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Environmental safety of nuclear power plants and construction of Russian-type NPP

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The issues related to the environmental safety of nuclear power plants are of high priority. NPPs of Russian design have always been exhibiting a high level of environmental safety. The study gives brief characteristics of all safety barriers and focuses on stress tests showing a high safety level at operating NPPs. Special attention is given to NPPs equipped with new-generation 3+ VVER reactors with the capacity of 1,200 MW. Keywords: Environmental safety, nuclear reactor, safety barriers, stress tests, nuclear power plant (NPP).

Objectives:

1. To analyse the safety barriers characteristics with a focus on stress tests.
2. To study the environmental safety of the Russian type NNPs.

Introduction: In Russia, all nuclear power plants (NPPs) are operated reliably and safely, which can be proved by the results of regular inspections carried out by independent bodies and international organizations such as the IAEA. Over the recent 16 years, no serious safety violations have been reported at Russian NPPs. It is a top priority of the Rosatom State Corporation to guarantee safety when using nuclear power. Throughout the whole period of their service life, NPPs show reliable and safe operation in all areas of their activities, including fields related to ensuring environmental safety.

Materials and Methods: The main Russian technology used in the construction of NPPs is the water-water energetic reactor (VVER). Over more than 50 years of their operation, Russian VVERs have proven to be efficient, reliable, and safe. The nuclear and radiation safety strategy for NPPs is based on applying a system of several protective barriers that prevent the spread of ionizing radiation and radioactive substances into the environment and/or unauthorized movement and accumulation of nuclear material in the quantities creating conditions for a self-sustained chain reaction on taking technical and organizational measures to protect barriers and preserve their efficacy as well as on protecting personnel, population, and the environment. Design solutions for ensuring nuclear, radiation, and environmental safety of NPPs are based on require-ments of the national standards that are supported by the IAEA's recommendations, and on experience in the designing, constructing, and operating civil nuclear facilities built according to Russian projects. Additional measures for improving the safety of operating NPPs were taken upon an estimation of the causes and consequences of the Fukushima Daiichi NPP accident (Japan, BWR-type reactor). In 2011, safety was additionally analyzed, and stress tests were carried out that took into account external extreme impacts.

Results: The stress tests of Russian NPPs confirmed their design protection against external natural and anthropogenic impacts. A number of additional safety measures were taken. For NPP sites that can be potentially flooded due to extreme external impacts, negative results of such safety impacts are compensated by mobile systems for organizing heat removal to the final absorber (with diesel pumps, motor-pumps, quick-assembly pipes). For units using RBMK-type reactors, the opportunity for installing a passive (air) cooling of the core was additionally substantiated by calculations and experiments. Extra measures were taken to improve the reliability of power supply for normal operation, and to implement redundant additional cooling systems (standard emergency diesel generators, can be used if the main cooling systems are lost). The high safety level of Russian NPPs is ensured by numerous factors. The main ones are the self-protection principle of the reactor facility, the availability of several safety barriers, and

the repeated duplication of safety channels. Russian NPPs employ both active (requiring human participation and an energy source) and passive (not requiring human participation and an energy source) security systems. The passive principle devices provide unlimited time emergency cooling of the reactor core in case of losing all sources of alternat-ing current or in case of losing the final heat absorber (sea, cooling pond, spray pool, etc.).

The safety principles of Russian NPPs:

- Defense-in-depth
- Self-protection of the reactor plant equipment
- Security barriers
- Multiple duplications of security channels
- Use of passive safety systems
- A safety concept that provides not only means for preventing accidents but also means for managing the consequences of non-project accidents that localize radioactive substances within the containment
- Safety culture at all stages of the life cycle—from site selection to decommissioning
- Employee forces and means of civil defense and emergency management at each NPP
- Principle of selecting an NPP site with no prohibiting factors present

Notes: