# About regulatory approaches

# to physical protection of nuclear vessels

# (vessels with small modular reactors)

A. A. EGOROV

Scientific and Engineering Centre for Nuclear and Radiation Safety (SEC NRS)

Moscow, Russian Federation

Email: egorov@secnrs.ru

**Abstract**

The Russian Federation has a unique experience in the operation of vessels powered with small modular reactors (icebreakers and lighter aboard ships). In accordance with Russian legislation, physical protection is required for the operation of such nuclear vessels. The Federal Environmental, Industrial and Nuclear Supervision Service (Rostechnadzor) is responsible for the development and support of a regulatory and legal framework for nuclear safety and security, including physical protection of nuclear vessels [1-4].

Rostechnadzor is an independent Russian state nuclear safety and security regulatory authority in the field of atomic energy use. Rostechnadzor is authorized to develop, approve and put into force federal rules and regulations in the field of atomic energy use for establishing among others requirements for the physical protection of nuclear vessels.

A physical protection system should be created at a nuclear vessel as well as at a stationary nuclear facility. Physical protection system includes a set of engineering and technical means of physical protection, physical protection personnel and organizational measures and should perform similar tasks:

deterrence of unauthorized actions;

timely detection of unauthorized actions;

detention of the intruder;

response to unauthorized actions.

But unlike a stationary nuclear facility, the provision of physical protection at nuclear vessels has its own features and differences. These differences and features require appropriate approaches to the legal regulation of the physical protection of nuclear vessels.

The report contains the review of current state of the regulatory framework for the physical protection of nuclear vessels (vessels with small modular reactors) in the Russian Federation, the role of Rostechnadzor in the development and approval of requirements for the physical protection of such vessels, regulatory approaches to physical protection of vessels, their features and differences in comparison with stationary nuclear installations.

## REVIEW OF REGULATIONS CONCERNING PHYSICAL PROTECTION OF NUCLEAR VESSELS (VESSELS WITH SMALL MODULAR REACTORS) IN THE RUSSIAN FEDERATION

Currently, the following main regulatory legal acts in the field of physical protection of nuclear vessels are effective in Russia:

* Federal Law of November 25, 1995 No. 170-FZ “On the Use of Atomic Energy” [5];
* “Rules for the Physical Protection of Nuclear Materials, Nuclear Installations and Storage Facilities for Nuclear Materials” (Decree of the Government of the Russian Federation) [6];
* Requirements for the Systems of Physical Protection of Nuclear Materials, Nuclear Facilities and Storage Facilities for Nuclear Materials (federal rules and regulations in the field of atomic energy use, NP-083-15) [1];
* Requirements for the Physical Protection of Nuclear Vessels, Nuclear Maintenance Vessels, Vessels Transporting Nuclear Materials and Floating Nuclear Power Plants (federal rules and regulations in the field of atomic energy use, NP-085-15) [2].

In addition to nuclear vessels, the abovementioned regulatory documents also establish the requirements for physical protection of:

* vessels carrying out inter-facility transportation of nuclear materials;
* nuclear technology service vessels (specialized vessels for transporting, storing, performing technological operations and nuclear fuel reloading);
* floating nuclear power plants.

### Federal Law “On the Use of Atomic Energy”

The Federal Law “On the Use of Atomic Energy” [5] is a fundamental document that defines the legal basis and principles for regulating relations arising from the use of atomic energy. The Federal Law defines physical protection as an independent type of activity in the field of the use of atomic energy and establishes its main goals and principles.

The law prohibits any work in the field of the use of atomic energy without providing physical protection. Physical protection is provided by operating organizations that are fully responsible for ensuring its implementation.

The law does not contain any detailed requirements for physical protection, but gives only general directions regarding its implementation.

Article 49 “Ensuring the physical protection of nuclear installations, radiation sources, storage facilities, nuclear and radioactive materials” determines that the physical protection of nuclear installations, radiation sources, storage facilities, nuclear materials and radioactive substances provides for a unified system of planning, coordination, control and implementation of a set of technical and organizational measures aimed at:

* Prevention of unauthorized entry into the territory of nuclear installations, radiation sources and storage facilities, prevention of unauthorized access to nuclear materials and radioactive substances, prevention of their theft or damage;
* Timely detection and suppression of any violations of the integrity and safety of nuclear materials and radioactive substances, timely detection and suppression of sabotage and terrorist acts that threaten the safety of nuclear installations, radiation sources and storage facilities;
* Detection and return of missing or stolen nuclear materials and radioactive substances.

Supervision of physical protection is carried out by state safety regulation authorities.

The law also establishes that:

* Requirements for physical protection are established by the rules and regulations in the field of the use of atomic energy;
* Physical protection must be implemented in accordance with international obligations.

Also, the law [5] establishes restrictions on rights (workers, citizens, their belongings and vehicles can be inspected) and restrictions on admission to work (only persons who have been granted access to state secrets, satisfy qualification requirements, and have no medical contraindications can be admitted to work).

### Rules for the Physical Protection of Nuclear Materials, Nuclear Installations and Storage Facilities for Nuclear Materials

The Rules for the Physical Protection of Nuclear Materials, Nuclear Installations and Storage Facilities for Nuclear Materials were approved by Decree of the Government of the Russian Federation of July 19, 2007 No. 456 [6].

The Rules [6] establish the requirements for the organization and provision of physical protection of nuclear materials, nuclear installations and storage facilities for nuclear materials in the territory of the Russian Federation, which are binding for all:

* Legal entities engaged in the production, use, storage, disposal, transportation of nuclear materials, design, construction, commissioning, operation and decommissioning of nuclear installations and storage facilities for nuclear materials, regardless of the legal form;
* Federal executive authorities and the State Atomic Energy Corporation Rosatom, which are engaged in management and coordination in this area of activity or provide for such activity, as well as supervise this activity.

The rules do not establish requirements for the physical protection of radiation sources and radioactive substances.

The Rules establish [6]:

* Basic terms of physical protection of nuclear materials, nuclear installations and storage facilities for nuclear materials and their definitions;
* The structure of the state system of physical protection and the powers of the federal executive bodies and nuclear sites included in it;
* Categories of nuclear materials, consequences of unauthorized actions in relation to physical protection subjects and categories of physical protection subjects themselves;
* Requirements for the organization and implementation of physical protection at a nuclear site;
* Requirements for the organization of physical protection of nuclear materials and nuclear installations during transportation;
* Requirements for state supervision, departmental and facility control of physical protection, as well as for the procedure for notification of unauthorized actions.

### Requirements for the Systems of Physical Protection of Nuclear Materials, Nuclear Facilities and Storage Facilities for Nuclear Materials

The Requirements for the Systems of Physical Protection of Nuclear Materials, Nuclear Facilities and Storage Facilities for Nuclear Materials NP-083-15 were approved by Order of the Federal Environmental, Industrial and Nuclear Supervision Service (Rostechnadzor) of September 8, 2015 No. 343 [1]. NP-083-15 establish requirements for the systems of physical protection of nuclear materials, nuclear installations and storage facilities for nuclear materials at a nuclear site. This document develops and specifies the requirements of the Rules [6] regarding stationary nuclear sites, as well as during transportation of nuclear materials and nuclear installations.

The federal rules and regulations NP-083-15 [1]:

* Define the procedure for categorizing physical protection subjects;
* Establish 4 categories of a nuclear site;
* Define the procedure for the creation, improvement and functioning of a physical protection system;
* Establish requirements for the analysis of vulnerability and assessment of the effectiveness of physical protection system;
* Establish requirements for the design of protected and restricted areas;
* Define the procedure for the development of technical specifications for the creation and improvement of a physical protection system, as well as technical specifications for the design of a set of engineering and technical means of physical protection or its components;
* Establish requirements for organizational measures of physical protection, physical protection engineering and technical means complex and functional systems of physical protection system (intrusion protection, alarms, electrooptical surveillance and situation assessment, access control and management, operational communication and alerts, information protection, power and lighting supply), for physical protection personnel;
* Define the procedure for providing physical protection during the decommissioning of nuclear installations and storage facilities for nuclear materials;
* Establish requirements for providing physical protection of nuclear materials and nuclear installations during transportation;
* Provide a list of physical protection documents developed at a nuclear site with general requirements for their content.

### Requirements for the Physical Protection of Nuclear Vessels, Nuclear Maintenance Vessels, Vessels Transporting Nuclear Materials and Floating Nuclear Power Plants

The Requirements for the Physical Protection of Nuclear Vessels, Nuclear Maintenance Vessels, Vessels Transporting Nuclear Materials and Floating Nuclear Power Plants NP-085-19 were approved by Order of the Federal Environmental, Industrial and Nuclear Supervision Service (Rostechnadzor) of April 1, 2019 No. 126 [2]. They establish requirements for physical protection of:

* Vessels and other watercraft with nuclear reactors, including floating nuclear power units with nuclear materials (hereinafter referred to as the floating power unit), with the exception of military nuclear power plants;
* Vessels carrying out interfacility transportation of nuclear materials;
* Nuclear maintenance vessels (specialized vessels carrying out transportation, storage, technological operations and transshipment of nuclear fuel);
* Floating nuclear power plants.

A floating nuclear power plant is a nuclear site with an operating floating power unit, and if necessary, engineering facilities to provide its parking, a coastal site with industrial buildings and facilities that transfer heat and electric energy to the consumer, administrative buildings and an adjacent area of the water surface and underwater section within the established boundaries of the nuclear site.

The federal rules and regulations NP-085-19 establish [2]:

* General requirements for the physical protection of vessels;
* Requirements for organizational measures of physical protection;
* Requirements for physical protection engineering and technical means complex;
* Requirements for equipping the protected areas of a vessel;
* Procedure for notification of unauthorized actions;
* Requirements for the physical protection of a floating nuclear power plant.

## Approaches to providing the physical protection of nuclear vessels in the Russian Federation

In accordance with the requirements of NP-085-19 [2], to provide the physical protection of a vessel, a system of physical protection is created on it, including, as at a stationary nuclear site, a set of engineering and technical means of physical protection, physical protection personnel and a set of organizational measures. The objectives of the physical protection system of a vessel are the same as at the stationary site:

* Prevention of unauthorized actions;
* Timely detection of unauthorized actions;
* Delaying (slowing down) the entry (movement) of the violator;
* Response to unauthorized actions and the neutralization of violators (in the presence of security services).

Protected and restricted areas are allocated to provide physical protection of the vessel. But at the same time, the physical protection system of the vessel should not interfere with safety measures on the vessel (including transport safety), operation of the vessel and should not reduce its survivability. There should be no obstacles for the timely and safe exit of people from any room and compartment (hold) of the vessel in case of emergency.

To ensure physical protection of a nuclear installation and nuclear materials on board, the following requirements must be met [2]:

* The head of the operating organization or the captain of the vessel should appoint an officer from among the command staff to be in charge of physical protection;
* A list of the physical protection personnel of the vessel should be defined and documented;
* Protected and restricted areas should be identified and documented in accordance with the requirements of the Rules for the Physical Protection [6];
* Vessel documents on the organization and provision of physical protection should be put into effect;
* The functioning of the system of physical protection, including the operation of engineering and technical means of physical protection, should be planned and organized;
* Compliance with the requirements for the physical protection of the vessel should be monitored.

The following should be considered as indicators of the categorization of physical protection subjects [2]:

* nuclear materials category, which generally complies with the recommendations of NSS 13 [7];
* Degree of secrecy of physical protection subjects;
* Category of consequences of unauthorized actions in relation to physical protection subjects;
* Presence of a significant amount of nuclear materials for direct use.

The creation or improvement of the physical protection system of a vessel is carried out only after the analysis of vulnerability and assessment of the effectiveness. The analysis of vulnerability and assessment of the effectiveness are also carried out in case of any changes in the project threat (model of violators) for the vessel and/or significant characteristics of the vessel and elements of the physical protection system.

The operating organization (operator) must approve a reasonable conclusion on the adequacy of the obtained value of the indicator(s) of the effectiveness of the physical protection system.

To provide physical protection, the following documents are put into effect and stored on board [2]:

* Vessel physical protection plan;
* Instruction on access control on the vessel;
* Regulation on the vessel regime;
* List of protected and restricted areas;
* Plan of action for physical protection personnel and for other members of the crew in regular and emergency situations;
* Plan of interaction with units (bodies) of the troops of the national guard of the Russian Federation and bodies of the federal security service in accordance with their powers in regular and emergency situations (hereinafter referred to as the plan of interaction);
* Education and training plan for physical protection personnel;
* Plan for the inspection of the technical condition and operability of engineering and technical means of physical protection;
* Plan of the improvement of the physical protection system (allowed to store in the operating organization).

As the main document in this list, one can single out a physical protection plan, which, in accordance with NP-085-19 [2], should contain:

* Description of the structure of the physical protection system and the procedures for its functioning in regular and emergency situations;
* Information on the categorization of nuclear materials;
* Measures of physical protection personnel and other crew members to ensure physical protection in each of the possible situations;
* Instruction on self-protection in protected areas;
* Measures for interaction and notification of the command staff of the vessel, physical protection personnel and other crew members in regular and emergency situations;
* Measures for interaction and information exchange in the provided situations with transport control centers (dispatching points) in accordance with the interaction plan;
* List and measures for the application of compensatory measures of physical protection in case of failures of engineering and technical means of physical protection;
* Measures to monitor the state of the physical protection system by the command staff of the vessel;
* Measures to investigate each fact of unauthorized actions that occurred on the vessel.

If there are documents on the vessel containing the above information, the physical protection plan may include links to such documents.

An integral part of the physical protection system of a vessel is physical protection personnel. The physical protection personnel on the vessel must be trained and prepared for the performance of official duties for physical protection, which should be documented. For the physical protection personnel, job descriptions [4] should be developed that determine the procedures for its actions not only in regular, but also in emergency situations. The crew members of the vessel found in the premises of the protected areas must carry out self-protection measures ensuring the function of immediate report of information on the detection of unauthorized actions and other emergencies to the control points of the physical protection system, the watch service and the command staff of the vessel.

Regarding the set of engineering and technical means of physical protection with which the vessel is equipped, the following functional subsystems can be distinguished [2]:

* Intrusion protection;
* Collection, display and processing of information;
* Alarm;
* Access control and management;
* Electrooptical surveillance and situation assessment;
* Operational communication and alerts (including wireline and radio communications);
* Engineering means;
* Information protection;
* Power and lighting supply.

According to the requirements of NP-085-19 [2], the main objectives of the set of engineering and technical means of physical protection are:

* Detection of unauthorized entry;
* Monitoring the boundaries of protected areas and premises to assess the situation by alarms, and detection of unauthorized actions;
* Delaying (slowing down) the entry of violators into the protected areas and premises of the vessel;
* Generation and transmission of alarms to control points of the physical protection system;
* Generation and transmission of video information by alarms to control points of the physical protection system;
* Operational communication between physical protection personnel and control points of the physical protection system, between control points of the physical protection system and the command staff of the vessel;
* Monitoring the condition and performance of technical means of physical protection;
* Collection, processing, storage, issuance and archiving of information on the functioning of the physical protection system and on cases of unauthorized actions;
* Transmission of an alarm signal in cases provided for by vessel documents to transport control centers (dispatching points);
* Communication between sections of protected areas and control points of the physical protection system;
* Communication with the transport control center(s) (dispatching points) and units (bodies) of the troops of the national guard of the Russian Federation and bodies of the federal security service in accordance with the interaction plan;
* Authorized access of individuals to protected areas and premises;
* Controlling the functioning of engineering and technical means of physical protection and the actions of physical protection personnel;
* Determining the time and place of unauthorized entry at the boundaries of protected areas.

The following stationary and portable means are considered engineering means of physical protection [2]:

* Fences on the perimeters of protected and restricted areas;
* Physical barriers (vessel structures, including hull, decks, hull bulkheads, doors and hatches in bulkheads, holds, decks);
* Engineering equipment in protected areas.

Engineering means of physical protection should provide [2]:

* Delaying (slowing down) the entry of violators into the protected areas and premises by methods defined in the violator model;
* Prevention of unauthorized access of individuals to and from protected areas and premises;
* Protection of persons from security services and security personnel against means of destruction by violators at control points of the physical protection system and in duty rooms, as well as during neutralization of violators by security services.

Technical means of physical protection on the vessel must remain operational in the event of a power outage. The transition (switching) of the power supply from the main to the backup should be carried out automatically with the display of information about this in the control points of the physical protection system.

An important property of the elements of technical means of physical protection on a vessel is redundancy, i.e. the failure of any element of technical means of physical protection should not interfere with the functioning of the physical protection system on the vessel as a whole [2].

The central control point of the physical protection system is allocated to control the physical protection system on the vessel [2]. Local control points can be additionally equipped on the vessel depending on its characteristics. Operator(s) from among the physical protection personnel of the vessel should be at the control points around the clock. All the necessary information from technical means of physical protection should be promptly displayed at the control points of the physical protection system.

Physical protection personnel must follow the procedure for notifying of unauthorized actions (attempts to perform such actions). In case of unauthorized actions on the vessel or emergency, alarms indicating the location of the vessel should be immediately transmitted from the vessel to the transport control centers (dispatching points).

On detected cases of theft or loss of nuclear materials, on attempts to commit sabotage or committed sabotage, the captain or another authorized person of the command staff of the vessel shall [2]:

1) Within an hour from the discovery of the incident, send an initial notification with information about the circumstances (including the location of the vessel) and events related to the detection of the theft of nuclear materials or sabotage, an attempt to carry out such actions or the discovery of stolen or missing nuclear materials (including information on the type and category of nuclear materials, on the quantitative characteristics of nuclear materials available on the vessel), on the measures taken, their result and the plan of further actions for solving problems to the following bodies and organizations:

* State Atomic Energy Corporation Rosatom;
* Bodies of the federal security service;
* Rostechnadzor;
* Operating organization.

2) Within 10 calendar days, submit a written report to the specified bodies and organizations, which should contain information on the initial notification and necessary additions about the incident.

Should new facts that became known after the initial notification or the written report be discovered, information about them should also be provided by the captain (another authorized person of the command staff of the vessel) to these bodies and organizations.

## SPECIFICS OF THE PHYSICAL PROTECTION OF FLOATING NUCLEAR POWER PLANTS AND FLOATING POWER UNITS IN THE RUSSIAN FEDERATION

A floating nuclear power plant is a nuclear site with an operating floating power unit, and if necessary, engineering facilities to provide its parking, a coastal site with industrial buildings and facilities that transfer heat and electric energy to the consumer, administrative buildings and an adjacent area of the water surface and underwater section within the established boundaries of the nuclear site. In other words, a floating nuclear power plant is a stationary site created to connect a vessel and a floating power unit.

In accordance with documents [1, 2, 6], the physical protection of a floating power unit, like the protection of the entire floating nuclear power plant, in the Russian Federation is carried out in the same way as for a stationary nuclear site, when it is part of a floating nuclear power plant. But there are a number of important features.

In accordance with NP-085-19 [2], the functioning of the physical protection system of a floating nuclear power plant should be ensured even before the arrival of a floating power unit at its permanent base in order to counter such violator tactics as preliminary insertion of an explosive device. The functioning of the physical protection system should also be carried out in the temporary absence of a floating power unit.

When basing a floating power unit as part of a floating nuclear power plant, there are two sets of engineering and technical means of physical protection functioning together [2]:

* Set of engineering and technical means of physical protection of a floating power unit;
* Set of engineering and technical means of physical protection intended for equipping protected and restricted areas on the coastal site and in the water area.

At the stage of construction, own system of physical protection of a floating power unit should be created and be fully operable [2]:

* In standalone mode while driving (towing) a floating power unit;
* As part of the physical protection system of a floating nuclear power plant at the place of operation in conjunction with additional engineering and technical means and measures of physical protection applied on the coastal site and in the water area of the floating nuclear power plant;
* When a floating power unit accepted for operation is located at a shipbuilding or specialized enterprise for the purposes of maintenance, repair, or decommissioning.

Finally, one more important feature of a floating nuclear power plant is the presence of the water area in the protected zone. This implies the following requirements established in NP-085-19 [2]:

* The protected zone of the water area should be equipped with technical means for detecting unauthorized actions, surveillance and engineering means determined by the design documentation for a set of engineering and technical means of physical protection;
* The boundaries of the protected zone should be determined and marked on the coastal territory and in the water area of the floating nuclear power plant;
* When the water section gets frozen along the border of the protected zone of the water area, temporary obstacles and warning signs should be additionally installed on ice.

REFERENCES

1. Federal Rules and Regulations in the Field of Atomic Energy Use “Requirements for the systems of physical protection of nuclear materials, nuclear facilities and storage facilities for nuclear materials” NP-083-15, Order of the Federal Environmental, Industrial and Nuclear Supervision Service (Rostechnadzor) of September 8, 2015 No. 343.
2. Federal Rules and Regulations in the Field of Atomic Energy Use “Requirements for the Physical Protection of Nuclear Vessels, Nuclear Maintenance Vessels, Vessels Transporting Nuclear Materials and Floating Nuclear Power Plants” NP-085-19, Order of the Federal Environmental, Industrial and Nuclear Supervision Service (Rostechnadzor) of April 1, 2019 No. 126
3. Federal Rules and Regulations in the Field of Atomic Energy Use “Rules for the physical protection of radiation sources, storage facilities, radioactive substances (federal rules and regulations in the field of atomic energy use” NP-034-15, Order of the Federal Environmental, Industrial and Nuclear Supervision Service (Rostechnadzor) of July 21, 2015 No. 280.
4. Federal Rules and Regulations in the Field of Atomic Energy Use “Rules for the physical protection of radioactive substances and radiation sources during their transportation” NP-073-11, Order of the Federal Environmental, Industrial and Nuclear Supervision Service (Rostechnadzor) of December 27, 2011 No. 747.
5. Federal Law of Russian Federation November 25, 1995 No. 170-FZ “On the Use of Atomic Energy”.
6. “Rules for the Physical Protection of Nuclear Materials, Nuclear Installations and Storage Facilities for Nuclear Materials”, Decree of the Government of the Russian Federation of July 19, 2007 No. 456.
7. IAEA- INTERNATIONAL ATOMIC ENERGY AGENCY, Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Rev.5), Nuclear Security Series nº 13 (2011).