Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-18, 2018

Commissioning Test and Experience for Pool Water Management System in an Open-pool Type Research Reactor

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1. Introduction

The consortium of Korea Atomic Energy Research Institute (KAERI) and DAEWOO E&C constructed a new research reactor with the power of 5 MWt in Jordan. Commissioning of this research reactor for various neutron applications and training was completed for normal operation in October 2016. This research reactor is an open pool-type, which consists of the reactor assembly and the related fluid systems inside the pool. The main fluid systems consist of a primary cooling system (PCS) for adequate cooling of the heat generated in the reactor core, a pool water management system (PWMS) for purifying the pool water and PCS coolant and cooling the pool water, and a hot water layer system (HWLS) for providing a good shielding barrier for many kinds of radio-nuclides from the reactor core.

The PWMS was designed to control the chemistry of the pool water and primary coolant within the allowable limits to minimize the corrosion of the nuclear fuel cladding and systems and to maintain the reactor and service pool water temperature within the design value.

Before starting the normal operation of the new research reactor, the systems should be tested to check whether they are operating well according to the performance requirements. In this paper, the brief system description, flushing methodology, system performance test procedure, and commissioning experiences of the PWMS are described.

2. System Description and Performance Test

2.1 System Description

The PWMS consists of one plate-type heat exchanger, two parallel PWMS pumps (one for standby), two filters (one for standby), two ion exchangers (one for standby), two strainers, one fresh resin supply tank, one pool water storage pump, one pool water storage tank, and necessary interconnecting pipes, valves and instruments as shown in the flow diagram of Fig. 1.

One PWMS pump takes water from two points in the reactor pool and the service pool. The coolant flows through a heat exchanger, a filter and an ion exchanger before returned back to the reactor and service pools. Secondary cooling water flows through the secondary side of the heat exchanger to cool the reactor and service pool water.

During the normal operation, the system purifies the water of the reactor and service pools. The filter and ion exchanger are used to remove suspended solids and radioactive ionic impurities, in the intake pool water, respectively.

The system is designed to maintain the service pool water temperature within the design range. The PWMS may provide cooling for the reactor pool water when the PCS pumps are not operating. Redundancy of this equipment is not required due to the large heat capacity of the pool water and the slow heat-up rate. However, two pumps in parallel are provided to enhance the availability of system functions in the event of the failure of one pump.

The system also provides a temporary storage function of the reactor pool water for maintenance work using a pool water storage tank (PWST) and pump.

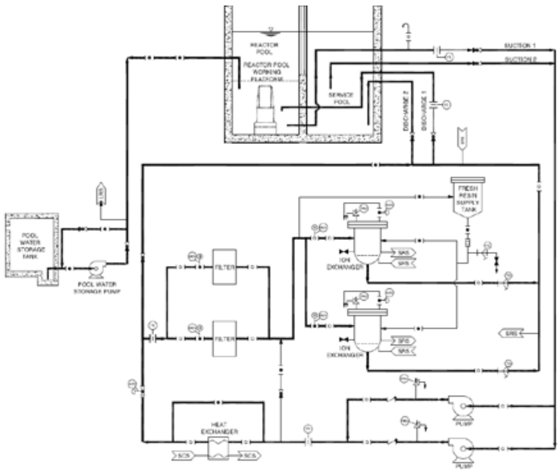

Fig. 1. Flow diagram of the pool water management system.

2.2 System Flushing and Performance Test

After the PWMS is installed in the reactor pool and equipment room, the system flushing is performed to remove the dust, particles, or other foreign matter using closed loop flushing methods.

Before the PWMS is connected to the reactor pool and in-pool pipes for system performance test, the closed loop flushing is performed by installing a temporary bypass piping. To check whether the pressure loss of the system is changed or not, the temporary pressure gages and strainer meshes are installed between the inlet and outlet of the strainers, pumps, heat exchanger, filters and ion exchangers. The PWMS pumps are used alternately to re-circulate system water after the demineralized water is supplied from the demineralized water supply tank to the system and the air of the system is fully vented. If the pressure losses increase and the strange materials are expected to be found, the flushing work is stopped and the temporary mesh of the strainer mesh is checked as shown in Fig. 2.

To remove foreign material from the system, valves are considered and installed to perform the draining and venting of the system easily during commissioning. Whenever the flushing is performed, the vibration, noise, and leakage of the pumps, heat exchanger, and pipes are checked to protect the equipment. When the differential pressure of the strainer mesh maintains a stabilized state for 30 minutes, the flushing is completed. Fig. 3 shows the inspection results of the PWMS strainer and fresh resin supply tank (FRST) inside after flushing.

(a) (b)

Fig. 2. Temporary strainer mesh and foreign materials of the PWMS pump inlet side. (a) after first flushing (#80), (b) after final flushing(#200).

Fig. 3. Inspection results of the PWMS strainer and FRST inside after flushing.

After the flushing and the required Construction Acceptance Test (CAT) are completed and the demineralized water is filled in the pool and system, a System Performance Test (SPT) is performed. The SPT of PWMS is to check and confirm performance of the PWMS and its equipment manufactured as designed, as follows.

a. To check the storage function of the PWST
b. To check the performance of the PWMS pumps
c. To adjust the system flow rate of the PWMS
d. To confirm the filling procedure of the resin
e. To check the alarm and discrepancy for the PWMS
f. To confirm the filter element replacement process

All results of the PWMS SPT, such as rated system flow rate, pressure drop, purification flow rate, etc. satisfied the test acceptance criteria, which confirmed the storage function of the PWST, the filling procedure of the fresh resin to ion exchanger, and the filter element replacement process.

2.3 Commissioning Experiences

There were many difficulties due to the specificity of Jordan from the construction phase to the commissioning stage. In Jordan, it was difficult to supply the necessary materials for the construction, and the working environment due to external dust and sand was not good, either. Many researchers of the KAERI have been directly dispatched to in the harsh construction site and have provided much support from the construction to the commissioning of the research reactor. As a result of these experiences, there have been suggestions for various design improvements to the system and most of them have been reflected in the field.

During the PWMS installation, since a lot of sand and dust got into the system, the PWMS flushing had many difficulties. In addition, as the concept of the system flushing was not sufficiently considered in the PWMS design, additional temporary strainer meshes were installed at inlet and outlet of the PWMS equipment in consultation with the field worker. The PWMS flushing could be efficiently completed using these temporary strainer meshes.

The PWST basically functions for temporary storage of the reactor pool water to do maintenance work for the equipment and instruments in the reactor pool. For storage function, the PWST was designed to store the half amount of the reactor pool water. However, during the commissioning, unpredicted works of the pool water storage or drainage to various pool levels were occurred. Because the pool water drainage procedure to specific level was not prepared, it was difficult to do work involving drainage. To solve these difficulties, the pool water drainage procedure was developed during the commissioning period.

There were many difficulties in constructing and commissioning the oversea research reactor, but a lot of field knowledge and commissioning experiences were accumulated through the process of resolution for the unpredicted problems.

3. Conclusions

Before starting normal operation of a new research reactor with 5 MWt in Jordan, the fluid system and instruments were installed and system performance was confirmed. Closed loop system flushing was performed to remove dust, particles, or other foreign matter in the PWMS. After the flushing and required CAT are completed, the PWMS SPT including measuring the system flow rate and pressure loss and checking the functions of pumps, valves, and system alarms were performed. It was shown that the SPT results satisfied the acceptance criteria. Although there were many difficulties in constructing and commissioning the research reactor firstly constructed in abroad by KAERI, but a lot of field knowledge and commissioning experiences were accumulated.

ACKNOWLEDGEMENT

This work has been conducted as a part of the Development of Research Reactor Technology project sponsored by Ministry of Science and ICT of Korean government.