



DESCRIPTION OF THE MEASURING INSTRUMENT TYPE

Whole body spectrometer BodySPEC-C

Purpose of the measuring device

The spectrometer is intended to measure energy distribution of gamma-radiation, identify gamma-emitting radionuclides and also measure activity of gamma-emitting radionuclides incorporated in the man's whole body, lungs and thyroid gland.

Description of the measuring device

The operation principle of spectrometers is based on the recording of gamma-quanta, emitted by radionuclides contained in the man's body, by an appropriate type of detector, which outputs an electrical impulse with amplitude, which is proportional to the energy of the recorded gamma-quantum.

Spectrometer **BodySPEC-C** is manufactured in four versions:

- BodySPEC-C-01 – to measure activity of gamma-emitting radionuclides incorporated in the whole body and lungs (two detection units BDEG-80-80) (fig. 1);
- BodySPEC-C-02 – to measure activity of gamma-emitting radionuclides incorporated in the man's whole body, lungs and thyroid gland (two detection units BDEG-80-80 and one detection unit BDEG-25-25) (fig. 2);
- BodySPEC-C-03 – to measure activity of gamma-emitting radionuclides incorporated in the whole body and lungs (one detection unit BDEG-150-100) (fig. 3);
- BodySPEC-C-04 – to measure activity of gamma-emitting radionuclides incorporated in the man's whole body, lungs and thyroid gland (one detection unit BDEG-150-100 and one detection unit BDEG-25-25) (fig. 4)
- BodySPEC-C-HPGe – to measure activity of gamma-emitting radionuclides incorporated in the man's whole body and lungs (one detection unit base on HPGe detector) (fig. 5)

Spectrometer is a laboratory device, implemented as a modular type, consisting of:

- multichannel analyzer (MCA);
- detection units, installed in a collimators;
- power supply adapter for analyzer;
- rack;
- bases and chairs;
- lead protective shield;
- PC with software "ASW2".

For the gamma-spectra measurements there are scintillation detection units BDEG-25-25, BDEG-80-80 or BDEG-150-100 on the basis of crystal NaI(Tl) with dimensions $\varnothing 25 \times 25 \text{mm}$, $\varnothing 80 \times 80 \text{mm}$ or $\varnothing 150 \times 100 \text{mm}$ respectively, connected to a photomultiplier (PMT).

Multichannel analyzer consists of a matching amplifier, analogue-digital converter (ADC) and digital-analogue converter (DAC). ADC is intended for measuring impulse signals amplitudes from a radiation detector, registration of the received digital code in the buffer memory and transfer the data to the computer through an USB or LAN interface.

Spectrometer is a stationary measuring instrument.

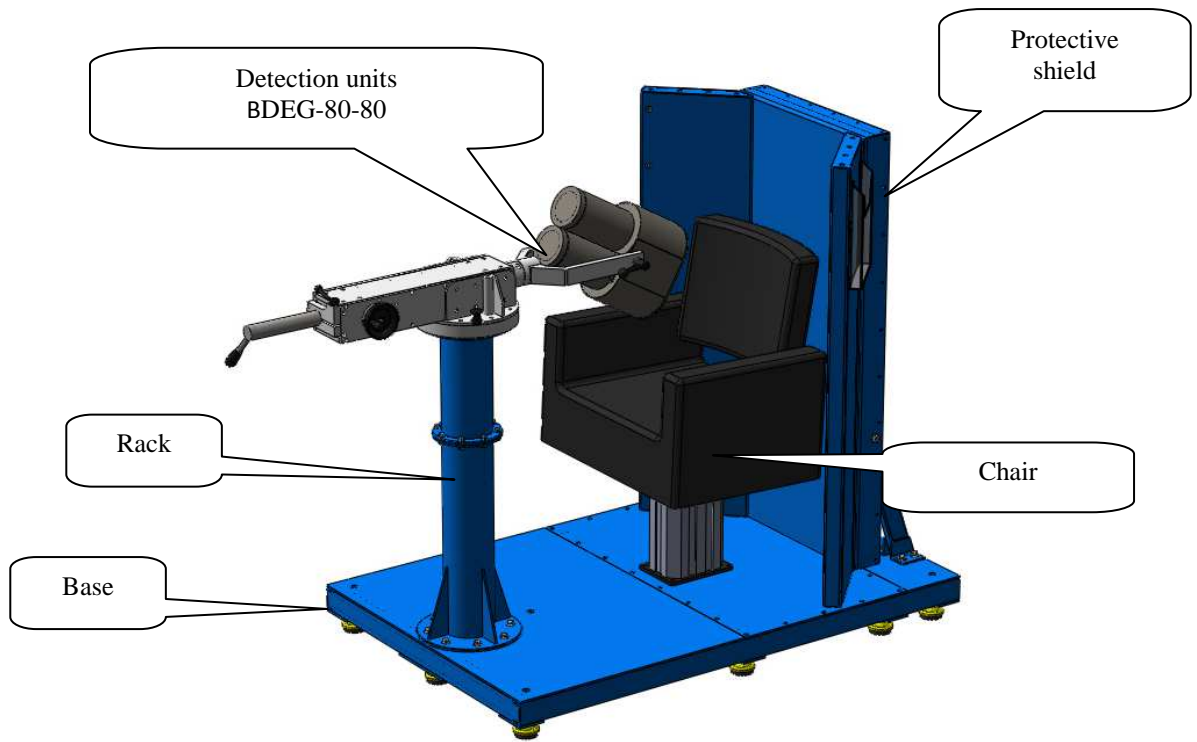


Figure 1 Assembled spectrometer. Version BodySPEC-C-01

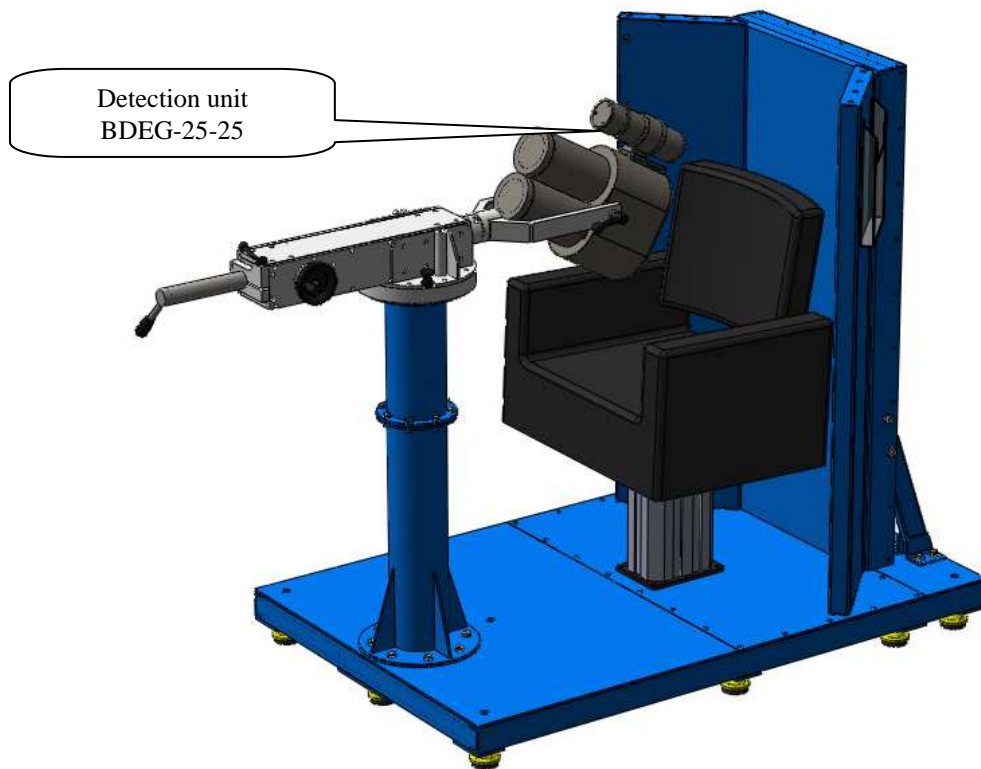


Figure 2 Assembled spectrometer. Version BodySPEC-C-02

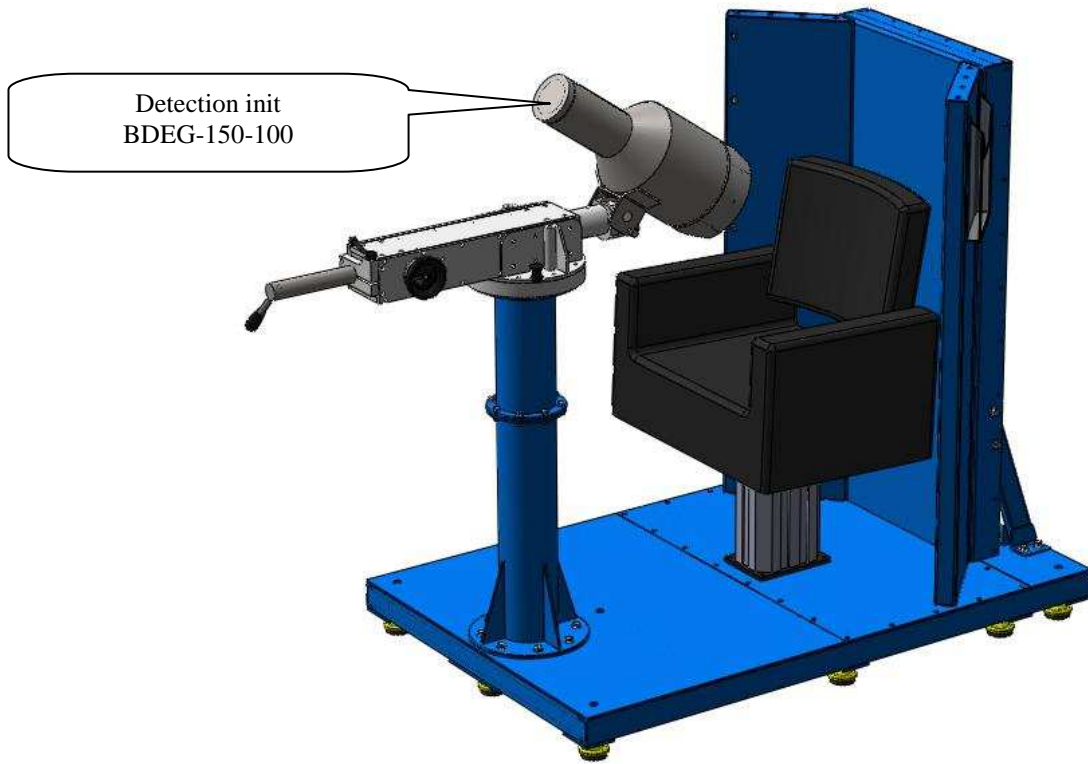


Figure 3 Assembled spectrometer. Version BodySPEC-C-03

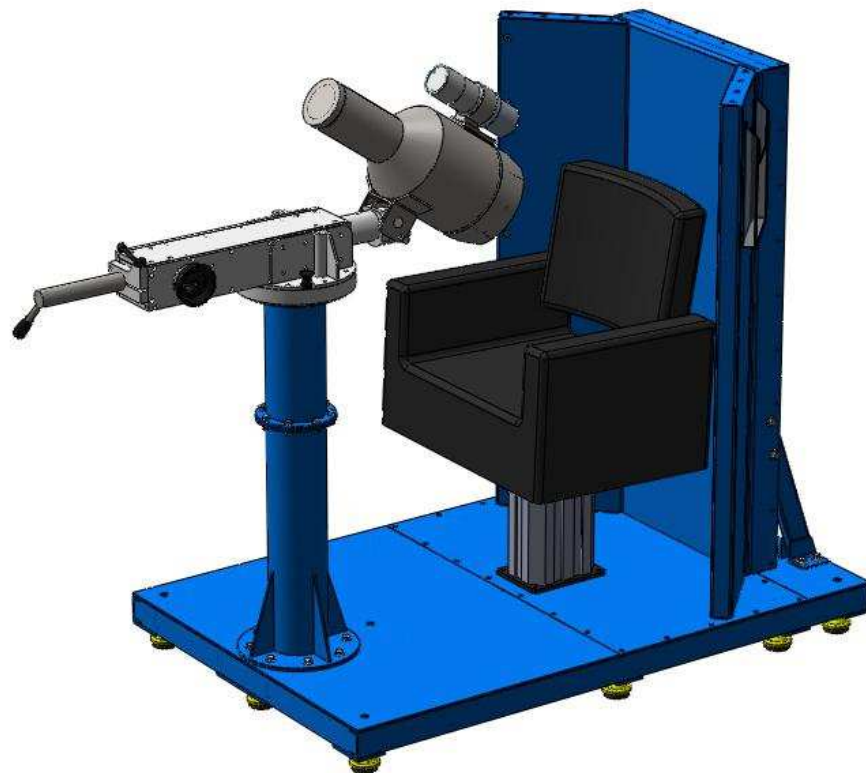


Figure 4 Assembled spectrometer. Version BodySPEC-C-04

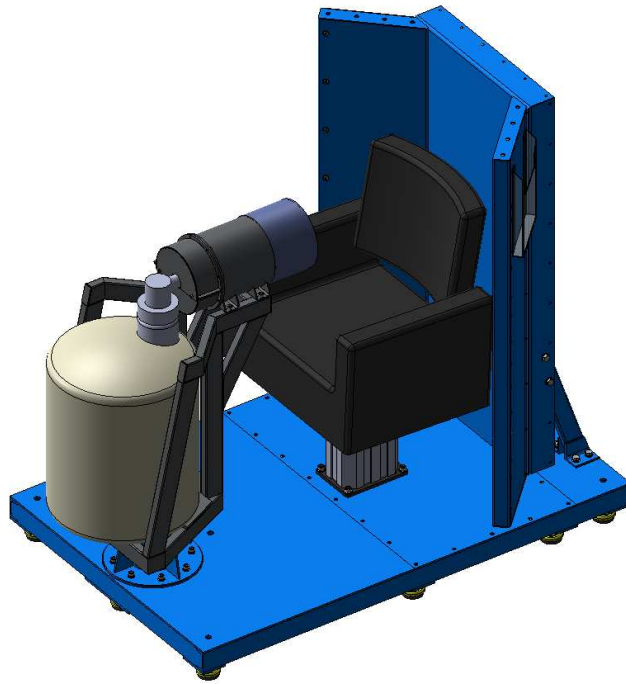


Figure 5. Assembled spectrometer. Version BodySPEC-C-HPGe



Figure 6. Gamma-radiation detection units (BDEG-25-25, BDEG-80-80, BDEG-150-100)

Software

The spectrometer is controlled using the software "ASW2" which provides monitoring of the equipment through the communication protocols as well as display of the energy distribution (spectra), calculation and display of activity, saving and logging of results.

Metrological and Technical Specifications

The basic metrological and technical specifications of the spectrometers are given in table 3 and 4.

Table 3

Description	Value
Range of detected gamma-radiation energies, keV	from 50 to 3000
Relative energy resolution for 661,7 keV, measuring with radionuclide source ^{137}Cs , point type (reference spectrometric gamma-radiation sources), %, not more: - detection unit BDEG-25-25 - detection unit BDEG -80-80 - detection unit BDEG -150-100	7 8 12
Permissible limits of the spectrometer conversion characteristic basic relative error with detection units BDEG-25-25, BDEG-80-80 and BDEG-150-100 (integral nonlinearity) in the range of gamma-radiation energies from 50 to 3000 keV, %	± 1
Detection efficiency of the gamma-radiation in the full energy peak of radionuclide ^{137}Cs , with energy 661,7 keV at a distance of 50 mm from the upper surface of detector, %, at least: - detection unit BDEG-25-25 - detection unit BDEG-80-80 - detection unit BDEG-150-100	0,1 2 7,5
Maximal input statistical load of spectrometer, cps, at least	$5 \cdot 10^4$
Instability of spectrometer indications (energy conversion characteristic) for detection units BDEG-150-100, BDEG-80-80 and BDEG-25-25 for 24 hours of a continuous operation, %, maximum:	± 1
Detection sensitivity of spectrometer for each detection unit BDEG-80-80 to radionuclide ^{137}Cs gamma-radiation in energy range from 620 to 700 keV, when measuring in the whole body geometry phantom, cps/Bq, at least: 1) with phantom of an adult (mass 70 kg, height 170 cm) 2) with phantom of an teenager 10 years old (mass 27 kg, height 135 cm) 3) with phantom of a child 2 years old (mass 12 kg, height 90 cm) Detection sensitivity of spectrometer for detection unit BDEG-150-100 to radionuclide ^{137}Cs gamma-radiation in energy range from 620 to 700 keV, when measuring in the whole body geometry phantom, cps/Bq, at least: 1) with phantom of an adult (mass 70 kg, height 170 cm) 2) with phantom of an teenager 10 years old (mass 27 kg, height 135 cm) 3) with phantom of a child 2 years old (mass 12 kg, height 90 cm)	$2,5 \cdot 10^{-4}$ $4,0 \cdot 10^{-4}$ $4,5 \cdot 10^{-4}$ $5,5 \cdot 10^{-4}$ $8,5 \cdot 10^{-4}$ $1,0 \cdot 10^{-3}$
Detection sensitivity of spectrometer for each detection unit BDEG-80-80 to radionuclide ^{60}Co gamma-radiation in energy range from 1100 up to 1410 keV, when measuring in an adult's lungs phantom, cps/Bq, at least : Detection sensitivity of spectrometer for detection unit BDEG-150-100 to radionuclide ^{60}Co gamma-radiation in energy range from 1100 up to 1410 keV, when measuring in an adult's lungs phantom, cps/Bq, at least :	$3 \cdot 10^{-3}$ $8 \cdot 10^{-3}$
Detection sensitivity of spectrometer for detection unit BDEG-25-25 to radionuclide ^{131}I gamma-radiation in energy range from 330 up to 400 keV, when measuring in the thyroid gland phantom, cps/Bq, at least	$1 \cdot 10^{-3}$

<p>Measuring range of activity of incorporated radionuclides for detection device with detectors BDEG-80-80 and BDEG-150-100, Bq :</p> <ul style="list-style-type: none"> - ^{137}Cs in body - ^{60}Co in lungs <p>Measuring range of activity of incorporated radionuclide ^{131}I in the thyroid gland with detection unit BDEG-25-25, Bq</p> <p>Permissible basic relative error for measuring activities does not exceed 50% (P=0,95).</p>	<p>from 330 to $15,0 \cdot 10^6$ from 50 to $9,0 \cdot 10^6$</p> <p>from 40 to $45 \cdot 10^6$</p>
<p>Minimal detectable activity of incorporated radionuclides for detection device with detectors BDEG-80-80 and BDEG-150-100 for 1 hour measuring period, Bq:</p> <ul style="list-style-type: none"> - ^{137}Cs in body - ^{60}Co in lungs 	<p>200 25</p>
<p>Minimal detectable activity of incorporated radionuclide ^{131}I in the thyroid gland with detection unit BDEG-25-25 for 1 hour measuring period, Bq</p>	<p>20</p>
<p>Time of operation mode setting, min, maximum</p>	<p>30</p>
<p>Period of continuous operation, hours, at least</p>	<p>24</p>
<p>Spectrometer resistant to temperature in the range from plus 10°C to plus 35°C</p>	
<p>Spectrometer detection units in shipping containers are shockproof at shock acceleration of 20 m/s^2, shock pulse duration of 15 ms and repetition rate of 10 bit per minute.</p>	
<p>Spectrometer detection units in shipping containers are resistant to temperature in the range from minus 10°C to plus 50°C (as well as to abrupt temperature changes), and at relative ambient humidity of 98% when the temperature is plus 35°C.</p>	
<p>Spectrometer is resistant to constant magnetic field with intensity up to 40 A/m.</p>	
<p>Spectrometer is resistant to changes in supply voltage within the limits of operating conditions.</p>	
<p>Operation conditions:</p> <ul style="list-style-type: none"> • ambient air temperature, $^\circ\text{C}$ • relative air humidity, % • atmospheric pressure in the range of, kPa • intensity of magnetic fields of the permanent and variable grid frequencies, A/m 	<p>from 10 to 40 up to 80 from 84 to 106,7 up to 40</p>
<p>Spectrometer is powered from AC supply with voltage, V with frequency, Hz Consumed power, V·A</p>	<p>220 (+10%; - 15%) $50 \pm 5\%$ 10</p>

Table 4. Overall dimensions and mass of spectrometer and its components

Item No.	Description	Diameter, mm	Height, mm	Width, mm	Length, mm	Mass, kg
1	Detection device with detectors BDEG-80-80 with detector BDEG-150-100		175	390	400	80
		235	235		570	85
2	Detection unit BDEG-25-25	105	285	-	-	10
3	Base	-	970	1,415	2,000	850
4	Assembled spectrometer without PC with detectors BDEG-80 with detector BDEG-150-100	-	1,420 (1,500)	970	2,025	975

Mean time to failure is 10000 hours.

Mean time to recovery is 12 hours.

Mean time to first overhaul is 6 years.

Recommendations on application

- provision of labor safe conditions and protection;
- provision of safety in emergency situations.