

# AGEING MANAGEMENT PROGRAM OF HANARO FOR CONTINUOUS OPERATION

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## ABSTRACT

Ageing means time-dependent changes of the quality and ageing may occur during the operating time of a facility and it is categorized into two basic types: physical ageing and non-physical ageing. The ageing management of equipment begins at the same time of installation. HANARO, the open-tank-in-pool type research reactor with 30MW thermal power, achieved its first criticality in 1995. It has been utilized for neutron science, material and fuel irradiation tests, radioisotope production, neutron transmutation doping (NTD), neutron activation analysis, and neutron radiography. Since ageing may affect the overall safety of a reactor facility, it is needed to detect and evaluate the effects on aged components and systems. After its initial criticality, various activities were conducted for the ageing management and the improvement of HANARO system, such as in-service inspection for the reactor structure and the safety related piping, preventive maintenance and the upgrade of the instrumentation and control system.

## 1. Introduction

HANARO is a 30 MW open-pool type multi-purpose research reactor which is operated by the Korea Atomic Energy Research Institute. Its initial criticality was achieved in Feb. 1995. The reactor power has been gradually increased to the full power reached in June 2004. HANARO has been utilized for various purposes such as neutron science, reactor material and fuel irradiation, radioisotope production, neutron transmutation doping, neutron activation analysis, and neutron radiography. HANARO complex, shown in Fig. 1, is composed of the HANARO building, the RIPF(Radio-Isotope Production Facility), the IMEF(Irradiated Material Examination Facility), and the CNL(Cold Neutron Laboratory). The construction of the former three facilities was completed in 1994, and the CNL was constructed in 2008. To keep the reactor in good and safety condition, upgrade and ageing

management has been conducted since its initial criticality. This paper describes the conducted ageing management activities and long term ageing management program for continuous operation of HANARO.



Fig. 1 View of the HANARO Complex in KAERI

## 2. Ageing Management in HANARO

Ageing management includes activities such as repair, refurbishment, replacement and inspection. Many activities for an ageing management including improvement and upgrade of the reactor systems in HANARO were conducted during 18 years. It is expected that the actual reactor life time will be much more than the design lifetime by an ageing management. We conducted surveillance inspection, periodic inspection and in-service inspection to maintain the reactor system in a safe condition.

### 2.1. Long Term In-Service Inspection (ISI) Plan in HANARO

We established ISI plans for the reactor structure components and the safety related piping system. The purpose of an ISI is to assess the status of reactor structures, systems and components related to safety in terms of an ageing effect. Several mechanical structure and components in HANARO are classified into ASME code Section III components which require ISI during a reactor operation. The process systems classified into safety class-3 boundaries in HANARO are the primary cooling system (PCS), the primary purification system (PPS) and the emergency

water supply system (EWSS). Reactor structures, such as inlet plenum and grid plate, reflector vessel, chimney and flow tubes, are subjected to ISI.

## **2.2. Ageing Management Program**

The surveillance inspection, maintenance and testing are required to ensure the reactor safety and compliance with operational limits and conditions. According to the results of inspections, many kinds of maintenances have been fulfilled in appropriate ways. Recently there is a fast development in the field of electronics. The many manufacturers of I&C equipments or components are disappeared or merged with the others. Most of the components of the instrumentation and control systems have become aged, obsolete or old fashioned. Problems by obsolescence can be expected by experiences and information from the markets and peers. The unavailability of spare parts and an increased failure rate is leading to frequent reactor shut downs. HANARO has developed ageing management matrix based on not only the maintenance history but surveillance inspection, testing, and ISI results. Korean government is going to legislate for applying the act of periodic safety review to research reactor. For continuous operation, it will be updated regularly on the basis of the results of special inspection and assessments such as periodic safety review which will be done in near future.

## **2.3. Ageing Management History in HANARO**

Various activities have been conducted for the system upgrade and ageing management based on a program initially set in 2000, and to resolve the issues found during operation. Preventive and corrective maintenance has been conducted to mitigate the effects of ageing. And the upgrade of the instrumentation and control system has been carried out gradually since 2001 to overcome ageing and obsolescence problem. The major maintenance activities were as follows:

- Reactor system and reactivity control unit
  - i. Measurement of reflector vessel inner-shell vertical straightness in 2004
  - ii. Visual inspection of SOR/CAR and fuel channel in 2004
  - iii. Endurance test of SOR for life extension in 2005
- Primary cooling system
  - i. Replacement of heat exchanger plate (HX1, HX2) in 2000
  - ii. Overhaul of cooling pumps as preventive maintenance in 2004 and 2005
  - iii. Removal of scale in secondary side of primary heat exchangers in 2004 and 2005
- Secondary cooling system
  - i. Replacement of cooling pump in 1995 and 2011

- ii. Replacement of filler of cooling tower in 1999 and 2000
- iii. Removal of scale in secondary side of primary heat exchangers in 2004 and 2005
- iv. Overhaul of cooling pump motors in 2009
- v. Replacement of check valves in 2013
- Instrumentation and control system
  - i. Replacement of neutron detectors in 2008, 2010 and 2012
- Other systems
  - i. Overhaul of reflector cooling pumps in 2004, 2005 and 2011
  - ii. Overhaul of diesel generator in 2003
  - iii. Overhaul of the compressed air system in 2006
  - iv. Overhaul of electrical distribution system in 2007
  - v. Safety review and repair of the reactor building and cooling tower buildings in 2006 and 2012

The major activities for system upgrade were as follows:

- Installation of a hot water layer system in 1997
- Upgrade of the OWS(Operator Work Station)
  - i. Installation of a Window-based Operator Work Station in 2002
  - ii. Development of new OWS including FTL system in 2007
  - iii. Completion of OWS upgrade with Integration of CNS system in 2009
- Installation of a steel compartment to confine D<sub>2</sub>O reflector system components in 2005
- Replacement of entrance doors to the reactor hall for physical protection in 2005
- Replacement of the AC and DC UPS system in 2005
- Replacement of NaI detectors with delayed neutron detectors for a failed fuel detection system in 2006
- Installation of gamma ion chambers for power measurement and a trip signal replacing the thermal power measurement system in 2006
- Installation of two large tanks in the reactor hall for the temporary storage of pool water in 2007
- Re-structuring of the user rooms in the reactor hall for the improvement of fire-resistance in 2007
- Installation of a voltage sag compensator to prevent the reactor trip due to a momentary interruption of electric power in 2007

### **3. Conclusions**

Preventive and corrective maintenance, and system upgrades to mitigate the effects of ageing have been conducted according to ageing management program for continuous operation in HANARO since it achieved initial criticality. Ageing management program should reflect non-physical ageing as well as physical ageing effect. Korean government is going to legislate for applying the act of periodic safety review to research reactor. More systematic and effective ageing management program will be developed using an ageing matrix which includes comprehensive history data for operation and maintenance of HANARO.

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