Regulatory framework of the new NPI technological platform

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Abstract. In the nuclear industry, the practical implementation of innovative projects of reactor facilities, such as NPP projects with the BN-1200 and BREST-300 reactors being developed within the new nuclear energy technological platform (NTP), is impossible without the adaptation of the existing or the creation of a corresponding new regulatory and legal framework. After the project development and licensing, the manufacture of separate elements, the NPP construction, commissioning and operation at all stages should be based on federal norms and rules (FNR) in the field of the atomic energy use. Another essential part of the work in the creation of innovative reactor facilities is scientifically based computer simulation to confirm the safety of the decisions made. The requirement to implement safety justifications with the use of software that has passed the relevant expertise is fixed at the legislative level. Thus, the processes of developing innovative NPP projects, new FNRs and advanced software (next-generation codes) should go almost simultaneously. Within the NTP framework IBRAE RAN, in collaboration with the scientific and design and engineering organizations of the industry, are developing new precision generation calculation complexes, describing in a related setting a wide range of physical processes and phenomena. The main features of the new generation software systems are multi-physical and multi-scale modeling. The FNR improvement in favor of the NTP is carried out under close cooperation between professionals and experts of Rostekhnadzor, “Rosatom” State Corporation, scientific organizations of the industry and the Russian Academy of Sciences, as well as innovative projects developers. An example of such effective cooperation is the activity of the working group created by the decisions of the heads of the Federal Service for Environmental, Technological and Nuclear Supervision and the Innovation Management Unit of “Rosatom” State Corporation in September 2015 to coordinate the work on the FNR improvement for the “Proryv” project. The WG members carried out a detailed analysis of the current FNRs and the needs of the “Proryv” Project, which allowed assessing and agreeing on the amount of necessary development of new or updating existing FNRs, as well as the priority of their development. As a result, “The List of Normative Documents regulating safety issues in implementing by organizations of “Rosatom” State Corporation the task of creating fast neutron reactors with a closed nuclear fuel cycle, to be developed or updated with prioritization and timing of their introduction into act” was agreed and accepted for further organization of work. To date, the editions of the priority FNRs have been developed and are being implemented. To detail the FNR requirements, a set of standards of “Rosatom” State Corporation has been developed and is being now approved. Thus, a reasonable approach is realized in the creation of innovative facilities, the technical solutions in which are adopted in accordance with the achieved level of science and technology and at the development stage naturally outrun existing norms and rules.
1. Introduction
The persistent efforts are made in the world nuclear power industry under the new technological platform (NTP) of the nuclear power industry. “Gen IV” international project for the fourth-generation nuclear reactor development and “INPRO” international project for innovative nuclear reactors and fuel cycles were established. In Russia, the modern set of current federal rules and regulations in the area of nuclear power use is on the relatively high level and corresponds to the modern approaches to the nuclear facility safety justification, the IAEA requirements and recommendations (including IAEA-TECDOC-1289 /1/, IAEA-TECDOC-1691 /2/, NP-T-1.6), INPRO methodology and NEA. Thus, the large list of essential FRR is fully applicable to the NTP requirements.

In Russia, the innovative reactor facility projects are developed under “Proryv” project direction included in the Federal Target Program “Nuclear power technologies of a new generation for the period of 2010-2015 and projected till 2020”. Among other things, “Proryv” project provided development and construction of the pilot and demonstration HLM reactor “BREST-OD-300” (the chief designer - NIKIET JSC) and the energy sodium fast reactor “BN-1200” (the chief designer is OKBM JSC).

The main objective of the program is development of the new generation nuclear power technologies on the basis of fast neutron reactors with the closed nuclear fuel cycle for the NPPs covering the country requirements in the power resources and increase of natural uranium and spent nuclear fuel utilization efficiency providing the harmony of safety and economic efficiency requirements. Prevention of severe accidents which may result in implementation of such safety measures as civilian population evacuation and resettlement is set as the basic safety requirement for the FR of the new generation.

The legislation of the Russian Federation order to perform activity at all stages of the nuclear facility construction life cycle on the basis of rules and regulations in the area of the nuclear power utilization (hereinafter referred to as the federal rules and regulations). The federal rules and regulations being in force on the territory of the Russian Federation are developed on the basis of the experience of the active reactor facilities operation and do not consider to the full extent the specific characteristics of the FR with the new technological platform.

The method used for implementation of “Proryv” project is effective in the terms of time and economical expenditures and involves adjustment of the current federal regulations and rules together with the implementation of new ones. Therefore, manufacture of separate elements, NPP construction, commissioning and operation at all stages after project development and certification should be based on the federal rules and regulations (FRR) in the area of nuclear power utilization corresponding to the innovative FR.

2. Design features of the new technological platform in the nuclear power industry
The reactor facilities of the new technological platform are designed on the basis of the requirements of the current federal rules and regulations to ensure safety of the constructed nuclear facilities (NF). Together with technical and organizational solutions approved by the previous operating experience, the innovative projects include solutions which have been not used previously in the NF and which are not reflected in the current federal rules and regulations for this reason.

For example, in the reactor facility “BREST-OD-3000”, there are the following solutions:
- use of lead as coolant;
- metallic-concrete vessel with built-in metallic shells;
- design of some equipment and pipelines.

Justification of design solution safety is performed by implementation of the comprehensive approach:
- analysis of the existing and new patent protected solutions;
- design development (final stage is the detailed design);
- design-basis justification;
- research in justification of application of new materials;
- testing of models and equipment elements.
Based on the development results, the accepted decisions are fixed in the FRR. The safety justification is performed using the advanced computer simulation by the computer codes validated against the representative data base of separate and integral phenomena. For safety justification, the legislation permits to use the codes which passed the proper expertise. Advanced system of computer codes of the new generation are being developed under the NTP in IBRAE RAS in cooperation with the industrial scientific and design organizations. These software tools describe wide range of physical processes and phenomena in the self-consisted way. The main features of the software packages of new generation are multiphysics and multiscale of modeling.

Hereby, development of innovative NPP projects, new FRR and advanced software tools (codes of new generation) should be performed almost simultaneously.

3. Analysis and improvement of the existing regulatory environment

The existing regulatory environment in the area of nuclear power utilization includes the federal rules and regulations which set the guiding safety principles and criteria and also the requirements to allocation, designing (engineering), operation and decommissioning of the NF, its systems and elements, and also to the NF physical protection, control and accounting of nuclear materials, radioactive substances, radioactive wastes, radioactive waste management.

The analysis of works for updating of the federal rules and regulations system in the Russian Federation shows that this process runs continuously and takes much time from the work beginning till approval taking into account the regulation evaluations including the public ones. The prerequisite for changes and corrections of the federal rules and regulations is the experience of the NPP units normal operation, and also accidents and other “negative” events. Development of new regulatory document for NF safety assurance taking into account FR innovative projects is impossible without gaining of practical knowledge at each stage of its life cycle (for example, achievement of construction material properties) and results of design-basis justification in the beginning of detailed design development.

This can be observed in the experience of the peaceful atom development in the Soviet Union and then also in the Russian Federation. The first NPP projects were developed, if applicable, using the general industrial standards and rules and scientific, engineering and production achievements where new factors appeared which had been not investigated earlier, for example, ionization radiation. “General provisions of a nuclear power plant safety assurance during designing, construction and operation (ОПБ 73)” was the first regulatory document which stipulated the conceptual approach to the NPP safety assurance. it was approved in 1973 after synthesis and analysis of the operation experience accumulated during almost twenty years.

Now, the same approach is used. It is vested by clause 1.1.2 of "General provisions of a nuclear power plant safety assurance. HII-001-15" and specifies to justify the certain engineering solutions according to the modern development of science, engineering and production in the absence of the required legal acts.

The close cooperation of the professionals and experts of Rostechnadzor, the State Atomic Energy Corporation “Rosatom”, industrial and RAS scientific institutions, design organizations developing the innovative projects was organized in order to update the federal rules and regulation in favor of the new technological platform. The work group was established in September of 2015 by the decisions of the directors of the Federal Service for Ecological, Technological and Atomic Supervision and the Innovation Management Block of the State Atomic Energy Corporation “Rosatom” for coordination of activities on update of the federal rules and regulations for “Proryv” project.

The WG members performed the detailed analysis of the current FRR and demands of “Proryv” project (the reactor section and CNFC industry) which allows to evaluate and agree the scope of the required development of the new FRR or update of the existing FRR and also the priority of their development.

The analysis of applicability of the current federal rules and regulations to the reactor facilities of the new technological platform reveals the following:
• the current federal rules and regulations can be used as the basis for regulation of the nuclear and radiation safety at the nuclear power plants with innovative FR;
• some federal rules and regulations can be directly used for regulation of the nuclear power plant safety; for example, these are NR-001-15, NR-031-01, NR-071 etc.;
• justification of some aspects of nuclear and radiological safety assurance requires revision of the current regulatory documents, these are, for example, NR-040-02, NR-061-05, etc; and development of the new similar regulatory documents, for example, analogues of НП-089-15.

The performed experiments and calculations performed by now for safety justification of the power unit with the FR “BREST-OD-300” enable to proceed to development and implementation of the new normative base on a step-by-step basis while gaining the experience at each life cycle stage as determined by law.

The works are performed according to the plan “Development (revision, updating) and enforcement of the normative documents regulating safety issues at achievement of the goal by the institutions of the State Atomic Energy Corporation “Rosatom” involving design of the fast neutron reactors with the closed nuclear fuel cycle with prioritization and setting the terms for their commissioning” (hereinafter referred to as “the Plan”). The plan is approved by the State Atomic Energy Corporation “Rosatom” and Rostechnadzor.

The fundamental documents from the specified plan regulate the requirements to the arrangement and safety operation of the block case, the reactor equipment and the pipelines of the nuclear facility with lead coolant and the requirements to the strength justification for the block case, the reactor equipment and the pipelines of the nuclear facility with lead coolant at the FRR level. The set of the State Atomic Energy Corporation “Rosatom” standards is being developed in order to detail the FRR requirements.

The following provisions were laid in the basis of new regulatory documentation development:
• synthesis of the native and foreign experience in standardization of requirements to assurance of the component’s integrity in the high temperature nuclear reactors and their adaptation to the reactor facilities with lead coolant;
• revealing of specific features of construction, manufacture, installation, erection, operation of the elements in the reactor facility with lead coolant.

The redactions of essential FRR have been already developed and they are being enforcing by now. The set of the State Atomic Energy Corporation “Rosatom” standards has been developed and it is under agreement now in order to detail the FRR requirements.

4. Conclusion
Implementation of the innovative fast reactor facility projects are impossible without adaptation of the existing regulatory and legal framework by adjustment of the current federal rules and regulations and development of new regulatory documentation.

In order to avoid arrearage of Russian technologies from the scientific achievements of the leading countries in the area of the nuclear power utilization and, as consequence, deterioration of competitiveness in the specified area in the medium- and long-term perspective, the rational combination of development rate and risks is implemented at designing of the facilities; the engineering solutions wherein are taken according to the achieved level of science, engineering and production and they naturally advance the current rules and regulations.

While gaining the experience in designing on the innovative projects at all life cycle stages, the existing regulatory framework is adjusted and updated by new documents.

References
[1] 2002 Comparative Assessment of Thermophysical and Thermohydraulic Characteristics of Lead, Lead-Bismuth and Sodium Coolants for Fast Reactors (Vienna: IAEA) IAEA-TECDOC-1289
[2] 2013 Status of Fast Reactor Research and Technology Development (Vienna: IAEA) IAEA-TECDOC-1691