
International Conference on
small modular reactors
and their applications
21–25 October 2024, Vienna, Austria

IMPLEMENTATION OF PROJECTS OF NUCLEAR FLOATING POWER UNITS WITHIN THE FRAMEWORK OF MARITIME AND NUCLEAR LAW AND APPROACHES TO REGULATION

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21–25 October 2024

Afrikantov OKBM - Scientific and Production Center of Nuclear Engineering of the Rosatom State Corporation

Date of foundation	— 27 December 1945

The company has a well-developed efficient infrastructure with a full production and technical cycle from design, manufacture and testing to comprehensive delivery of products to the customer and provision of their service support throughout the entire life cycle

Rewords:

1960 — Order of Lenin
1985 — Order of October Revolution

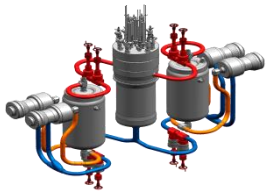
Afrikantov OKBM, as the chief designer and complete supplier of reactor installations for all nuclear icebreakers, is a reliable and responsible partner in solving scientific, technical and production tasks of any complexity

Preserving traditions, we create the future

Development and experience of marine reactor units operation

ROSATOM

OK-150



90 MW

Decommissioned: nuclear icebreaker Lenin

Decommissioned: nuclear icebreakers Arktika, Sibir, Rossiya, Sovetsky Soyuz

In operation: nuclear icebreakers 50 let Pobedy, Yamal

OK-900
OK-900A

159 MW

KLT-40 KLT-40M

135 – 150 MW

In operation: LASH Sevmorput, nuclear icebreakers Taymyr, Vaygach, FPU Akademik Lomonosov

RITM-200

198 MW

In operation: nuclear icebreakers Arktika, Sibir, Ural

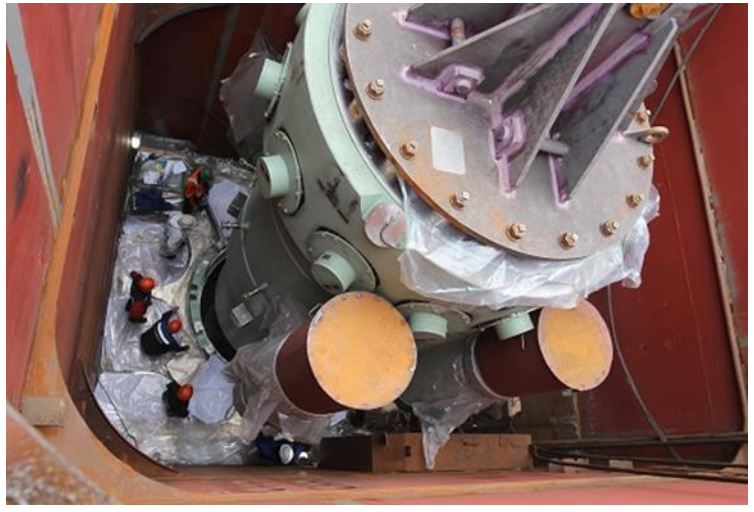
Under construction: nuclear icebreakers Chukotka, Yakutiya, Leningrad, Stalingrad

RITM-400

340 MW

Under construction: nuclear icebreaker of increased power capacity

Installation of reactor RITM on board a nuclear icebreaker



In 2024, 2 steam generating units of RITM were installed on board the Chukotka nuclear icebreaker

A total of 10 steam generating units of the RITM series for 5 nuclear icebreakers have already been manufactured, the manufacturing of new units is also ongoing

https://www.rosenergoatom.ru/zhurnalistam/news/

Floating power units on the basis of RITM series reactors

CHARACTERISTICS OF FPU \ PRODUCT LINE	Pilot project  FPU «Akademik Lomonosov»	 FPU-106 for the Russian market	 FPU-180 for the Russian market	 FPU-100 for the international market
VESSEL TYPE	Non-self-propelled vessel			
LENGTH X WIDTH X DRAFT (m)	144 x 30 x 5,6	143,3 x 30 x 5,5	191,7 x 32,6 x 7	120 x 32,4 x 6
DISPLACEMENT	22 516 t	21 261 t	30 500 t	21 395 t
REACTOR TYPE	2 x KLT-40S	2 x RITM-200S	2 x RITM-400M	2 x RITM-200M
ELECTRICAL CAPACITY (TRANSFERING ON SHORE)	70 MW	106 MW	180 MW	100 MW
TIME PERIOD EBTWEEN REFUELINGS	2,5-3 years	5-7 years	5-6 years	Up to 10 years
LIFE CYCLE	40 years	40 years	60 years	
PERSONNEL (taking into account compatibility)	366 people	128 people	128 people	108 people

ADVANAGES OF FPU PROJECTS:

- Minimization of capital construction at the operation site due to the construction of onshore hydraulic structures
- Adaptation of onshore hydraulic structures to a specific site, without changes to the design of the FPU
- Possibility of unification of FPU and series production
- Possibility of relocating the FPU for power supply to other areas if necessary
- Ability to work in load following mode
- Unique business model of FPU projects implementation

Operation experience of FPU «Akademik Lomonosov»

MAY 2020
FPU Akademik Lomonosov is commissioned

- Emissions of carbon dioxide equivalent in excess of **300 THOUSAND TONS** into the atmosphere have been prevented
- Supply of electricity to **MORE THAN 50 PERCENT** of consumers in the Chukotka area
- **OVER 500 MILLION KWH (194 MILLION KWH IN 2023)** of electricity has been generated
- **OVER 410 THOUSAND GIGACALORIES (76 THOUSAND GIGACALORIES IN 2023)** of thermal energy have been generated

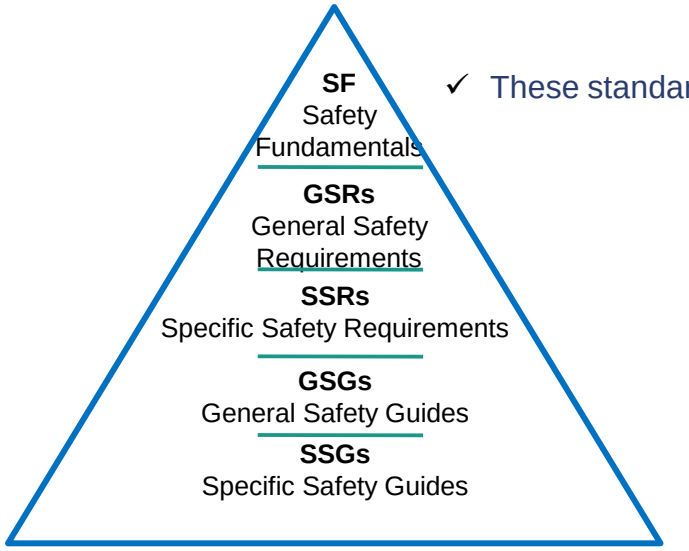
The first refueling of the first reactor unit was completed in 2023, and refueling of the second reactor unit is being performed. The fuel handling equipment placed on board the FPU is used.

IAEA and IMO: development of legal norms for safety

The IAEA safety standards

In accordance with article III of its statute, the IAEA is authorized to establish or adopt standards of safety for protection of health and minimization of danger to life and property and to provide the application of these standards

The publications through which the IAEA establishes safety standards are issued in the IAEA Safety Standards series, which cover issues of nuclear safety, radiation safety, transportation safety and waste safety



✓ These standards are of a non-obligatory nature.

Structure of the maritime legal norms

UN Convention on the Law of the Sea, 1982
Thematic blocks of conventions and agreements (blocks of conventions and agreements in the field of maritime safety, e.g., SOLAS, 1974)
Regional and bilateral agreements on various issues of maritime activities (e.g., Convention on the Protection of the Black Sea Against Pollution, 1992)
National norms and rules (e.g., Merchant Shipping Code of the Russian Federation, 1999)

Maritime safety: the specifics of IMO activities

The main objectives of the organization are reflected in the IMO Convention: "Safe, secure and efficient navigation in clean oceans"

- ✓ IMO has contributed to the adoption of about 50 conventions and protocols, more than 1,000 codes and recommendations related to safety and security at sea
- ✓ Regulatory documents within the framework of maritime law, including those issued by IMO, do not have a strict and generally accepted hierarchy
- ✓ In addition, IMO recommendations are usually not legally binding on Governments, but rather serve as guidelines for the development of national rules and requirements. However, some codes have become binding in accordance with the relevant provisions of the SOLAS Convention and/or the MARPOL Convention
- ✓ At the same time, the key issues of international navigation covered by the provisions of international law are binding for all participants in relations arising from navigation and other uses of the oceans, including for those States that are not members of IMO

Business model of implementation of FPU-100 project

The operation site is a green lawn, there is no equipment for handling nuclear fuel both on board and at the operation site

Transportation for maintenance and refueling

LIFE CYCLE

60

years

THE HOST COUNTRY

Consumer in the host country

Place of operation

THE RUSSIAN FEDERATION

Port of dispatch

Maintenance and refueling

Handling with nuclear waste

Transportation to the operation site

On-site power generation (up to ten years)

Possible relocation of the FPU to another operation site

All fuel operations are performed only at a specialized enterprise in the Russian Federation

Within the framework of the Energoflot business model, the transfer of the object to the ownership of the host country does not occur.

The construction of the FPU fleet takes place at the shipyard of the Russian Federation, a legal entity of the Russian Federation is the owner of the FPU fleet and is responsible for transportation, operation and maintenance throughout the life cycle of the FPU, as well as for decommissioning.

After transportation to the host country, the FPU is connected to the power grid of the host country, that is, to the coastal infrastructure built by the host country according to the initial technical requirements provided by the supplier country

A Russian legal entity is the operator of FPU

Classification of FPU under the SOLAS Convention

SOLAS Convention 1974 – a document on the safety of marine navigation at the international level

- The present Regulations, unless expressly provided otherwise, do not apply to ships not propelled by mechanical means (Chapter I, Part A, Regulation 3)
- However, a nuclear ship shall not, in any circumstances, be exempted from compliance with any Regulations of this Convention (Chapter VIII, Regulation 3)

A NUCLEAR FLOATING POWER UNIT IS A NUCLEAR VESSEL:

It has a nuclear power plant on board

It has the necessary seaworthiness properties of the vessel

It is classified by the Russian Classification Society

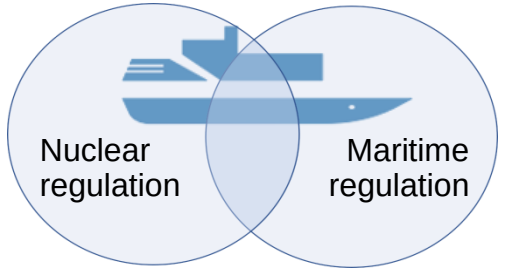
Additional documents in the field of the maritime and nuclear law:

- Code of the Safety for Nuclear Merchant Ships
- INF Code
- IMDG Code
- UN Recommendations on the Transport of Dangerous Goods Model Regulations “Orange Book”
- *Special document on non-self-propelled nuclear vessels*

Requirements for safety of FPU

IAEA

The IAEA norms: SF-1, GSR Part 4, SSR-1, SSR-2/1, SSR-6, SSG-52, SSG-53 etc.



IMO

SOLAS Convention, Code of Safety for Nuclear Merchant Ships, INF Code, etc.

- The IAEA Safety Report Series No. 123 Applicability of Safety Standards to Non-Water-Cooled Reactors contains the results of analysis of the applicability of the IAEA standards to SMR
- The requirements of SF1, GSR Part 4, SSR-1, SSR-2/1, SSG-52 and others are applicable to FPU with a reactor unit.
- SSR-6 is not applicable to FPU, as the standard applies to the transportation of nuclear material in packages, which is not the case of FPU
- Transportation is part of the operation, therefore, all operational requirements should be met

- The Code of Safety for Nuclear Merchant Ships contains detailed requirements for the safety of self-propelled nuclear vessels, which are applicable to the FPU mutatis mutandis (without the part related to propulsion)
- The INF, IMDG Codes correspond to the IAEA SSR-6 standard and not applicable

- **The requirements for the safety of transportation of FPUs should take into account approaches to ensuring the safety of nuclear merchant ships**
- **As experience is gained during the implementation of pilot FPU projects, the most successful practices can be consolidated in a special regulatory framework created under the auspices and with the cooperation of the IAEA and IMO**
- **Requirements for its safety can be developed by the IAEA and IMO jointly, taking into account their mandates, by analogy with the document Safety Considerations in the Use of Ports and Approaches by Nuclear Merchant Ships, Safety Series No. 27, 1968.**

Licensing of FPU in the Russian Federation

External contractors (general designer of the reactor unit, manufacturer, etc.)

Package of documents to be submitted to the operator

Activities related to the preparation of a license application

A set of documents (including a Safety Analysis Report) for applying for a license

Interaction with the nuclear regulator – Rostechnadzor

Operator submits an application to Rostechnadzor

Consideration of the application by Rostechnadzor

Rostechnadzor's report on the verification of the application

Issuing a license for the operation of a reactor unit of FPU and putting it into operation

Interaction with the marine regulator - Classification Society

Operator submits documents to the classification society

Consideration of documents by the Classification Society of the Russian Federation

Examination by the Classification Society of the Russian Federation

Issuance of a certificate for a nuclear vessel

Approaches to regulation.
The scheme of regulation of FPU abroad

1. CONSTRUCTION AND OPERATION

2. ENTERING THE WATERS OF THE HOST COUNTRY

COMMISSIONING

On the territory of the Russian Federation

RELOCATION OF FPU-100

1.1

Design and construction is carried out according to the norms of the Russian Federation and according to international maritime standards (in particular, the SOLAS Convention). Due to the series production, the adaptation of the project to the norms of the host country is not provided.

1.2

- The operating organization registered in the Russian Federation receives a license from Rostechnadzor for the operation of the nuclear installation on board FPU and certificates from the Maritime Regulator.
- FPU-100 is registered in the Russian international register of ships and receives the flag of the Russian Federation
- Safety Information of FPU-100 is approved by the Government of the Russian Federation

2.1

The operating organization provides Safety Assessment to the Government of the host country for review

2.2

The Government of the host country reviews the Safety Assessment and takes into account the results of the review of the safety documentation for the FPU-100 by Rostechnadzor
The assessment will require the involvement of the nuclear regulator of the host country, which must issue its opinion. The conclusion can be issued in the form of an operating license or any other form by agreement of the parties

2.3

The Government of the host country approves the documents on the safety of the vessel, issues a permit to the FPU entering the port of the host country

Conclusions

01

Nuclear energy has a leading position in stabilizing the energy sector, in line with the global environmental agenda, and the FPU is an innovative tool for ensuring the need for clean energy in regions remote from large power grids

02

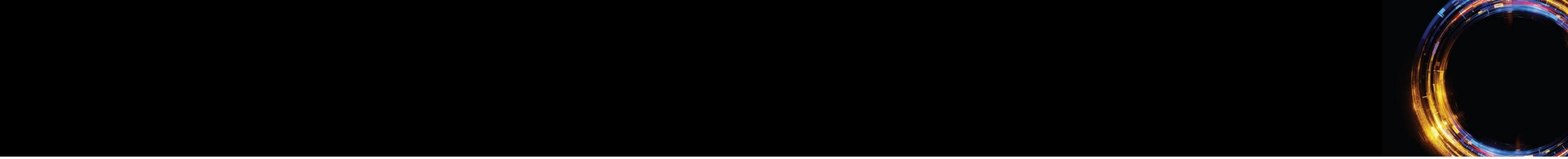
The FPU is a nuclear vessel, and the reactor is an inseparable part of it. The definition of a FPU as a vessel with a nuclear reactor also opens up the possibility of using regulatory approaches adopted in the maritime law, which make it possible to increase the efficiency of regulating an object moved between operating sites during its life cycle

03

The requirements for the maritime and nuclear safety of the IAEA and IMO, developed over more than half a century of operation of water cooled reactors, should be taken into account when designing an FPU

04

Right now, nothing prevents the implementation of FPU projects. At the same time, as experience accumulates, it is possible to develop specialized standards of the IAEA and IMO



Thank you!