Safety enhancement of nuclear power plants in Russia: response to challenges of the time

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1. SAFETY ENHANCEMENT OF NPPS IN OPERATION
LESSONS LEARNT FROM FUKUSHIMA ACCIDENT

Accident at Fukushima Daiichi showed:

- Necessity of additional evaluation of external impacts
- Necessity of mobile equipment as backup safety systems
- Lack of preparedness of the staff to cope with beyond design basis accidents (BDBA) leads to a critical loss of time in the first hours after the accident
ENHANCEMENT TO WITHSTAND SEISMIC IMPACTS

• Additional researches and analysis of seismic zoning were carried out for each NPP

• Calculations were performed and actual load factors of seismic stability of NPP units were estimated

• Measures were taken for equipment and pipelines strong fixation

• Anti-seismic reactor protection I&CS was implemented at NPPs
PROVISION OF MOBILE EMERGENCY EQUIPMENT

There were supplied on 10 NPPs:

- **Mobile 2.0 MW diesel-generators** (6kV, 0.4kV, 220V DC)
- **Mobile 0.2 MW diesel-generators** (0.4kV)
- **Mobile high pressure pumps**
- **Motorpumps of various capacity and pressure**
ELEMENTS OF SUPPORTING INFRASTRUCTURE

Connection nodes for mobile pumps to SGs and other consumers

A connection node for a mobile pump to the fire water pipeline
ELEMENTS OF SUPPORTING INFRASTRUCTURE

Dry pipe sprinkler system for water supply to SG from mobile pipe units

Electric heating system for the dry pipe system
MEASURES TO IMPROVE STAFF EMERGENCY PREPAREDNESS

Whole-plant emergency response training – annually at each NPP

Complex emergency response training – annually at one NPP

Prompt assistance to nuclear power plants in emergency (OPAS group)

NPP staff
MEASURES TO IMPROVE STAFF EMERGENCY PREPAREDNESS

• Information support system for staff was implemented at all units (Safety-Related Parameters Monitoring System);

• Staff is being trained at full-scale simulators to cope with accidents;

• Number of regular BDBA response trainings was doubled
MEASURES TO IMPROVE STAFF EMERGENCY PREPAREDNESS

• Full-scale simulators are equipped with modules for severe accidents modeling;

• Plans of emergency response trainings were supplemented with scenarios of whole-plant severe accidents with the simultaneous use of all available units of mobile emergency equipment;

• Annually Rosenergoatom conducts a comprehensive emergency training with the use of all existing mobile emergency equipment
Trainings with OPAS Group are to practice:
• Actions when events are similar to Fukushima accident;
• Use of the emergency equipment on site;
• Actions under loss of communication channels between NPP and the Emergency Response Center.
2. NEW DESIGN “AES-2006”
<table>
<thead>
<tr>
<th>Parameter</th>
<th>VVER-1000</th>
<th>VVER-1200</th>
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</thead>
<tbody>
<tr>
<td>Nominal thermal capacity, MW</td>
<td>3000</td>
<td>3200</td>
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<tr>
<td>Nominal electric capacity, MW</td>
<td>1000</td>
<td>1200</td>
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<tr>
<td>Nominal pressure of the 1&lt;sup&gt;st&lt;/sup&gt; loop, MPa</td>
<td>15,7</td>
<td>16,2</td>
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<td>Nominal pressure in SGs, MPa</td>
<td>6,27</td>
<td>6,9</td>
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<tr>
<td>Nominal steam capacity of SG, t/h</td>
<td>1470</td>
<td>1602</td>
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</tbody>
</table>
RESISTANCE TO EXTERNAL IMPACTS

- Robustness to the snow and ice load
- Increased wind resistance (hurricanes, tornados)
- Aircraft crash resistance
- Increased seismic robustness
- Resistance to external explosions
SAFETY SYSTEMS OF VVER-1200

Compared to VVER-1000, additional safety systems are provided:

1. Second hydraulic tanks stage of the passive core cooling system;
2. Passive heat removal system;
3. Double protective shell;
4. Passive filtration system of the intershell space;
5. Emergency SGs cooling system (closed loop);
6. Melt localization system (core catcher).
REACTOR SYSTEM V-392M

- Hydraulic tanks
- Reactor
- Pressurizer
- Steam generators
- Main circulation pumps
- Bubbler
THE SECOND HT STAGE

Each of 8 HT contains 120 m³ of boric acid solution providing feed-up of the reactor during 26-280 hours (dependent on the rate of the 1st loop leak) upon failure of the active safety systems including the plant blackout.
PASSIVE HEAT REMOVAL SYSTEM

PHRS (4 channels) with 2 air-cooled heat exchangers in each channel. Thermal capacity of each is 8 MW.

Action period is unlimited.
PASSIVE FILTRATION SYSTEM OF THE INTERSHELL SPACE

PFS provides air exhaustion and discharge of the internal shell leakages to the atmosphere after deep cleaning upon failure of the active safety systems including the plant blackout. Action period is unlimited.
EMERGENCY STEAM GENERATORS COOLING SYSTEM

2 channel of emergency steam generators cooling system (2 pumps in each channel) with closed loop.

Action period is unlimited.
**COMMISSIONING OF NOVOVORONEZHZH-6 – A UNIT OF GENERATION 3+**

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
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<tbody>
<tr>
<td>Fuel loading</td>
<td>24.03.2016</td>
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<tr>
<td>First criticality</td>
<td>19.05.2016</td>
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<td>Energy startup</td>
<td>08.07.2016</td>
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<td>Connection to the grid</td>
<td>05.08.2016</td>
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<td>100% power level</td>
<td>26.10.2016</td>
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<tr>
<td>Start of commercial operation</td>
<td>27.02.2017</td>
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Thank you for your attention!