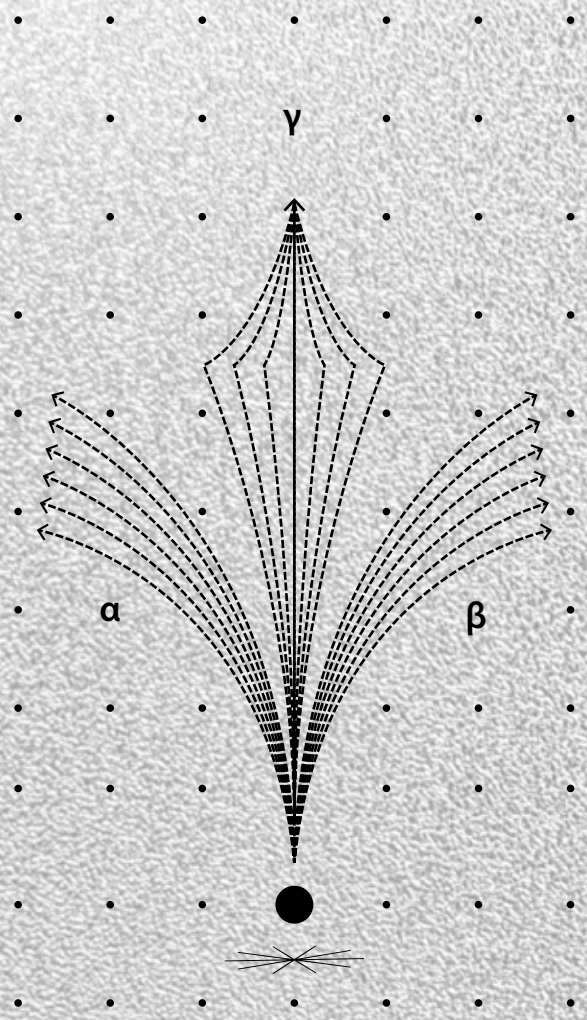
NUCLEAR PHYSICS INSTRUMENTATION



IPTP
ROSATOM

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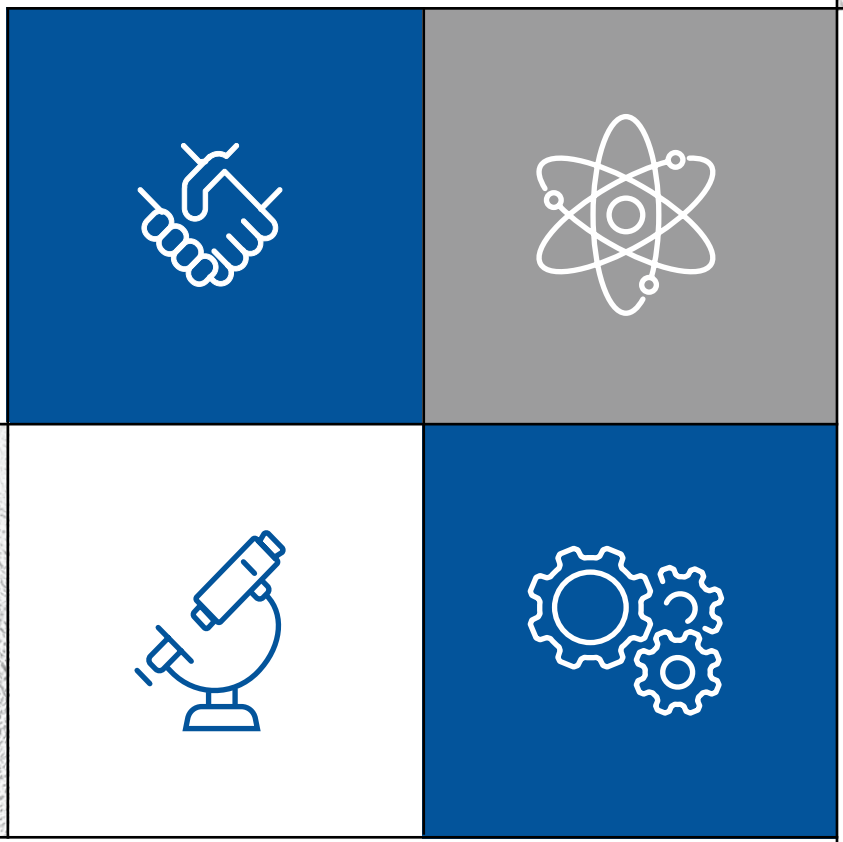
IPTP AT A GLANCE



Dear colleagues,

The nuclear industry is developing rapidly. Every new day brings the technologies and inventions, which set the future trends for the industry. Our Institute is now ready to offer a range of state-of-the-art solutions to our partners.

The Institute of Physical-Technical Problems (JSC IPTP) has been delivering reliable high-quality products for trouble-free operation of enterprises of the nuclear industry in Russia and other countries for over 30 years. Our good standing is based on a responsible attitude of all members of our solid team to the industry, our colleagues and clients. We value our reputation, and we are ready for new cooperation opportunities!

Alexander SMIRNOV,
Director, IPTP

Our History

IPTP is one of the leading Russian research and production organizations dealing with nuclear instrumentation.

The Institute was established in Dubna science city, Moscow region, in 1991 on the basis of the Joint Institute for Nuclear Research. The core team included a group of radioisotope instrumentation specialists from Riga Research and Development Institute for Radio-Isotope Apparatus (RNIIRP, Riga), and experts on scintillation detectors from the Sukhumi Institute of Physics and Technology (SIPT, Sukhumi). In 1992, the Institute became an independent legal entity encharged with the development of radioisotope instrumentation.

In 2019, JSC IPTP became part of Rosatom's division responsible for the development of I&C business under the management of RASU, the integrator of the Russian nuclear industry dealing with instrumentation and control systems and comprehensive electrical engineering solutions.

The Institute has been providing its products for the needs of the nuclear sector, industrial enterprises, oil and gas facilities and other applications for over 30 years.

Nowadays, IPTP is Russia's leader in development and production of semiconductor detectors and plastic scintillators, highly demanded in nuclear power and other industries. Similar scintillators are offered by less than 10 other companies in the country. IPTP provides the best value for money, as we are the only national vendor that applies the ampoule technology and bulk polymerization technologies for cheaper production with the same level of quality.

Mission, Goals, Values

OUR MISSION is to assist in assurance of environmental safety and failure-free operation of enterprises of the nuclear industry and other sectors by developing nuclear physics instrumentation engineering.

OUR PRIORITIES include superior quality standards applied to our products and services. We pursue the customer's interests and fulfill our contract obligations during the course of continual growth.

OUR STRATEGIC GOALS:

increasing the share of hi-tech products offered in the Russian nuclear market.

expanding the presence in the international market.

building long-term win-win cooperation with Russian and foreign partners.

Main Developments and Products of IPTP

Today, IPTP produces 86 types of nuclear physics devices: silicon detectors, germanium detectors, cadmium telluride detectors, diamond detectors, ionization chambers. The detectors are used in spectrometers and analyzers for measurement of energy spectra of ionizing radiation, remote monitoring of process parameters in I&C systems of industrial enterprises, non-destructive testing of thickness, density, level, humidity, ash content.

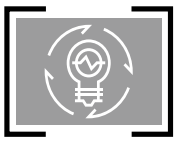
Our Advantages

Modern R&D and production facilities. IPTP has everything necessary to ensure the development and supply of a range of top-class radioisotope devices and ionizing radiation monitors.

Dedication to quality. We focus on high quality and continuous improvement of our products. Our quality management system is based on ISO 9001, and our manufacturing sites comply with ISO 14001 “Environmental Management Systems”.

Competitive products. We ensure continuous improvement of engineering and manufacturing processes, which makes it possible for us to manufacture products in line with international standards and best practices.

Highly-competent specialists. We rely on our qualified and motivated employees who are provided with a wide range of opportunities for continuous training and extended education.



Strategy for new discoveries. Specialists of the enterprise have a comprehensive experience of participation in megascience projects together with research institutes and scientific organizations: NICA and DANSS-3 Projects.

Flexible pricing. The knowledge of the industry specifics of our customers allows us to price our products accordingly and offer more affordable prices compared to foreign analogs

Availability of product maintenance. We provide maintenance services to our customers in Russia for all of our products.

Commitment. We are aimed at long-term and mutually beneficial cooperation with our international and Russian partners.

Sales Geography by Industries

Enterprises of fuel and energy sector:

- oil and gas companies and refineries
- coal mining industry
- nuclear power plants (nuclear power industry)
- ore mining and processing plants
- mining industry

General-purpose industrial facilities:

- research institutes
- laboratories

Enterprises of construction sector:

- manufacturers of construction materials

Enterprises of processing sector:

- metals industry (ferrous and non-ferrous, precious metals)
- chemical industry
- food industry

Enterprises of wood sector:

- woodworking plants
- pulp-and-paper industry

Enterprises of nuclear industry and other sectors:

- radioisotope products, radionuclide sources of ionizing radiation
- manufacturers of polyethylene terephthalate
- manufacturers of fire safety systems
- manufacturers of geosynthetic materials
- production of radiation, chemical and biological protection equipment
- disposal of spent nuclear fuel and other radioactive waste
- production of instrumentation and analytical equipment
- production of radiation monitoring systems
- nuclear medicine (cancer detection centers, cardiology centers, oncology centers, radiation therapy centers)
- radio-electronics industry
- production of equipment and software for measurement and indication of level, density, pressure, pressure drop and flow rate in industrial conditions
- production of radioisotope products and x-ray equipment

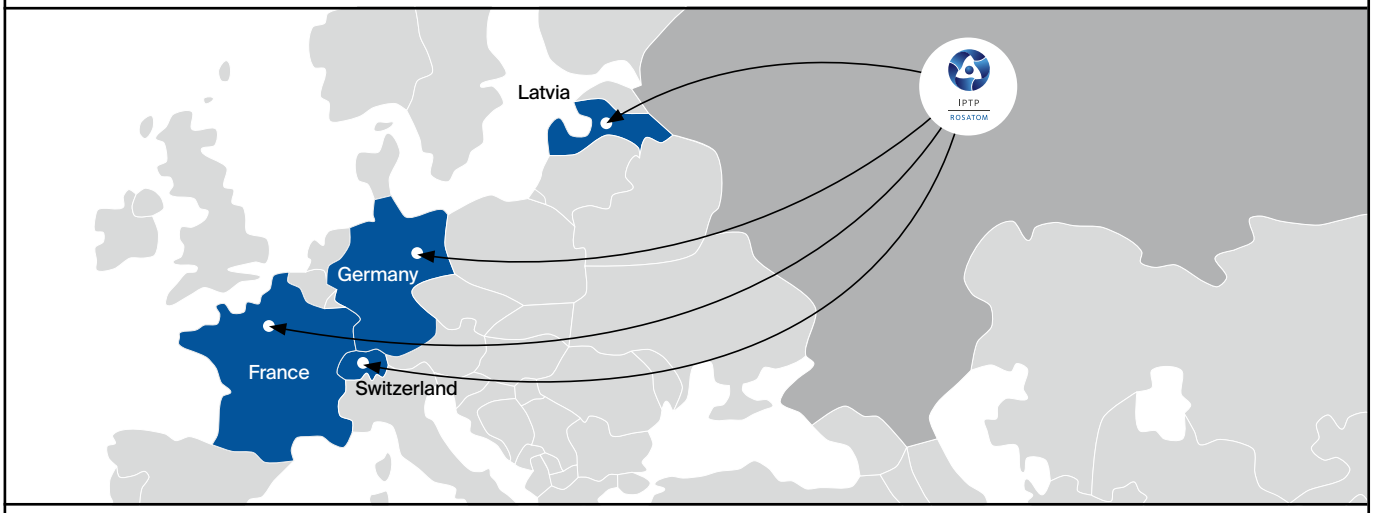
Prospects of IPTP Development in Russia and Abroad

We commit our future to nuclear instrumentation, development of high-tech products and nuclear physics equipment, so that reliable and high-quality products made in Russia are available to enterprises of the nuclear industry and scientific institutes. In particular, we plan to develop state-of-the-art devices for measurement of ionizing radiation based on wide-band-gap semiconductors (CdTe, CdZnTe), and create components for physical protection of nuclear hazardous facilities, prevention of illicit trafficking of radioactive materials, radiation control and monitoring of radioactive materials trafficking.

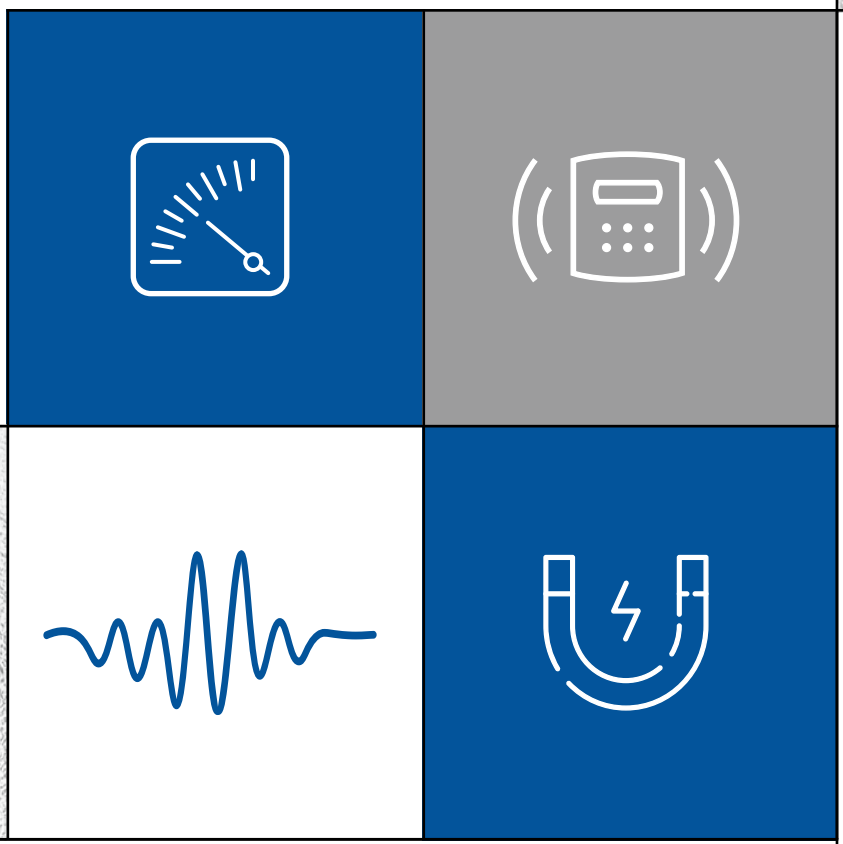
Nowadays, we are facing ambitious tasks as part of international projects. They are related to the supply of our products to Akkuyu NPP (Turkey) and Rooppur NPP (Bangladesh), as well as the organization of supply networks of highly-demanded radioisotope devices to Belarus, Kazakhstan, Uzbekistan, Mongolia, with the aim to ensure safe and uninterrupted operation of nuclear facilities and other industrial enterprises in Russia and abroad.

Network of Partners

We aim to develop and strengthen cooperation with major international leaders of radioisotope devices market: Endress & Hauser (Switzerland), BSI (Latvia), BERTHOLD (Germany), Mirion Technologies (France). For many years, we have been successfully cooperating with the Joint Institute for Nuclear Research (JINR) in the delivery of products for the collider facility and on NICA and DANSS-3 megascience projects.



IPTP Product Catalog



PDPA-1K
Alpha Radiation Detector

Purpose

The PDPA-1K detector is designed to convert the energy of alpha-emitting radionuclides into an electric signal proportional to its amplitude. Alpha radiation is detected by a silicon planar ion-implanted detecting structure created on the basis of the n-type silicon.

Scope of Application

- Radiochemical laboratories
- Production of instrumentation and analytical equipment

Features and Advantages

1. High energy resolution
2. Small thickness of the dead layer
3. Washable sensitive surface
4. Wide range of output connectors used
5. Ion-implanted detector
6. Operation possible in vacuum alpha-chambers

Technical Characteristics and Main Parameters

The detector is manufactured in seven designs that differ in the area of the sensitive surface of the detector and technical characteristics.

Design code	Sensitive surface area mm^2	Energy resolution, keV, max.	Energy equivalent of noise, keV, max.	Capacity, pF, max.
PDPA-1K	20	13	7	30
PDPA-1K5	150	17	11	220
PDPA-1K6	300	21 (18)	15	380
PDPA-1K7	450	23 (19)	18	550
PDPA-1K1	600	28 (24)	23	750
PDPA-1K4	1,200	40 (32)	32	1,400
PDPA-K3	2,000	55 (50)	50	2,200

150 µm
Minimum depletion depth

>0.08 µm
Entrance window thickness

>0.15 imp/cm^2·h
Standard natural background in the range of 3-8 MeV

Dimensions of detectors (with different connectors):

Designation of the detector	Diameter of the sensitive surface, mm, max.	Dimensions of the casing ØD, mm, max.
PDPA-1K	5.1	Ø20
PDPA-1K5	13.9	Ø29.5
PDPA-1K6	19.5	Ø35.5
PDPA-1K7	23.9	Ø39.5
PDPA-1K1	27.6	Ø45
PDPA-1K4	39.1	Ø55.4
PDPA-K3	50.4	Ø67

Connector type	Z, mm	H, mm
SMA (socket)	9.5	13.5
SR-50-74FV	28.6	7
SR-50-73FV	26	7
Flexible outputs	8	7

DKG Detector

Purpose

A two-channel detector containing “rough” and “sensitive” channels.

The detector is designed to measure the exposure dose rate in the pulse counting mode in the range from 10^{-4} to 10^{3} R/h of gamma radiation with an energy from 0.08 to 7.0 MeV.

Scope of Application

- Laboratories / research institutes
- Onboard dosimetry equipment
- Automated Radiation Monitoring System (ARMS)
- Environmental Radiation Monitoring System (ERMS)

Features and Advantages

1. Wide range of exposure dose rate registration
2. Localization of production in Russia

Operating Principle

Mobile charge carriers are formed as a result of the interaction of gamma radiation with the material of the plates. They are collected at the contacts under the applied voltage and recorded by radiometric equipment.

Tasks Performed

Gamma-radiation power measurement.

Technical Characteristics and Main Parameters

The detector measures the exposure dose rate in the range from 10^{-4} to 10^{3} R/h of gamma radiation with an energy from 0.08 to 7.0 MeV.

The following detector parameters are provided at a discrimination threshold of 70 keV:

- sensitivity to gamma radiation with an energy of 0.661 MeV of the ^{137}Cs isotope:
  - from 22.5 to 35 imp/μR for plate No. 1;
  - from 0.4 to 0.7 imp/μR for plate No. 2;
- maximum change in the sensitivity of the plates in the range of gamma radiation energies from 0.08 to 1.25 MeV is ± 35% relative to the sensitivity at the energy of 0.661 MeV;
- maximum detector sensitivity difference to the gamma radiation of the ^{137}Cs source at any angle is 10% of the rated value for each plate;
- maximum counting rate of plates No. 1 and No. 2 due to their own noise is 0.1 imp/s at 60°C;
- maximum changes in the sensitivity of the plates when the ambient temperature changes from +20°C to +60°C are ± 1.5% for every 10°C fluctuation in temperature;
- operating voltage of the detector shall amount to (60±3) V.

10^{-4}–10^{3} R/h
Exposure dose rate measurement

0.08–7.0 MeV
Gamma radiation energy

60±3 V
Detector operating voltage

	Energy equivalent of noise, keV, max.	Reverse current, μA, max.	
	at (20±1)°C	at (20±1)°C	at (60±3)°C
Plate 1	20	1.5	15.0
Plate 2	20	0.8	10.0

DKD-Pm-2.5-3A
Detector

Purpose

DKD-Pm-2.5-3A silicon beta and gamma radiation detector is designed to register beta and gamma radiation as part of radiometric equipment and is an integral part thereof.

Scope of Application

- Laboratories / research institutes
- Onboard dosimetry equipment
- Automated Radiation Monitoring System (ARMS)
- Environmental Radiation Monitoring System (ERMS)

Features and Advantages

Recommended for use as part of radiation monitoring equipment.

Operating Principle

Ionizing radiation entering the sensitive area of the detector creates a non-equilibrium charge of electrons and holes in its sensitive volume. They are proportional to the absorbed energy. Charges drift to the electrodes and are recorded by subsequent equipment under the impact of an electric field generated by the voltage applied to the detector.

Tasks Performed

Measurement of beta and gamma radiation power, reproduction of ambient equivalent dose rate (ADER), exposure dose rate (EDR) of gamma radiation.

Technical Characteristics and Main Parameters

The value of the sensitive surface area is in the range from 2.0 to 3.0 cm^2 and is defined in a specific detector data sheet.

Minimum thickness of the sensitive area is W = 3 mm.

The operating voltage of the detector is Up = (150±5) V.

The values of the detector's reverse current, as well as the energy equivalent of noise and energy resolution, measured at a constant time of 1 μs, shall meet the following requirements:

Parameter	Value	Measurement conditions
Reverse current, μA, max.	2.0	(20±1)°C
Reverse current, μA, max.	20.0	(50±3)°C
Energy equivalent of noise, keV	17.0–50.0	(20±1)°C
Energy resolution for beta particles with an energy of 975.6 keV of the ^{207}Bi isotope, keV, max.	17.0–60.0	(20±1)°C

2.0–3.0 cm^2
Sensitive surface area value

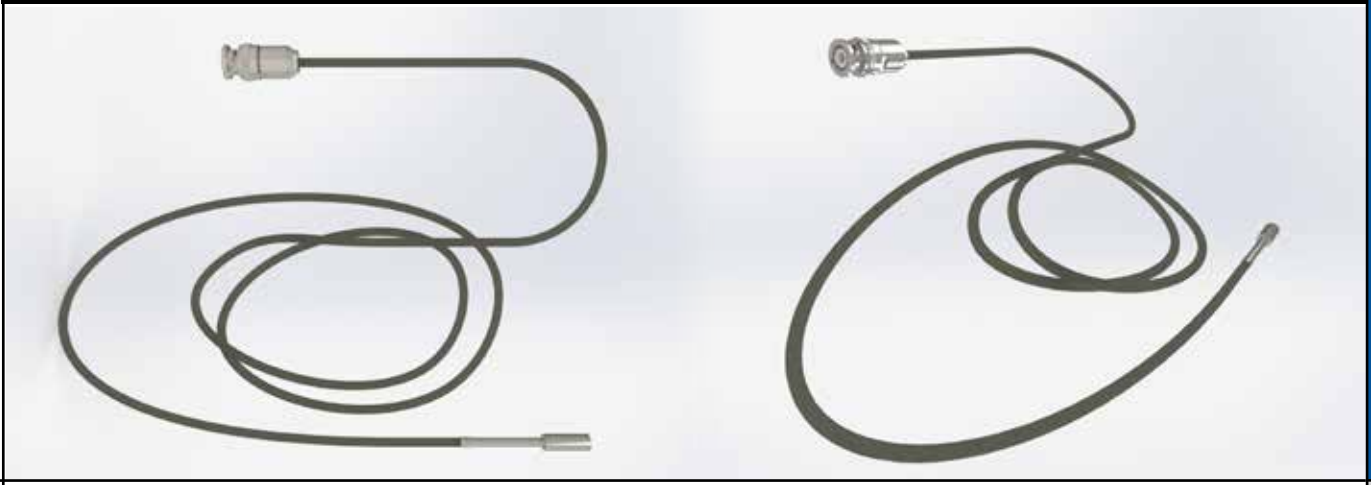
minimum 3 mm
Sensitive area thickness

150±5 V
Detector operating voltage

The detector retains its parameters after the following exposure:

- vibration loads in the range from 1 to 600 Hz and acceleration of 50 m/s^2 (5 g) in three mutually perpendicular directions;
- linear centrifugal loads with acceleration of 100 m/s^2 (10 g);
- ambient temperature in the range from –60°C to +70°C;
- environmental atmospheric pressure in the range from 10 to $3 \cdot 10^5$ Pa (from $7.5 \cdot 10^{-2}$ mmHg to $22.5 \cdot 10^2$ mmHg);
- multiple shocks with acceleration up to 120 m/s^2 (12 g) and impact duration from 1 to 10 ms in three mutually perpendicular directions;
- single shocks with acceleration up to 10,000 m/s^2 (1,000 g) and duration from 0.5 to 2.0 ms in three mutually perpendicular directions;
- relative humidity of (98±2)% at 40°C.

Diamond Dosimetric Detector PDPS-1K



Purpose

The detector is a part of dosimetry equipment (including dose field analyzers of medical radiotherapy units), and it provides measurement of relative distribution of dose rates of photon, electron and proton radiation.

Tasks Performed

Measurement of relative distribution of dose rates of photon, electron and proton radiation.

Features and Advantages over Silicon Detectors and Ionization Chambers

1. Tissue equivalence;
2. Sensitivity of radiation detection ensures high accuracy of radiation dose detection;
3. High radiation resistance ensures a long-term use;
4. Detection sensitivity independent from energy and incidence angle of radiation;
5. Stable detector operation;
6. Detector's output signal independent from temperature within the radiation detection range.

Technical Characteristics and Main Parameters

Range of photon and electron radiation dose rates, Gy/min 0.05–30

Range of detected energy, MeV:

› for photons 0.08–25
› for electrons 4–25

Analog detection sensitivity, C/Gy ..... $(0.5–5.0) \cdot 10^{-7}$

Nonlinearity of conversion characteristic, % ..... ±2

Power supply voltage, V ..... +100

Dark current, A ..... $\leq 5 \cdot 10^{-13}$

Pre-irradiation dose, Gy ..... ≤ 10

Sensitive volume thickness, mm 0.1–0.4

Sensitive volume, mm^3 1–6

Radiation durability, Gy ..... 10^7

0.05–30 Gy/min

Range of photon and electron radiation dose rates

+100 V

Power supply voltage

Scintillation Detectors SPS-N1, PS-N2, PS-N3, PS-B2, PS-B3

Purpose

Plastic scintillation detectors are designed for detection of neutron flux, beta- and gamma-rays.

They are used as part of monitoring equipment in nuclear power industry, production of radioactive materials, in environmental monitoring systems, nuclear material storage and relocation monitoring systems, in metallurgy, chemical industry, as well as in other fields of science and technology, where detection of natural and artificial radio-nuclides is required.

Scope of Application

- Research institutes
- Nuclear power
- Organizations involved in the field of nuclear safety and nuclear warheads
- Manufacturers of radioisotope products and x-ray equipment
- Manufacturers of radiation monitoring systems, radiation, chemical and biological protection devices, as well as manufacturers of equipment and software for measurement and indication of level, density, pressure, pressure drop and flow rate in industrial conditions
- Stadiums

Features and Advantages

1. Bulk Polymerization Technology. We are the only company that owns bulk polymerization and ampoules technologies, which makes it possible to reduce production costs while maintaining quality.
2. Products Adaptation to Specific Requirements. Plastic scintillators are manufactured according to the customer's requirements specification and can be customized.
3. Product Composition Flexibility. Organic scintillators in polystyrene matrix can be manufactured with different composition and percentage of scintillation additives.
4. Product Forms to Meet Customer Needs. Scintillators can be molded into any shape and easily machined, so they are successfully used for special-purpose detectors, counters and many other applications.

Operating Principle

Plastic scintillation detectors are widely used for detection of nuclear radiation. Scintillation resulting from interaction of elementary particles, including photons, with scintillator elements produces flash of light in both invisible and visible areas. The scintillation detector then collects the scintillation light on the photodetector and converts it into a current pulse, amplifies and records it in a recording system.

Tasks Performed

1. Detection, capture, record and control of radio-isotope materials to ensure radiation safety at strategically important/special-purpose facilities, as well as in crowd concentration areas (stadiums, theaters, subways, etc.).
2. Detection of fission products and nuclear contaminated products.
3. Nuclear substances control at the plant.
4. Security of nuclear facilities (archway detectors).
5. Scintillators are used for scientific purposes, including the search for antineutrinos and neutrinos, as well as the search for dark matter.

Bulk polymerization technology

Product composition flexibility

Technical Characteristics and Main Parameters

Density, g/cm^3 ..... 1.05

Maximum luminescence wavelength, nm 420

Scintillation pulse duration at half-height, ns 2.8

The range of geometric dimensions for the cylinders:

- Diameter ..... from 10 mm to 350 mm
- Height ..... from 5 mm to 1,700 mm

The range of geometric dimensions for parallelepipeds:

- Base size ..... from 10*10mm to 500*500mm
- Height ..... from 5 mm to 1,700 mm

Light attenuation distance 2,500mm

Energy resolution 7–15%

Luminescence time depending on composition (duration of scintillation pulse at half the amplitude value)::

- PS-B2 ..... (0.7±0.1) ns
- PS-B3 ..... (1.0±0.2) ns
- PS-N2; SPS-N1; PS-N3; SPS-N4 ..... (2.5±0.1) ns

Wavelength of maximum luminescence depending on composition:

- PS-B2 ..... 380 nm
- PS-B3 ..... 420 nm
- PS-N2; SPS-N1; PS-N3; SPS-N4 ..... 420 nm

Standard light output values in accordance with GOST 23077:

- from 0.01 (for products painted with light-reflecting enamel of PS-B2, PS-B3 composition)
- to 0.8 (for products painted with reflecting enamel of SPS-H1, SPS-H2, SPS-H3; SPS-H4 composition)

Detectors shall be used and remain durable, retaining their operating parameters at:

- Temperature: ..... from +65°C to –50°C
- Pressure: ..... from 86.6 kPa to 104.0 kPa
- Relative humidity: ..... up to 98%

Warranty period with operating conditions met: ..... 10 years

SPS-N1			PS-N2		
diameter, mm	height, mm	Standard light output value	diameter, mm	height, mm	Standard light output value
$50.4_{-0.5}$	$50.4_{-0.5}$	≥ 0.1	$50.4_{-0.5}$	$100.4_{-0.5}$	0.42
$63.4_{-0.5}$	$63.4_{-0.5}$		$150.4_{-0.5}$	$150.4_{-0.5}$	0.39
$79.9_{-0.5}$	$2.0_{-0.06}$		$150.4–_{0.5}$	$400.0_{-1.0}$	0.29
$79.9_{-0.5}$	$100.4_{-0.5}$				
$150.4_{-0.5}$	$150.4_{-0.5}$				

PS-N3			PS-N4			
diameter, mm	height, mm	Standard light output value	length, mm	width, mm	thickness, mm	Attenuation distance, m
250^{-5}	250^{-5}	120^{-3}	0.31	180	68	≥2.5
500^{-5}	500^{-5}	120^{-3}	0.28			

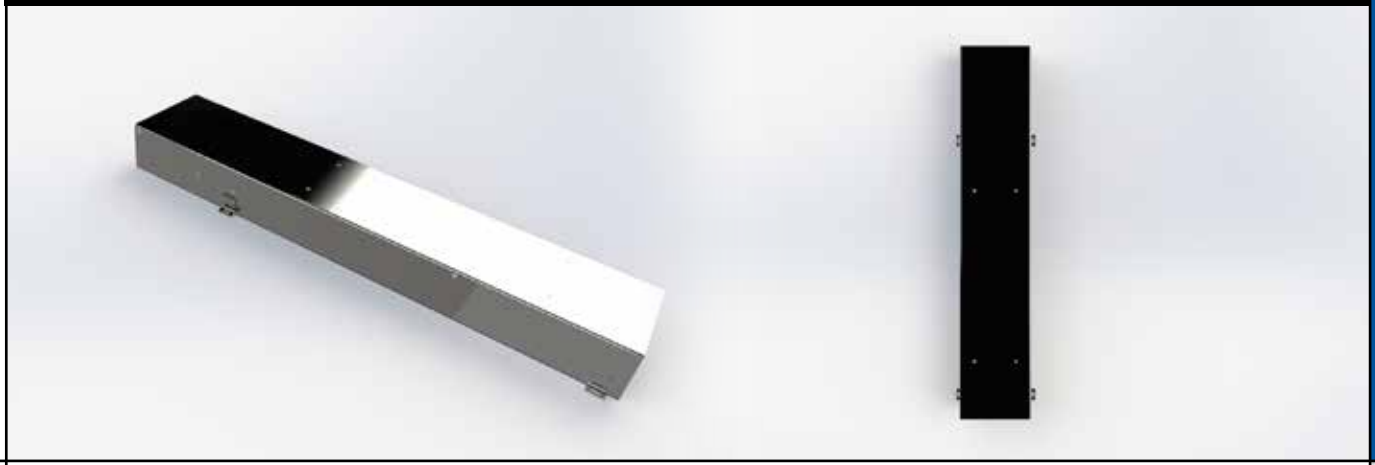
PS-B2			PS-B3		
diameter, mm	height, mm	Standard light output value	diameter, mm	height, mm	Standard light output value
63.0	63.0	≥0.01	50.0	50.0	≥0.1

1.05 g/cm³
Density

420 nm
Maximum luminescence wavelength

2.8 ns
Scintillation pulse duration at half-height

Scintillation Gamma-Radiation Detection Units BDGS-61.280, BDGS-600.180.70, BDGS-260.120.85, BDGS-770.180.70



Purpose

BDGS detector units are designed for use in contamination monitoring systems, radiation monitoring systems, and as part of dosimetry equipment.

Scope of Application

- Within contamination monitoring systems
- Within radiation monitoring systems
- As part of dosimetry equipment

Operating Principle

The detection unit includes an organic scintillation detector. When interacting with the substance of the detector, radiation causes a flash of light, which is converted into an electrical pulse by means of a photomultiplier tube (PMT). The signal from PMT is amplified by a charge sensitive amplifier and sent to the shaper. At the shaper output there are TTL logic signals of 1.0±0.2 μs duration proportional to the dose rate of ionizing radiation.

Technical Characteristics and Main Parameters

Parameters	Type of unit				
	BDGS-61.280	BDGS-260.120.85	BDGS-500.200.40	BDGS-770.180.70	BDGS-600.180.70
Overall dimensions of BDGS, mm, max.	65 × 500	430×128×80	740 × 234 × 100	1000 × 229 × 89	1000×229×100
Overall dimensions of PS, mm	290 × Ø60	260 × 120 × 85	500 × 200 × 40	770 × 180 × 70	600×180×70
Weight, kg	1.2	5.7	5.0	10.0	15.0
Operating range of gamma radiation energy, keV	50–1,500	50–1,500	50–1,500	50–1,500	50–1,500
Detector sensitivity to Am-241 radiation (imp/s)/(μSv/h), min.	2.4 × 103	2.5	250 × 103	450 × 103	250.0 × 103
Detector sensitivity to Cs-137 radiation (imp/s)/(μSv/h), min.	9.0 × 103	4.5	30 × 103	70 × 103	30.0 × 103
Detector sensitivity Co-60 radiation (imp/s)/(μSv/h), min.	3.3 × 103	8.5	22.0 × 103	35.0 × 103	21.0 × 103
Operating range of equivalent dose rates, μSv/h	0.06–10.0	0.06–15.0	0.06–5.0	0.06–5.0	0.06–5.0

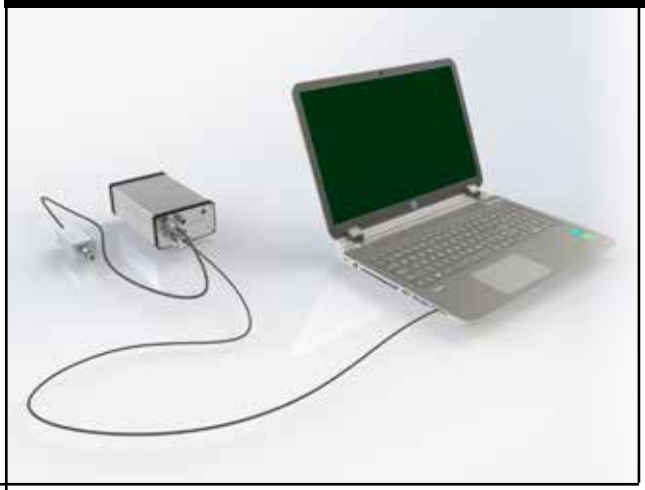
50–1,500 keV

Operating range of gamma radiation energy

0.06–15.0 μSv/h

Operating range of equivalent dose rates

X-Ray Spectrometer SER-1KP



Purpose

X-ray spectrometer is designed to obtain measurement data on X-ray distribution spectrum by one or more parameters characterizing X-ray sources, fields and flux.

The spectrometer is available in the following modifications:

- SER-1KP-(KI-11K) nitrogen-free with BDER-KI-11K detection units based on silicon planar p-i-n semiconductor detectors with thermoelectric cooler.
- SER-1KP-(K-7K) with BDER-K-7K detection units based on silicon-lithium semiconductor detectors.
- SER-1KP-(G-7K) with BDER-G-7K detection units based on planar semiconductor detectors of high purity germanium (HPGe).

Scope of Application

- Research institutes
- Ore mining and processing plants

Features and Advantages

1. Depending on its configuration (specific units), the spectrometer can be used in laboratory, common industrial and field conditions ensuring high-quality precise measurement of X-ray parameters within a wide energy range.
2. Prompt maintenance on the territory of the Russian Federation in contrast to its foreign analogs.
3. Warranty and post-warranty service.

Tasks Performed

1. Measurement of parameters, registration, accumulation, visualization and processing of X-ray spectra during in-process inspection and qualification of radioactive sources and agents, during X-ray fluorescence analysis of substance composition, during studies of spectra, X-ray radiation in experimental nuclear physics.
2. Used in combination with the coating thickness gauges of conveyor analyzers.

Operating Principle

The spectrometer is based on the principle of conversion of X-ray photons in the sensitive volume of a semiconductor detector into electric pulses of proportional amplitude with their subsequent registration and analysis by a multi-channel amplitude analyzer with appropriate software.

Technical Characteristics and Main Parameters

Name of parameter (spectrometer)	Nominal value of the characteristic with detection units		
	SER-1KP-(PIN) BD BDER-KI-11K with silicon p i-n semiconductor detector	SER-1KP-(K-7K) BD BDER-K-7K with silicon-lithium semiconductor detector	SER-1KP-(G-7K) BD BDER-G-7K with semiconductor detector of HPGe
1	2	3	4
Range of detected X-ray energy, keV	1 ÷ 30	1.5 ÷ 60	5 ÷ 150
Energy resolution for radiation with energy of:			
› 5.9 keV (Fe^{55}), max., eV	230 for 7 mm^2 270 for 12 mm^2	180 for 20 mm^2 480 for 500 mm^2	190 for 20 mm^2 550 for 2,000 mm^2
› 59.6 keV (Am^{241}), max., eV	–	430 for 20 mm^2 570 for 500 mm^2	–
› 122 keV (Co^{57}), max., eV	–	–	500 for 20 mm^2 980 for 2000 mm^2
Sensitivity of detection, minimum, mm^2:			
› for 5.9 keV	7 for 7 mm^2 12 for 12 mm^2	16 for 0.2 cm^2 400 for 5 cm^2	116 for 0.2 cm^2 1,300 for 20 cm^2
› for 59.6 keV	0.04 for 7 mm^2 0.08 for 12 mm^2	1 for 0.2 cm^2 25 for 5 cm^2	–
› for 122 keV (Co57)	–	–	6 for 0.2 cm^2 550 for 20 cm^2
Maximum input statistic load, imp/s.	2×10^4 at 5.9 keV	5×10^4 at 59.6 keV	2.5×10^4 at 122 keV
Time of operating mode establishing, max., minutes	30	30	30
Time of continuous operation, min., hours	24	24	24
Instability of conversion characteristic during continuous operation (temporary instability), max., %	±0.1	±0.2	±0.2
Main relative permissible error limits of conversion characteristic (integral nonlinearity) within the measured energy range, %	±0.1	±0.1	±0.1
Number of spectrometer channels, channel	2K, 4K, 8K,16K	2K, 4K, 8K,16K	2K, 4K, 8K,16K
Spectrometer is powered from AC mains:			
› voltage, V	220 ± 22	220 ± 22	220 ± 22
› frequency, Hz	50 ± 1	50 ± 1	50 ± 1
Spectrometer power consumption, max., VA	25	20	20
Instability of conversion characteristic when ambient temperature changes from plus 10°C to plus 35°C, %/10°C	±0.1	±0.1	±0.1
Instability of conversion characteristic at relative humidity of ambient air up to 75% and temperature of +30°C, %	±0.1	±0.1	±0.1
Mean time between failures, min., hours	20,000	20,000	20,000
Average service life, min., years	8	8	8

X-Ray Detection Unit
BDER-G-7K

Purpose

Detection units with germanium detectors are designed for use as part of high-resolution gamma spectrometric devices, facilities and systems.

The detection unit is designed for conversion of energy of X-ray and low-energy gamma ray photons into electric pulses proportional in amplitude for their further processing by a spectrometric device and analytical software.

The detection units can be used at nuclear power plants, nuclear fuel cycle companies, scientific and medical institutions, as well as in other organizations performing activities related to measurement of gamma radiation parameters.

Features and Advantages

1. Prompt maintenance on the territory of the Russian Federation
2. Wide range of detected radiation energy (from 3 keV to 1,000 keV)
3. High energy resolution
4. Wide range of detection efficiency with E=5-100 keV — 100% (with E=1330 keV — from 1 to 9%)
5. Thin beryllium window (50–250 μm)
6. Rational layout of a detection unit, integration into low-background measuring chambers
7. Possibility to measure radiation parameters of any spatial orientation
8. Possibility of transportation and storage without liquid nitrogen
9. Warranty and post-warranty service

Scope of Application

- Laboratories / research institutes
- Environmental and customs control
- Metals industry (ferrous and non-ferrous)
- Chemical industry
- Production of radioactive materials, preparations, radiation sources

Tasks Performed

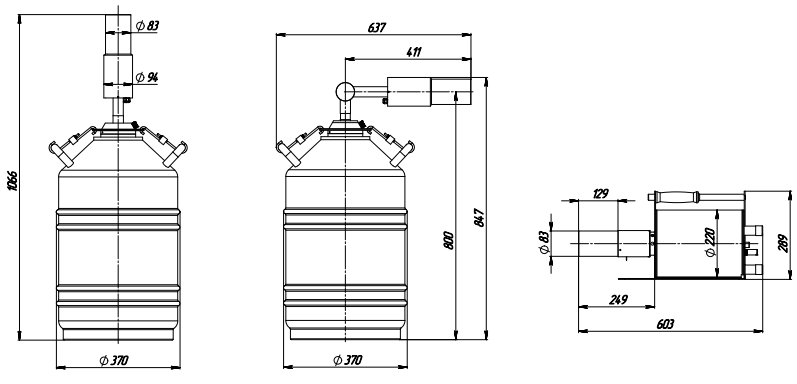
Registration of X-rays and low-energy gamma rays.

Technical Characteristics and Main Parameters

Detection units of X-ray and gamma radiation of BDER-G-7K type based on planar semiconductor detector of HPGe:

Detection Unit Type	Detector Dimensions			Energy Resolution		
	diameter, mm	area, cm^2	thickness, mm	for 5.9 keV, eV	for 122 keV, eV	for 1333 keV, keV
BDER-G-7K-02-	5	0.2	≥ 5	≤ 170	≤ 480	–
BDER-G-7K-05-	8	0.5	5÷7	≤ 185	≤ 490	–
BDER-G-7K-1-	11	1.0	7÷10	≤ 195	≤ 500	–
BDER-G-7K-2-	16	2.0	7÷10	≤ 220	≤ 510	–
BDER-G-7K-3-	19	3.0	10÷13	≤ 250	≤ 530	–
BDER-G-7K-5-	25	5.0	10÷13	≤ 320	≤ 560	–
BDER-G-7K-8-	32	8.0	13÷15	≤ 360	≤ 590	–
BDER-G-7K-10-	36	10.0	13÷15	≤ 400	≤ 630	≤ 1.8
BDER-G-7K-15-	44	15.0	15÷17	≤ 550	≤ 780	≤ 1.9
BDER-G-7K-20-	50	20.0	15÷17	≤ 700	≤ 900	≤ 2.0

Design Versions of BDER-G-7K Detection Units



Modification 1 Modification 2 Modification 3

X-Ray Detection Unit
BDER-K-7K

Purpose

X-ray detection unit BDER-K-7K based on silicon detectors is designed for conversion of energy of X-ray and low-energy gamma ray photons into electric pulses proportional in amplitude for their further processing by a spectrometric device and analytical software.

Features and Advantages

1. Prompt maintenance on the territory of the Russian Federation
2. Wide range of the detected radiation energy
3. Perfect energy resolution
4. Wide parametric range of sensitive surface areas
5. Warranty and post-warranty service

Scope of Application

- Geology and mineral exploration
- Monitoring systems for nuclear power plants
- Laboratories / research institutes

Tasks Performed

1. Detection and spectrometry of X-ray and gamma radiation
2. Detection of X-ray and fluorescent radiation

Technical Characteristics and Main Parameters

Energy range of detected radiation, keV 1–60

Energy resolution for energy of 5.9 keV, eV:

Sensitive surface area of the semiconductor detector, mm^2					
20	50	100	200	300	500
165–240	185–270	210–300	250–350	280–430	430–550

Maximum frequency load at 5.9 keV energy, s^{-1} ..... 1.5×10^4

Dimensions, mm ..... Ø367 × 1,005

Weight with a filled Dewar flask, kg 30

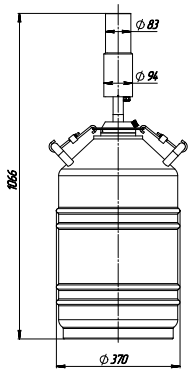
1.5×10^4 s^{-1}

Maximum frequency load at 5.9 keV energy

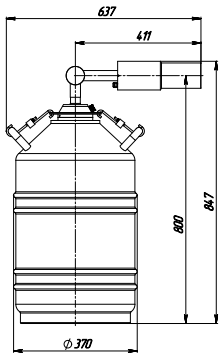
30 kg

Weight with a filled Dewar flask

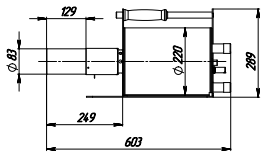
Design Versions of BDER-K-7K Detection Units



Modification 1



Modification 2



Modification 3

Detection Unit with Thermoelectric Cooler BDER-KI-11K

Purpose

The X-ray detection unit is designed for converting the energy of X-ray and low-energy gamma ray photons into electrical signals proportional in amplitude and amplifying them for their further detection by nuclear equipment.

Features and Advantages

1. Prompt maintenance on the territory of the Russian Federation
2. High energy resolution
3. Perfect background characteristics
4. Small dimensions and weight
5. No liquid nitrogen required
6. High EMC
7. Operation possible in sealed vacuum chambers

Scope of Application

- Non-destructive tests
- Ore mining and processing plants
- Mining and metallurgical sector
- Nuclear power
- Metallurgical industry
- Customs inspection and supervision over storage and relocation of nuclear materials

Tasks Performed

1. Control followed by process adjustment of the application of one substance to another (coating thickness control).
2. Detection and control of the thickness of the rolled product.
3. Analysis of substance composition, thickness of applied spray coating.

Operating Principle

Photons of X-rays and low-energy gamma rays pass through the beryllium foil window and enter the sensitive volume of the silicon detector. Interaction of radiation with the semiconductor material of the detector leads to the formation of hole-electron pairs in the sensitive volume, which are collected on its electrodes under the electric field of the voltage imposed on the detector. The charge collection takes about 10^{-7}s and is equivalent to a pulse of electric current flowing through the electrodes into an external circuit. This pulse is integrated by the charge sensitive preamplifier, converted into a voltage drop at its output, and then transmitted to the spectrometric amplifier.

Technical Characteristics and Main Parameters

Sensitive surface area of the detector ..... 7 mm^2 and 12 mm^2
Thickness of the detector's sensitive area ..... 300 µm
Energy resolution at 5.9 keV at a formation time constant of 10 µs for the detector:
- with an area of 7 mm^2 ..... 200 eV max.
- with an area of 12 mm^2 ..... 250 eV max.

Energy resolution at 59.6 keV at a formation time constant of 10 µs for the detector:
- with an area of 7 mm^2 ..... 200 eV max.
- with an area of 12 mm^2 ..... 250 eV max.

Ratio of total absorption peak value for 5.9 keV energy to continuous amplitude distribution level for 3.5 keV energy (peak/background) ..... 800 min.
Thickness of the beryllium window:
- standard ..... 25 µm
- special order ..... 12 µm and 8 µm

Conversion coefficient at a load not less than 1 kOhm ..... 1 mV/keV min.
Output impedance ..... 75 ± 1 Ohm
Polarity of the output signal is negative
Maximum electric bias of detector at a current less than 1 µA ..... 100 V
Preamplifier supply voltage at a maximum current of 35 mA ..... 12 V
Maximum current of cooler ..... 0.7 A at 1.6 V
Weight ..... 0.25 kg max.
Dimensions ..... 15 × 61 × 34 mm

Gamma-Radiation Spectrometer SEG-1KP

Purpose

The gamma radiation energy spectrometer with semiconductor detector is designed to obtain measurement data on gamma radiation distribution spectrum by one or more parameters characterizing gamma radiation sources, fields and flux of gamma radiation.

Features and Advantages

1. Depending on the configuration (availability of specific units), the spectrometer can be used in laboratories, common industrial and field operations, ensuring high-quality and precise measurement of gamma radiation parameters within a wide energy range.
2. High level of stability of the energy signal and conversion ratio.

Scope of Application

› Research institutes
› Nuclear power plants

Operating Principle

Gamma photons are recorded in a sensitive volume of semiconductor detector and converted into an electrical voltage pulse signal with amplitude proportional to the energy of the recorded photon. Then the signal is transmitted for its further processing by a spectrometric device and analytics software.

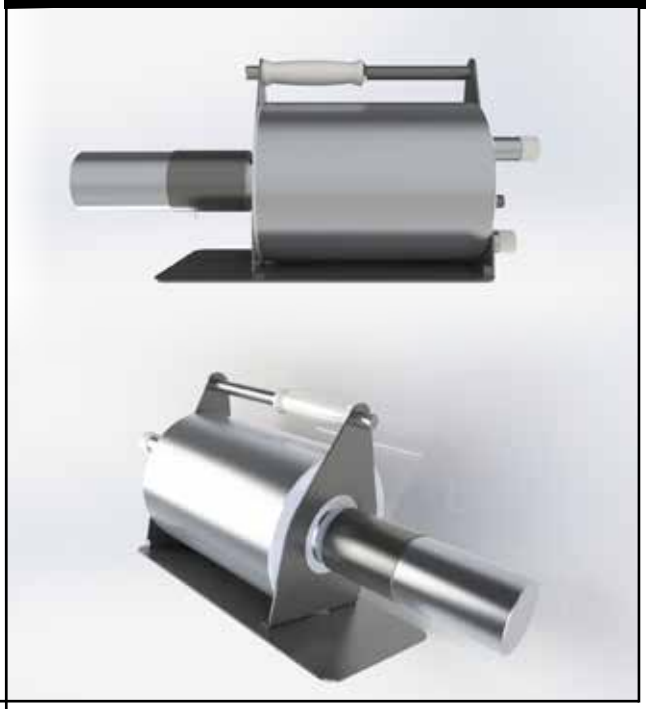
Tasks Performed

1. Monitoring of processes in radiochemical production, areas of environmental issues, physics, medicine, geology, agriculture and other areas of national economy.
2. Testing of surrounding areas for radioactive substances in radiation monitoring laboratories.

Technical Characteristics and Main Parameters

Characteristic	Nominal Value
Range of detected gamma radiation energy, MeV	0.05÷10
Spectrometer energy resolution for gamma radiation with energy of: › 122 keV (^{57}Co), max., keV › 1332 keV (^{60}Co), max., keV	 0.9 (1.4)* 1.9 (3.5)* *under EMC conditions
Maximum input statistic load, min., s^{-1}	5×10^5
Time of spectrometer operating mode establishment, max., minutes	30
Time of spectrometer continuous operation, min., hours	24
Instability of the conversion characteristic during continuous operation (temporary instability), max., %	± 2
Permissible relative error limits of the conversion characteristic (integral nonlinearity) within the measured energy range, %	±0.05
Detection efficiency of gamma photons in the total absorption peak for the point-like source of ^{60}Co nuclide along the line with an energy of 1332 keV, the distance between the source and the detector is 25 cm (in relation to NaJ (Tl) scintillator with size of 3”x 3”), %	1.5÷60
Main relative permissible error limits of detection efficiency in the total absorption peak for the point-like source, %	±10
Additional permissible error limits of detection efficiency in the total absorption peak for the point-like source with ambient temperature variation every 10 °C, %	±0.2
Additional permissible error limits of detection efficiency in the total absorption peak for the point-like source with increased ambient air humidity up to 75 % and temperature up to 30 °C, %	±0.2
Number of spectrometer channels, channels	1000; 2000; 4000; 8000; 16000
The spectrometer is powered from AC mains: › voltage, V › frequency, Hz	 220 ± 22 50 ± 1
Power consumption, VA, max.	20
Mean time between failures, hours, min.	20000
Average service life, years, min.	8

Gamma Radiation Detection Units of BDEG Type



Purpose

Detection units are designed for conversion of energy of gamma radiation photons into electric pulses proportional in amplitude for their further processing by a spectrometric device and analysis by a multichannel amplitude analyzer with the corresponding software installed.

Features and Advantages

1. Energy range of detected radiation – from 40 keV to 10 MeV.
2. High energy resolution and high peak symmetry.
3. Wide parametric range (see the table in Technical Characteristics section)
4. No liquid nitrogen required for transportation and storage.
5. Measurement of radiation parameters of any dimensional orientation.

Scope of Application

- Production and processing of nuclear materials
- Nuclear power
- Customs inspection and supervision over storage and relocation of nuclear materials
- Other areas requiring compositional analysis of the substances using activation methods, and requiring detection of natural and man-made radionuclides
- Environmental monitoring
- Health care facilities
- Chemical industry
- Metallurgical industry

Operating Principle

Gamma radiation photons are transmitted through the inlet of a cryostat or a cooling system of the detection unit and enter a sensitive volume of semiconductor detector. Interaction of radiation with the detector materials leads to generation of non-equilibrium discharge of electrons and holes within the detector sensitive volume which are drifting towards the electrodes under impact of an electric field generated by the high voltage applied to the semiconductor detector.

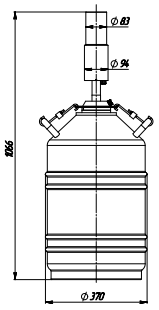
Under the voltage imposed on the semiconductor detector, current pulse is generated with the charge proportional to the energy of interaction of radiation photons with the detector material.

The detector generates pulses transmitted to the preamplifier which converts current pulses into voltage pulses whose amplitude is proportional to the charge quantity.

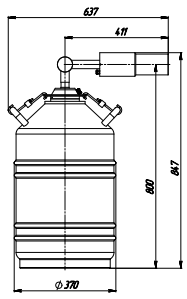
Technical Characteristics and Main Parameters

Detection Unit Type	Efficiency with NaJ (3 × 3), %	Energy Resolution		Peak-to-Compton Ratio	Peak Shape	
		122 keV, eV	1.33 MeV, keV		FW·1M	FWHM FW·02M FWHM
BDEG-10.175 **BDEG-10.185**	10 10	825 1000	1.75 1.85	41:1 37:1	1.90 1.98	2.65 2.98
BDEG-13.180 **BDEG-13.190**	13 13	825 1000	1.80 1.90	43:1 39:1	1.90 1.98	2.65 2.98
BDEG-15.180 **BDEG-15.190**	15 15	825 1000	1.80 1.90	46:1 41:1	1.90 1.98	2.65 1.98
BDEG-20.180 **BDEG-20.190**	20 20	850 1100	1.80 1.90	48:1 43:1	1.90 1.98	2.65 2.98
BDEG-25.185 **BDEG-25.195**	25 25	850 1100	1.85 1.95	55:1 50:1	1.90 1.98	2.65 2.98
BDEG-30.185 **BDEG-30.195**	30 30	875 1100	1.85 1.95	58:1 54:1	1.90 1.95	2.65 2.98
BDEG-35.190 **BDEG-35.200**	35 35	875 1100	1.90 2.00	60:1 56:1	1.90 1.98	2.65 2.98
BDEG-40.190 **BDEG-40.200**	40 40	875 1100	1.90 2.00	62:1 58:1	1.90 1.98	2.65 2.98
BDEG-45.190 **BDEG-45.210**	45 45	900 1100	1.90 2.10	64:1 60:1	1.90 1.98	2.65 2.95
BDEG-50.195 **BDEG-50.210**	50 50	950 1100	1.90 2.10	65:1 62:1	1.90 1.98	2.65 2.98
BDEG-55.200 **BDEG-55.210**	55 55	1000 1200	2.00 2.10	67:1 64:1	2.00 2.00	3.00 3.00
BDEG-60.200 **BDEG-60.210**	60 60	1000 1200	2.00 2.10	68:1 66:1	2.00 2.00	3.00 3.00

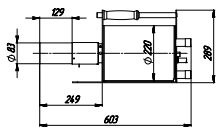
The detection units have three design types with different cooling devices of a semiconductor detector and a main preamplifier cascade:



Modification 1

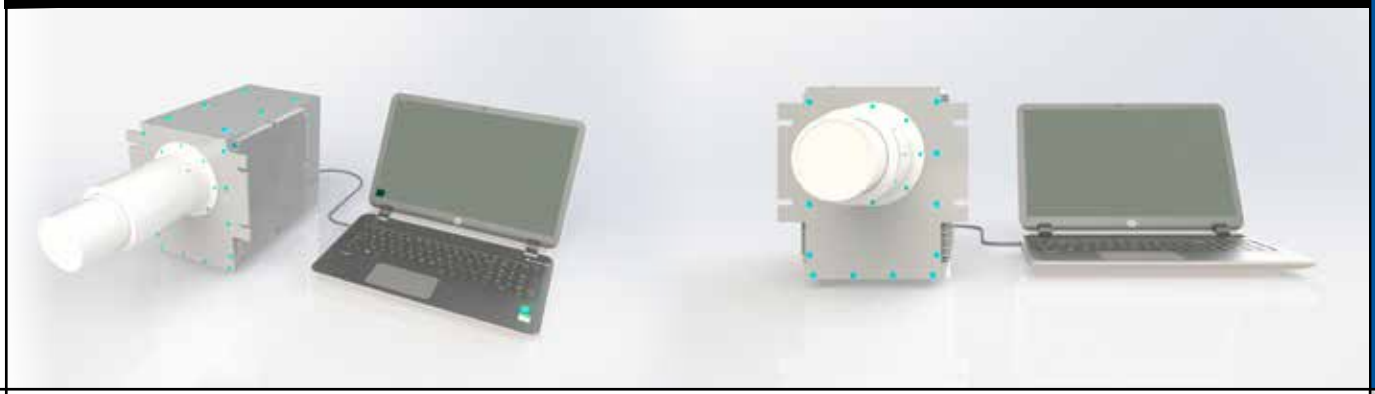


Modification 2



Modification 3

Gamma Radiation Spectrometer with Micro Cryogenic Cooling System SEG-GZ-4K



Purpose

SEG-GZ-4K is designed to quantitatively and qualitatively analyze energy distribution of ionizing radiation gamma photons. This spectrometer significantly extends the scope of semiconductor detectors application since the cooling of the semiconductor detector is ensured not by liquid nitrogen evaporation but with the use of micro cryogenic system.

Features and Advantages

1. No continuous supply of nitrogen is required since cooling is ensured with the use of a cryogenic refrigerator.
2. High level of stability of the energy signal and conversion ratio.
3. Portable design of spectrometer, for example, for mobile laboratories.
4. Ease of use in the following cases:

- limited or intermittent supply of liquid nitrogen;
- no liquid nitrogen available;
- unacceptable conditions for the use of liquid nitrogen for the applications;
- stringent requirements for minimization of spectrometer weight and dimensions.

Scope of Application

- Research institutes
- Geological facilities for search, development and processing of mineral resources
- Radiological services of sanitary and epidemiological stations
- Services ensuring qualification, storage and transportation of nuclear materials
- Organizations developing technologies for production and processing of nuclear materials
- Manufacturing of radiation monitoring and safety systems (for NPP and other organizations using ionizing radiation sources and facilities)

Operating Principle

The spectrometer operation principleIt is based on conversion of gamma photons energy into electric pulses of proportional amplitude within the sensitive volume of a semiconductor detector. The electric pulses are then recorded by a multichannel amplitude analyzer and analytics software.

Tasks Performed

Recording and conversion of gamma photons flux energy.

Technical Characteristics and Main Parameters

Range of detected energy – from 0.06 MeV to 3.0 MeV

Energy resolution, keV:

- for ^{241}Am (59,6 keV) ..... ≤ 1.4
- ^{57}Co (122 keV) ..... ≤ 1.5
- ^{137}Cs (662 keV) ..... ≤ 1.8
- ^{60}Co (1333 keV) ..... ≤ 2.0

Spectrometer warm-up period, hours 3.5–4

Detection device weight, kg 10.5

Dimensions, mm:

- length 390
- width 200
- height 175

Alpha Radiation Spectrometer SEA-4K

Purpose

The SEA-4K Alpha Radiation Spectrometer is designed to measure distribution spectrum of alpha-emitting radionuclides energy, determination of composition, relative content or activity of radionuclides in the analyzed sample prepared with the use of radiochemical methods or on the filter used for air sampling.

Scope of Application

- Industrial enterprises
- Research institutes and laboratories
- Health care facilities
- Radiological and radiation monitoring services

Operating Principle

It is based on conversion of alpha particles energy into electric pulses of proportional amplitude within the sensitive volume of a silicon detector. The electric pulses are then recorded and analyzed by a multichannel amplitude analyzer with the corresponding software installed.

Tasks Performed

1. Ensuring high-quality and precise measurement of alpha radiation parameters within a wide energy range.
2. Monitoring of processes in radiochemical production.
3. Monitoring of natural environments and products.
4. Measuring the distribution spectrum of alpha-emitting radionuclides energy; determining the composition, relative content or activity of radionuclides in the analyzed sample.

Technical Characteristics and Main Parameters

Range of detected alpha radiation energy, MeV 3–9

Integral nonlinearity within the operating range of alpha radiation energy, %, max. 0.1

Energy resolution along the line of 5157 keV with ^{239}Pu from the set of reference source of alpha radiation located at the distance of 50 mm from the alpha radiation detector, area:

- 450 mm^2 , keV, max. 24
- 600 mm^2 , keV, max. 28
- 1200 mm^2 , keV, max. 40
- 2000 mm^2 , keV, max. 60

Temporary instability during continuous operation, %, max. 0.1

Number of spectrometer channels, channels 1024; 2048; 4096

Time of spectrometer continuous operation, hours, min. 8

Design features of a vacuum chamber:

- Solenoid valve
- Vacuum connector of SMA type
- Large size of a vacuum chamber – 74 mm
- 10^{-3} mmHg vacuum measuring device – 10 mmHg

Digital Spectrometer Device
CSU-V(N)-1K

Purpose

The CSU-1K Digital Spectrometric Device is designed to generate spectrometric route of ionizing radiation and to ensure linear conversion of output signal obtained from ionizing radiation detection unit into digital code. The digital code is collected in the form of amplitude spectrum with its consequent read-out in PC via universal serial bus.

Tasks Performed

Conversion of detection unit signals into digital spectrum.

Scope of Application

- Research institutes
- Geological facilities for search, development and processing of mineral resources
- Radiological services of sanitary and epidemiological stations
- Services ensuring qualification, storage and transportation of nuclear materials
- Organizations developing technologies for production and processing of nuclear materials
- Manufacturing of radiation monitoring and safety systems (for NPP and other organizations using ionizing radiation sources and facilities)

Features and Advantages

1. **Stability, accuracy and repeatability of results.** Contrary to the conventional systems performing digitization of signals at the end of signal processing chain, the CSU device has a signal transmitted from a detection unit to the front end of the spectrometric device, and the signal is digitized. This approach decreases the number of input analog circuits to the minimum and ensures increase in stability, accuracy and repeatability of results.
2. **Implementation of filtering functions and obtaining pulse forms**, which is impossible using analog circuit designs.
3. **Speed and accuracy of pulse processing** with the use of a trapezoid filter ensuring improvement of spectrum resolution and performance.
4. **The pileup rejection function** increases the throughput capacity of the analyzer by recording partially piled-up pulses.
5. **Availability of the virtual dual-channel oscillograph mode.** This mode allows the operator to display the graphical representation of the digitized signal that passed through the filter. In addition to two channels of "analog" signals, the oscillograph can display 4 "digital" channels, thus significantly enhancing the functionality of CSU-1K digital oscillograph.
6. **Embedded signal averaging function.** This function ensures the decrease of noise to improve waveform validity.
7. **A unique virtual spectrum analyzer mode** significantly simplifies the detection of noise affecting the quality of the whole complex operation.
8. **Operational flexibility.** Depending on measurement tasks to be performed, CSU-1K ensures compatible operation with ionizing radiation detection units based on semiconductor detectors, as well as scintillators, proportional counters, and ionization chambers.
9. **API DLL open library.**

Operating Principle

The CSU digital spectrometric device is a single-unit software programmable multichannel amplitude analyzer with up to 16K channels. The device is developed based on digital signal processor (DSP) technologies. Several CSU devices can be connected to a single PC.

CSU devices are designed to be used as part of gamma spectrometric devices, high-resolution facilities and systems. The devices include main assemblies required for operation of spectrometric route, including detector electric bias sources.

CSU devices can be used at nuclear power plants, nuclear fuel cycle companies, scientific and medical institutions, as well as in other organizations performing activities related to measurement of amplitude and time distribution of pulses obtained from spectrometric detection units.

Technical Characteristics and Main Parameters

Basic error of conversion characteristic (integral nonlinearity), %, max. 0.02

Number of channels 16K

Digital filter response rise time, μs . . . . . 0.5÷50 with a step of 0.1 μs

Polarity "+" or "–"

Temporary instability of conversion during 24-hour continuous operation, %, max. 0.02

Temperature instability of conversion characteristic, %/°C, max. 0.01

Maximum input statistic load, s^{-1}, min. . . . . $5 \cdot 10^5$

Gamma Radiation Spectrometer Based on CdZnTe SEG-TK-1K

Purpose

The SEG-TK-1K Spectrometer is designed for application in systems of radiation situation monitoring, radioactive substances and materials identification, radionuclides activity determination, as well as for operation as part of portable and stationary radiation monitors, waste assay monitors and as a standalone device at plant radiochemical laboratories and in various scientific research areas.

Operating Principle

The spectrometer is based on the CdZnTe semiconductor detector. Rradiation interacts with the detector material and generates electron-hole pairs which are recorded by a low-noise preamplifier in the form of current pulses proportional to radiation energy. Then, the pulses are transmitted at the input of digital spectrum analyzer that performs amplitude analysis and accumulates the spectrum in the buffer. Management of operation modes and read-out of partial (counting rate in the energy window) or complete information on detected radiation spectrum are performed via the external interface.

Technical Characteristics and Main Parameters

Casing overall dimensions, mm, max. . . . . 135 × 45 × 45

Design . . . . . enclosed single unit

Spectrometer configuration: – CdZnTe detector, mm, min. . . . . 10 × 10 × 5

Energy resolution:

› for line 662 keV (Cs-137), keV, max. 17

› for line 356 keV (Ba-133), keV, max. 14

› for line 81 keV (Ba-133), keV, max. 8

› for line 60 keV (Am-241), keV, max. 6

› built-in digital spectrum analyzer (RS-485 interface)

Electric bias, V 2000

› generation type . . . . . trapezoid

› filter setting time, μs 0.1–50

› number of analyzer channels 2K, 4K, 8K

Detector type . . . . . quasi-hemisphere

Range of detected energy, MeV 0.04–3.0

Peak-to-Compton ratio for (Cs-137) isotope 2

Power supply voltage, V . . . . . +6

Current consumption, mA, max. 80

Operating temperature range, °C . . . . . –40÷+50

Time required for spectrum recording mode setting (from power supply), s. 10

Radiation Meter System for Monitoring the Contamination of Special-purpose Shoes with Alpha-emitting Radionuclides

RZA-1K

Purpose

The RZA-1K Radiation Meter System is designed for measurement of alpha particles flux density to define surface contamination of special-purpose shoes with alpha-emitting radionuclides in accordance with the Radiation Safety Standards (NRB-99/2009).

Features and Advantages

1. Measurement of alpha particles' flux density
2. Two light-protected ion-implanted silicon detectors of alpha radiation of the PDPA-1K type, each with an area of 19 cm^2.
3. High efficiency within the entire energy range of alpha particles.
4. Wide dynamic range.
5. High resistance to gamma radiation.
6. Ease of control and operation.
7. The photo sensor for the proper leg position check.
8. The protective polyethylene terephthalate film coating, 2.5 micron thick.

Scope of Application

- Radiochemical laboratories and production facilities
- Manufacturers of radioisotope products
- Laboratories of external dosimetry services and radiologic laboratories of the Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing of the Russian Federation (Rospotrebnadzor)
- Radiation monitoring services of organizations

Tasks Performed

Monitoring of surface contamination of special-purpose shoes with alpha-emitting radionuclides using light-protected ion-implanted silicon semiconductor detectors.

Operating Principle

Output electric signals, obtained from the light-protected silicon detector and whose values are proportional to energy of detected alpha particles, are amplified by a preamplifier and transmitted at the input of a shaping amplifier. Then, the signals are discriminated by low and upper levels. The discriminated signals are transmitted at the input of a microcontroller and converted into the density of alpha particles flux received from the tested object. The value of alpha particles flux density is displayed by the indicators.

Technical Characteristics and Main Parameters

Range of measured alpha particles flux densities, φ, particles/cm^2 · min. . . . . 0.5...10^4

Range of detected alpha radiation energy, keV . . . . . 3000...9000

Limits of measurement permissible basic error, % . . . . . $\pm(25 + 35/\varphi)$

Efficiency of detection of ^{239}Pu radionuclide alpha particles, min. 0.3

Own background level, particles/cm^2, max. 0.5

Measurement time, s 40

Power voltage, V . . . . . 220 (50 ± 1 Hz)

Power consumption, VA, max. 20

Overall dimensions, mm:

- BDZA-1K . . . . . 370 × 300 × 70
- BOI-3K . . . . . 170 × 300 × 200

Weight, kg, max.. 14

Portable Alpha-Radiometer RZA-2K

Purpose

The RZA-2K Radiometer is designed for express measurement of contamination of equipment work surfaces with alpha-emitting radionuclides. The radiometer is supplied in a portable design and can be used to ensure compliance with sanitary requirements for radioactive contamination of work surfaces and equipment in accordance with the Radiation Safety Standards (NRB-99/2009) in laboratory and production premises that may be contaminated with alpha-emitting radionuclides during operation.

Features and Advantages

1. The silicon ion-implanted light-protected detector of alpha radiation of the PDPA-1K type with an area of 19 cm^2.
2. High efficiency within the entire energy range of alpha particles.
3. Wide dynamic range.
4. High resistance to gamma radiation.
5. Ease of control and operation.
6. Ability to measure in hard-to-reach places due to small dimensions.
7. The pProtective polyethylene terephthalate film coating, 2.5 micron thick.

Scope of Application

- Radiochemical laboratories and production facilities
- Manufacturers of radioisotope products
- Laboratories of external dosimetry services and radiologic laboratories of the Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing of the Russian Federation (Rospotrebnadzor)
- Radiation monitoring services of organizations

Operating Principle

Output electric signals obtained from the light-protected silicon detector and whose values are proportional to energy of detected alpha particles, are amplified by a preamplifier and transmitted at the input of a shaping amplifier. Then, the signals are discriminated by low and upper levels. The discriminated signals are transmitted at the input of a microcontroller and converted into the density of alpha particles flux received from the tested object. The value of alpha particles flux density is displayed by the indicators.

Tasks Performed

Measuring the flow of alpha particles to determine the degree of contamination of equipment and workstations with alpha-emitting radionuclides.

Technical Characteristics and Main Parameters

Range of measured alpha particles flux densities, φ, particles/cm^2 · min.	0.5...10^4
Range of detected alpha radiation energy, keV	3000...9000
Limits of measurement permissible basic error, %	$\pm(25 + 25/\varphi)$
Efficiency of detection of ^{239}Pu radionuclide alpha particles, min.	0.3
Own background level, particles/cm^2, max.	0.5
Measurement time, s	50
Time of continuous operation, hours, min.	8
Power supply	6 built-in Ni-Mg AA batteries
Overall dimensions, mm, max.	∅140 × 180
Weight, kg, max.	1.7

RGA-1K
Radiometer of Volumetric Activity of Alpha-emitting Nuclides

Purpose

The RGA-1K with a silicon ion-implanted spectrometric detector is designed for continuous monitoring of the operating environment for the presence of alpha-active aerosols.

Features and Advantages

1. The RSP-20 analytical aerosol filter of the AFA type – RSP-20.
2. Spectrometric method of compensation of radon and thoron daughters contribution.
3. Activation of light and sound signaling activated in case the set limits of volumetric activity are exceeded.

Operating Principle

The pumped air passes through the filter operating area where aerosols are deposited. The detector is located above the filter's operating area and it records alpha particles emitted from the aerosol particles deposited on the filter. Detector electric pulses with the amplitude proportional to the particles energy are transmitted to the input of the preamplifier. The electric signal converted by the shaping amplifier is transmitted to one of the inputs of two-input ADC with 2048 channels. Thus, the information on the energy spectrum of alpha particles in the filter is obtained. The obtained spectra and data on the air flow and volume are transmitted to the computer to be processed by the special software. Calculation results are displayed on the monitor. The obtained data are compared to the threshold setpoints predefined by the user in radiometer settings. If the volumetric activity values defined by the setpoints are exceeded, the light indication is enabled (red LED lights up) and sound signaling is activated.

Tasks Performed

1. Measuring of volumetric activity of alpha-emitting aerosols in the air of working premises and release utility systems.
2. Monitoring of radioactive contamination of transuranium elements against the background of alpha radiation produced by radon and thoron fission products.
3. Ensuring the compliance with sanitary requirements for radioactive contamination of the air of working premises with plutonium-239.
4. Continuous monitoring of the air of working premises for alpha-active aerosols.

Technical Characteristics and Main Parameters

Volumetric activity measurement range, Bq/m^3 . . . . . $10^{-2} \div 10^5$

Limits of permissible basic relative error of volumetric activity measurement, %, max.:

› within the range of 0.01–1 Bq/m^3 . . . . . ±50

› within the range of 1–105 Bq/m^3 . . . . . ±30

Range of detected alpha radiation of particles, MeV 3–9

Alpha-active aerosol detection sensitivity (for Pu-239)
with measurement time interval of 60 minutes, permissible volumetric activity · h 5

Range of air flow rate within the filter, l/minute. 20–60

Clinical Dosimeter Based on Diamond Detector for Radiotherapy Units DKDa-01-IFTP

Purpose

The DKDa-01-IFTP clinical dosimeter based on diamond detector for radiotherapy units is designed to measure absorbed dose in water and absorbed dose rate of photon and electron radiation in water in radiation therapy centers, as well as to monitor radiation situation in special storages of spent sources of ionizing radiation.

Scope of Application

- Nuclear medicine (cancer detection centers, cardiology centers, cancer dispensaries, PET, radiation therapy centers)
- Radioelectronics industry
- Research institutes
- Manufacturers of medical equipment/radiation therapy equipment.

Features and Advantages

1. The dosimeter maintains its performance characteristics during continuous operation in water (water phantom).
2. Tissue equivalence.
3. Sensitivity of radiation detection ensures high accuracy of radiation dose detection.
4. High radiation resistance ensures a long-term life time.
5. Detection sensitivity independent from the energy and incidence angle of radiation.
6. Detector stable operation.
7. Detector output signal independent from temperatures within the 10–30 °C range.

Operating Principle

A detector element sensitive to ionizing radiation is a diamond detecting structure being a plate made of diamond with a width of 0.1–0.4 mm and area of 5–15 mm^2, equipped with a special system of contacts. Radiation enters the detector sensitive volume and generates ionization causing formation of electron-hole pairs. Electrons and holes drift to the electrodes under the impact of an electric field generated by the voltage applied to the detector. Accumulation of a charge leads to generation of ionization current in the external circuit which value is proportional to the absorbed dose rate of radiation.

Detector ionization current is transmitted to the input of a data recording and processing unit, BOI-2K, via a connection cable. The microprocessor unit performs the main processing of measurement results, controls measurement limits and ADC, transmits information on a measured value and measurement modes to the indication panel and to PC via the RS-232 interface. The PC records the conversion ratio of a particular detector to the processor nonvolatile memory.

Tasks Performed

1. Measurement of the absorbed dose rate of ionizing radiation generated by radiotherapy units.
2. Monitoring of the radiation situation under conditions of high dose rates and high temperatures.
3. Measurement of a detector ionization current, value of accumulated charge and value of radiation absorbed dose rate and absorbed dose.

Technical Characteristics and Main Parameters

The recording unit displays data on charge quantity, C (dose, Gy); current, A (dose rate, Gy/s)

Measurement range for photon, electron and proton radiation absorbed dose rates, Gy/s 0.001–1.0

Measurement range for photon, electron and proton radiation absorbed dose, Gy 0.1–100

Range of detected energy, MeV:

› for photons 0.08–25

› for electrons 4–25

Limit of permissible basic measurement error, % ..... ±2

Detection sensitivity dependence on energy, % ..... ±2

Pre-irradiation dose, Gy ..... ≤ 10

Detector radiation durability, Gy ..... 10^7

Detector sensitive volume thickness, mm 0.1–0.4

Detector sensitive volume, mm^3 1–6

Power supply:

› voltage, V ..... 220 ± 15%

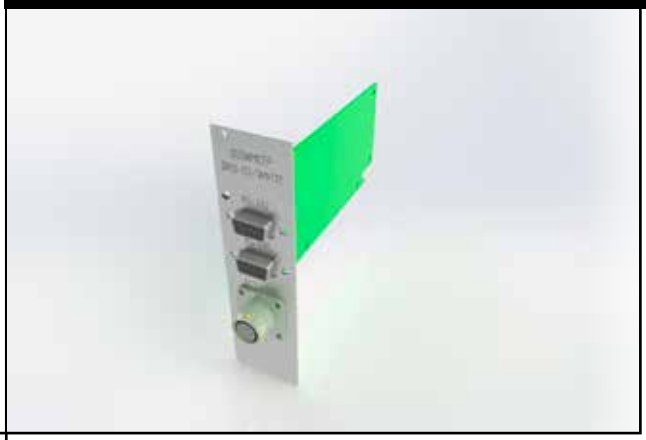
› frequency, Hz ..... 50 ± 1

Power consumption, VA, max. 30

Recording unit overall dimensions, mm ..... 260 × 220 × 100

Weight (w/o connection cable and phantom), kg, max. 2.0

Dosimeter Based on Diamond Detector DKD-03-IFTP



Purpose

The DKD-03-IFTP dosimeter based on diamond detector is designed to measure absorbed dose in water and absorbed dose rate of photon radiation of irradiation facilities in water, as well as to monitor radiation situation in special storages of spent sources of ionizing radiation.

Tasks Performed

The dosimeter ensures measurement of detector ionization current and values of absorbed dose rate.

Operating Principle

A detector element sensitive to ionizing radiation is a diamond detecting structure being a plate made of diamond with a width of 0.1–0.4 mm and area of 5–15 mm^2, equipped with a special system of contacts. Radiation enters the detector sensitive volume and generates ionization causing formation of electron-hole pairs. Electrons and holes drift to the electrodes under the impact of an electric field generated by the voltage applied to the detector. Accumulation of a charge leads to generation of ionization current in the external circuit which value is proportional to the absorbed dose rate of radiation.

Detector ionization current is amplified by the preamplifier and transmitted to the input of a data recording and processing unit, BOI-3K, via a connection cable. The microprocessor unit performs the main processing of measurement results, controls measurement limits and ADC, transmits information on a measured value and measurement modes to PC via the RS-232 interface.

The PC records the conversion ratio of a particular detector to the processor nonvolatile memory.

Technical Characteristics and Main Parameters

Range of photon radiation energy detected by the dosimeter, within the range ..... from 0.08 MeV to 25 MeV

The dosimeter's sensitivity dependence on energy within the photon energy range of 1.2–20 MeV ..... ±2% max.

Anisotropy of the dosimeter's sensitivity during detector rotation along longitudinal axis (within the range of radiation incidence angles from 0 to 360°) and during detector rotation along the axis normal to detector longitudinal axis (within the range of angles from 0 to 180°) within the photon energy range from 1.2 MeV to 20 MeV ..... ±2% max.

Time of operating mode establishment ..... 15 minutes max.

Time of continuous operation ..... 8 hours min.

The detector's pre-irradiation dose required for stabilization of its conversion characteristic ..... 10 Gy max.

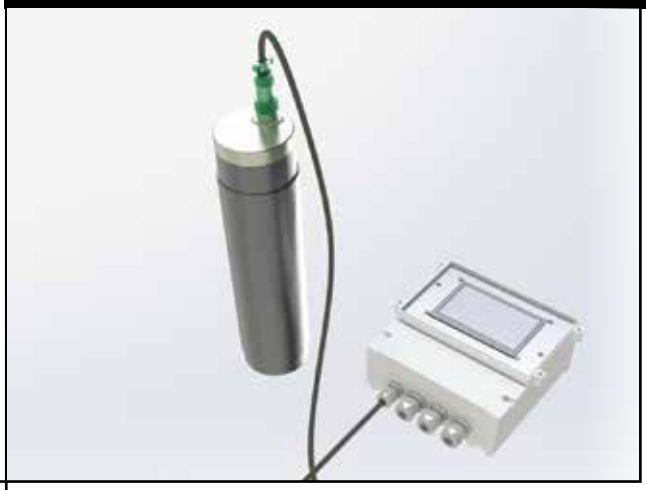
Overall dimensions of the data recording and processing unit ..... 40x170x125 mm max.

Weight (w/o connection cable) ..... 0.5 kg max.

Mean time between failures ..... 5,000 hours min.

Average service life ..... 5 years min.

Radioisotope Relay Device RRP-3M



Features and Advantages

1. Constant indication of the frequency value from the detection unit, which greatly simplifies the setup (setting the trigger threshold) of the device.
2. Continuous monitoring of performance and stability.
3. Accurate (digital) setting of the trigger threshold and time constant.
4. Consistency with the PC for controlling or accumulating the process information, including data on the device stability.
5. Use of modern electronic components, including solid-state optoelectronic relays that do not interfere with switching.

Purpose

The device is designed for automatic monitoring and control of processes in various industries and can perform the following types of monitoring:

- contactless positional control of the level of liquid and bulk materials in closed vessels, bins, and other containers;
- monitoring displacements of the objects;
- monitoring the boundaries of two media (interfaces);
- monitoring the leaks and gutters clogging, hanging of materials on the walls of the bin;
- presence of the material on the conveyor belt;
- changes in the properties (density) of the monitored object.

Scope of Application

- Pulp-and-paper industry
- Metals industry (ferrous and non-ferrous)
- Extractive sectors (mining and chemical raw materials, ore and non-ferrous metals, coal mining enterprises, oil, gas, salt, gold, diamonds)

Tasks Performed

1. Contactless positional control of the level of liquid and bulk materials in closed vessels, bins, and other containers.
2. Ensuring the reliability and accuracy of determining the boundaries of medium (interfaces).
3. Carrying out measurements and solving measurement tasks in extreme conditions: temperature, vibration and humidity, where other measurement principles cannot be applied.
4. Monitoring displacements of the objects.
5. Monitoring the leaks and gutters clogging, hanging of materials on the walls of the bin.
6. Monitoring that the material is on the conveyor belt.

Technical Characteristics and Main Parameters

Sensitivity of the BDG-17M unit as per gamma radiation of the radionuclide cesium-137 is at least $2.5 \cdot 10^{12}$ imp·kg/C ($0.65 \cdot 10^{9}$ imp/R).

The electrical threshold of operation is set from at least 10 imp/s to no more than 9990 imp/s with a discreteness of 1 imp/s to a threshold value of 999 imp/s, and with a discreteness of 10 imp/s in the range from 1000 to 9990 imp/s.

The hysteresis factor is 0.5 (the hysteresis factor can be set (reprogrammed) in the range from 0.1 to 0.9 with a discreteness step of 0.1 when the device is connected to a personal computer).

The average service life of the device is at least 6 years. Mean time between failures of the device is no less than 12500 h.

The maximum distance of the detection unit from the processing unit is not more than 300 m.

Overall dimensions and weight of the device units are as follows:

› BDG-17M Ø 80 x 300 mm

weight of 3.5 kg max.;

› BOI-4K 280 x 210 x 100 mm

weight of 2.0 kg max.

Operating Principle

Radioisotope devices (RID) are highly effective means of non-destructive testing in the production of materials and substances.

Its operation is based on recording the gamma radiation dose rate drop on the surface of the BDG-17M detection unit, which is caused by a change in the state of the monitored object between the BGI gamma source unit and the BDG-17M unit.

Electrical pulses are generated in the detection unit, the frequency of which is proportional to the gamma radiation dose rate. These pulses are transmitted to the input of the BOI-4K information processing unit by cable. Frequency of the incoming statistical signal is compared in BOI-4K with the threshold value of the signal frequency set when setting up the device, and the output signal is generated.

Operating Conditions

1. In terms of ambient temperature and humidity, the device units are resistant to the following:

› BDG-17M – temperatures from –50°C to +50°C, relative humidity up to 95% at temperatures up to +35°C);

› BOI-4K – temperatures from 0°C to +35°C, relative humidity of 80% at temperatures up to +35°C.

2. In terms of protection from the penetration of water and foreign solid particles, the device units have the following designs:

› DG-17 M – JP 67;

› BOI-4K – JP 54.

3. The device unit retains its technical characteristics within the limits established for them by standards in terms of external vibration effects, and does not have mechanical damage when exposed to the following:

› vibrations with a frequency from 5 to 120 Hz, a displacement amplitude of 0.15 mm ± 20%, and an acceleration of 19.6 m/s2 ± 20% for the BDG-17M unit;

› vibrations with a frequency from 5 to 25 Hz and a displacement amplitude up to 0.1 ±20% for the BOI-4K unit.

Radioisotope Relay Device RRP-3S

Purpose

The device is designed for automatic monitoring and control of processes in various industries and can perform the following types of monitoring:

- contactless positional control of the level of liquid and bulk materials in closed vessels, bins, and other containers;
- monitoring displacements of the objects;
- monitoring the boundaries of two media (interfaces);
- monitoring the leaks and gutters clogging, hanging of materials on the walls of the bin;
- presence of the material on the conveyor belt;
- changes in the properties (density) of the monitored object.

Features and Advantages

1. High resistance to environmental temperature and humidity:
   - temperatures from 50 °C to +50 °C, relative humidity up to 95% at a temperature up to +35 °C for the BDS-76.175 unit;
   - temperatures from 0 °C to +35 °C and relative humidity up to 80% at a temperature of +35 °C for the BOI-7 unit.
2. High degree of protection from the penetration of water and foreign solid particles:
   - JP 67 for the BDS-76.175 unit;
   - JP 54 for the BOI-7 unit.
3. The sensitivity is ten times higher than that of similar equipment.

Scope of Application

- Pulp-and-paper industry
- Metals industry (ferrous and non-ferrous)
- Extractive sectors (mining and chemical raw materials, ore and non-ferrous metals, coal mining enterprises, oil, gas, salt, gold, and diamonds)

Tasks Performed

1. Contactless positional control of the level of liquid and bulk materials in closed vessels, bins, and other containers.
2. Ensuring the reliability and accuracy of determining the boundaries of medium (interfaces).
3. Carrying out measurements and solving measurement tasks in extreme conditions: temperature, vibration and humidity, where other measurement principles cannot be applied.
4. Monitoring displacements of the objects.
5. Monitoring the leaks and gutters clogging, hanging of materials on the walls of the bin.
6. Monitoring that the material is on the conveyor belt.

Operating Principle

Radioisotope devices (RID) are highly effective means of non-destructive testing in the production of materials and substances.

Its operation is based on recording the gamma radiation dose rate drop on the surface of the BDS-76.175 detection unit, which is caused by a change in the state of the monitored object between the BGI gamma source unit and the BDS-76.175 unit.

Electrical pulses are generated in the detection unit, the frequency of which is proportional to the gamma radiation dose rate. The pulse frequency data are transmitted via the cable. The information is transmitted to the input of the BOI-7 information processing unit. Frequency of the incoming statistical signal is compared in BOI-7 with the threshold value of the signal frequency set when setting up the device, and the output signal is generated.

Radioisotope Fire Annunciator IP-211-1

Purpose

Radioisotope fire annunciators are designed to detect signs of ignition (when smoke and aerosol emissions appear) in harsh operating conditions: high temperatures, high humidity, the presence of radiation, etc.

Features and Advantages

1. It works efficiently in unheated rooms, in rooms with midges, mosquitoes and other insects.
2. The annunciator is designed for continuous 24h operation in the conditions of NPP reactor compartment sealed areas characterized by enhanced neutron and gamma radiation with a high temperature and high ambient humidity.
3. It restores its operability after triggering of the Automatic Fire Fighting System (other types of annunciators shall be replaced after the system triggering).
4. The technology of new alpha sources used in the annunciators allows continuing the operation of operable radioisotope detectors for another 10 years, instead of their forced dismantling and industrial disposal.
5. The annunciator works together with the PPK-2, PPS-3 fire alarm panels types and other similar Instrumentation and Control Systems.
6. Low cost of products compared to foreign analogues.
7. Prompt maintenance on the territory of the Russian Federation.

Scope of Application

- Nuclear power plants
- Manufacturers of fire safety systems
- Manufacturers of geosynthetic materials
- Storage of low-level waste at NPP
- Oil and gas sector enterprises
- Mining and metallurgical sector

Operating Principle

The action of the fire annunciator sensor is based on a decrease in the current of the ionization chamber when ignition products enter it. The annunciator electronics are triggered when aerosol or ignition products enter the chamber and generate a current surge of (20 + 2 mA), which corresponds to the “Fire” signal. It is transmitted to the control automation, which triggers a fire alarm, and the Fire Extinguishing System in the Automated Support and Suspension System.

Tasks Performed

1. Ensuring safety and protection of personnel and the public from exceeding the radiation doses/dangerous fire factors and standard values for emission and content of radioactive substances in the environment during and after a possible fire at the NPP.
2. Minimizing emissions to the environment in case of fire.
3. Minimizing the probability of fire.
4. Minimizing the need for the systematic replacement of fire annunciators after responding to smoke.

Technical Characteristics and Main Parameters

Main technical characteristics:

- output electric signal,mA 20
- power supply voltage, V . . . . . from 20 to 26
- power consumption in standby mode, mW 25

Operating conditions:

- operating temperature ranges, °C . . . . . from –30 to +100
- relative humidity at 35 °C, % . . . . . 8 maximum
- permissible air velocity, m/s . . . . . 7 maximum
- presence of gamma radiation with exposure dose rate, A/kg (P/s)[R/h] . . . . . $7.22 \cdot 10^{-6}$ ($2.8 \cdot 10^{-2}$) [100] maximum
- presence of neutron radiation with a flux density, n/s · m^2, maximum, $5 \cdot 107$ with energy, J (keV), ... $40 \cdot 10^{-16}$ (25)
- the annunciator is resistant to mechanical loads equivalent to an earthquake of . . . . . up to nine points.

The BGI-45A, BGI-60A, BGI-75A, BGI-90A, BGI-50P, BGI-MK-10 Gamma Radiation Units with a Cone and Slit Beam Aperture

Purpose

The gamma radiation unit (BGI) is used to place an ionizing radiation source in it, to form a radiation beam of closed gamma sources, and to protect service personnel from exposure to ionizing radiation during operation, storage, and transportation. It is used as part of radioisotope devices for continuous level measurement, limit level, density measurement, and together with other devices that use radioisotope methods for recording and measuring the ionizing radiation rate. Improved design solutions have been used in the manufacturing of the units to improve the quality of biological protection.

Features and Advantages

1. The valves and embedded parts are made of stainless steel, which significantly increases the reliability and durability of the units in corrosive environments.
2. The BGI units can operate in aggressive environments.
3. The use of the unit makes it possible to determine the characteristics of liquid and solid masses, i.e., molten metal, oil products in pipelines, the thickness of sheet products and various non-woven materials.
4. Prompt maintenance on the territory of the Russian Federation.
5. RID have a higher sensitivity compared with non-isotopic methods (vibration, ultrasonic). Therefore, they provide higher measurement accuracy.
6. It is possible to form a directed beam of radiation relative to the vertical or horizontal according to the customer's requirements specification (example: ±5° from the vertical plane, 45° up from the horizontal plane).
7. The radiation source is stored in a hard block, which guarantees its safety even in extreme conditions.
8. IP54 shell and stainless steel components ensure stable operation, protect against dust, moisture, and corrosion.
9. The units have four modifications, which differ in the degree of activity of the closed source and the biological protection parameters.
10. It is possible to manufacture different modifications of the gamma-ray beam depending on the production purposes: cone, slit, and multichannel.

Scope of Application

- Metals industry (ferrous and non-ferrous)
- Pulp-and-paper sector
- Chemical industry
- Food industry
- Extractive industries (MPP)
- Production of building materials and polyethylene terephthalate
- Oil and gas companies and refineries
- Coal mining industry
- Woodworking integrated plants

Operating Principle

BGI are reliable gamma radiation units that exclude the contact of the ionizing radiation source with the environment, which ensures the safety of its use.

Cs-137 is used in the BGI as an ionizing radiation source. Gamma-ray sources are placed inside a protective steel/lead shell and create a flux of particles with a certain rate and geometry. The directed beam passes through a monitored medium, which changes the characteristics of the gamma-ray flux. The detector on the other side records the degree of beam absorption and calculates the parameters of the medium. This algorithm ensures the continuity of measurements and rapid adaptation to changes in the recorded parameters.

Tasks Performed

1. It is used within the RID to measure the density of liquid products, suspensions, pulps in pipelines, as well as levels and thicknesses. Units of different sizes and with ionizing radiation sources of different activity are used in accordance with the needs of the customer.
2. Protection of personnel from the ionizing radiation during operation, transportation, and storage of the source.
3. Storage and transportation of closed ionizing radiation sources with an active component based on cesium-137.
4. They are used at the enterprises of the pulp and paper sector as part of devices for measuring the thickness of the paper web or monitoring its density.

Technical Characteristics and Main Parameters

Designation according to TS	Code name	Protection thickness (for lead), mm	Gamma source parameters				
			Source type and source category according to RB-042-07	Exposure dose rate of gamma radiation at a distance of 1 m	The activity of isotopes in the source, Bq (Cu), no more than	Dimensions, mm	
						diameter	length
ULKA. 418234.001	BGI-45A IP54	45	IGIC-3-8 Category 5	$(3.76\pm1.28)\cdot10^{-10}$ A/kg (52.1±17.2) μSv/h	$8.36\cdot10^{8}$ $(2.2\cdot10^{-2})$	6.0±0.2	$10^{-1.0}$
-01	BGI-60A IP54	60	IGIC-4-1 Category 4	$(3.76\pm1.28)\cdot10^{-9}$ A/kg (521±172) μSv/h	$8.29\cdot10^{9}$ $(2.2\cdot10^{-1})$	8.0±0.2	$12^{-1.0}$
-02	BGI-75A IP54	75	IGIC-4-4 Category 4	$(2.80\pm0.56)\cdot10^{-8}$ A/kg (3.88±0.77) μSv/h	$5.6\cdot10^{10}$ (1.5)	8.0±0.2	$12^{-1.0}$
-03	BGI-90A IP54	90	IGIC-4-6 Category 3	$(1.05\pm0.21)\cdot10^{-7}$ A/kg (145.8±29.1) μSv/h	$2.1\cdot10^{11}$ (5.6)	8.0±0.2	$12^{-1.0}$

Type of unit	Overall dimensions, mm			Weight, kg
	Length	Width	Height	
BGI-45A IP54	285	200	215	38
BGI-60A IP54	320	225	245	55
BGI-75A IP54	360	255	285	85
BGI-90A IP54	390	280	315	115

*** It is possible to manufacture different modifications of gamma radiation units for individual tasks. Modifications of the BGI-50P units and the BGI-MK-10 multichannel unit have already been developed as part of custom orders.

X-ray Fluorescence Coating Thickness Gauge RTVK-1K

Purpose

The RTVK-1K X-ray fluorescence sampling thickness gauge is designed to measure the thickness of silver-on-copper and nickel-on-duralumin coatings.

Features and Advantages

Determination of composition of coating elements is ensured.

Scope of Application

- Mechanical engineering
- Companies developing technologies for manufacturing special products with metal-based coatings

Operating Principle

The monitored object is irradiated by an external radiation source. In this case, the characteristic X-ray radiation of the coating substance, the base and possible impurities is excited in the object. The characteristic radiation has a strictly defined energy for each chemical element. The thickness (and composition of elements) of the monitored object is determined by measuring the spectral characteristics of the X-ray radiation of the elements available.

An electrical signal, the magnitude of which is proportional to the energy transmitted by the recorded radiation to the substance of the silicon detector, is transmitted from the output of the detection unit to the input of a digital spectrometric device, where it is amplified and digitally filtered. Data from the CSU digital spectrometric device are collected and processed using a dedicated program. The value of the measured coating thickness is obtained by preliminary calibration through selecting the boundaries of the window for recording the radiation of the corresponding element and the counting rate in this window.

Tasks Performed

Determination of thickness and composition.

Technical Characteristics and Main Parameters

No. Item	Parameter	Value
1.	Permissible measurement error, at least, μm	±0.1
2.	Measuring range of silver-on-copper coating, μm	0÷35
3.	Measuring range of nickel-on-duralumin coating, μm	0.2÷20
4.	The time of one measurement at one point of the silver-on-copper coating is 0.3–0.6 μm, sec	20
5.	The time of one measurement at one point of the nickel-duralumin coating is 0.3–2.5 μm, sec	20
6.	Energy range of X-ray radiation registration, keV	2.0÷30
7.	The size of the working desks, minimum, mm	100 × 100
8.	Mechanical interlock of X-ray radiation, availability	yes
9.	Light alarm on the presence of X-ray radiation, availability	yes
10.	Fixing samples on the working desk, availability	yes
11.	Sound alarm on the radiation hazard	yes
12.	The equivalent dose rate in any accessible point at a distance of 0.1 m does not exceed, μSv/h	1.0

Thickness Gauge for X-ray Fluorescence Thickness Monitoring of Special Process Coatings

RTVK-1KR

Purpose

The thickness gauge is designed to monitor the thickness of the silver coating on finned (rib from 1 mm) cylindrical parts by measuring the characteristic X-ray radiation excited by an external generating source, i.e., an X-ray tube in the coating and base material. The monitoring is carried out by recording the intensity of the characteristic X-ray radiation of the coating chemical element with a semiconductor detector in the range of 1÷60 keV.

Operating Principle

The monitored object is irradiated by an external radiation source. In this case, the characteristic X-ray radiation of the silver, base and possible impurities is excited in the object. The characteristic radiation has a strictly defined energy for each chemical element. The thickness (and composition of elements) of the monitored object is determined by measuring the spectral characteristics of the X-ray radiation of the elements available.

An electrical signal, the magnitude of which is proportional to the energy transmitted by the recorded radiation to the substance of the silicon detector, is transmitted from the output of the detection unit to the input of a digital spectrometric device, where it is amplified, digitally filtered and converted into a digital code, which is transmitted to the computer.

The value of the measured coating thickness is obtained by preliminary calibration through selecting the boundaries of the window for recording the radiation of the corresponding element and the counting rate in this window.

Technical Characteristics and Main Parameters

The measurement range of the silver coating thickness ..... 3–16 μm

Time to enter the operating mode ..... 30 min

The basic error does not exceed 1 μm for the upper value of the coating thickness monitoring range.

Thickness Gauge for Radiometric Thickness Monitoring of Special Process Coatings

Purpose

The equipment for radiometric thickness control of special structural coatings of the parts of the liquid rocket engine is designed to monitor the thickness of coatings made of precious metals on automation parts, as well as metal-fluoroplastic coatings on seal parts by measuring the spectrum of characteristic X-ray radiation in the energy range of 1÷60 keV excited by a closed radionuclide source of Am-241 in the coating and base material. The measurement is carried out by recording the intensity of the characteristic X-ray radiation of the coating chemical element.

Tasks Performed

Monitoring the thickness of precious metal coatings on automation parts, as well as metal-fluoroplastic coatings on seal parts.

Operating Principle

The monitored object is irradiated with a closed radionuclide source Americium-241. In this case, the characteristic X-ray radiation of the coating, base and possible impurities is excited in the object. The characteristic radiation has a strictly defined energy for each chemical element.

The thickness of the coating on the monitored object is determined by measuring the areas of the X-ray radiation spectral lines of the coating and base.

An electrical signal, the magnitude of which is proportional to the energy transmitted by the recorded radiation to the substance of the silicon detector, is transmitted from the output of the detection unit to the input of a digital spectrometric device, where it is amplified, digitally filtered and converted into a digital code, which is transmitted to the computer. Data from the CSU digital spectrometric device are collected and processed using a dedicated program.

The calibration file sets the window boundaries for recording a spectral radiation line of the coating and base, as well as calibration factors. We obtain the value of the measured coating thickness through the preliminary calibration by fixing the counting rate in this window.

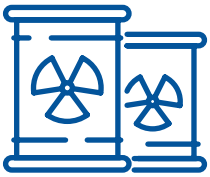
Technical Characteristics and Main Parameters

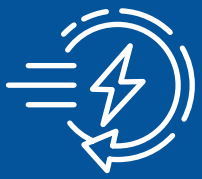
The thickness gauge measures and monitors the thickness in the following ranges:

- golden coating, μm . . . . . 1÷18;
- silver coating, μm . . . . . 1÷16;
- metal-fluoroplastic coating, μm . . . . . 10÷100.

The value of the main relative error of the equipment shall not exceed ± 15% of the actual thickness measure (surface density) of the coating.

Services





IPTP Services for Enterprises and Scientific Organizations

For Enterprises

- Charging/recharging of gamma radiation units.
- Transportation of radiation sources by special vehicles.
- Supply of radiation source units of the following types: BGI-A/FQG Berthold/Endress+Hauser (Russian and foreign).
- Supply of closed radionuclide sources of Cesium Cs-137; Cobalt Co-60, Americium Am-241.
- Transportation and temporary storage of closed radionuclide sources for the time of routine maintenance.
- Design of methods for measuring the process parameters using radioisotope methods.
- Supplying the equipment for measuring the process parameters using radioisotope methods.
- Development of layout plans for the installation of radioisotope devices (RID) on process equipment.
- Layout plans for the installation of flaw detectors with generating sources (linear accelerators).
- Design and delivery of non-destructive testing complexes with linear accelerators of domestic and foreign production.
- Maintenance and installation of complexes, installations, products, devices, and equipment containing radioactive substances.
- Design of storage facilities for sources of ionizing radiation, radioactive substances and waste.
- Delivery and follow-up setup of imported radiation source units and charging them with Russian-made radiation sources.
- Installation, adjustment, calibration, dismantling, and commissioning of Russian and imported radioisotope devices at the enterprises of the Russian Federation and neighboring countries.
- Radiation monitoring of RID by an accredited radiation monitoring laboratory.
- Installation, commissioning, calibration, maintenance of radioisotope devices and equipment: warranty and post-warranty.
- Maintenance and installation of X-ray equipment (inspection complexes/industrial tomography).
- Development of RID installation projects, its installation and commissioning.
- RID maintenance on the customer's equipment.
- Arranging transportation of RID (closed radionuclide sources) and RW in accordance with the concluded contracts.

For Scientific Organizations

- Repair of domestic and imported semiconductor detectors.
- Equipping the detectors with digital spectrometric devices that have state-of-the-art software.
- Repair of cryostats.
- Development of analytical instruments for the customer's tasks: portable X-ray analyzers; alpha, beta, gamma radiation spectrometers.
- Production and development of scintillation detectors of various shapes.
- Development and manufacturing of custom radioisotope devices.
- Verification of radioisotope density meters, thickness gauges and level gauges.
- Supply of density meters, level gauges and moisture meters from Berthold and Endress+Hauser, equipping them with domestic gamma radiation units, commissioning.
- Production of custom gamma and X-ray detection units according to the customer's requirements specification for working in special conditions, for example in hot chambers.
- Repair of the ORTEC and CANBERRA spectrometers and detectors based on high-purity germanium (HPGe).

Custom Product Manufacturing

IPTP is ready to supply custom-made products as part of the research and development activities and manufacturing the products under the customer's individual projects.

The following devices have been developed in recent years under individual needs:

- **USPEG universal gamma spectrometer.** The spectrometer is designed to identify radionuclides by the spectrum of their gamma radiation and by their activity when it is used as part of a system for analyzing reactor cores with a heavy liquid metal coolant. The spectrometer can be used to detect defective assemblies and fuel elements during the disposal and handling of the spent reactor core and to monitor radiation in spent fuel storage facilities.
- **Spectrometer of alpha-nuclide energies in aqueous and nitric acid solutions.** The device is designed to measure the energy distribution of alpha particles and conduct qualitative and quantitative analyses of aqueous and nitric acid solutions containing alpha-emitting radionuclides.
- **Coal ash content meter RKTP-6.** The device is designed for continuous non-contact measurement of the content of mineral impurities (ash content) in coal by gamma radiation backscattering.

Contacts

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