GRADED APPROACH TO SAFETY REGULATION OF RUSSIAN NUCLEAR RESEARCH FACILITIES: PRESENT AND FUTURE

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ABSTRACT

Following the concept of a graded approach the volume and content of safety documentation, level of analysis, scope of activities, and procedures used to comply with the safety requirements should be commensurate with the potential hazard, associated with nuclear research facilities (NRFs). It does not mean refusing the obligatory safety requirements but defines the optimal way to meet them. The IAEA published guidance SSG-22 on use of a graded approach in application of safety requirements in all areas/activities of a research reactor lifetime. However, as practice shows, there are issues for further consideration and improvement, such as scientific and methodological support of NRFs categorization, detailing of safety analysis, level of information required, and implementation of regulatory oversight. The paper presents status of the requirements for application of a graded approach in legislative and regulatory framework of the Russian Federation and considers further planned measures for its implementation to enhance efficiency of NRFs safety regulation and emergency preparedness and response.

1. Introduction

Nuclear research facilities (NRFs) are used to resolve various fundamental, scientific, applied and engineering issues to achieve which different technical and technological solutions applied in the design [1,2]. Depending on specific type, design, functional and technical specification, the facilities may present different potential hazards to the personnel, the population and the environment. The NRF potential radiation hazard may be impacted by many factors that affect nuclear and radiation safety of the facility. Such factors include:

- reactor power;
- amount and enrichment of fuel and nuclear materials (fissile materials) at the facility;
- amount of fissionable material accumulated at the facility;
- radiological source term;
- amount of reactivity and speed of its introduction;
- existence of high-pressure systems;
- amount and condition of spent fuel;
- quality of containment /confinement systems;
- type and mass of moderator, reflector, coolant;
- programme of research and experiments;
- location and density of the population in the surrounding area, and
- other factors.

Taking into account the difference in the potential radiation hazards of NRFs, a graded approach in safety regulation of these facilities should be applied to reflect the difference in applying safety requirements depending on the type of NRF, functional and technical specifications, stage of facility life cycle and its current status, institutional management structure, and other factors essential for safety of NRFs potential.

The regulatory legal acts of the Russian Federation have requirements for the application of a graded approach to activities in the field of the use of atomic energy. However, in order to be efficient in their realization, it is necessary to develop methodology for practical implementation of a graded approach in the design, construction, siting, commissioning, operation and decommissioning of NRF, including the licensing process and safety analyzing, planning inspections, strengthening emergency preparedness and response.

The report considers a multifaceted task of identifying and implementing measures aimed at applying a graded approach in the regulatory activities of Federal Service for Environmental, Technological and Nuclear Supervision (Rostechnadzor)[1] in the area of ensuring safety of NRFs.

2. Categorization of radiation facilities according to their potential radiation hazard

The potential hazard of a radiation facility is determined by its possible radiation impact on the public and personnel in case of a radiation accident. Potentially, more hazardous are those radiation facilities, which, in case of an accident, may irradiate both workers and the public. The less hazardous radiation facilities are the facilities, which do not have possibility of irradiating persons not belonging to personnel.
In accordance with the basic sanitary codes OSPORB-99/2010 [3] and guidelines MU 2.6.1.2005 [4], the following four radiation hazard facility categories are established:

- category I includes radiation facilities which in case of an accident may have radiation impact on the public and specific measures to protect the public may be required;
- category II includes radiation facilities, which radiation impact in case of an accident is limited by the buffer area;
- category III includes facilities, which radiation impact in case of an accident is limited to the facility territory;
- category IV includes facilities with radiation impact limited to the compartments where works with radiation sources are carried out.

The category of a radiation facility should be determined at the stage of design of the facility based on assessment of the potential accident consequences. The assessment does not cover transportation of radiation sources beyond the facility territory or hypothetical external impact (explosions caused by a missile and aircraft crash, or by a terrorist attack). For radiation facilities in operation, the category is determined by managers of the facility and should be approved by the state sanitary and epidemiological supervision authority.

The NRFs, which have been classified as the 1st and 2nd categories of potential hazard are shown in Table 1. It is seen that the both research reactors PIK (100 MW) and MBIR (100 MW), as well as the critical stand of the Sevastopol University (CS SGU) are of the 2nd category of potential hazard facilities. BFS-1, BFS-2 belong to the 1st category of potential hazard along with research reactors BOR-60 (60 MW) and VK-50 (200 MW).

It should be noted that the above stated categorization has been created and used during several decades to facilitate application of hygiene regulatory standards in the process of the facility design and operation. However, this NRFs categorization does not give clear basis for a graded approach to application of regulatory requirements in emergency preparedness and response (EPR) for a nuclear or radiological emergency, as it is required in the IAEA general safety requirements GSR Part 7 [5]. For the purpose of a graded approach in establishing EPR arrangements, the existing NFRs categorization should be reviewed based on the modern approach recommended by the IAEA.

1 Rostechnadzor is the state regulatory authority in the field of the use of atomic energy, including functions of normative regulation of NRF safety, federal state supervision and activities licensing

Type NRF	Title NRF	Cate-gory	Operator	Place	Criticality	State
RR	VVR-Tz	1	Karpov IPC	Obninsk	1964	Operation
RR	IBR-2	1	JINR	Dubna	1978	Operation
RR	VK-50	1	SSC RIAR	Dimitrovgrad	1964	Operation
RR	SM-3	1	SSC RIAR	Dimitrovgrad	1961	Operation
RR	MIR.M1	1	SSC RIAR	Dimitrovgrad	1966	Operation
RR	BOR-60	1	SSC RIAR	Dimitrovgrad	1969	Operation
RR	RBT-10/2	1	SSC RIAR	Dimitrovgrad	1983	Operation
RR	RBT-6	1	SSC RIAR	Dimitrovgrad	1975	Operation
CS	BFS-1	1	IPPE	Obninsk	1962	Operation
CS	BFS-2	1	IPPE	Obninsk	1969	Operation
RR	IRT-T	2	TPU	Tomsk	1967	Operation
RR	VVR-M	2	PIYaF	Gatchina	1959	Operation
RR	MBIR	2	SSC RIAR	Dimitrovgrad	plan 2019	Commissioning
RR	PIC	2	PIYaF	Gatchina	2011	Commissioning
CS	FM PIC	2	PIYaF	Gatchina	1983	Operation
RR	IRT MIPhI	2	MIPhI	Moscow	1967	Long shutdown
RR	IR-100	2	SGU	Sevastopol	1967	Long shutdown
CS	CS SGU	2	SGU	Sevastopol	1974	Long shutdown

TABLE 1. NRFs of I и II categories of potential hazard

3. The powers of Rostechnadzor in the field of the atomic energy use

The responsibilities of nuclear regulatory body cover developing national safety regulations, verifying compliance with these regulations, and implementing an enforcement.

Rostechnadzor as a regulatory body in the field of nuclear energy use possess following main powers [6]:

- independently adopt normative legal acts, namely:
  - the federal safety standards and codes (regulations) in the field of atomic energy use;
  - requirements to the structure and content of the documents substantiating safety of nuclear installations, radiation sources, storages of nuclear materials and radioactive substances, storages of radioactive wastes and (or) safety of activities performed in the field of use of atomic energy, which are necessary for licensing of activities in this field, as well as the procedure for reviewing of the above-mentioned documents;
- perform monitoring and supervision of compliance with the regulations in the field atomic energy use, control over conditions of permits (licences) for performance of works in the field of atomic energy use;
- carry out licensing of activities in the field of use of atomic energy;
- issue permits for the right to conduct work the field of the use of atomic energy to employees in certain positions of nuclear of nuclear industry organizations;
- conduct inspections of compliance by the legal entities and individuals with the Russian Federation legislation, legal regulatory acts, regulations in the field of the use of atomic energy;
- organize and ensure the functioning of a system for control of nuclear facilities in the event of an accident.

Within the framework of the above stated Rostechnadzor's powers, there is a task to analyze challenges and plan measures for implementation of a graded approach into its regulatory activity taking into account the IAEA recommendations for improving the efficiency of nuclear and radiation safety regulation of the NFR.

4. The IAEA recommendations on application of a graded approach in safety regulation of NRFs

In the report of the International Nuclear Safety Group INSAG-22 [7] the nuclear safety infrastructure is defined as "the set of institutional, organizational and technical elements and conditions established in a Member State to provide a sound foundation for ensuring a sustainable high level of nuclear safety". The elements of the safety infrastructure should be constant and consistent with the IAEA Fundamental Safety Principles SF-1 [8], which are applied throughout the full lifetime cycle of all existing and new facilities and activities to reduce existing radiation risks. These safety principles provide basis to establish safety requirements for facilities, activities, and safety measures that should be implemented in order to achieve the fundamental safety objective.

The mechanism for evaluation of the national infrastructure development is based on implementation of the state obligations compliance with in international conventions relating to nuclear and radiation activities, the IAEA safety standards (regulatory framework) and supporting non-legally-binding instruments for safety. It should be mentioned that neither the Convention on Nuclear Safety nor the Code of Conduct on the Safety of Research Reactors cover the facilities like experimental and demonstration reactors.

Throughout the life cycle of nuclear facility various activities are carried out, and conditions and obligations to ensure safety are different (graded) depending on the stage in the lifetime of a facility, including planning, siting, design, manufacturing, construction, commissioning and operation, as well as decommissioning and closure.

The principle 3 "Leadership and management for safety" of the IAEA safety fundamentals SF-1 states that the safety of all facilities and all activities has to be assessed in accordance with a graded approach.

The IAEA specific safety guide SSG-22 [9] summarizes the international experience in application a graded approach in activities of regulatory bodies, operating organizations, and other organizations and enterprises that participate in design, construction, commissioning, operation and decommissioning of NRFs. The IAEA general safety requirements GSR Part 7 includes a requirement that emergency planning should be commensurate with the revealed hazards (radiation risks) of the facility and consequences of potential emergencies.

According to the IAEA recommendations, the use of a graded approach does not mean that mandatory safety requirements are waived but determines the most appropriate way to meet the safety requirements based on the method of two steps:

- **Step 1**: categorization of the facility in accordance with its potential hazard regarding to possible release of radiation: 1) facilities with potential off-site consequences; 2) facilities with potential on-site consequences; and 3) facilities with no potential hazard beyond the reactor building or experimental areas;
- **Step 2:** clarification of the conditions and particular details of the national nuclear infrastructure at which safety requirements apply to activity and facility, its systems and elements to achieve the fundamental safety objective at the specific stage of the life cycle.

To evaluate a progress in implementation of a nuclear power programme the IAEA approach is based on integrated infrastructure evaluation. The activities are split (graded) into a few progressive phases of development. The completion of each phase is marked by a specific milestone at which the progress of the development effort can be evaluated and a decision made to move on to the next phase. For reaching each milestone, there are list of issues that need to be considered.

The national nuclear infrastructure and lifecycle stages (phases) of a facility are presented in Table 2, that was created (i) with due regard to experience in safety regulation of various activities at Russian NRFs, (ii) in compliance with the structure of the IAEA's safety standards, (iii) based on the report by the International Nuclear Safety Group INSAG-22 and the IAEA report on the specific considerations and milestones for a research reactor project NP-T-5.1 [10]. Based on Russian experience of NRFs safety regulation two supplementary elements have been included in nuclear infrastructure: Standardization, Fire protection.

Infrastructure issues (are not subject for grading)	**design**	**Construction**	**Commissionig**	**Operation**	**Decommissioning**
National Position	Conditions	Conditions	Conditions	Conditions	Conditions
Nuclear safety					
Management					
Funding and financing					
Legislative framework					
Safeguards					
Regulatory framework					
Radiation protection					
Research reactor utilization					
Human resources development					
Stakeholder involvement					
Site survey and evaluation					
Environmental protection					
Emergency planning					
Nuclear security					
Nuclear fuel management					
Radioactive waste management					
Industrial involvement					
Procurement					
Standardization					
Fire protection					

TABLE 2. National nuclear infrastructure and lifecycle stages of a facility

5. A graded approach in regulatory legal acts in the field of atomic energy use

The requirements on application of a graded approach are included in the legislative and regulatory system of the Russian Federation at different levels of its hierarchy. As it is shown below these include federal laws, administrative regulations on rendering the state services and performing the state functions, and federal safety standards and codes in the field of atomic energy use.

5.1. Federal laws of the Russian Federation

The Federal Law on Atomic Energy Use [11] defines that "measures undertaken by the state safety regulatory authorities to exercise their responsibilities shall be commensurate with the potential hazard of the nuclear facilities and activities in the field of atomic energy use".

The Federal Law on Protection of Rights of Legal Entities and Individual Entrepreneurs [12] demands from regulatory bodies' application of a risk-oriented approach to exercise the certain types of state control (supervision) established by the Government of the Russian Federation, including control (supervision) in the field of atomic energy use. The outcome of applying a risk-based approach is expected as optimization of human, material and financial resources involved in the state control (supervision); reduce expenses of legal entities individual entrepreneurs; and enhanced efficiency of the state control (supervision).

5.2. Administrative regulations

The administrative regulations on licensing activities in the field of atomic energy use [13] contain the requirements for the composition of a set of documents needed to justify facility safety, which are differentiated according to the types of activities and facilities.

The administrative regulation on issuing permits for the right to work in the field of atomic energy use for personnel [14] defines that the permits to senior managers of research reactors are issued by Rostechnadzor's Headquarters; the permits to senior managers of critical and subcritical stands, as well as the permits to operating personnel of NRFs and personnel conducting in-service control at NRFs are issued by Rostechnadzor's Regional Offices.

The administrative regulation on performing state supervising activities in the field of atomic energy use [15] contains requirements on exercising the planned inspections and requirements for control (inspection) in regime of permanent state supervision. The periodicity of planned inspections by the state regulatory body is restricted to once per year in compliance with the requirements of Federal Laws [11, 12]. At the same time, the frequency and content of systematic control of compliance of NRF conditions with mandatory safety requirements and monitoring of safety in regime of permanent state supervision are not legally regulated.

5.3. Federal safety standards and codes in the field of atomic energy use

A survey of current state and major amendments of safety requirements in light of the lessons learned from the accident at the Fukushima Daiichi nuclear power plant was introduced at the 18th IGORR Conference [16]. Below shows a good practice of forming conditions in the NRF safety regulations for the application of a graded approach with a view to enhancing efficiency of regulatory activities.

<u>General Safety Regulations for NRFs (NP-033-11)</u>

The following conditions are considered for grading:

- stages of life cycle (design; siting, construction, commissioning, operation; decommissioning);
- systems and NRF components (normal operation systems, safety systems, experimental facilities and devices),
- modes of operation (at power, temporary shutdown, long time shutdown, final shutdown);
- levels of defence in depth;
- other issues and factors affecting safety.

Codes on nuclear safety

The safety requirements are considered for specific types of facilities - research reactors with stationary and pulse methods of obtaining neutron flux, critical and subcritical stands:

- Codes on Nuclear Safety of Research Reactors (NP-009-17);
- Codes on Nuclear Safety of Pulse Reactors (NP-048-03);
- Codes on Nuclear Safety of Critical Stands (NP-008-16);
- Codes on Nuclear Safety of Subcritical Stands (NP-059-05).

The safety requirements might be considered for the other specific facilities, for example, subcritical accelerator driven systems (technical proposal has been drafted), homogeneous solution research reactors (for production of Mo-99 and other short lived radioisotopes), fast neutron research reactors using liquid metal coolants and others.

Requirements to Safety Analysis Report of NRFs (NP-049-17)

This safety regulation include requirements to content and information to be submitted to Rostechnadzor for the review and assessment of NRF safety. The Safety Analysis Report (SAR) should include features of initial design, systems and elements, information on the modifications made and the current state of the NRF, the results of systems setup and testing, facility criticality and facility starting-up, changes in design and documentation corrections, management programme, safety analysis covering design basis accidents (DBA) and beyond design basis accidents (BDBA). The specification of requirements should be carried out taking into account the NRF category (research reactors, critical and subcritical stands).

Safety Codes on Decommissioning of NRFs (NP-028-16)

The conditions for arrangements and performance of NRF decommissioning should take into account the structural, technological and operational features of NRF, feedback from the operational experience and potential hazard of the decommissioning works.

Action Plan for Personnel Protection in Case of an Accident at NRF,NP-075-06

The requirements to emergency planning for personnel protection should be developed depending on category of potential radiation hazard of NRF. At present this regulation is being revised to take into account modern international approaches and recommendations on emergency preparedness and response [5].

Requirements to the quality of manufacture, production and storage fuel elements, fuel assemblies NRF - specification at the level of the enterpriser-manufacturer, federal safety standards and codes are not developed.

6. Implementation of a graded approach into practice of safety regulation

Rostechnadzor jointly with the State Corporation "Rosatom" and with engagement of operating organizations is implementing the concept of a graded approach in safety regulation of nuclear installations on the basis of national experience and good international practices. The implementation of a graded approach should consider following topical issues:

- identification of areas, for which the application of a graded approach in regulation is advisable;
- development of methodology for categorization of nuclear facilities depending on their potential hazard including NRF and experimental reactors;
- consideration of proposals and the experience of operating organizations on the implementation of the concept of a graded approach to NRFs and experimental reactors, for example, as following:
    - grading the structure of SAR, scope of analysis and details of consideration should be specified separately for groups of experimental reactors, research reactors, critical stands, and subcritical stands;

- a safety guidance should be developed to specify the basic set of safety requirements applied in licensing of specific activities and/or facilities;

– development of methodology for planning the frequency and content of inspections conducted by regional offices of Rostechnadzor in regime of permanent state supervision, depending on the facility potential hazard, its life cycle stage, mode of operation, the number and category of violations in work, deviations from mandatory requirements in the field of atomic energy use and other factors affecting the state of safety.

7. Conclusion

In the Russian Federation, a systematic activity is carried out to implement a graded approach in practice of safety regulation of nuclear facilities. A graded approach is used as a tool to enhance the efficiency of the regulatory activity in the field of atomic energy use, including regulation of safety of nuclear research facilities and experimental reactors. Measures and arrangements for enhancement of regulatory effectiveness are addressed licensing process, planning and conducting inspections, and emergency preparedness and response.

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