2$ has lost its absorbing properties. As usual, agglomeration or changing in granule size occurs close to the inlet union of the dehydrator-cartridge. The latter can be recovered by partial removing of rejected absorber. When stored, unions of a dehydrator-cartridge should be sealed with caps!

[2] *As water is accumulated, silica gel granules change their color from bright-blue to rose-pink which can be considered as a sign of water saturation. Silica gel granules can be recovered by heating at 80÷150°C. For this purpose, unscrew the decorative lid of the front panel and get the filter-dehydrator out. Then filter-dehydrator with granules inside should be heated till granules become bright-blue again. For example, when heated by 60÷75 Wt incandescent electric lamp, granules can be recovered in 0.5 hour or less. Please note that granules should not be heated to 200°C or higher as they may fail.*

5.6. Marking and sealing

5.6.1. The radiometer front board has the following marking designations: a trade-mark of manufacturer and a sign of certification as a measuring instrumentation.

5.6.2. Radiometer conventional designation and instrument's number are marked on the back panel of the radiometer.

5.6.3. The control unit body is sealed with stamps by the manufacturer. Seals with stamps are set inside the radiometer and cover screws that fix the upper lid. **Warranty of the manufacturer void if seals are broken.**

5.7. Packing

5.7.1. The radiometer package should guarantee its undamaged state during transportation.

5.7.2. Before packing the radiometer, manufacturer performs preservation in compliance with the VZ-10 GOST 9.014-78 State Standard by putting the radiometer into a hermetically sealed polyethylene case with dehydrator-silica gel inside.

5.7.3. When put in storage, front flange of the measuring chamber must be sealed by a union with a rubber cap on it. Remove the decorative lid and screw the union instead.

5.7.4. When unpacked after long storage, the radiometer should be inspected visually and tested as stated in Section 3.

6. SAFETY REQUIREMENTS

6.1. Do not open the lid of the mains adapter and the back board of the control unit when the mains adapter plug is inserted into the wall outlet.

6.2. Do not switch the radiometer on when flanges of the measuring chamber are taken off.

REMEMBER! High voltage can be present inside the control and detecting units when the 'POWER ON/OFF' switch is pressed upward (in "ON" position) even if the mains adapter plug IS NOT inserted into the wall outlet.

6.3. To avoid detector damage do not touch the sensitive surface of the semiconductor detector and do not clean the detector with any liquid.

6.4. To safely and properly use the radiometer please be guided by "Rules for exploitation of the user's electrical installations and safety code for exploitation of the user's electrical installations (PTE and PTB-84)"

7. PREPARATION FOR OPERATION

7.1. General instructions.

7.1.1. Perform visual inspection before operation every time when you take the radiometer out of the package bag.

7.1.2. Please read this Operation Manual carefully and understand it, familiarize yourself with designation of controls before operating the radiometer.

7.1.3. The radiometer should be operated under the conditions stated in the Specifications section. When the radiometer is operated under the increased humidity for a long time, it is recommended to use a dehydrator-cartridge for sampling (see 5.5.3).

7.2. Radiometer startup.

7.2.1. To avoid damage, please keep the radiometer at a room temperature for at least two hours after transfer from cold to warm environment before switching the radiometer ON. The 'POWER ON/OFF' switch is in OFF position when turned down.

Insert a DC plug of the mains adapter BPT-01 into the 'POWER' socket at the back panel of the radiometer. Insert an electric plug of the mains adapter into the wall outlet AC 220 V/ 50 Hz. The LED at the back panel and the display of the radiometer will light up (irrespectively of the 'POWER ON/OFF' position).

The radiometer will automatically switch to the mains supply and the charging process starts (if the battery is low). The charge period doesn't exceed 5 hours; after that period the radiometer interrupts it and the "Charge" LED goes dim.

7.2.2. Switch the radiometer on by turning the 'POWER ON/OFF' switch in UP position. You will see the following messages on the LCD indicator and hear short audio signals.

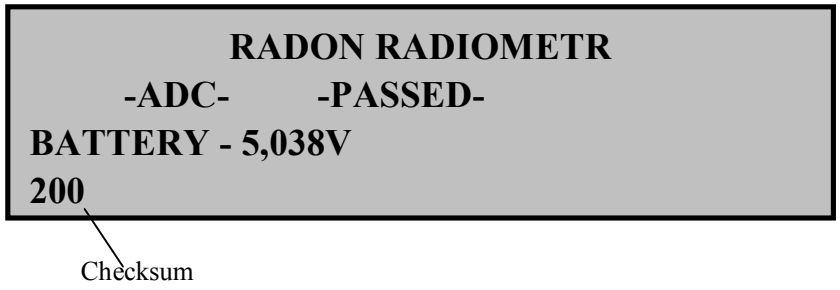
RADON RADIOMETER **RRA-01M-03**

RADON RADIOMETR **BATTERY U-5,08V**

At the start of power-on test the battery voltage is determined and indicated on the LCD. If the battery is low, the **"BATTERY DISCHARGED"** message appears and

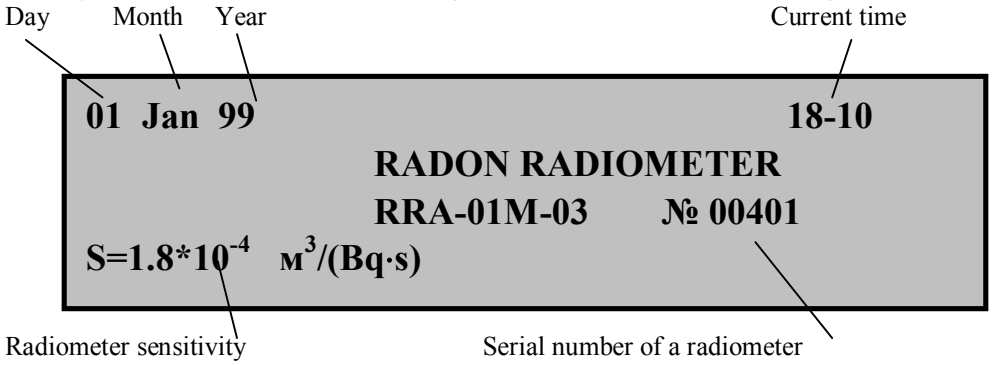
the radiometer shuts down. In this case switch the radiometer off by turning the "POWER" switch down and charge the battery using mains adapter BPT-01 (see 7.2.1).

7.2.3. The power-on test proceeds with testing the spectrometric channel. If this test is successful, the following message appears on the display:



This test characterizes the spectrometric channel of the radiometer; if the checksum is equal to 200±5 then the spectrometric channel is OK.

7.2.4. The radiometer's memory (RAM) is tested in the last test and if this test is successful, you will hear an audio signal and see the following screen on the LCD:



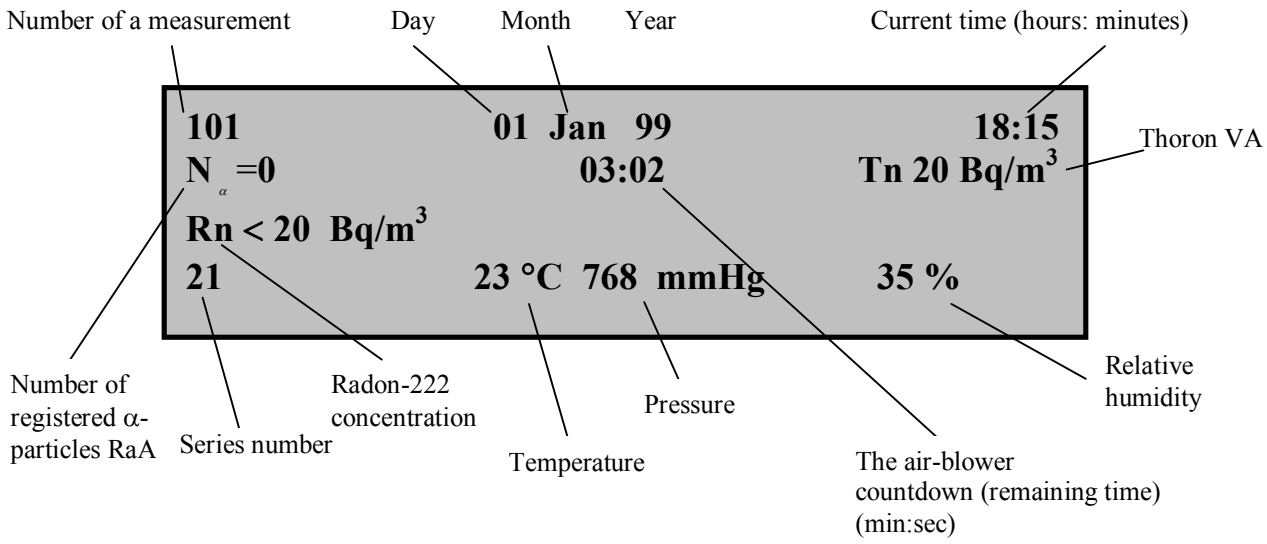
After the power-on test the radiometer is in standby mode, waiting for commands of the user.

7.2.5. Each time the radiometer is switched on, the series number increments. Series numbers allow identifying of different series of measurements when the results are analyzed.

7.3. Operation in continuous measurements mode.

7.3.1. If you press the "**RESET**" button at the front panel, you will see the information about parameters of the ambient air (temperature (°C), pressure (mmHg) and relative humidity (%)) on the LCD. You may choose to omit this and proceed to 7.3.2

7.3.2. Press "START" button. The air-blower starts air is pumped through the measuring chamber over five minutes while the following information is indicated on the display:

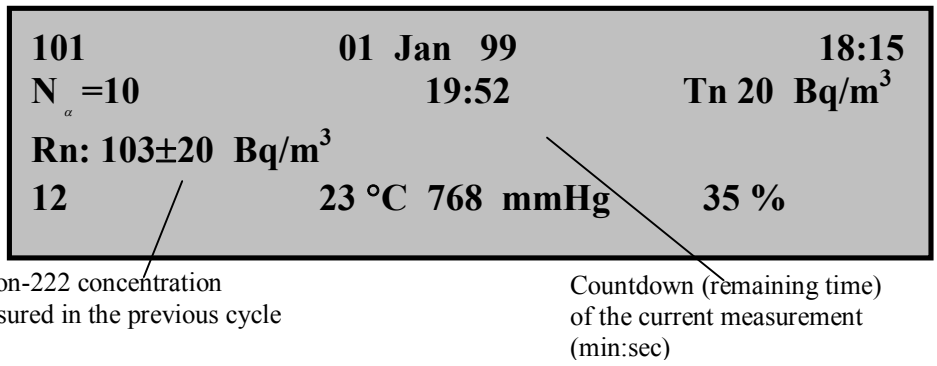


In 4,5 minutes after the built-in air-blower startup, high voltage is applied to a grid electrode of the measuring chamber. The air-blower stops after 5 (five) minutes of operation, and the radiometer begins a 20-minutes measurement.

Upon completion of measurements, the complex results are automatically stored in the RAM together with a time mark (the moment when this particular measurement in the series was started). Measurements are repeated three times without pumping the air into the measuring chamber. Upon completion of three 20-minutes measurements, the air-blower automatically starts again and the whole measuring cycle is repeated.

The final value of radon-222 concentration is calculated by the radiometer's software when each 20-minutes measurement is complete. If the calculated value of the radon-222 concentration does not exceeds the lower limit of the radiometer's specified range, the message Rn**<20 Bq/m^3** appears on the display. To interrupt measuring cycle, press and hold for 2 seconds the "**RESET**" button.

During continuous measurements the following information is displayed:



7.3.3. Selection of interval between measurement cycles.
Interrupt measuring cycle by pressing **"RESET"** button for 2 seconds.
Press "**1**" button to select the interval between measurement cycles. The following options are available:

1 Hour
4 Hours
8 Hours.

Select the interval using ▲ and ▼ buttons (move cursor (***) on the LCD to a desired value). When the interval is selected, start a measurement by pressing the "**START"** button. The measurement cycle includes automated air sampling (operation of the air-blower during 5 minutes) followed by a 20 minutes measurement. Then the data are automatically stored in the RAM, the radiometers pauses for 30 seconds and then automatically shuts off all resources except the internal timer and LCD. Power consumption from the batteries decreases tenfold. In pause mode the results of the last measurement are indicated on the LCD. After a predetermined interval between measurements (1 hour, 4 hours or 8 hours) the radiometer automatically turns on the air-blower for 5 minutes. Further next measurement cycles are repeated until the operation is stopped by the "RESET" button.

7.3.4. Selection of measurement run time
You can select the desired measurement run time (20; 60; 120 minutes). The measurement run time determines the lower limit of measurement range (with specified relative error, see sect. 3.3) in the following way:

Measurement run time, min	Lower limit, Bq·m^{-3}
20	110
40	40
120	20

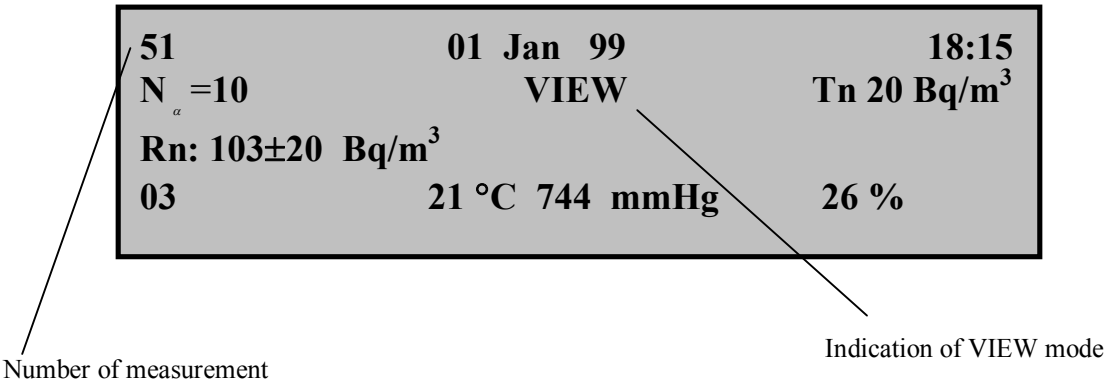
The default measurement run time (after power on) is set to 20 min. To change the measurement run time press the “Mode 2” button and select 60 min, 120 min or “time-integrated measurement” mode (**Integral**) by moving the «***» cursor on the display using ▲ and ▼ buttons. When the desired value is selected, press "START” button to start measurement.

The measurement cycle includes automated air sampling (operation of the air-blower during 5 minutes) followed by a measurement during selected time and a 10 second pause. In this mode you can view the measurement results by pressing “VIEW” button.

If the **Integral** measuring mode is selected, then after pressing "START” the radiometer starts continuous measurement without pumping air into the measuring chamber. Air enters into the measuring chamber by diffusion though the aerosol filter with air exchange period of about 50 minutes. Radon-222 concentration is calculated every minute and the accuracy of the indicated result is progressively improved taking into account previous measurement results. When a minute expires, RaA α-particles counting information (number N_α) is zeroed. In the integral mode viewing of the previous measurements results is not available. To view the obtained integral value stop a measuring cycle by pressing the “RESET” button for 2 seconds.

7.4. Viewing mode.

7.4.1. In the VIEW mode you can view data stored in the RAM of the radiometer. Except for some cases specified in this Operation Manual, the data can be viewed in any mode of operation (during a measuring cycle or standby). To view the data press the “VIEW” button. The following message is displayed on the indicator:



The last measurement (with max number of measurement (NM)) is shown first. To view the rest of the data, use ▲ button to increase the NM (go to later measurements) or ▼ button to decrease it (go to earlier measurements).

An attempt to view a measurement with a number exceeding maximum MN or going to the previous measurement when MN=1 or if no actual data present in the RAM will result in message "**No data**" on LCD.

7.4.2. Press the "VIEW" button to exit view mode. This must be done to ensure correct operation of the radiometer's software.

7.5. Connection of the radiometer to the personal computer.
By means of communication of the radiometer and PC you can do the following:

a) delete data from the radiometer memory (RAM);
b) set current date and time (PC time will be set for radiometer);
c) change the values of sensitivity and instruments number of the radiometer;
d) change the calibration constants (6 constants) for measuring climatic parameters;
e) transfer complex measurement results to PC;
f) view data on the PC display in graphic or table form, print reports and save measurement data in files.

7.6. Testing the spectrometric circuit[3].

7.6.1. Connect radiometer with a computer using kR.18446736.20 communication cable included in the radiometer delivery kit. 9-pin connectors of the cable are equivalent. Plug one connector into a socket at the rear panel of the radiometer (2, Fig.3b), another connector of a cable connect to a serial port of computer. Use USB-RS232 adapter if your computer has no serial port connector. Perform simultaneous 20 minutes measurements using the radiometer and computer software (see Appendix 1 and Appendix 2 of this Operation Manual). Compare calculated peak area corresponding to α-particles of RaA on computer with the number of α-particles shown on the LCD of the radiometer. These numbers should coincide within ±15%. You can save the spectrum acquired by the radiometer using software Data Center.

7.7. Operation system restart.

7.7.1. To reset the radiometer's operation system in case of failure, press the "RESET" button and hold it for 2 seconds.

7.7.2. The system can also be restarted by turning off and then on the "POWER ON/OFF" switch.

7.8. Turning off the radiometer.

7.8.1. Turn the "POWER ON/OFF" switch down. Measurement data will be saved and available to you when the radiometer is switched on next time.

[3] - *Data Center software is included in the delivery kit upon customer request.*

7.8.2. If you do not intend to charge the battery, disconnect mains adapter from the wall outlet.

7.8.3. Pack the radiometer and mains adapter into a bag for storage and transportation.

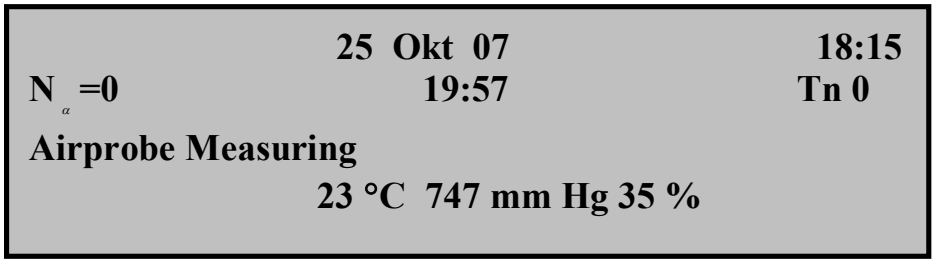
7.9. Working with samplers (**"Mode 3"**).

7.9.1. This mode of operation is intended for performing measurements in conjunction with the Sampler Kit "POU". It is supposed that samples are taken according to the corresponding Procedure Manual and Operation Manual for Sampler Kit and the radiometer background is known, measured as described in section 8.3 of this Manual. Approved procedure manuals are included in the POU delivery kit.

7.9.2. Measurement of the radon concentration in the air sample using POU samplers

7.9.2.1. Connect the radiometer, sampler and air-blowing unit as described in the "Procedure manual for fast measurement of Rn-222 concentration in the air using the RRA-type radon radiometers" (hereafter "Procedure Manual") using tubes included in the sampling kit. Switch on the radiometer (see sect. 7.2 in this Manual). Switch on the air-blowing unit POU. Mix the air in sampler and in the measuring chamber of radiometer according to sect. 7.2 of the Procedure Manual.

7.9.2.2. Press the "Mode 3" button on the front panel of the radiometer. Select the "Airprb" option by moving the cursor *** to this option in the screen menu (use ▲ and ▼ buttons) and then press the "Start" button to initiate a measurement (with duration of 20 minutes). You will see the following screen on the LCD:



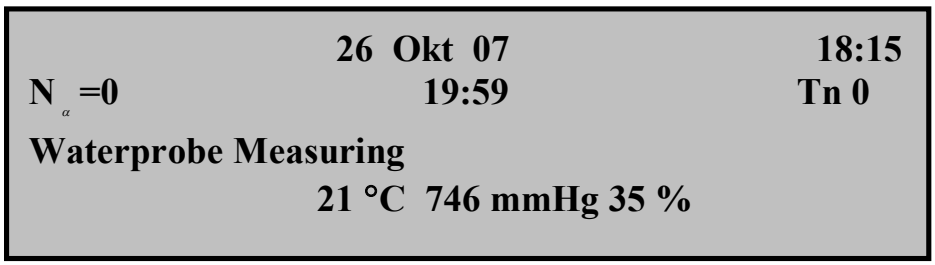
After the measurement is complete the result will be shown on the LCD (write this result in the record sheet). In accordance with the Procedure Manual, five consequent measurements should be performed and the calculated mean value is registered in the record sheet. In case it is necessary to register measurement result in terms of the EEC_{Rn}, calculate it using recommended value for equilibrium factor between radon and radon decay products.

7.9.2.3. The use of samplers broaden possible applications of the radiometer allowing to take air samples when the temperature is below zero, in the explosive atmosphere and so on.

7.9.3. Measurement of the radon concentration in the water sample using POU water sampler.

7.9.3.1. Connect the radiometer, bubbler and air-blowing unit as described in the "Procedure manual for fast measurement of Rn-222 concentration in the water using the RRA-type radon radiometers" using tubes included in the sampling kit. Switch on the radiometer (see sect. 7.2 in this Manual). Switch on the air-blowing unit POU. Transfer of the radon dissolved in water into the measuring chamber of radiometer is performed when the air circulates through the water in the bubbler.

7.9.2.2. Press the "Mode 3" button on the front panel of the radiometer. Select the "Water" option by moving the cursor *** to this option in the screen menu (use ▲ and ▼ buttons) and then press the "Start" button to initiate a measurement (with duration of 20 minutes). You will see the following screen on the LCD:



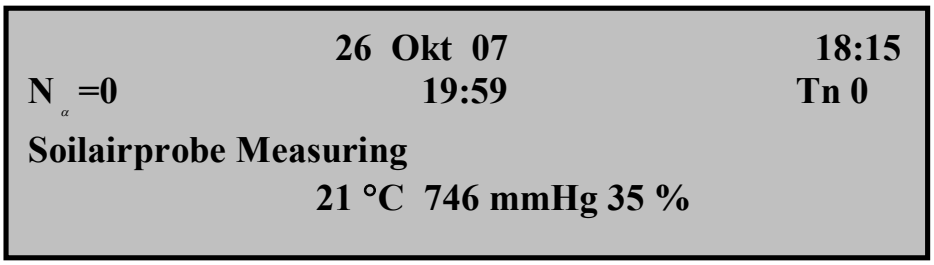
After the measurement is complete the result will be shown on the LCD (write this result in the record sheet). In accordance with the Procedure Manual, five consequent measurements should be performed and the calculated mean value is registered in the record sheet. The result shown on the LCD is calculated according to the formula (3) in the section 7.3 of the Procedure Manual taking into account the background measured in advance.

7.9.3.3. To prevent water injection into the measuring chamber and damage of the radiometer, please ensure that the circuit is assembled as described in the Procedure Manual (check the direction of air flow!). As an option, you can insert the dehydrator-cartridge to additionally dehumidify the air that flows from the bubbler towards the radiometer – this will help to prolong up to 6-fold the resource of the silica gel in the filter-dehydrator and to.

7.9.4. Measurement of the radon concentration in the soil air using POU soil air probe

7.9.4.1. Connect the radiometer, probe and air-blowing unit as described in the "Procedure manual for fast measurement of Rn-222 concentration in the soil air using the RRA-type radon radiometers" using tubes included in the sampling kit. Switch on the radiometer (see sect. 7.2 in this Manual). Switch on the air-blowing unit POU. Mix the air in probe and in the measuring chamber of radiometer according to sect. 7.2 of the Procedure Manual.

7.9.4.1. Press the “Mode 3” button on the front panel of the radiometer. Select the “SoilAir” option by moving the cursor *** to this option in the screen menu (use ▲ and ▼ buttons) and then press the “Start” button to initiate a measurement (with duration of 20 minutes). You will see the following screen on the LCD:



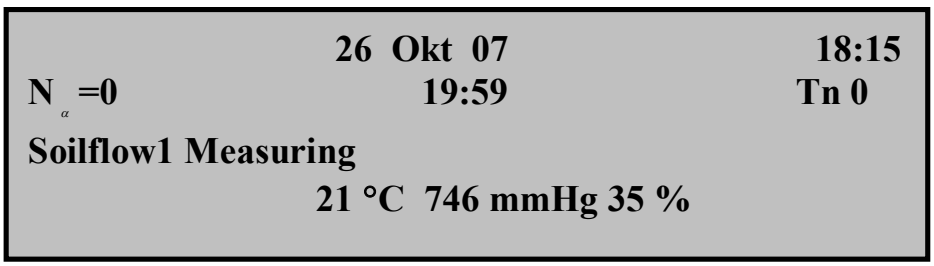
After the measurement is complete the result will be shown on the LCD (write this result in the record sheet). In accordance with the Procedure Manual, five consequent measurements should be performed and the calculated mean value is registered in the record sheet. The result shown on the LCD is calculated according to the formula in the section 8.1 of the Procedure Manual taking into account the background measured in advance.

7.9.5. Measurement of the radon flux from the soil surface.

Prepare the soil on the selected test point according to the “Procedure manual for fast measurement of Rn-222 flux from the soil surface using the RRA-type radon radiometers”.

7.9.5.1. Connect the radiometer, air-blowing unit and appropriate accumulation chamber (1 or 2; consult the two modes of radon flux measurement in the section 7 of the “Procedure manual for fast measurement of Rn-222 flux from the soil surface using the RRA-type radon radiometers”). Use tubes and accumulation chamber included in the sampling kit. Switch on the radiometer (see sect. 7.2 in this Manual). Switch on the air-blowing unit POU.

7.9.5.1. Press the “Mode 3” button on the front panel of the radiometer. Select the “Soilflow1” or “Soilflow2”option by moving the cursor *** to this option in the screen menu (use ▲ and ▼ buttons) and then press the “Start” button to initiate a measurement (with duration of 20 minutes). Promptly place the accumulation chamber on the prepared soil surface. You will see the following screen on the LCD:



After the measurement is complete the result will be shown on the LCD (write this result in the record sheet). In accordance with the Procedure Manual, five consequent measurements should be performed and the calculated mean value is registered in the record sheet. The result shown on the LCD is calculated according to the formulas in the section 8.1 or 8.2 of the Procedure Manual (for modes 1 and 2, accordingly) taking into account the background measured in advance.

8. OPERATION

8.1. Whenever you use the radiometer outdoors, protect it and its parts from direct sunlight and atmospheric precipitation. Always charge the battery in advance (see 7.2.1 for instructions).

8.2. Sampling procedure and preparation for measurements.

8.2.1. Pull the radiometer out of the bag. Turn the holder in the most convenient position and fix it.

8.2.2. It is recommended to perform air sampling at a distance no less than 0.5 m from the walls and the floor of a room. Required number of points to be tested for radon in a basement of a building, the building itself, in a separate room, and the sequence of measurements are regulated by appropriate regulations (in the Russian Federation – MU 2.6.1.715-98).

8.3. Measurement of background radon value.

8.3.1. Switch the radiometer on and wait 3 minutes. Using options "MODE 3" and the "Background measurement (Background)", perform the background measurement. The last option ("Background") allows obtaining the radiometer's background readings without applying high voltage to the electrode in the measuring chamber. The radiometer's background should not exceed the specified value.

8.4. Sample measurement in the mode of continuous monitoring[4].

8.4.1. Press the "START" button. The air sample is taken by means of build-in air-blower over 5 minutes and a sample is then measured over 20 minutes. Upon completion of a measurement, an indicator displays measured radon and thoron concentrations and climatic parameters. During a measurement cycle previous result of radon concentration is displayed. Results are stored in the RAM of the radiometer. The end of each measurement cycle is accompanied by audio-signal that lasts 10 seconds.

8.5. To calculate the effective equivalent concentration (EEC) of radon-222, use appropriate equilibrium coefficient (F) between radon-222 and its daughters (decay products). For example, mean value of coefficient F for typical indoor environments is estimated as 0.4 (ICRP Publication 65, 1998) or 0.5 (recommended value in the Russian Federation). If the results are to be presented in terms of EEC_{Rn} in the measurement record sheet, the measured radon-222 concentration should be multiplied by F to obtain the EEC_{Rn} value.

8.6. Operation procedure for data exchange with personal computer.

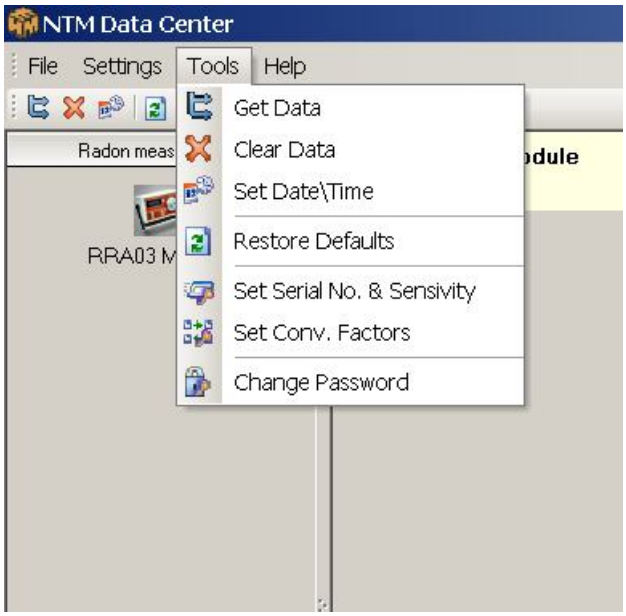
[4] *when supplied from AC mains, the radiometer should not be placed close to high-power electrical installations (refrigerator, kettle, oven etc.) so that power interference can be avoided.*

8.6.1. Press the “RESET” button to interrupt current test (if the test is running), otherwise the radiometer will not respond to computer.

8.6.2. Connect radiometer with a computer using kR.18446736.20 communication cable included in the radiometer delivery kit. 9-pin connectors of the cable are equivalent. Plug one connector into a socket at the rear panel of the radiometer (2, Fig.3b), another connector of a cable connect to a serial port of computer. Use USB-RS232 adapter if your computer has no serial port connector.

8.6.3. Copy all files from data medium supplied with radiometer (CD, flash drive) in a separate folder on your computer, install **Data Center** software under OS Windows. Copy the settings-by-default 472-09.rra03defs file from CD to the \Datacenter\ directory. The description of the program is contained in **Appendix 1**. The program uses COM1 port as default. You can change a port through the program menu.

8.6.4. To establish connection between radiometer and computer and to load data from radiometer, use “Tools/Get data” menu of the program.



During data transfer progress the bar on the radiometer’s indicator will be shown until the transfer process is finished – that means that all measurement data stored in the radiometer were sent to computer. You can also see total number of bytes transferred in corresponding box in the program’s window. When the process is finished, the radiometer will let the user know by an audio-signal and the following massage will appear on the display:

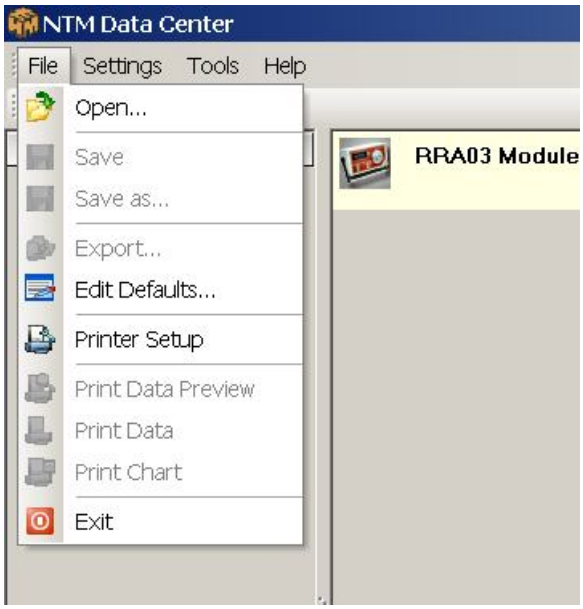
01 Jan 99 **18-10**

RAM_out: □□□□□□□□□□□□□□□□ **= 32K**

RRA-01M-03 № 00299

S=1.8*10^{-4} m^3/(Bq·s)

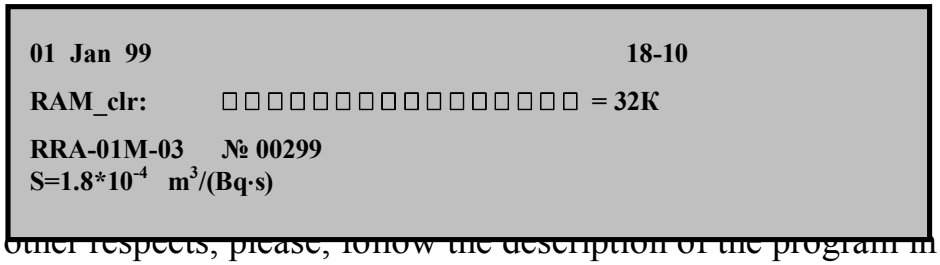
8.6.5. Saving the data transferred to the computer.



By default data files are saved in the program's folder. To save the data, use "File/Save" or "File/Save as" in the program menu and enter a filename in the dialog box (extension "rra03" will be added by the program). It is possible to convert an *.rra03 file into an *.xls file for further analysis.

8.6.6. Deleting data from the memory of radiometer.

To delete data stored in the radiometer's RAM it is necessary to use "Tools/Clear data" in the program menu. A progress bar on the radiometer's indicator will be shown until the process is finished – that means that all measurement data were deleted from the radiometer's memory. When the process is finished, the radiometer will let the user know by an audio-signal and the following massage will appear on the indicator:



8.6.7. In other respects, please, follow the description of the program in **Appendix 1**.

9. MAINTENANCE

9.1. Maintenance should be performed by a personnel that is:

a) qualified to service the radiation measurement instrumentation;

б) qualified to work with the ionizing radiation sources.

9.2. Read carefully this manual before performing maintenance operations.

9.3. Follow safety precautions according to section 6 of this Operation Manual.

9.4. The radiometer maintenance work includes:

a) dust and dirt removal from the radiometer outer surfaces – weekly;

b) completeness checks – quarterly;

c) preventive maintenance according to section 9.5.

9.5. Preventive maintenance rate and procedures.

9.5.1. Preventive maintenance includes:

a) visual inspection of the radiometer;

b) performance testing;

9.5.2. Visual inspection of the radiometer should be performed quarterly and after repairs. The following should be checked:

a) condition of surfaces and labeling on the radiometer control unit;

b) operability of mains adapter;

c) function of switches and buttons;

d) operability of air-blower;

e) silica gel condition in the dehydrating filter.

9.5.3. Performance testing is carried out as required but not less then once a year after the warranty expires. The following should be checked:

a) instrument background level;

b) reproducibility of readings from the standard source.

9.5.4. The radiometer verification should be performed according to a procedure described in Section 12.

10. TROUBLESHOOTING

10.1. Possible problems and their solutions are presented in Table 2.

Table 2.

Failure	Probable cause	Solution
No LED indication on the back panel when the radiometer is powered from the mains adapter	a). absence of 220 V voltage in the wall outlet b). the break of cord of the mains adapter c). failure of the mains adapter	a). check the voltage in the wall outlet b). replace the cord of the mains adapter c). replace mains adapter
The message "Battery discharged" appears on the LCD after startup	a). the battery is too low b). failure of the battery	a). charge the battery and restart the radiometer b). replace the battery and restart the radiometer.
The checksum falls out of the (200±5) range during the power-on test	ADC failure (spectrometric circuit is out of order)	Contact the manufacturer

10.2. In the case of failures not listed in the Table 2 consult the service department of the manufacturer.

11. STORAGE AND TRANSPORTATION

11.1. Conditions for radiometer storage in the manufacturer's package should comply with the "type 2 storage conditions" according to the state standard GOST 15150-69, namely a warehouse with natural ventilation, at temperatures of the ambient air from minus 5 to +40°C and relative humidity up to 98 % at +25°C. No climate control is necessary.

11.2. The shelf life of radiometer in original package under conditions described in section 11.1 is 3 years without repacking.

11.3. The accompanying documentation in a welded polyethylene bag should be placed into the case in a way that allows taking it out without damaging the moisture-proof package of the radiometer.

11.4. Radiometer in the manufacture's package may be shipped by any mode of transport at any distance provided that the integrity of package and protection from precipitations are ensured.

11.5. Package with the radiometer should be secured from displacement and shocks during transportation. The radiometer withstands vibrations during transportation by country road (up to 500 kilometres).

11.6. Temperature range during transportation – from minus 50 to +50°C. Relative humidity up to 98 % at +35°C.

11.6. Temperature range during transportation is from minus 50 ^{0}C up to +50 ^{0}C, relative humidity 98% at 35 ^{0}C.

11.7. All outlets of the measuring chamber should be sealed with caps during transportation.

NOTE: Condensate may appear inside the measuring chamber of the radiometer in case the measuring chamber is not sealed and abrupt ambient temperature drops happened during transportation. This can damage the semiconductor detector and cause the sensitivity loss.

12. VERIFICATION

12.1. *General*

This verification procedure was developed in compliance with the Recommendation "GSI. Radiometers for measurement of volumetric activity of radon. Verification procedure. MI 2470-97".

12.1.1. The present procedure is applied to radiometer RRA-01M-03 БВЕК.431110.03, intended for measurement of radon concentration in the range from 20 to 20000 $Bq \cdot m^{-3}$ with a maximum permissible intrinsic relative error no more than ±30% (at confidence level 0.95), and defines the techniques for initial and periodic verifications.

12.1.2. The interval between periodic verifications – 1 year.

12.2. *Operations of the verification*

The following operations should be completed during verification process:

- Visual inspection (12.8.1);
- Testing (12.8.2);
- Checking of volume throughput of the built-in air-blower (12.8.3);
- Determination of the background signal (12.8.4);
- Determination of the sensitivity (12.8.5);
- Determination of relative measurement error (12.8.6).

12.3. *Verification tools*

12.3.1. When performing verification, the following reference tools and support equipment should be used:

Working standard installation designed for reproduction and measurement of volumetric activity of radon in the range from 500 to $1.0 \cdot 10^6$ $Bq \cdot m^{-3}$ with a basic relative error ±15% at confidence level P=0.95, comprising the following items:

1. Reference radon monitor Alpha GUARD PQ2000, certified for measurement of VAR in the range from 500 to $1.0 \cdot 10^6$ $Bq \cdot m^{-3}$ with a basic relative error ±15%;
2. Radon-222 generator including the protective housing (chamber) 1BP2-OS (volume 0.8 m^3), emanating Ra-226 source with activity (1.0…1.5) $\cdot 10^5$ Bq, placed inside a chamber 6BP1-OS (volume 0.15 m^3). The source constitutes a bubbler with valves, it can generate a VAR level in the range from 500 to 3000 $Bq \cdot m^{-3}$ inside the chamber 1BP2-OS. The bubbler is shielded by a 10 mm lead sheet. Hermetic chamber 1BP2-OS is equipped with a fan (type BH2) for induction of air circulation, an aneroid (type M67), allowing to measure the air pressure in the range 610…790 mmHg, a branching filter with mains outlets (220±11 V; 50 Hz) for powering the verified instruments, holes with gloves for performing operations inside the chamber and with a digital meter (type HT-3) for measuring the air temperature in the range from minus 20 to +50°C with accuracy ±0,5°C and relative humidity in the range 5…95% with accuracy ±4%.

3. Digital thermo-moisture gauge NT-3 designated for measuring temperature within the range from minus 20 to +50°C with the absolute error of ±0.5°C and relative humidity from 5 to 95 % with the absolute error ±4 %;
4. Drum gas counter GSB-400 class 1 with liquid lock as specified in the State Standard GOST 6463-53;
5. Sliding vane rotary vacuum pump, type 2NVR-5DM;
6. Micro-blower MR2-2G as specified in the Standard TU 333-1054;
7. Stop-watch, type SOPpr-2a-3.

Support equipment for verification:
1. Cartridges with drying agent (granulated anhydrous calcium chloride $CaCl_2$);
2. Absorbing cartridges with charcoal (type SKT-3);
3. Communicating pipes complying with specifications TU 64-2-286-79 and four valves (type MKV-250);
4. adapters for coupling of tubes of different diameters.

12.3.2. Measuring instrumentation used should be certified and certificates should be valid at the moment of verification.

12.3.3. Use of another verification tools and support equipment is allowed provided that specifications are equivalent or better.

12.4. *Qualification requirements*

12.4.1. Verification should be performed by qualified personnel certified as "verification officer" and as "radiation worker".

12.5. *Safety requirements*

When performing verification procedures, requirements of the regulations should be complied, namely:
- SP 2.6.1.758-99 "Radiation safety norms (NRB-99)";
- SP 2.6.1.799-99 "Basic rules for radiation safety (OSPORB-99)";
- "The Rules for technical operation of consumer electrical installations and for safety measures applied to operation of consumer electrical installations (PTE/PTB-84)".

12.6. *Ambient conditions*

Ambient conditions should be as follows (in compliance with GOST 8.395-89):
- Temperature …… 15 ÷ 25 °C;
- Relative humidity ……..…..…… 40 ÷ 80 %;
- Atmospheric pressure ……. 98 ÷ 105.1 kPa (735 ÷ 790 mmHg).

12.7. *Preparation for verification.*

The following operations should be performed before verification.

If the radiometer was transported to the place where verification is performed at a temperature below 0°C it is necessary to keep the radiometer at normal conditions for at least two hours.

If relative humidity value determined by a humidity gauge is more than 80% it is necessary to dehumidify the measuring chamber by air circulating through a dehydrator-cartridge filled with granulated anhydrous calcium chloride $CaCl_2$. For this purpose connect an outlet of the measuring chamber with an inlet of a MR2-2G micro-blower. Then an outlet of the MR2-2G micro-blower connect to one outlet of a dehydrator-cartridge and the second outlet connect to the inlet of the measuring chamber. Turn on the micro-blower. When the relative humidity value determined by humidity gauge falls below 80%, turn off the micro-blower.

The outlet of the measuring chamber should be sealed while the outlet of the built-in air-blower should be open.

12.8. *Verification procedure and measurement results processing.*

12.8.1. *Visual inspection*.

12.8.1.1. By visual inspection the following should be established:

* absence of mechanical damages of the radiometer;
* completeness;
* availability of the instrument's Passport, Operation Manual and certificate of the previous verification.

12.8.2. *Testing*

Switch on the radiometer and check the radiometer operation in accordance with the Operation Manual.

12.8.3. *Checking of volume throughput of the built-in air-blower*

When checking a volume throughput of the built-in air-blower the following operations should be performed.

Connect the radiometer's inlet with GSB-400 outlet using connecting tubes and adapters.

Turn on the built-in air-blower as specified in the Operation Manual. In 10 seconds or later write a reading on the GSB-400. When the GSB-400 needle reaches any decimal scale division run a stop watch. When the GSB-400 counts a volume of pumped air not less than 2 liters note the time by the stop watch. Record the volume of pumped air and time. Calculate the volume pumping rate *w* by the formula:

$$w = \frac{V \cdot 60}{t} \quad , \ (1)$$

where w is a volume throughput, l·min^{-1};

V is a volume of pumped air, l;

t is counting time, s.

Repeat the operation three times at least. Obtained values of volume throughput of the built-in air-blower should be not less than 0.8 l·min^{-1}.

12.8.4. *Determination of instrument background*

When determining a background level of the radiometer, the following operations should be performed.

To remove radon-222 from the measuring chamber it is necessary to ventilate the measuring chamber by air passed through a cartridge filled with a charcoal of SKT-3 type. With this purpose it is necessary to connect an outlet of the measuring chamber with an inlet of a MR2-2G micro-blower. Then an outlet of the MR2-2G micro-blower is connected to the cartridge with charcoal. The second outlet of the cartridge is to be connected to the inlet of the radiometer.

Turn on the micro-blower for half an hour at least. Then turn the micro-blower off.

Measure the background level of the radiometer. With this purpose connect the inlet of the measuring chamber with the outlet of the built-in air-blower. Activate the "Background measurement" mode as specified in the Operating Instructions and measure a background level of the radiometer three times at least, with duration of each measurement being not less than 120 minutes. Record numbers of α–particles RaA registered during each measurement (N_α). Sum up all values N_α.

Calculate a value of background Q_{bgr} by the formula:

$$Q_{bgr} = \frac{N_{bgr}}{t_{meas} \cdot \varepsilon}, \qquad (6)$$

where Q_{bgr} is radiometer's background, Bq·m^{-3};

N_{bgr} is a sum of α–particles RaA registered in each measurement;

t_{meas} is a total time of all measurements, s;

ε is the sensitivity of the radiometer, s^{-1}·Bq^{-1}·m^3.

The obtained background value should not exceed 7.0 Bq/m^3.

12.8.5. *Sensitivity determination.*

The sensitivity of the tested radiometer is determined by comparing its readings with the readings of the reference device. For this purpose it is necessary to assemble the verifying scheme presented on Fig.4. Place the tested radiometer into a 1BP2-OS box though a lock. Shutoff valves K1-K4 should be closed. Open a valve of a bubbler. Open the K3 valve and turn on a pump to evacuate the 1BP2-OS box. Control a pressure level in the 1BP2-OS box with by a barometer. When pressure drop in the box reaches 2 mmHg, turn off the pump and close the KE valve. In the

process of verification, temperature and relative humidity in the 1BP2-OS box can be controlled by a digital thermo-moisture gauge.

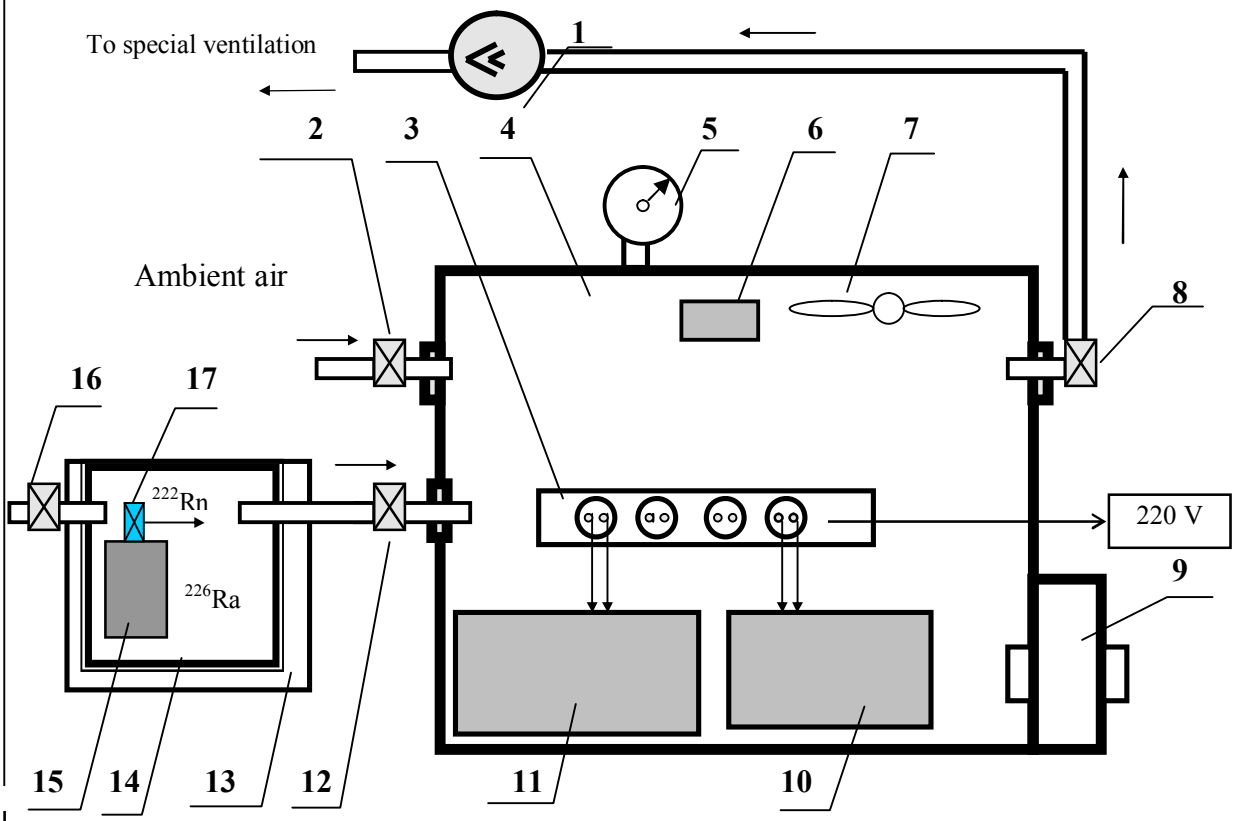


Figure 4. Diagram for verification of the radiometer

Notation conventions:

1. Pump;
2. Shutoff valve K1;
3. AC mains socket;
4. 1BP2-OS box;
5. Reference barometer-aneroid;
6. Digital thermo-moisture gauge;
7. Ventilator;
8. Shutoff valve K3;
9. Lock;
10. The radiometer under verification;
11. Reference radiometer;
12. Shutoff valve K2;
13. 6BP1-OS box;
14. Lead covering;
15. Bubbler;
16. Shutoff valve K4;
17. Bubbler valve.

Direction of air motion is indicated by arrows.

Turn on the reference radiometer as specified in the Operation Manual. Open K2 and K4 valves to create radon concentration in the range of 600 to 3000 Bq·m^{-3} in the 1BP2-OS box for the time required for pressure balance. It is necessary to control radon concentration in the 1BP2-OS box by the reference radiometer as

specified in the Operating Instructions. Turn on a ventilator to mix air in the box. Turn on the reference radiometer and the radiometer under verification as specified in corresponding Operation Manuals and make at least 5 measurements of radon concentration by the reference radiometer and the radiometer under verification. The mean value Q_s calculated by the formula (3) is to be taken as the result of radon concentration measured by the reference radiometer.

$$Q_s = \frac{\sum_{i=1}^{n} Q_{is}}{n} \quad , \quad (3)$$

where Q_s is the results of measuring radon concentration by the reference radiometer, $Bq \cdot m^{-3}$;

n is a number of measurements;

Q_{is} is an i-th measurement of radon concentration by the reference radiometer, $Bq \cdot m^{-3}$.

12.8.5.3. Measure a number of pulses Nin corresponding to a number of registered α-particles RaA for the sample taken by the reference radiometer within time t. Perform at least three measurements. From the obtained values N_{in} it is possible to determine an average value N_n by the formula

$$N_n = \frac{\sum_{i=1}^{n} N_{in}}{n} \quad , \quad (4)$$

where N_n is an average number of pulses corresponding to a number of registered α-particles RaA, relative unit;

N_{in} is a result of i-th measurement of a number of pulses corresponding to a number of α-particles RaA registered by the reference radiometer, relative unit;

n is a number of measurements.

Sensitivity ε_i of the radiometer under verification can be determined by the formula:

$$\varepsilon_i = \frac{N_n}{Q_s \cdot t} \quad , \quad (5)$$

where ε_i is the sensitivity of the radiometer under verification determined in the i-th measurement, $Bq^{-1} \cdot m^3 \cdot s^{-1}$;

N_n is an average number of pulses corresponding to a number of α-particles RaA registered by the reference radiometer, relative unit;

Q_s is an average value of radon concentration measured by the reference radiometer, $Bq \cdot m^{-3}$;

t is duration of one measurement cycle, s.

12.8.5.4. Repeat sect.12.8.5.2-12.8.5.3 at least three times. Calculate the average value of sensitivity over all measurements by the formula:

$$\varepsilon = \frac{\sum_{i=1}^{m} \varepsilon_i}{m} \quad , \quad (6)$$

where ε is an averaged value of sensitivity of the radiometer under verification, $Bq^{-1} \cdot m^3 \cdot s^{-1}$;

ε_i is sensitivity of the radiometer under verification measured in the i-th measurement, $Bq^{-1} \cdot m^3 \cdot s^{-1}$;

m is a number of sensitivity measurements performed at different measuring conditions.

The obtained value of sensitivity should not be less than $1.4 \cdot 10^{-4}$ $Bq^{-1} \cdot m^3 \cdot s^{-1}$. If the obtained value is lower than the nominal value, the radiometer is considered to be rejected. If the obtained value **ε** falls beyond the allowance range specified in the certificate of the previous verification but is not less than $1{,}4 \cdot 10^{-4}$ $Bq^{-1} \cdot m^3 \cdot s^{-1}$, the newly obtained value **ε** should be recorded in the passport of the radiometer under verification and the verification certificate. The obtained sensitivity value **ε** should be written in the memory of radiometer under verification as specified in the Operation Manual.

12.8.6. *Determination of the measurement error*

12.8.6.1. An error of the radiometer under verification can be calculated by the formula:

$$\delta = (\Theta + t_p \cdot S) \cdot 100\ \% \quad , \quad (7)$$

where δ is an error of the radiometer under verification, %;

Θ is the systematic error equal to the relative error of the reference radiometer, relative units;

t_p is Student's coefficient, relative unit; the coefficient value at the confidence probability of 0.95 and depending on a number of measurements m can be determined from the below table:

m-1	2	3	4	5	6	7	8	9
t	4.303	3.182	2.776	2.571	2.447	2.365	2.306	2.262

A standard deviation S of sensitivity measurement can be calculated by the formula:

$$S = \frac{1}{\varepsilon} \sqrt{\frac{\sum_{i=1}^{m} (\varepsilon - \varepsilon_i)^2}{m(m-1)}} \quad , \quad (8)$$

where S is a standard deviation of a result of sensitivity measurement for the whole measuring series;

ε is an averaged sensitivity value of the radiometer under verification, $Bq^{-1} \cdot m^3 \cdot s^{-1}$;

ε_i is sensitivity of the radiometer under verification measured in the i-th measurement series, $Bq^{-1} \cdot m^3 \cdot s^{-1}$;

m is a number of sensitivity measurement series performed under different measuring conditions.

12.8.6.2. The basic relative error of the radiometer under verification should not exceed ±30%. Otherwise the notification about the radiometer's unserviceability is issued (sect.12.8.8.3).

12.8.7. The procedure of radiometer's sensitivity verification for thoron (radon-220) is the same as for radon-222 with a single exception that the radon-222 source is replaced by the emanating thoron source.

12.8.8. *Registration of verification results.*

12.8.8.1. Verification results should be recorded.

12.8.8.2. For the radiometer that has successfully passed the verification, the "Certification of verification" is issued in accordance with PR 50.2.006-94 (Appendix 1).

12.8.8.3. The radiometer that has failed to pass the verification is not allowed for use; in this case the "Notification of Unserviceability" is issued in accordance with PR 50.2.006-94 (Appendix 2).

12.8.8.4. The radiometer that has passed the initial verification should be sealed with stamps of the manufacturer. The stamps are installed into the cups with screws that fix the back panel of a radiometer.

Appendix 1

Radon monitor RRA-03 application software

Overview of RRA-03 software

Main screen of the program

To launch the radon monitor RRA-03 application software run **Data Center** program, in the module pickup panel (left vertical panel) select the tab “Radon measurement” (3) nd click on the RRA03 button (4) The following window will appear (fig. 1)

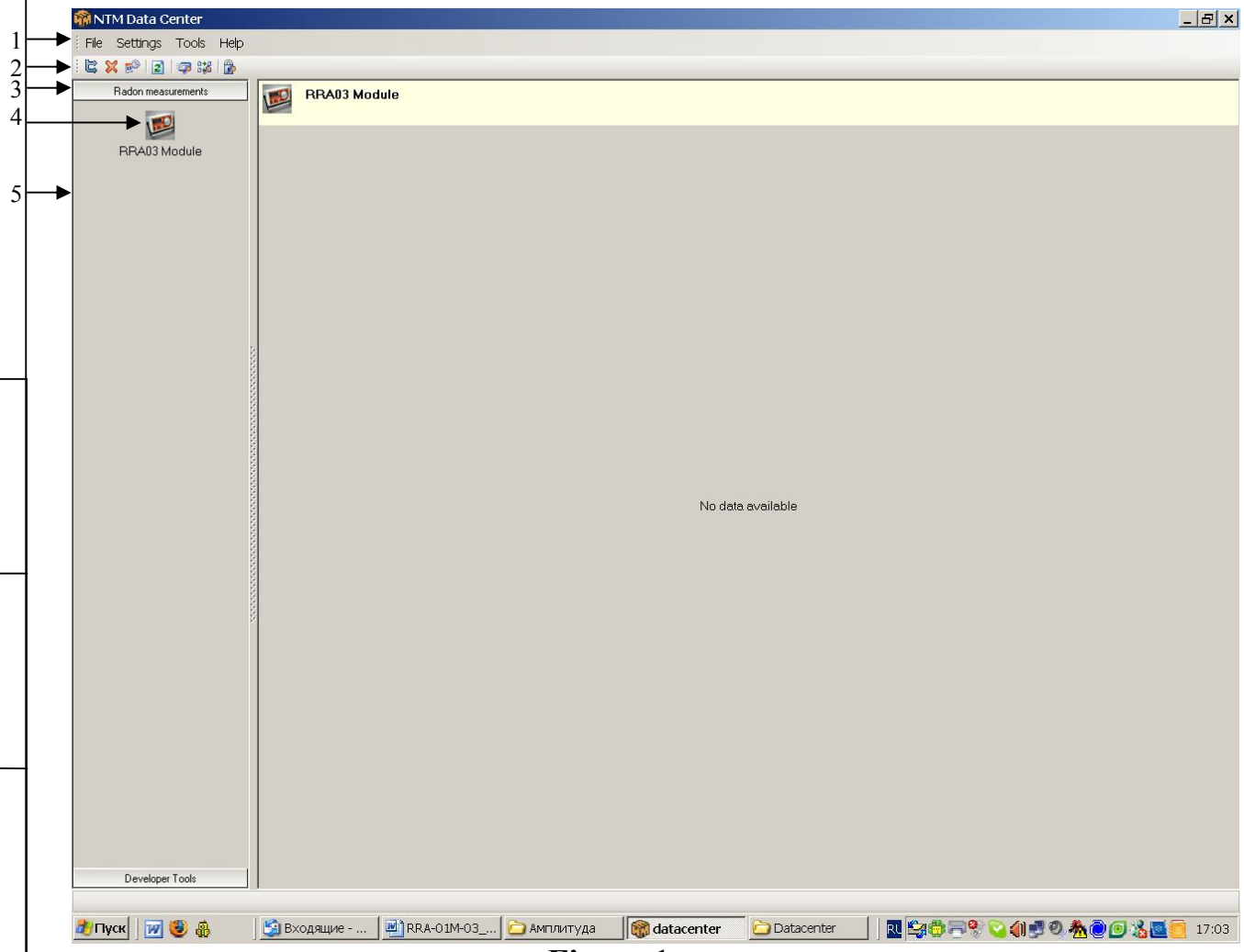


Figure 1

In this main screen the following elements are shown (fig 1):

1 – Main menu
2 – Toolbar
3 – “Radon measurement” tab
4 – “RRA03 module” button
5 – Program modules bar

Main menu

Main menu bar appears as shown in fig. 2.

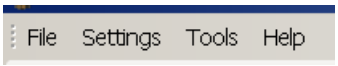


Figure 2

The menu bar contains menu commands for operating the program:

- **File**
- **Settings**
- **Tools**
- **Help**

File

The **File** menu is shown in fig. 3.

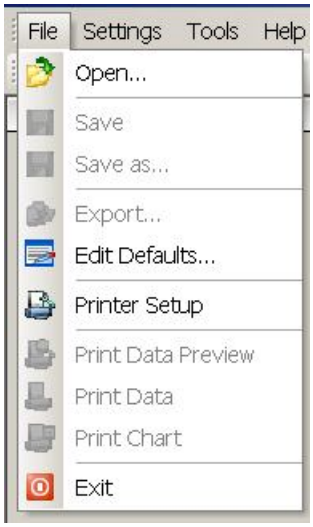


Figure 3

The **File** menu allows you to:

- Open a file with saved data;
- Save data into a file;
- Save data under another filename;
- Export data to MS Excel;
- Edit the “settings-by-default” file;
- Setup a printer;
- Preview and print data;
- Print charts with graphical representation of data;
- exit the Data Center program.

File / Open

This menu option opens a standard dialog box (fig.4).

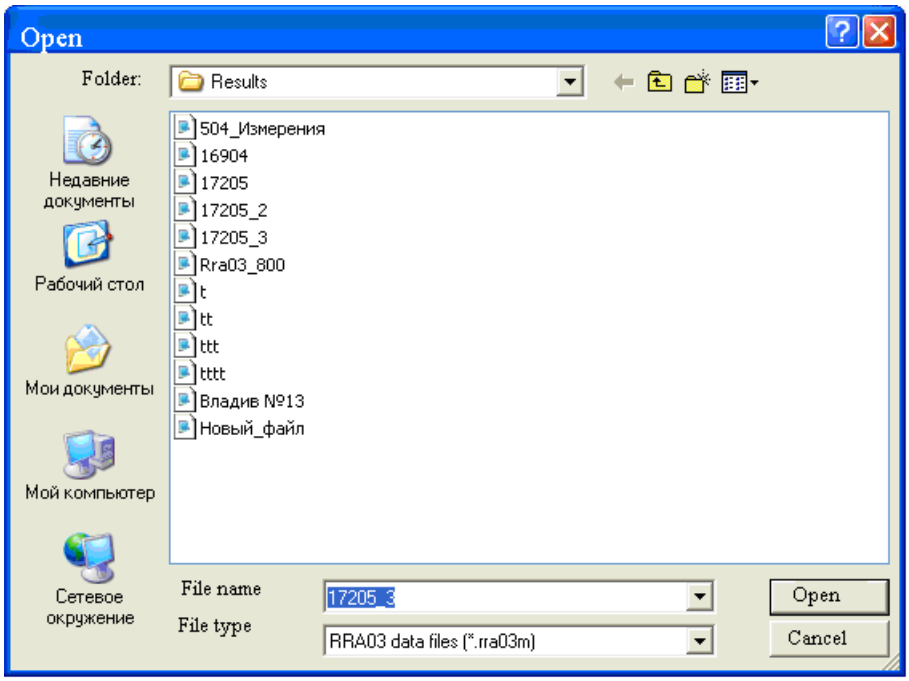


Figure 4

You can open files saved in the new RRA-03 software format (*.rra03) as well as in the older version of the RRA-03 software (*.rra03m). Select the desired file type using the drop-down list in the bottom of the dialog box.

File / Save

This menu option opens a standard dialog box (fig.5).

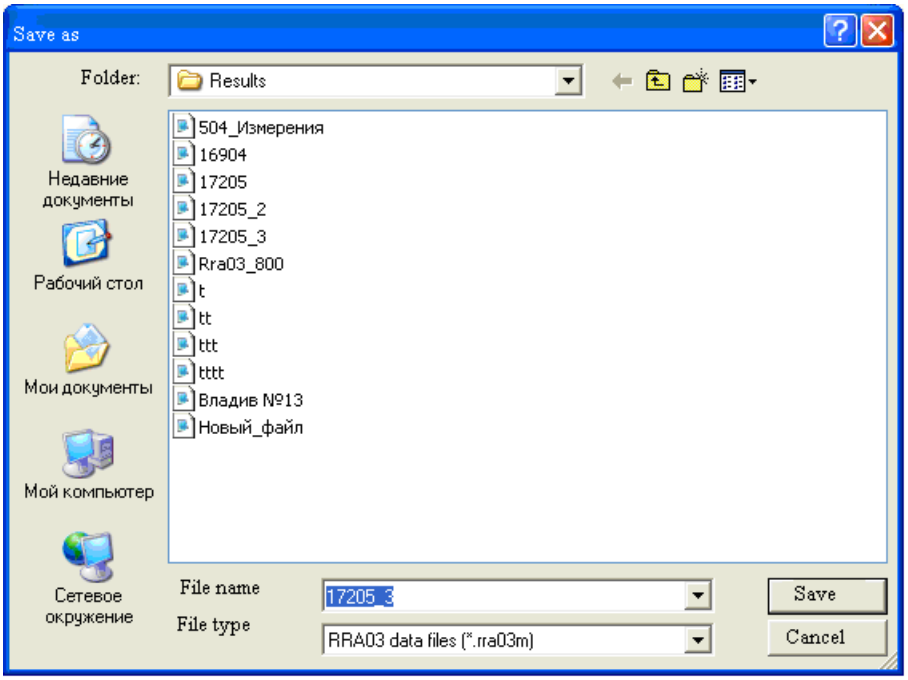


Figure 5

Using this dialog box you can save data loaded from the radiometer RRA-03 to the computer. Select the folder where you want to save the file, enter the filename in the box and click “Save”.

The “File / Save” option is ONLY available if there are actual data loaded from the radiometer and not saved yet.

File / Export

Using this option you can save the data in the Excel format (*.xls) for further processing in the Microsoft Excel. When you select this option, a dialog box will appear (fig. 6). Select the folder where you want to save the file, enter the filename in the box and click “Save”.

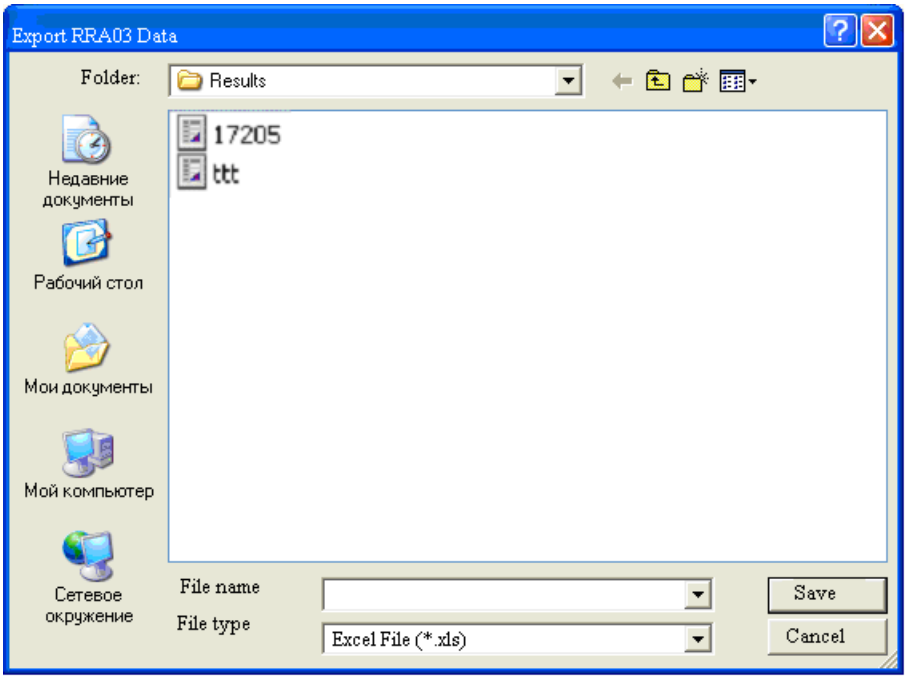


Figure 6

File / Edit Defaults

Using this option you can edit the settings-by-default stored in *.rra03defs* file located in the \Datacenter\ directory. The option allows access to the main constants used for measurement results calculatings.
Each Device's defaults set is dedicated to a specific serial № of an RRA device. Thus the number of "settings-by-default" files must correspond to the same number of RRA used. When selecting an RRA device to work with, it is necessary to choose button "Load" in the dialogue box and load the correspondent "settings-by-default" file.
To change the settings just type in new values in each position of the dilogue box and press Save.
The constants are used each time the software is launched with the dedicated RRA device.

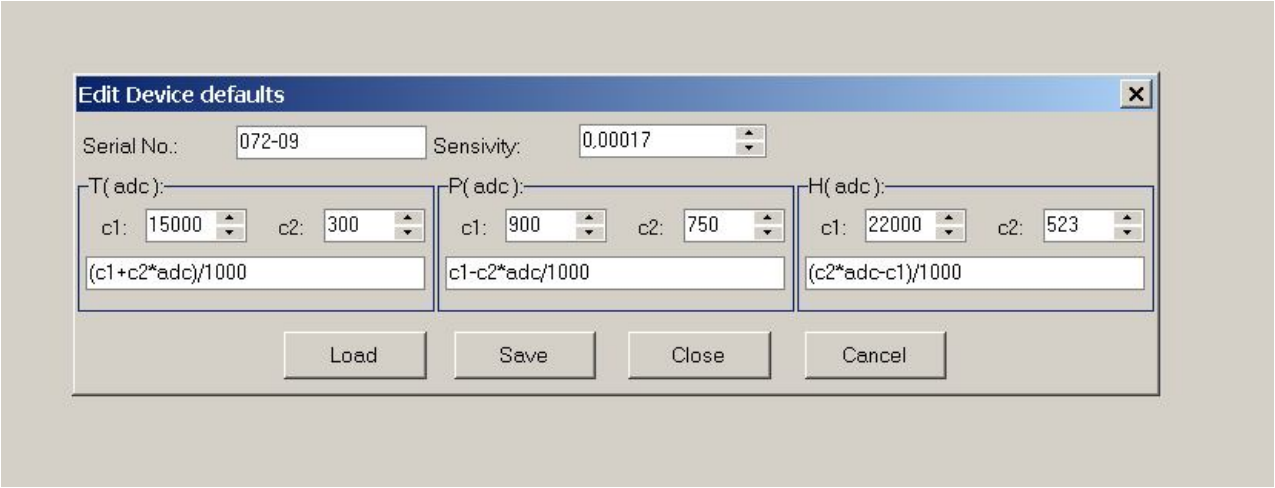


Figure 7

File / Printer Setup

When you select this option, a standard dialog box for printer setup will appear (fig. 8). You can define a printer which will be used by the Data Center program, set properties for that printer, select page orientation and paper feeding option.

There is also free software available that allows the user to “print” to PDF files. This is useful if you want to save reports in this format. If you have this software on your computer, you can select this virtual printer as well (for example, PDF Creator).

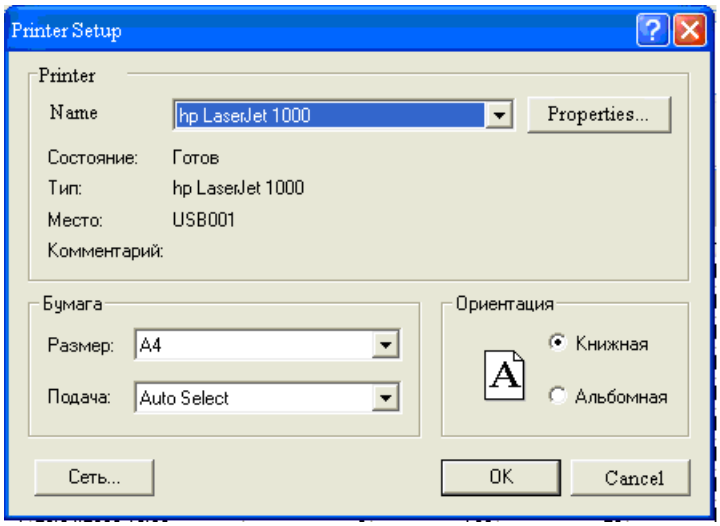
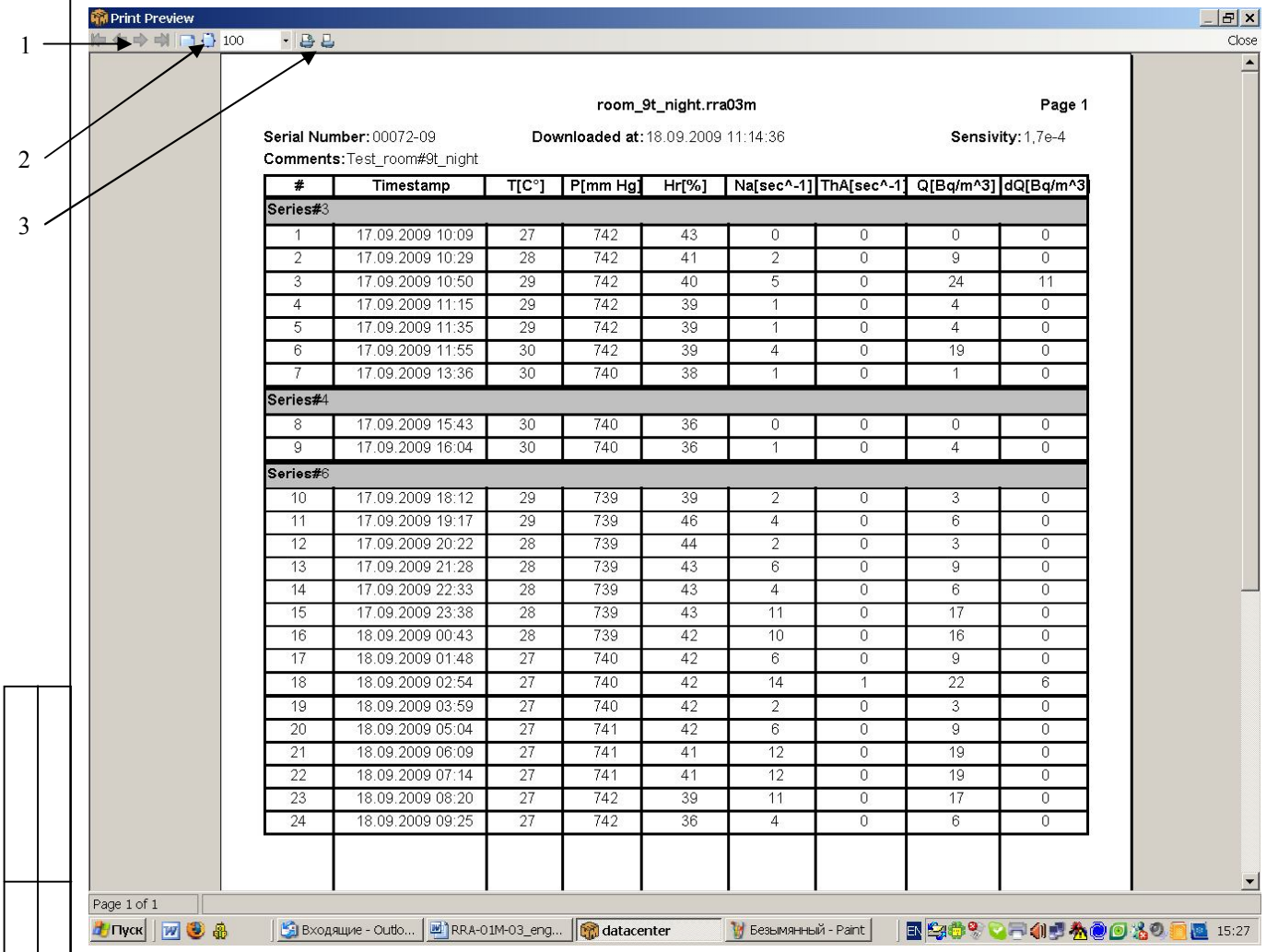


Figure 8

File / Print Data Preview

Select this option you want to preview the report on the screen before printing it. Typical preview screen is shown in fig. 8.



#	Timestamp	T[C°]	P[mm Hg]	Hr[%]	Na[sec^-1]	ThA[sec^-1]	Q[Bq/m^3]	dQ[Bq/m^3]
Series#3								
1	17.09.2009 10:09	27	742	43	0	0	0	0
2	17.09.2009 10:29	28	742	41	2	0	9	0
3	17.09.2009 10:50	29	742	40	5	0	24	11
4	17.09.2009 11:15	29	742	39	1	0	4	0
5	17.09.2009 11:35	29	742	39	1	0	4	0
6	17.09.2009 11:55	30	742	39	4	0	19	0
7	17.09.2009 13:36	30	740	38	1	0	1	0
Series#4								
8	17.09.2009 15:43	30	740	36	0	0	0	0
9	17.09.2009 16:04	30	740	36	1	0	4	0
Series#6								
10	17.09.2009 18:12	29	739	39	2	0	3	0
11	17.09.2009 19:17	29	739	46	4	0	6	0
12	17.09.2009 20:22	28	739	44	2	0	3	0
13	17.09.2009 21:28	28	739	43	6	0	9	0
14	17.09.2009 22:33	28	739	43	4	0	6	0
15	17.09.2009 23:38	28	739	43	11	0	17	0
16	18.09.2009 00:43	28	739	42	10	0	16	0
17	18.09.2009 01:48	27	740	42	6	0	9	0
18	18.09.2009 02:54	27	740	42	14	1	22	6
19	18.09.2009 03:59	27	740	42	2	0	3	0
20	18.09.2009 05:04	27	741	42	6	0	9	0
21	18.09.2009 06:09	27	741	41	12	0	19	0
22	18.09.2009 07:14	27	741	41	12	0	19	0
23	18.09.2009 08:20	27	742	39	11	0	17	0
24	18.09.2009 09:25	27	742	36	4	0	6	0

Figure 8

The following buttons will help you to fit the page and navigate:

1 – List buttons: home / up / down / end;

2 – Zoom buttons: set the width of the preview – Fit page OR Set scale (%);

3 – Print buttons: Setup Printer / Print.

File / Print

Select this option to send the report with measurement data to the printer.

File / Print chart

Select this option to print the chart based on measurement data. Only those parameters will be printed that are selected for the main screen chart.

File / Exit

Select this option to exit the Data Center program. In case that the data were loaded from the radiometer but not saved, the program will offer you to save the data before exiting.

Settings menu

Overview of the "Setttings" menu is shown in fig.9.

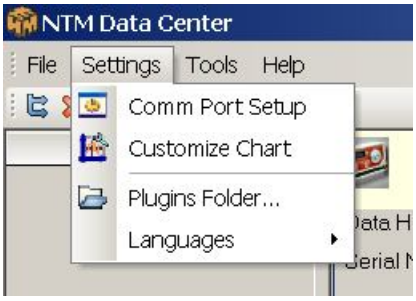


Figure 9

Using this option you can:

- Select a serial port and specify its settings for connection between the radiometer and computer;
- Setup the appearance of charts;
- Specify the folder where the Data Center program modules will be stored;
- Select the Language (English and Russian options are available).

Settings / Comm Port Setup

The dialog box for setting the serial port is shown in the fig.10.

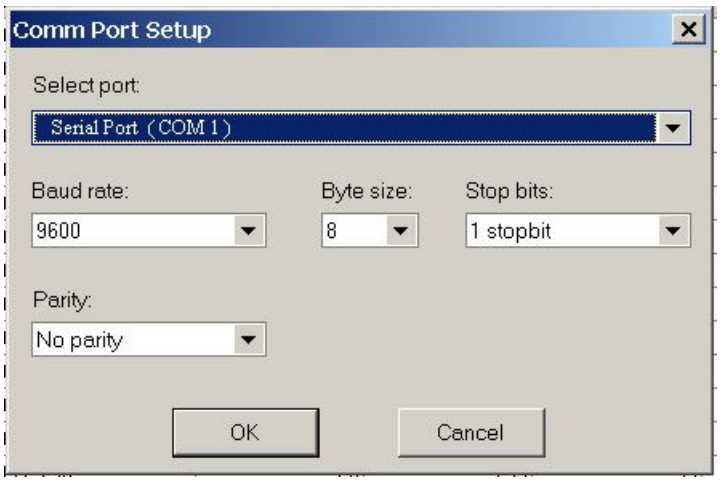


Figure10

Use this menu option to select the serial port (usually COM1 or COM2) for

communication with the radiometer. Set the data transfer rate to 9600 baud.

Other communication parameters for the current version of the radiometer should be set as shown in the fig.10.

Setup / Customize Chart

Use this menu option to view and set properties of chart elements. You will see the dialog box as shown in the fig.11.

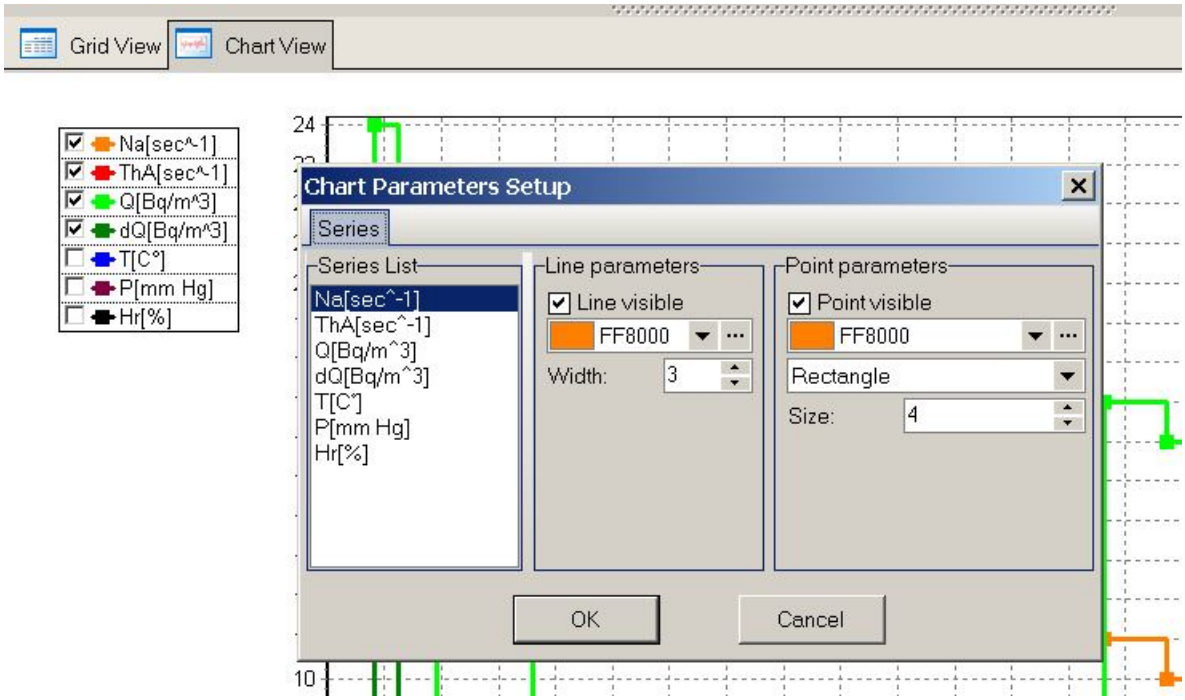


Figure 11

In this dialog box you can select the following properties for each chart:

- Line thickness and color;
- Show / Hide chart of selected parameter;
- Show / Hide data points on the chart;
- Color, shape and size of dots;

Setup / Plugins Folder

Use this menu option to define a folder where the program will store its modules and program files. Corresponding dialog box is shown in the fig.12. By default the program files are stored in the "Modules" folder situated in the root folder of the Data Center program. This "Modules" folder contains different components of the program (for example, "spectrometry module" described below).

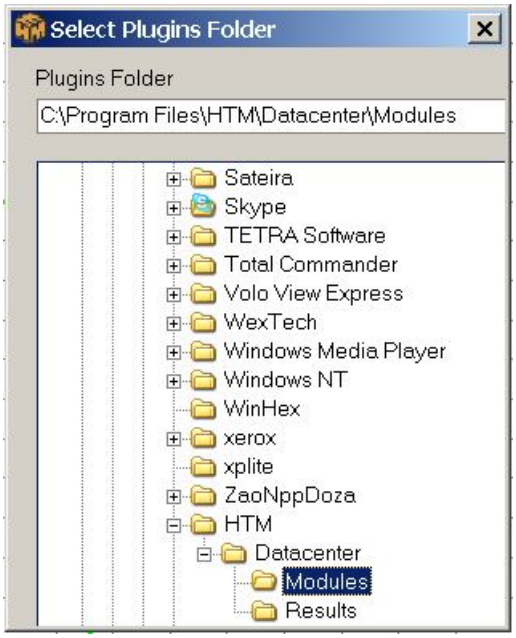


Figure12

Tools menu

Tools / Load data

This menu option allows you to load measurement data from the radiometer RRA-01M-03 to the computer.

NOTE: Use ONLY serial cable included in the radiometer delivery kit! (THE USE OF ANY OTHER CABLES IS PROHIBITED!)

In case the radiometer is in the measurement mode, current measurement should be interrupted before connection (press the RESET button for 2 seconds to do that). After the connection is established, the process of data transfer will be represented by the program.

Tools / Clear data

Use this menu option to delete measurement data stored in the radiometer.

NOTE! There is NO option to recover the deleted data**!** Load data to the computer and save to files before you delete them from the radiometer memory!

Tools / Set date\Time

After selection of this menu option the following dialog box will appear (fig.13).

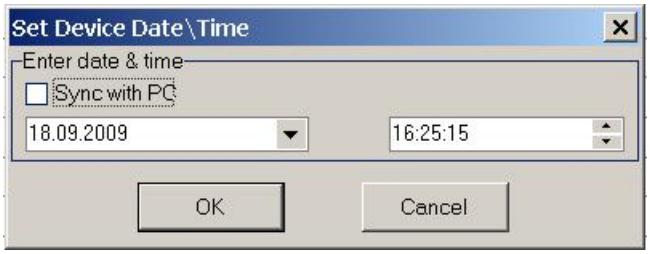


Figure13

If you check the box “synchronize with PC” and click OK button, than current date and time on the computer will be sent to the radiometer (regardless of the date and time fields).

If the box “synchronize with PC” is not checked, the date and time entered in the corresponding fields will be sent to the radiometer.

Tools / Restore defaults

After selection of this menu option the dialog box will appear (fig.14) where you can open a file with the default parameters of the radiometer connected to the computer.

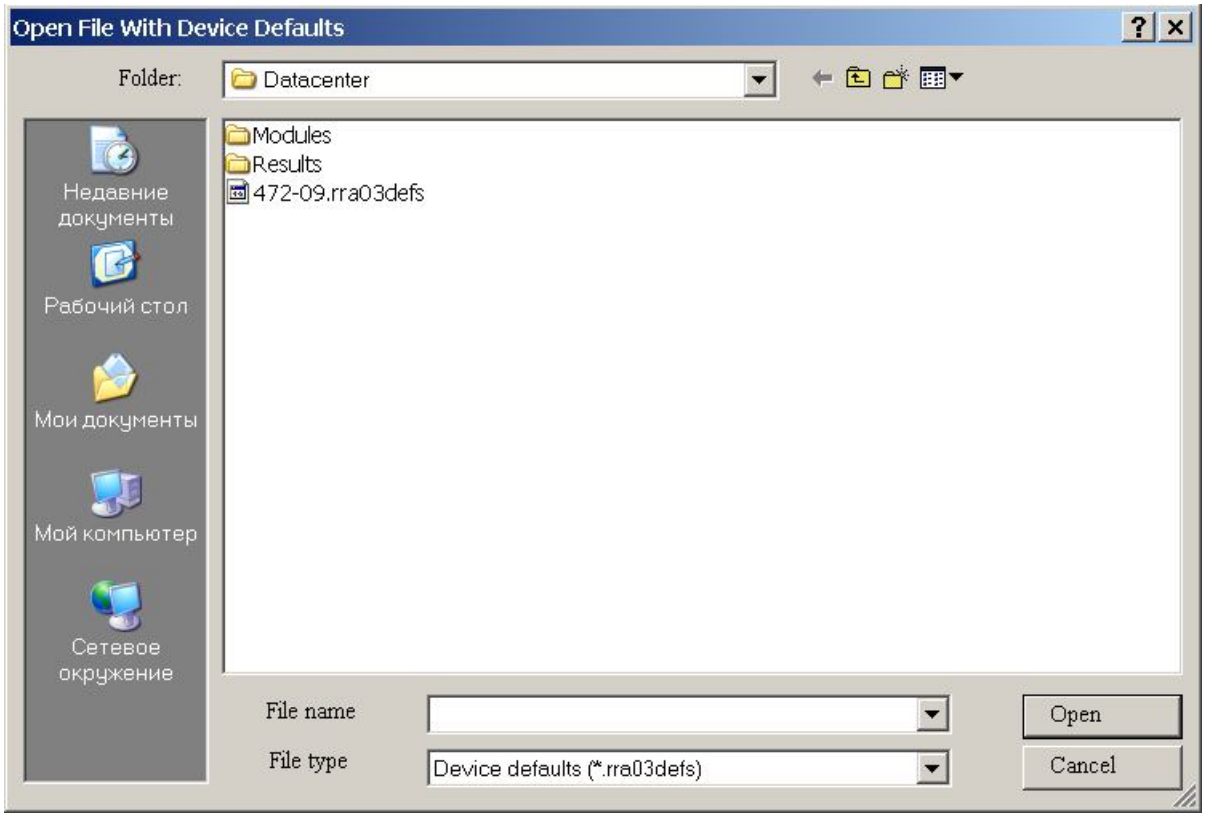


Figure14

This menu option is intended to restore system parameters of the radiometer after the failure, including:

- Serial number of the radiometer;
- Sensitivity to radon;
- Factors for calculation of climatic parameters.

These device specific parameters are stored in a configuration file with extension *.rra03defs, supplied with each radon radiometer RRA-01M-03.

Tools / Set serial number and sensitivity

This menu option is intended for service only. Password is required.

Tools / Set recalculation factors

This menu option is intended for service only. Password is required.

Tools / Set password

This menu option is intended for service only. Password is required.

Tools panel

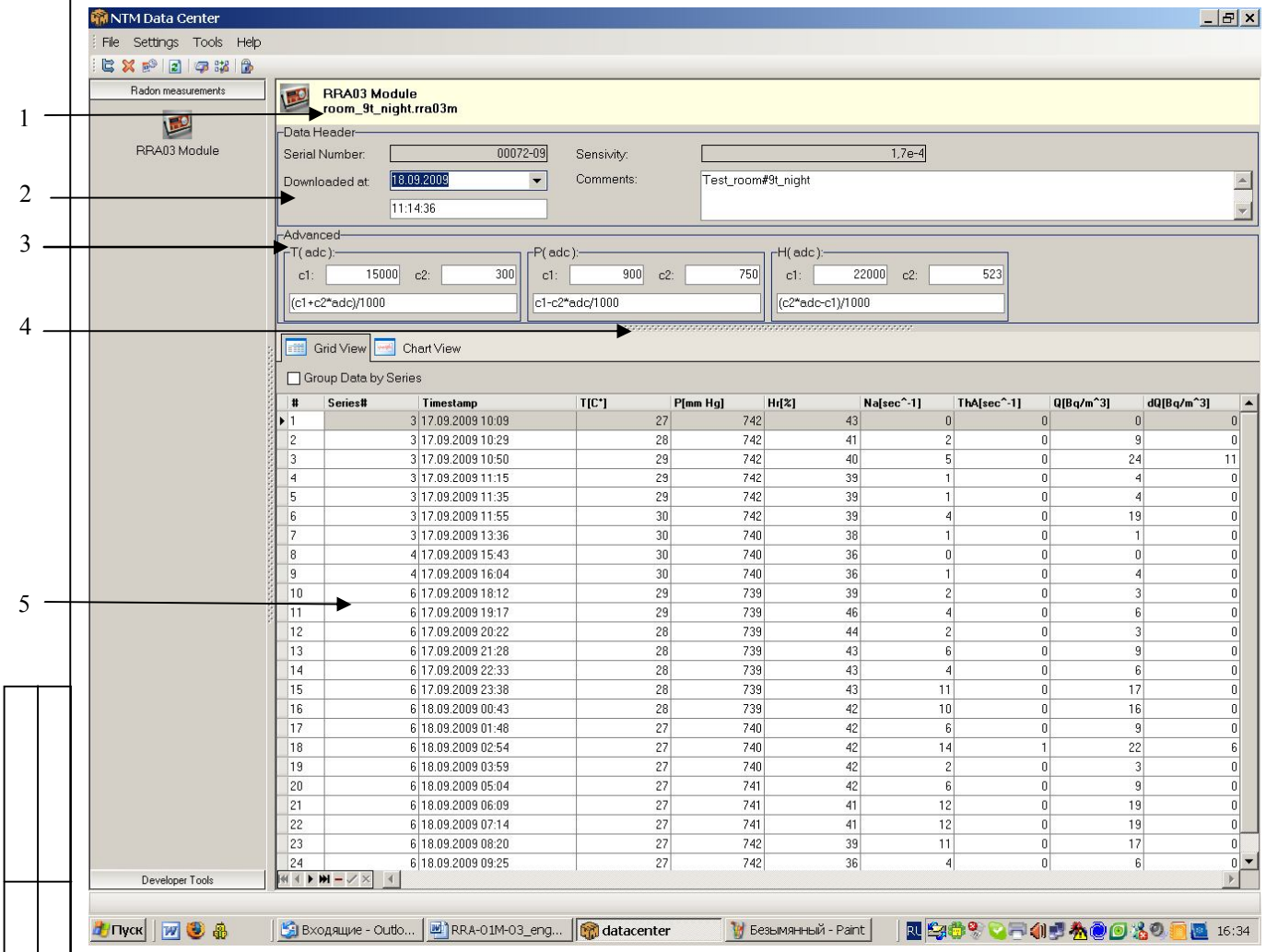
The overview of the **Tools panel** is shown in fig.15.

Figure 15

For easy access, options of the **"Tools"** menu are duplicated as buttons on this panel. See corresponding button functions in the description of the "Tools" menu above.

Working with data

When you transfer data from the radiometer or open a data file, you will see a screen such as shown in fig. 16.



#	Series#	Timestamp	T[C°]	P[mm Hg]	Hr[%]	Na[sec^-1]	ThA[sec^-1]	Q[Bq/m^3]	dQ[Bq/m^3]
1	3	17.09.2009 10:09	27	742	43	0	0	0	0
2	3	17.09.2009 10:29	28	742	41	2	0	9	0
3	3	17.09.2009 10:50	29	742	40	5	0	24	11
4	3	17.09.2009 11:15	29	742	39	1	0	4	0
5	3	17.09.2009 11:35	29	742	39	1	0	4	0
6	3	17.09.2009 11:55	30	742	39	4	0	19	0
7	3	17.09.2009 13:36	30	740	38	1	0	1	0
8	4	17.09.2009 15:43	30	740	36	0	0	0	0
9	4	17.09.2009 16:04	30	740	36	1	0	4	0
10	6	17.09.2009 18:12	29	739	39	2	0	3	0
11	6	17.09.2009 19:17	29	739	46	4	0	6	0
12	6	17.09.2009 20:22	28	739	44	2	0	3	0
13	6	17.09.2009 21:28	28	739	43	6	0	9	0
14	6	17.09.2009 22:33	28	739	43	4	0	6	0
15	6	17.09.2009 23:38	28	739	43	11	0	17	0
16	6	18.09.2009 00:43	28	739	42	10	0	16	0
17	6	18.09.2009 01:48	27	740	42	6	0	9	0
18	6	18.09.2009 02:54	27	740	42	14	1	22	6
19	6	18.09.2009 03:59	27	740	42	2	0	3	0
20	6	18.09.2009 05:04	27	741	42	6	0	9	0
21	6	18.09.2009 06:09	27	741	41	12	0	19	0
22	6	18.09.2009 07:14	27	741	41	12	0	19	0
23	6	18.09.2009 08:20	27	742	39	11	0	17	0
24	6	18.09.2009 09:25	27	742	36	4	0	6	0

Figure 16

The following elements are presented in the program's window:

1 – Name of the program module and name of data file

2 – Header with the following information about loaded measurement data:

- Serial number of the radiometer;
- Date and time when the data were transferred from the radiometer;
- Radiometer's sensitivity to radon;
- Comments linked to current data file.

3 – Extension of the header. You can show or hide this information by clicking on "show / hide" tab (4). In the extension of the header the following information is shown:

- Formula and factors for calculation of temperature (°C) based on the sensor signal (adc);
- Formula and factors for calculation of atmospheric pressure (mmHg) based on the sensor signal (adc);
- Formula and factors for calculation of humidity (%) based on the sensor signal (adc);

The above mentioned formulas and factors can be modified, but the results of recalculations will only be seen in tables and charts of the current session of Data Center program. Changes are not saved in data file(s).

5 – Data visualization area. Two modes are available:
- Table mode (select tab "Grid view").
- Graph mode (select tab "Chart view").

Table mode

Structure of the table with measurement data is shown in fig. 16.

Columns in the table are:
- Number of measurement in the series;
- Number of series;
- Date and time of the end of measurement;
- Temperature;
- Atmospheric pressure;
- Humidity;
- Number of detected RaA decays;
- Number of detected ThA decays;
- Radon concentration;
- Error of the radon concentration.

You can delete or edit faulty data. Click on the line with contain this data or move to this line using keyboard. Use "Del" button on keyboard to delete the current line or "Enter" - to edit it. You can not edit lines without data for number of RaA and ThA decays and radon concentration.

Graphic representation of data

An example of graphic representation of data is shown in fig.17.

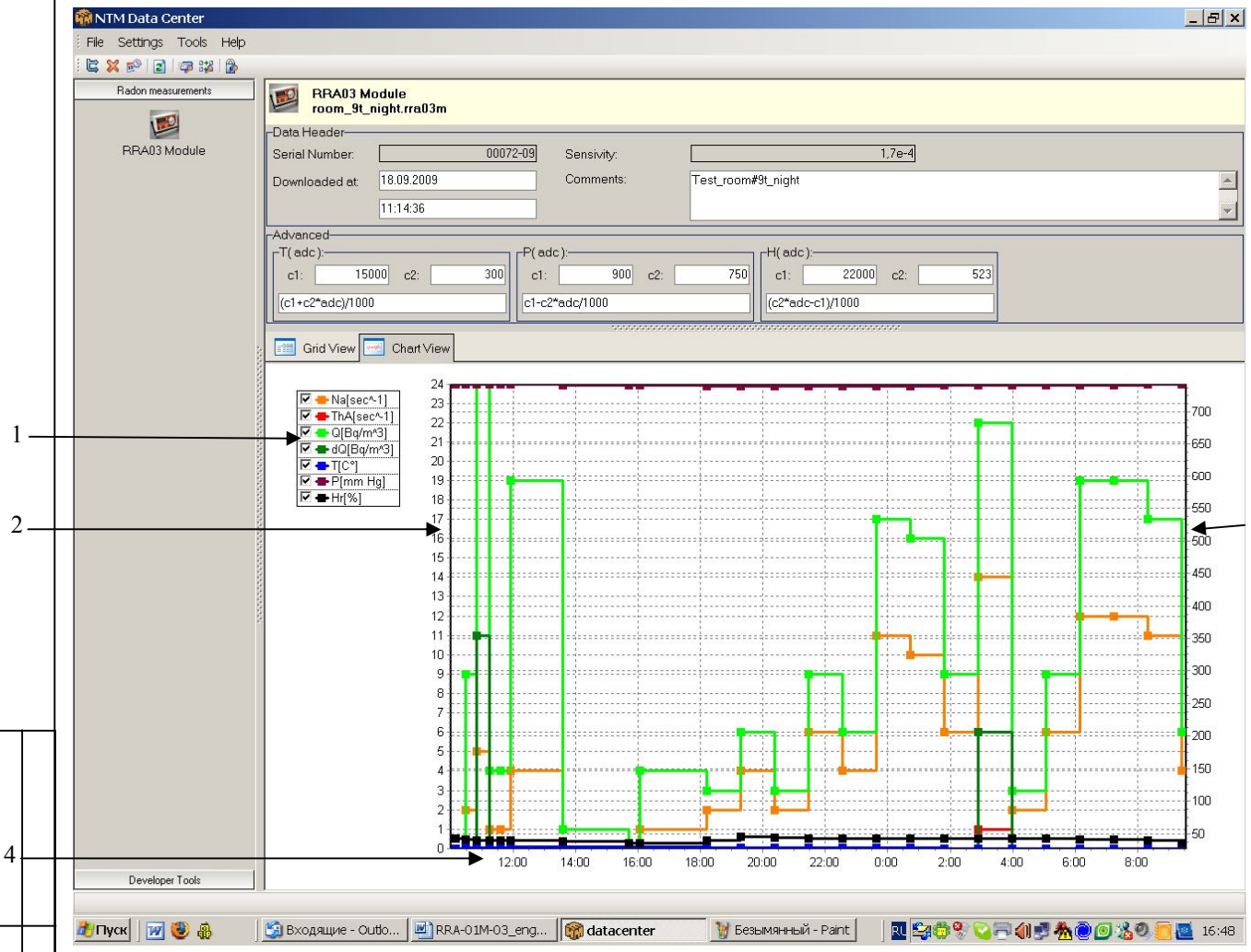


Figure 17

The following information is presented on the screen in this mode:

1 – Checkboxes for selection of the parameters that are visible in the chart;

2 – Radon and thoron scale;

3 – Scale for climatic parameters;

4 – Time scale.

Check corresponding box to show / hide desired parameter in the chart (1).

Point the cursor over a dot on the chart to see a tip with the related information: name and numeric value of the parameter, date and time of measurement. Click on a dot while holding “Ctrl” button and the program will switch to the table mode with the cursor set on corresponding line of data.

You can zoom any area of the chart: click in the upper left corner of the desired area, drag (while holding the left mouse button) to the bottom right corner and release the button. To restore previous scale (zoom out), mark in the reverse direction: from the bottom right corner to the upper left.
Properties of the chart elements (line thickness and color; shape, color and size of dots and their presence on the chart) are set using “Setup / Chart settings” menu option as described above.

Appendix 2

Using the "Spectrometry module"

The purpose of the "Spectrometry module" of the Data Center program is acquisition and analysis of spectra from the built-in detectors of radon radiometers such as RRA-01M-01, RRA-01M-03, RAA-10 and some other devices manufactured by the "NTM-Zashita".

The common feature of these devices is that the measurement process includes pulse-amplitude analysis. The "Spectrometry module" allows visualizing and working with acquired alpha-spectra.

While running the "Spectrometry module", Data Center program communicates with the radiometer RRA-01M-03 via standard serial port (COM port) of the computer. If your computer doesn't have a serial port, you can use USB-RS232 adapter. NOTE: Use ONLY serial cable included in the radiometer delivery kit! THE USE OF OTHER CABLE OF ANY TYPE IS PROHIBITED! This can damage the radiometer.

To use the "Spectrometry module", run the Data Center program and in the "Modules" panel (1) select the tab "Developer tools" (2) an then click on the button "Spectrometry plugin" (3). You will see the following screen (fig. 1):

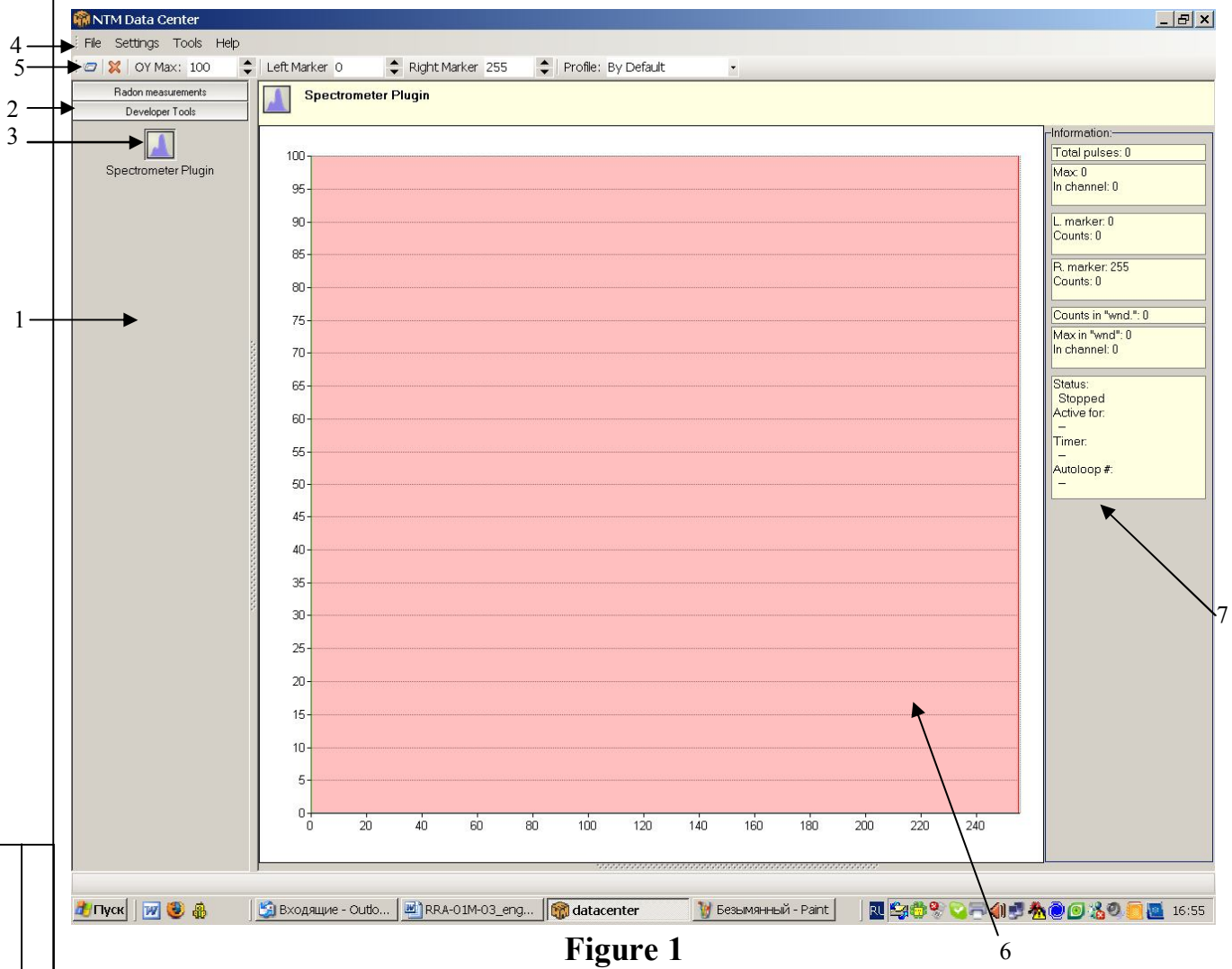


Figure 1

In this screen the following elements are shown (fig 1):

4 – Main menu

5 – Toolbar

6 – Spectrum area

7 – Spectrum information area

Main menu

Main menu bar appears as shown in fig. 2.

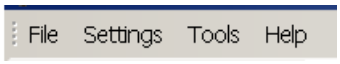


Figure 2

The menu bar contains menu commands for operating the program:

- File
- Settings
- Tools
- Help

File menu

The **File** menu is shown in fig. 3.

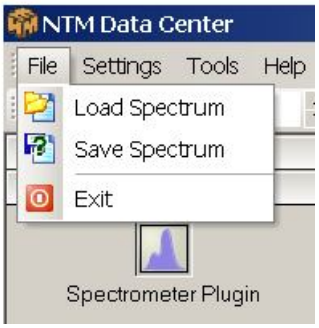


Figure 3

The **File** menu allows you to save files with spectrometric data, to open files saved previously, and to exit the Data Center program.

File / Load Spectrum

This menu option opens a standard dialog box (fig.4).

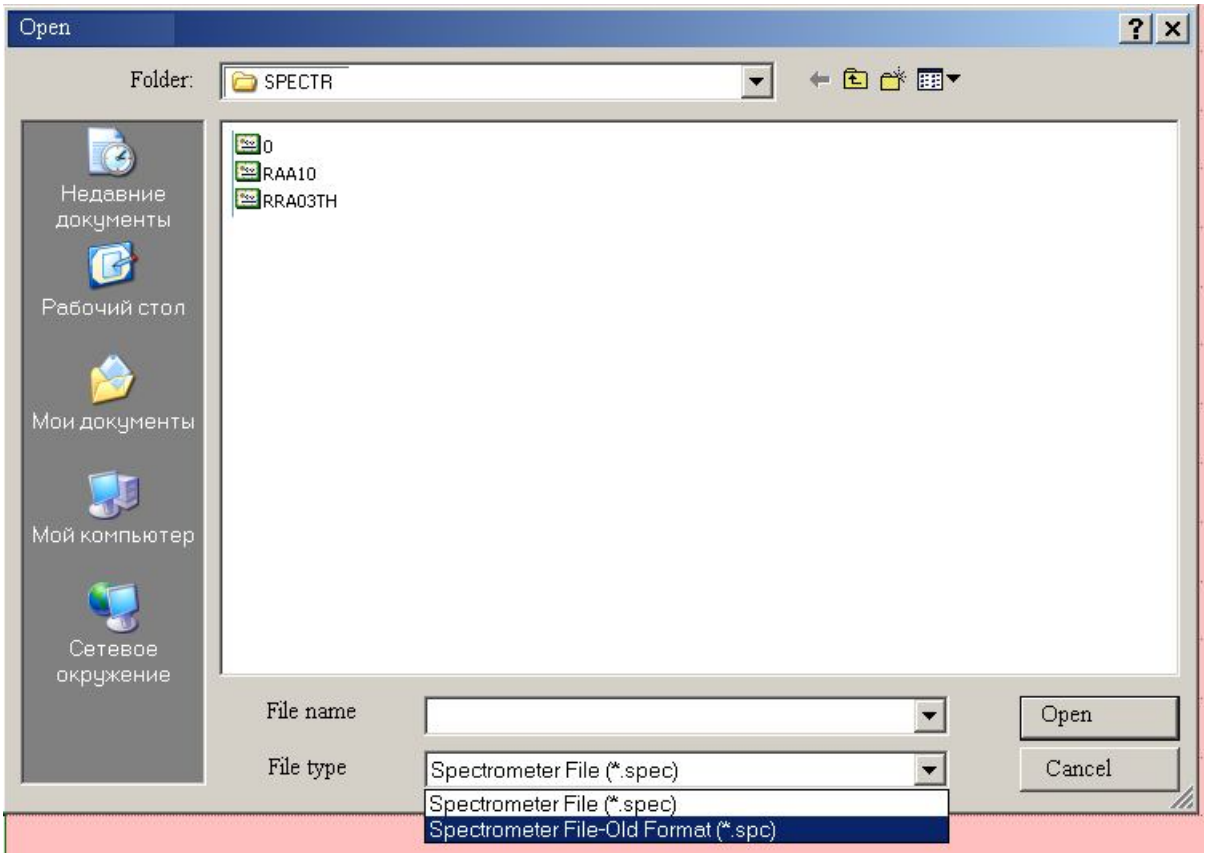


Figure 4

You can open files with spectrometric data saved in the new RRA-03 software format (*.spec), as well as in the older version of the RRA-03 software (*.sps). Select the desired file type using the drop-down list in the bottom of the dialog box. After the file is open, you will see the spectrum (see an example in fig. 12 on page 63).

File / Save Spectrum

This menu option opens a standard "save file" dialog box (fig.5).

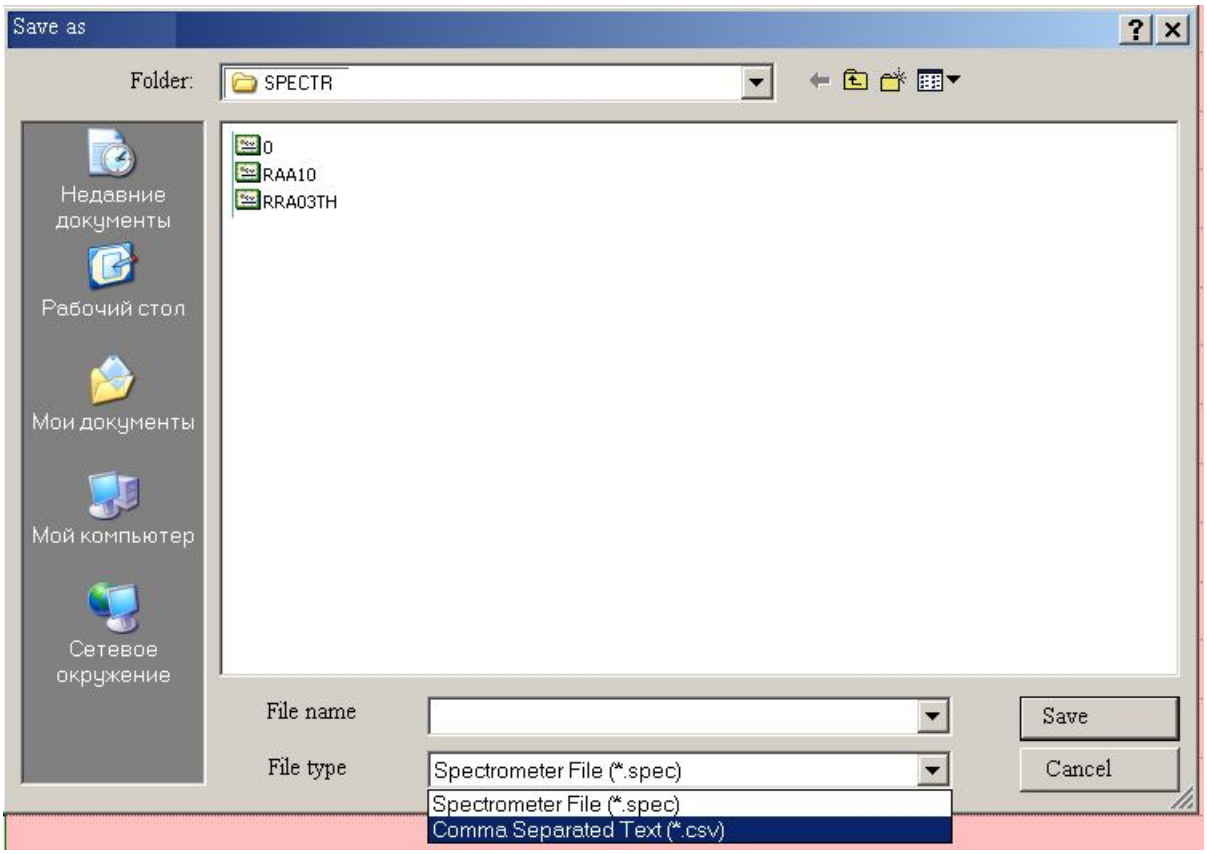


Figure 5

Select the folder where you want to save the file, enter the filename in the box and click "Save".

File / Exit

Select this option to exit the Data Center program. In case that the spectrometric data were loaded from the radiometer but not saved, the program will offer you to save the data before exiting.

Settings menu

Overview of the "Settings" menu is shown in fig. 6.

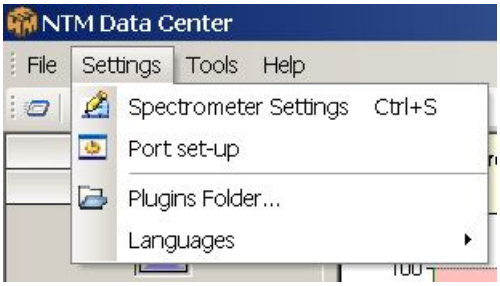


Figure 6

Using this option you can:

- Setup parameters of the spectrometer (spectrometric circuit of the radiometer);
- Select a serial port and specify its settings for connection between the radiometer and computer;
- Specify the folder where the Data Center program modules will be stored.

Spectrometer settings

The dialog box for setting up the spectrometer is shown in fig. 7

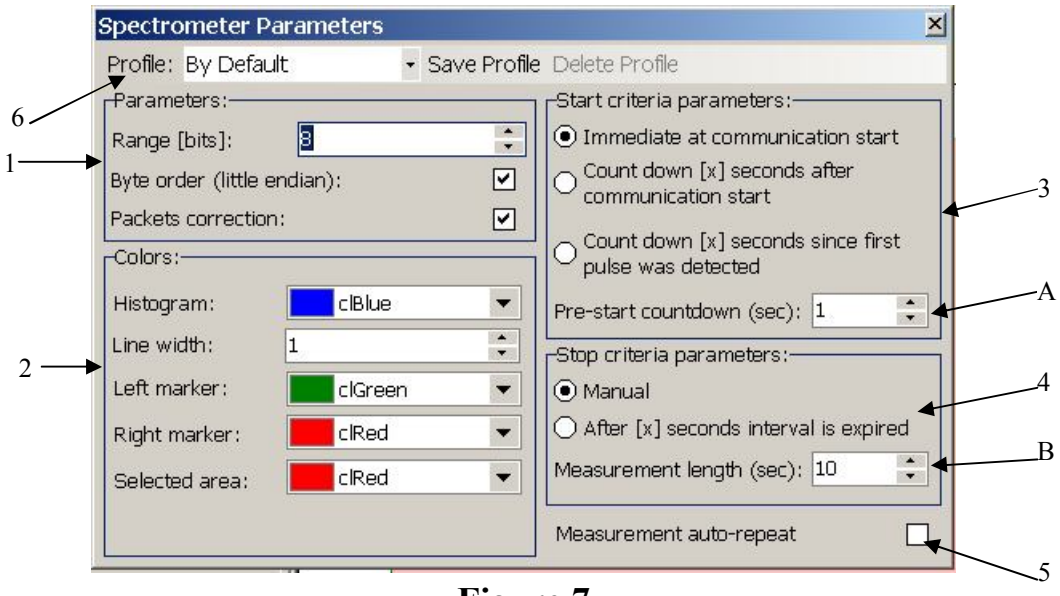


Figure 7

You can change the following settings:

1 – Parameters. Section with parameters of data, loaded from the radiometer. Do not alter these settings because this option is not enabled in the current version of the software.

2 - Colors. In this section you can define colors for the spectrum, left and right markers and the area between markers, as well as the thickness of bars of the spectrum.

3 - Measurement presets

The spectrum acquisition can be started in one of the following ways:

- When connection with the radiometer is established. Acquisition starts immediately after you click on a button 1 (fig. 11);
- After acquisition interval (preset in the box (A) in seconds) has passed since the click on a button 1 (fig. 11);
- After acquisition interval (preset in the box (A) in seconds) has passed since the first alpha particle was detected.

4 - You can choose the mode of stopping the acquisition:

- Manual – by clicking the button 1 (fig. 11);
- Automatic – after acquisition interval preset in the box (B) (in seconds).

If you have checked the box «Recurrent measurements» (5), the spectrum data will be cleared and next measurement will be started after each of acquisition interval (defined in the box B) elapses.

All preset parameters of spectrum acquisition will be valid for future measurements. You can save different combinations of parameters using the profile option (enter the profile name in box 6).

Setup / Port Setup

The dialog box for setting the serial port is shown in the fig. 8.

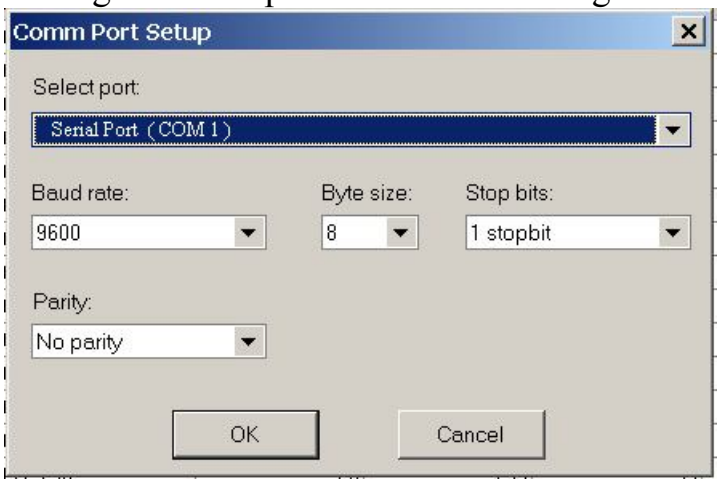


Figure 8

Use this menu option to select the serial port (usually COM1 or COM2) for communication with the radiometer. Set the data transfer rate to:

- 9600 baud (for radon radiometers RRA-01M-03 and RAA-10)
- 1200 baud (for radon radiometer RRA-01M-01 “Alpharad”).

Other communication parameters for the current version of the radiometer should be set as shown in the fig. 8.

Setup / Plugins folder

Use this menu option to define a folder where the program will store its modules and program files. Corresponding dialog box is shown in the fig.9. By default the program files are stored in the "Modules" folder situated in the root folder of the Data Center program. This "Modules" folder contains different components of the program (for example, "spectrometry module" described here).

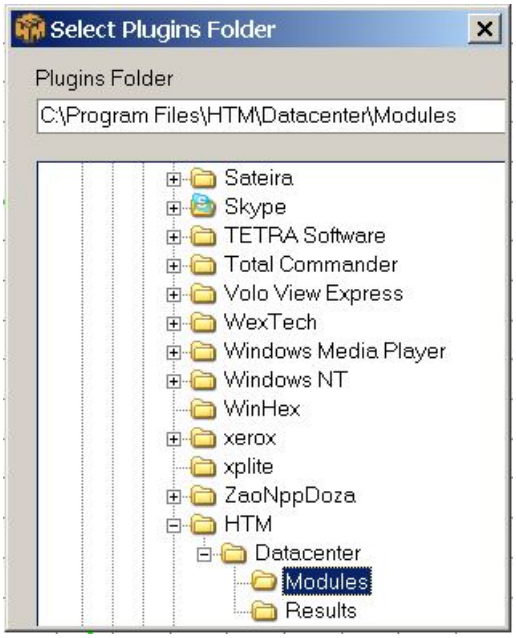


Figure 9

Tools menu

The **Tools** menu is shown in fig. 10.

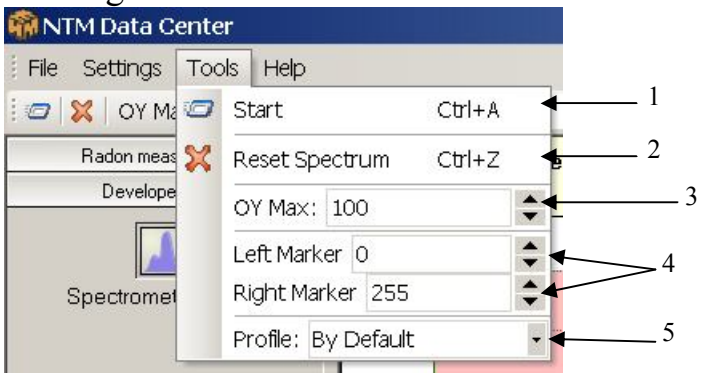


Figure 10

This menu option allows you to control the spectrometry features of the radiometer. The following control options are available:

1 – Start / Stop spectrum acquisition (connection with the radiometer).
2 – Clear spectrum data.
3 – Define the Y axis scale (number of counts in the channel).
4 – Set marker channels.
5 – Profile option with presets of spectrum acquisition.

Tools panel

The Tools Panel is shown in the fig.11.

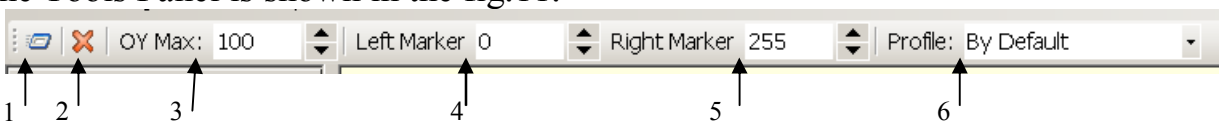


Figure 11

For easy access, options of the "Tools" menu are duplicated as buttons on this panel.

1 – Start / Stop spectrum acquisition (connection with the radiometer). If you click on this button when the measurement mode is ON in the radiometer, then the spectrum acquisition will be started. To stop spectrum acquisition, click on this button again.
2 – Click on this button to clear spectrum data.
3 – Y axis scale. Here you can define the number of counts in a channel, visible on the screen without overflow. For example, in the fig. 12 below the Y axis scale is set to 500.
4 – Left marker channel. You can move marker by entering the desired channel number in the box, by clicking on up/down arrows on the right side of the box; or just pick up and move the marker in the spectrum area using left mouse button.
5 – Right marker channel. You can move this marker as described above.
6 – Load / save profile.

An example of spectrum

An example of spectrum is shown in the fig. 12.

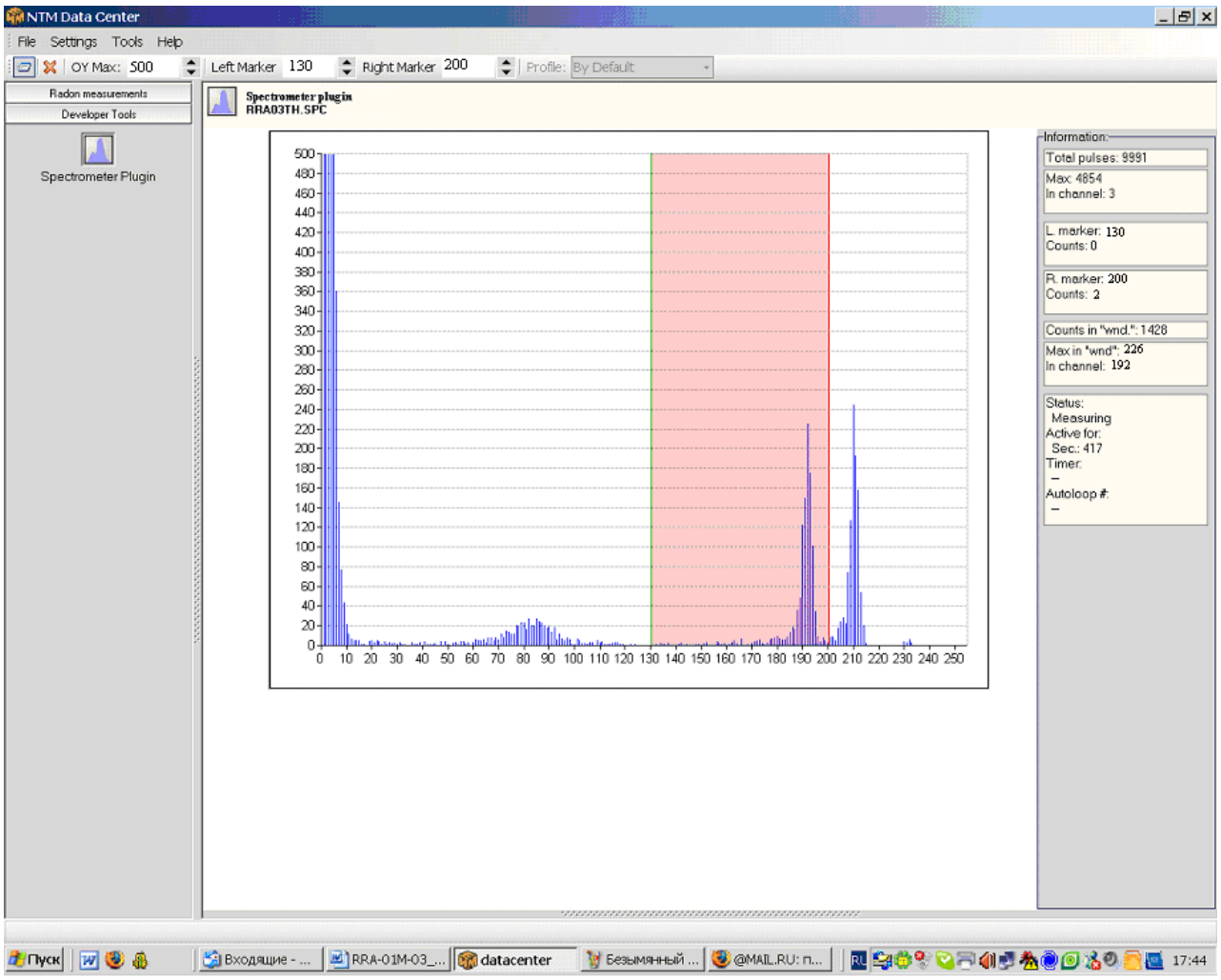

NTM Data Center
File Settings Tools Help
OY Max: 500
Left Marker 130
Right Marker 200
Profile: By Default
Radon measurements
Developer Tools
Spectrometer Plugin
Spectrometer plugin
RRA03TH.SPC
Information:
Total pulses: 9991
Max: 4854
In channel: 3
L. marker: 130
Counts: 0
R. marker: 200
Counts: 2
Counts in "wnd.": 1428
Max in "wnd": 226
In channel: 192
Status:
Measuring
Active for:
Sec.: 417
Timer:
–
Autoloop #:
–
Пуск
Входящие - ...
RRA-01M-03_...
datacenter
Безымянный ...
@MAIL.RU: п...
17:44

Figure 12

The area for spectrum parameters presentation is shown in fig. 13.

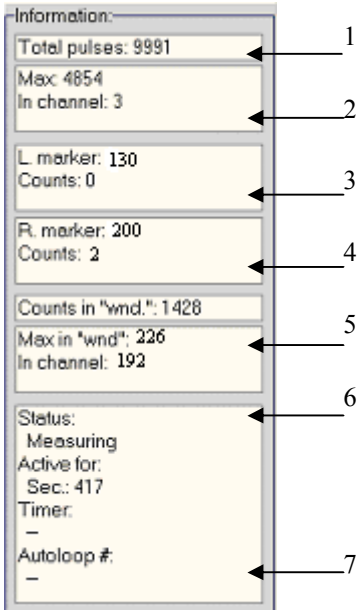


Figure 13

In this window the following parameters of the spectrum are presented:
1 – Total number of counts in all channels.
2 – Channel with the maximum number of counts: number of channel and number of counts in that channel.
3 – Position of the left marker (channel) and number of counts in that channel.
4 – Position of the right marker (channel) and number of counts in that channel.
5 – Total number of counts in the "region of interest" (ROI) between left and right markers.
6 – Channel with the maximum number of counts within the ROI: number of channel and number of counts in that channel.
7 – Parameters of data acquisition, including:

Status. Shows current status of the spectrometer (the following alternatives are possible):
Acquisition. Acquisition of spectrum is on the way.
Stopped. Acquisition of spectrum is stopped.
Waiting. Spectrometer is waiting for predetermined condition (the end of pause or the first count detected by the radiometer) to start measurement.
Live time. Shows the time since the start of spectrum acquisition.
Countdown Timer. Stands for indicating of the time left to Meas.Start or till the Meas.Stop.
Recurrent measurements. Shows of the number of recurrent measurements performed, if this option was selected in the setup menu.