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Analytical Instruments

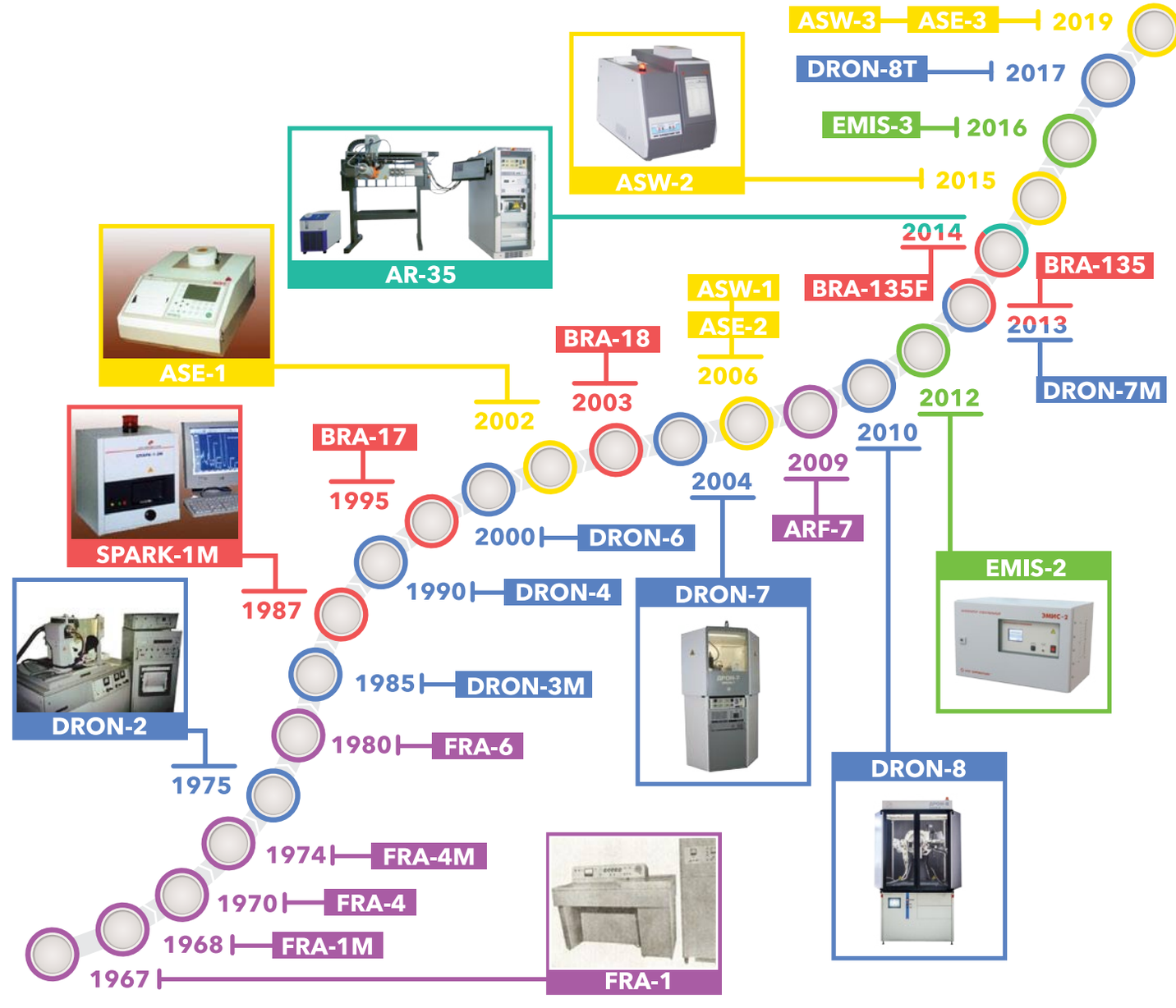
"Bourevestnik" JSC – is the CIS's largest enterprise for research, development and manufacture of X-ray equipment for industrial and scientific purpose The enterprise dates back to the year 1959, when the special design office of X-ray equipment (SKB RA) has been established and jointed together with the Bourevestnik factory, which had been produced the first domestic X-ray equipment in 1928.

For more than half a century "Bourevestnik" JSC has been creating devices for the needs of different industries and areas of scientific and technical activities such as mining and ore dressing industry, atomic power energetics, oil refining, metallurgy and machine industry, electronic industry, nanoindustry and environmental monitoring, at every turn improving the technologies with regard to progressive market requirements.

High technical level and quality of the output products still remain the guiding lines of our activities, along with custom-tailored approach of solving specific tasks , rendering of comprehensive support including personnel training, after-sales service, technical and software maintenance.

The enterprise's Quality Management System is certified for compliance with ISO 9001:2011 requirements. In addition, Bourevestnik, Inc. is certified as per the Environmental Management System ISO 14001:2007 and Occupational Health and Safety Assessment System OHSAS 18001:2007.

History of development of analytical instruments



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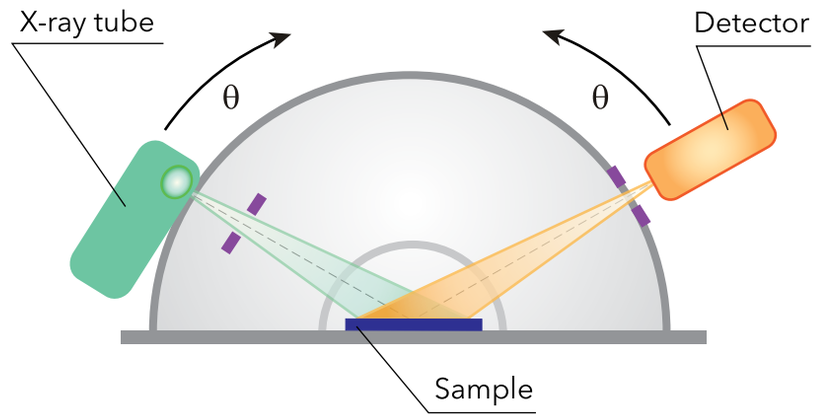
CONTENTS

DRON-8/8T X-ray Multifunctional Diffractometer

- High-precision wide-angle vertical goniometer with changeable radius
- Automated alignment of sample plane
- Implementation of various X-ray diffraction techniques
- Flexible design and wide range of options
- Variety of X-ray optical schemes
- Remote control of all devices and systems



DRON-8/8T X-ray general purpose diffractometer with vertical θ–θ goniometer and horizontal sample plane enables to perform X-ray diffraction analysis of phase composition, structural state and orientation of wide range of crystalline objects with different shape and size.

Technical data

Technical parameter		DRON-8/8T	DRON-7M
Goniometer type		Vertical θ–θ	Horizontal 2θ–θ
X-ray optical scheme		Bragg-Brentano/Debye-Sherrer/parallel-beam	
Radius R, mm		180 – 250	200
Angular range, deg	2θ	from -10 to 165	from -100 to 165
	θ		from -180 to 180
	θ_F	from -5 to 165	
	θ_D	from -5 to 95	
Scanning modes		discrete/ continuous	
Scanning methods		θ–θ, θ_F, θ_D, Ω, 2θ-Ω, ψ, $\sin^2\psi$	θ–2θ, 2θ, θ, 2θ-Ω
Smallest addressable increment, deg		0.0005/0.0001	0.001
Scanning rate, deg/min		0.1 - 50	
Reproducibility, deg		±0.001/±0.0001	±0.0025
Maximum angular speed, deg/min		600/2000	720
Radiation doze rate, mSv/h		Not more than 1	

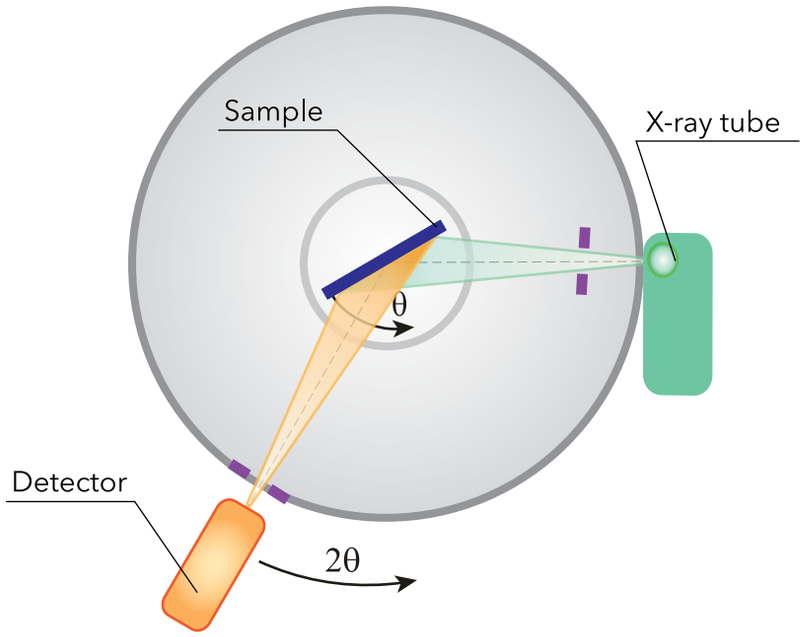
DRON-7M X-ray General Purpose Diffractometer

Horizontal two-circle 2θ–θ goniometer

High reliability and user-friendly operation

Flexible design and wide range of options

High automation for setting and measurements

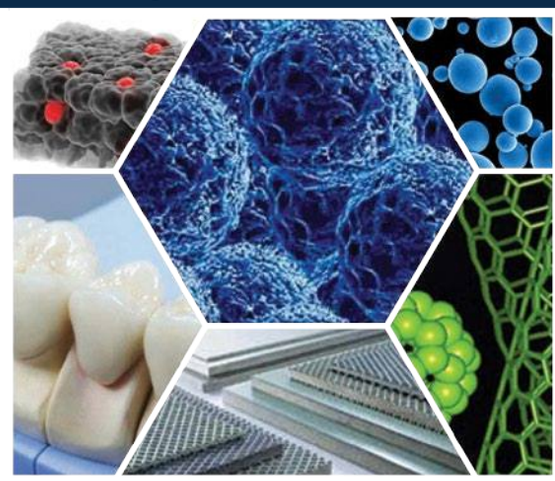


DRON-7M X-ray diffractometer is capable to solve a wide variety of tasks for powder diffraction analysis. Independent control of 2θ and θ movements allows research of single crystals.

Basic configuration includes:

- Protective cabinet with interlock system of doors
- Two-circle goniometer
- High-voltage power supply for X-ray tube
- X-ray tube with Cu anode
- Scintillation NaI detector
- Rotating sample holder for powders
- X-ray collimation system with a set of changeable slits
- Beta-filter : Ni (for copper radiation)
- Reference sample of polycrystalline quartz
- Data Collection software package for control and data collection
- Set of spares tools, accessories and replacement parts
- Personal computer

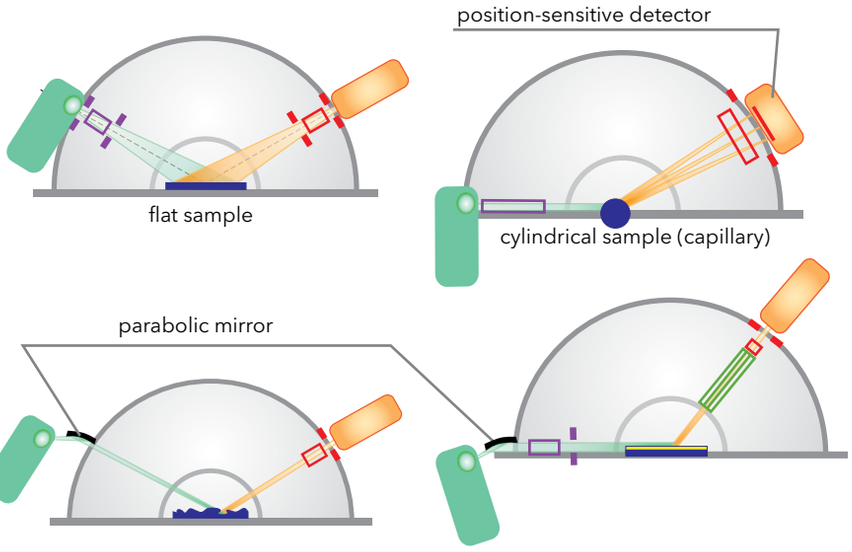
Applications of DRON-7M and DRON-8/8T X-ray Diffractometers

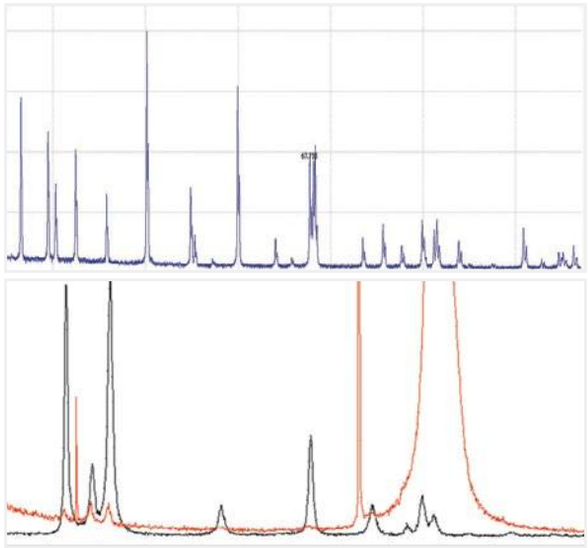
Application fields	Problems	Samples
Powder diffraction analysis in Bragg-Brentano,		
Mining industry Mineralogy Construction Machinery Energetics Oil and gas industry Chemistry Electronics Criminalistics Forensics Pharmaceuticals Crystallography Nanotechnology Examination of cultural valuables Ecology	• Qualitative and quantitative phase analysis of polycrystalline materials and objects including coatings and thin films. • Determination of crystallinity, crystallite sizes and microstrains of lattice. • Determination of lattice type and dimensions, crystal structure refinement. • Tracing of phase transitions, chemical reactions and thermal deformations of lattice in variable environment (temperature, pressure, humidity, gaseous medium or vacuum).	
Analysis of residual stresses, textures		
Metallurgy Machinery Electronics Technical crystals	• Analysis of preferred orientation of particles in metals and in other polycrystalline materials. • Determination of linear, planar and volumetric stresses in welded seams, parts and frameworks. • Determination of orientation of single crystals and different articles made of them.	
Analysis of thin films structure and		
Micro- and nano-electronics	• Determination of composition, thickness, mismatch and defects of layers in thin films, epitaxial and nanoheterostructures. • Quality control of materials for micro- and nanoelectronics.	
Structure investigation of nanomaterials		
Catalysis Colloid chemistry Electronics Molecular biology Automotive- and aircraft industry (plastics and polymers) Protection of main pipelines and cable industry Packaging industry (nanocomposites and films)	• Determination of shape, size, phase composition, internal structure, orientation and distribution of nanoparticles in surface-active material, emulsions (including in biological mediums), fibres, catalysts, polymers, nanocomposites, liquid crystals and other disperse systems.	

X-ray optical schemes

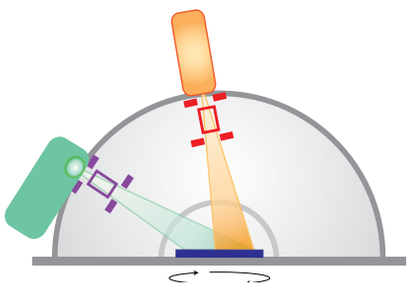
Typical diffraction patterns

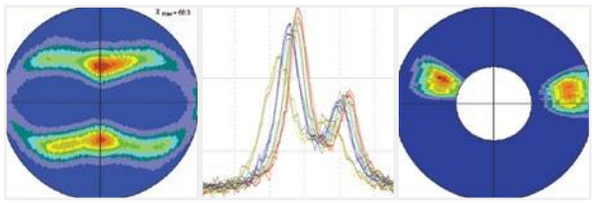
Debye-Sherrer, grazing incidence and parallel-beam geometries.



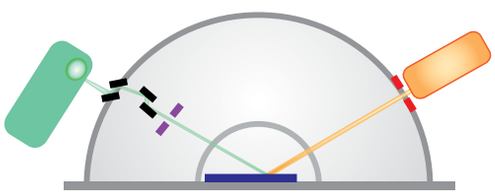


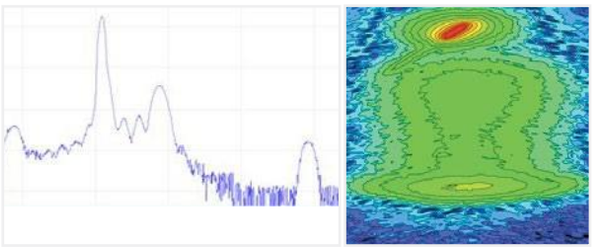
determination of crystal orientation



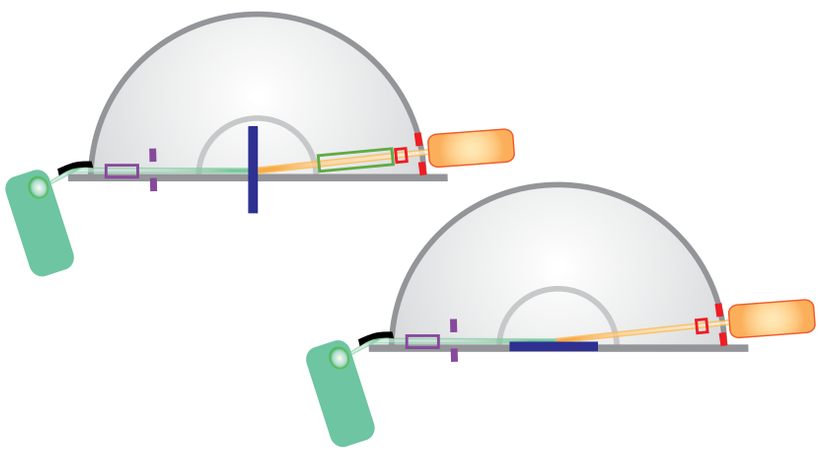


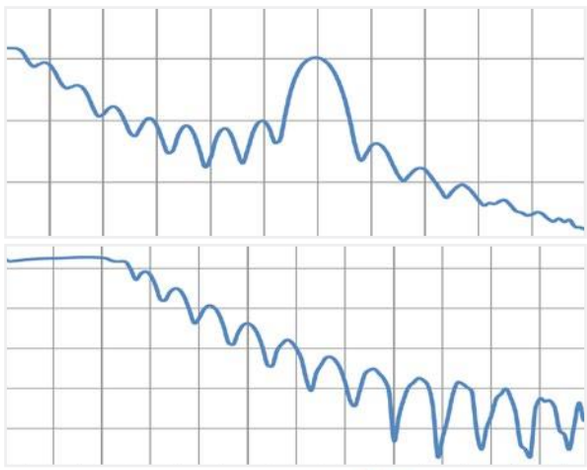
single crystals in high resolution geometry



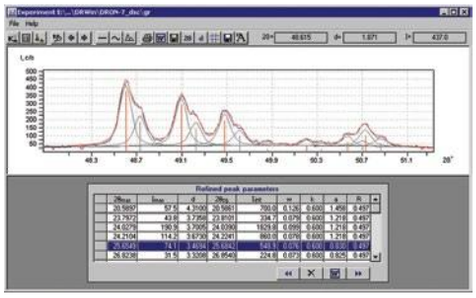


by small-angle X-ray scattering and reflectometry





Software for DRON-7M and DRON-8/8T X-ray Diffractometers

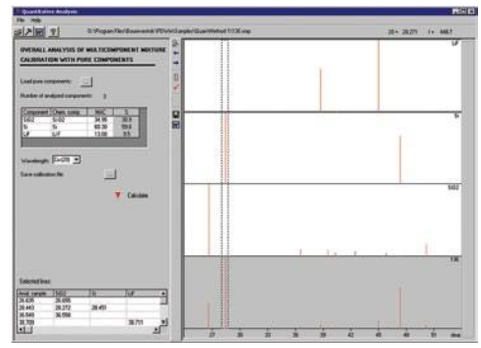


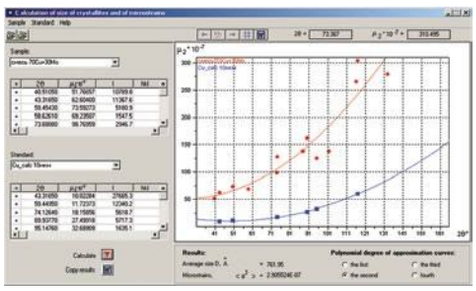
Data processing - DrWin

- Processing of diffraction pattern or selection
- Background approximation (by polynomial or user curve)
- Separation of Kα-doublets
- Peak seach and determination of their anglular positions
- Approximation of reflection profiles by pseudo-Voigt function (for the entire array or independently for each peak)
- Calculation of peak heights and their integral intensities
- Calculation of FWHM of reflections

Quantitative phase analysis - Quan

- Overall analysis of multicomponent mixture
- Analysis of n-component system
- Analysis of sample with known mass absorption coefficient
- Method of internal standard
- Method of Reference Intensity Ratios (RIR's)
- Method of additives
- Method of reduction



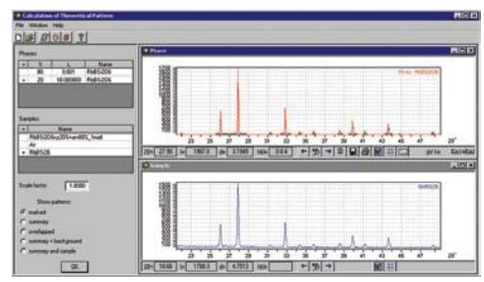


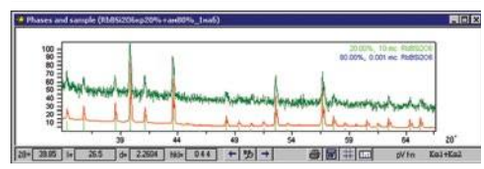
Calculation of average size of coherent domains and of microstrains - Size&Strain

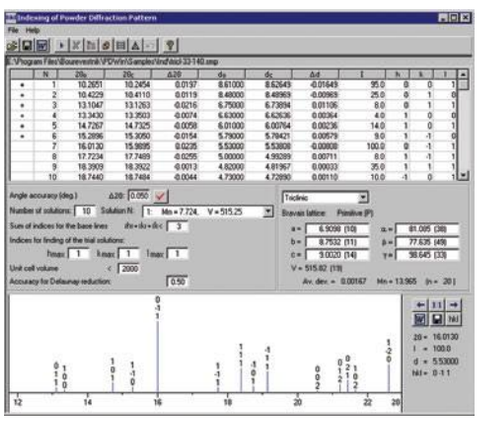
- Calculation of size of coherent domains and microstrains by the method of second central moments
- Calculation of instrumental line broadening
- Application of absorption correction to the samples with another composition

Calculation of theoretical diffraction pattern - TheorPattern

- Simulation of diffraction patterns of multicomponent mixtures from structural data
- Account for of instrumental factor
- Account for texture and crystalline size for each component
- Comparison of simulated and measured diffraction patterns
- Integrated package of geometrical crystallography



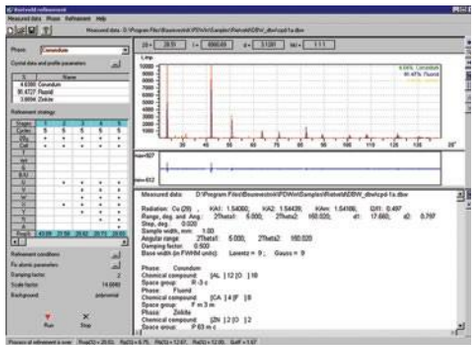




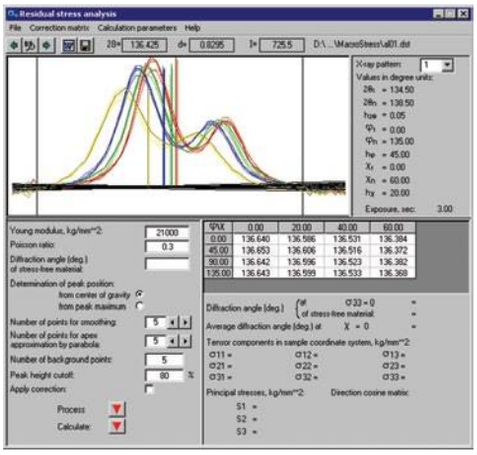
Auto indexing of Powder Diffraction Pattern - Ind

- Determination of Bravais lattice type
- Choice of unit cell
- Computation of Miller indices for selected lines
- Bar graph of input diffraction pattern

Full profile analysis by Rietveld method - Rietveld



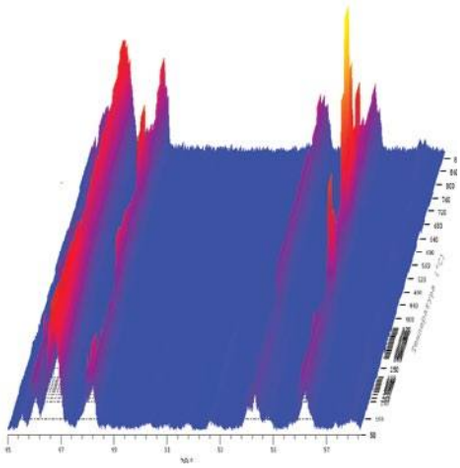
- Refinement of crystal structures from X-ray powder diffraction data of single crystalline phases and mixtures
- Calculation of polynominal and physical background
- Independent refinement of U, V, W, X, Y profile for different phases and for different groups of reflections
- Refinement of unit cell parameters, atomic and thermal parameters, occupations of atomic positions for each phase
- Choice of refinement strategy
- Control of Refinement conditions
- Calculation of five R-factors



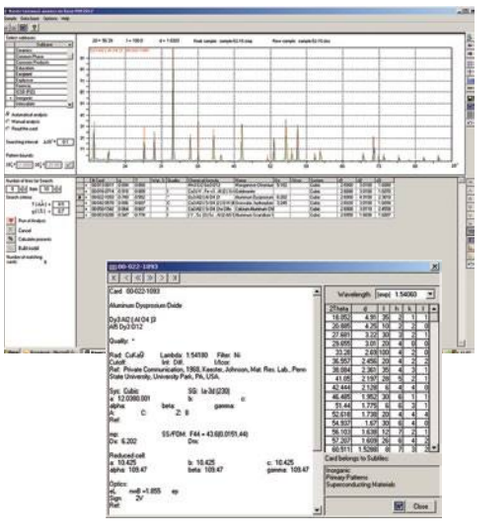
Residual stress analysis - MacroStress

- Calculation of peak angular position from center of gravity or from peak topapex
- Application of correction matrix
- Calculation of linear, planar and volumetric stresses
- Calculation of stress deviations

High temperature-X-ray diffraction - Thermo



- 3D-imaging of measured data in “diffraction angle - intensity - temperature” co-ordinates
- Calibration of the measured data set by internal or external standard
- Refinement of unit cell parameters of the calibrated data set
- Determination of phase transition points
- Determination of thermal expansion coefficients (TEC) in different directions and thermal deformation tensors
- Building of TEC figures

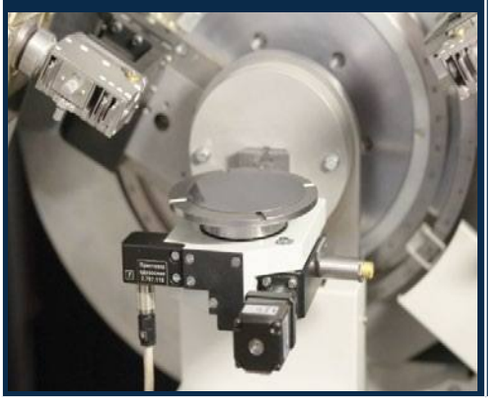
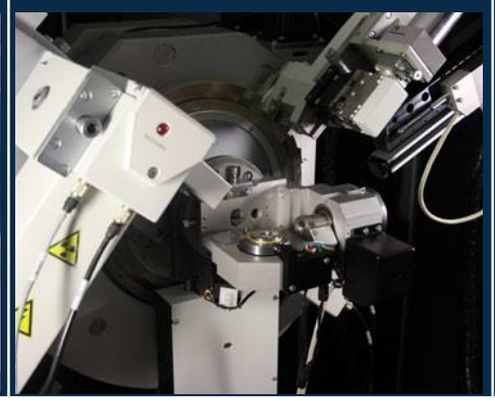
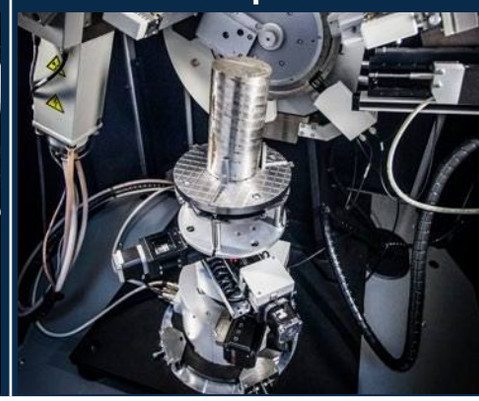


Qualitative phase analysis and access to the Powder Diffraction File database - Retrieve and Search-Match

- Use of PDF-2/PDF-4 database of International Center of Diffraction Data (ICDD) for qualitative analysis
- Automatic or manual search algorithm
- Creation of user subbases for search facilitation
- Addition of user standards into subbases
- Qualitative phase analysis by different criteria, bases (subbases)
- Analysis of lines matched by angular position and intensity
- Quantitative phase analysis by Reference Intensity Ratios (RIR’s) method
- Access to the data base including search by selected criteria

Options for DRON-7M and DRON-8/8T Diffractometers

Multidrive attachments and sample stages

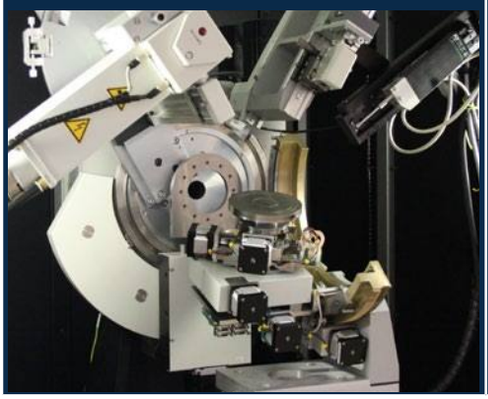
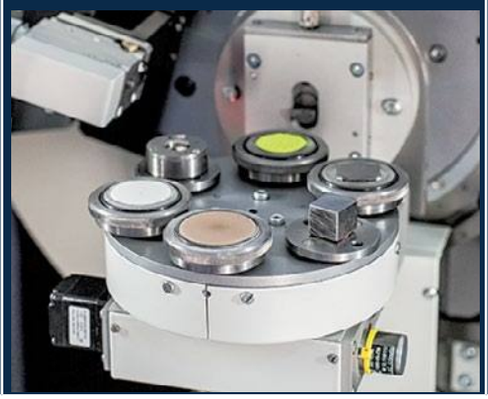
Single-axis φ-attachment	Two-axis φχ-attachment	Four-axis xyzφ holder for large samples
		
for DRON-8/8T	for DRON-7M, DRON-8/8T	for DRON-8/8T

Analysis of textures and residual stresses in polycrystalline materials, determination of single crystal orientation, study of phase composition and structural characteristics of powder and bulk objects.

Analysis of lattice dimensions and quality of single crystals in different crystallographic directions.

Mapping of phase composition and structural characteristics across sample surface, analysis of layer composition and structure in thin films.

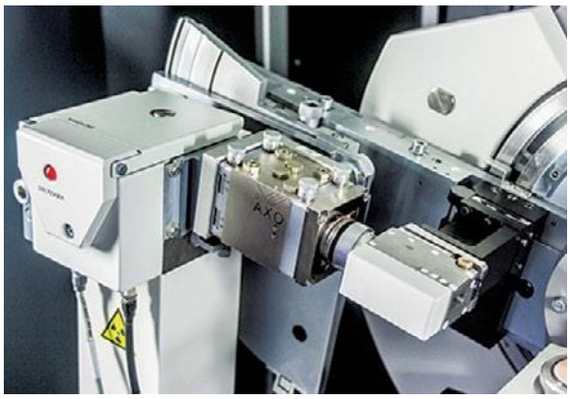
Maximal sample weight		
1 kg	0.3 kg	50 kg
Maximal sample dimensions (Ø x h)		
100x20 mm	28x10, 15x100 mm	300x250 mm
Automatic alignment of sample plane, accuracy		
5 µm	-	5 µm
Smallest selectable step of φ-rotation		
0.001 deg.	0.1 deg.	0.001 deg.
Smallest selectable step of χ-inclination		
-	0.001 deg.	-
Range of χ-inclination		
-	from -3 to +70 deg.	-
Range of xy-movement		
-	-	±100 mm
Smallest selectable step of xy-movement		
-	-	0.1 mm
Scanning modes		
Ω, Ω–ϕ, 2θ–Ω, ψ, $\sin^2\psi$	Ω, Ω–ϕ, χ–ϕ 2θ–Ω, ψ, $\sin^2\psi$	Ω, Ω–ϕ, 2θ–Ω, ψ, $\sin^2\psi$

Multi-purpose five-axis xyzφχ-attachment	Autosampler	Stage for cylindrical samples
		
for DRON-8/8T	for DRON-7M, DRON-8/8T	for DRON-7M, DRON-8/8T
Analysis of textures and residual stresses in polycrystalline materials, determination of single crystal orientation, study of phase composition and structural characteristics of powder and bulk objects. Mapping of phase composition and structural characteristics across sample surface, analysis of layer composition and structure in thin films. Analysis of lattice dimensions and quality of single crystals in different crystallographic directions, mapping of reciprocal space.	Continuous measurement of powder and bulk samples in automatic mode. Speed of sample rotation: 0.5 or 1 rps.	Measurements of cylindrical samples (capillaries) of 0.1-1.0 mm in diameter in Debye-Sherrer geometry (transition mode).

Maximal sample weight		
1 kg	-	-
Maximal sample dimensions (Ø x h)		
100x10 mm	28x25 mm	Ø 0,1-1,0 mm;length up to 100 mm
Automatic alignment of sample plane, accuracy		
5 µm	5 µm	-
Smallest selectable step of φ-rotation		
0.001 deg.	-	-
Smallest selectable step of χ-inclination		
0.001 deg.	-	-
Range of χ-inclination		
from -5 to +95 deg.	-	-
Range of xy-movement		
±20 mm	-	-
Smallest selectable step of xy-movement		
0.1 mm	-	-
Scanning modes		
Ω, Ω–ϕ, χ–ϕ 2θ–Ω, ψ, $\sin^2\psi$	θ–θ(DRON-8/8T); 2θ–θ(DRON-7M)	2θ

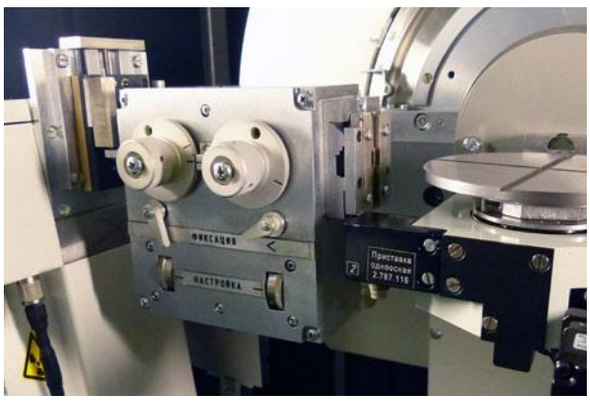
Options for DRON-7M and DRON-8/8T Diffractometers

X-ray optical elements



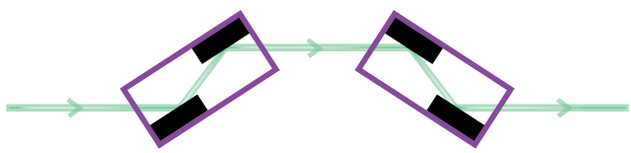
One-dimensional parabolic mirror for DRON-7, DRON-8/8T.
Converts a divergent primary beam to a parallel one, makes it monochromatic and enhances intensity.
Application:

- Measurements of samples with uneven surface.
- Small-angle X-ray scattering (SAXS).
- Grazing-incidence X-Ray diffraction (GIXRD).
- X-Ray reflectivity (XRR).



4-bounce channel-cut Ge 220 x 4 monochromator of Bartels type for DRON-8/8T

- Converts to high-resolution geometry.
- Singles out pure monochromatic Kα1 line with the angular resolution of 12 arc. sec.

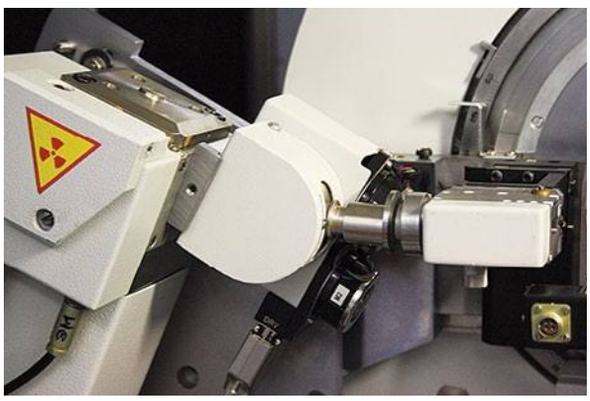


Polycapillary lenses for DRON-8/8T
Focusing lens provides:

- Intensity gain of primary beam 50-100 times.
- beam spot on sample surface is 50-100 μm.
- Microanalysis in different points of sample surface.

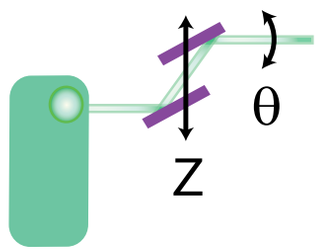
Collimating semi-lens forms quasi-parallel beam of Ø 10 mm to perform:

- Measurement of uneven surfaces in parallel-beam geometry
- Analysis of texture and residual stress.

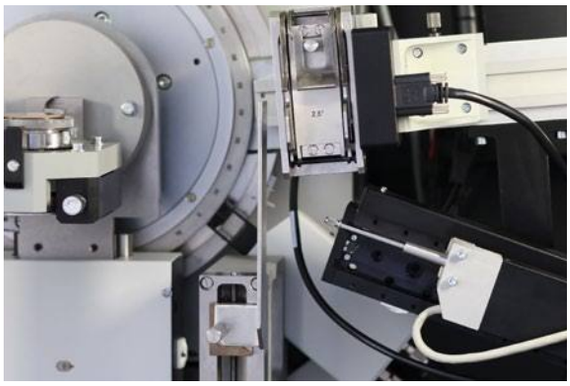


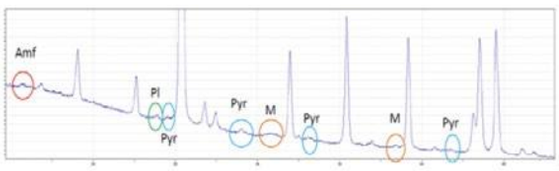
Versatile motorized monochromators for DRON-7M, DRON-8/8T

- Plate or channel-cut crystals.
- Any material (Ge, Si, SiO_2, LiF, graphite, etc.).
- Any crystallographic orientation (111, 100, 110 etc.).
- Any radiation (from Mo to Cr).
- Cuts background and beta-line.
- Singles out monochromatic Kα1 line.
- Remote adjustment of crystal.



Fast registration system





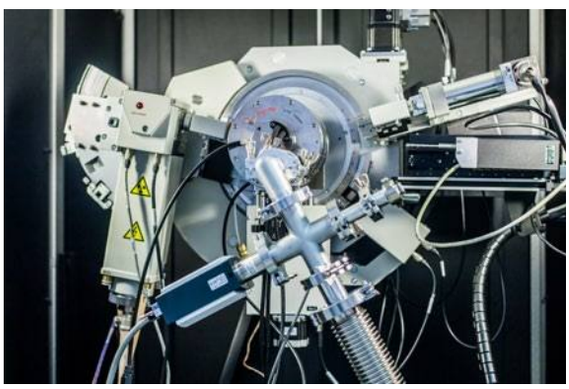
Fast registration system with linear stripped PSD Mythen2 R 1D и Mythen2 R 1K (Dectris, Switzerland) for DRON-7M, DRON-8/8T.

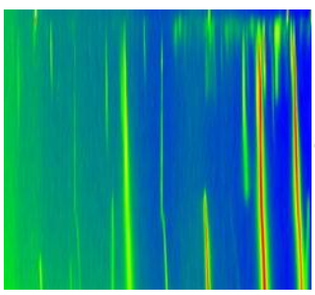
- Strip width, μm: 50 ± 3.
- Number of channels: 1280 (2 R 1K) and 640 (2 R 1D).
- Active area, mm^2: 8 x 64 (2R 1K) and 8 x 32, 4 x 32 (2R 1D).
- Measurement time is 100 times less.
- Angular resolution is the same as for scintillation counter.
- Increase of signal/noise ratio, especially for the weak reflections.
- Increase of sensitivity limit.
- Suppression of X-ray fluorescence background.
- Automatic calculation of strip aperture, goniometer radius and zero angle during alignment and calibration of PSD.

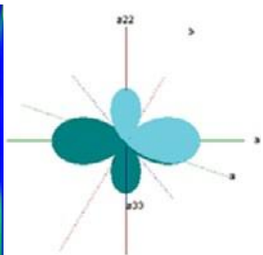
Application:

- Measurements of large number of samples in a limited period of time.
- Analysis of residual stress.
- Study of poorly crystallized and quickly decomposed materials.
- Real-time studies of phase transformations and chemical reactions.
- Identification of minor impurities.
- Measurements of small quantities of material.

Non-ambient chambers







HTK-1200N oven-chamber for DRON-7M, DRON-8/8T
Operation temperatures: from +25 to +1200 ºC
Atmospheres: vacuum (10^{-4} mbar), air, inert gases

HTK-16N/2000N strip-heater chambers for DRON-8/8T
Tungsten (W) heater (in vacuum): from +25 to +2300 ºC
Platinum (Pt) heater (in vacuum, on air, or in atmosphere of inert gas): from +25 to +1600 ºC

TTK-600 Low-temperature chamber for DRON-8/8T
Operation temperatures: from -190 to +600 ºC
Atmospheres: vacuum (10^{-2} mbar), air, inert gases

CHC$^+$ cryo & humidity chamber for DRON-8/8T
Operation temperatures (in vacuum): from -5 to +400 ºC
Humidity range: 5 – 95% at temperatures from +10 to +60 ºC

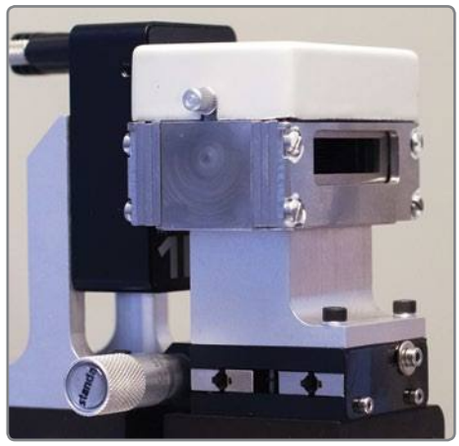
Vacuum equipment for DRON-8/8T

Application: tracing of phase transitions and chemical reactions, polymorh screening, analysis of thermal deformations of lattice in variable environment (temperature, pressure, humidity, gaseous medium or vacuum).

COLIBRI Benchtop X-ray Diffractometer

COLIBRI portable XRD system is a new advanced solution of Bourevestnik JSC for scientific, educational and industrial applications.

The instrument is a convenient and mobile tool for phase identification and structural analysis of various polycrystalline materials.



Vertical θ–θ goniometer of unique design with horizontal sample position

Available configuration with Mythen 1D linear position-sensitive detector

Built-in cooling system

Pre-aligned and ready to use

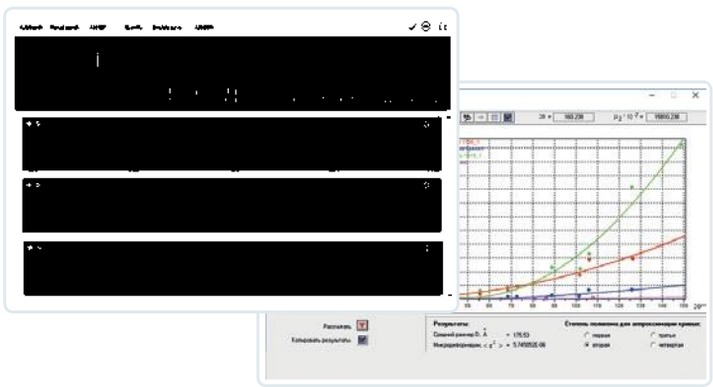
Main technical specification

Goniometer	Vertical θ–θ
X-ray optical scheme	Bragg-Brentano
Goniometer radius, mm	150
Angular 2θ range, degree	from -5 to +160 (basic configuration) from -3 to +140 (with Mythen 1D PSD)
Slew speed, deg/min	1000
Scanning mode	discrete/continuous
Scanning 2θ speed, deg/min	from 0,01 to 100
Smallest selectable 2θ increment, degree	0,005
Angular accuracy of peak position determination, degree	0,02
High voltage power supply, maximal output power, W	600
Power requirements, V/Hz	220/50 single phase
Power consumption, VA	3500
Weight, kg	100

Software for instrument control, data acquisition and processing of XRD patterns

- Access control to customized functions for different users
- Push-button execution of high-voltage regime and measurement
- Build-in touch screen for flexible operation
- Remote operation and measurement control
- Easy switch between minimum scan time and maximum resolution to get required data quality
- Automated data processing after measurement

Crystallographic software suite for analysis of powder diffraction data (optional)



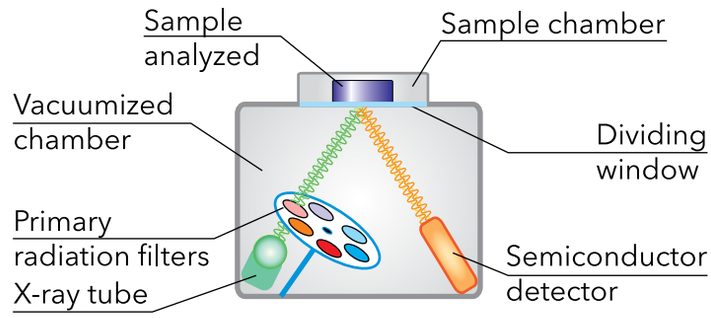
- Phase identification and quantification of mixtures
- Degree of crystallinity estimation
- Unit cell determination
- Crystallite size & Lattice strain analysis
- Rietveld refinement of crystal structure

Application fields

- Mineralogy and Mining
- Metallurgy and Machinery
- Cements and Refractories
- Chemistry and Catalysis
- Forensics and Expertise
- Medicine and Pharmacy
- Science and Education
- Environmental control

BRA-135F XRF Energy Dispersive General Purpose Spectrometer

- Wide range of detected chemical elements – $_{9}F$ - $_{92}U$
- High sensitivity due to optimal X-ray optical path
- High resolution of ultra-modern SDD detector
- Fundamental parameter (FP) Method for steel and alloy quantitative analysis
- Built-in control PC
- Patent for X-ray transparent dividing window



Completely satisfies the requirements of radiation safety.

X-ray fluorescence energy dispersive general purpose spectrometer BRA-135F allows simultaneous determination of chemical elements by characteristic energies in the 1 to 30 keV range (where elements from F till U are fitted) over a wide scope of concentrations from hundreds ppb. BRA-135F analyzes solid, powder and liquid samples, thin layer on the surface or precipitated on filters.

Operating principle

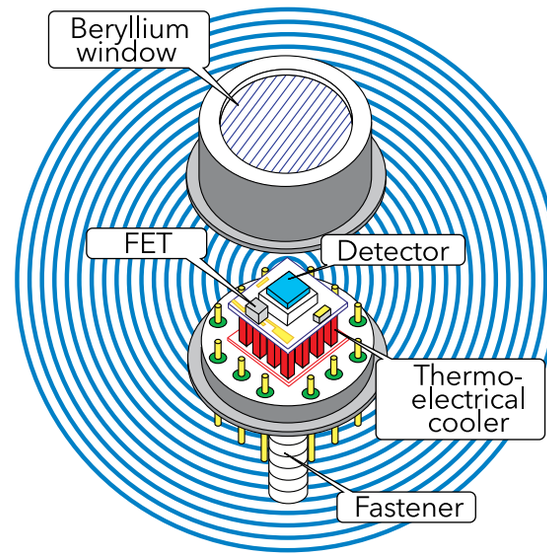
The spectrometer operating principle is based on excitation of fluorescence radiation of atoms in the substance being analyzed by radiation coming from the low-power X-ray tube. The fluorescence radiation from the sample gets into the SDD semiconductor detector where quanta of different energies are converted into electrical pulses, which amplitudes are proportional to the energy of absorbed quanta. Pulse-frequency rate with the certain amplitude is proportional to the chemical element concentration in the sample.

Method advantages

X-ray fluorescence analysis (XRF) occupies a leading position among the other methods for determination of the quantitative elemental composition of substances. XRF advantages are as follows: nondestructive measurements, multielement determination, express method, high accuracy of analysis, wide range of measured concentrations, development level of quantitative analysis theory, possibility for quantitative analysis with absence of standard samples.

High efficiency SDD detector

The silicon drift detector (SDD) with ultra-thin entrance window allows to register x-ray radiation in wide energy range on retention of energy resolution and response.



Detector scheme

Low detection limit

Owing to optimally selected materials and thickness of primary radiation filters, high transparent X-ray optical scheme, a low detection limit can be achieved for all elements to be analyzed. In the range of light elements from ^{9}F to ^{17}Cl low-energy radiation registration becomes possible using vacuum where the optical path of radiation passes.

Changer is able to carry solid, liquid or powder samples

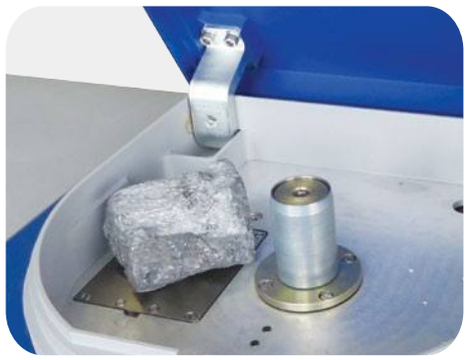
Large or irregular shape samples

It is possible to measure large-size or odd-shaped samples:

- Large-size minerals and nuggets;
- Industrial articles for analysis for ROHS requirements;
- Metals and alloys incoming control;
- Analysis of liquids in the special cells or on the special filters.

Compact body and functionality

- The housing spectrometer ensure fully radiation-protection;
- Handles for carrying;
- Built-in operational computer (PC);
- LAN port for remote control and archiving of measurement results;
- LIMS integration is available;
- Easy report creation;
- Password protection and separation of access rights.



Irregular shape samples

Technical data

Range of detected elements	^{9}F - ^{92}U
Limits of detection without preliminary enrichment, % - for elements from Na to Mg - for elements from Al to Cl - for elements from K to U	 $n*10^{-2}$ 0,002 0,0005
Limit of determination at sample preconcentration (depending on chemical element), %	$1.5*10^{-5}$
Limit of determination in mid group element (liquid), g/dm^3	$n*10^{-3}$
Average time of one sample analysis, s	100
Energy resolution on MnKa line at pulses counting rate up to 10^4 s^{-1}, not more than, eV	145
Max. voltage of X-ray tube, kV	50
X-ray power, W	10
X-ray tube cooling	by air
Primary X-ray radiation filters, pcs	5
Number of samples installed into sample changer, up to changer #1 (Ø34 mm samples) changer #2 (Ø34,36,40,44 mm samples)	 15 11
Maximum sample size, mm	Ø 200x60
Ethernet connection	Yes
Possibility for remote control	Yes
Overall dimensions (LxWxH), mm	700x410x400
Instrument weight, max, kg	65
Power	220 V, 50 Hz
Power consumption, W	500

Fileds of application

Methodology description

Oil analysis

For measuring purposes of trace elements Al, Ba, Ca, Cu, Fe, Mn, V, Ni, Pb, Zn, P into oil and petrochemicals appropriate methodology was developed.

Analytic complex consisting of BRA-135F and measuring methodology is capable of carrying out quantitative element analysis of petrochemicals in order to define metal trace elements and can be used to analyse exhausted motor oils of aircraft, machines, special motor vehicle in order to identify deterioration rate of engines and define applicability of technical service for it. Methodology is purchased additionally.

Besides BRA-135F could be used for testing as per ASTM D4294 and ASTM D6481. These test methods cover the measurement of sulfur, Barium, Calcium, Magnesium, Phosphorus, Zinc & Chlorine in hydrocarbons, such as lubricating used oil, diesel, naphtha, kerosene, residuals, lubricating base oils, hydraulic oils, grease, jet fuels, crude oils, gasoline (all unleaded), and other distillates. Additionally, sulfur in other products, such as M-85 and M-100, may be analyzed using this technique.

Detection limits of BRA-135F according to certified methodology (ppm):

P	Al	Mn	Ba	Pb	V	Cu	Ni	Fe	Zn	Ca
100	100	5	50	5	5	5	5	5	5	50

Cement materials analysis

For measuring purposes of mass fraction of Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, Cr, Mn, Fe, Zn, Rb, Sr into cements and cement production materials (clinkers, raw mixes) suitable methodology was developed.

Analysis methodology includes algorithms of principal components determination using X-ray energy-dispersive fluorescent spectrometers BRA-135F and is based on recommendations from GOST 5382-91, GOST R 55410-2013 (ISO 12677:2011).

There is provided remelting method into platinum crucibles (according to GOST R 55410-2013) for samples preparation in the methodology.

Advanced software

BRA-135F software is the optimal combination of high performance and functionality with an intuitive interface and tooltips. Owing to this, performance of routine measurements requires no special trained staff.
Only few simple steps are enough to make a measurement: select the sample position, enter its code, choose the research method and run the analysis.

Excellent methodical support

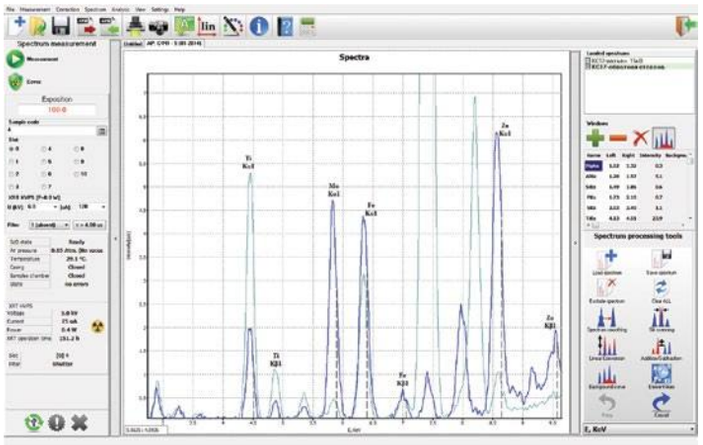
Bourevestnik JSC has a methodological support of spectrometers, including the development and validation of methods for determining the elemental composition of various materials: oil products, ores, rock, slag, refining products, cement and raw mixes, soil and sediment, water, air.

Qualitative and quantitative analysis

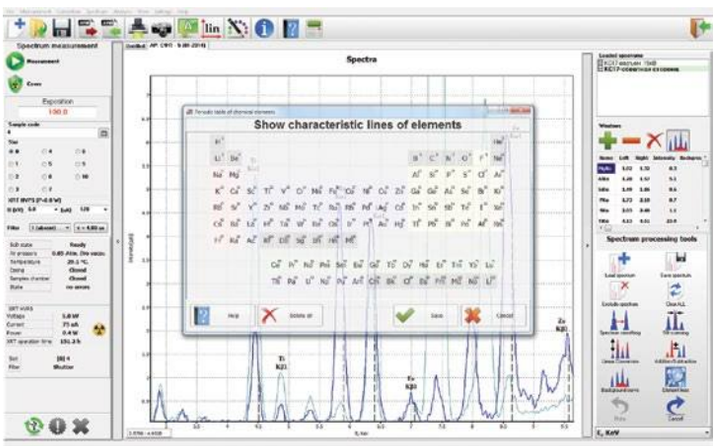
BRA-135F software unveils wide opportunities for on-line receiving of information on the chemical composition of the material to be analyzed. The user chooses the method of substance analysis: qualitative or quantitative.
Registered spectra can be:

- saved in suitably structured archive;
- got out for repeat analysis based on a new calibration characteristics;
- processed as per user's request: added, deducted, KLM-marked;
- scaled.

For operator convenience in operation, the auxiliary utilities were implemented to minimize errors during the analysis. For example, semi-automatic marker of lines allows correct identification of spectral lines of different elements.



Spectrum measuring and its processing conditions

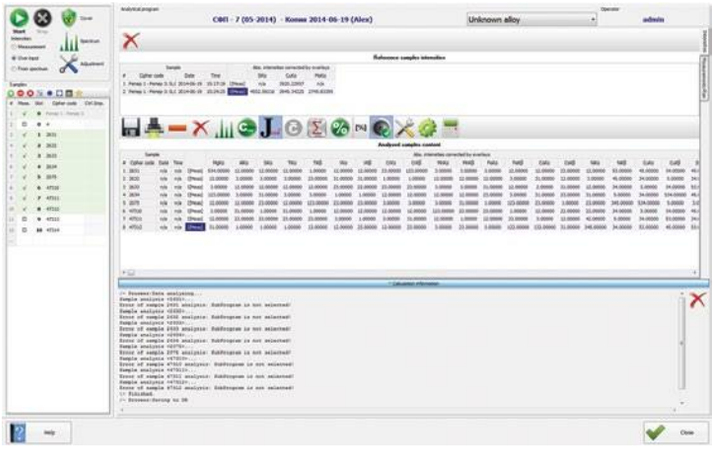


Spectrum measuring and its processing conditions

Fundamental parameters method

The software implementing fundamental parameters method allows semi-quantitative and quantitative determination of elements within the range from Mg (12) to Pb (82) in solid samples of steels and alloys with composition of 0.1% to 100%.
If there are no standard composition samples, to calibrate the spectrometer and with large list of materials under analysis, the standardless semi-quantitative analysis is implemented, which represents the following dependences:

- integrated spectrometer sensitivity on Z element;
- relative (to the integral sensitivity) intensity of analytical line corrected for background and drift, on sample composition (this dependence was implemented through absorption parameter P).



Fundamental parameters method

ASE-2 XRF Energy Dispersive Sulfur Analyzer

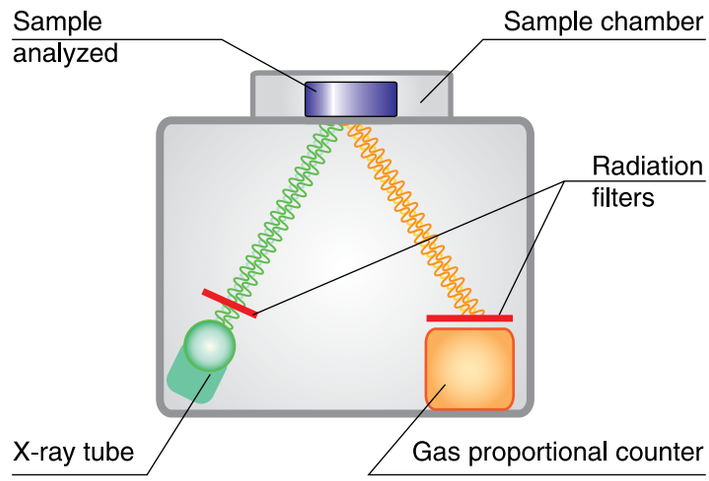
Range of determined sulfur concentrations – from 5 mg/kg to 5 %

Measurement process meets ASTM D4294, ISO 20847

Helium is not required

Connection to PC

LIMS integration



The energy dispersive sulfur (EDX) analyzer for determination of sulfur mass fraction in petrochemicals is according to: EN ISO 20847:2004; ASTM D4294; ISO 13032:2012; EN ISO 8754:2003

Fully radiation-protected.

X-ray fluorescence energy dispersive sulfur analyzer ASE-2 is used for the measurement of mass concentration of the sulfur in unleaded gasoline, diesel oil, crude oil, kerosene, petroleum residues, lubricating oil, hydraulic oil, jet engine fuel and other types of cutter oil.
X-ray radiation of low-powered X-ray tube converted by primary radiation filter excites atoms fluorescence radiation of the sample being analyzed. Radiation beams (primary X-ray radiation scattered on the sample and secondary fluorescence one) are fed to the gas proportional counter; in this case the fluorescence radiation of sulfur atoms (SKα) is separated from radiation of other energies with the help of selective filters. Intensity of fluorescence radiation of sulfur atoms registered by the gas proportional counter is proportional to sulphur mass fraction in the sample.

Technical data

Sulfur mass fraction determination method	X-ray fluorescence energy dispersive sulfur (EDX) analyzer with selective filters
Statistic limit of detection, max., ppm	3
Range of determined sulphur concentrations, ppm	5 - 50000
Limits of basic relative error, %	±0.5
Power consumption, W (220 ACV, 50 Hz mains)	60
Instrument weight, max, kg	12
Overall dimensions (LxWxH), mm	430x350x200

ASW-2 XRF Wavelength Dispersive Sulfur Analyzer

Range of determined sulfur concentrations – from 3 mg/kg to 5 %

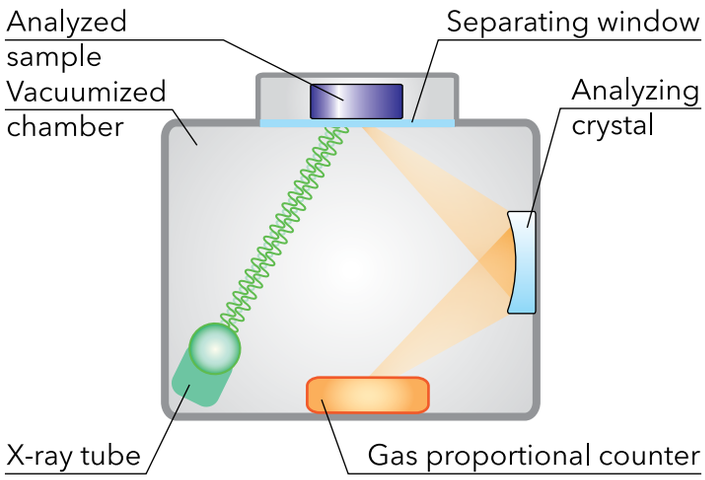
Vacuumized measurement chamber, helium purging is not required

Helium purging option is avalible

Touch screen display

LIMS integration

Results storage



The wavelength energy dispersive sulfur (WDX) analyzer for determination of sulphur mass fraction in petrochemicals is according to:
EN ISO 20884:2004; ASTM D 6334, ASTM D 2622

Fully radiation-protected.

X-ray wavelength dispersive sulfur analyzer ASW-2 is used for the measurement of mass concentration of the sulfur in unleaded gasoline, diesel oil, crude oil, kerosene, petroleum residues, lubricating oil, hydraulic oil, jet engine fuel and other types of cutter oil.
Analyzer ASW-2 allows to measure mass concentration of the sulfur in vacuumized measurement chamber mode, as well as in helium purging mode. For this purpose the instrument is equipped with the set of tooling for the connection to helium station.

Technical data

Sulfur mass fraction determination method	X-ray fluorescence wavelength energy dispersive (WDX) analyzer with vacuumized chamber
Statistic limit of detection, max., ppm	1.5
Range of determined sulphur concentrations, ppm	3 - 50000
Limits of basic relative error, %	±0.5
Power consumption, W (220 ACV, 50 Hz mains)	250
Instrument weight, max, kg	45
Overall dimensions (LxWxH), mm - analysis unit - vacuum system	 450x415x530 320x320x150

ASE-3 XRF Energy Dispersive Sulfur Analyzer

The energy dispersive sulfur (EDX) analyzer for determination of sulfur mass fraction in petrochemicals is according to: EN ISO 20847:2004; ASTM D4294; ISO 13032:2012; EN ISO 8754:2003

Fully radiation-protected.

Range of determined sulfur concentrations – from 5 mg/kg to 5 %

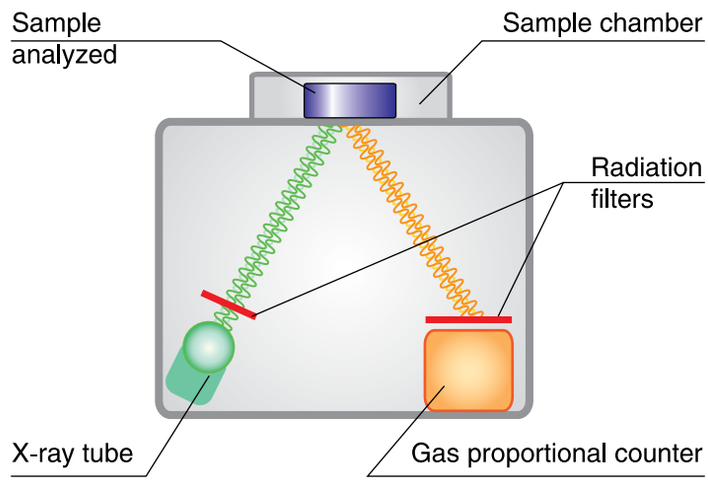
Helium is not required but helium purged optical path to maximize sensitivity is available

Touch screen display

Connection to PC

LIMS integration

Autosampler



X-ray fluorescence energy dispersive sulfur analyzer ASE-3 is used for the measurement of mass concentration of the sulfur in unleaded gasoline, diesel oil, crude oil, kerosene, petroleum residues, lubricating oil, hydraulic oil, jet engine fuel and other types of cutter oil.
X-ray radiation of low-powered X-ray tube converted by primary radiation filter excites atoms fluorescence radiation of the sample being analyzed. Radiation beams (primary X-ray radiation scattered on the sample and secondary fluorescence one) are to get to the gas proportional counter; in this case the fluorescence radiation of sulfur atoms (SKα) is separated from radiation of other energies with the help of selective filters. Intensity of fluorescence radiation of sulfur atoms registered by the gas proportional counter is proportional to sulphur mass fraction in the sample.

Technical data

Sulfur mass fraction determination method	X-ray fluorescence energy dispersive sulfur (EDX) analyzer with selective filters
Statistic limit of detection, max., ppm	3
Range of determined sulphur concentrations, ppm	5 - 50000
Limits of basic relative error, %	±0.5
Number of samples installed into sample changer, up to	3
Power consumption, W (220 ACV, 50 Hz mains)	60
Instrument weight, max, kg	12
Overall dimensions (LxWxH), mm	483x423x209

ASW-3 XRF Wavelength Dispersive Sulfur Analyzer

Range of determined sulfur concentrations – from 3 mg/kg to 5 %

Vacuumized measurement chamber, helium purging is not required

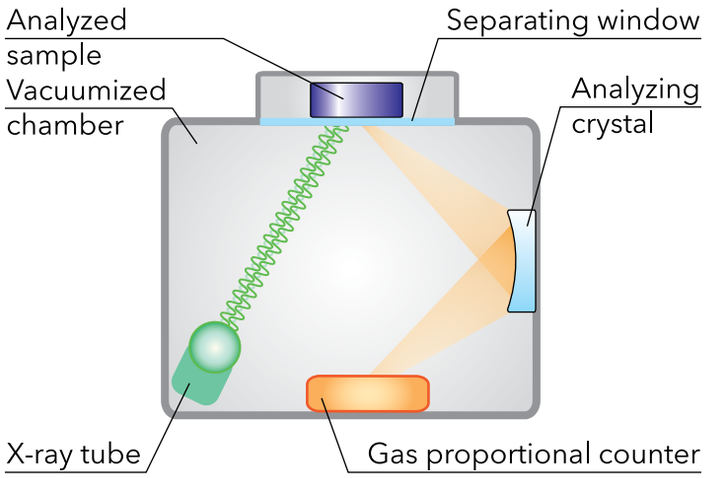
Helium purging option is avalible

Touch screen display

LIMS integration

Results storage

Autosampler



The wavelength energy dispersive sulfur (WDX) analyzer for determination of sulphur mass fraction in petrochemicals is according to:
EN ISO 20884:2004; ASTM D 6334, ASTM D 2622, ASTM D 4927

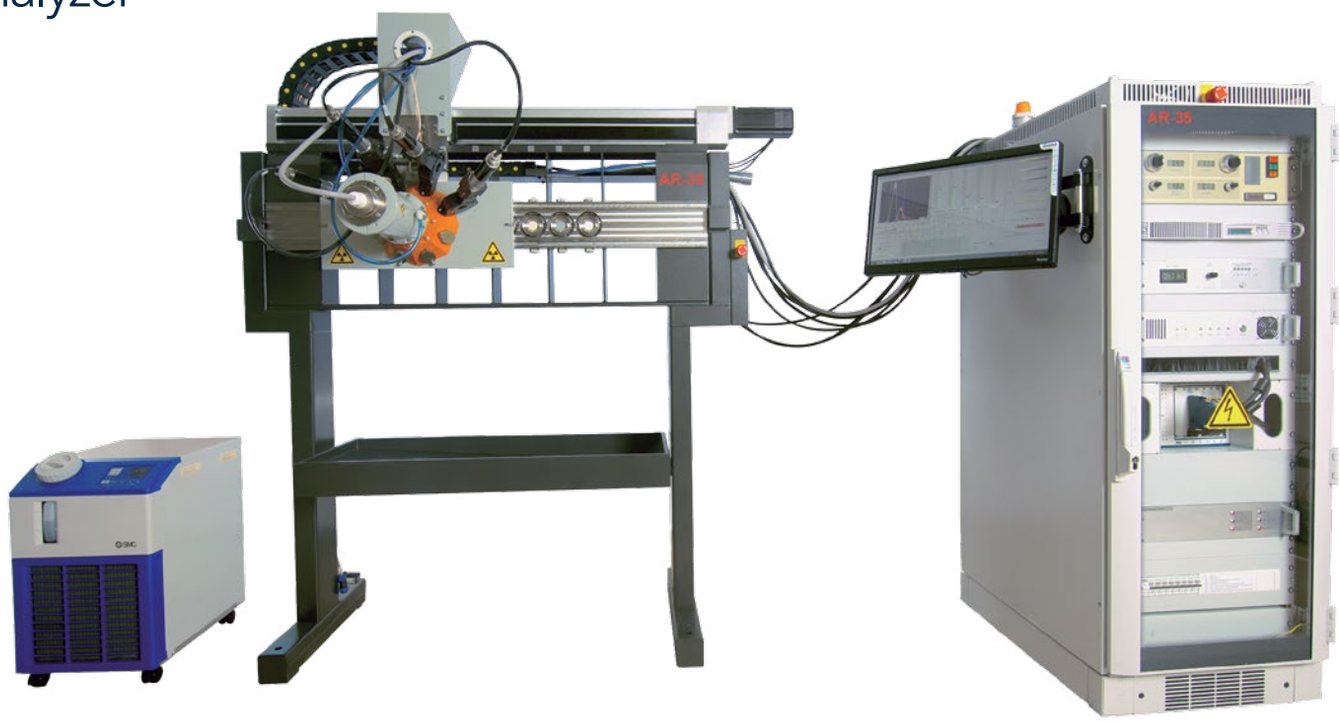
Fully radiation-protected.

X-ray wavelength dispersive sulfur analyzer ASW-3 is used for the measurement of mass concentration of the sulfur in unleaded gasoline, diesel oil, crude oil, kerosene, petroleum residues, lubricating oil, hydraulic oil, jet engine fuel and other types of cutter oil.
Analyzer ASW-3 allows to measure mass concentration of the sulfur in vacuumized measurement chamber mode, as well as in helium purging mode. For this purpose the instrument is equipped with the set of tooling for the connection to helium station.

Technical data

Sulfur mass fraction determination method	X-ray fluorescence wavelength energy dispersive (WDX) analyzer with vacuumized chamber
Statistic limit of detection, max., ppm	1.5
Range of determined sulphur concentrations, ppm	3 - 50000
Limits of basic relative error, %	±0.5
Number of samples installed into sample changer, up to	9
Power consumption, W (220 ACV, 50 Hz mains)	250
Instrument weight, max, kg	45
Overall dimensions (LxWxH), mm - analysis unit - vacuum system	 570x462x369 320x320x150

AR-35 Automated On-line XRF Wavelength Dispersive slurry analyzer



The analyzer design provides overall protection of operation personnel against X-ray radiation.

AR-35 analyzer is designed for on-line flowstream X-ray fluorescence analysis of solutions, suspensions and slurries of ore processing. AR-35 analyzer simultaneously measures concentrations of up to 8 chemical elements in technological product that saves time and reduces the cost of element determination.

The analyzer operation principle is based on the excitation of atomic fluorescence radiation of substance sample by X-ray tube radiation. The fluorescence radiation of various chemical elements is dispensed by the analyzing crystal, and then radiation of a particular wavelength is registered by X-ray detector. Intensity of fluorescence radiation registered of a certain wavelength is directly proportional to the mass fraction of a chemical element in the substance tested.

Technical data

Range of determined chemical element	^{20}Ca - ^{92}U
Number of simultaneously defined chemical elements	7
Number of flow measuring cells (sequentially analyzed products, flows), per one unit, depending on customer's requirements	6,12 or 15
Limits of basic relative error, %	±0.5 %
Detection limits, ppm - in solutions - in suspensions and slurries	 10 ... n*0.1 500 ... 10
Average time of one flow analysis, s	20 - 100
Power consumption, W	5
Instrument weight, max, kg	1200

Distinctive features

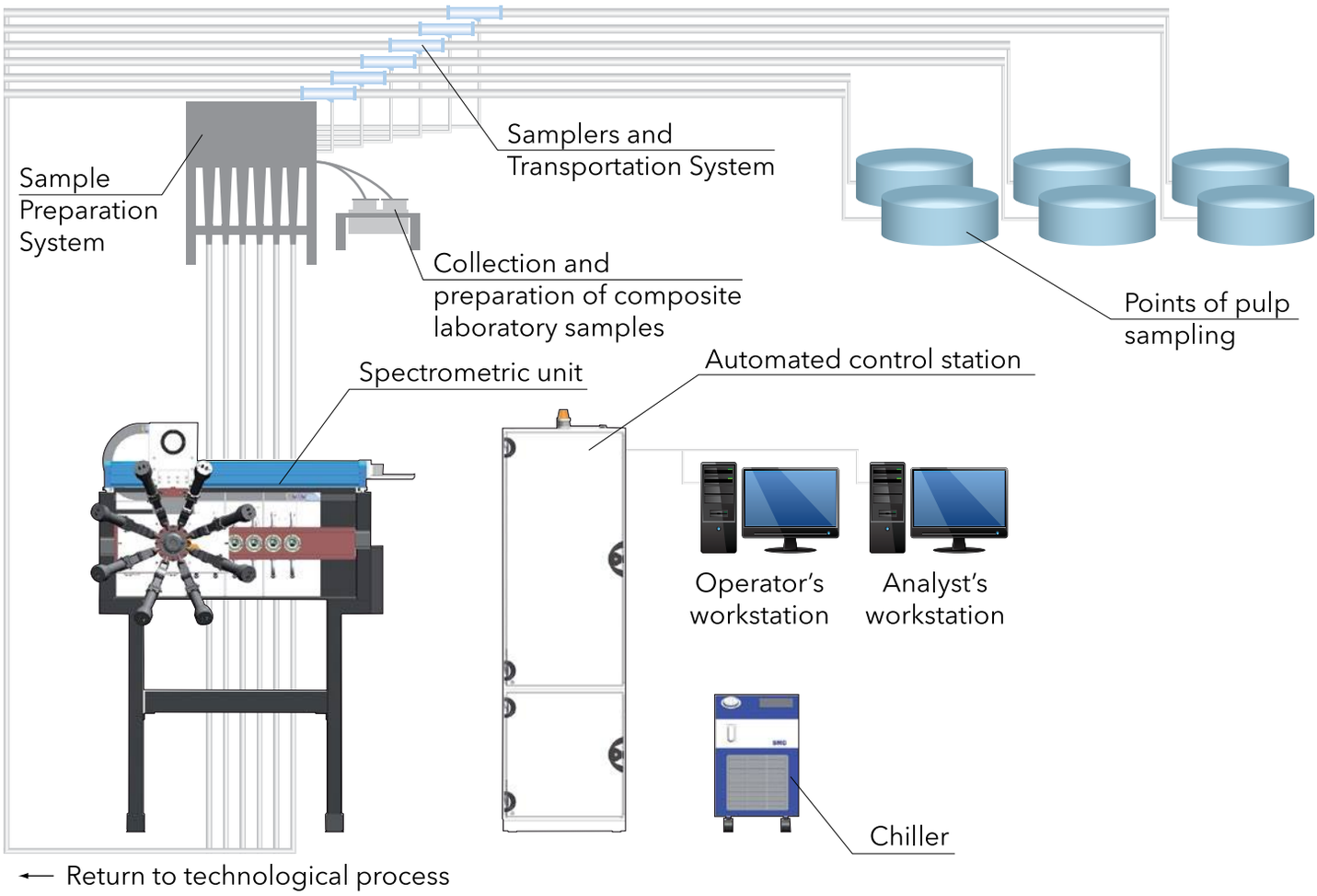
- At concentrating mills of mining enterprises of ferrous and non-ferrous metallurgy, in chemical industry, etc.
- Compatible with systems of automated sampling, sample delivering, processing and presentation of the analysis results, organization of data analysis archive storage.
- Communication with the factory automated process control system
- High expressity, accuracy of the analysis, low detection limit, analysis reproducibility
- High reliability.

Scope of application

- Automated system of analytical monitoring and SCADA of nonferrous metals ore processing plants (Fe-Cu-Zn-Pb, Fe-Ni-Co-Ni, Cu-Mo, Mo-W) with branched mixed flotation circuits.
- Hydrometallurgical limits of extraction and refining of non-ferrous, rare and scattered elements (Co, Ni, In, Tl, Sc, Y, rare earth elements, Nb, Ta, Mo, W, Re, U).

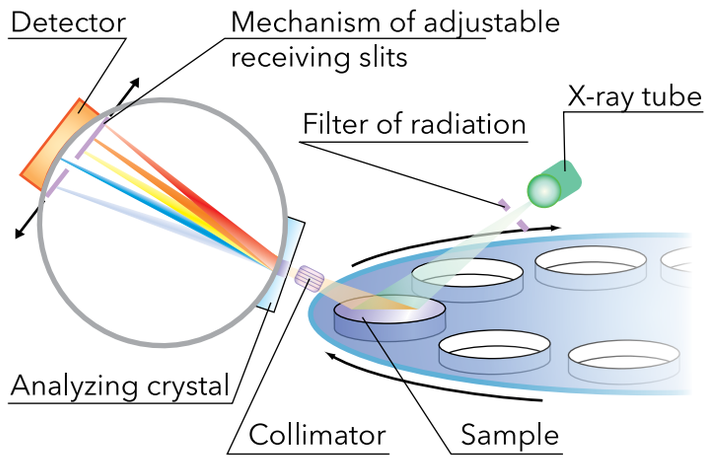
Functional diagram of the analytical control based on AR-35

Automated workstations are based on advanced software and hardware.
The software implements two main methods for quantitative analysis: on regression equations and method of standard scattered radiation.



ARF-7 Specialized XRF Wavelength Dispersive Analyzer

High spectral resolution at short wavelengths of X-ray radiation (up to 40 eV)



The instrument design provides overall protection of operation personnel against X-ray radiation.

Specialized wavelength energy dispersive analyzer constructed by Cauchois scheme is designed for high-precision quantitative determination of U, Th, Mo, Au, W, Tl, As, Pb, as well as other elements in the ore, rocks and waste deposits development.

Technical data

Range of determined elements	^{27}Co - ^{92}U ^{27}Co - ^{58}Ce, K-series radiation, ^{73}Ta - ^{92}U, L-series radiation.
Spectral resolution (half-width of line U $L_{\alpha 1}$), less than, eV	40
Range of determined concentrations, %	from 10^{-4} to 100
Limits of basic relative error, %	0.5
Detection limit of ^{92}U for 100 s, max, ppm	1.5
Number of simultaneously loaded samples, pcs.	30
Power consumption, kW	4.6
Instrument weight, max, kg	400
Overall dimensions (L x W x H), mm	1300 x 1150 x 850

The analyzer operation principle is based on the excitation of atomic fluorescence radiation of substance sample by X-ray tube radiation. Fluorescence emission can be decomposed in spectrum by Cauchois method. Fluorescence radiation focused by the analyzing crystal of the determined element and the line of standard are allocated onto the Rowland circle. Then they are recorded by turns by the X-ray detector. Intensity of fluorescence radiation registered of a certain wavelength is directly proportional to the mass fraction of a chemical element in the substance tested.

Distinctive scopes of application

Geology and mining industry:

- determination of rock and ore composition;
- determination of concentrates composition.

Environmental safety:

- ddetermination of Co, Ni, Cu, Zn, Ga, As, Rb, Sr, Ba, Pb in soils, sediments and rocks at ppm contents.

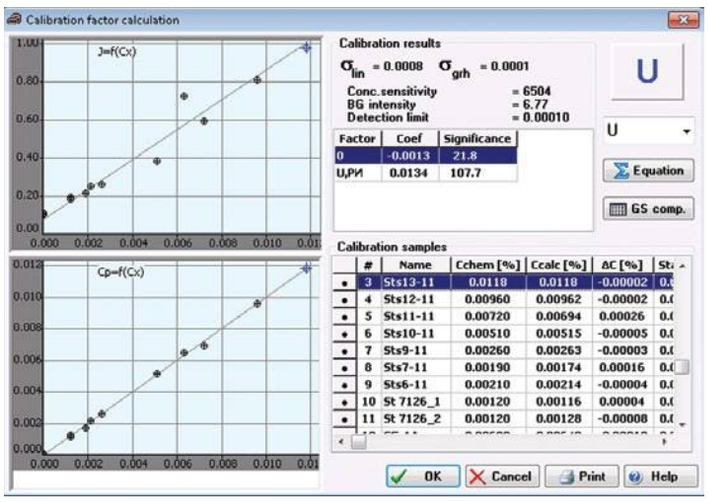
Determination of uranium and new advanced nuclear fuel thorium in rocks, ores and technological products in a wide range of concentrations from 10-4% and above.

Determination of uranium in rocks, ores and products of their processing by X-ray fluorescence measurements is carried out according to the procedure No. 420-PC developed by VIMS.

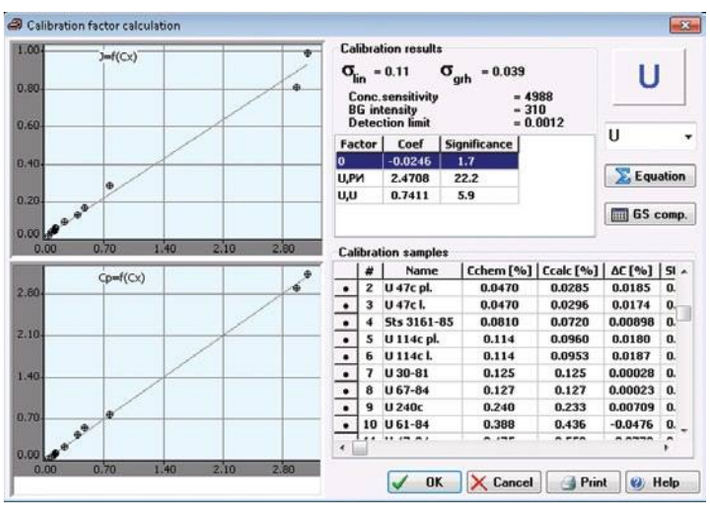
Distinctive features

- Ability to define groups of elements without reconfiguring analyzing crystal.
- Extremely high resolution of Cauchois X-ray optical scheme with quartz analyzing crystal(1011).
- Intelligent mathematical support.

Program interface

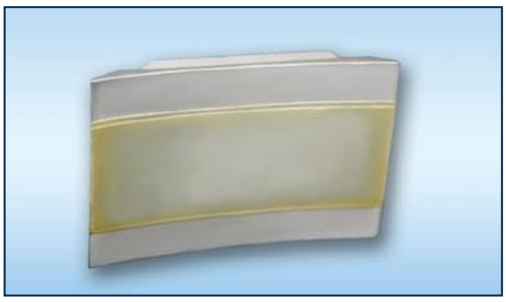


Calibration diagram for low concentrations of uranium in geological samples.



Calibration diagram for high concentrations of uranium in geological samples.

X-ray Optical Elements and Crystals-monochromators

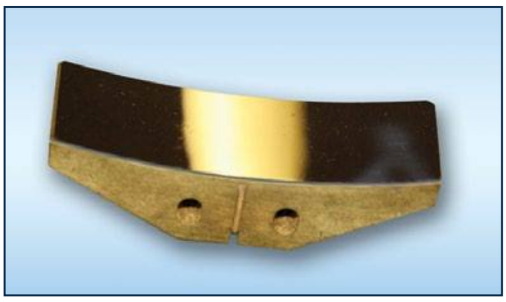


Asymmetrical Johansson Monochromator, R188, cut angle $10^{o}59$, LiF (220), 2d=0.284 nm

Crystal diffraction dispersing elements (CDEs)

Crystal diffraction dispersing elements (CDEs) are designed for X-ray dispersion in equipment for spectral (analyzing crystals) and structural analysis (monochromator crystal).

"Bourevestnik" JSC manufactures CDEs optimized with respect to diffraction parameters for serial instruments produced by domestic and world's leading manufacturers and by the orders of research centres.

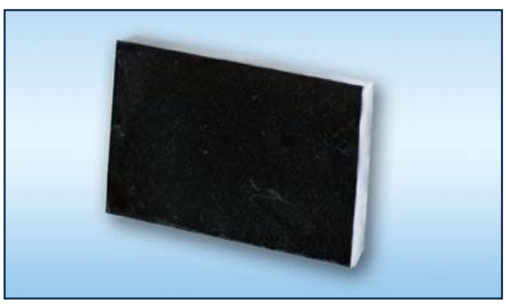


Johann cylindrical analyzer. InSb(111), 2d=0,748 nm

Distinctive features

Materials and reflecting planes of CDEs

- lithium fluoride (200), (220), (420)
- germanium (111), (220), (422)
- silicon (111), (220), (422)
- quartz (1011), (1010), (1340)
- graphite (0002)
- pentaerythritol PET(002)
- potassium biphthalate KAP(001)
- rubidium biphthalate RbAP(001)
- multilayer coatings of different types
- other materials and reflecting planes at the customer's request



Flat monochromator. Graphite (0002), 2d= 0,668 nm

Different orientation of reflecting plane:

- parallel to working surfaces (reflection geometry)
- parallel to working surfaces (transmission geometry)
- an optional angle to the working surface

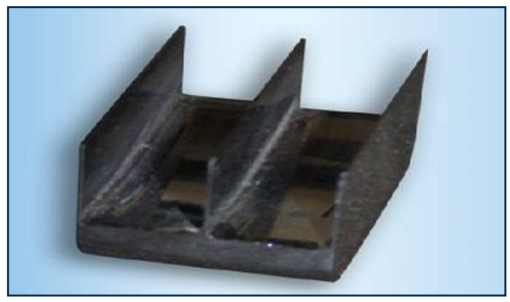
Toroidal monochromator. R1=150, R2=75, LiF(200), 2d=0,403 nm

CDEs of complex configuration:

- single bent (cylindrical, conical)
- double bent (spherical, toroidal)
- with complex contour (triangular, elliptical, etc.)
- cylindrically grinded and bent (Johansson type)
- bent to logarithmic spiral
- channel-cut for multiple reflection and interference

Single-crystal sample holders

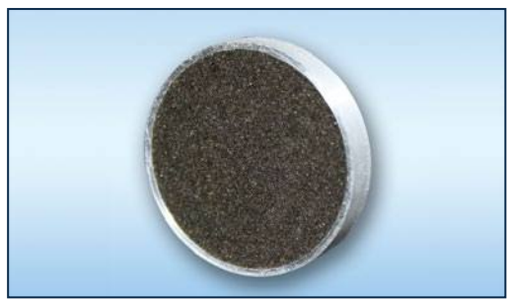
Single-crystal sample holders are designed for diffraction analysis of weak reflections and microquantity of samples on diffractometers of various brands including DRON. Due to interference in the single-crystal, they eliminate coherent scattering which is the main part of the registered background while using other holders.



X-ray interferometer.
Si(220), 2d=0,384 nm

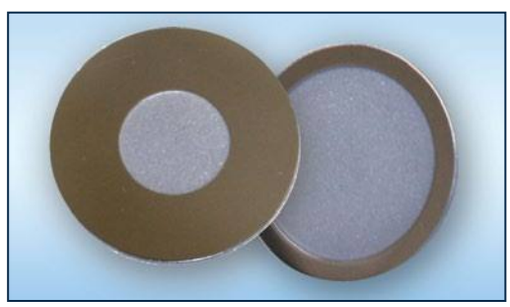
Distinctive features

- Materials: silicon, quarz
- Shape: round, rectangular
- Working surface: flat polished or with a sample cavity (cell)



Spherical analyzer.
R500, KAP(001), 2d=2,664 nm

Flat silicon single crystal holders.



Single-crystal silicone holders with a cavity.

Equipment for diamond-mining industry

X-ray luminescence sorters

In the diamond industry separation equipment is widely used based on radiometric methods for enrichment of diamond materials. Among this equipment, X-ray luminescence sorters are most widely used.
The X-ray luminescence sorters operating principle is based on the property of diamonds to luminesce under X-ray radiation and on contrast nature of diamonds x-ray luminescence generated from accompanying minerals luminescence.

Advantageous of X-ray luminescence sorters in comparison, for example, with equipment based on gravity or viscosity separation methods are as follows:

- higher selectivity;
- high percentage of diamonds recovery;
- low operational costs;
- noticeably less environmental impact.

Bourevestnik, Inc. is rich in traditions of X-ray luminescence sorters development and manufacture, starting with the first industrial prototype in the world of the X-ray luminescent sorter LS-20 for the diamond industry, made in 1969.
By now more than 1600 sorters have been produced and 600 of them are in operation.

X-ray transmission sorters

Transmission sorters are ideally-suited for determination of weakly luminescent and non-luminescent diamonds, and diamonds with non-typical kinetics of luminescence. These diamonds are relatively small percentage of the total volume of diamonds in the processed material, but in some fields, this share is relatively high. Therefore, this new radiometric method of diamond-containing materials enrichment gradually takes its position in the market, but it is not widely used yet.

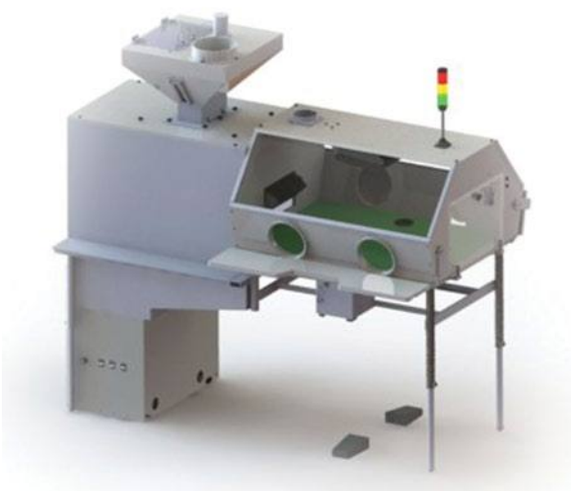
Portable Sorter POLUS-M

Luminescence sorter POLUS-M is designed for geological exploration of diamond deposits and for enrichment of dry diamond bearing concentrates in field conditions.
The sorter consists of the sorting machine and the operation and registration unit.
The registration unit and the X-ray source are located on opposite sides of the material flow.
Access to the transport channel is via removable doors. It allows operating in field conditions. No water and compressed air are required.

Analyzer Of Minerals Luminescence Kinetics UOK-2

Control operational analyzer UOK-2 is designed for measurement of kinetics values of diamonds and associated materials luminescence. The obtained data are used for adjustment of process parameters of X-ray luminescence sorters of “Bourevestnik” JSC.

Glove box



The glove box is designed for manual sorting of rough diamonds in finish shops at dressing works and dredges. The box provides:

- possibility for manual sorting of dry and wetted concentrate;
- prevention of unauthorized access to rough diamonds;
- safety of end product by means of exclusion of operator’s contacts with concentrate.

The glove box is manufactured in four versions differed by overall dimensions, material feed mechanism, quantity of so rter workstations, particle size of selected material.

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