3.14. INSTITUTE OF PHYSICS AND ENGINEERING
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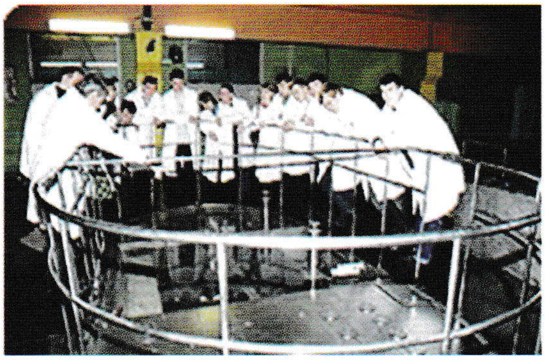
The Institute of Physics and Engineering of the National Research Tomsk Polytechnic University (FTI TPU) was established by a resolution of the Scientific Council of the University in 2010 through amalgamation of the Research Institute of Nuclear Physics (founded in 1958) and two university departments: Physics & Engineering and Natural Science & Mathematics. The Tomsk Polytechnic University came to mark a new stage in development of technical education in Siberia. From the day of its foundation (April 29, 1896), the University trained about one hundred thousand specialists; in fact, it had a crucial effect on the emergence and development of the higher technical school on the territory stretching from the Urals to the Pacific Ocean.



Hands-on training at the IRT-T

The Institute has at its disposal a unique complex of facilities, such as: nuclear research reactor IRT-T; electronic synchrotron “Sirius” (for 1.5 GeV); a cyclotron with the pole diameter of 1.2 m; high-current pulsed electron and ion accelerators; a microtron; and an electrostatic accelerator (for 2.5 MeV).

The main scientific work areas of the Institute include basic research in nuclear and theoretical physics, nuclear reactor physics and engineering, medical physics, solid-state physics, neutron activation analysis, and other scientific and applied activities. Today, the base facilities of the Institute are the research reactor IRT-T and the cyclotron. These facilities are used by students of energy-related disciplines for hands-on and laboratory studies.

Two facilities – the electronic synchrotron “Sirius” and the nuclear research reactor – are on the list of unique research facilities of national significance.

The facilities serve for fundamental studies in: nuclear and elementary-particle physics; interaction of charged particles with crystalline structures; radiation material science; pulsed-beam technologies; generation of high-current beams of charged particles and strong pulses of microwave radiation; nuclear medicine.

Institute building

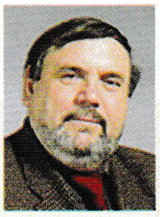
Research reactor of FTI TPU

Name	IRT-T
Thermal power	6 000 kW
Year of first criticality	1967
Status	In operation
Operation time (as of 2012)	45 years

The Institute’s nuclear research reactor has a unique technology for production of technetium-99 generators for radiological laboratories of medical institutions. The process line was put into operation upon its acceptance by a Ministry of Health commission in compliance with the international requirements for production of pharmaceuticals (GMP standard).

The IRT-T reactor operation has been under the Institute’s management since October 1, 2010.

The Institute has got licenses from the RF Ministry of Health and the Siberian Gostekhnadzor for production, storage and transportation of technetium generators.



V.P. KRIVOBOKOV
Professor, Dr. Sc. (Phys.&Math)
Pro-rector – Director of the Institute

RESEARCH REACTOR IRT-T

The pool-type nuclear research reactor IRT-T was designed for training TPU students specializing in energy disciplines, as well as for material behavior studies and production of radioisotopes.

The reactor built to NIKIET design was brought to first criticality on July 22, 1967 and to first power, on July 27, 1967.

From the time of its startup, IRT-T was repeatedly retrofitted (in 1971, 1977–1984, 2005). It had substantial changes: the reactor core shroud was replaced and a beryllium reflector installed, the pool was lined with stainless steel; the cooling circuit was modified, with its components replaced; the instrumentation and control hardware was largely upgraded; fuel assemblies were converted to type IRT-3M.

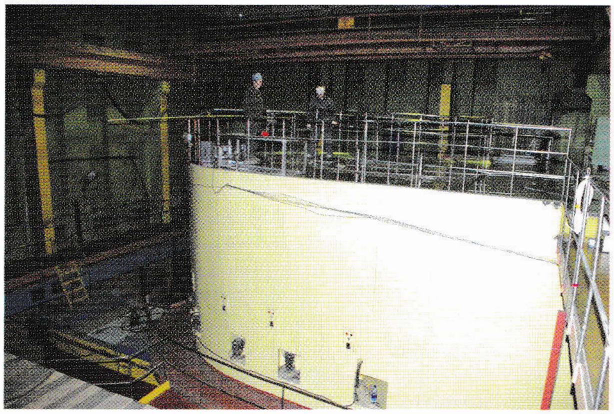
The design service life of IRT-T ends in 2034, as calculated with allowance for the loading cycles of the basic components and the lifetime of he base metal in regard to fast neutron fluence.

The reactor core consists of fuel assemblies surrounded by a beryllium reflector. In its center there are neutron trap blocks with channels up to 40 mm in diameter for experimental devices.

Main performance of the IRT-T reactor

Power	6 MW
Moderator	Water
Coolant	Water
Coolant temperature	40…60 °C
Reflector	Beryllium
Neutron flux:	
thermal, in the core	$1.5 \cdot 10^{13}$ cm^{-2}·s^{-1}
fast, in the core	$1.12 \cdot 10^{13}$ cm^{-2}·s^{-1}
thermal, in central channels of the beryllium trap	$1.5 \cdot 10^{14}$ cm^{-2}·s^{-1}
Number of horizontal experimental channels	10 (8 with Ø100 mm, 2 with Ø150 mm)
Number of vertical experimental channels	14[*] (Ø 36…100 mm)
Microcampaign	Up to 60 days

[*] *Four of which are found in the central beryllium trap*



General view of IRT-T central hall

Upgraded IRT-T control room

Characteristics of IRT-T fuel assemblies

Number of fuel elements in a fuel assembly	8 (6)
Type of fuel elements	Three-layered plates with dispersion fuel
Fuel element thickness	1.4 mm
Fuel enrichment in ^{235}U	90 %
Content of ^{235}U in a fuel assembly	300 (264) g
^{235}U concentration in the core	101 (89) g/l
^{235}U quantity per unit area of heat exchange surface	192 g/m^2
Fuel assembly heat transfer area	1.56 (1.37) m^2
Heat exchange surface per unit volume of the core	5.25 (4.62) cm^2/cm^3
Material of fuel claddings and end pieces	Aluminum alloy
Fuel cladding temperature	Up to 100 °C[*]

* *Boiling on fuel surface is impermissible*

The side reflector of the core is made of square beryllium blocks.

The fuel assemblies are of the IRT-3M type, made of 8 or 6 tubes.

The reactor core is immersed in the pool at a depth of 6.5 m. The pool is enclosed in mass concrete which serves the purpose of biological shielding. The pool water acts as coolant, moderator, top reflector and biological shield.

The primary circuit provided for core cooling includes the reactor tank with built-in retention and distribution reservoirs, an external retention reservoir, reactor coolant pumps, an emergency cooling pump, heat exchangers, pipelines and valves.

Fuel meat length

The stainless steel tank, which serves as the reactor pool lining, is found in the aluminum tank. Primary water is cooled in heat exchangers by service water of the secondary circuit, with heat removed to a cooling tower.

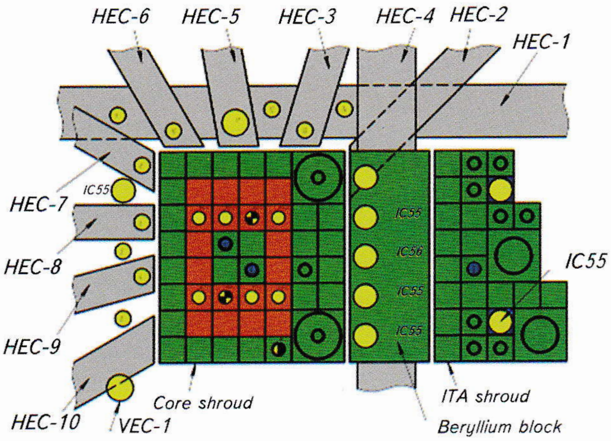
Experimental capabilities of IRT-T

The experimental capabilities of the reactor are fit for a broad spectrum studies.

The horizontal channel HEC-4 is used for neutron transmutation doping of silicon.

One of the horizontal channels has a facility installed for irradiation of specimens at cryogenic temperatures.

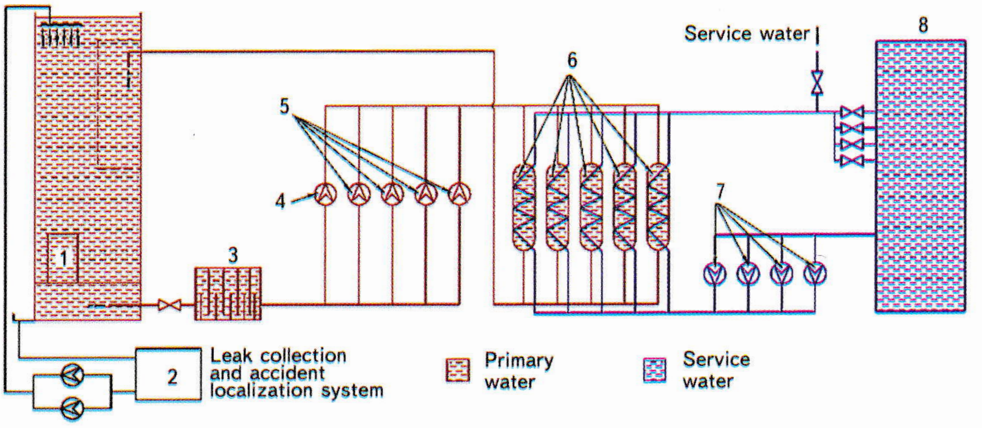
Studies on neutron activation analysis are in progress. The determination methods for



Basic IRT-T configuration:

🟥	*8-tube fuel assembly*
○	*Channel*
●	*Displacer with a channel for an ionization chamber*
🟥	*6-tube fuel assembly with a channel for a CPS rod*
🟩	*Beryllium block with a channel for an AC rod*
🟩	*Beryllium block with a plug d32 mm, measuring 67x67 mm, in the inner thermal assembly*
🟩	*Beryllium block*
🟩	*Beryllium block with a "wet" channel*
🟩	*Beryllium block with plugs d90 mm, D110 mm, measuring 134 x134 mm*
🟩	*Beryllium block with plugs d44 mm, measuring 138.5 x 138.5 mm*

HEC – horizontal experimental channel
VEC – vertical experimental channel
IC-551562 – ionization chamber
ITA – inner thermal assembly



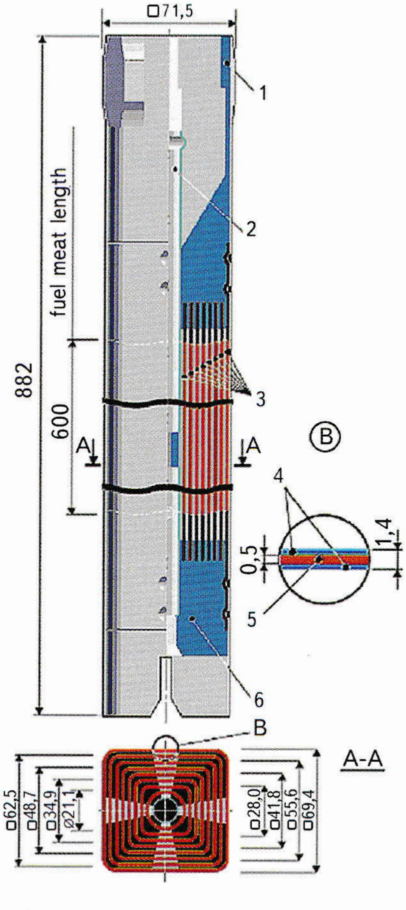
Cooling circuit of IRT-T:
1 – core; 2 – 8 m^3 tank; 3 – retention reservoir; 4 – emergency cooling pumps; 5 – primary pumps; 6 – heat exchangers; 7 – secondary pumps; 8 – cooling tower; 9 – service water

noble, rare and dispersed elements, species traces in samples of any composition with the use of radiochemistry are useful to geologists, geochemists, and oil field development specialists.

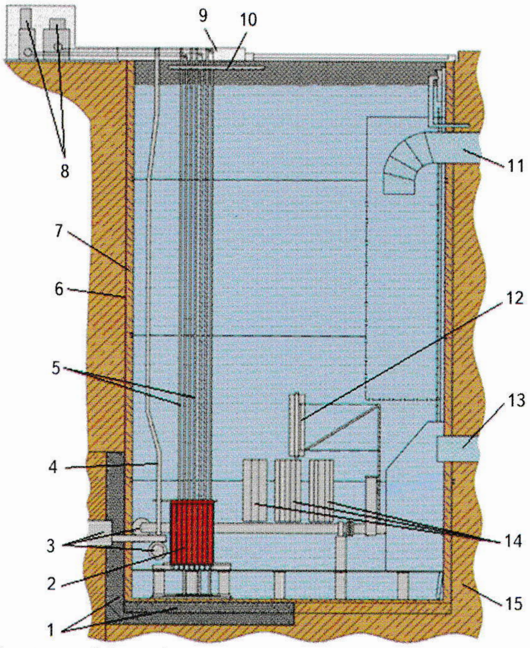
One of the processes at the reactor is employed for separation of diamonds from source material flows, with the methods for radioactive labeling of diamonds and the hardware for their logging well-developed.

An experimental facility was designed and built for detecting emissions of π^0-mesons during in-pile neutron-induced fission of ^{235}U nuclei. Two Cherenkov total-absorption spectrometers for recording and measuring the energy of two γ-quanta from disintegration of π^0-mesons, are placed at the exits of two axially aligned horizontal channels – HEC-2 and HEC-10.

A GMP-quality facility is based on one of the two hot cells for production of radiopharmaceuticals to meet the diagnostic needs of clinics.



IRT-3M fuel assembly:
1 – head-piece; 2 – displacer; 3 – fuel elements; 4 – cladding; 5 – fuel core; 6 – tail-piece



Reactor tank in section:
1 – thermal shield; 2 – reactor core; 3 – HEC; 4 – VEC; 5 – CPS channels; 6 – aluminum tank; 7 – stainless steel tank; 8 – CPS rod drives; 9 – CPS pad; 10 – sprayer; 11 – pressure pipeline; 12 – fuel assembly transfer device; 13 – suction pipeline; 14 – temporary fuel storage; 15 – heavy concrete

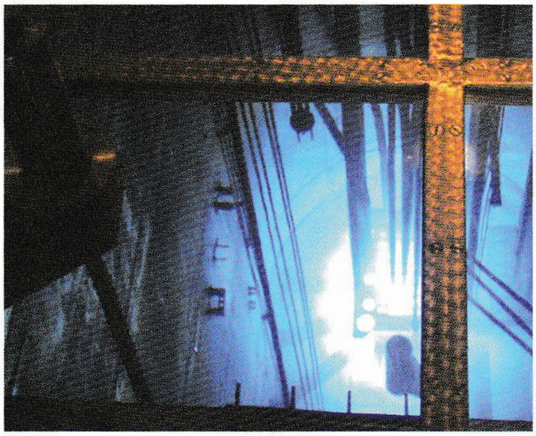
Small ^{99m}Tc generators were developed, and are being produced and supplied. Preparations are under way for production of therapeutic ^{125}I products. Targets made of enriched ^{98}Mo are irradiated with the use of central vertical channels with the thermal neutron flux of $1.1 \cdot 10^{14}$ $cm^{-2} \cdot s^{-1}$. Sorption-type technetium generators "^{99m}Tc-GT-TOM" are produced for the output of 30 GBq.

To promote development of the silicon doping operations, production of radiopharmaceuticals, and provision of an NCT complex as part of the Nuclear Medical Center Project in Tomsk, it was decided to initiate conversion of the IRT-T reactor to the power level of 12 MW and to start the associated organizational work.

Main activities

The IRT-T reactor is employed mainly for:

- education of students of the energy-related disciplines;
- generation of ^{99}Mo by the activation method and for production of ^{99m}Tc for medical applications in the Siberian and Ural regions;
- neutron transmutation doping of single-crystal ingots up to 127 mm in diameter and up to 700 mm in length;



View of the IRT-T core in the pool

– neutron activation analysis of material for geological exploration activities and improvement of the analytical capabilities of the University;

– modification of crystalline structures by neutron and gamma radiation;

– expansion of the range of radioisotope products.

International cooperation

The laboratories set up around the IRT-T reactor pursue joint activities with specialized laboratories in countries of the CIS and beyond.

Principal collaborators:

- National Laboratories of the USA (Oak Ridge, Brookhaven, Pacific North West, Los Alamos, Sandia);
- GT Semiconductor Materials Co., Ltd (China, Beijing);
- National Nuclear Center of the Institute of Radiation Safety and Ecology (Kazakhstan);
- Nuclear Research Center of the Mongolian National University;
- Topsil Semiconductor Materials A/S, Denmark;
- Wacker-Chemic, GmbH, Germany.

Main activities

In 2011, the IRT-T utilization factor was estimated at 0.32.

Along with the main lines of activities, design of the radiation monitoring system for the IRT-T buildings was finalized and passed the State peer review.

Engineering solutions were adopted and technical assignments were prepared for design of the hot cell building and for construction of the three-storied laboratory building.

History

Between the time of startup in 1967 and 1970, the IRT-T core had fuel assemblies made of EK-10 rods with 10 % enrichment in ^{235}U and a graphite reflector. The reactor power was 2 MW.

The first upgrades of the IRT-T took place in 1971, when the core shroud was replaced. On completion of those activities, the core was loaded with IRT-2M fuel assemblies whose enrichment in ^{235}U was as high as 90 %, and was provided with a beryllium reflector. The reactor power came to 2.5 MW.

In July 1977, when an accident occurred with loss of tightness of the reactor pool lining and failure of heat exchangers, it was decided to shut the reactor down for retrofitting. Those operations completed in 1984 included:

– replacement of the reactor pool lining with that of steel 5 mm in thickness, whose surface was finished by one-side electropolishing;

– change of the ejector-type core cooling circuit for a once-through one;

– installation of the primary and secondary cooling pipelines of an increased diameter and five heat exchangers, each with the heat removal area of 200 m^2; construction of a three-section cooling tower of sprinkler design with the secondary coolant flow rate up to 2100 m^3;

– installation of new CPS, instrumentation and control systems, radiation monitoring and power supply systems, a special ventilation system, and a liquid radwaste collection system.

At the final stage of the upgrades, the reactor core was loaded with IRT-3M fuel assemblies and a beryllium reflector, and an outer “thermal” assembly was built from beryllium blocks.

In June 1984, the IRT-T was brought to first criticality. During the first-power operations in December of the same year, it was proved that the reactor could work steadily at the design power level of 6 MW without overloading its systems.

The first-power activities showed that the reactor power could be raised to 11.5 MW without any significant modifications in the safety-related systems.

In 2005, the CPS and I&C systems were subjected to extensive retrofitting, with the electronics completely replaced. The control and protection system was built around "MIRAZH MB" safety modules and the process parameter monitoring system, around "Metran" instruments. The reactor was successfully brought to criticality in December 2005.

In 2005–2007, three new safety-related systems were placed in service at the IRT-T, namely: control and protection system; process parameter monitoring system; and radiation monitoring system.

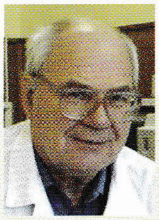
In the same period, a liquid radioactive waste (LRW) treatment system was put into operation; as of today its throughput reached 550 m^3 of LRW.

A.N. Gerasimenko at the IRT-T control board

The operating team of the IRT-T facility

Personalities

YU.A. TSIBULNIKOV.
Deputy Director of the Institute for the Research Complex "Nuclear Reactor"



I.N. GRIGOROV
Deputy Chief Engineer of the IRT-T

Veterans at their post

Contact person

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