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Federal State-Funded Organization "State Scientific Center of the Russian Federation – A.I. Alikhanov Institute for Theoretical and Experimental Physics" (ITEP) is a world-known multi-discipline scientific center, a leader in the field of nuclear and particle physics, astrophysics, mathematical physics, solid-state radiation physics, ion-beam physics, medical physics, and physics of safe nuclear power plants.

ITEP headquarters

A.I. ALIKHANOV,
Member of the USSR Academy of Sciences

YU.F. KOZLOV,
Dr. Sc. (Tech.), Professor, Director of ITEP

Since 2011, by a Russian Government order, the National Research Center "Kurchatov Institute" has exercised the functions and powers as the ITEP founder on behalf of the Russian Federation.

ITEP supports and evolves the national system of knowledge in the field of nuclear science, engineering and technologies.

ITEP possesses a unique experimentation framework, which is employed primarily to investigate the fundamental properties of matter and offers a broad range of development capabilities to support the prime tasks of the nuclear industry. At present time, the Institute includes the following base facilities:

1. The ITEP-TVN integrated acceleration and accumulation facility, comprising:

– a proton accelerator, U-10, for the energy 10 GeV;

– a multipurpose hadron facility, ITEP-TVN, for ion acceleration and accumulation;

– a linear high-current proton accelerator for the energy 24 MeV;

– a medical facility for proton therapy of oncologic diseases;

– unique experimental facilities for research in matter high energy density physics, elementary particle physics, nuclear physics and condensed-matter physics.

2. A heavy-water critical facility (zero-power reactor), MAKET.

3. A center for nuclear-scale research in condensed-matter radiation physics and reactor material science.

The proton-beam medical center set up at the TVN facility, which uses radiobiological methods of therapy for malignant tumors, is the second largest in the world in the volume of medical services provided.

The MAKET zero-power reactor, which is part of the heavy-water nuclear reactors department, is used for physical and mathematical modeling of the production heavy-water reactor core. It is also where work is continued to decommission the TVR heavy-water reactor.

ITEP has taken part in many international experiments at the largest foreign colliders and accelerators (KEK, TEVATRON, SLAC, JNAF, GSI, SIS/ESR, LHC – Large Hadron Collider, FAIR).

ITEP is Russia's and worldwide leader in a number of research activities, including search for and research into the properties of dark material, neutrino oscillation experiments, search for neutrinoless double beta decay and neutrino magnetic moment. The world's highest detector sensitivity and the best ever neutrino magnetic moment existence limit were achieved in the neutrino magnetic moment measurement at the Kalinin NPP.

ITEP's efforts are undertaken within the frameworks of Rosatom's long-term program

ITEP's nuclear research facility

Type	Designation	Thermal power, kW	First criticality year	Status	Operating time, years*
CF	MAKET	1.00	1976	In operation	36

** As of 2012*

of activities and the Federal Target Program "Assurance of Nuclear and Radiation Safety for 2008–2015", "Research and Development in Top-Priority Evolution Fields of Russia's Scientific and Technological Complex for 2017-2012", and "Scientific and Educational Research Staff of Innovative Russia".

Apart from research in the fundamental properties of matter, ITEP's activities include applied scientific research and development work in top-priority evolution fields of science, technology and engineering in power and energy-saving, and in creation of the nanosystems and nanomaterials industry.

For the ongoing decade, the evolution program for ITEP's integrated acceleration facility envisions the following: raising considerably the efficiency of the integrated facility utilization, including ion therapy, radiobiological research, radiation stability tests of electronic components, research in physics of shock-wave processes, relativistic nuclear physics and physics of dense baryonic matter.

MAKET CRITICAL FACILITY (HEAVY-WATER ZERO-POWER REACTOR)

The MAKET heavy-water critical facility (CF) was put into operation in March 1977 (first criticality was achieved on 30.12.1976).

The MAKET CF was built as a physical model of production reactor facilities and is intended for research on neutronic core parameters of the heavy-water reactor facilities in operation and under design.

MAKET CF building

Main performance of the MAKET CF

Maximum CF power
- rated .... 0.1 kW
- design .... 1 kW

Moderator .... Heavy water

Coolant (no forced heat removal) .... Heavy water

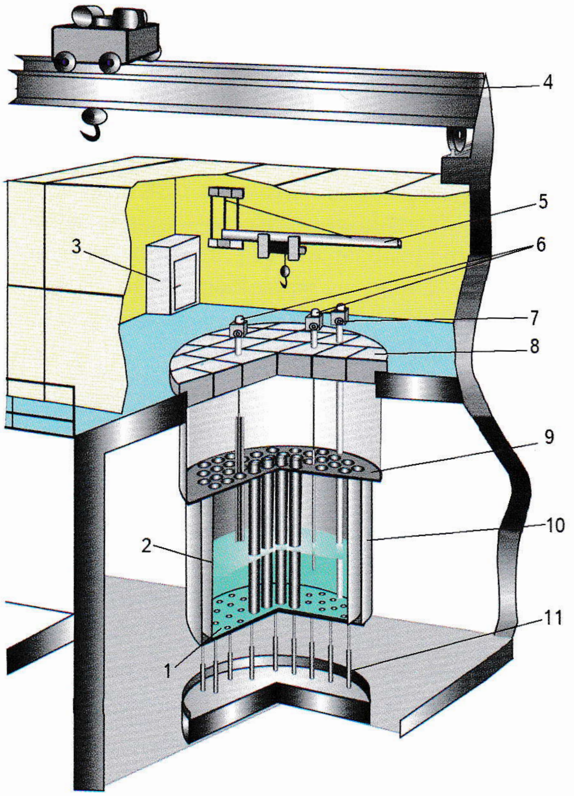
Reflector .... Heavy water

Maximum flux*: ....
- thermal neutron flux** .... $2 \cdot 10^9$ $cm^{-2} \cdot s^{-1}$
- fast neutron flux** .... $3 \cdot 10^8$ $cm^{-2} \cdot s^{-1}$

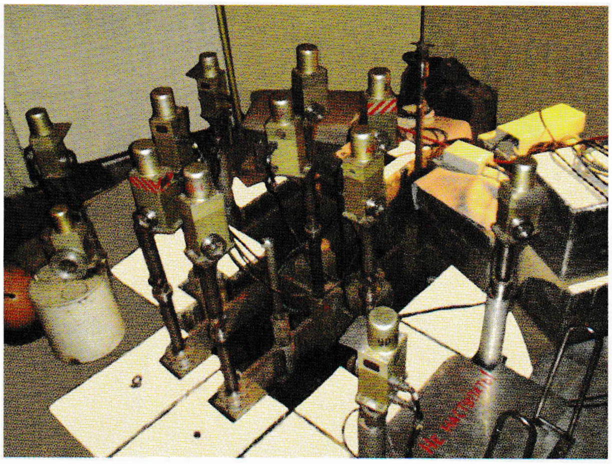
Maximum number of CPS rods:
- automatic control (AC) 1
- emergency protection and extra absorption (EP and EA) 6

Number of CPS control and protection channels: ....
- current 6
- pulse 5

** Measured in experiments*
*** Depends on the investigated core model*



Arrangement of the MAKET CF systems:
1 – lower grid; 2 – B-1 tank; 3 – lock; 4 – bridge crane; 5 – cord crane; 6 – CPS ES-EA and AC rod drives; 7 – level gage; 8 – biological shielding; 10 – B-0 tank; 11 – jack pads



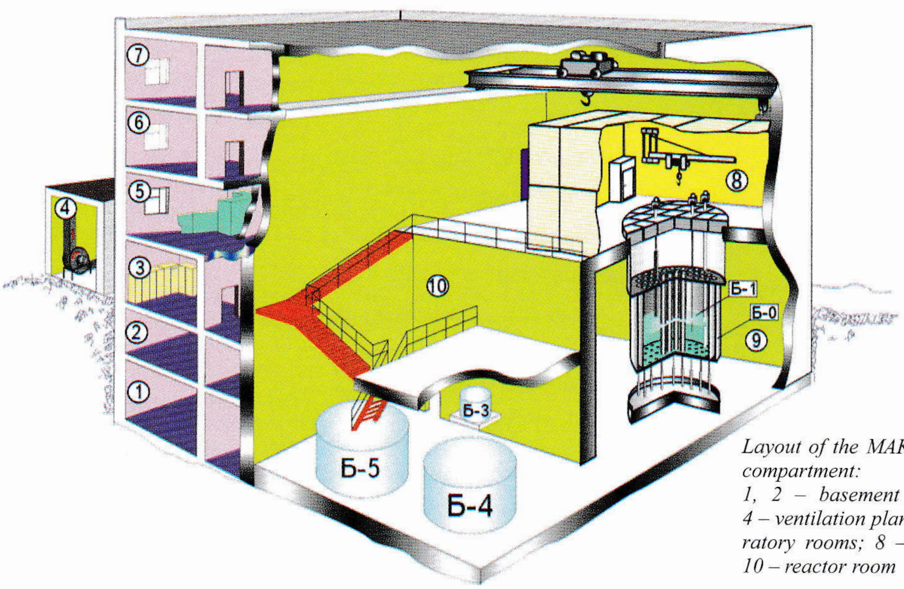
Reactor room. A view of the MAKET CF head assembly

The MAKET CF was retrofitted in 1982-83 to give it increased operating capabilities and higher nuclear safety. The reliability and stability of the CPS operation was improved, the facility's hydraulic system was upgraded and the reactor room floor was hydraulically insulated throughout to ensure that the moderator (heavy water) is preserved in the event the hydraulic system depressurization.

MAKET features and experimental capabilities

The critical facility is deployed in a room, which is isolated from the control room and other rooms in the building by a biological shielding (the concrete wall thickness is ~1.2 m), safety doors and a labyrinth passageway. The biological shielding is designed for the facility operation at up to 1 kW.

To avoid the radioactivity release into the building in the event of an accident, there is a safety box built over the critical facility. This has conditionally leak-tight walls and doors and



Layout of the MAKET CF building, safety box and core compartment:
1, 2 – basement rooms; 3 – decontamination lock; 4 – ventilation plant room; 5 – control room; 6, 7 – laboratory rooms; 8 – safety box; 9 – core compartment; 10 – reactor room

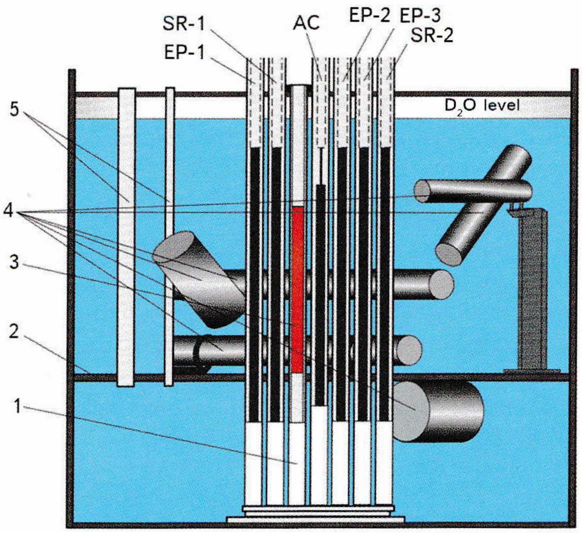


Diagram of the B-1 core tank:
1 – FA tube; 2 – circular plate; 3 – FA core; 4 – experimental channels; 5 – vertical experimental channels

communicates with the other process rooms via a lock. The facility is equipped with standard radiation monitoring, CPS and I&C systems that ensure reliable monitoring and control of the required neutronic and process parameters of the facility.

The experimental and operating capabilities of the MAKET CF make it possible to investigate multiplication lattices, including full-scale cores of other reactor facilities, while modifying them in terms of configuration and composition.

Basically, the MAKET CF features the following:

– the B-1 tank of the diameter 2600 m, which accommodates the core, is capable of receiving 19 m^3 of heavy water. The facility design makes it possible to expand the core volume to 33 m^3 thanks to a backup tank (B-0) of the diameter 3400 mm, which permits to conduct experiments on full-scale models of reactor cores, notwithstanding their type and function;

– the B-1 core tank is not less than 2 m off the room walls and floor and rests on tube-type jack pads, which minimizes the effects of the back scattering of neutrons, which have left the core, on the critical dimensions of the lattices under investigation;

– the B-1 core tank is inside a leak-tight safety box with a lock, which prevents heavy water from contacting the facility room air and becoming depleted, and acts as a localizing system that limits the release of fission products into the facility room and the building during potential emergencies;

Operating parameters of the MAKET CF systems

B-1 core tank (aluminum, wall thickness 10 mm, bottom thickness 16 mm):

- diameter × height .... 2.6 × 3.65 m
- volume .... 19.0 m^3

B-0 shielding tank (aluminum, wall thickness 10 mm, bottom thickness 16 mm):

- diameter × height .... 3.4 × 3.7 m
- volume .... 33.0 m^3

Automatic water level gages in B-1 tank:

- number of level gages (UR-1, UR-2) 2
- absolute level detection accuracy .... 1.5 mm
- level detection accuracy .... 0.5 mm

Water level limiters in B-1 tank:

- number of level limiters (OU-1, OU-2) 2
- level detection accuracy .... 1.5 mm

Water level alarm in B-1 tank:

- number of level alarms (SU-1) 1
- level detection accuracy .... 1 mm

Maximum rate of the heavy water pumping into the B-1 tank .... 0.7 l/s

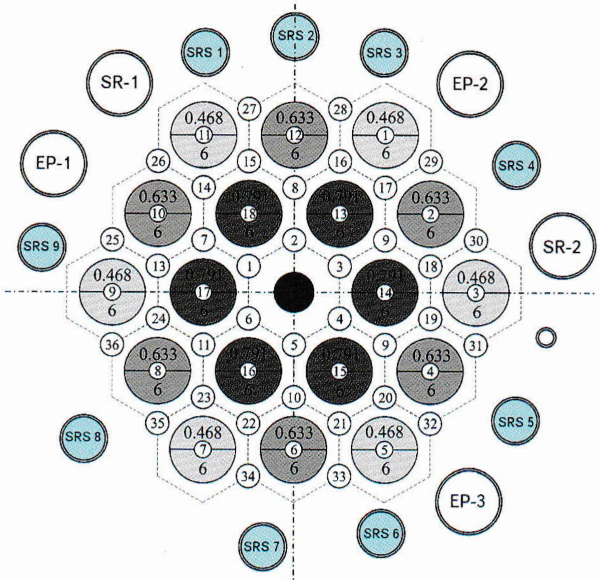
Fixed radiation monitors:

- thermal neutrons 2
- intermediate neutrons 2
- fast neutrons 2
- gamma-radiation 30

– the floor of the facility room, which accommodates most of the hydraulic system's components, has a leak-tight stainless-steel liner capable of receiving and keeping all water spills in the event of the hydraulic system depressurization;

– the chemical water treatment system, which uses ion-exchange resins, ensures that the heavy water is of the required quality;

– the MAKET facility's ventilation system makes it possible to change the air temperature in the facility rooms and, respectively, the temperature in the B-4 and B-5 discharge tanks by 15 °C at a rate of 1.5…2 °C per day, enabling so the required temperature conditions to be maintained in the core and the temperature effects assessed.



Map of a TVR-M core full-scale physical model:

0.791/6-type FA; *EP rod channel;*

0.633/6-type FA; *AC rod simulator (Fe);*

0.468/6-type FA; *shim rod simulator;*

vacant LCS channel; *neutron source channel*

The MAKET CF had its life expired by the end of 2007.

Under the Requirements to the Feasibility Study for Extending the Specified Life of Nuclear Power Facilities, since 2007 work is under way at ITEP to evaluate if it is possible to extend the life of the MAKET CF safety-related systems and components to over 30 years with their previous examination.

Configuration of the MAKET CF core

Depending on the type of the lattice under investigation, the core configuration differs greatly both in the number and in the type of the FAs employed. As an example, a map of an investigated lattice is presented, which is a full-scale physical model of the TVR-M reactor core. The fuel used for the experiments has its enrichment in ^{235}U ranging broadly, from the natural percentage to 90 %.

There is no forced heat removal at the MAKET CF while being removed by means of air natural convection.

Experimental and irradiation capabilities of the MAKET CF

The CF offers capabilities for carrying out a broad range of static and dynamic experiments on heavy-water multiplication lattice.

The CF operating capabilities enable spacer grids and other components to be rapidly reconfigured to mount the cores to be investigated. Local insert grids of the diameter 800 mm can be installed in the base spacer grids for setting up core models or changing the grid spacing. The geometrical dimensions of the core tank make it possible to study full-scale core models.

The CF irradiation volumes are used normally only for experimental research; practically all of the core space can be used as such. Different types of experimental channels installed into a formed lattice can be used to irradiate samples requiring a particular fluence to be achieved. It is also possible to form special cores for these purposes.

Main areas of studies

Research into the neutronic parameters of the real heavy-water reactor facility cores at design, commissioning and operation stages.

Nuclear safety analysis for operating modes of real production reactor facilities of the OK series, a physical model of which is the MAKET facility.

Generation of precision experimental data banks for testing calculation systems.

International cooperation

Experimental activities as part of joint efforts with the ISTC in 1995, 2000 and 2001 for studying the physics of accelerator-driven facility blankets with micromodels of salt and homogeneous cores.

Main activities

The experiments as such at the MAKET CF occupy about 4 months per year. The rest of the time is used to prepare for the experiments and carry out routine maintenance of the CF systems.

A cycle of experimental research was undertaken at the facility in 1983-1986 to investigate the neutronic and operating parameters of the TVR-M (upgraded heavy-water high-flux research reactor) full-scale model for the purpose of its safety justification.

In 1986–1987 pre-startup experiments were conducted at the MAKET CF with the L-2 production facility lattice models. The experiments approved the procedures for achieving the critical mass, justified its nuclear safety and demonstrated high sensitivity of the employed neutron field control system to local irregularities in the lattice. The proposed procedures were successfully used for the first criticality of the L-2 facility.

Since 1988, experimental research has been under way at the MAKET CF to study new advanced operating modes for the LF-2 facility.

In 1995 and 2000–2001 experiments were conducted at the MAKET CF as part of the joint work with the ISTC to investigate the neutronic characteristics of accelerator-driven facility blankets with micromodels of salt cores ($NaF+ZrF_4$) and homogeneous cores with heavy-water solutions of actinides (^{237}Np and ^{232}Th).

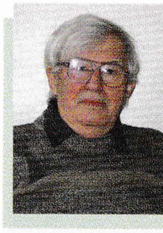
In the near future it is planned to:

– support the LF-2 production facility operations;

– extend the service life of the standard CF safety-related systems.

The greatest problem concerning the MAKET CF is the lack in funding for the CF CPS upgrading.

Personalities



OLEG SHVEDOV
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