



RKG-14
“VIRTUOSO”
multipurpose environment activity radiometer

Operating manual

BICT.412139.003-02 HE

Dear users,

You have chosen the device in which engineers and developers of our company had realized a completely new approach to detect and measure radiocesium, which spread from nuclear accidents in the environment, particularly in food. Now control of cesium radioisotopes in products will find its application not only in specialized laboratories but also at home without professional radiologists.

We managed to create a set of new original gamma spectrometry solutions which made it possible to use in measurements the detector crystals smaller in size and cheaper than those of laboratory equipment. This allowed us to significantly reduce the device price in general compared to laboratory equipment.

We continue developing a new trend in radiocesium monitoring and constantly improve new mathematical solutions used in our device. We see a great opportunity for improving the quality of measurements and the device performance and are going to update our software regularly. Using the experience of successful application of the device for measuring radiocesium activity in food and different materials, we have added a separate function for measuring dose rate (DER) of radioactive cesium in the environment. This feature simplifies the detection of radiocesium emission, which can be hidden in the background radiation, and thus allows making quick conclusion of the overall pollution or purity of the area or premises where we are.

Since the device focuses on universal application in domestic and professional environment, having considered the users requests, we have introduced one more additional function – measurement of specific activity of naturally occurring radioactive materials (radium, thorium, potassium) in soils, construction materials and buildings. The device can simply, quickly and on the spot do the measurement, which is very complicated and time-consuming by the traditional methods (as a rule, samples of materials are selected and taken to the laboratory for measurement). This mode of the device operation is useful for geologists, builders, environmentalists, students, etc.

Development of the device encompasses the unique experience of contamination monitoring after the Chernobyl disaster. However, we understand that the Fukushima accident has its unique features. That is why we expect to get information about your first-hand experience of our device use. Experience of the device behavior under real conditions, plus our new steps towards mathematical and metrological enhancements will be implemented in later versions of the software. Together we will make measurements easier and more comfortable. Our device will make you feel confident that radiocesium is under reliable control

The device enables a user to independently update a software version using the Internet. The Virtuoso software is available on the Google Play for free.

Best regards,
“ECOTEST” team

Version 8
Last updated: June 2016

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INTERESTING FACTS

Why do we monitor exactly cesium?

Human external exposure and a risk to inhale radioactive substances are attributed to the early phase of a nuclear and radiological accident. In the years following the Chernobyl nuclear accident in Ukraine, of the most long-lasting and dangerous factors of radiation impact has remained radionuclide intake with food in humans. For this reason, control of radioisotopes content in food becomes a burning issue for quite a long period of time.

Among radioisotopes, which were released after the accident into the environment, most capable of spatial distribution and transfer via biological pathways are radioactive iodine and cesium. However, radioactive iodine tends to decay rapidly so that its residence time coincides with the early phase of the accident.

In this way, radiocesium further remains a leading contributor to distribution in the environment. The natural environment may contain other types of radioisotopes released from a damaged reactor, but in practice, say, uranium is unlikely to reach those regions lacking such a mobile radioisotope as cesium. The presence of cesium clearly shows that the radioactive contamination from the reactor has reached a certain area; on the contrary, the absence of cesium in that particular area means that other contaminants from the reactor are considered unlikely.

Therefore, radiocesium is the so called marker of the distribution of the radioactive contamination. In addition, cesium is readily absorbed and can be transferred through biological chains (plants-animals-people). Keeping radiocesium content in food under control, we can address the issue of consumption of contaminated food, as well as detect pathways through which radioisotopes migrate in various ecosystems and regions.

How to measure cesium isotopes specific activity in food?

Traditional approaches are based on laboratory studies that involve a selection of individual samples from the food volume. These samples are placed in containers and for measurements are positioned towards detectors enclosed in protective facilities which are located in special rooms. The advantage of these surveys is that they ensure high accuracy of a radiometric measurement of a sample. Their main drawback is that this accuracy is provided only for an individual sample but not for the whole batch. The extent to which this sample is typical of the overall volume of food is a classic problem (heterogeneity of contamination is not considered as the sample may be randomly selected either

from a point not typical of the environment or from a material too clean or too contaminated).

Moreover, carrying out an examination by sampling practices appear to be quite a time-consuming, inconvenient and sometimes even unacceptable procedure as the sample collection might cause damage to the integrity of a product (or packaging). In this way, traditional laboratory surveys play a major role in ensuring accurate official analysis (especially in situations of complex analysis of heavy contamination), but traditional methodology for investigating samples is inconvenient for practical applications on a large scale, and for this reason it is unable to address the issue of efficient, massive monitoring that could be a reliable “filter” on the way of radioactive migration.

With a need for a large-scale practical use, we have created another concept of monitoring radiocesium content in food products. We have also developed the method used to measure radiocesium contained in the food (not only in products but also in any other packages) by the way of placing the detector close to an object under testing. This approach does not always yield such a profound analysis as laboratory studies do, but it is convenient and practical.

Due to a simple measurement procedure, “VIRTUOSO” monitors radiocesium content under almost any conditions and causes no damage to a food package. Apart from this, with no need for a sample collection the device allows you to test for cesium not only food products but also soils under cultivation, as well as any other objects or substances that may contain or transmit cesium themselves. In general, the possibility to place the detector close to different points of the tested objects provides more current information, and this feature makes the concept of “VIRTUOSO” device completely different from the laboratory studies participating in a limited sample testing.

Why testing food products using “VIRTUOSO” is so convenient?

At first you can simply and quickly assess the potential contamination of the area or premises where we are, or some large volumes of materials (e.g. wood piles, containers with food, etc.). No samples, not laboratories. Holding the device in your hands just turn on "Cesium DER" mode and see if characteristic radiation of radiocesium is present in this place along with background radiation. If the detector notices radiocesium, then any objects (materials, products, etc.) in this place or in this room may also contain contamination. Then you should switch to a specific testing of materials and products of interest. This examination using “VIRTUOSO” is very simple.

While testing large food volumes instead of taking samples, one places the detector close to the food. At this point, the detector is exposed to radiation coming

from the volume significantly larger in size than a common Marinelli sample container. Depending on a state and density of tested food, information about radiation is transferred to the attached detector from the food with the volume of ~50÷250 l. If performing the same number of measurements by placing the detector as that of taking samples by a traditional method, one will get much more reliable integrated image of large volumes of food as there is a sort of direct data communication with the substantially larger volume of tested object. Apart from this, positioning the detector is more convenient and easier than selecting, crashing and placing a sample in the container.

As far as testing of small packages is concerned, measurement made by placing the detector is not only more convenient, as it requires no burdensome sampling procedure, but also more reliable, as radiation is measured from almost all volume of packaging rather than from the collected one of 0.1 l to 1 l.

Apart from radiocesium monitoring, “VIRTUOSO” enables very simple measurement of specific activity of naturally occurring radioactive materials in various materials without traditional sampling (soil, building materials, mineral raw materials, etc.). It is enough to put the device on soil or material of interest and get the result. You have just to follow some simple rules of placing the device for measurement that are listed in this manual and "Help" of the device. You can even measure the average activity of naturally occurring radioactive materials (NORM) in building materials, which are in the walls, floor and ceiling of a certain room. You do not need to hammer or pry out anything of the walls, but simply put the device inside the room. NORM content in soils or mineral accumulations in field work is also tested very simply and quickly - just put the device.

1 DESCRIPTION

1.1 Purpose of use

The RKG-14 “VIRTUOSO” multipurpose environment activity radiometer (hereinafter called – the radiometer) is designed for

- detection of ^{137}Cs and ^{134}Cs radioisotopes (hereinafter - radiocesium) in the objects of the environment;

- evaluation of the detected radiocesium content in the values of specific, volume and surface activities;

- control of background radiation level in the environment, including evaluation of the radiocesium emission level as the value of ambient dose equivalent rate strictly from radiocesium, which is included in the natural background;

- measurement of volume and specific activities of naturally occurring radioactive materials ^{40}K , ^{226}Ra , ^{232}Th (hereinafter - NORM) in the objects of the environment.

1.2 Technical specifications

Key specifications of the radiometer are presented in Table 1.1.

Table 1.1 - Key specifications of the radiometer

Name	Unit of measurement	Standardized value
Measurement range of specific activity of radionuclides ^{137}Cs , ^{134}Cs in the objects of the environment in geometries “ 2π ”, “ 4π ”	Bq/kg	50 - 200 000
Main relative permissible error limits of measurement of specific activity of radionuclides ^{137}Cs , ^{134}Cs in the objects of the environment in geometries “ 2π ”, “ 4π ”, $P=0.95$	%	± 35
Estimation range of surface activity of radionuclides ^{137}Cs , ^{134}Cs in the objects of the environment	Bq/m ²	500 – 1 000 000
Measurement range of the effective specific activity of naturally occurring radionuclides ^{226}Ra , ^{232}Th , ^{40}K in the objects of the environment in geometries “ 2π ”, “ 4π ”	Bq/kg	200 - 20 000

Table 1.1 (continued)

Name	Unit of measurement	Standardized value
Main relative permissible error limit of measurement of the effective specific activity of naturally occurring radionuclides ^{226}Ra , ^{232}Th , ^{40}K in the objects of the environment in geometries “ 2π ”, “ 4π ”, $P=0.95$	%	± 35
Measurement range of gamma radiation ambient dose equivalent rate from ^{137}Cs , ^{134}Cs	$\mu\text{Sv/h}$	0.001 - 10
Main relative permissible error limits of measurement of gamma radiation ambient dose equivalent rate from ^{137}Cs , ^{134}Cs , given $P=0.95$	%	± 20
Unstable readings of the radiometer during 8 hours of operation, not more than	%	5
Measurement range of gamma radiation ambient dose equivalent rate $\dot{H}^*(10)$	$\mu\text{Sv/h}$	0.01 – 50.00
Main relative permissible error limit of measurement of ambient dose equivalent rate (DER) of gamma radiation, given $P=0.95$	%	$15+1/\dot{H}^*(10)$, where $\dot{H}^*(10)$ – is a numeric value of gamma radiation DER, $\mu\text{Sv/h}$
Sensitivity to gamma radiation for ^{137}Cs , ^{134}Cs , not less than	(pulse/s) / ($\mu\text{Sv/h}$)	500
Energy dependence of readings for energies 59 keV (^{241}Am), 1.3 MeV (^{60}Co) and 0.66 MeV (^{137}Cs)	%	30

Table 1.1 (continued)

Name	Unit of measurement	Standardized value
Dependence of sensitivity from the angle of recorded radiation incidence (anisotropy), does not exceed	%	30
Time of continuous operation of the detecting device from full battery under gamma background not more than 0.5 μ Sv/h, not less than	hrs	24
Dimensions of the detecting device, not more than	mm	114×36×83
Weight of the detecting device without case	kg	0.352 (with the battery)
Note – Weight and dimensions of the Android device are provided in the manufacturer’s documentation for the device		

1.2.1 Time of continuous operation of the Android device is specified in its user’s guide.

1.2.2 Data communications between the radiometer’s detecting device and the Android device is done via Bluetooth wireless technology. Communication range is no less than 10 m (under line of sight).

1.2.3 The radiometer’s detecting device endures:

- ambient air temperature from minus 20 to +50 °C;
- relative humidity up to 95 % at +35 °C temperature, non-condensing;
- atmospheric pressure from 60 to 106.7 kPa according to ГOCT 12997-84 standard.

1.2.4 The radiometer’s detecting device contains no precious materials.

1.3 Delivery kit

Table 1.2 – Delivery kit of RKG-14 “VIRTUOSO” radiometer

Type	Name	Q-ty	Note
BICT.468166.030-02	Detecting device of RKG-14 “VIRTUOSO” multipurpose environment activity radiometer	1 pc.	With the installed LIR14500 Lithium-Polymer battery of AA type
	Android device	1 pc.	Supplied under separate order. Model is not specified
BICT.436231.003	Battery charger	1 pc.	Model is not specified.
	Leather case	1 pc.	
PELI 1170	Transport case	1 pc.	
PELI 1020	Additional waterproof case	1 pc.	Supplied under separate order
BICT.412139.003-02 ПС	Passport	1 pc.	
BICT.412139.003-02 РЭ	Operating manual	1 pc.	
<p>Note – If you order the Android device included in the radiometer’s kit, this device comes with the installed custom-made "Virtuoso" software.</p> <p>If there is no separate order for the Android device and you buy it independently in the outlet chain, please download the custom-made "Virtuoso" software into the Android device from Google Play.</p>			

1.4 Design of the “VIRTUOSO” radiometer

The RKG-14 “VIRTUOSO” multipurpose environment activity radiometer consists of the detecting device of the radiometer, an Android device (a tablet PC or a smartphone running Android OS) and special-purpose software “Virtuoso” for the Android device.

1.4.1 Android device

Android device* is a smartphone or a tablet PC, which runs the Android™ operating system.

* Android is a trademark of Google Inc.

If some other Android device is used instead of the one included in the delivery kit, you should make sure it meets the following technical requirements:

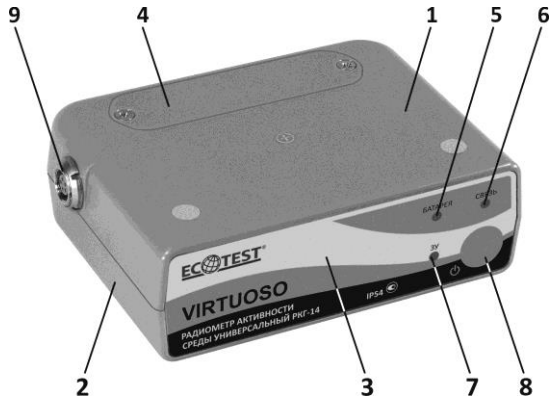
1. Built-in Bluetooth module;
2. Built-in GPS-module
3. Android 2.3 version and later.

The Android device is intended to process and display data obtained from the detector.

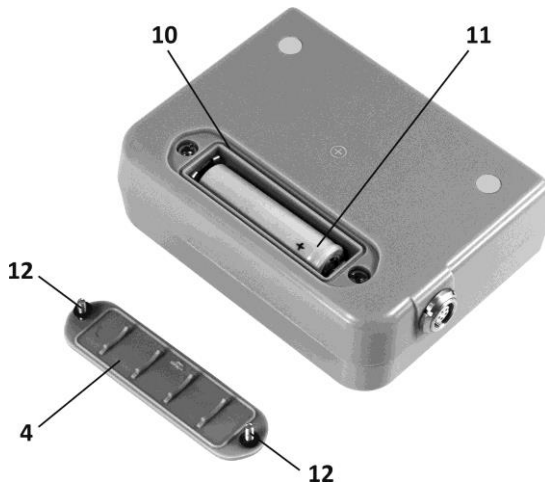
Data exchange with the detecting device is done via Bluetooth wireless technology.

For detailed information about the Android device, please see its user’s guide.

1.4.2 Radiometer's detecting device is shown in Figure 1.1.




(a)



(b)


Figure 1.1 - Detecting device of RKG-14 "VIRTUOSO" multipurpose environment activity radiometer


The radiometer's detecting device is designed in a plastic dump- and dustproof housing. The ingress protection rating is IP54. The housing of the radiometer consists of covers (1, 2), a panel (3) and a battery compartment lid (4), and a connector for storage battery charging (9). The "BATTERY" (5), "COM." (6) and "BC" (battery charger (7)) light-emitting diodes (LEDs), as well as the on/off button  (8) of the detecting device are located on the panel.

There is a compartment (10) for storage battery (11) on the cover (1), which is closed with the lid (4) with two screws (12).

The radiometer's detecting device includes: the scintillation detecting unit of gamma radiation CsI(Tl) of 23 cm³ volume with semiconductor photomultiplier, the spectrometric channel with the analogue-digital processing unit, the Bluetooth radio channel module and the battery charging circuit.

1.5 Switching the detecting device on and off

The detecting device is switched on by pressing the  button (8). Once the detecting device switches on, the "COM." LED (6) should be highlighted and start blinking quickly (twice a second).

The detecting device switches off automatically every 3 minutes provided that the Android device is not connected to it, or it can be switched off either operated by the Android device when exiting "Virtuoso" application, or when the storage battery capacity is critically low. With the  button (8) still held (approximately 3 seconds) until "COM." (6) and "BATTERY" (5) start blinking quickly, you can also force the detecting device to switch off.

The "BATTERY" (5) LED indicates the status of the detecting device's storage battery. If the storage battery capacity is less than 25%, the "BATTERY" LED starts blinking red once every two seconds; given the capacity is less than 5%, the "BATTERY" LED blinks twice a second.

The "COM." (6) LED shows the status of connection between the Android device and the radiometer's detecting device. If the connection is established, the LED starts blinking once every 1.5 seconds. High-frequency blinking (10 times per second) means that there is no connection with the Android device.

1.6 Charging the storage battery of the detecting device

The external battery charger, which is included in the radiometer's kit, is connected to the connector (9). When you connect the charger to the detecting device, the "BC" LED (meaning that external power is supplied) and the "BATTERY" LED should light up. Upon completion of the charging process, the "BATTERY" LED should go out and the "BC" LED should stay on. The "BC" LED goes out only after removing the charger from the detecting device.

The process of battery charging does not affect the performance of the device. If necessary, the detecting device can continuously operate from an external power supply.

Important! Charge the battery of the detecting device within the ambient temperature range from 0 to 45°C. Noncompliance with this temperature range can cause failure or significant reduction in capacity of Li-Po battery.

Important! In case of the storage battery (11) failure it should be replaced with a new one of the same type (14500 (AA) Li-Po battery). Unscrew the screws (12), remove the lid (4) and insert a new battery in the battery compartment (10) observing the polarity. Replacement of a faulty battery can be performed by the manufacturing company of the detecting device or its authorized service center.


Important! If Li-Po battery is improperly installed, the radiometer goes out of service. Warranty does not apply to this damage and the client is solely responsible for the failure.

2 OPERATION OF THE “VIRTUOSO” RADIOMETER

2.1 Installing the Virtuoso application on an Android device




If a tablet PC or a smartphone were included in the delivery kit of the device, the Virtuoso application would be already installed on it. If some other Android device is used, you should download and install the application on the latter.

To do this, please use your Android device to visit Google Play, find and install Virtuoso application from the manufacturer PE «SPPE «Spring-Vist Center».

As soon as installation is completed a window with the “Application installed” message will be displayed over a period of time. The icon  will appear in a list of the installed applications, and on the desktop.

Note. The Virtuoso application interface uses the term "detector" instead of the "detecting device", therefore we are going to use the term "detector" for convenience in the description of this software to refer to the detecting device of the "VIRTUOSO" radiometer.

2.2 Starting the Virtuoso application on an Android-device

If the icon  does not appear on the desktop, tap on the icon "Programs" () at the bottom of the Home screen of the Android device, which opens a window with icons for all installed applications. If icons cannot fit on the screen in one view, you can swipe it to view more. To open the Virtuoso application, find icon  in the list and tap it.

For detailed instructions for working with the Android device, refer to the user’s guide of the Android operating system.

The window of the Virtuoso application is divided into two areas:

- 1) a symbol area;
- 2) a work area.

The symbol area is always at the top of the Virtuoso application window and is shown in Figure 2.1.



Figure 2.1 - Symbol area

The “Antenna” (1) symbol indicates the status of the connection to the detector. The background of “Antenna” turns green if your Android device is connected to the detector. The blinking symbol in the red background means that connection to the detector is either unstable or absent. The latter may be caused by too long distance between the Android device and the detector.

The “Battery” (2) symbol shows the rechargeable battery charge level of the detector, and whether the charging device is connected to the detector.

The number of a connected detector (3) is displayed in the center of the symbol area.

2.3 Connecting the Android device to the detector

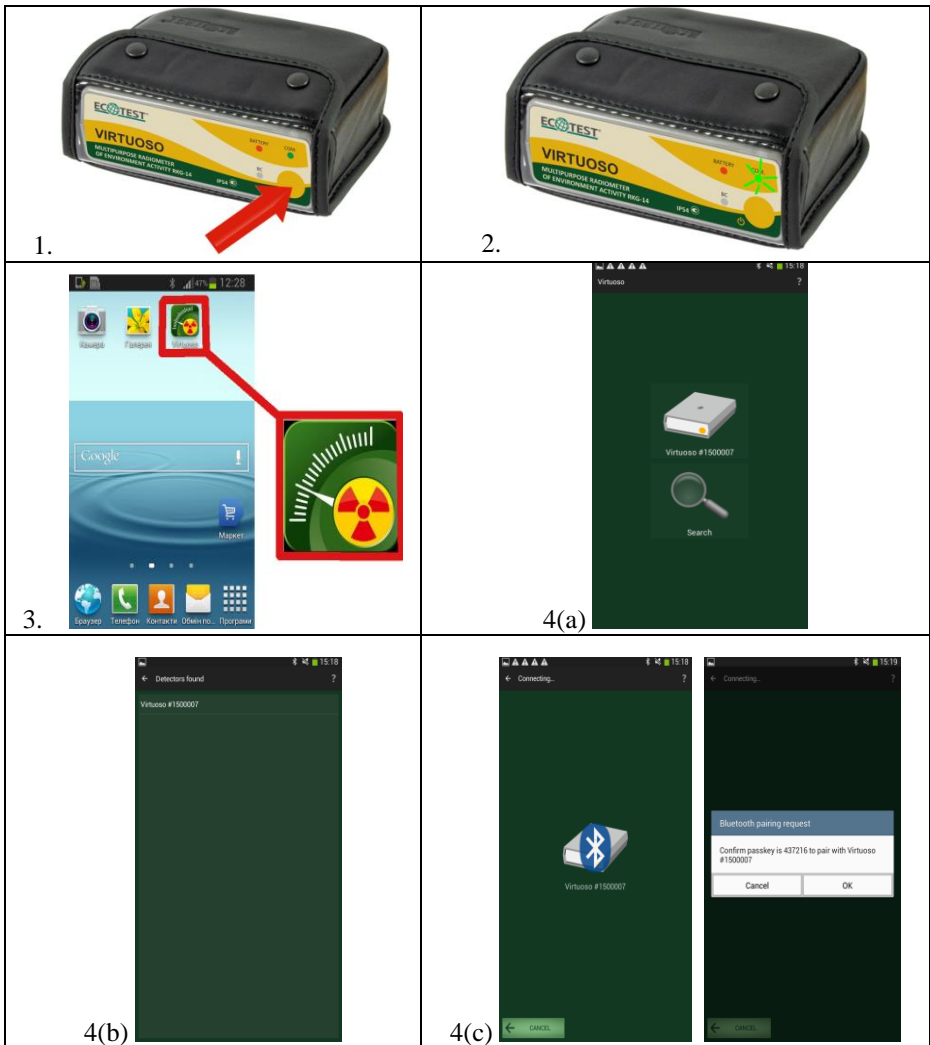


Figure 2.2 - Connecting the Android device to the detector

To connect the Android device to the detector, do as follows (see Fig. 2.2):

1 Press the on/off button on the detector's housing to turn the detector on.

2 Make sure a green LED is blinking at high frequency.

3 Run the Virtuoso application on the Android device.

4 If the required detector has already connected to the Android device, choose it from the list in the start window (see Fig. 2.2 (4a)).

If the Bluetooth-device of the Android-device is turned off, you will be asked for permission to turn it on. It is necessary to allow enabling the Bluetooth device. Proceed to 4.2. If the initial window does not display the detector's number go to 4.1.

4.1 Tap "Search". If the Bluetooth-device of the Android-device is disconnected, you will be asked for permission to turn it on. It is necessary to allow enabling the Bluetooth device. The Android device will perform search and show a list of found "VIRTUOSO" detectors (see Fig. 2.2 (4(b))). Choose the necessary detector from the list.

4.2 Confirm (if necessary) the creation of the Android-device/detector pair (see. Fig. 2.2 (4(c))). This detector will be "bound" to the Android-device and connected to it.

To view the information about the "bound" detector, tap the "Menu" button on the Android device, and select the "Settings" icon. In the application settings window that opens, touch the "Detector" item in the "Measurement" category. The settings screen of the detector will appear.

After an attempt to connect with the detector, the window shown in Figure 2.3 may appear.

The probable causes are:

- a) the detector is not switched on;
- b) the detector is located too far from the Android device (at a distance of more than 3 m);
- c) there are problems with a Bluetooth enabled device of the Android device or the detector.

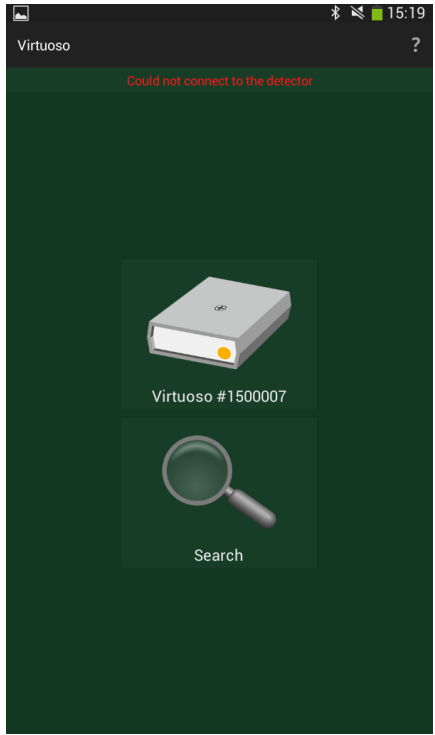


Figure 2.3 - Connection to the detector failed


If you cannot isolate the possible source of a problem regarding a failed connection to the detector, you can use another detector (should you have one). For connecting to that detector, switch it on and tap the “Search” button (see Fig. 2.3).

2.4 Mode of gamma radiation dose rate measurement

The detector enters this mode immediately after the Android device is connected to the detector. The Virtuoso application window in the mode of gamma radiation dose rate measurement is shown in Figure 2.4.




Figure 2.4 - Mode of gamma radiation dose rate measurement

This window shows ambient dose equivalent rate of gamma radiation (2) and counts per second from the gamma detector (shown graphically and numerically) (3). Counts per second are graphically represented in green color in the range from 0 to 200, while from 200 to 1000 – in yellow, and from 1000 to 20000 – in red. It also shows the  icon used to save measurement results of gamma radiation dose rate (1), and icons of switching to the testing modes (4) and tracks recording (5).

The mode of gamma radiation dose rate measurement makes it possible to measure dose rate of background radiation (environmental radiation), as well as perform preliminary (rough) measurements of radiological purity of the environmental objects.

Attention: For correct measurement of low levels of specific/volume activity of radiocesium (from 0 to about 100 Bq/kg) in relatively small objects (smaller than 50 cm), dose rate of environmental background radiation should not exceed 0.15 $\mu\text{Sv/h}$.

2.4.1 Saving measurement results of gamma radiation dose rate

When you tap on the icon  (see Fig. 2.4) the window of measurement results saving appears (Fig. 2.5):

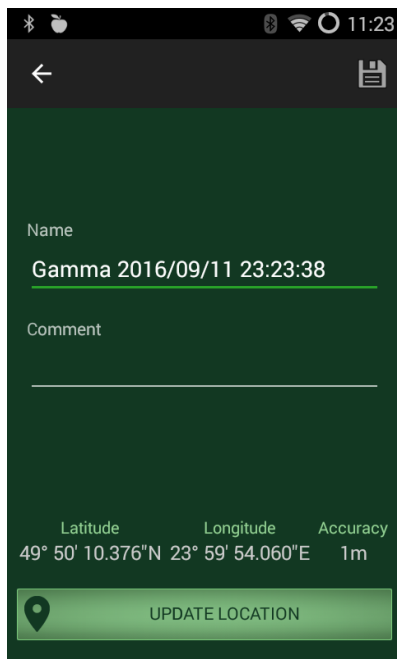



Figure 2.5 - Window of measurement results saving of gamma radiation dose rate

You can change the name of the record, and add a comment. If the Android device is equipped with a GPS-receiver and measurements are carried out in an open air, the record will be added with coordinates of a location, where the measurement was carried out. If necessary, you can tap "UPDATE LOCATION" to record the coordinates of the current location of the Android device. When coordinates are updated and the required (or maximum possible) level of accuracy are reached, you must tap "STOP". To save measurement results, tap the  icon.

2.5 Mode of radiocesium specific/volume activity measurement

In this section we consider a procedure of measurement of specific/volume activity of radiocesium on the example of food. Testing of soil and wood should be carried out in a similar sequence.

To enter the mode of specific/volume activity measurement of food, touch the TEST button in the mode of gamma radiation dose rate measurement (see Fig. 2.4). You will see a window as shown in Figure 2.6.

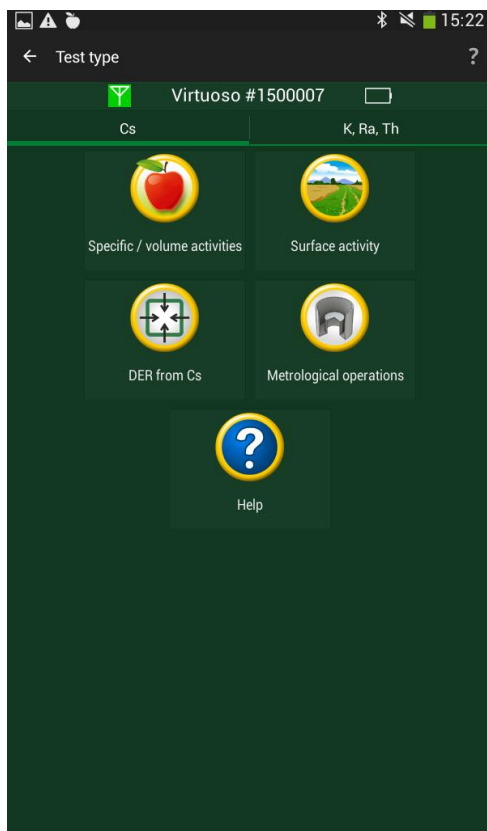


Figure 2.6 – Selecting a test type

Select “Cs” tab and then the icon "Specific/volume activities".

Before starting food testing, please read carefully the guidelines on carrying out measurements described in Section 2.5.2 “Important recommendations for measuring cesium specific/volume activity”. Pay attention to the required type of a food packaging or a container, as well as the way of positioning the detector towards the food, etc. You can also find the guidelines in the application help window by tapping the Help button (see Fig. 2.6).

Attention: Disregarding the guidelines on carrying out measurements described in Section 2.5.2 “Important recommendations for measuring cesium specific/volume activity” may lead to incorrect measurement results.

The mode of specific/volume activity measurement consists of six steps (2.5.1.1 - 2.5.1.6 of this OM). The first steps specify the parameters of the food, which will be tested for the presence of cesium isotopes, and the last step evaluates their specific and volume activities. The device features two modes for presenting test results: a basic mode and an expert mode.

The basic mode displays the process of measurement and the results in a simplified form, while the expert mode allows observing the process of measurement in more details and receiving the information about the presence of cesium and its activity much earlier.

The expert mode provides much more information, however requires some skills in radiation measurements, especially understanding of the nature of statistical trends typical of radiation measurements.

The expert mode ensures display of specific and volume activities from the very beginning, which become more accurate in the process of measurement. But a reliable result will become available only after the shape and the width of the trend assume their typical view. It will serve an indication that sufficient data has been collected.

2.5.1 Sequence of determining specific/volume activity of radiocesium in food

2.5.1.1 “Selecting a food group”

Figure 2.7 illustrates the window of specific/volume activity measurement mode of radiocesium on the “Food” tab.

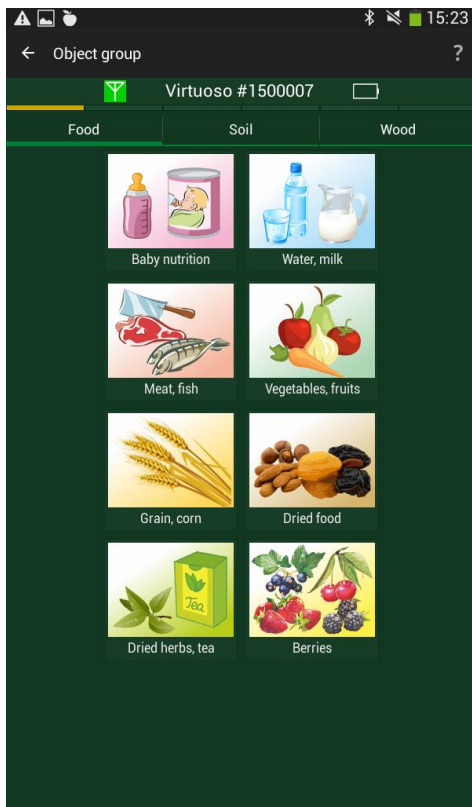










Figure 2.7 - Selecting a group to which the food belongs

Tap an icon showing a group with the food to be tested. The table below will help you determine a food group to which your food belongs.

Group	Food product (food)
	Powdered baby formula, dried milk
	Water, juice, tea, milk, fermented milk drink, yoghurt, cottage cheese, butter, sour cream
	Meat, smoked meat products, fresh fish, sushi, eggs. Canned goods
	Vegetables, fruits, mushrooms
	Grain crops, cereals, dried pasta, rusks, biscuits, sugar, salt
	Dried vegetables, fruits, mushrooms. Dried apricots, raisins, dried nuts and fish
	Herbs, herbal and leaf tea
	Berries

In the absence of the required object for measurement in the above table, select the one, which is the closest by characteristics.

2.5.1.2 “Selecting an object thickness”

Depending on the object of measurement selected from the list, its recommended thickness will be set automatically. However, measurements can be carried out on thinner objects and the objects that are not provided in the recommended list. To do this, select a food container thickness (in centimeters) with the help of a special scroll box (see Figure 2.8).

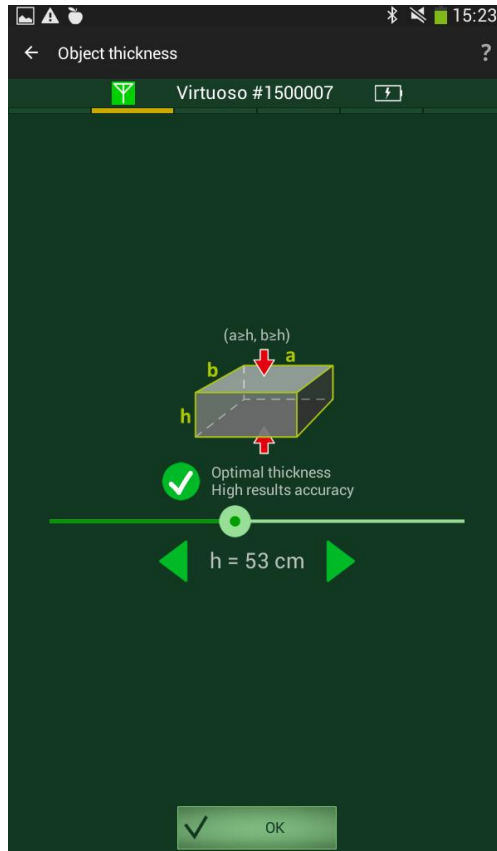


Figure 2.8 – Selecting an object thickness

Depending on the selected container thickness you will see the hints as to how accurate the final measurement results will be. For objects that are not provided in the recommended list, you should set an object thickness less than optimal, which will later allow setting its density (see Fig. 2.10).

2.5.1.3 “Selecting an object position”

A window will appear (see Fig. 2.9) in which you should specify the way of positioning the detector towards the tested object – either placed on the surface (optimum alternative for measurement) or between the two “large objects” (ideally).



Figure 2.9 – Selecting an object position

2.5.1.4 "Selected parameters"

In the next window that appears, all the parameters that you specified in the previous paragraphs will be listed. You can also change the value of density of the tested object. To do this, tap on "Edit" and enter a different value. If all the parameters are correct, place the detector as it was selected in the previous step and tap "START" to run the test (see Fig. 2.10). If there is a need to change some settings, you can return to the window you need using the "Back" button of the Android-device:

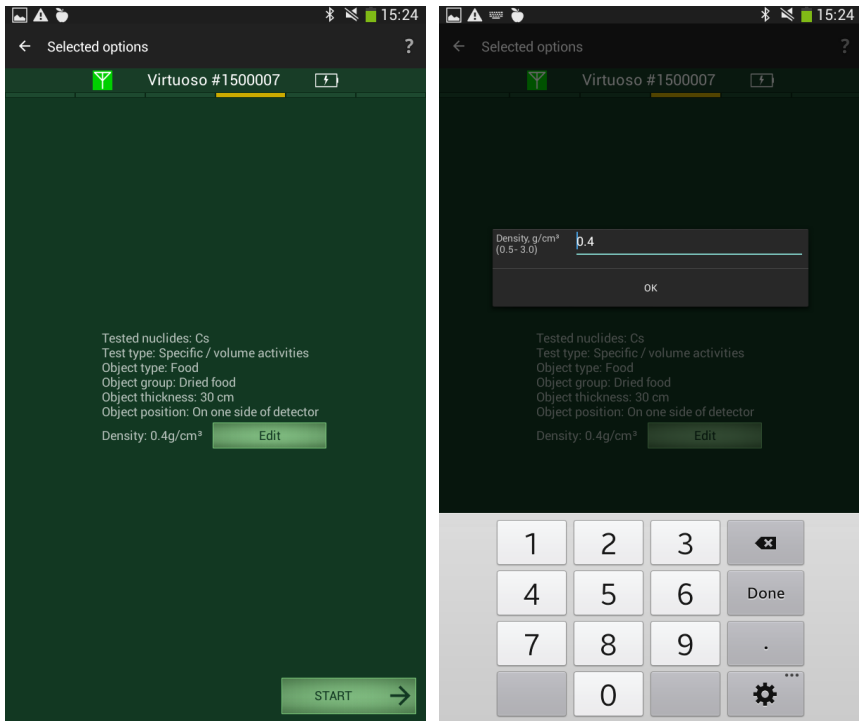


Figure 2.10 – Changing object density and starting the test

Attention: If you need to measure smaller activities than the minimum detected activity (for non-optimal conditions), find a place for a test with a lower background level or increase the object size.

2.5.1.5 "Searching for cesium isotopes in food"

Important: After you tap "START", the very food testing begins. Information about the parameters specified in previous windows can be viewed via the "About measurement" menu item.

The radiometer features two modes for presenting testing process: 1) a basic mode; 2) an expert mode.

1) The application window in the basic mode is shown in Figure 2.11.

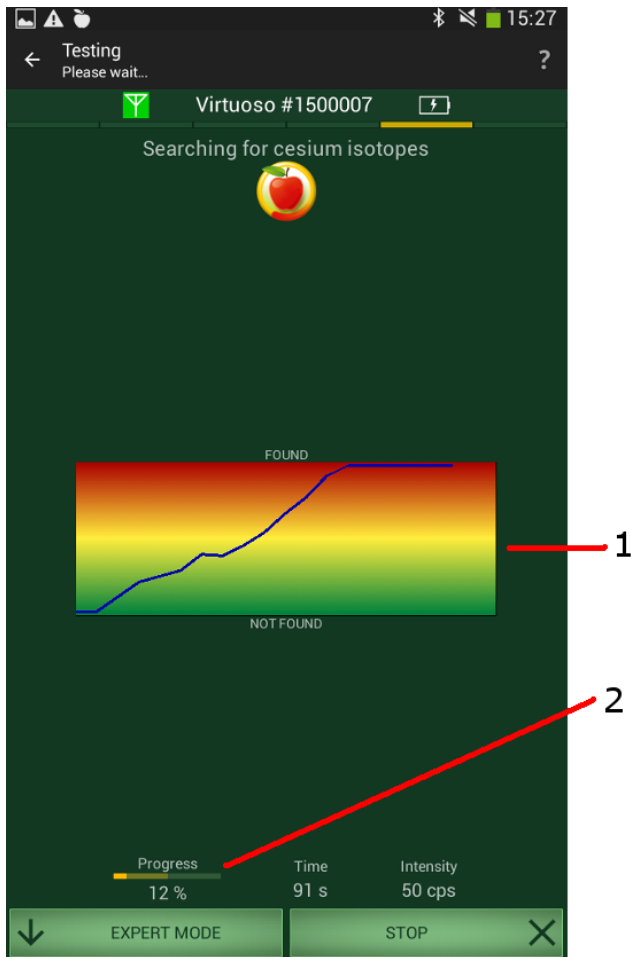


Figure 2.11 - Searching for cesium isotopes (basic mode)

The user can observe current results of radiocesium isotopes detection in food in the basic mode. The line 1 will move either to the “NOT FOUND” or “FOUND” labels during measurement depending on the presence or absence of cesium in the food, respectively. The progress indicator 2 displays accumulation of necessary radiological information in the process of testing and in length of time fills from 0 % to 100 %. The indicator will no longer be displayed as soon as 100 % is reached. Measurement time and pulse intensity from the gamma radiation detector are displayed in the same way.

The basic mode has been developed for novice users who have no experience in radiation measurements and prevents them from hasty conclusions: it disallows calculating specific activity without all necessary information obtained.

2) The expert mode features two display options as shown in Figure 2.12.

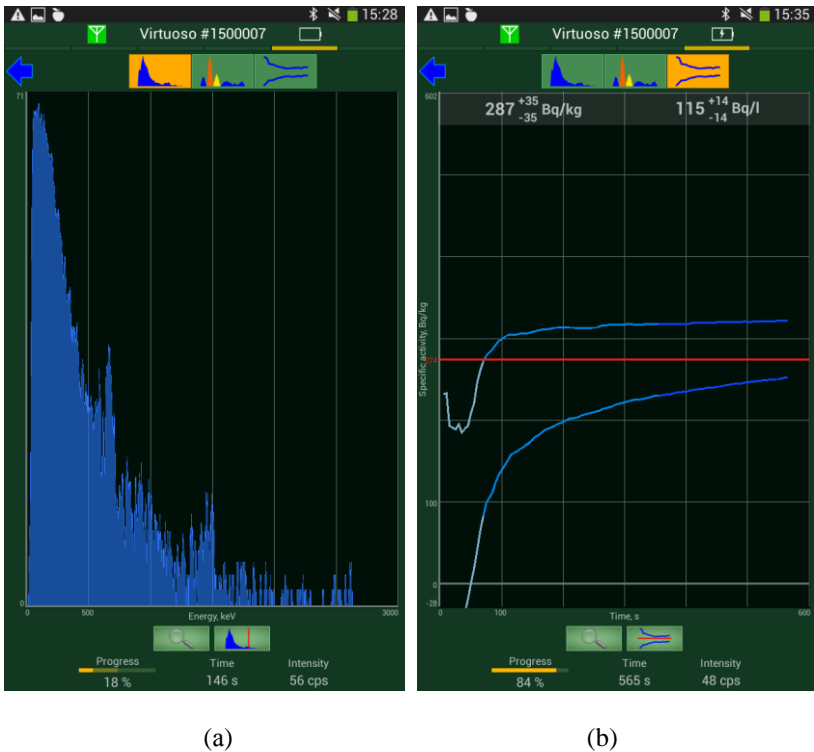







Figure 2.12 - Searching for cesium isotopes (expert mode)


Display options in the expert mode:

1 A gamma radiation spectrum (Figure 2.12 (a)) is activated upon tapping a  button. The experienced users with its help can visually control (observe) typical display of cesium radiation in the spectrum or control potential abnormalities of background radiation.



There are such tools available in this mode:

- a) **spectrum scaling**, which is activated with a  button (the tool expands and reduces the spectrum either horizontally or vertically);
- b) **cursor**, which is activated with a  button. It allows placing the cursor (a red vertical line) in the required position. The diagram represents the values of channel and energy at this cursor position;
- c) **spectrum display option** – a view of the button depends on the display option selected:  (input spectrum display) or  (output spectrum display).

The input spectrum includes a background constituent, while the output one is free from background. Moreover, in the output spectrum channels associated with ^{34}Cs and ^{137}Cs are highlighted in yellow and orange, respectively.

2 A “trend” display (Figure 2.12 (b)) is activated with a  button and features a diagram of maximum and minimum activity values with a true value within their limits. The values of specific activity in Bq/kg and volume activity in Bq/l, as well as a current measurement error are represented in the diagram.

There are such tools available in this mode:

- a. **scaling**, which is activated with a  button (expands and reduces the trend from top to bottom);
- b. **cursor**, which is activated with a  button. It allows placing the cursor (a red horizontal line) at the required level of specific activity.

2.1 The upper and the lower trend lines create a band diving probable values of specific activity. A true value of specific activity is within the limits of the upper and the lower band edges. This band is wider at first and is getting narrower in the course of measurement time, since the detector accumulates more and more data and the statistic uncertainty reduces.

2.2 The band of values visualizes the development of measurement in time. A configuration of the values band gives us the basis to evaluate the process of measurement. To be more specific, we can visually determine if there is sufficient time for measurement, and what level of measurement precision has been reached at a given time.

We can also see some abnormalities in the process of measurement and depending on their presence or absence judge about the reliability of measurement or decide whether to carry out additional or repeated measurements.

2.3 Ideally, the band should gradually and symmetrically move towards a conditional central line in horizontal direction (examples are shown in Figure 2.13). If the band behaves that way during measurement (we can see that band edges are more or less symmetric with respect to the horizontal center shown with a red line-cursor), it means that the current result of specific activity calculation is valid enough.

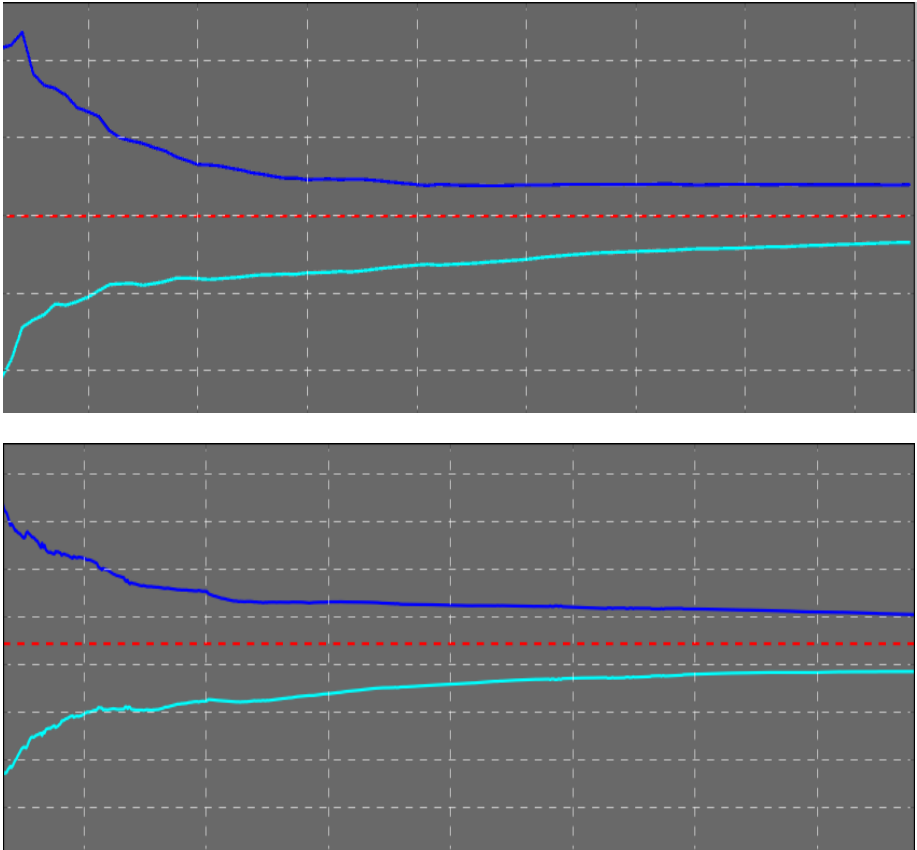


Figure 2.13 – Perfect progress of the trend band

2.4 In reality, the band almost always behaves in a different way. If the band during measurement clearly deviates from a horizontal direction (moves up or down), it means that spectrum balancing processes are not steady yet (Figure 2.14 illustrates some examples of the unstable band). In order to get more reliable measurement results you should wait until the band begins moving in a stable horizontal direction (Figure 2.15 illustrates the examples of a gradual change for a stable measurement mode).

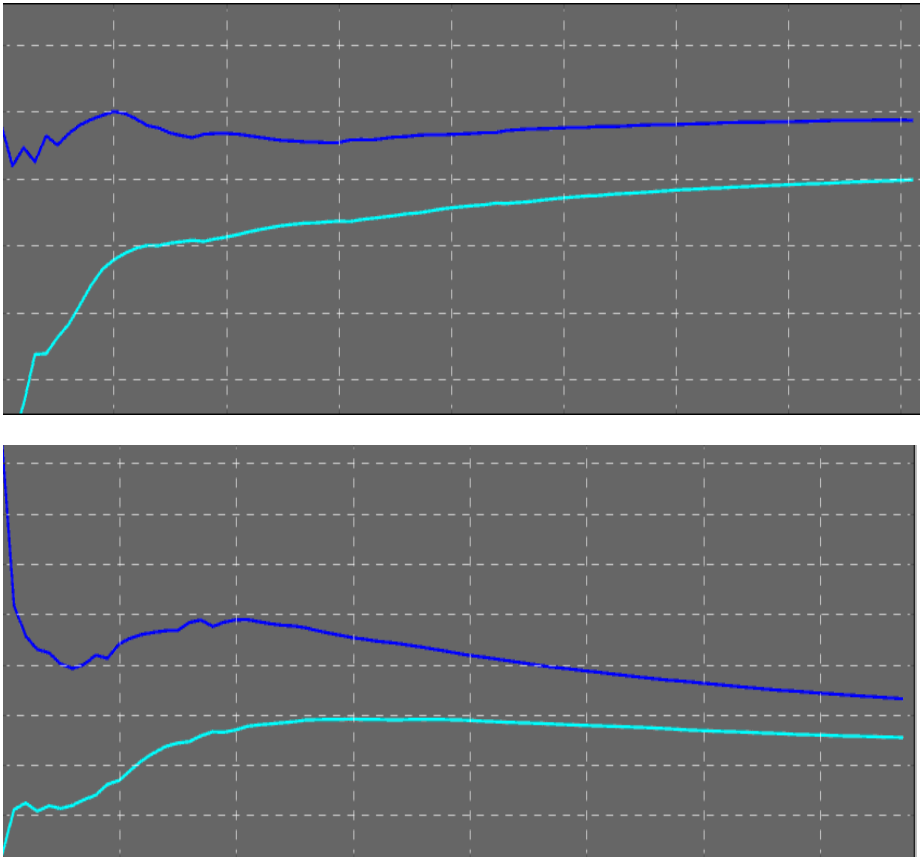


Figure 2.14 – Unstable trend band

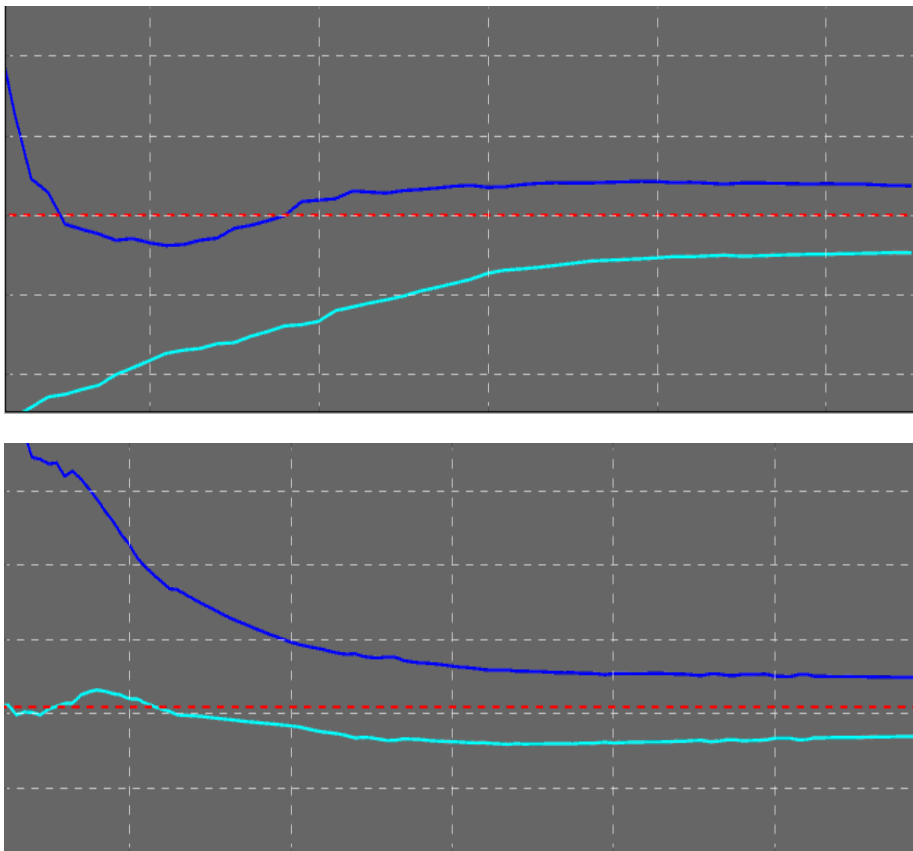


Figure 2.15 – Stable trend band

2.5 A bandwidth is another important feature apart from its shape and direction, since it displays the error in measurement. Considering the level of accuracy you want to obtain, please wait until the band reaches an acceptable width. You can observe numeric values of maximum and minimum specific activity at the moment of measurement along with its graphic display in order to evaluate the bandwidth. Figure 2.16 shows that if the current numeric value is 267^{+31}_{-31} Bq/kg, the right end of the band's lower edge is at the level of $267-31=236$ Bq/kg, while the right end of the band's upper edge is at the level of $267+31=298$ Bq/kg.



Figure 2.16 – Evaluating the width of the trend band

2.6 The line-cursor can also be used to control the bandwidth. By placing the cursor at the level of the right end of the band's upper edge, and then shifting it to the lower edge (see Figure 2.17), we can observe a numeric value, which corresponds to the level of a cursor position. In general, the line-cursor helps to control the band direction and see the level of specific activity for any point of the band.

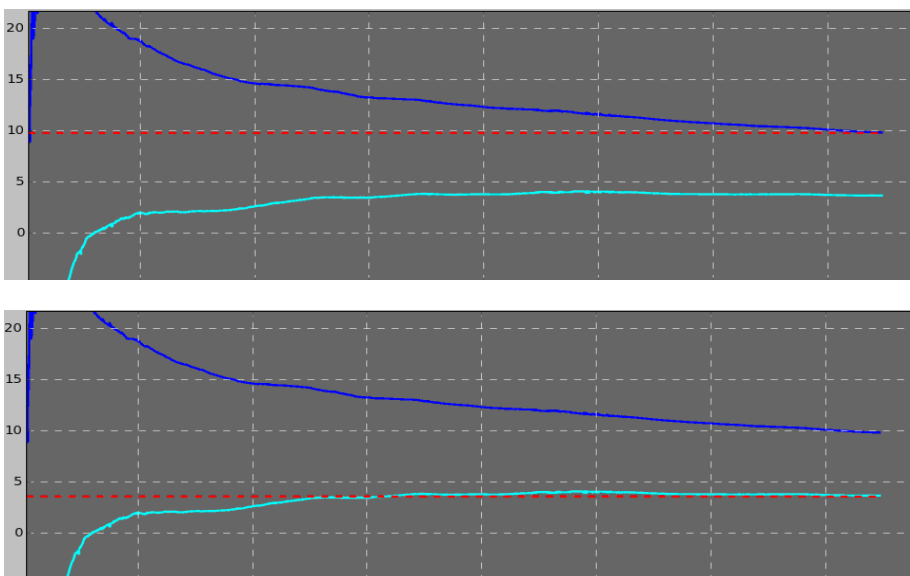


Figure 2.17 – Control of the trend bandwidth with the help of the cursor

2.7 The band is always much narrower and more stable when a large object is under measurement. All the figures, described in the following subsections, will be improved and reached much more quickly in such a case.

2.8 If the aim of your measurement is to make sure whether the specific activity exceeds some specified level (threshold value), the trend mode appears to be **the most time-effective**. Right after the measurement start, place the red line-cursor at such a level of specific activity you want to control when exceeded or not. Then you should follow the change of position and width of the band and wait until the entire band becomes obviously lower than the specified level. The following example (Figure 2.18) shows that the entire band of possible values of specific activity has gone below the specified threshold (threshold is a red dotted line) after about 200 seconds of measurement. You should not jump to the conclusion too quickly at the early stage of measurement, since the band may go down at the beginning and then move up the threshold. To get more reliable result you should wait for a relatively stable condition of the band when its lines change their color (color change means that the confidence level has increased: the color changes from grey to blue, and then from blue to dark blue).

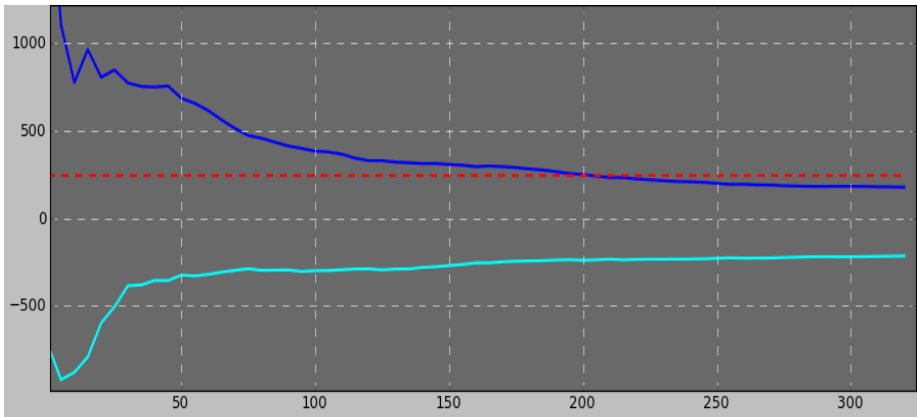


Figure 2.18 – Control of threshold exceeding with the help of the cursor

2.9 If the line of the specified threshold remains within the band for a long period of time (entire trend band neither goes up or down the threshold), this is that very rare case when an actual activity value of the examined object is close to the specified threshold level. If you still need to know whether the activity threshold level is exceeded or not, you should continue measurement till the band becomes more or less stable regarding the threshold.

2.10 If cesium is detected in the product under testing, the lower band edge will move up the line of “zero activity” (i.e. 0 Bq/kg threshold is exceeded). Moreover, for a more confident conclusion you should wait until the gap between the edge and the zero line becomes well-defined and lasting enough, and there is no apparent tendency for a repeated dropping of the lower band edge below the zero line. One of the examples (Figure 2.19) shows that the lower band edge has crossed the zero line (red dotted line) and moves upwards after 250 seconds of measurement, and there are no signs that the direction of the lower band edge will change “downwards”.

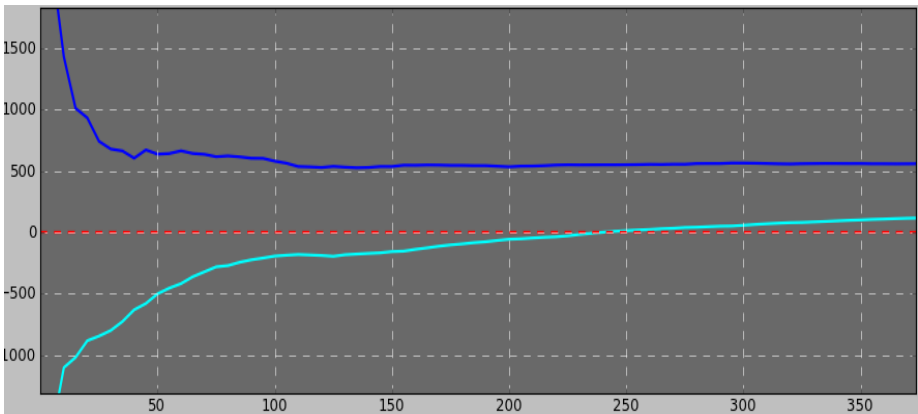
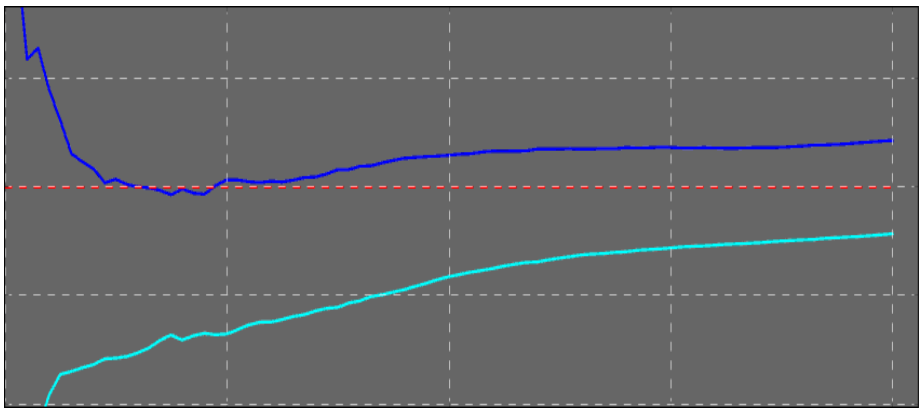
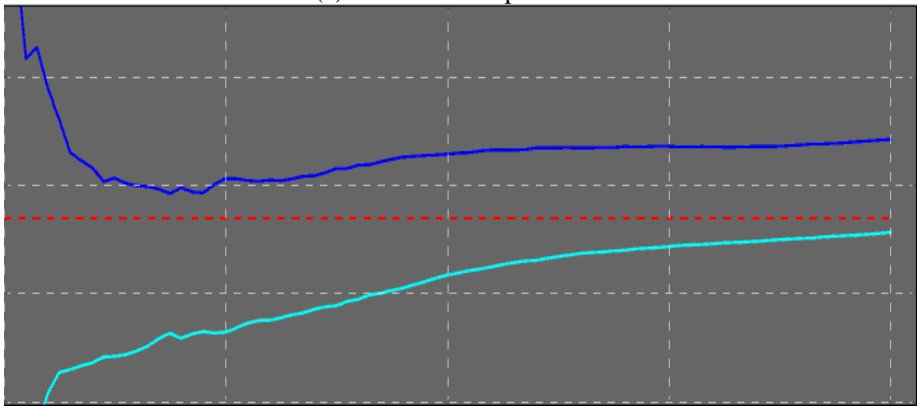


Figure 2.19 – Cesium presence monitoring in food with the help of the cursor

2.11 You should keep in mind that the right side of the band gives the most reliable information about the specific activity, since it uses all data collected at a given time. Even if the band has not reached its stable condition yet (there is a tendency to move up or down), the most correct specific activity at a given instant is depicted in the middle of the right band edge, but not as a mean value throughout the length of the band. The example illustrates a correct location of the line-cursor (red dotted line) in the middle of the right edge of the band, which is the most probable value of specific activity (Figure 2.20 (a)), and an incorrect mid-level location of the line-cursor on the whole band (Figure 2.20 (b)). A perfect band shape (as in Figure 2.13), when the middle of the right band edge coincides with the middle of the whole band length, is rather a rare occurrence.



(a) correct cursor position



(b) incorrect cursor position

Figure 2.20 – Control of the current activity value with the help of the cursor

2.12 If the band shape becomes stable, i.e. its edges are coming together towards the horizontal central line in a stable and continuous manner (ideally as in Figure 2.13), one can anticipate that this very central line will later on converge with the most accurate value of the specific activity. Thus we can predictably accept a central value of the band as a final measurement result. In such a way measurement can be rather time-effective, but its result should be treated with care and such predictions should be allowed only when measurements are not very critical.

2.13 The issue of radiocesium absence is a separate task. If the band surface covers the zero line, it means that cesium is probably absent. There are some aspects described below.

2.13.1 If the band center coincides with the zero line (Figure 2.21 shows that the red line-cursor is at zero position and in the center at the same time), this is the

maximum probable case that there is no cesium present. The figures will show the following value of specific activity: 0_{-0}^{+25} Bq/kg

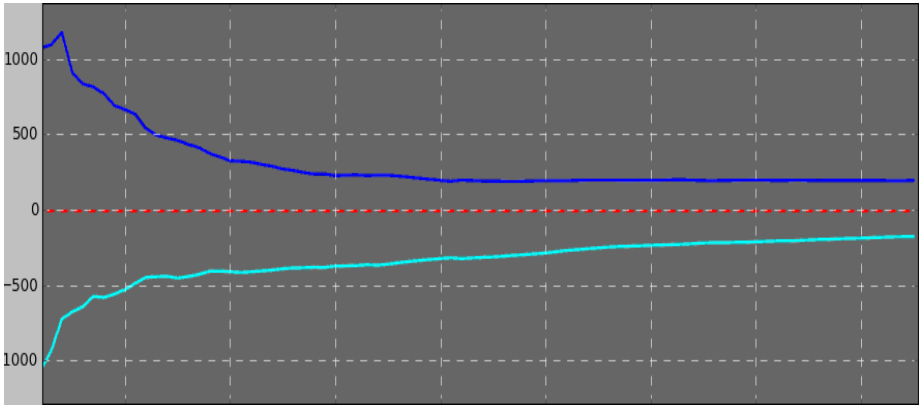


Figure 2.21 – Cesium absence

2.13.2 If the band covers the zero line (in Figure 2.22 the red line-cursor shows the zero level, which falls within the band edges), but the band center is a bit beyond the zero line, it means either cesium is absent or there is relatively little cesium present. The figures will show the following value of specific activity:

$$15_{-15}^{+27} \text{ Bq/kg.}$$

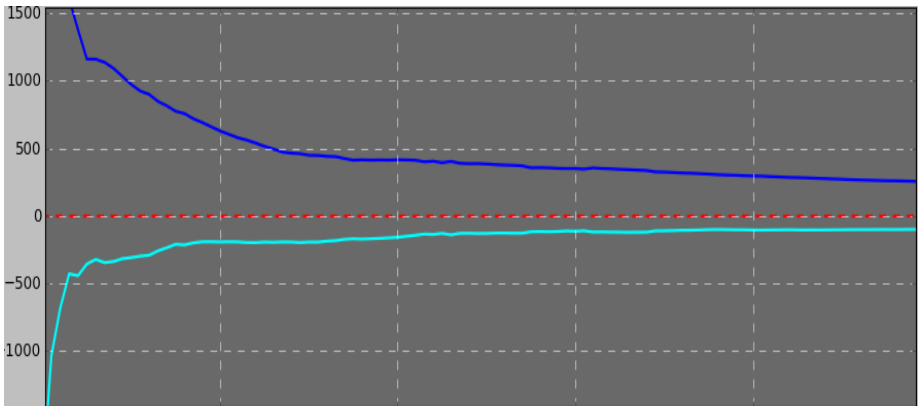
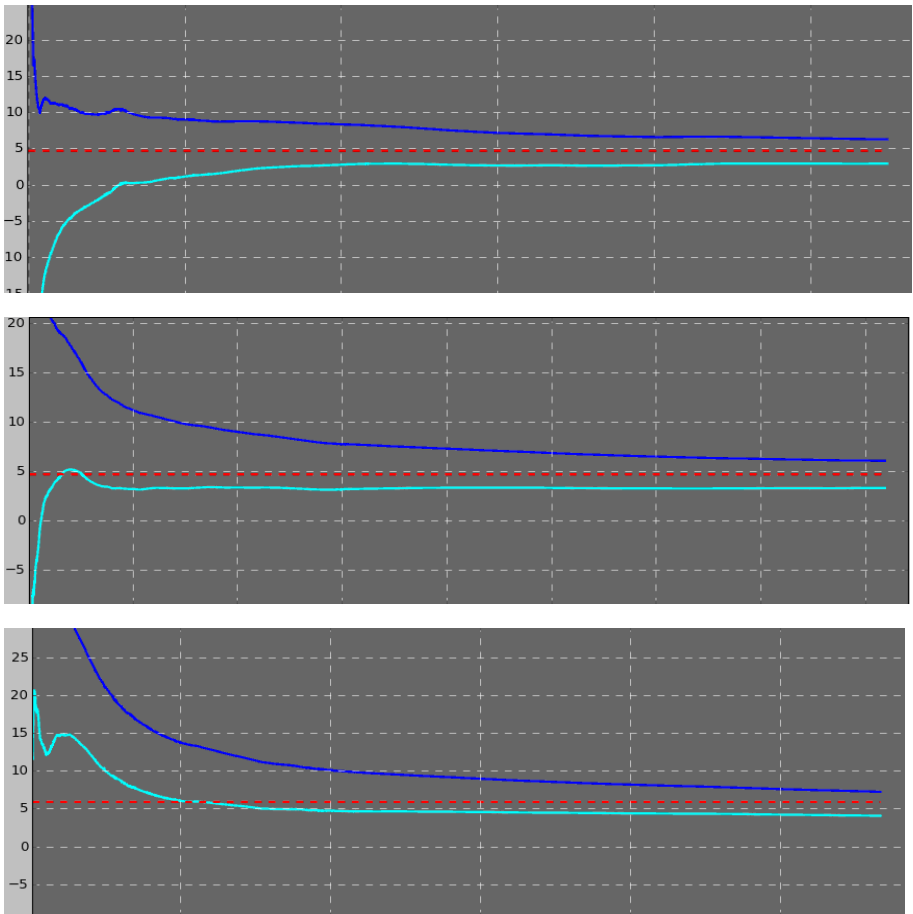


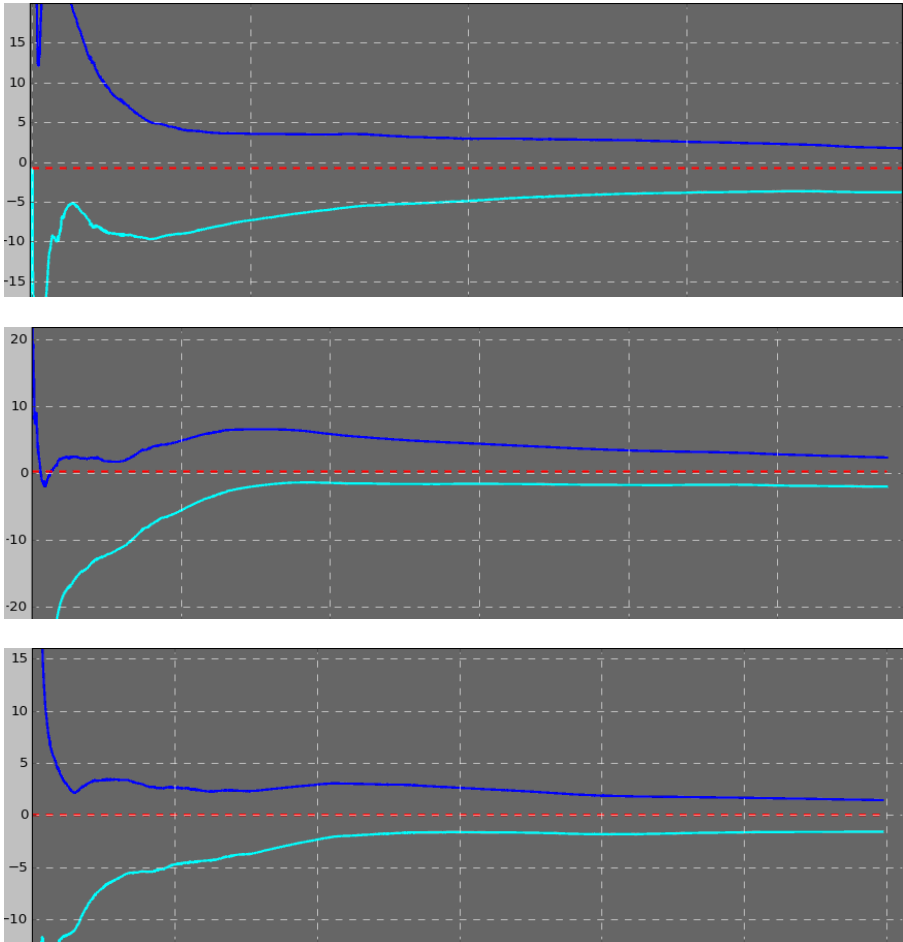
Figure 2.22 – Probable presence of small cesium amount

2.13.3 If your task is to ascertain the fact of cesium presence or absence in food as accurately as possible, you should carry on measurement as long as possible to get the final answer. In such a case the figures of subsections 2.13.1 and

2.13.2 will assume increasingly accurate and “constricted” values. It is important to realize that even if the band covers the zero line at a given time, cesium might still be present. To get more specific answer you should continue measurement. The band, in this instant, will get narrower around zero, or, perhaps, around some relatively small real value of specific activity. But, if you still want to continue measurement in order to get more specific result, you should realize that these more specific values are almost always smaller, than the upper band edge at the moment. In other words, the value of the specified result will most probably fall within the upper and the lower edges of the already obtained band. Figure 2.23 illustrates several examples of the trend band behavior during long-term measurements



(a) three results of a long-term measurement of a “large sample” with ≈ 5 Bq/kg specific activity



(b) three results of a long-term measurement of a “large sample” with ≈ 0 Bq/kg

Figure 2.23 - Examples of the trend band behavior during long-term measurements

2.13.4 The above-mentioned features of the band development pattern during measurement can serve the basis for control of the presence or absence of cesium radiation within background radiation irrespective of the task to monitor either food or surface contamination.

There are three ways to complete the search for cesium radioisotopes in food:

1 Automatic completion upon achieving measurement progress equal to 100 %;

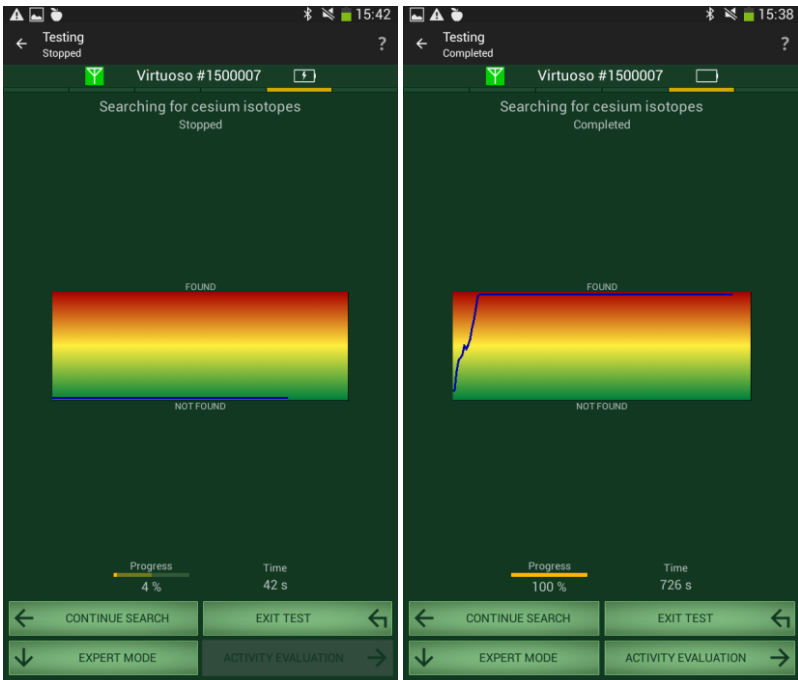
2 Forced completion after you tap the “Stop” button (the option of activity evaluation will become available, provided that you have currently gathered sufficient information and the progress equals to more than 50%);

3 Search interruption upon achieving maximum test time, which is 6 hours (the “Continue search button” will be disabled).

Important: It is recommended to wait for automatic completion when measurement progress becomes equal to 100%. In the case of forced completion, you should consider that the specific activity determination becomes more accurate in the process of testing. You will get more reliable results only if you continue measurement.

After completing the search for cesium isotopes, the window of the basic mode will look as shown in Figure 2.24 (a) if cesium isotopes in a tested food product are absent or as in Figure 2.24 (b) if cesium radioisotopes are present.

In case of forced completion of measurement with less than 50% of measurement progress, the activity evaluation option will be disabled (Figure 2.24 (a)). In case of measurement completion with the progress more than 50% but less than 100%, approximate value of activity is available. For more accurate value, please continue the search until its auto-completion with 100% of measurement progress. (Figure 2.24 (b)). If you need to get as accurate result as possible, continue testing even after achieving 100% of measurement progress. Touch the “Continue search” button to continue the search. Maximum testing time makes 6 hours. Then the search is automatically stopped and no further testing is possible (the “Continue search” button is disabled).



(a)

(b)

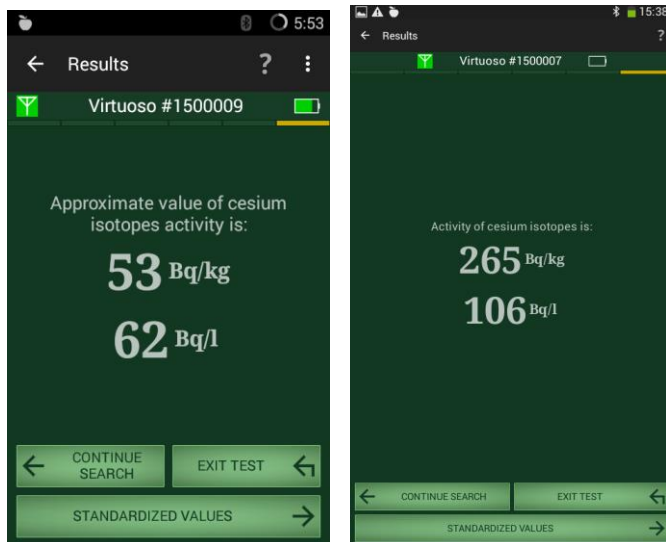
Figure 2.24 - Search for cesium isotopes in food is completed

To evaluate specific and volume activities of cesium radioisotopes, touch the “Activity evaluation” button. To exit the mode of specific/volume activity measurement and return to the mode of gamma radiation dose rate measurement, touch the “Exit Test” button.

While exiting the mode of specific/volume activity measurement, the application warns you that measured data will be lost. If the progress indicator has achieved 50%, you can save a measurement report that includes parameters of food and results received. Moreover, measurement description that you can enter will be also saved. The example of a report is presented in Appendix 1 (a). For more information about reports, see Section 2.9.

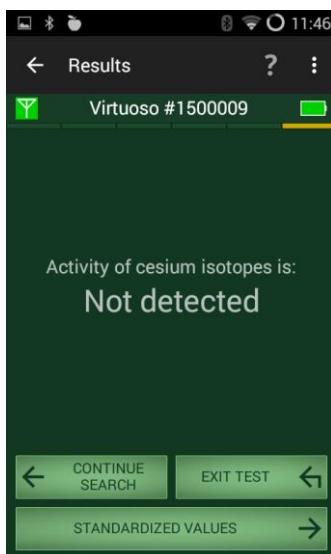
2.5.1.6 “Activity evaluation”

The final window of the mode of specific/volume activity measurement with the values of specific and volume activities of cesium isotopes is shown in Figure 2.25.



(a)

(b)



(c)

Figure 2.25 – Evaluation of activity

This window shows the results of calculated specific and volume activities for cesium isotopes in a food product under testing in the events of forced (Figure 2.25 (a)) and automatic (Figure 2.25 (b)) measurement completion.

If the calculated activity exceeds the minimum detectable activity of the device (50 Bq/kg) as well as the minimum monitoring level of cesium for the chosen location and specified object dimensions, the results will appear as in Figure 2.25 (b). If the calculated activity is less than at least one of the values, the results will appear as in Figure 2.25 (a). To view the results in case of cesium absence, see Figure 2.25 (c).

The “CONTINUE SEARCH” button allows further detection of radiocesium isotopes in food.

To view the standardized values of cesium isotopes specific activity, touch the “STANDARDIZED VALUES” button (the application provides the values adopted in Japan).

Specify sanitary standards for cesium isotopes specific activity in food in your country. Some standards can be found in “Safety standards for cesium isotopes specific activity in food” of this operating manual.

To return to the mode of gamma radiation dose rate measurement, touch the “EXIT TEST” button.

When you exit the mode of specific and volume activity measurement, the program warns you that the measured data will be lost. If the progress indicator reaches 100%, you can save measurement data containing information on geographical coordinates (if measurements were carried out in open air), specified parameters and obtained results. The process of its saving is similar to the process of saving measurement results on gamma radiation dose rate (see 2.4.1).

2.5.2 Important recommendations for specific/volume activity measurement

Attention: Failure to adhere to the following recommendations may lead to incorrect measurement results.

This section provides recommendations on measurement of specific/volume activity of radioactive cesium on the example of food. Best practices for testing of soil and timber are the same. You may also view these recommendations in the help window (see Fig. 2.6).

Before starting testing the food products it is strongly recommended to find a place with a low background level – not more than 0.15 $\mu\text{Sv/h}$. Higher radiation background may distort measurement results. To measure background, use VIRTUOSO in the mode of gamma radiation dose rate measurement.

2.5.3.1 Preparing a food product for testing

1 The food packaging (container) may be made of any kind of material. In the case of a metal container, its thickness should not exceed 1 mm.

2 Do not mix food products of different types for testing (since different food types cannot be equally contaminated). For instance, do not mix mushrooms with fish. The product should be of homogeneous consistency.



Figure 2.26 – Uniformity of product types

However, it is possible to carry out a study of a basket with different types of products, if you need to make a rapid assessment of the presence or absence of contamination among the collected products. In such a case, a correct measurement is impossible, but you may still search for contamination this way.

2.5.3.2 Food shape and dimensions

1. Larger food product size deliver greater precision and shorter period of time to get measurement results. The best way to conduct measurements of products is when they are stacked in a fairly large piles or large containers – it is quite easy to put the device on a pile, or a container. However, when it is necessary to control the products in relatively small packages, it is recommended to have a food container with dimensions of no less than 25 cm in each direction.

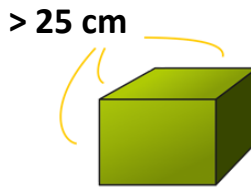


Figure 2.27 – Recommended container dimensions

Ideally, the detector should be placed in a position between packages or sacks of food with dimensions of more than ≈ 25 cm in any direction from the detector.

The detector can be attached to the surface of the food product with the same dimensions as described above (optimum alternative) if there is no possibility to put it between the packages.

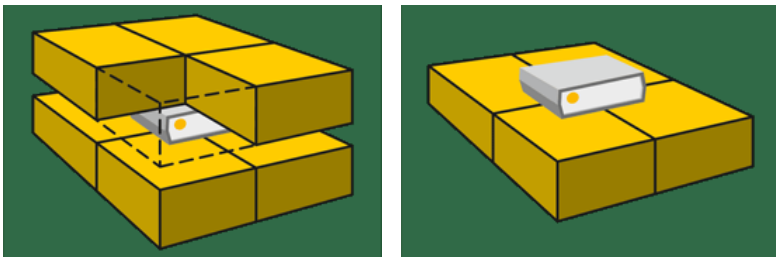


Figure 2.28 – Ideal and optimum alternatives of food product dimensions

2. If the container is smaller in size, put several containers of the same type together to get the overall dimensions of no less than ≈ 25 cm in any direction (otherwise, dimensions has to be less than 14x14x11 cm).



Figure 2.29 – Putting single-type containers together

3 The relatively small-sized containers (up to ≈ 25 cm) are required to have a parallelepiped-like or cylinder-like shape. If the dimensions of the object exceed ca 25 cm in all directions, the shape of the container is of no importance.

Attention: Testing of food products with the dimensions of less than $14 \times 14 \times 11$ cm should be considered as indicative, i.e. they give approximate evaluation of cesium specific activity.

2.5.2.3 Positioning the detector near a food product

1 Place the detector close to the widest side of the food container.

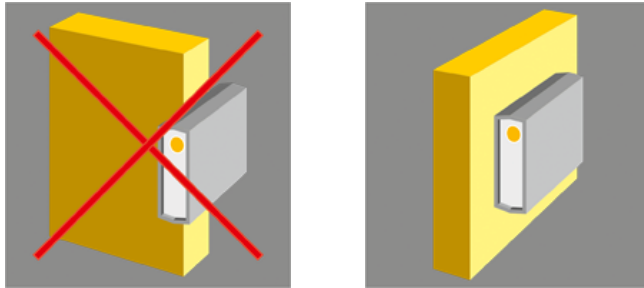


Figure 2.30 – Attaching the detector to the widest side of the container

2 Place the detector with its reference point (side labeled with the “+” symbol) close to the food. The reference point “+” is inscribed on the detector’s housing under the case.

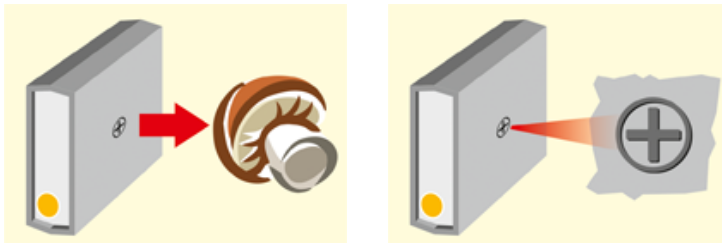


Figure 2.31 – Placing a food product close to the detector’s reference point

3 Place the detector on the surface of the container so that there is no significant air layer between the detector and the food product.

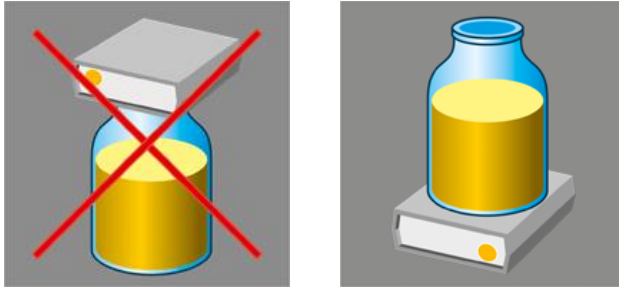


Figure 2.32 – No air layer

4 Place the detector above the surface of the food container in the case there is some air layer at the package top and the food container is large-sized and heavyweight. In such a way, firstly, you can avoid too much pressure on the detector's housing; secondly, reduce the influence of a possibly contaminated surface on which a tested product is located.

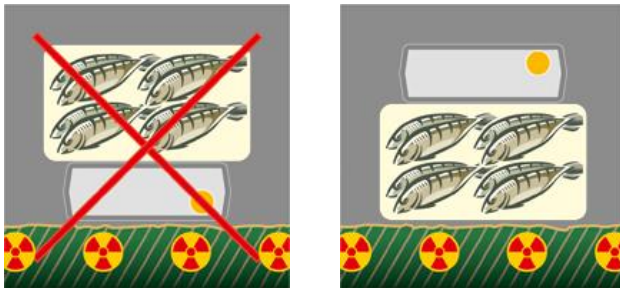


Figure 2.33 – Placing the detector above the food container

5 Use a plastic bag and change it from time to time to prevent the detector from being polluted.

2.6 Mode of radiocesium surface activity measurement

Measurement of surface activity is appropriate only when there is evidence that the radioactive cesium is right on the surface and has not penetrated into the soil deeper than for 5 cm. If this is not achieved, we should understand that the result serves as an estimate. This is not a fault of the device, but these are the states of the measurement object, when the term "surface activity" becomes invalid.

The mode of radioactive cesium surface activity measurement can be accessed by tapping the “TEST” button in the mode of gamma dose rate measurement (see Fig. 2.4). This opens the window shown in Figure 2.34.

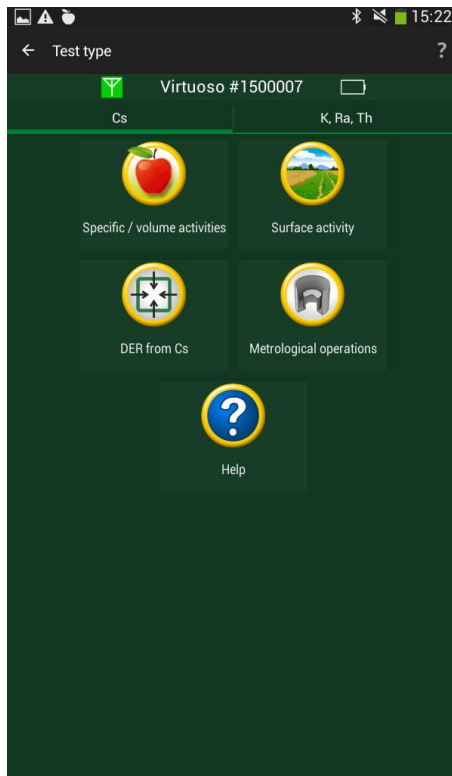


Figure 2.34 – Selecting measurement type

Select “Cs” tab, and then “Surface activity” icon. Before starting soil testing, please read carefully the guidelines on carrying out measurements described in Section 2.6.2 “Important recommendations for soil testing”. Pay attention to the way of selecting the type of measurement, as well as positioning the detector above the soil surface, etc. Guidelines are also available in the help window of the application, which appears when you tap the “Help” button. (see Fig. 2.34).

Attention: Disregarding the guidelines on carrying out measurements described in Section 2.6.2 “Important recommendations for soil testing” may lead to incorrect measurement results.

There are five steps to determine specific activity of radiocesium (subsections 2.6.1.1 – 2.6.1.5). The first steps specify the parameters of measurement, and a test for the presence of cesium isotopes is conducted, while the last step evaluates their specific activity.







The device features two options for presenting test results: a basic mode and an expert mode.

The basic mode displays the process of measurement and the results in a simplified form, while the expert mode allows observing the process of measurement in more details and receiving the information about the presence of cesium and its activity much earlier.

The expert mode provides much more information, however requires some skills in radiation measurements, especially understanding of the nature of statistical trends typical of radiation measurements.

The expert mode ensures display of activity from the very beginning, which becomes more accurate in the process of measurement. However, a reliable result will become available only after a certain period of time, when the shape and the width of the trend assume their typical view. It will serve an indication that sufficient data has been collected.

The mode of radioactive cesium surface activity measurement allows testing the following soil types:

	Fertile soil
	Lawn
	Marsh soils
	Sand
	Crushed stone
	Asphalt, concrete

2.6.1 Sequence of determining surface activity of radiocesium in soil

2.6.1.1 “Selecting a soil type”

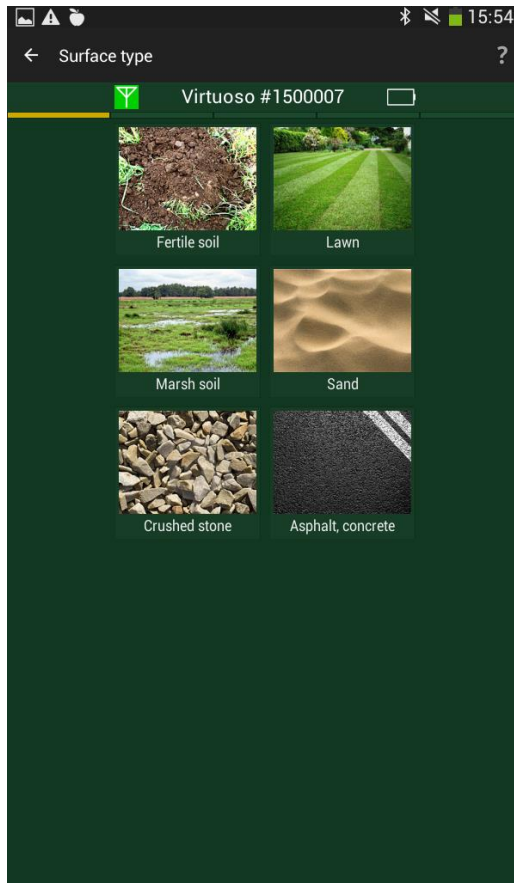


Figure 2.35 - Selecting a soil type for testing

Tap an icon showing a type of soil to be tested.

2.6.1.2 “Selecting height”

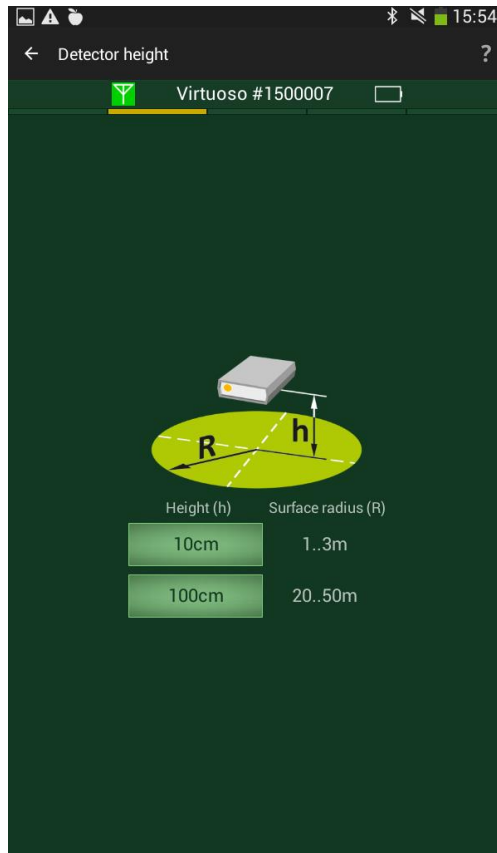


Figure 2.36 - Selecting height

Select a height above a surface where the detector will be located during testing. The higher the detector, the bigger the tested surface area is.

Select 10 cm height for local testing (surface radius up to 1-3 m), select 100 cm height for large areas (surface radius up to 20-50 m).

Important: Please read the guidelines outlined in Section 2.6.2 to make a right choice of measurement height.

2.6.1.3 “Selected options”

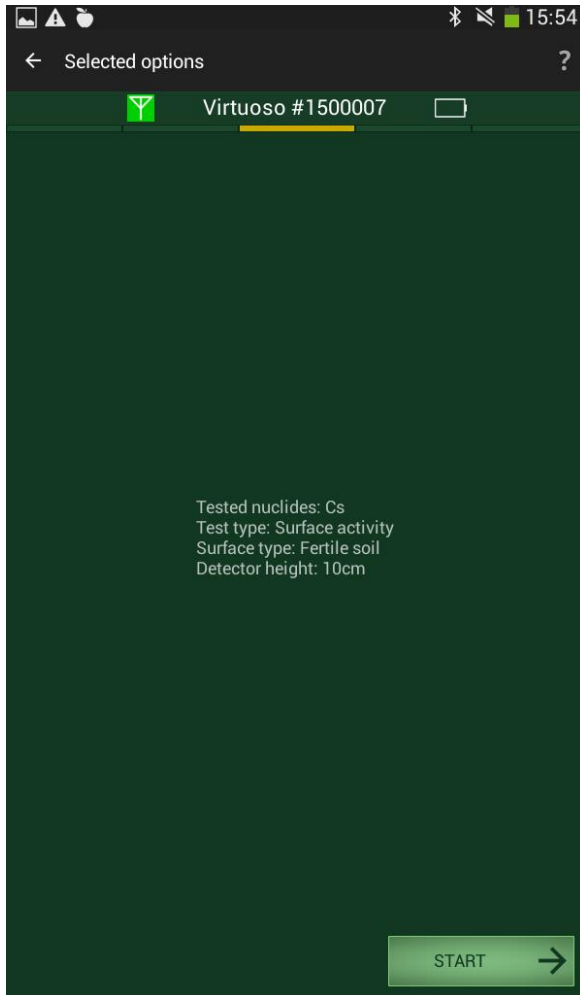


Figure 2.37 - Starting a test

In the next window that appears, all the parameters that you specified in the previous paragraphs will be listed. If the parameters are correct, place the detector over the surface at a height selected in the previous step, and tap "START" to begin testing. If you need to change some settings, you can return to the required window using the “Back” button of the Android-devices.

2.6.1.4 “Searching for cesium isotopes on surface”

Search for cesium isotopes on surface is performed the same way as search for cesium isotopes in food. All peculiarities of the measurement process monitoring and interpretation of measurement results in the basic and expert modes are absolutely identical to those described in 2.5.1.5 of the mode of specific/volume activity measurement.

2.6.1.5 “Activity evaluation”

The final window of the surface activity measurement mode with the values of cesium isotopes surface activity is shown in Figure 2.38.

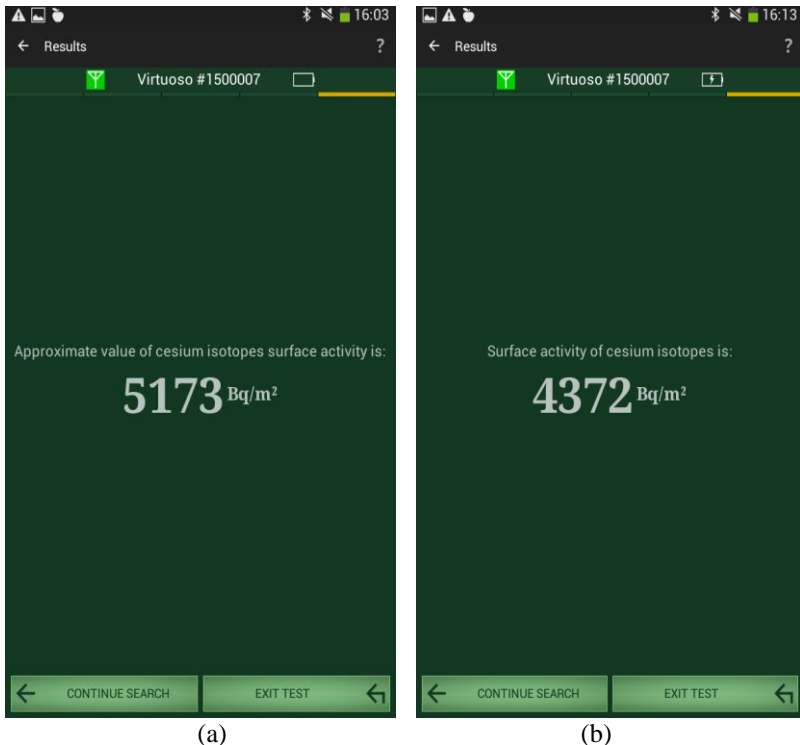


Figure 2.38 - Surface activity evaluation

This window shows the results of calculated surface activity for cesium isotopes in soil in the event of forced (Figure 2.38 (a)) and automatic (Figure 2.38 (b)) measurement completion.

Specify sanitary standards for cesium isotopes surface activity in your country.

The “Continue search” button allows further detection of cesium isotopes.

To return to the mode of gamma dose rate measurement, touch the “EXIT TEST” button.

As you exit the surface activity measurement mode, the application warns you that the measured data will be lost. If the progress indicator reaches 100 %, you can save measurement data containing information about geographical coordinates (if measurements were conducted in an open air), specified parameters and obtained results. The process of saving is similar to the process of measurement results saving on gamma radiation dose rate (see Section 2.4.1).

2.6.2 Important recommendations for radiocesium surface activity measurement

Attention: Failure to adhere to the following recommendations may lead to incorrect measurement results.

2.6.2.1 Placing the detector above the soil surface

1. Measurement of soil surface activity can yield an accurate result averaged for quite a large area (within a radius of tens of meters), if a surface of the area under monitoring is flat (without obvious hills or holes). The slope of the targeted area is not as important as its flatness.

2. The radius of data collection depends on the condition of the area under monitoring. Thus, if the area has a smooth flat surface (for instance, concrete area), radiological data can be collected from rather remote area zones. However, if the area is flat in general, but its surface is rough (for example, it is a gravel road or it is covered with small plants or lawn grass), the radius of data collection becomes smaller.

3. If the detector is placed at a height of 100 cm above the soil surface, averaged measurement of soil surface contamination within the radius of up to 20÷50 m is performed.

4. If the detector is placed at a height of 10 cm above the soil surface, local measurement of soil surface contamination within the radius of up to 1÷3 m is made.

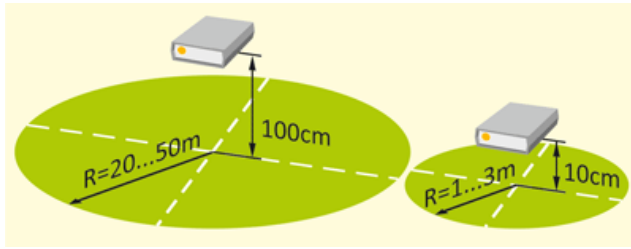


Figure 2.39 - Radius covered by the detector

2.6.2.2 Recommendations for choosing the type of measurement

1. When choosing the type of measurement, check out the size of a tested area. If the area is limited in size (for example, one of its directions does not exceed 3 m or buildings are located within a few meters), local measurement performed by positioning the detector at the height of 10 cm is recommended.

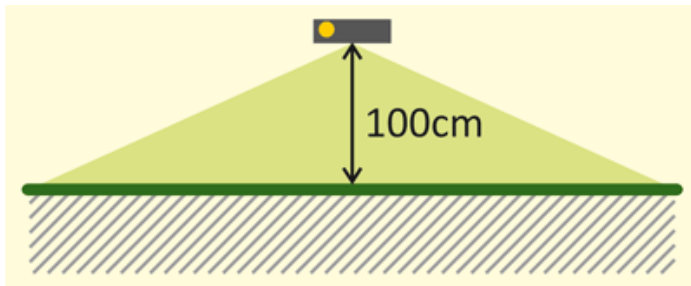


Figure 2.40 – Measurements on an open terrain

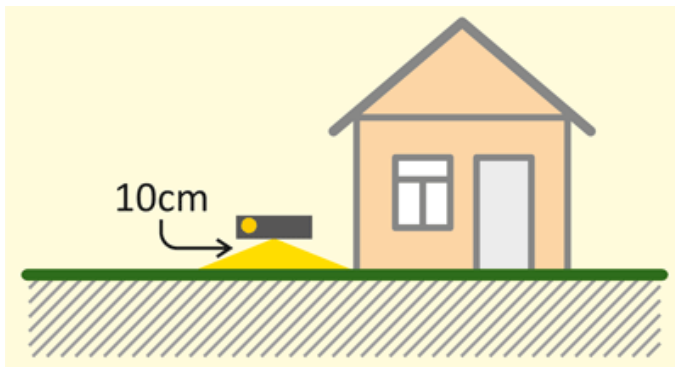


Figure 2.41 – Measurements near the buildings

2.Regardless of the overall size of the area, if it features local holes (with a radius extending from tens of centimeters to several meters) that are potentially susceptible to contamination, local measurement is recommended

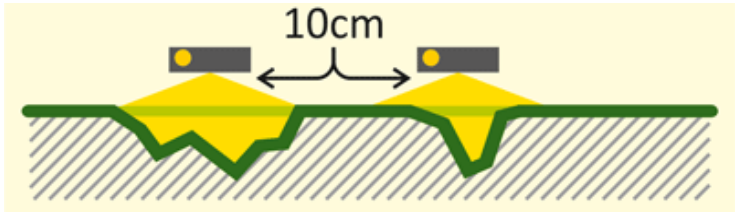


Figure 2.42 – Measurement of rough surface

3.Averaged measurements performed by positioning the detector at the height of 100 cm cannot be applied if a large area is under testing and you know that it is locally contaminated, as well as if lateral dimensions of a contaminated plume are known in advance (or visually obvious). Local measurements of obviously contaminated plumes are recommended

4.If there are noticeable holes or bulges in the area, but the surface is relatively flat within the radius of 10-30 m, make averaged measurement of surface activity in that area (at the height of 100 cm), and measure surface activity of certain holes as if measuring local contamination (at the height of 10 cm).

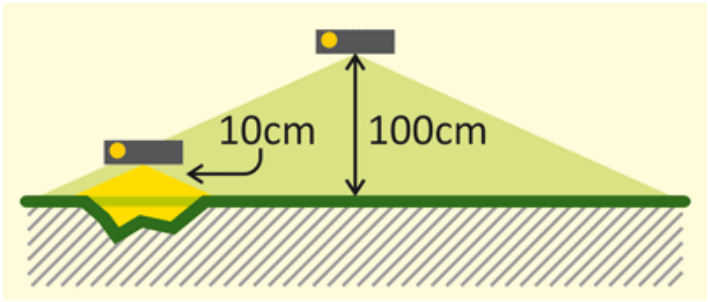


Figure 2.43 – Measurement of separate bumps

5.If the area under testing is big and flat enough, and varied covers are typical of its different regions (for example, patches of bare ground and grass), it is recommended to make local measurements in certain places with a homogeneous surface.

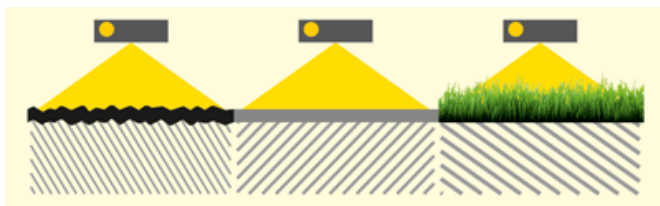


Figure 2.44 – Measurement of heterogeneous surface

2.6.2.3 Additional recommendations for measurements

1. Use simple supporting stands made of light materials (for example, the 10 cm thick sheet of foamed plastic can be put under the device for local measurement) to hold the device at a necessary height during measurement time. Keep the stand free from contaminants.

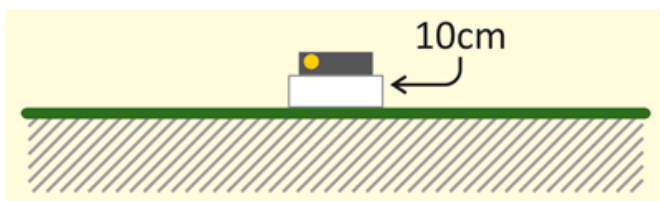


Figure 2.45 – Local measurements

2. Local measurements are preferable to make averaged measurements more precise.
3. Even if the area is ideally flat and smooth it is recommended to make a series of measurements at different points (averaged measurements in each 5-10 m, while local ones – 1-3 m).
4. If contamination is known to penetrate the soil at the depth of up to 5 cm and deeper, monitor a contaminated area in the mode of specific activity measurement by placing the device on the soil or by collecting samples.
5. Before you start measuring, make sure there are no relatively high objects (buildings or trees) contaminated with cesium in the vicinity (at a distance of one meter to tens of meters), since the detector may sense radiation emitted by such objects and yield incorrect measurement results of soil contamination.

2.6.3. Mode of DER from radiocesium measurement

The mode of DER measurement from radiocesium is designed to detect cesium emissions in the environment and to assess the values of the man-made radiocesium radiation component in the natural background.

The mode of DER measurement from radiocesium can be accessed by tapping the “TEST” button in the gamma dose rate measurement mode (see Fig. 2.4). This opens a window shown in Figure 2.46.

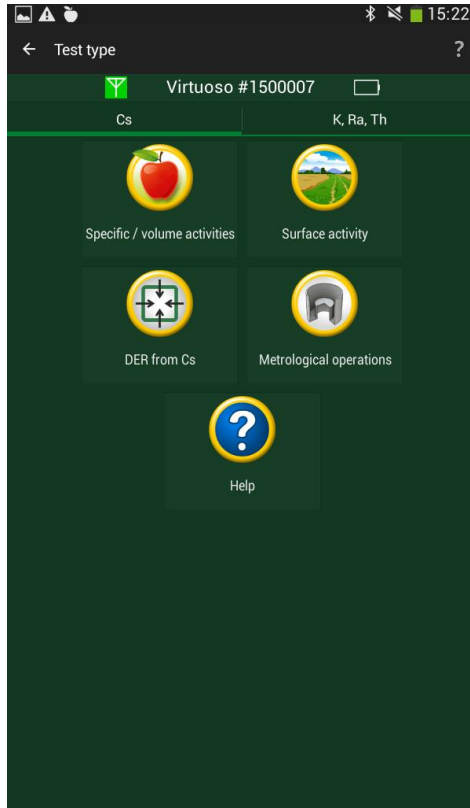


Figure 2.46 – Selecting test type

Choose “Cs” tab and then “DER from Cs” icon.

Before you start testing, carefully read the rules of measurement. Please take a note of how to choose the measurement option, how to position the detector, etc.

You can find the rules in the application help window, which is called with the "Help" button (see Fig. 2.46).

2.6.3.1 Measurement of cesium radiation DER can be performed in any position of the detector, i.e. the detector may be located in an open space, or may be attached to any objects or materials, or even deepened in their mass.

2.6.3.2 In the DER from radiocesium measurement mode you can make an advance or periodic evaluation of the purity of a location (no contamination with radioactive cesium), where the supposed research of the specific activity of relatively small packages with products or other materials is to be carried out.

2.6.3.3 The fact of the radioactive cesium emission detection, above all, shows that the point of the detector location is relatively close to the contaminated objects (for example, contaminated land, buildings, plants, etc.). That is, we get a generalized answer that this area (location, room) has been exposed to man-made radioactive contamination. And the next steps of the examination can identify, which objects include pollution and in what amount.

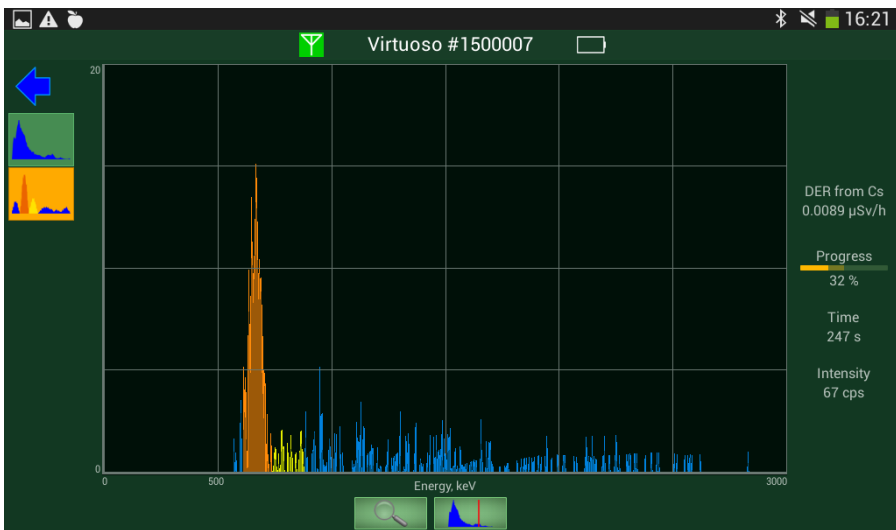
2.6.3.4 Please read the following recommendations for proper understanding of the results of cesium radiation detection.

2.6.3.5 Wait for the measurement completion, i.e. achievement of 100% of measurement progress.

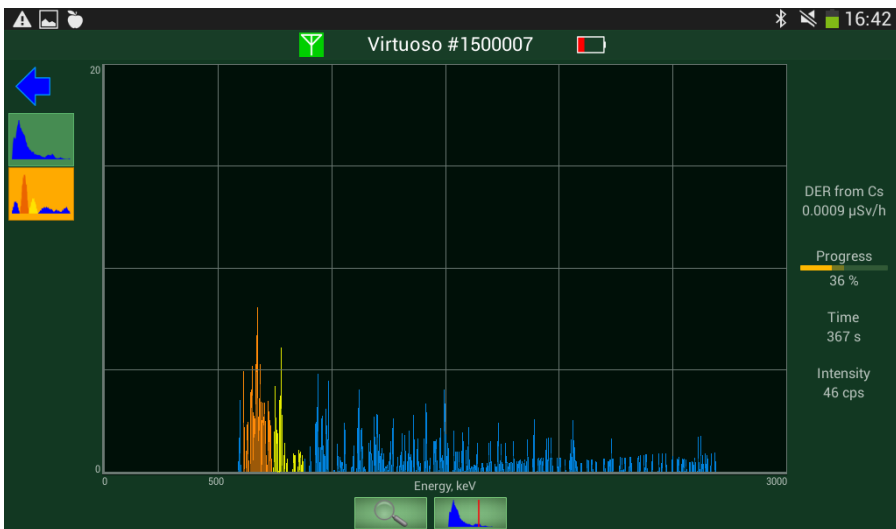
2.6.3.6 The fact of cesium emission detection will be a corresponding position of the "FOUND-NOT FOUND" indicator and DER value other than zero, for example, DER = 0.0081 mSv/h (see Fig. 2.47). Moreover, you will see a typical image of cesium spectrum in the "expert" mode (currently, a spectrum in Japan will look as shown in Fig. 2.48).



Figure 2.47 – Radiocesium detection



Spectrum of explicit radiocesium



Spectrum of less explicit radiocesium

Figure 2.48 – Examples of radiocesium spectrum;
orange color - a characteristic peak of radiocesium-137,
yellow color - a characteristic peak of radiocesium-134

2.6.3.7 In the absence of radiocesium emission you will see the following view of the "FOUND-NOT FOUND" indicator and DER value = X.XXXX mSv/h (see Fig. 2.49). The spectrum will be approximately as follows (see Fig. 2.50).



Figure 2.49 – No radiocesium

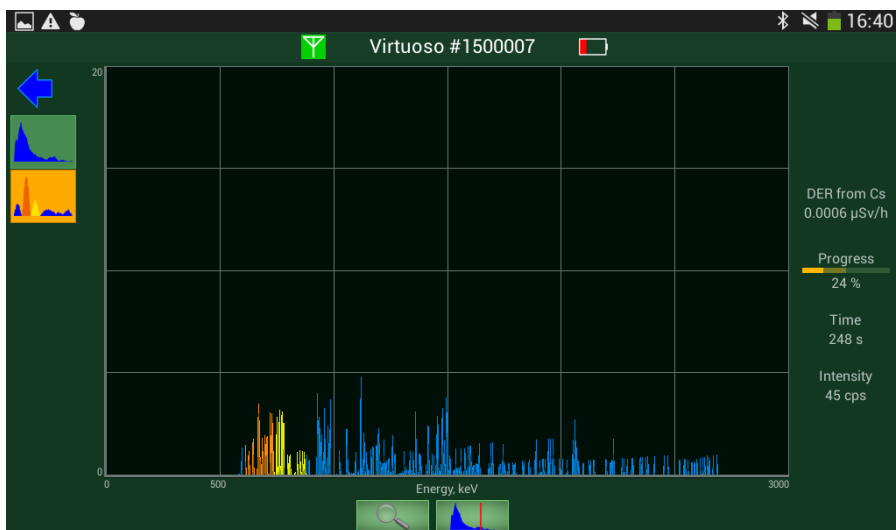


Figure 2.50 – Spectrum when radiocesium is missing

2.6.3.8 If the measurement progress indicator gains 100%, it does not mean that everything has been completely and thoroughly measured. If you continue the measurement time, the reliability and accuracy of measurement will increase.

2.6.3.9 The result will be much more reliable if we continue measurement after 100% by tapping "CONTINUE SEARCH". If you stop measurement by tapping "STOP" button, you will see the following message (see Fig. 2.51). If after this interruption (during which the result correction takes place) measurement time is prolonged, the measurement result will become even more accurate.

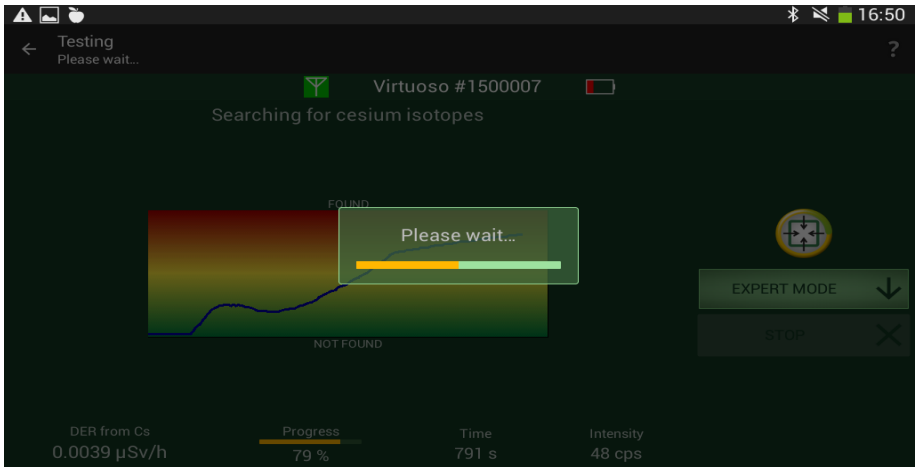


Figure 2.51 – Result correction

To return to the mode of gamma dose rate measurement, touch the “EXIT TEST” button.

As you exit the mode of DER measurement from radiocesium, the application warns you that measured data will be lost. If the progress indicator reaches 50 %, you can save measurement data containing information about geographical coordinates (if measurements were conducted in an open air), specified parameters and obtained results. The process of saving is similar to the process of measurement results saving on gamma radiation dose rate (see 2.4.1).

2.7 Measurement mode of specific/volume activity of naturally occurring radioactive materials

2.7.1 Sequence of determining specific/volume activity of naturally occurring radioactive materials

The measurement procedure of specific/volume activity of naturally occurring radioactive materials is similar to the measurement procedure of specific/volume activity of radioactive cesium, as described in Section 2.5.

Before starting the test, please read carefully the guidelines on carrying out measurements described in Section 2.7.2 “Important recommendations for measuring specific/volume activity of naturally occurring radioactive materials”. You can also find the guidelines in the application help window by tapping the Help button.

2.7.2 Important recommendations for measurement of specific/volume activity of naturally occurring radioactive materials

Attention: Disregarding the guidelines provided below may lead to incorrect measurement results.

2.7.2.1 Object shape and dimensions.

Recommendations regarding the shape and dimensions of objects for testing of specific/volume activity of naturally occurring radioactive materials comply with the recommendations regarding the shape and dimensions of objects for testing specific/volume activity of radioactive cesium, as described in Section 2.5.2.2, or in the application help window.

2.7.2.2 Placing the detector close to the object.

When the detector is attached to a surface, one should follow the recommendations below in order to improve reliability of the activity measurement results:

1. The materials should be measured, if possible, at a maximum distance from large objects or buildings.



Figure 2.52 – Distancing from large objects

2. The side of the object the detector is attached to should be selected so as to avoid visibility of large foreign objects (especially of land, stone facilities or buildings). If this is not possible, choose that side, where the external radiation may be the least.

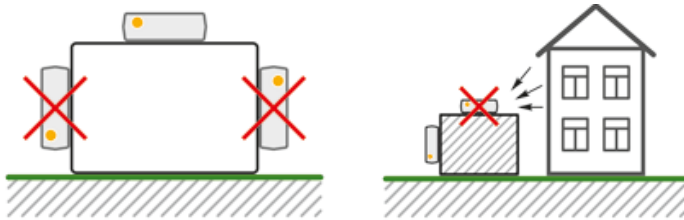


Figure 2.53 – Measurement near large objects

3. The most simple and correct measurement is obtained when the detector is attached to the surface on a level open terrain. For example, in case of the activity measurement in the field (regardless of the object type: stone, sand, fertile soil, etc.), it is not necessary to put the detector directly to the surface, but one may hold it at a certain height (up to 1 m). If the NORM are uniformly distributed in the soil, it will bring almost the same result of specific activity measurement. If NORM are unevenly distributed, we obtain average activity value for the surface of larger size, which is sometimes the main task.

4. If it is impossible to avoid visibility of large foreign objects from the position of the detector, the activity measurement result will be overestimated (activity of foreign objects will be added to measurement result).

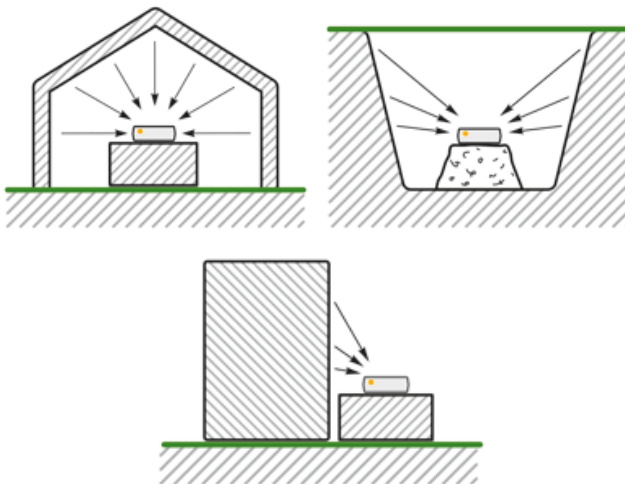


Figure 2.54 – Measurement near large objects

However, if we only want to know if the activity of the tested object exceeds the sanitary standards, measurements can still be conducted. If even in this case the value of the activity is lower than the sanitary standards, the tested object meets the standard for sure. And if the result is higher than normal, it is necessary to conduct a specifying measurement as described in the next section.

2.7.2.3 Placing the detector inside the object

The most correct, all purpose and fast way to perform measurement is to place the detector inside the object. In this case the detector is exposed to radiation only from the tested object. You can place the detector in this mode as follows:

1. If the tested object is made up of separate parts (boxes, packages, pieces, slabs, etc.), they should be arranged so that there is space to put the detector inside. Material thickness on all sides of the detector should be at least 30 cm (relatively small openings and air gaps are allowed).

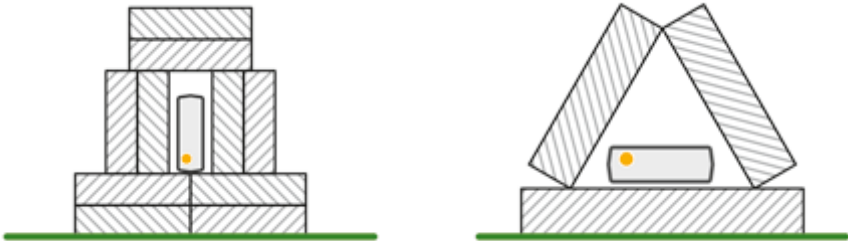


Figure 2.55 – Measurement inside the objects

2. If the tested material is piled and it is necessary to avoid external radiation, the detector can be installed on the tested material and the container (box, bag) with the same material can be put on its top. The size of the container should be at least 30 cm in any direction from the detector. There should be some space left inside to put the detector and to ensure its connectivity.

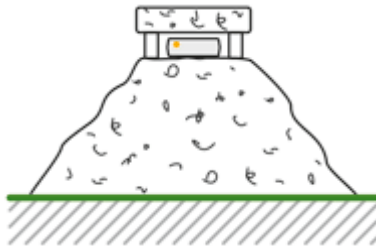


Figure 2.56 – Measurement inside the objects

3. One of the measurement types is measurement of NORM activity inside the building. The thickness of the walls, floor and ceiling should be no less than 20 cm (with less thickness the measurement result will be somewhat underestimated). In case of such measurement, it is sufficient to place the detector in any point in the room (preferably closer to the center). If the detector is placed close to one of the walls, the NORM activity of that wall will produce the largest effect on calculation of the average activity.

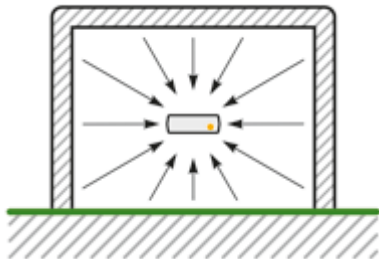



Figure 2.57 – Measurement inside a room

2.8 Tracks

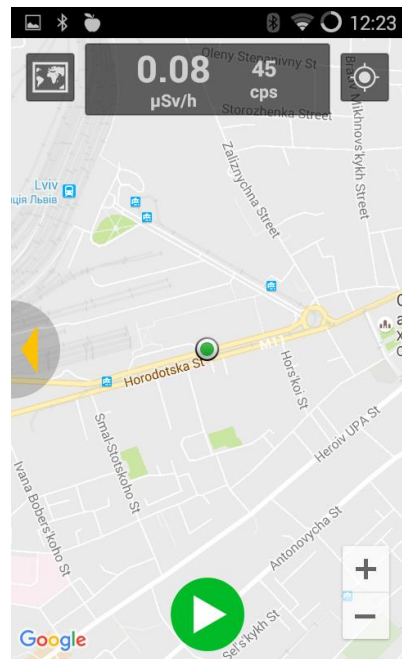
The mode of tracks recording is designed to measure gamma radiation dose rate on a particular route and pooling of measurement points into a track with reference to geographical coordinates. Before recording the track, you should carry out setup (see Section 2.11).

One can access the mode of tracks recording by tapping “TRACK” in the mode of dose rate measurement (see Fig. 2.4). A window as in 2.58 (a) appears, which show the current results of gamma dose rate measurement and geographical coordinates (if your Android-device is equipped with a GPS-receiver and you are

outdoors). To move to the map display window (see Fig. 2.58 (b)), tap  icon.





(a)




(b)

Figure 2.58 - Window of tracks recording






Use a similar icon to switch from the map display window to the window of measured gamma dose rate display.


In the map mode you can switch to display of the current location of the Android-device by tapping the  icon. If the coordinates are determined, the current location will be showed with a green  icon. The icon turns gray if you lose a signal from the GPS-receiver.

There is also an option to switch to a satellite view of the map and back using the  icon.

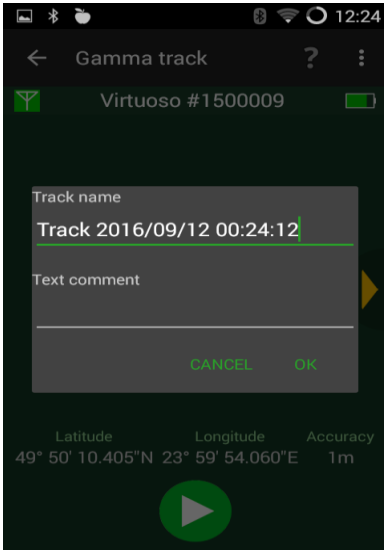
Attention! Google Play services should be installed on your Android-devices to display the map. If the map is not displayed, you will see a message on the screen about the need to install or update Google Play services and links to download the program.

Attention! The function of tracks display on the map will work only if your Android-device has a continuous access to the Internet. Some charge may apply for this service according to your operator tariffs.

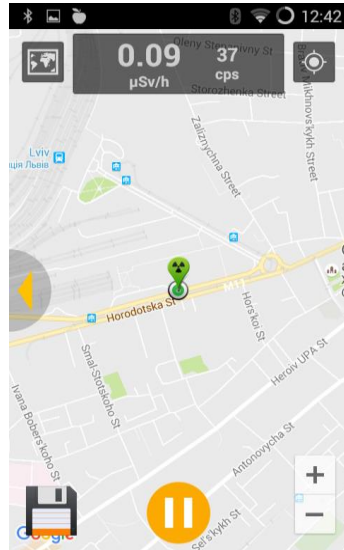
To start recording the track, tap the  icon – a window with a suggestion to give name to the track and add a comment will appear on the display (see Fig. 2.59 (a)), enter data (if necessary) and tap OK. Track recording starts and an icon  appears used to pause recording (see Fig. 2.59 (b)). As soon as you pause recording an  icon appears, which allows finishing track recording, and an icon  that allows you to continue recording the current track (see Fig. 2.60). Manual recording icon  allows you to save points anytime, regardless of the track recording settings. Manual recording option can be disabled in the settings menu (see Section 2.11).

To finish the track recording you must tap the  icon, or exit the mode of track recording. In the latter case, a window appears warning about record pausing after exiting the mode of track recording.

Each point corresponds to the icon of green, yellow or red color (depending on the dose rate of gamma radiation). By tapping the icon, you can view the date of recording and the dose rate of gamma radiation in it and then proceed to more detailed data (you need to tap on the data display area on the required point).



(a)



(b)

Figure 2.59 – Track recording

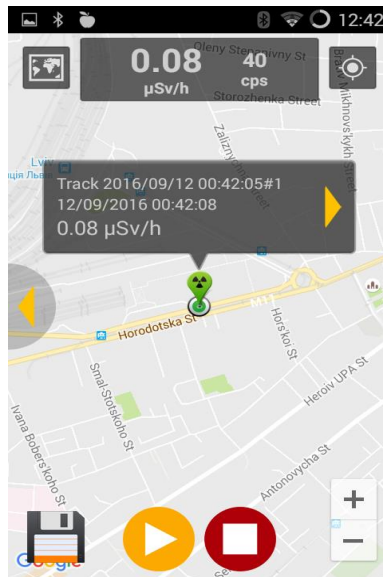


Figure 2.60 – Track pausing

2.9 Data management and viewing

2.9.1 Data viewing

Tap on the "Menu" button of the Android device and select "Settings" from the menu. Choose "Data Management" item in the "Data" section of the open settings window of the program. A window opens, shown in Figure 2.61, which includes the categories of saved data available for viewing.

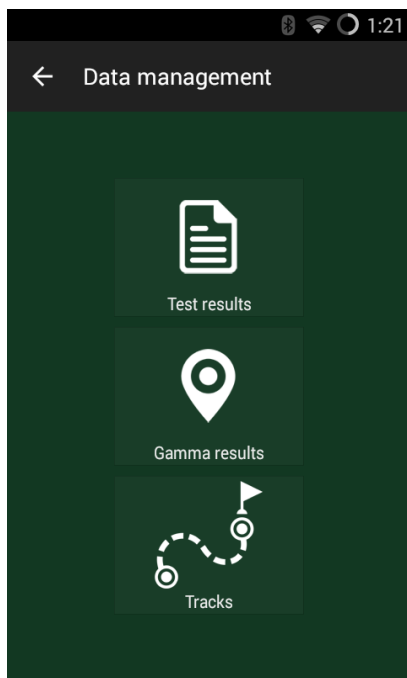


Figure 2.61 – Categories of saved data

This section will describe viewing of data about recorded tracks. Access to the data of other measurements (Gamma Results or Test Results) is done in a similar way.

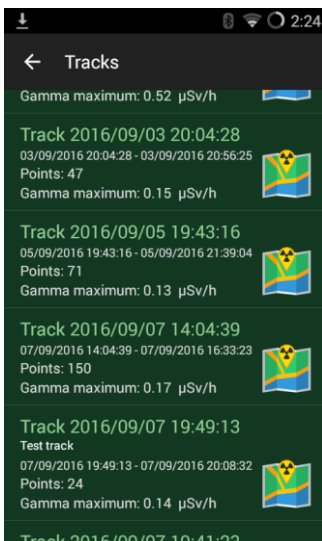


Figure 2.62 – The list of saved tracks

Each track name in the list includes the date and time of recording start (see Fig. 2.62). The track can be viewed by selecting its name from the list (see Fig. 2.63). You can specify one or more tracks and perform additional operations by long tap (see Section 2.9.2).

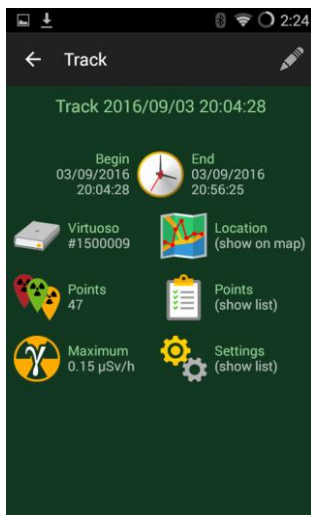




Figure 2.63 – Viewing saved tracks

By tapping on the  icon opposite the required track, you can view the route with plotted points (see Fig. 2.64) and the results of measurement in any of these points by tapping the required one.

There is an option to switch to the satellite map view and back with the  icon.

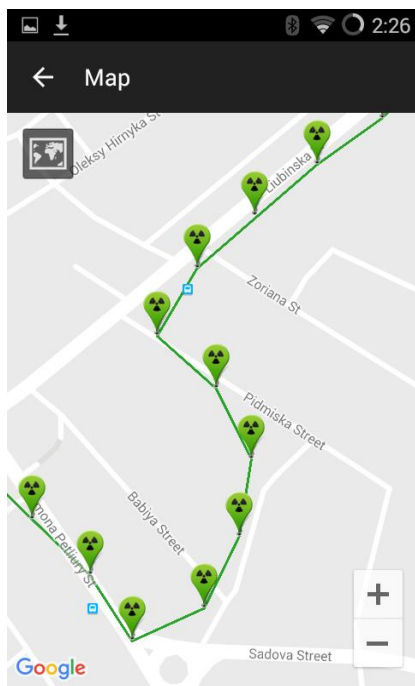


Figure 2.64 – Viewing saved tracks on the map of the area

Attention! The function of gamma results or tests display on the map will work only if the geographical coordinates were added to the record and your Android device has a continuous access to the Internet. Some charge may apply for this service according to your operator tariffs.

2.9.2 Data Management

Tap the "Menu" button on the Android devices and select "Settings". Select "Data Management" in the "Data" section of the open settings window of the program. A window opens, shown in Figure 2.61, which includes the categories of saved data available for viewing. Select the required data category (Test Results, Gamma Results or Tracks).

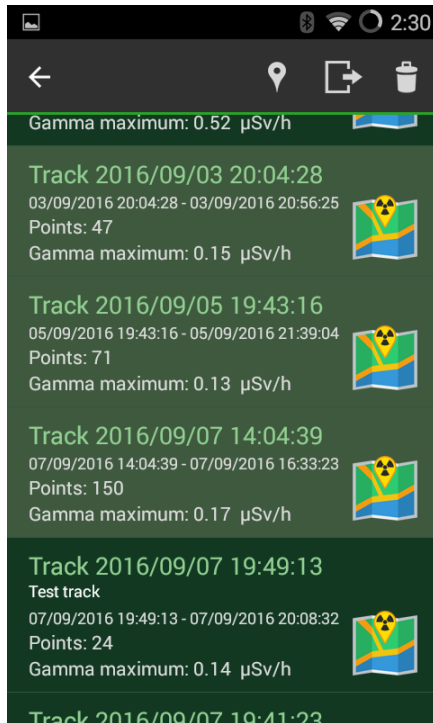


Figure 2.65 – Additional operations with tracks

2.9.2.1 Additional operations with tracks and gamma results

The following additional operation can be performed with the specified track records or gamma results (long tap on the required record): Show on map (📍 icon), Export to .KMZ file (📁➔ icon) and Delete (🗑 icon). Figure 2.65 shows a window with marked track records, and Figure 2.66 – a window of the track export to .KMZ file; similar additional operations can be performed with gamma results. The exported .KMZ file can be opened via Google Maps or Google Earth (on a smartphone, a PC or other compatible equipment) to view the saved tracks or gamma results regardless of the Virtuoso application.

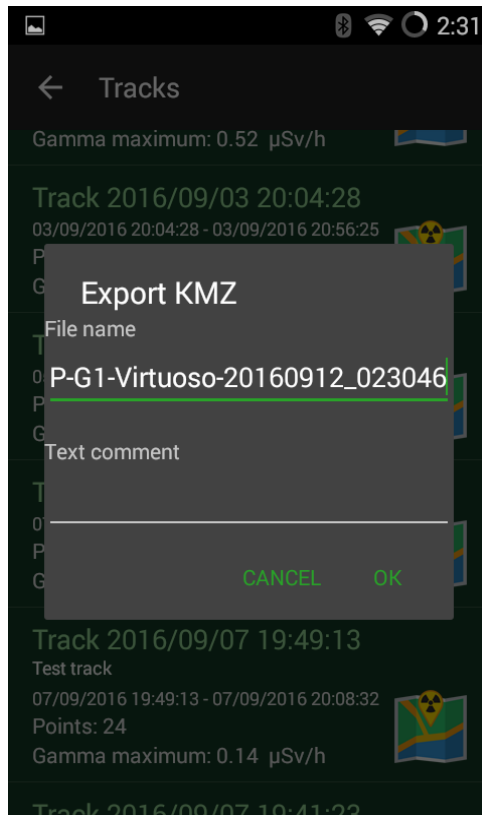


Figure 2.66 – Track export to .KMZ file

2.9.2.2 Additional operations with test results

The following additional operation can be performed with the specified records of test results (long tap on the required record): Show on map (📍 icon), Export to .KMZ file (📁 icon), Export to .HTML file to generate the report (📄 icon) and Delete (🗑 icon). The exported .HTML report file can be opened via an Internet browser or a specialized program (on a smartphone, a PC or other compatible equipment) to view the saved reports regardless of the Virtuoso application. Figure 2.67 shows a window with marked records of test results.

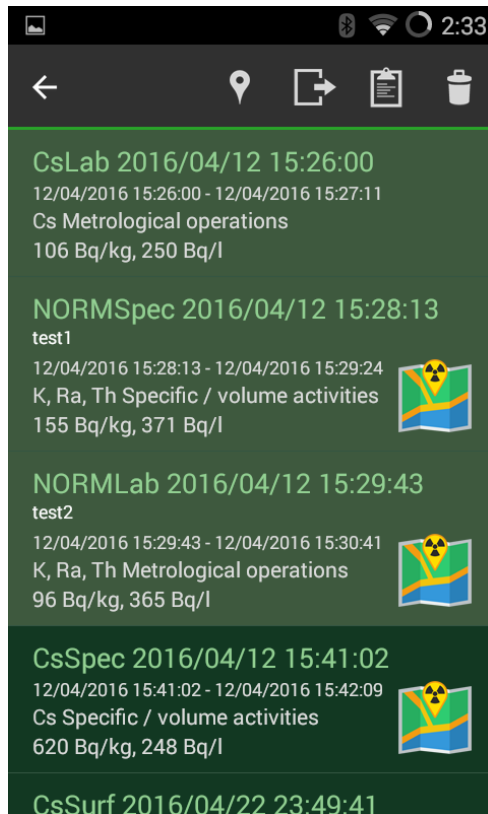


Figure 2.67 – Additional operations with test results

Export to .KMZ file is done similarly to export of tracks or gamma results. The exported .KMZ file can be opened via Google Maps or Google Earth (on a smartphone, a PC or other compatible equipment) to view the saved test results regardless of the Virtuoso application.

Attention! The function of display on the map will work only if geographical coordinates were added to the record and your Android-device has a continuous access to the Internet. Some charge may apply for this service according to your operator tariffs.

All exported data are saved in the Virtuoso folder of the internal memory of the Android device. Further options of work with the exported files (view, transfer to a PC, printout, sending by e-mail, etc.) are limited by the Android device capabilities and ordered services. A charge may apply for some operations according to your operator tariffs.

To send the exported report from the Android device to the PC, find an .HTML-file of the required report using the File Manager of the Android-device in a folder where exported files are stored. Next specify the required report (or several at a time) with the means of the File Manager of the Android device and transfer it by a convenient method (via Bluetooth, Wi-Fi, e-mail, etc.) to the PC with the "Share" icon. If the manufacturer of your Android device has not installed the File Manager, you can use any other downloaded to your Android device from Google Play or other sources (e.g. ES Explorer or ASTRO File Manager). You may also connect the Android device to the PC via USB interface and then transfer the report by means of the PC's file manager. As soon as the report is transferred, you can open and/or print it out by means of the PC.

The reports examples are provided in Appendix 1 (a, b, c).

2.10 Metrological operations

The mode of metrological operations is used in cases where it is necessary to make sure that the device preserves metrological characteristics in the most responsible type of measurement - namely, in the measurements of specific activity.

This mode is also used when it is necessary to compare the device measurement results with those of other measuring instruments, especially laboratory spectrometers-radiometers.

This mode is recommended only in specific cases and only to experienced professionals who know the rules and how to select conditions, geometry and measurement modes.

The "Metrological operations" measurement mode can be accessed by tapping "TEST" button in the mode of gamma dose rate measurement (see Fig. 2.4). Select either "Cs" or "K, Ra, Th" tabs and touch the "Metrological operations" icon.

Since metrological samples are typically located in the Marinelli vessels, this mode is designed for such measurement geometry.

The detector should be put on the top surface of Marinelli vessel.

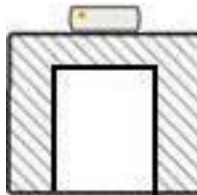


Figure 2.68 – Detector on the top of Marinelli vessel

If the comparative measurements are performed in the laboratory, where there is a lead shield, the metrological vessel with the detector can also be placed in the shield. However, it is possible to carry out this measurement without additional shield after checking natural background level at the point of measurement (it should not exceed 0.15 mSv/h) and the absence of outside (background) radiation.

In the event of a similar test for measurement of specific activity of naturally occurring radioactive materials the background radiation component should be properly considered (especially with low-level metrology samples). Only an expert familiar with the method of background radiation compensation can do that.

2.11 Program setting, help text, information

The icons, illustrated on Fig. 2.69 will appear in the upper part depending on an open application window or a measurement mode.



Figure 2.69 – Icons “Menu” and “Help”

Button (1) shows contextual hints depending on the currently open windows.

Button (2) opens a menu, wherefrom you can switch to the program settings (see Fig. 2.70), open information about the "VIRTUOSO" version (see "About the program"), or switch to a demo mode (see Section 2.12). This menu can also be opened by tapping the corresponding button (if available) of the Android-device.

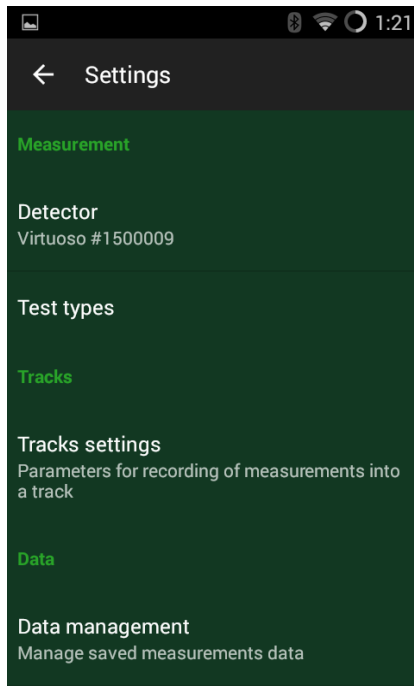


Figure 2.70 – Program setting

The program setup menu contains the following items:

1. Measurement - you can review the information about the detector, which is currently connected to the Android device, delete information about the “bound” detector and select the text types, which will be displayed in the test selection window.

2. Tracks - you can view or change tracks recording parameters (see Fig. 2.71), namely:

- Enable/disable manual point recording;
- Set a time interval for automatic recording of points (minimum interval is 1 second, maximum - 1 hour);
- Set a distance, when a new point is recorded as you move (minimum displacement distance is 50 meters, maximum - 1000 meters).

If any of these settings is unnecessary for the next track recording, it can be disabled by removing the check mark in front of that line.

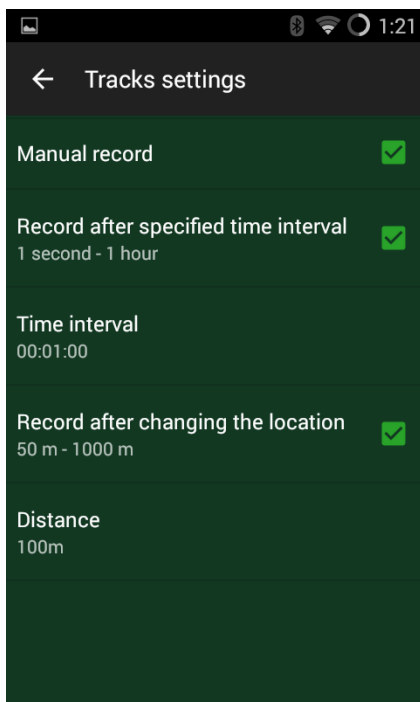


Figure 2.71 – Tracks settings

For detailed information about the tracks, please refer to Section 2.8.

3. Data – moving to the data management window. For more information, please refer to Section 2.9. You can also switch to the menu of database management (see Fig. 2.72), wherefrom you can make backup copying/restore and clean up the database.

4. Calibration - switching to the window of calibration of the detecting device. Detailed information can be found in Section 4.

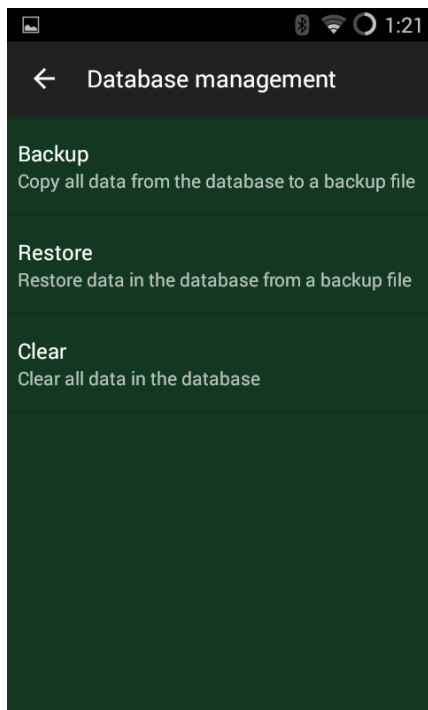


Figure 2.72 – Database management

2.12 Demo mode

The application provides for a demo mode that allows you to learn about functional capabilities of the radiometer even if you do not have the detector.

Open the Virtuoso application. Do not connect the Android device to the detector (do not tap the “Connect” button). Tap the “Menu” button on the Android device and select the “Demo” menu item.

Important: Data shown in the demo mode are emulated by the application, i.e. they are not real values from the device’s detector. A red “Virtuoso Demo” label in the symbol area, where the number of the connected VIRTUOSO detector is normally displayed, will serve as an indication to you.

After you start the demo mode, an application screen opens in the mode of gamma radiation dose rate measurement. The values of DER and counts per second will gradually increase within a whole measurement range of the radiometer. After maximum values are achieved, minimum values will be displayed again. The graphical view of counts per second will change from green to red colors.

Moreover, you can find the information on how the application works in different measurement modes and the mode of tracks recording.

When choosing parameters in the mode of specific/volume activity measurement and the mode of surface activity measurement, enter any values you want. After the search for cesium isotopes starts, testing data will appear. You can see the measurement progress both in basic and expert modes. When the progress indicator reaches 100 %, testing will end automatically. You can continue searching until maximum measurement time is reached.

Attention: Measurement time in the demo mode is displayed conditionally. The test that lasts 6 hours under real conditions will take just a few minutes.

3 VIRTUOSO APPLICATION UPDATE

The Virtuoso app is constantly updated and filled with new features, useful information. It is therefore recommended to check for the new program versions on Google Play.

Do the following:

1. Set up an Internet connection in your Android device.
2. Go to the “VIRTUOSO” SP “SPEE “Sparing-Vist Center” page on Google Play or run the “VIRTUOSO” app.
3. If the application update is available, you will be prompted to upgrade to the latest version online.
4. If you have a continuous Internet access, the Android operating system checks and suggests updates of the installed programs on its own.

4 ENERGY CALIBRATION

The energy calibration is done with the aim to correct spectrometric tract parameters, which tend to be changed during a device operation. The recommended calibration intervals – not less than one every six months.

The energy calibration is based on the measurement of naturally occurring isotope ^{40}K , which in most cases exists in the environment, with a subsequent automatic recalculation of coefficients of the “VIRTUOSO” radiometer. To perform a time-effective calibration procedure, it is recommended to use potassium-containing substances. For example, purchase the so-called potassium chloride fertilizer of 1 kg weight, which is available in hardware stores, garden centers or nurseries specializing in fertilizers.

To perform calibration, enter the mode of gamma radiation dose rate measurement, tap the “Menu” button on the Android device, and select the “Settings” menu item. In the application settings window that opens, tap the “Energy calibration” item in the “Calibration” category. Figure 4.1 illustrates the window that will appear.

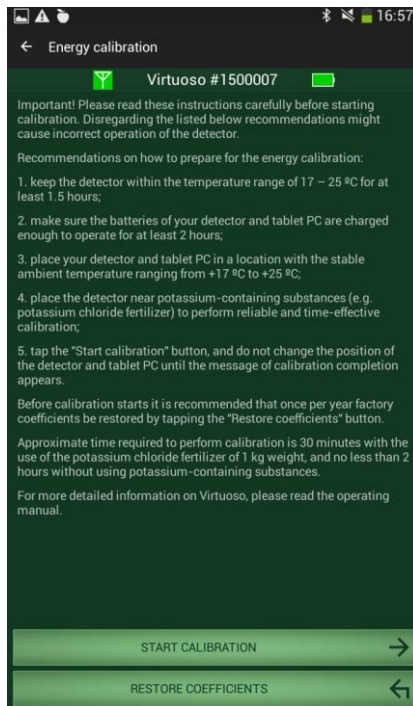


Figure 4.1 – Energy calibration

Important: Please read these instructions carefully before starting calibration. Disregarding the listed below recommendations might cause incorrect operation of “VIRTUOSO”!

Recommendations on how to prepare for the energy calibration:

1 Keep the detector within the temperature range from +17 °C to +25 °C for at least 1.5 hours;

2 Make sure that the batteries of your detector and Android device are charged enough to operate for at least 2 hours;

3 Place your detector and Android device in a location with the stable ambient air temperature ranging from +17 °C to +25 °C;

4 Place the detector near potassium-containing substances (e.g. potassium chloride fertilizer) to perform a reliable and time-effective calibration;

5 Tap the “Start calibration” button (see Fig. 4.1), and do not change the position of the detector and Android device until a message of calibration completion appears.

Important: If during calibration the “**Could not calibrate the detector. Potassium was not found**” message appears, try to change the position of the detector (for example, place it as close to the wall of a room as possible) and repeat calibration.

Important: If during calibration procedure the “**Parameter is out of range**” message appears, please restore coefficients by pressing the “Restore coefficients” button. Repeat calibration following the recommendations on how to prepare for the energy calibration. If the message appears again, contact a manufacturer.

Before the calibration starts, it is recommended that once per year factory coefficients be restored by tapping the “Restore coefficients” button (see Fig. 4.1).

Approximate time required to perform a calibration is 15 minutes with the use of the potassium chloride fertilizer of 1 kg weight, and no less than 1 hour without using potassium-containing substances.

5 TROUBLESHOOTING AND MESSAGES

The “**Detector damaged**” message appears.

There is a problem with the “VIRTUOSO” detector. Switch the detector off, and then turn it on. If the message appears again, contact the service center or the manufacturer.

The “**Could not calibrate detector. Potassium was not found**” message appears during the energy calibration.

Try to change the detector position (for example, place the detector as close to a wall of the room as possible or use the potassium chloride fertilizer of 1 kg weight) and repeat a calibration.

The “**Parameter out of range**” message appears during the calibration relative to energy.

Tap the “Restore coefficients” button in the energy calibration window to restore coefficients. Repeat calibration following the given recommendations on preparing for a calibration (see Section 4 “Energy calibration”). If the message appears again, contact a manufacturer.

6 SAFETY STANDARDS FOR CESIUM ISOTOPES ACTIVITY
6.1 SAFETY STANDARDS FOR CESIUM ISOTOPES SPECIFIC
ACTIVITY IN FOOD

Attention: Applicable safety standards for cesium isotopes specific activity in food in your country may be different from those included in this section.

Food safety standards for cesium isotopes specific activity in Japan
(dated April 2012)

Food products	Standardized value, Bq/kg
Drinking water	10
Milk, Milk products	50
Baby nutrition	50
Vegetables, grains, meat, eggs, fish, etc.	100

Food safety standards for cesium isotopes specific activity in Ukraine in
accordance with the order of the Ukrainian Ministry of Health Care
No 255 as of 19.08.1997

Name	Bq/kg
Bread, bread products	20
Potatoes	60
Vegetables (leaf and root vegetables, cooking herbs)	40
Fruits	70
Meat and meat products	200
Fish and fish products	150
Milk and milk products	100
Egg (pc)	6
Water	2
Condensed and concentrated milk	300
Dried milk	500
Wild berries and mushrooms	500
Dried wild berries and mushrooms	2500
Medicinal plants	600
Other products	600
Special baby nutrition	40

6.2 CESIUM ISOTOPES SURFACE ACTIVITY STANDARDS UNDER NRB-97 STANDARD

Table D.9.1 (NRBU 97) – The lower limits of justification, absolutely justifiable intervention levels and action levels for a decision on the permanent relocation (shortened).

Criteria for as decision	Lower limits of justification *	Absolutely justifiable intervention levels** and action levels***
The dose averted for the period of resettlement, Sv	0.2	1
The dose averted for the first 12 months after the accident, Sv.	0.05	0.5
The density of radioactive contamination of territory with long-lived radionuclides, kBq·m ⁻² : ● ¹³⁷ Cs	400	4000

* **The level of justification** - the value of the averted dose is such that the *benefits* (for health) from the introduced countermeasure would be less than the damage caused by this intervention.

** **The level of intervention** - the level of the averted radiation dose, which when being exceeded a specific *countermeasure* should be applied in the event of an emergency or chronic exposure.

*** **The level of action** - the value being a derivative of the intervention levels, which is expressed in terms of such indicators of radiation environment, which can be measured: the absorbed dose rate in the air on an open terrain, volume activity of radionuclides in the air, their concentration in food, radionuclides fallout density in soil, etc.

6.3 STANDARDS OF EFFECTIVE SPECIFIC ACTIVITY OF NORM UNDER NRBU-97

6.3.1 Effective specific activity of naturally occurring radioactive materials in construction and mineral raw materials.

6.3.1.1 The value of A_{eff} (effective specific activity of naturally occurring radioactive materials) in construction and mineral raw materials that is used for all types of construction without restrictions (I class) should not exceed $370 \text{ Bq}\cdot\text{kg}^{-1}$.

6.3.1.2 Construction materials, where A_{eff} is above $370 \text{ Bq}\cdot\text{kg}^{-1}$, but less than or equal to $740 \text{ Bq}\cdot\text{kg}^{-1}$ (class II), can be used:

- for industrial buildings;
- for construction of roads.

6.3.1.3 Construction materials, where A_{eff} is above $740 \text{ Bq}\cdot\text{kg}^{-1}$, but less than or equal to $1\,350 \text{ Bq}\cdot\text{kg}^{-1}$ (class III), can be used as follows:

within settlements:

- for construction of underground structures, covered with a layer of soil more than 0.5 m thick, where long stay of people is not envisaged;

outside the settlements:

- for construction of roads;
- for construction of dams;
- for construction of other industrial facilities, where people stay for a small amount of time.

6.3.1.4 The A_{eff} value should not exceed $3700 \text{ Bq}\cdot\text{kg}^{-1}$ for materials that have aesthetic value and are used as follows:

- for interior and exterior finishing of public facilities, with the exception of childcare institutions;
- for exterior finishing of semi-basement parts of dwelling houses.

For interior furnishing of dwelling rooms and furnishing of childcare institutions such materials can be used on the basis of separate regulations, approved by the State Sanitary Inspection of the Ministry of Health of Ukraine.

The A_{eff} values provided above belong to the average values within the reservoir, area, dumping, or a batch of material used.

7 MANUFACTURER INFORMATION

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APPENDIX 1

EXAMPLES OF MEASUREMENT REPORTS

a)

VIRTUOSO measurement report (with the added geographical coordinates and an option to display data on the map of the area)

Measurement report

CsSpec 2016/06/06 11:15:02

Specific / volume activities

Tested nuclides Cs

Begin 06/06/2016 11:15:02

End 06/06/2016 11:36:22

Virtuoso #1400003

Parameters

Object group Bark compost

Object thickness 63 cm

Object position On one side of detector

Results

Time 1000 s

Progress 100 %

Specific activity

Volume activity 0 Bq/l

Location

Latitude 49° 48' 33.213"N

Longitude 24° 0' 27.602"E

[\(show on map\)](#)

Measurement report

CsSurf 2016/06/17 15:05:00

Surface activity

Tested nuclides Cs

Begin 17/06/2016 15:05:00

End 17/06/2016 15:26:15

Virtuoso #1400003

Parameters

Object group Asphalt, concrete

Detector height 10 cm

Results

Time 1004 s

Progress 100 %

Surface activity 483 Bq/m²

Measurement report

CsDER 2016/06/07 12:32:31

DER from Cs

Tested nuclides Cs

Begin 07/06/2016 12:32:31

End 07/06/2016 12:49:25

Virtuoso #1400003

Results

Time 1000 s

Progress 100 %

DER from Cs 0.0001 μ Sv/h