

# SOLUTIONS FOR THE SHIPBUILDING INDUSTRY

Atomenergomash JSC



# ABOUT COMPANY



Atomenergomash —  
is a machine-building division of the State Atomic Energy Corporation Rosatom.  
Global machine-building holding company represented in key industries.

- We assist our customers in delivering high performance, create new technologies and modern technical solutions that ensure efficient and safe operation of equipment throughout its entire lifecycle.
- We combine leading scientific research, engineering, manufacturing centers in Russia, CIS and European Union countries.
- Our products are presented in nuclear and thermal power, oil & gas industries, shipbuilding, special steel market, in small hydro generation and other economic and industrial sectors.
- We see our mission in a constant work together with our partners and customers to improve the welfare of people today and tomorrow.

# EXPERTISE

Our capabilities include a wide range of solutions for ships of various types and purposes

- Reactor unit (design, construction and integrated supply)
- Heat exchange equipment
- Shaft lines with components (supply of semi-finished products, manufacturing of the products and components)
- Steering equipment (supply of semi-finished products and manufacturing of components)
- Pumping equipment for marine systems
- Hull castings
- Ground gear (supply of semi-finished products and manufacturing of components)
- Fittings for various marine systems
- Filtration, ventilation and air conditioning equipment
- Hoisting equipment

AEM's design and manufacturing unit includes:

- Research and design unit
- Materials research support
- Forgings
- Metallurgical production
- Thermal production
- Welding production
- Mechanical assembly production
- Machining production

We are trusted by

- United Shipbuilding Corporation
- SSC "Zvezda"
- Elkon (Turkey)
- Motortech Consulting d.o.o. (Croatia)
- Novenco Marine & Offshore (Norway) and other companies



# SHIPBUILDING, MARINE REACTORS AND SMALL NPPS

**Starting with the first domestic nuclear-powered ships, we create reactor equipment for all ships with a nuclear propulsion system.**

The latest generation is the RU RITM-200 range. They will be used not only in the nuclear icebreaker fleet, but will also become the basis for small-sized nuclear power plant (small-modular reactors), both onshore and offshore.

# 1

**unit of FNPP**

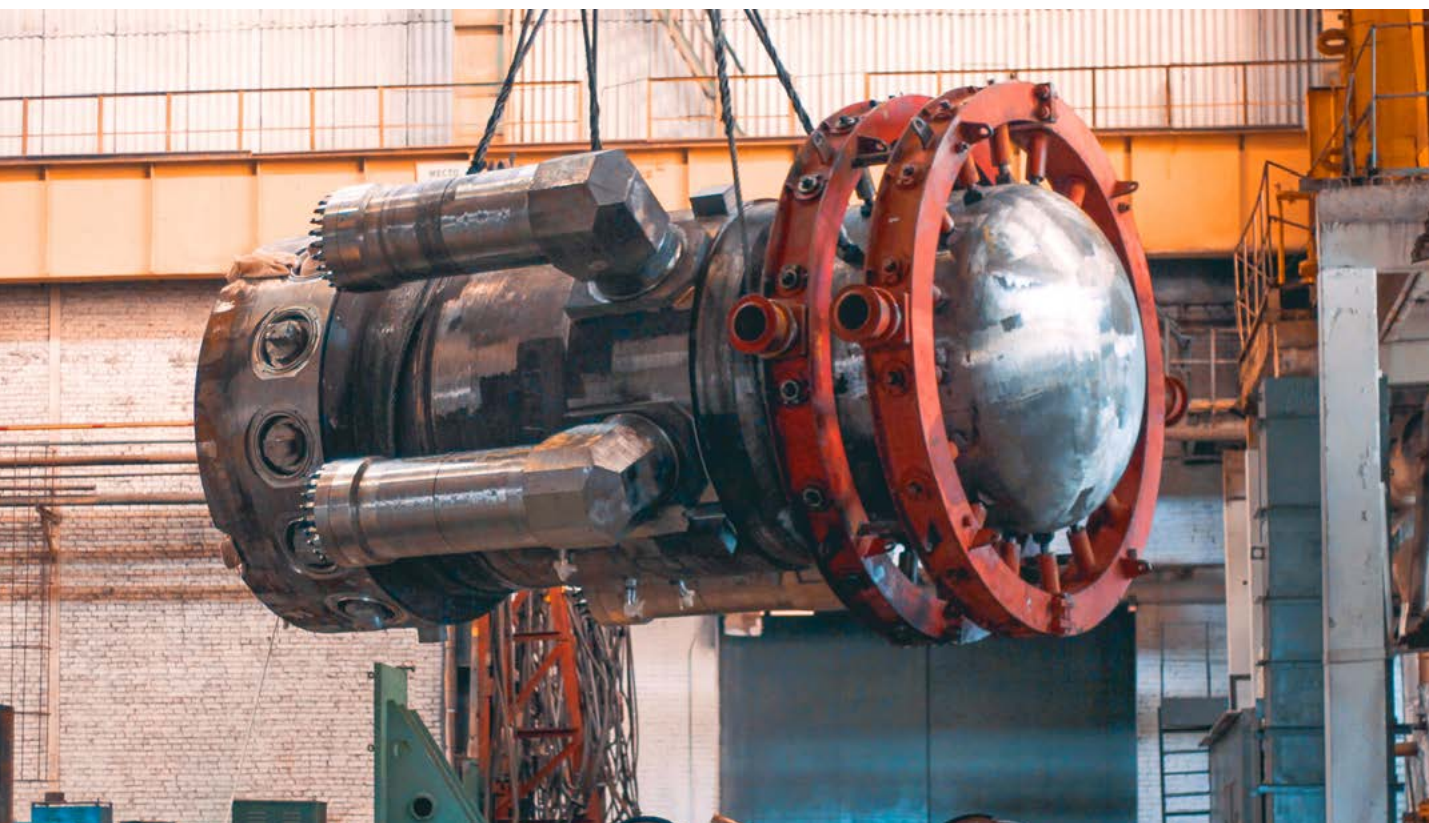
with an electric capacity of up to 100 MW can replace the combustion of 140 thousand tons of coal per year at TPPs

# 200

 mln tons

**cargo for various purposes**

were transported with the help of our reactor units along the Northern Sea Route during the entire use period of ice class icebreakers



# NEW-GENERATION ICEBREAKING FLEET



Currently\* there are three nuclear-powered LK-60 of project 22220 ships at various stages of construction.

They will be able to lay a corridor in ice up to 3 meters thick and pilot ships with a displacement of up to 70 tsd tons due to the enlarged width.

In 2019, it was decided to build two more nuclear icebreakers of this series.

\* As of November 2019.

## Main design parameters

Length on CWL, m	160
Width on CWL, m	33
Depth, m	15,2
Icebreaking capability, m	до 3
Crew size, person	75
Draft on CWL (linear icebreaker mode), m	10,5
Minimum working draft, m	8,5

# RITM-200 REACTOR UNIT

## Main technical solutions

- The nuclear power unit (NPU) has two reactor units based on an integrated type water-moderated reactor with a thermal capacity of 175 MW, located in individual containment shells.
- Steam (248 t/h from each RU) is generated according to a two-circuit scheme, which has been traditionally worked out in nuclear power engineering by transferring heat from the primary circuit to feed water and to a second circuit steam in the steam generator.
- Reducing the neutron fluence on the case allows you to increase the radiation durability of the steam generation unit case and reduce the temperature during hydraulic pressure tests.
- Active and passive security systems have been introduced.
- The safety control of RITM-200 RU is based on the following principles: high heat-storage capacity, natural circulation of the primary coolant, sufficient for the reactor shut-down cooling, the minimum length of the primary pipelines, the use of outflow restrictors in small pipe branches, a larger volume of the primary coolant in the reactor shell compared to the block design. All this increases the time slack until the core section is drained in accidents with a primary coolant leak.





### Technical characteristics

- integrated case of the steam generation unit (SGU), which allows to downsize RU within the containment shell significantly
- low-enriched cluster core, providing continuous operation without reloading and meeting international requirements for the non-proliferation of nuclear arms
- extended service life and lifetime of the major equipment
- extended emergency time slacks for personnel to take corrective actions compared to previous-gen marine RUs

### Main design parameters for 1 SGU

SGU type	integrated
Thermal power, MW	175
ICUF (technical requirement at RU)	0,65
On-stream period, h	26 000
Assigned energy source r.c., TWh	4,5 (7,0*)
Fuel preparation	< 20%
Specified lifetime:	
– non-replaceable equipment, years	40
– replaceable equipment, years	20
Specified service life:	
– non-replaceable equipment, years	320
– replaceable equipment, years	160

### Specified conditions

Primary operating pressure, MPa	15,7
Primary coolant temperature:	
– r.c. inlet, °C	277
– r.c. outlet, °C	313
Primary coolant flow rate through the r.c., t/h	3250
Steaming capacity, t/h	248
Steam parameters:	
– Temperature, °C	295
– Pressure, MPa (abs.)	3,82
Temperature during hydrotesting at the end of lifetime, °C	30
Neutron fluence at the end of lifetime, N/cm <sup>2</sup>	5,2·10 <sup>19</sup>

\* Design perspective.

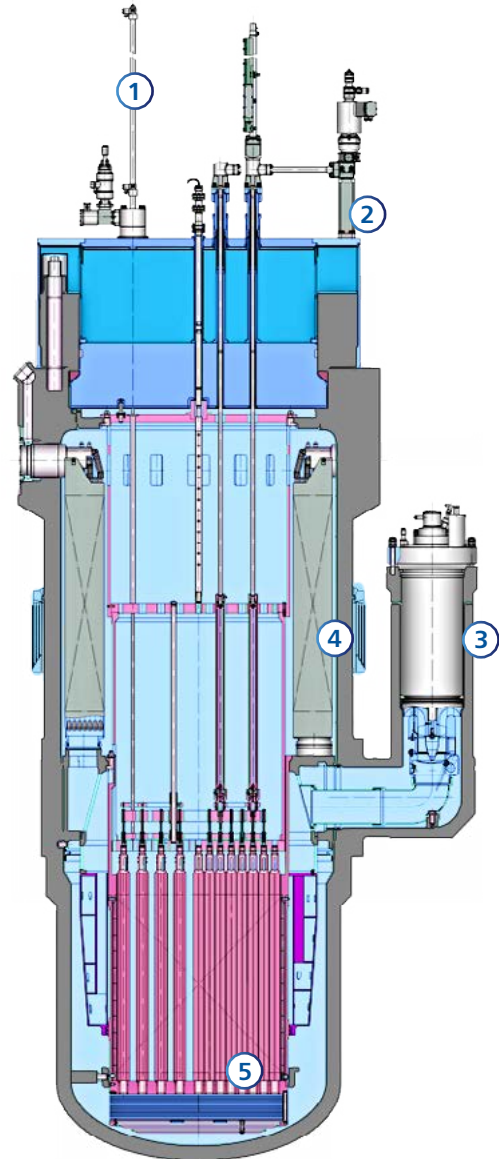
# MAIN EQUIPMENT

## Steam-generation unit

The design of the RITM-200 reactor unit is based on integrated type SGU with forced circulation, the steam generator cassettes (SG) are located inside the case, the primary central pumps (PCP) in separate remote hydraulic chambers, and the reactor core with increased energy source. This type of SGU is defined by greater compactability compared to block type SGU used on active nuclear-powered ships, where steam generators are located in separate cases.

Also, a more compact design of the steam generator, a cassette reactor core with a higher uranium capacity, and a denser arrangement of equipment in the compartment were used to minimize the dimensions.

The compactability of the steam generation unit allows to reduce the weight and dimensions, which cuts down the volume and duration of installation work directly at the shipyard, as well as improves the manufacturing quality of the steam generation unit due to the completion of all works under the machine-building plant conditions. At the same time, the disposal of the unit is simplified due to the possible unloading of the entire steam generation unit with a minimum amount of disassembly.



	Amount
Reactor core	1
Steam generator	4
PCP	4
CPS drives:	
– CH drive	12
– RC drive	6

### SGU general view

- ① RC drive
- ② CH drive
- ③ PCP
- ④ Steam generator
- ⑤ Reactor core



## Reactor core

The design used a cassette-type reactor core with cermet fuel of increased uranium intensity, which, unlike intermetallic fuel, meets the requirements of non-proliferation of nuclear arms (enrichment of less than 20%).

Service life, h	75 000
Lifetime, years	12
Dimensions dop. x H mm	≈ 1600 x 1200
Power capacity, TW · h/m <sup>3</sup>	2,13
Number of fuel assemblies	199
U-235 core charge, kg	438
Moderate enrichment, %	< 20
U-235 specific consumption, g/MW · day	2,3

## Steam generator

A highly efficient straight-tube steam generator is used in the reactor unit. Its specific steam capacity is more than two times higher than in the operating coil-type ones. The configuration of the steam generating cassettes allows you to compactly place them in the case of the steam generation unit.

Number of SG cassettes	12
Reactor core length, mm	2000
Heat transfer surface area, m <sup>2</sup>	93,4

## Pumps

PCP of conventional design, vane-type, single-stage one with a sealed asynchronous motor. The motor is single-winding. The rotation speed is changed by converting the supply frequency.

## CPS drives

The group of protection system (PS) actuators is designed to quickly shut down the reactor and maintain it in a subcritical state in an emergency situation. The group of compensating groups (CG) actuators is designed to compensate the excess reactivity in the start mode, power operation and shutdown of the reactor. The CPS RITM-200 RU drives are based on the drives used in the KLT-40 S RU.

## Features of CPS RITM-200 RU drives

- extended service life and lifetime
- extended operating stroke length

# SAFETY OF THE RITM-200 RU

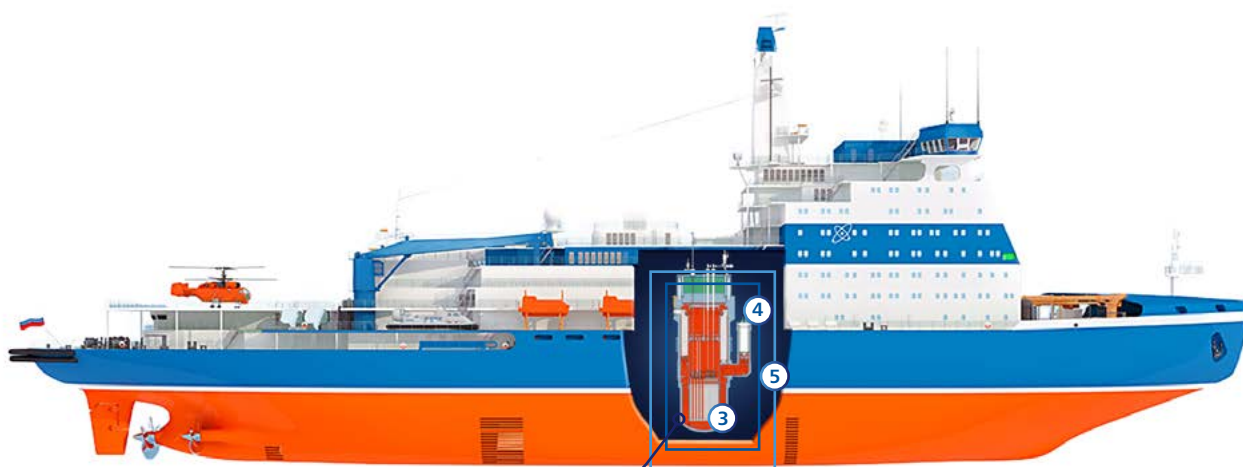
## Radiation and environmental safety

Dose budget on the crew during normal operation and design-basis accidents does not exceed 0.01% of the natural radiation background. The dose exposure of the population in a beyond-design-basis accident with severe core damage does not exceed the values at which protective measures are required.

Due to the operation of RU, the overboard water strength is 0.1 bq/l, which is 100 times lower than the regulated value of the drinking water activity.

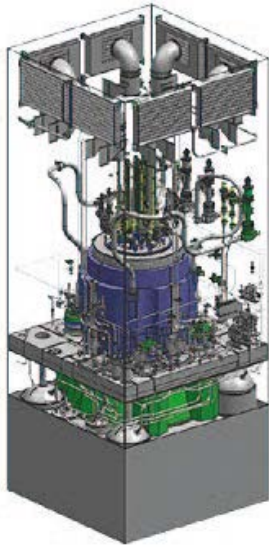
## How RW volume minimization is ensured

- by using a cassette reactor core — reducing the volume of solid radioactive waste by eliminating the replacement of the removable unit during the RU lifetime
- by increasing the intervals between core refuelling — decreasing the frequency of RW arrival associated with refuelling
- by using non-waste technology systems — reducing the volume of liquid radioactive waste by organizing the primary water circulation along closed paths during technological operations involving primary circuit system



## Defense-in-depth (5 RW distribution barriers)

- ① Fuel composition
- ② Fuel-element cladding
- ③ Primary circuit
- ④ Reactor containment
- ⑤ Safety cage



### Technical solutions that differ from operating RUs

- passive incident pressure release system and emergency cooling (the effectiveness of the systems is confirmed by bench tests)
- connecting of external systems at the top of the SGU
- the circulation path of the primary coolant is located in a single housing
- collector circuit of the primary coolant circulation

	OK-900A	RITM-200
Specified service life of the major equipment, h	100 000 (177 000*)	320 000
Specified lifetime of of the major equipment, years	25 (33*)	40
The mass of two RUs within the containment, t	2603	2200
Containment dimensions of two RUs, L x B x H, m	7,6 x 13,3 x 20	6 x 13,2 x 15,5
Reactor core energy source, TWh	1,8	4,5 (7**)

\* Maximum value achieved during operation  
 \*\* Maximum design value

The use of passive and self-actuating systems and safety devices are extremely important for ensuring the safety of RU, while it limits the adverse influence of external system failures, energy sources, and human errors. Passive operation devices and systems, which operate on the basis of natural processes and do not require any external power, are used in the design.

### Processes that do not require external power

- emergency core cooling system with hydraulic accumulators supplying water to the reactor due to the set pressure of blanketing, using one of the pressure compensation groups as a hydraulic accumulator
- a reactor containment with an emergency pressure reduction system that can operate in a passive mode

# RITM-200 REACTOR UNIT

The RITM-200 reactor unit is the basis for the creation of fixed and transportable low-power NPPs, including floating power units. For this purpose, the RITM-200M RU project and the conceptual design of an optimized floating power unit were developed. OFPU is an improved and more efficient technology of the first-of-a-kind Akademik Lomonosov floating nuclear power unit. The use of RITM-200 allows you to increase its capacity, energy source with a simultaneous reduction in area and displacement.

Power units will become a powerful driver in the stable regional development that is not covered by a single energy system and needs reliable and economically acceptable energy sources, ensuring independence from the scarce traditional energy sources.

## Main design parameters for RITM-200 RU

Electric capacity of the generator, MW	2 x 50
Steaming capacity, t/h	280
U-235 enrichment, %	No more than 20
Operating period before core refuelling, years	10–12
Containment dimensions of two RUs, L x B x H, m	6,8 x 14,6 x 16,0
The mass of two RUs, t	2600





### Main design parameters for OFPU

Length, m	112
Width, m	25
Draft, m	4,5
Displacement, t	12 000

### Main areas of use for OFPU

- remote areas without centralized power supply
- places of mining works
- places of temporary accommodation of population, equipment, etc.
- territories where fuel supply for fixed power supply sources is difficult



First-of-a-kind Akademik Lomonosov floating nuclear power unit

# RITM-400 REACTOR UNIT



**5,7**

years

is the period between refuellings

**40**

years

lifetime before disposal

**26 000**

hours

of on-stream period

## Other technical features of RITM-400 RU

Thermal power, MW	315
Steaming capacity, t/h	450
Steam temperature, °C	295
Steam pressure, MPa	3,8
Feed water temperature, °C	105
Core energy content, TWh	6,0
Rate of change of capacity (normal/allowable), % Nnom/s	0,1/1,0
Service life before disposal, h	320 000
Lifetime of replaceable equipment, years	20
Service life before renovation, h	160 000
Unit mass of two RUs, t	3920
Unit dimensions of two RUs, m	9 × 18,2 × 17,5

# “LEADER” NUCLEAR ICEBREAKER

An extra-power nuclear icebreaker that can provide year-round navigation along the Northern Sea Route as well as the piloting of large-capacity ships.

RITM-400 reactor unit developed by Afrikantov OKBM provides the increased capacity.



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**50**  
meters  
channel width

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**120**  
MW  
unlimited screw power

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**8**  
months  
of provisions endurance

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**Unlimited cruising range**

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Icebreaking capability:  
**4.3 m at V = 2 knots**  
**2.0 m at V = 15 knots**

# PRODUCTION CAPABILITIES

## ZiO-Podolsk

One of the largest machine-building enterprises in Russia with a centennial history. Nowadays the enterprise possesses almost all types of basic machine-building facilities, which make it possible to produce modern technological equipment.

The main competitive advantage of ZiO-Podolsk is the unification of the unique production complex, design and marketing services potential, capable of carrying out a wide range of work in the field of power engineering: from design to supply and maintenance service of equipment.

The technological capabilities of the machine-building plant allow to conduct unique operations, while welding production is one of the most qualified in Russia both in the mastered welding and cutting processes, weld materials, and long-term experience in the delivery of critical welded metal structures for various industries.

## Energomashpetsstal (EMSS)

The largest enterprise in Eastern Europe producing large cast and forged semi-finished products from special steels. EMSS has a wide fleet of metal-cutting equipment, including turning, boring, boring-and-turning, deep-boring, plane-milling, mortising, gear-hobbing, band-sawing, and other machines.

The production facilities of the arc-furnace melting shop make it possible to produce forged steel semi-finished products from various large-sized steel grades.

## Afrikantov OKBM

I.I. Afrikantov Mechanical Engineering Experimental Design Bureau possesses advanced technologies and know-how, dominates the field of creating power equipment of various types.

The Design Bureau customers are the enterprises of Rosatom, nuclear power engineering, and shipbuilding industry.

70-year experience in design, high scientific, technical and production potential allow JSC "Afrikantov OKBM" to solve high-level scientific and technical tasks of creating nuclear power units of various types and equipment for them with respect to the highest safety and reliability requirements.

The OKBM production complex equipped with modern technological equipment allows you to perform the functions of the lead supplier for the entire range of designed equipment.

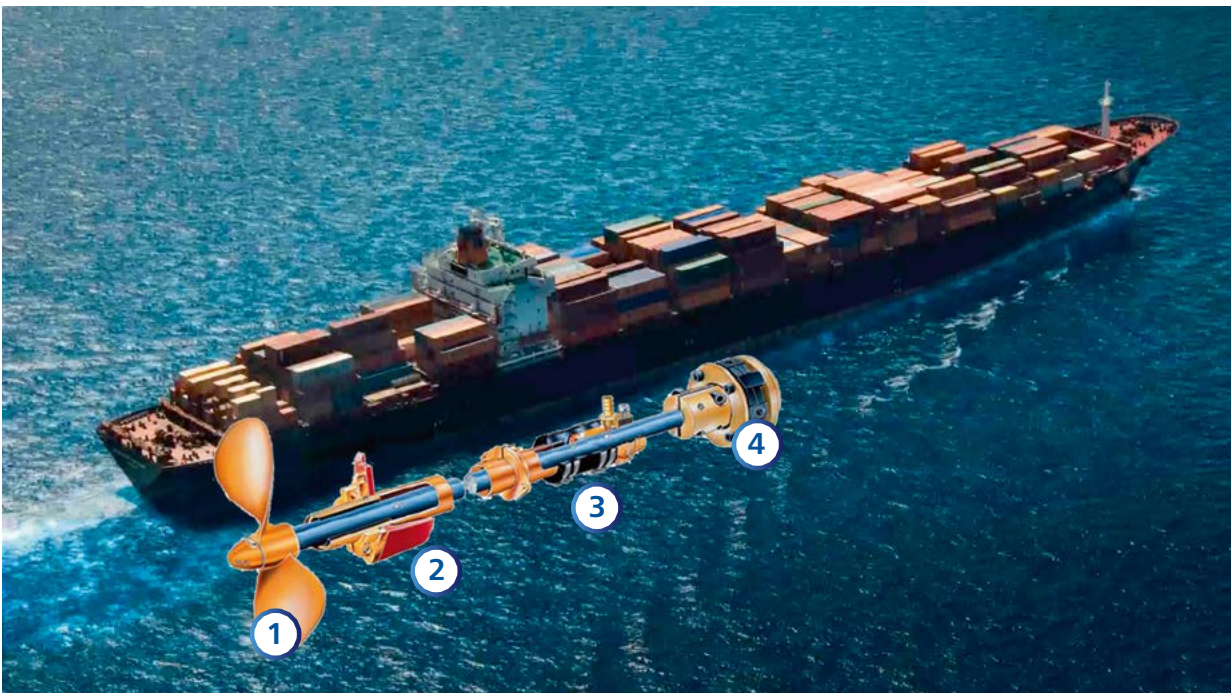
OKBM participates in the program for the comprehensive utilization of nuclear ships at the stages of ensuring safe unloaded fuel sedimentation and spent nuclear fuel unloading. It has the status of the parent enterprise for the technical support of refuelling, and develops the corresponding technological equipment. At the same time, OKBM is involved in the management of spent nuclear fuel from ship reactors and the development of means for its storage and transportation.



# SOLUTIONS FOR THE SHIPBUILDING

## Metallurgical industry

- steel forged semi-finished products of carbon, alloy, stainless and other steel grades available in any size
- ingots of structural and high alloy steel grades up to 415 t
- stamped sheet semi-finished products of various shapes (vessel heads, splash boards, collars, troughs, etc.)



1 Propeller blades

2 Stern shaft

3 Propeller shaft

4 Intermediate shaft

# SHAFT LINES AND PROPELLERS

## Propellers



**Propeller blades for the LK-25 icebreaker**



**LK-16 blades**



**Semi-finished LK-60 right-handed propeller blade**

## Shaft lines and stern gear



**Rudder head UMP  
f. 15-990 z. 554034**



**Intermediate shaft**



**Propeller shaft**

## Mold casting



**Stern-post casting  
Part № 21-15206 LK-60**



**Portside and starboard  
brackets 1-15122 LK-60**

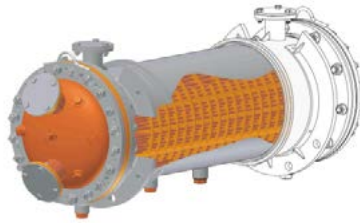


**Stern-post weld-in-  
piece 2-15201 LK-60**

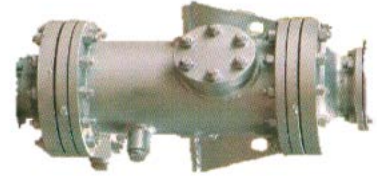
# HEAT EXCHANGE EQUIPMENT



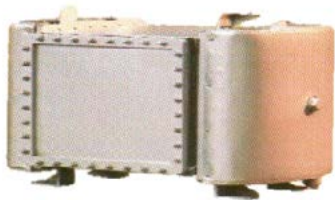
**Coolers**



**Onboard oil and water coolers**



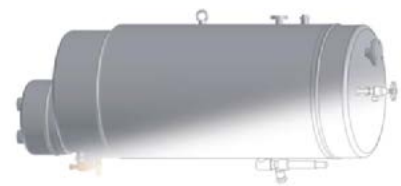
**Overboard water heaters**



**Air heater**



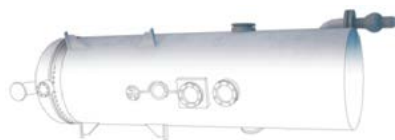
**Condenser cooler**



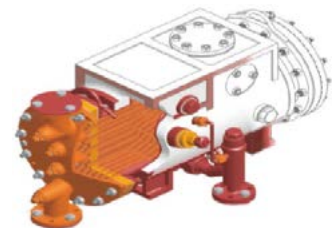
**Liquid fuel heater**



**Capacitive water heater**



**Onboard steam-powered oil heaters**



**Condenders**



# FILTERING EQUIPMENT



Single mesh wire filters for oil, fuel and fresh water



Single overboard water filters

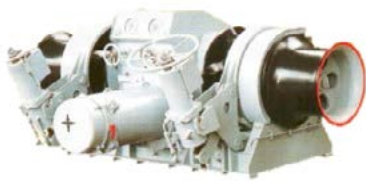


Oil and fuel slot pre-filters



Ion-exchange filter

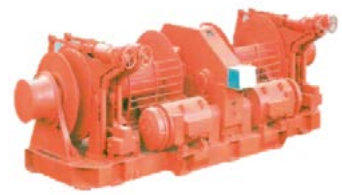
# DECK MACHINERY



Windlasses



Reels



Winches

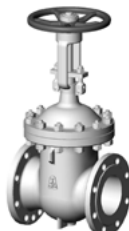
# ONBOARD VALVES



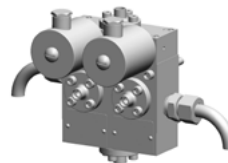
Isolating and regulating valve



Isolating nipple valve



Isolating and regulating valve



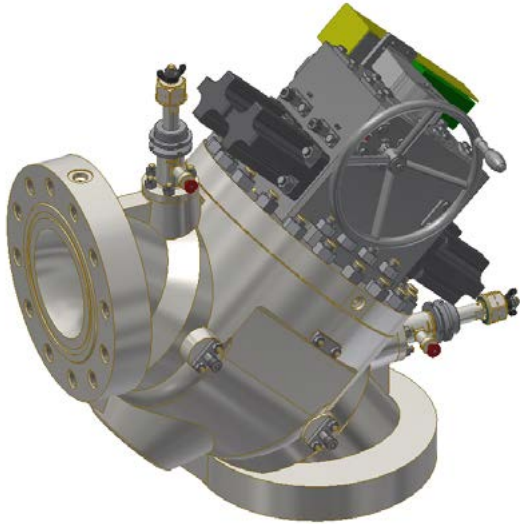
Pneumatic breakers



Isolating pass valve



## Flooding ball valve DN200



**Flooding valve is designed for installation in marine systems as an onboard locking device and is used to receive and discharge overboard water.**

Developed flooding valve has low hydraulic resistance (20 times less than that of serial disk-type flooding valves), improved vibronoise features at as low as practicable overall values for this design.

The need to create a flooding ball valve DN200 is caused by the lack of low-noise spherical flooding ball valves in the domestic industry.

### Main technical features

- Nominal diameter DN - 200
- Working medium - sea, bilge and fresh water
- Estimated pressure P - 6.3 MPa
- Estimated temperature T - 50 °C
- Valve gate shutoff class according to GOST 9544-2015 - A

The design of flooding valve with a stopper in the supports and hydraulic contracting of floating-type saddles allows to unload the sealing surfaces of the bulb stopper and o-rings and rotate the bulb stopper without wear-and-tear by relieving the control medium pressure on the saddles.

A metal-to-metal seal is used in the flooding valve design. This means that the sealing surfaces of the saddles, bulb stoppers and conical surfaces of the o-rings are made in the form of hard facing.

The wedge-shaped arrangement of the saddles side surfaces allows the installation and dismantling of the removable flooding valve parts without dismantling the case from the pipeline.

This valve gate design was tested on the layout in 2015. At the end of the tests, a revision of the layout was carried out. As a result, we may conclude that positive results were obtained.

The flow part is made of titanium alloy TL-3 OST 5P.9071-88 and PT-3V GOST 19807-91 to ensure corrosion resistance of flooding valve to the marine environment.

# PUMPING EQUIPMENT

## NSO 250/30 motor pump



The NSO 250/30 motor pump is designed to work in fresh water cooling systems suitable for an unlimited navigation area. The motor pump is powered by the power-supply and control unit, which is packaged with the motor pump. The O1 letter is assigned to the WCD of the motor pump.

### Main features

- Rated pumping capacity — 250 m<sup>3</sup>/h
- Head at the rated pumping capacity — 30 m
- Range of smooth control of rotor speed — 50 ... 100%

The handled medium is a distilled water according to OST V5R.4296-88 or water for utility and drinking water supply of ships with a quality indicators according to GOST 29183-91 and a temperature of +2 ... +40 °C.

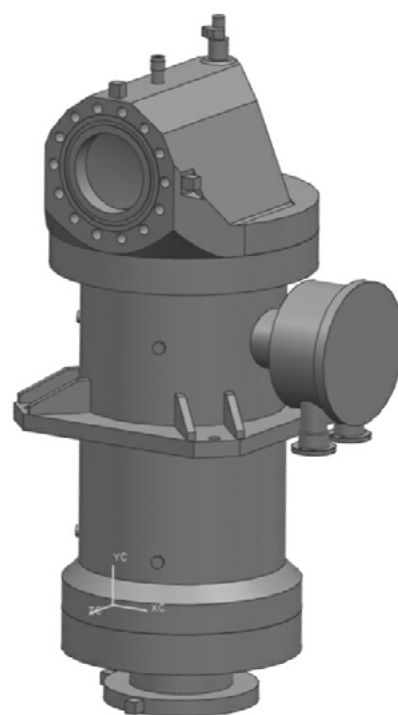
## NSO 250/30 motor pump

The NSO 250/30 motor pump is designed to work in sea water cooling systems suitable for an unlimited navigation area. The motor pump is powered by the power-supply and control unit, which is packaged with the motor pump. The O1 letter is assigned to the WCD of the motor pump.

### Main features

- Rated pumping capacity — 250 m<sup>3</sup>/h
- Head at the rated pumping capacity — 15 m
- Range of smooth control of rotor speed — 10 ... 100%

The handled medium is sea water with a density of not more than 1028 kg/m<sup>3</sup>, salinity of not more than 36 g/dm<sup>3</sup> and a temperature of -2 ... +32 °C.



## NSO 120/35 motor pump



The NSO 120/35 motor pump is designed to work in fresh water cooling systems suitable for an unlimited navigation area. The motor pump is powered by the converting unit, which is packaged with the motor pump.

### Main features

- Rated pumping capacity — 120 m<sup>3</sup>/h
- Head at the rated pumping capacity — 35 m
- Range of smooth control of rotor speed — 50 ... 100%

The handled medium is distilled water according to OSTV5P.4296 or water for utility and drinking water supply of ships with a quality indicators according to GOST 29183 with a temperature of +2 ... +40 °C.

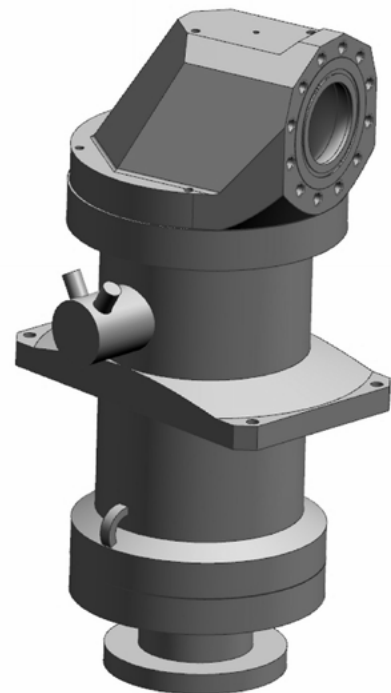
## NSO 240/12 motor pump

The NSO 240/12 motor pump is designed to work in overboard water cooling systems suitable for an unlimited navigation area. It is designed to operate at high and low rotor speeds (HRS and LRS, respectively). The O1 letter is assigned to the WCD of the motor pump.

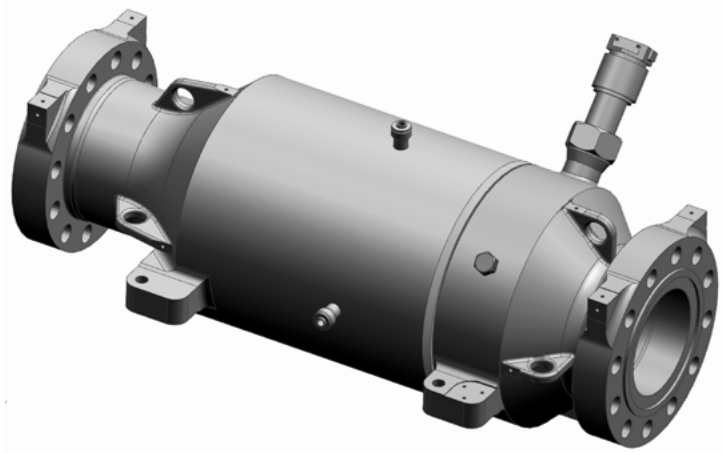
### Main features

- Rated pumping capacity — 240 m<sup>3</sup>/h at HRS, 120 m<sup>3</sup>/h at LRS,
- Head at the rated pumping capacity — 12 ± 1.2 m at HRS, 3 ± 0.3 m at LRS

The handled medium is sea water with a density of not more than 1030 kg/m<sup>3</sup>, salinity of not more than 36 g/dm<sup>3</sup> and a temperature of -2 ... +35 °C.



## NSO 120/15 motor pump



The NSO 120/15 motor pump is designed to work in overboard water cooling systems suitable for an unlimited navigation area. The motor pump is powered by the converting unit, which is packaged with the motor pump.

### Main features

- Rated pumping capacity — 120 m<sup>3</sup>/h
- Head at the rated pumping capacity — 15 m
- Range of smooth control of rotor speed — 10 ... 100%

The handled medium is sea water with a density of not more than 1028 kg/m<sup>3</sup>, salinity of not more than 41 g/dm<sup>3</sup> and a temperature of -2 ... +35 °C.

### The advantages of motor pumps

- vibronoise features of the motor pump meet the requirements № 4
- long lifetime and service life without the need for factory repair
- variable feature of the motor pump depending on the rotor speed



# LOCALISATION AND SUPPLY CAPABILITIES TOGETHER WITH PARTNERS



## Elkon (Turkey)

Design, production, integration and commissioning of low-voltage electrical equipment and automation systems for the marine industry

- Low-voltage switchboards
- Distribution board - engine starters - MCC (motor control cabinets) - various panels (e.g. electromagnetic shutdown system, indicator lamps post)
- Console desks
- Kongsberg alarm management monitoring system
- Transformers and static converter
- Analysis and design system



## Motortech Consulting d. o. o. (Croatia)

Production and supply of diesel generators and after-sales services

- emergency/harbor modules of the generating unit
- hybrid electric offshore units



## Novenco Marine & Offshore (Norway)

Heating, ventilation and air conditioning systems for ships and seacraft.

### Systems

- heating
- ventilation
- air conditioning
- provision rooms

### Services

- design
- project management
- installation
- commissioning and supervised installation
- after-sales service

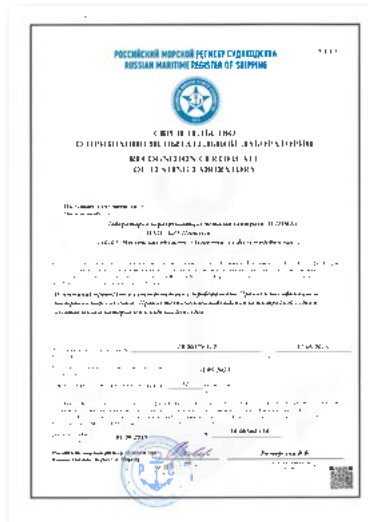
### Generating unit standard supply

- diesel generator: MAN, Mitsubishi, Deutz, Isuzu, MTU, Caterpillar
- generator: Stamford, Uljanik TESU, Sincro, Leroy Somer
- couplings and absorbers: Vulkan
- sensors and switches: Danfoss, Bedia
- engine monitoring system: ComAp modular components
- electrical equipment: Schneider

# ATTESTATION AND INTERNATIONAL CERTIFICATION

Atomenergomash enterprises have over 60 years of experience in manufacturing and supplying shipbuilding equipment

- The quality control system is similar to that applied during NPP construction - there is an independent acceptance service and supervision authority
- Atomenergomash enterprises are certified for compliance with the ISO 9001 standard
- Key Atomenergomash manufacturers hold the Certificate of Manufacturer's Recognition issued by the Russian Maritime Register of Shipping
- Atomenergomash enterprises are certified and hold licenses of numerous Russian and foreign companies



# OUR ENTERPRISES

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