

## Ageing Management of Nuclear Power Plants in China

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### ABSTRACT

Currently China has 22 units of nuclear power reactors (NPPs) in operation, 27 units under construction. The first NPP Qinshan-I has been operated for 23 years, while the design life time is 30 years. In order to maintain safety operation of NPPs, it is very important to detect ageing effects, to understand related reduction in safety margins and to take actions before loss of integrity and functions. Ageing management program is set up for systems, structures and components important to safety to understand, monitor, and manage ageing effects in China. In addition, ageing, as one of safety factors, is reviewed during Periodical Safety Review. The regulation on licence renewal or long term operation should be decided by Chinese regulatory body in the near future.

### KEYWORDS

*Ageing management, long term operation, periodical safety review, Qinshan-I nuclear power plant*

### ARTICLE INFORMATION

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## 1. Introduction

Currently China has 22 units of nuclear power reactors (NPPs) in operation, 27 units under construction. Nuclear power contributed 2.1% of the total electricity generation in 2013, while most of electricity is produced from fossil fuels (76% from coal in 2013) and hydropower [1]. Coal mainly reserves in the north or northwest of China, which poses great challenges for railway transportation – nearly half of rail capacity is used for transporting coal. Heavy reliance on fossil fuels has led to air pollution and electricity demand increases, which are the strong reasons to increase nuclear power share. In 2013, the central government issued “Twelfth Five Year Plan” and Mid-long Term Development Planning for Nuclear Power, according to which, generating capacity from nuclear power is planned to reach 40 GW by 2015.

Following the Fukushima Dai-ichi accident, on March 16<sup>th</sup>, 2011, Premier emphasized the nuclear safety in China and decided to take four actions immediately: conduct safety evaluation on all operating nuclear facilities immediately; enhance safety management of all operating nuclear facilities; perform a comprehensive review based on advanced standards and technology to all the NPPs under construction; and suspend approval of new NPP projects until the Nuclear Safety Plan is in place. On 13 June 2014, President Xi emphasized that restart construction of new NPPs in eastern coastal areas soon while maintaining the highest safety standard in the world.

## 2. Plant life management in China

The first NPP in China, Qinshan-I, was put into operation in 1991. Daya Bay has two nuclear reactors, which started commercial operation in 1993 and 1994, respectively. These plants have been operated for more than 20 years. Managing ageing for NPPs is to ensure the availability of required safety functions throughout the service life of the plant. In IAEA Safety Guide NS-G-2.12, two kinds of time dependent changes are addressed: one is physical ageing of structures, systems and

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components (SSCs), which results in degradation of their performance characteristics, the other is obsolescence of SSCs, such as their becoming out of date in comparison with current knowledge, standards, regulations and technology. Effective management of ageing of SSCs is a key element of ensuring the safe and reliable operation of nuclear power plants [2].

Chinese regulatory body National Nuclear Safety Administration (NNSA) requires that Periodical Safety Review (PSR) should be performed every 10 years during operation of NPPs. Ageing as one of safety factors is reviewed at the overall plant management level and at the SSC level as well [3].

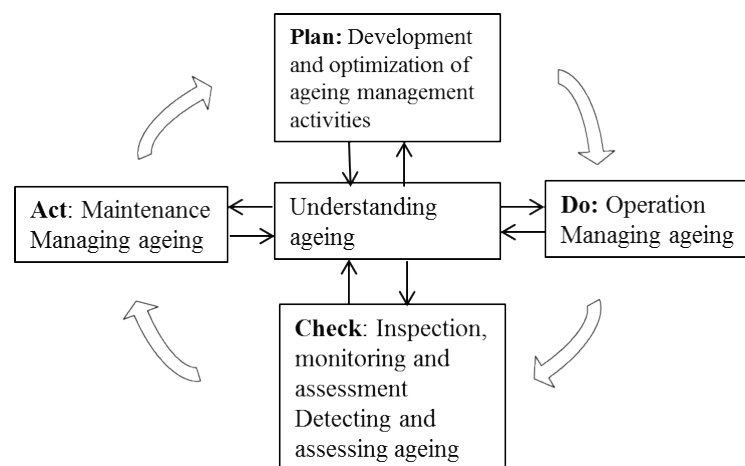
Currently, there is no nuclear power plant that has reached its design life in China. Chinese NPP regulator NNSA has not decided the licensing requirements for continuous operation of NPPs beyond their design life yet [4]. However, the design life of Qinshan-I and Daya Bay NPPs are 30 years and 40 years, respectively. And both have been operated for more than 20 years. The regulation on licence renewal and ageing management should be decided in the near future.

### 3. Ageing management practice in Qinshan NPP

Qinshan-I nuclear power plant (~300 MW, PWR) was the first domestically designed and constructed nuclear power plant in China. The first PSR had been completed in 2003. Ageing of SSCs important to safety was reviewed as one of safety factors of PSR, which is based on IAEA Specific Safety Guide No. SSG-25 “Periodic safety review for nuclear power plants” [5].

Currently, organizational arrangement for ageing management has been set up. Necessary resources are allocated. The policy and objective of the ageing management program are set out, including establishing a systematic approach to ageing management, development of ageing management program for major SSCs important to safety, establishing a data collection and record keeping system.

Qinshan-I NPP takes a systematic approach ‘Plan–Do–Check–Act’ cycle to manage ageing that provides a framework for coordinating all programs and activities relating to the understanding, control, monitoring and mitigation of ageing effects of the plant component or structure, (seen in Fig.1) which is recommended in IAEA safety reports series No. 62 “proactive management of ageing for NPPs” [6].



**Fig. 1. Systematic approach to manage ageing**

The scoping and screening of SSCs for ageing management was performed according to principles recommended by IAEA and US NRC. Reactor pressure vessel, steam generator, pressurized surge line, I&C cables, concrete containment are firstly selected. Ageing management programs for

those SSCs are set up to monitor ageing conditions, and to do lifetime assessment. In addition, ageing management database for those are also planned to be developed. The following lists part of work related to those selected SSCs that have been carried out. [4]

- Reactor pressure vessel
  - Assessment of irradiation embrittlement effects in RPV steels
  - Stress and Fracture analysis
  - Integrity analysis of RPV
  - Assessment of surveillance program and prediction method
- Steam generator
  - Ageing mechanisms analysis, etc.
- Pressurized surge line
  - Identified to be sensitive to thermal fatigue and thermal stratification.
  - On online temperature monitoring system was installed in 2006.
  - A detailed fatigue analysis and lifetime assessment.
- I&C cables
  - Screening, ageing mechanism research and lifetime assessment
  - Cable condition monitoring and evaluation
- Piping
  - Flow accelerated corrosion in the secondary loop
  - “BOP piping wall-thickness supervision program” was established in Qinshan III, focusing on 13 steam pipeline systems in 2006.
- Concrete containment
  - Ageing mechanisms analysis

#### **4. International activities**

International information exchange of operational experience regarding ageing management could provide considerable benefit to improve ageing management program in China. China has actively involved in many international collaboration projects, such as IAEA Coordinated Research Projects (CRP) on review and benchmark of calculation methods of piping wall thinning due to erosion-corrosion in nuclear power plants, IAEA Safety Aspects of Long Term Operation (SALTO) workshop, Technical Working Group on Life Management of Nuclear Power Plant (TWG-LMNPP), International Generic Ageing Lessons Learned (IGALL), International symposium on ageing management program development for system safety of NPPs (ISaG), the International Group on Radiation Damage Mechanisms (IGRDM) in Reactor Pressure Vessel Steels and so on. These activities provide information and advice on policies and strategies of plant ageing and life management, facilitate the exchange of information and experience in the field of understanding and monitoring of ageing mechanisms to ensure the continued safety operation of nuclear power plants.

#### **5. Conclusion**

China will steadily and safely develop nuclear power in a reasonable rhythm. It is important to implement proactive ageing management of SSCs important to safety throughout the full plant's lifetime, including design, fabrication and construction, commissioning, operation and decommissioning. Regulatory requirement on long term operation should be addressed. In addition, the scoping and screening method for ageing management should be taken into account of lessons learned from Fukushima Dai-ichi nuclear accident. All these challenges require the involvement and support of many stakeholders, e.g. regulator, operating organization, technical support organization, owners, and design, manufacturing and construction organizations.

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