Safety Design Criteria and Approaches to Safety Substantiation of the BN-1200

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Russian experience in SFR area (1/2)

Activities on development of safety design criteria for SFRs of the 4th generation is carried out within the GIF framework.

Although this reactor technology is considered as innovative that is relevant to the 4th generation, however, it has already a certain history.

In this relation, it seems to be useful to analyze the corresponding experience that is available in various countries.

4 SFRs have been successfully operated in the USSR and in the Russian Federation:

- *Experimental reactor BR-5/10*
- *Research reactor BOR-60*
- *Prototype BN-350 power reactor*
- *Commercial BN-600 power unit at the Beloyarsk NPP.*

Russian experience in SFR area (2/2)

Thus, Russia gained a considerable experience of design, construction and operation of SFRs.

In particular, a certain experience has been acquired on safety substantiation of reactors of this type and their licensing.

Now BOR-60 and BN-600 continue their operation, BN-800 power unit is under construction, development of the commercial BN-1200 power unit, that is considered as the 4th generation reactor, has been started.

Due to limited number of operating SFRs in the world, successful Russian experience in this area should be taken into account for further development and improvement of SFR SDC developed by the GIF Task Force.

In particular, participation of SFR designers in this activities would be fruitful and useful.

Requirements of acting national safety regulatory documents

There are no specific regulatory documents for SFRs in Russia.

Safety requirements to operating Russian SFRs are determined by national safety regulatory documents, such as NP-001-97 (OPB-88/97), NP-082-07 (PBYa RU AS-89) etc, that contain safety design criteria for NPPs with various types of reactors operated in Russia.

These documents are strongly correlated with the IAEA SSR 2/1 document and their safety design criteria are correspondent to the NPPs with reactors of the 2nd and 3rd generation.

Level of safety requirements in Russian regulatory documents to NPPs of the 2nd and 3rd generation can be illustrated by the following ones:

- *NPP design should provide for the required technical means and organizational measures aimed for prevention of exceeding safe operation limits and conditions, including prevention of DBAs and minimization of their consequences and ensuring safety in case of any single initial event considered in the design with superposition of independent failure of:*
  - *One element of safety systems – active or passive one having mechanical moving elements*
  - *Or one personnel error independent on the initiating event.*
- *Value of probability of the core disruptive accident (CDA) should not exceed 10^{-5} per reactor year.*
- *For avoiding the necessity to evacuate the population efforts should be made in design to ensure that probability of limiting emergency radioactivity release beyond established boundaries will not exceed 10^{-7} per reactor year.*

Safety requirements to the BN-1200 design

For the BN-1200, claimed as the 4th generation NPP, safety requirements and safety design criteria are formulated within the framework of the "Breakthrough" Project.

The most important of them are as follows:

BN-1200 design should provide elimination of severe accidents that require evacuation of the population from the area adjacent to the NPP by means of maximal application of *inherent safety features* and *passive safety systems*.

These measures should provide under any *possible realistic accident*:

- *Reactor shutdown with maintaining core components temperature at acceptable level*
- *Decay heat removal from the reactor without any damage of its structures*
- *Confinement of the major part of radioactive products released from the reactor under possible accident conditions within reactor building.*

Term "*possible realistic accident*" means any initial event, even with very low probability, accompanied by superposition on the initial event of:

- *Failures of all active safety systems*
- *Single failures of elements of passive safety systems (having mechanical moving parts) provided by the design for restriction of consequences of the given initial event*
- *Failures of active safety-related systems of normal operation*
- *And erroneous actions of the personnel.*

BN-1200 design should meet the following requirements:

- *Total probability of severe accidents that can lead to significant damage or meltdown of the reactor core should not exceed 10^{-6} 1/reactor-year, and all damaged structural elements of the core should be kept within the reactor vessel*
- *Value of radioactivity release into environment under any possible realistic accident should not exceed radiation dose for population outside of the NPP site boundaries, specified by the regulatory documents, that requires evacuation of residents.*

Comparison of safety design criteria for the 3rd and 4th generation NPPs

Significant and clear strengthening of the safety design criteria for the 4th generation NPPs in comparison with relevant ones for the 3rd generation NPPs.

As regards the safety design criteria developed by the GIF Task Force, some safety requirements are based on term "*practical elimination*".

The expression "*Practical Elimination*" is defined in the following way:

- *"The possibility of certain conditions occurring is considered to have been practically eliminated if it is physically impossible for the conditions to occur or if the conditions can be considered with a high level of confidence to be extremely unlikely to arise".*

Application of this term does not permit to fix a border between SFRs of the 3rd and 4th generation.

Technology based on SFR is an innovative technology of the 4th generation, but it does not mean that any SFR design automatically belongs to the 4th generation.

It is necessary to prove it.

For this goal we need clear segregation between safety requirements and design criteria relevant to the 3rd and 4th generation.

I agree with proposal C. Behar that it is important to define quantitative safety criteria for SFRs of the 4th generation.

In particular, it is necessary to set up quantitative values for term "practical elimination" and may be for probability of CDA or to determine clearly combinations of additional failures in safety systems superposed on initial event when considering design extension conditions for SFR design.

Thank you
for your attention !