Evolution of VVER Technology And Modern Design Solutions

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VVER.1200 DESIGN

VVER.1200 is an export name of the Russian design of the nuclear power plant known as AES-2006.

It is an evolutionary NPP design developed on the basis of a Russian design VVER.1000.

The AES-2006 design belongs to Generation III+.

It meets all up-to-date Russian, European and international requirements for new NPP.

One of the first units AES-2006 design is the unit #1 of Leningrad NPP-2 (LNPP-2) in Russia.

The unit #1 of Leningrad NPP-2 was put into operation in October 2018.
CURRENT PROJECTS

Nuclear power plants

Operation
- Tianwan NPP, China (units 1-4, VVER-1000)
- Leningrad NPP-2 (unit 1, VVER-1200)

Construction stage
construction documentation release:
- Belarus NPP (units 1-2, VVER-1200)
- Leningrad NPP-2 (unit 2, VVER-1200)

Design stage
design documentation preparation for licensing purposes:
- Hanhikivi-1 NPP (unit 1, VVER-1200)
- Paks II NPP (unit 5-6, VVER-1200)
- El-Dabaa NPP, Egypt (units 1-2, VVER-1200)
- Tianwan NPP, China (units 7-8, VVER-1200)
- Xudapu NPP, China (units 3-4, VVER-1200)
LICENSING OF THE DESIGN

- Site license of Units 1, 2, 3 and 4 of LNPP-2;
- Site license of Units 1, 2 of Baltic NPP;
- Construction Licenses for Units 1, 2 of LNPP-2;

- Construction License for Unit 1 of Baltic NPP;
- Construction Licenses for Units 1, 2 of Belarus NPP.
- Operation License for Unit 1 of LNPP-2
### SAFETY ENGINEERING FEATURES EVOLUTION IN NPP DESIGN

<table>
<thead>
<tr>
<th>VVER-1000 (V-320)</th>
<th>VVER-1000 (AES-91)</th>
<th>VVER-1200 (LAES-2)</th>
<th>VVER-1200 (Hanhikivi-1, Paks II, El-Dabaa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 safety trains</td>
<td>4 safety trains</td>
<td>4 safety trains</td>
<td>4 safety trains</td>
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<tr>
<td>Single containment</td>
<td>Double containment</td>
<td>Double containment</td>
<td>Double containment</td>
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<tr>
<td>-</td>
<td>Engineering measures for SA management</td>
<td>Engineering measures for SA management</td>
<td>Engineering measures for SA management</td>
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<tr>
<td>-</td>
<td>Enhanced seismic stability</td>
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<td>-</td>
<td>C-PHRS and PHRS-SG</td>
<td>C-PHRS and PHRS-SG</td>
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<td>-</td>
<td>-</td>
<td>Independence from outer power supply – 72 hours</td>
<td>Independence from outer power supply – 72 hours</td>
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<td>-</td>
<td>-</td>
<td>Emergency Storage Water Tank inside the Containment</td>
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<tr>
<td>-</td>
<td>-</td>
<td>DEC – extended list of accidents and external impacts</td>
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</tr>
</tbody>
</table>

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THE REASONS FOR NEW DESIGN SOLUTIONS

Modern regulations, codes and standards (YVL guides version 2013, NCS3a, EUR, WENRA)

Customer’s requirements (thousands of special requirements)

Site condition (initial data for design)
NEW REQUIREMENTS (PART 1)

- Consideration of initial events related to DEC A, DEC B, DEC C

- New acceptance criteria of radiation effect on population in DEC (not more than 20 mSv)

- Independence and diversity principles should be applied in defence-in-depth approach

- Additional safety analyses

- Requirements to load-following characteristics from the Customer and from the national distribution grids
### NEW REQUIREMENTS (PART 2)

<table>
<thead>
<tr>
<th>Significantly increased characteristics of external effects</th>
<th>Stricter requirements</th>
<th>Consideration of future modification</th>
</tr>
</thead>
</table>
| ▪ Crash of heavy-weight commercial aircraft with a mass up to 400 t, while the design of VVER-1200 (LNPP-2) considers only light-weight aircraft of 5.7 t. | ▪ Structures lifetime (100 years) - lifetime of civil engineering structures in VVER-1200 is 60 years  
▪ Space for equipment maintenance  
▪ Maximum area of electrical rooms shall be not more than 100 m².  
▪ Minimization of personnel for operation of NPP | ▪ Space shall be reserved in buildings, electrical cabinets and I&C cabinets (approximately 20%) to ensure feasibility of future modification |
In AES-2006 design DiD is implemented by a combination of five successive and independent levels of protection.

<table>
<thead>
<tr>
<th>DiD level</th>
<th>SSC classification</th>
<th>Purpose of functional trains</th>
<th>Failure criterion</th>
<th>Operable event category</th>
<th>Automated process control systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Not classified or SC3</td>
<td>Generation electric energy, maintenance of NPP systems and structures</td>
<td>N+0, N+1</td>
<td>DBC1, DBC2</td>
<td>Normal operation I&amp;C</td>
</tr>
<tr>
<td>Level 2</td>
<td>SC3</td>
<td>Control and maintenance of safety related parameters, Management in AOO, Long-term management in Postulated Accident</td>
<td>N+1</td>
<td>DBC1, DBC2, DBC3 and DBC4</td>
<td>Safety related normal operation I&amp;C</td>
</tr>
<tr>
<td>Level 3a</td>
<td>SC2</td>
<td>Management in Postulated Accident (LP and HP SIS, EWST, EFWS, EDG and etc.)</td>
<td>N+2</td>
<td>DBC1, DBC2, DBC3 and DBC4</td>
<td>I&amp;C of safety systems</td>
</tr>
<tr>
<td>Level 3b</td>
<td>SC3</td>
<td>Management in Design Extension Conditions (PHRS-C, PHRS-SG, SBO-DG and etc.)</td>
<td>N+1</td>
<td>DEC</td>
<td>Hardware diversity Safety I&amp;C</td>
</tr>
<tr>
<td>Level 4</td>
<td>Not classified or SC3</td>
<td>Management in SA (core catcher, alkaline supply system, SADG and etc.)</td>
<td>N+1*</td>
<td>SA</td>
<td>SA I&amp;C</td>
</tr>
</tbody>
</table>

* - active components only
EFFECTS OF NEW REQUIREMENTS ON DESIGN (PART 2)

Wall thickness and structures sustainability was increased due to consideration of DEC initial events *(large commercial airplane crash, load of tornado and etc).*

Wall thickness and structures sustainability was increased due to consideration of DEC C initial events *(large commercial airplane crash, load of tornado and etc).*

Wall thickness and structures sustainability was increased due to consideration of DEC initial events *(large commercial airplane crash, load of tornado and etc).*
CONCLUSION (PART 1)

During elaboration of the concept and basic design documentation of AES-2006 NPPs a number of new technical solutions has been implemented:

- **The measures for protection against large commercial aircraft crash:**
  - Increased wall thickness;
  - Ventilation systems modernization;
  - Protection of NPP SSC against side effects of APC.

- **Additional safety features for management in DEC and SA conditions.**

- **Power supply system modernization.**
  SBO diesel-generators are added to ensure power supply in DEC;

- **I&C modernization**

- **Design protection against extreme hazards**
  - extreme earthquakes (up to 0.35g);
  - malicious acts;
  - external explosions;
  - external and internal flooding;
  - etc.
CONCLUSION (PART 2)

The above-stated new technical solutions allow to speak about more solid design of AES-2006.

The AES-2006 design is a result of an evolutionary development of the NPP designs with VVER reactors. This design confirms to all up-to-date Russian and International safety standards including IAEA, EUR and WENRA.

Also flexible AES-2006 design can be adopted and localized to a specific site and normative base.
Thank you for your attention!

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