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**Panel 2 on "International Activities: Collaborative Programs, Harmonization of Prototypes, Sharing of Facilities, Standardization, etc."**

# EXPERIMENTAL FACILITIES OF SSC RF – IPPE FOR STUDIES ON FAST REACTORS: CURRENT STATUS AND PROSPECTS

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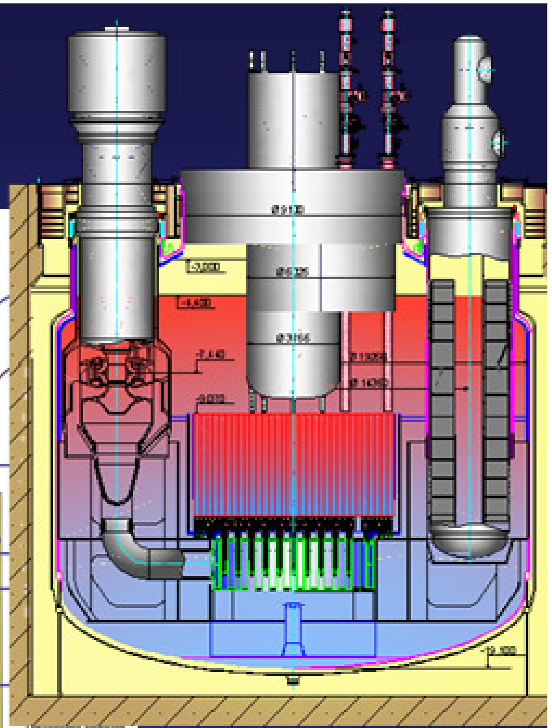
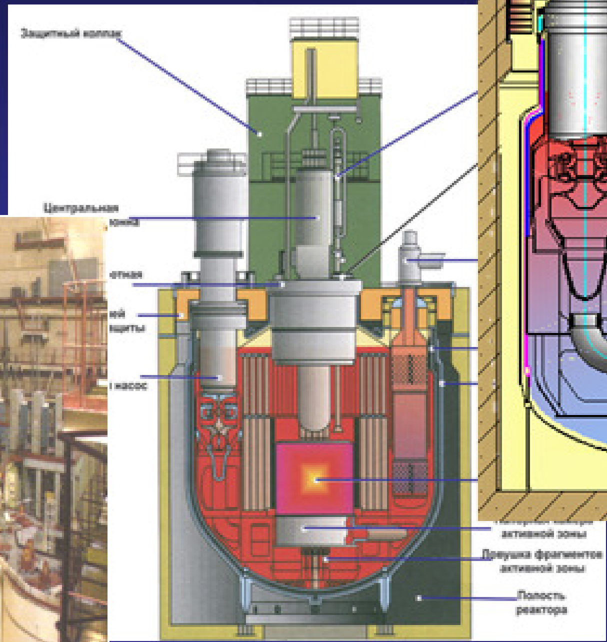
# Development stages of maturity of fast sodium cooled reactor technology in Russia

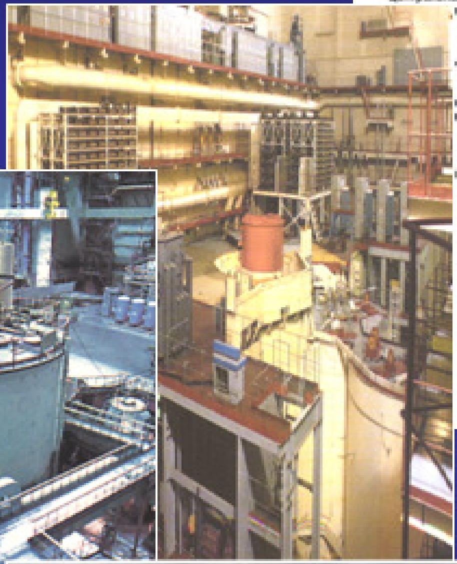
6 BN-C 2018-2078



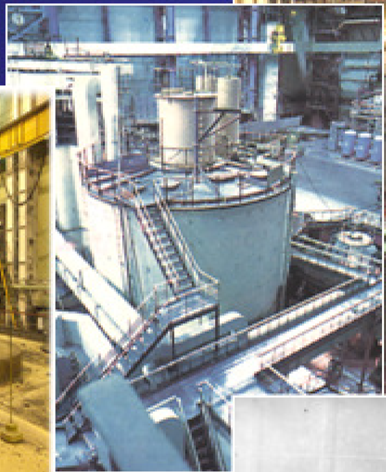
5 BN-800 2012-2052



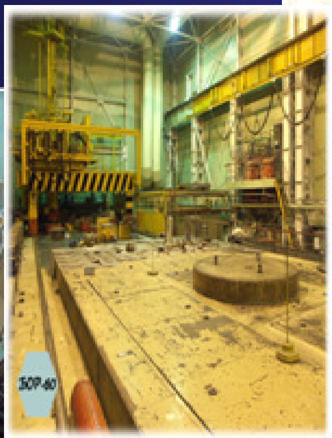
4 BN-600 1980-2010+15



3 BN-350 1972-1999



2 BOR-60 Since 1969



BR-5/10 1958-2002

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# EXISTING EXPERIMENTAL FACILITIES

**SSC RF – IPPE possesses many experimental facilities (several dozens) for studies in the area of fast reactors.**

**The main areas of studies are:**

- ***Fast reactors with sodium coolant (SFR);***
- ***Fast reactors (FR) with heavy liquid metal coolant.***

## There are several categories of experimental facilities for different purposes:

- ***FR core neutronics*** *(slides 7-8)*;
- ***Fuel and material irradiation studies*** *(slides 9-11)*;
- ***FR safety*** *(slides 12-17)*;
- ***Thermal hydraulics*** *(slides 18-22)*;
- ***Technology of coolants*** *(slides 23-30)*;
- ***Issues of FR decommissioning*** *(slide 31)* .

# FR CORE NEUTRONICS

## BFS-2 Critical Facility (BFS-1 Critical Facility)

### Purpose

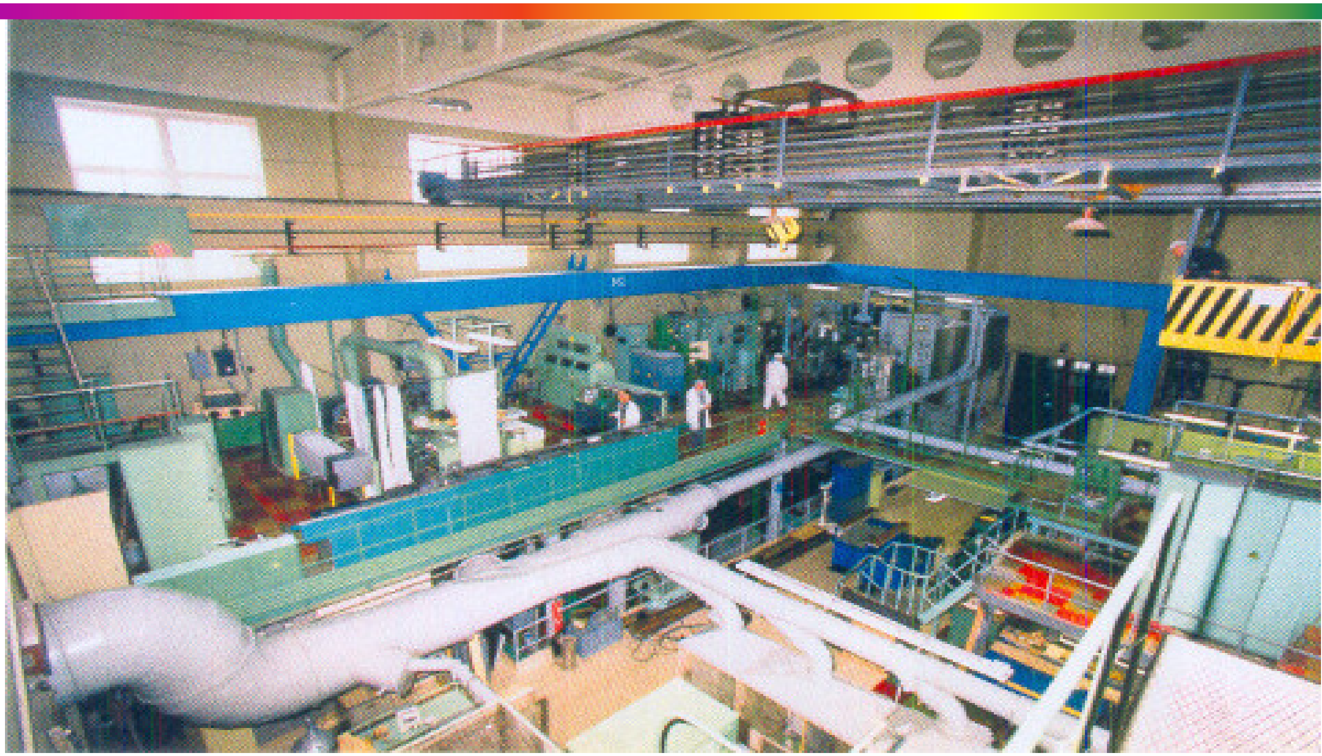
– Studies on full-scale models of the core, blanket, in-vessel storage and shielding of large size fast reactors with various coolants.

### Main characteristics

| | |
|---|---|
| Type of critical assembly | Core models for power fast reactors |
| Diameter, m | up to 5 |
| Height, m | up to 3.7 |
| Permitted power level, kW | 1.0 |
| Reactor materials (disks) | Fissile materials (Pu metal, U of high enrichment). Fertile materials. Structural materials, absorber and moderator materials, lead and lead-bismuth |
| Facility is equipped with unique measuring instruments and up-to-date nuclear Material Protection, Control, and Accounting system | |

# POST-IRRADIATION STUDIES OF FUEL AND STRUCTURAL MATERIALS

## Technological complex for fabrication of fuel elements, absorber elements and start-up neutron sources (Technological complex for fabrication of plutonium-containing fuel compositions and fuel elements, Hot Laboratory Complex)



### Purpose

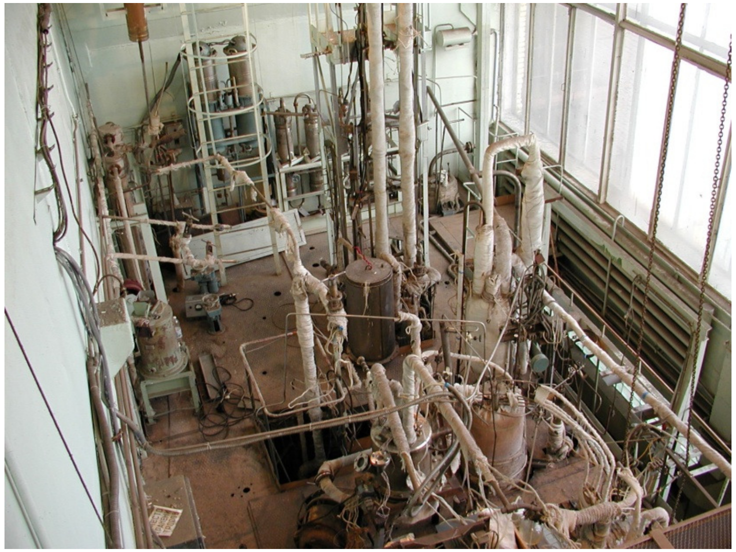
– Designing and pilot production of the new types of fuel elements, absorber elements and start-up neutron sources for in-pile tests and use in nuclear power plants.

### Main components

| |
|---|
| Machining section for fabrication of structural elements |
| Assembly area with glove boxes |
| Welding complex |
| Facilities for filling fuel-cladding gap with liquid metal |
| Product quality control equipment |
| Facilities for measurement of thermal parameters of structural and fuel materials |

# FR SAFETY

**Multi-purpose test facility (SPRUT)** (PLUTON Test Facility, Test facility “AR-1" (accidental modes), Decay heat removal test facility (SARH), Test facility for studies on sodium leaks (IK-MT), Aerosol filter test facility (SIAF-1), SG safety system test facility (SAZ))



## Purpose

– Studies on thermal and hydraulic characteristics as applied to the components of the BN-800 and BREST-OD-300 reactors;
– Studies on severe accidents for the purpose of justification of the new generation reactor designs;
– Experimental studies on methods of heat transfer intensification for corium confinement within the reactor vessel.

## Main parameters

| Coolant | Na | Pb-Bi | Water | NaK |
|---|---|---|---|---|
| Pressure, MPa | 1.0 | 1.5 | 25 | 0.5 |
| Temperature, °C | 600 | 600 | 550 | 250 |
| Flow rate, $m^3$/hour | 10 | 5 | 8 | 2 |
| Electric power, kW | 600 | 1000 | 1200 | 15 |
| There are 4 independent loops in the facility, namely: 1 –sodium; 2 –heavy metal; 3 – high pressure water loop; 4 – sodium-potassium. | | | | |

# THERMAL HYDRAULICS

**Liquid metal thermal hydraulics test facility (6-B)** (TO test facility, Test facility for measuring contact thermal resistance (KTS), SGDI and V-2 aerodynamic test facilities),

## Purpose

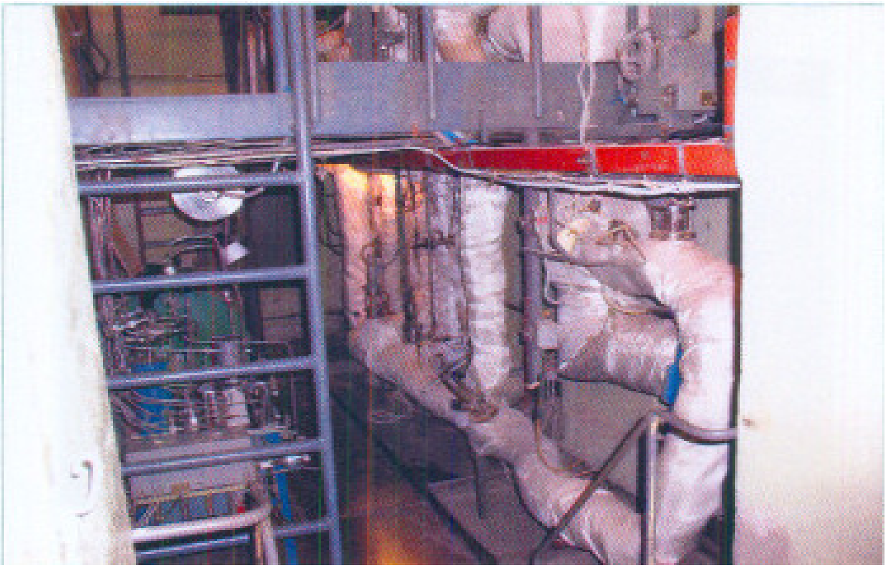
– Studies on thermal physics and hydrodynamics in the core elements and liquid metal heat exchangers.

## Main parameters

| Circuits | 1 | 2 |
|---|---|---|
| Coolant | NaK | Na |
| Flow rate, $m^3$/hour | 150 | 150 |
| Pressure, MPa | 0.6 | 0.6 |
| Temperature, °C | 400 | 400 |
| Electric power, kW | 400 | 400 |

# COOLANT TECHNOLOGY

**IRINA test facility** (PROTVA -1 sodium test facility, PROTVA -2 sodium test facility, Lead and lead bismuth test facility (SVT-3M), Liquid metal test facility (TT-1M), Liquid metal test facility (TT-2M), Complex of large scale liquid metal corrosion test facilities, High pressure water test facility (SVD-2))



## Purpose

– Studies on mass transfer of impurities in sodium circuit components using radioactive labels as applied to SFR;
– Studies on features of tritium mass transfer in sodium circuits, its release to the environment and methods of its entrapment and confinement.

## Main parameters

| | |
|---|---|
| Coolant | Sodium |
| Sodium inventory, kg | 130 |
| Max temperature, °C | 700 |
| Max flow rate, $m^3$/hour | 10 |
| Main heater capacity, kW | 100 |
| Max input power, kW | 200 |
| Max pressure, MPa | 0.5 |
| Structural material of the main circuit | Cr18N10Ti s.s. |

# ISSUES OF FR DECOMMISSIONING

## BR-10 research fast reactor

**BR-10 research fast reactor provides test site for SFR decommissioning technologies development. This reactor located on IPPE site is now in the stage of preparation for its decommissioning.**

**Current status of the BR-10 reactor is as follows:**

- ***All FSA have been unloaded from the core and replaced by the dummy subassemblies;***
- ***All FSA of two core loadings with nitride fuel have been washed out from sodium and placed into the interim storage;***
- ***Sodium has been drained from the primary and secondary circuits to the storage tanks and frozen;***
- ***The inner surfaces of the primary circuit have been cleaned from sodium and decontaminated;***
- ***Both loops of the secondary circuit and inter-circuit heat exchanger of the central loop have been cleaned from sodium.***

**The following technologies have been adjusted:**

- ***Conversion of Na and NaK to the safe condition by solid phase oxidation method (test facilities «Mineral-1.5» and «Mineral-50»);***
- ***Conditioning non-drained sodium residues by their oxidation by nitrous oxide ($N_2O$);***
- ***Purification of sodium-potassium alloy from mercury impurities;***
- ***Cleaning of the cold traps by water-alkaline vacuum method etc.***

# PROSPECTS OF DEVELOPMENT OF EXPERIMENTAL FACILITIES

**According to the adopted Federal Target-oriented Program (FTP) "Nuclear power technologies of the new generation for 2010-2020 period" it is planned to update existing experimental facilities on FR including those installed at the SSC RF - IPPE, in order to assure achieving goals stated in FTP, namely: designing and introducing IV generation FR with sodium coolant and with HLMC and relevant fuel cycles.**

**The most important measures listed in FTP on upgrading experimental facilities of nuclear industry are the following:**

- ***Upgrading of BFS complex (fast reactor neutronics);***
- ***Development, design, and construction of multi-purpose sodium cooled research fast reactor MBIR;***
- ***Completion of construction and putting into operation of SG safety system test facility SAZ etc.***

# RESEARCH FAST REACTOR MBIR

**Multi-purpose research fast reactor MBIR with sodium coolant is aimed to conduct reactor studies, including tests of new types of fuel, different coolants, fuel and structural materials.**

**Main characteristics and capabilities of MBIR are as follows:**

- **Thermal power – 150 MW**
- **Max neutron flux – 4.5 * $10^{15}$ n/cm$^2$*s**
- **Number of autonomous test loops with different coolants – up to 4**
- **Total number of experimental subassemblies and target devices for radioisotope production – up to 12 (in the core) and up to 5 (in radial shielding)**
- **Number of experimental channels (inside the core) – up to 3**
- **Number of experimental horizontal channels (outside the reactor vessel) – up to 6**
- **Number of experimental vertical channels (outside the reactor vessel) – up to 8**

**Schedule: Development of a detailed design – 2014-2015.**

**Scheduled time of the reactor commissioning – 2018-2019.**

**Participation of other interested countries in designing and construction of the MBIR research fast reactor is welcomed for subsequent joint experimental studies and irradiation tests of fuel compositions and structural materials.**