

POLICY STATEMENT ON APPLICATION OF PROBABILISTIC SAFETY ASSESSMENT AND RISK-INFORMED METHODS FOR NUCLEAR POWER PLANTS

1. Preamble

In 1999 Gosatomnadzor of Russia had published Declaration about policy “Application of Probabilistic Safety Assessment for units of nuclear power plants under operation”. This document for the first time has indicated the necessity of use of probabilistic safety analysis (PSA) for assessment of safety level and for regulation of safety of NPP power units in the Russian Federation.

The necessity and urgency of the PSA application in the course of design, operation and reconstruction of nuclear facilities was indicated at meeting of Council of General designers and Chief designers in the sphere of the high-technology sectors of economic activity under the Chairman of the Government of the Russian Federation (protocol No.4 from December 7, 2009, para.6 and 7).

Taking into consideration all experience accumulated for the last period of time both in the Russian Federation and abroad, Rostekhnadzor, as considered to be a state authority for regulation of safety when implementing use of atomic energy, thinks it necessary to declare about the relevance of in-depth and broaden application of Probabilistic Safety Assessment and risk-informed methods (approaches, which are based on joint accounting of results gained from probabilistic and deterministic investigations) treated as integrated instrument for assessment of NPP units safety.

2. PSA as an approach for NPP safety evaluation

In time from announcing in 1975 by Nuclear Regulatory Commission of the USA of WASH-1400 report “The Reactor Safety Study”, the PSA has been improved and it becomes widely applied in the international practice during design, operation and regulation of NPP safety. Since the 1999 year publication of the RF Gostatomnadzor’s Declaration about policy (in the sphere of the PSA), this method has also received significant development and broad-spectrum application within the practice of design, operation and regulation of safety of NPP power units.

The advanced countries with nuclear power engineering in the course of evaluation of decision-making at NPP, which are to influence safety, do really apply the risk-informed approaches as an assessment instrument/tool of NPPs’

power units safety. In 2011 the International Nuclear Safety Group (under the auspices of the IAEA Director General) has prepared report “A Framework for an Integrated Risk Informed Decision Making Process”, INSAG-25, which was focused on the use of risk-informed methods.

The objectives of a probabilistic safety assessment are to determine real conditions of a unit of nuclear power plant, including condition analysis of all safety-important systems and components, analysis of results gained from their checking and testing; analysis of procedure and organization of operation and analysis of reliability of actions performed by NPP personnel. Probabilistic safety assessment gives an opportunity to reveal factors to maximum affecting the safety. These factors may be conditioned by specific features of NPP siting, peculiarities of an NPP design decisions and its operating conditions.

Probabilistic Safety Assessment and the risk-informed methods are considered to be instruments, which allow the possibility to:

- evaluate the current safety condition/level of NPP unit and, if necessary, to determine the options for its reliability increasing;
- reveal initiating events, accident sequences, NPP units components and actions of personnel, which are the most safety-significant ones;
- consider recommendations on arrangements directed at enhancement of safety level and establish their implementation priorities;
- evaluate influence from arrangements on modernization over safety level of NPP unit;
- evaluate the level of reliability of systems (components) which are safety-important ones with taking into account the ageing effects, the level of protection from common cause failures as well as from incorrect actions of personnel of NPP unit;
- substantiate conditions of NPP unit safe operation;
- substantiate amending of design and operational documentation;
- plan and assess results gained from inspections;
- evaluate the significance of operational substantiate occurrences;
- justify the lists of design-basis and beyond-design-basis accidents;
- substantiate the Beyond Design Basis Accidents Management Guides (BDBA MG).

The most part from the mentioned above branches of PSA and risk-informed methods application are of great current interest for other nuclear facilities ,

apart from NPPs (nuclear research installations, nuclear installations of ships and its service ships, nuclear fuel cycle facilities, storage facilities, means for transportation for spent nuclear fuel).

Depending from investigation of types of consequences from initiating events, traditionally PSA is being sub-divided into three levels:

- Level 1 PSA – is determination of overall (summarized) probability of the severe BDBAs within the time period of 1 year. In terms of Level 1 PSA all strong and weak sides of safety ensuring at NPPs' unit are assessed and evaluated; it is focused at analysis of accident sequences which lead to severe beyond design basis accidents and both the available and planned measures aimed at accidents' elimination are considered;
- Level 2 PSA – provides determination of probability of increasing of permissible (limit) emergency releases of radioactive substances within the period of time of 1 year. Level 2 PSA is to be performed in addition to analysis accomplished during Level 1 PSA; the phenomenology of severe accidents, functioning and performance of localizing safety systems in the course of severe accidents (for example, of containment), transport of radioactive substances from the damaged fuel assemblies into environment are considered in Level 2 PSA as well as the effectiveness of available and planned arrangements for reducing of severe accidents consequences is being evaluated;
- Level 3 PSA – are risks of damage determination and estimation. Level 3 PSA is being carried out in addition to analysis performed within the Level 2 PSA; Level 3 PSA examines distribution of radioactive substances in case of accident around the NPP territory; risks of fatal cases and harm for health, risks of radiological contamination of the territory are estimated.

Probabilistic Safety Assessment for a power unit of NPP is performed for internal initiating events (conditioned by originating of failures of NPP units' components, NPP unit personnel's errors), for on-site fires, flooding and for other impacts as well as for initiating events conditioned by external natural phenomena (earthquakes, flooding, extreme weather conditions and etc.) and by man-induced impacts (accidental explosion, accidents at hydraulic engineering structures and others) with taking into consideration of all possible modes of NPP operation, including operation

at nominal power and at reduced power level, start up and shutdown conditions, regimes of shutdown for maintenance and repair, and for refueling.

By now the first phase of works on PSA development for Russian nuclear power plants is finalized; Rostekhnadzor is provided (within set of documents substantiating safety of NPP units) with Level 1 PSA for internal initiating events in the course of on-power operation for all NPP units under construction/operation. Level 1 PSA has been prepared and exercised for several power units in shutdown regimes of operation. Rostekhnadzor expects that the operating organization within the scope of implementation of periodic safety assessment activity should develop and present to Rostekhnadzor Level 1 PSA for other types of initiating events, conditioned by on-site fires and flooding, external impacts of nature and man-induced origin, and Level 2 PSA. Rostekhnadzor believes that Fukushima-Daiichi NPP accident has demonstrated that the level of protection available at NPP units from external impacts of nature and man-induced origin is the highest-level priority aspect for NPP units' safety.

In the compliance with the said above, Rostekhnadzor indicates the urgency of programmes of activities on PSA for the next years to come necessarily to be developed by the operating organization to guarantee preparation of the full-scope Level 1 PSA and Level 2 PSA (for all types of initiating events and operational modes) for NPPs under operation/construction.

3. Probabilistic Safety Assessment in the course of regulation

Starting in 1988, Rostekhnadzor is implementing stage-by-stage creation of regulatory requirements to application of PSA for an NPP power unit.

By the reason of the necessity of comprehensive research of safety of NPP units, the document "General Safety Provision of Nuclear Power Plants" (OPB-88/97) includes requirements, which determine relevance of PSA exercising for NPP units and provides milestones of probabilistic indicators of safety of NPP unit. The requirement to present Level 1 PSA within the set of documents substantiating ensuring of nuclear and radiation safety of NPP unit is introduced into "Administrative Regulations on Provision by the Federal

Environmental, Industrial and Nuclear Supervision Service of the State Service of Licensing of Activities in the Field of Atomic energy Use”.

In the past decade Rostekhnadzor had introduced into effect the following Safety Guidelines which cover recommendations for PSA development:

1. Evaluation of frequency of severe damage of reactors' core (for external initiating events of nature and man-induced origin) , RB-021-02 (was put into effect from January 1, 2012);
2. Main recommendations on performing of Probabilistic Safety Assessment for nuclear power plants, RB-032-04 (was put into effect from June 1, 2004);
3. Main recommendations to Level 2 PSA for VVER-type NPPs, RB-044-09 (was put into effect from September 1, 2009);
4. Provision on main recommendations to Level 1 PSA development for internal initiating events and all operational modes of NPP unit, RB-024-11 (was put into effect from September 9, 2011);
5. Provision on main recommendations to Level 2 PSA development for NPPs with RBMK-type reactors.

The following Safety Guides are under preparation:

1. Provision on main recommendations to development of Level 1 PSA for on-site fires and flooding.
2. Provision on application of the risk-informed approaches in the course of substantiation of changes of NPP unit safe operation.

Rostekhnadzor considers it reasonable to continue development of regulatory and methodological framework on Probabilistic Safety Assessment and application of the risk-informed approaches/methods for NPP safety regulation.

4. Probabilistic Safety Assessment to be adequate for regulatory authority's needs.

The feedback from documentation review which substantiate NPP power unit safety clearly demonstrates that PSA of the highest quality incorporates the following characteristics:

- Methodological framework and software used in the course of PSA implementation corresponds with up-to-date international practice;
- PSA is being implemented with the involvement of NPP unit personnel;

- PSA uses data on reliability of systems and components of NPP unit which to maximum correspond with NPP unit under assessment;
- PSA to full extent takes into account the current condition of NPP unit;
- The development models (scenario) of accident sequences accepted by PSA are confirmed by deterministic substantiations;
- PSA is being implemented with application of quality assurance procedures.

Rostekhnadzor shall take advantage of the mentioned characteristics during evaluation of NPP unit PSA's provided to the regulatory authority.

In correspondence with international practice, Rostekhnadzor shall recognize PSA results for NPP units under construction and operation only after finalization of the comprehensive independent review, which confirms the quality of analysis and adequacy of the gained results with the targets declared.

5. Practical application of Probabilistic Safety Assessment

Rostekhnadzor considers it reasonable to continue application of Level 1 PSA results and Level 2 PSA results when exercising the supervision activity.

Rostekhnadzor is planning the application of the risk-informed approaches in the course of supervision activity implementation, and, in particular, within the assessment of the current safety level of NPP units, in the course of decision-making about modernization of systems and components which are important to safety or about amendments of conditions of safe operation of NPP unit; during planning and evaluation of results gained during inspections, and, namely during evaluation of analysis performed within investigations of NPP unit operation violations.

Rostekhnadzor, in every possible way, shall assist the efforts from operating organization directed at development of Level 1 PSA and Level 2 PSA for NPP units as well as the initiative on widespread application of PSA results in the course of activities related with NPP unit safety (assessment of the current safety level, planning of arrangements on modernization; significance analysis of deviations from requirements from rules and regulations; optimization of maintenance and repair of equipment, equipment resource management and others).

Special emphasis shall be paid to development of PSA for NPPs' units which are planned to be operated over the scheduled life-time period. The application

of PSA and the risk-informed approaches is necessary condition during substantiation of the possibility to extend the life-time period for such power units.

At the same moment, the absence of the initiative from the side of the operating organization to apply PSA for assessment and enhancement of NPPs units safety as well as application of PSA of low quality level in the course of the of activity concerned with safety substantiation of NPP units under construction and operation shall be treated by Rostekhnadzor as inappropriate exercising of the requirements from the Federal law “On the Use of Atomic Energy” by the operating organization in the part of realization of full responsibility for NPP units safety ensuring and ignoring of safety culture principles.

6. Conclusion.

Rostekhnadzor believes that application of the risk-informed approaches based on the coupled application of the deterministic and the probabilistic methods of safety assessment shall be used to ensure the extensive support to nuclear and radiation safety assessment of NPPs units along with improvement of safety regulation effectiveness.

Rostekhnadzor schedules the development of the federal rules and regulations to be used in the course of the atomic energy use which determine requirements for Probabilistic Safety Assessment.

Rostekhnadzor expects that the operating organization will continue performance of the full-scope Level 1 OSA and Level 2 PSA and it will apply the risk-informed approaches in the course of decision-making related wit safety of NPPs units.

Rostekhnadzor considers it reasonable to apply PSA and the risk-informed approaches for not only PSA but for other nuclear facilities as well.

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