Country Report

I&C application status in NPPs in China

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Jiang Hong, Tang Yi, Ma Xiaoyu
IAEA TWG NPPIC 24rd Meeting,
Status of nuclear power plant in China

Introduction of I&C design and implementation in NPPs which are under construction

Improvements on NPP design after Fukushima accident

Recommendations to the IAEA
Status of nuclear power plant in China

1. Introduction of I&C design and implementation in NPPs which are under construction

2. Improvements on NPP design after Fukushima accident

3. Recommendations to the IAEA
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<td>Qinshan I (unit 1)</td>
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<td>Qinshan II (unit 1,2)</td>
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## NPPs under construction

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<th>Projects</th>
<th>Province</th>
<th>Total Capacity (MW)</th>
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<td>Fujian</td>
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<td>Fangchengan</td>
<td>Guangxi</td>
<td>2x1080</td>
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<td>Taishan (unit 1,2)</td>
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<td>2x1700 (EPR)</td>
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<td>Fuqing I (unit 1,2)</td>
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<td>Fangjiashan (unit 1,2)</td>
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<td>2x1250 (AP1000)</td>
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<td>Rongcheng (HTR-PM)</td>
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<td>200</td>
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<td>2x1000</td>
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China NPPs development process

Imported units: Dayabay 1/2, Lingao 1/2
Self-development: Qinshan II 1/2

- Self-reliance: Qinshan II 3/4, Lingao II, Hongyanhe, Ningde, Fangjiashan, Fuqing, Yangjiang
- CNNC self-development 600MW PWR Qinshan II 1/2
- Self-design and localized equipments manufacturing
- Standardized, series, DCS
- Improvement in safety and economics

Self-Innovated PWR: CP1000
- New design on reactor core and system based on 10 years R&D
- 177 fuel assemblies, single unit layout and double containments, etc (CDF <1×10-5 /y, LERF<1×10-6 /y )
- Further Improvement in safety & economics

Imported Gen III: AP1000, EPR
- Advanced reactor design
- Passive safety technology
- Severe accident prevention and mitigation technology
- Single unit layout
- Double containments
- Prevent aircraft hazards
- ...
ACP1000, an advanced 1000MW Nuclear Power Plant, is developed by China National Nuclear Corporation (CNNC) on the basis of 25-years experiences in design, construction, commissioning and operation of the NPPs in China.

- Standardized 3-loop PWR with high safety and economy performance
- Combination of deterministic, probabilistic engineering judgment method
- Taking the latest NPP construction and operating feedback and PSA result as reference
- Improvements to increase the safety of plant
- Design features: 177 fuel assemblies in reactor core, single-unit plant layout, double-shell containment design, passive technologies for residual heat removal and containment heat removal, specific features to cope with severe accident, etc.

ACP1000 will be built for Fuqing 5/6 and for the export project.
Fuqing 5,6 will be the demonstration project of ACP1000

- Authorized for pre-phase work in April 2009,
- ACP1000 demonstration project after Fukushima,
- FCD: December 2013
• **Major PWR Program Demonstration Project** implemented by SNPTC under authorization of state council.

• **Based on introduction, technology transfer, and further innovation of imported AP1000 technology with installed capacity of 1400 MW.**

• **Implementation to make a important step towards self-reliance and innovation of advanced nuclear power technology.**
• Project FCD: May 2012
• Features: inherence safety, economic viability, high efficiency in power generation and fuel utilization.
• Ball fuel production line construction in March 2013
• Key technology provided by the Institute of Nuclear and New Energy Technology (INET) of Tsinghai University
• Full scope digital control system and reactor protection system with localized platform
• Full scope simulator for MCR design and validation.
Introduction of I&C design and implementation in NPPs which are under construction
- TRICONEX being used for safety system, I/A being used for non safety system, and ADACS being used for HMI;
- Improved I&C design based on characters of digital technology;
- Advanced main control room, based on HFE study, including optimized alarm processing system and computerized procedure;
- Diversified reactor protection system to deal with software common mode failure

- Project implemented jointly by Invensys and CNCS (8 units in total).
General architecture of Fangjiashan\Fuqing\Hainan DCS
- MELTAC-N plus R3 for safety system, HOLLiAS MACS for non-safety system and human-machine interface;
- Improved I&C design, advanced MCR;
- NC workstation can be used to control safety-related actuators, while the commands need to be confirmed by S-VDU.
Taishan EPR DCS structure

Level 0
Process interface

Level 1
Automatic control and protection

Level 2
Supervision and control

SICS

MCR
QDS
indicator

Conventional control means

PI

PS (F1A)
RCSL (F2)
SA I&C (F2)

SAS (F1B)

HKS (NC)

SAS DEC-B (F2)

PAS (F2)

TG I&C (NC)

Note 1 – This is just sketch, not physical configuration and connection.

I&C SC

Configuration workstation

I&C

RT devices

RodPilot

Teleperm XS

SPPA T2000/S7

Others
Joint Regulatory Position Statement on the EPR Pressurised Water Reactor

1. The UK nuclear safety regulator (HSE’s ND), the French nuclear regulator (ASN), and the Finnish nuclear regulator (STUK) are currently working to assess the EPR Pressurised Water Reactor.

2. In carrying out individual assessments, we have all raised issues regarding the EPR Control and Instrumentation (C&I) systems, which the proposed licensees and/or the manufacturer (AREVA) are in the process of addressing.

3. Although the EPR design being developed for each country varies slightly, the issues we raised with the current C&I system are broadly similar, our aim being to collectively obtain the highest levels of safety from the EPR.

4. The issue is primarily around ensuring the adequacy of the safety systems (those used to maintain control of the plant if it goes outside normal conditions), and their independence from the control systems (those used to operate the plant under normal conditions).

5. Independence is important because, if a safety system provides protection against the failure of a control system, then they should not fail together. The EPR design, as originally proposed by the licensees and the manufacturer, AREVA, doesn’t comply with the independence principle, as there is a very high degree of complex interconnectivity between the control and safety systems.

6. As a consequence of this, the UK nuclear safety regulator (HSE’s ND), the French nuclear regulator (ASN), and the Finnish nuclear regulator (STUK) have asked the licensee and manufacturer to make improvements to the initial EPR design. The licensees, and AREVA, have agreed to make architectural changes to the initial EPR design which will be reviewed by the regulators.

7. It is for the licensees and the manufacturer, AREVA, to respond to its regulator’s issues. However, as designs are similar, it is likely that the solution will be similar, although not necessarily identical, taking into account individual licensees’ requirements and national regulatory requirements or practises. As an example, in providing defence-in-depth, different solutions could be proposed to back-up safety systems. In all cases, however, the solutions will lead to equivalent high levels of safety.

8. This is a good example of how independent regulators working closely together can promote a shared understanding and application of existing international standards, and promote the harmonisation of regulatory standards and the build of reactor designs with the highest levels of safety.
Taishan EPR has been reviewed by China National Nuclear Safety Authority (NNSA) in year 2008 and 2009. NNSA put forward 260 work sheets on I&C design, those work sheets also covered the questions indicated in the Joint Regulatory Position Statement. After that, CGN and AREVA do their effort in improvement on the I&C structure, and activity communication with NNSA, hold several specific meetings, the project gradually going forward now.
I&C system for CAP1400 will be provided by State Nuclear Power Automation System Engineering Company (SNPAS) based on self-reliant development of I&C technology, equipment and system.
More than 20 years experience in development, engineering, manufacturing and supply of nuclear power plant I&C system.

Supply full scope DCS system including reactor protection system with self-developed platform for HTR-PM project.
Reactor Protection System of CAP1400 is based on FPGA safety platform – NuPAC, which is cooperatively developed by SNPAS and Lockheed Martin Company.
Cooperation
- Participation in IAEA, IEEE, IEC, etc. workshops and conferences
- Jointly implementing the DCS project
- R&D cooperation with CNPE and NIPC for safety platform
- Participation in international standard compile

Product
- Non-safety platform NicSys™
- Specific application software module for NPP
- HMI for NPP
- Nuclear detector product

Capability
- HAF601 certified by NNSA for HVAC control system
- Integrated I&C solution for NPP
- ITER qualified supplier
- IEEE, IEC, National standard compile
Our Efforts in the past 5 years:

- V&V the opening company that independently execute whole-process V&V activities of nuclear power projects in China
- Strictly conforming to IEEE-1012 standards, meeting SIL 3 requirement
- Integral V&V system and procedure
- Independently developed V&V tools, including project management tools, abnormity control tools
- Dedicating in level 1 V&V, level 2 HFE,R&D field

NicSys™ Products
- Hardware
- Software
CNCS hosted IAEA International FPGA workshop

The 5th FPGA WS In Beijing, China (2012.10)
CNCS host International I&C conference

The 2nd China (International) I&C Technology Conference in Nuclear Power Field in Xi’an, China (2013.4)
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4. Recommendations to the IAEA
2011,3 China suspend the new NPP projects
2011,6 Safety review of all the NPP in China,
2012,6 The State Environmental Protection Department <Nuclear safety and radioactive pollution prevention "Twelfth Five-Year Plan" and the 2020 Vision>,
2012,10 The government issued a white paper on energy policy--- restart the approval of NPP ,
2012,6, NNSA issued <The General Technical Requirements for Improvement of the nuclear power plants > trial version.
The General Technical Requirements for Improvement of the nuclear power plants contain 8 enhancement requirements, concerning I&C area are:

- Enhancement of the spent fuel pool monitoring, upgraded the classification of instruments to 1E class, and provided continuous level and temperature measurements, to satisfy with the supervision requirement during normal operation, also for the accident situation and post accident situation.

- Monitor the hydrogen inside the containment after SA, continuous measurement signals will be sent to main control room, also sent to emergency response center for indications and alarms.

- Enforce the environmental radiation monitoring after SA. For example, two more environment radiation monitoring stations, one emergency supervision vehicle, more moveable γ monitors and aerosol acquisition devices were added for Fuqing area.
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4. Recommendations to the IAEA
Recommendations

- IAEA has complete set of ‘Requirements’ and ‘Guides’, but there is no ‘Standard’ which can be used as support of the Requirements and Guides, and can give more detail instructions for implementation. On the other hand, when applying IEC standards, it’s also lack of instruction or endorse by the top level Code and Guidance. We suggest IAEA and IEC work more closely, to setup a complete series of ‘Requirements-Guides-Standards’ system.

- IAEA to support more education and training actives for I&C application in NPP depends on need.

- Enhance corporation and communication on technical research, such as, on software reliability study, on Human Risk Analysis (HRA), and on advanced surveillance and diagnosis system of NPP study, etc.
Further study is needed on ‘availability of I&C device’, especially during and after severe accident, and the environment qualification requirements, the seismic margin requirements, etc. What those requirements for NPP already in service, and what those requirements for new NPP.

Co-research on dealing with common mode failure of software based safety system and diversity requirement, IAEA please give more clear opinion.

Co-research on I&C improvements after Fukushima accident, IAEA to give clear opinion or guidance.
- Co-research on DVU based control room, operating experience collection, sharing the benefit gets and the deficiency need to be improved.

- For NPP, normally full scope simulator is need for operator training one year before fuel load, but full scope simulator build rely on NPP design data, such as core design data, process systems design data, control system configuration and HMI final design results, so on. Some time there are mismatch on schedule. Advice or experience on this issue is expected from IAEA.

- Suggest IAEA to constitute guidance on Commercial Grade Dedication activities for equipments (including spare parts) to be used in safety system of NPP.
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THANK YOU!