

## An Analysis of the Reflector Cooling System Repair Status after the Initial Operation of HANARO

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### 1. Introduction

HANARO<sup>(1)</sup>, an open-tank-in-pool type multi-purpose research reactor of 30 MWth power in Korea, has been operating normally since its initial criticality in February, 1995. During the last operation period of HANARO, when a trouble occurred, the trouble was fixed on site. As preventive maintenance can reduce the corrective maintenance, the reasons of the occurred troubles are reviewed to prepare preventive maintenance. About twelve hundred cases of work requests and non-conformance reports (NCRs) have been issued since the initial criticality of HANARO. The cases are analyzed according to the trouble status, the trouble equipment function and the cause of the major trouble for reflector cooling system (RCS, hereinafter) including cover gas system and leakage monitoring and collection system.

### 2. Methods and results

#### 2.1 Reflector cooling system

A RCS<sup>(2)</sup> is composed of two-one hundred (100) percent capacity circulation pumps in parallel, a heat exchanger, two-one hundred (100) percent capacity ion exchangers in parallel, an expansion tank, a leakage collection tank, piping and valves, and instruments. The RCS shall have heavy water cooling, purification, cover gas control, and leakage monitoring and collection functions.

The heavy water cooling function shall remove the heat generated by reflector (heavy water) through the heat exchanger. The absorbed heat is cooled by forced air blowup of each cooling fan installed in the four cells of the cooling tower. The purification function shall maintain the heavy water quality within limits through the ion exchangers.

The cover gas control function, through the expansion tank, shall protect an over-pressurization of the system and the heavy water vessel under a normal operation and a heavy water boiling event respectively. The leakage monitoring and collection function shall monitor a leak of heavy water in the RCS, collect the leak and drain for equipment repair through the collection tank, and return the collected heavy water to the expansion tank by the dried air pressurization.

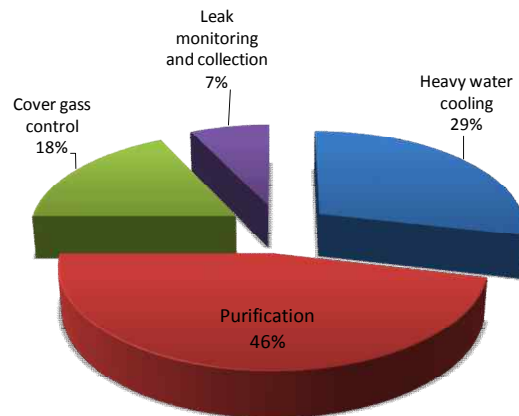


Figure 1 Trouble incidence of SCS

#### 2.2 Review of trouble

Until the end of 2009 from the initial criticality of HANARO, about twenty eight (28) cases of work requests including NCRs in the RCS were issued<sup>(3),(4)</sup>. It is about two (2) percent of the total cases issued in HANARO. As shown in figure 1, it is classified by the trouble case of the major trouble, forty-six (46) percent of the purification function, twenty-nine (29) percent of heavy water cooling function, eighteen (18) percent of cover gas control function and seven (7) percent of leak monitoring and collection function. Most troubles were found by periodic system checks and repaired by maintenance people with manufacturer's assistance in site.

##### 2.2.1 Trouble of purification function

Fig. 2 shows the list of troubles and the trouble quantities. The major trouble sources of the purification function are the replacement of resin loaded in the ion exchanger to capture nuclide ion, flow element replacement of purification flow meter, high fluctuation vibration of conductivity meter indicator, and stick of purification flow control valve stem. When the conductivity meters installed before and after the ion exchangers indicate above the limit<sup>(2)</sup>, the used resin cartridge shall be replaced with new one. This trouble naturally occurs during a normal operating period.

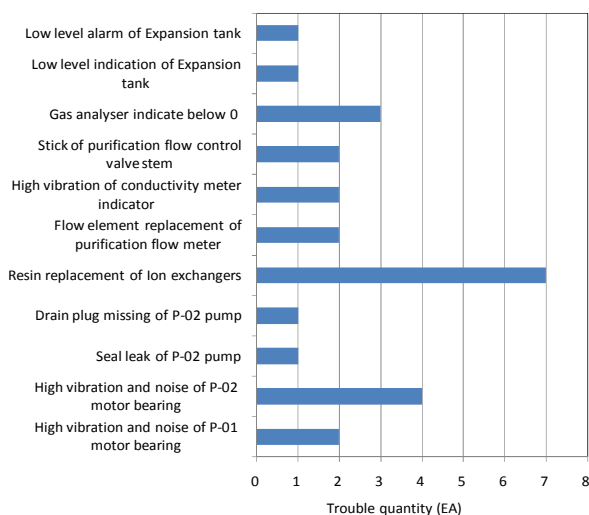


Figure 2 Troubles of RCS during operating years

The trouble occurred seven (7) times for fourteen year operating period. Hence it is recommended that the resin cartridge will be replaced every two-year operation period. The other three kinds of troubles occurred twice during the operating period as shown in Fig.2.

### 2.2.2 Trouble of heavy water cooling function

As shown in Fig. 2, the major trouble sources of the heavy water cooling function are high vibration and noise, seal leak, and drain plug missing. The high vibration and noise was the major trouble. The causes of the trouble are bearing frictional wear, miss-alignment of shaft, un-weight balance of rotating parts including an impeller etc. As a bearing is worn down, the high vibration of the bearing results seal leak.

As the trouble occurred 2 times in no. 1 pump and 4 times in no. 2 pump, the trouble occurred occasionally in no. 2 pump. After we checked closely the cause in manufacturer's shop, it was found that the shaft was a few eccentric and there was a slight weight balance mismatched<sup>(5)</sup>.

After maintenance it, the pump was operated normally<sup>(5)</sup>. From this practice, as the trouble parts could not be fixed perfectly on site, it is recommended that each pump should be overhauled in manufacturer's shop every five (5) year operating period.

### 2.2.3 Troubles of cover gas control and leakage monitoring and collection functions

As shown in Fig. 2, the major trouble source of cover gas control function was low level indication and alarm of expansion tank. The cause was the malfunction of the instruments. The malfunction of the level indicator

occurred one time for nine year operating period and the level alarm for ten (10) year operating period.

The major trouble source of leakage monitoring and collection functions was a malfunction of the gas analyzer. The malfunction occurred three times during operation period. As the troubles of cover gas control and leakage monitoring and collection functions are minor, it is acceptable to check them the same as at present system check schedule<sup>(4)</sup>.

## 3. Conclusions

When we reviewed the trouble status of RCS based on work requests including NCRs issued by HANARO during last fourteen year operating period, we came to the following conclusions.

- 1) It is classified by the case of the major trouble for RCS during the operating period, forty-six (46) percent of the purification function, twenty-nine (29) percent of heavy water cooling function, eighteen (18) percent of cover gas control function and seven (7) percent of leakage monitoring and collection function.
- 2) As the major trouble sources of purification function are the replacement of resin loaded in the ion exchanger to capture nuclide ion, it is recommended that the resin cartridge be replaced every two-year operation period.
- 3) As the major trouble sources of heavy water cooling function are high vibration and noise, it is recommended that each pump should be overhauled in manufacturer's shop every five (5) year operating period.
- 4) As the trouble sources of cover gas control and leakage monitoring and collection functions are minor, it is acceptable to check them the same as at present system check schedule.

## References

- [1] Young-Chul Park, Jong-Sub Wu, 1996, "System Performance Test in HANARO," the Proceeding of the 5th ASRR Vol. 1, pp. 240-246.
- [2] KOPEC, "Design Manual of Reflector Cooling System," KM-321-DM-P01, KAERI, 1992.
- [3] Young-Chul Park, Jung-Hee Lee, Yong-Sub Lee and Hwan-Sung Jung, 2009, "An Analysis of the Primary Cooling System Repair Status after the Initial Operation of HANARO," 2009 HANARO symposium.
- [4] HANARO, "HANARO Application System Operation," KAERI MR- KAERI/MR-501/2009, pp.167-170.
- [5] Young-Chul Park, "Performance Test Results after repair of Reflector Cooling Pump NO.1," KAERI, HANTAP-05-OD-ROP-MA-46, 2004.