Status of Life Extension Program for HANARO Shutoff Units

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1. Introduction

The HANARO, an open-tank-in-pool type research reactor of a 30MWth power in Korea, has been operating for 10 years since its initial criticality in February of 1995.

The reactor trip or shutdown is accomplished by four shutoff units by insertion of the shutoff rods. The shutoff rod(SOR) is actuated by a directly linked hydraulic cylinder on the reactor chimney, which is pressurized by a hydraulic pump. The rod is released to drop by gravity, when triplicate solenoid valves ("dump valves") are opened to vent the cylinder.

This paper summarizes the history of the performance, maintenance, drop cycles and the life extension program for the shutoff units.

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2. Status of the Shutoff Units

2.1 Performance

For more than 10 years since the installation the drop performances of the shutoff rods have been kept at less than the drop time limit, 1.13 seconds. Figure 5 shows the history of the drop time for SOR#4 ranged in-between 92-105% of average, the worst case from four SOR's. We confirmed that all four shutoff units keep their drop performance well for the safe shutdown of the reactor.

2.2 Maintenance History

The withdrawal time and indication of the SOR position were sensitive to the pool water temperature and system valve settings due to the inherent hydraulic system. The only problem during the operation was the leakage of the filter housings due to the mis-assembling of the housing caps and a crack happened after 10 years operation. The original filter housings, made of polypropylene, were replaced by stainless steel housings to resolve the leak problem and for a better workability of the filter replacements. All the hydraulic pumps were replaced with new ones in 2004 as a preventive maintenance. There was no problem at all for the mechanical components such as the hydraulic cylinders, tracks, carriages, shrouds, and SOR's which are installed in the reactor structure.

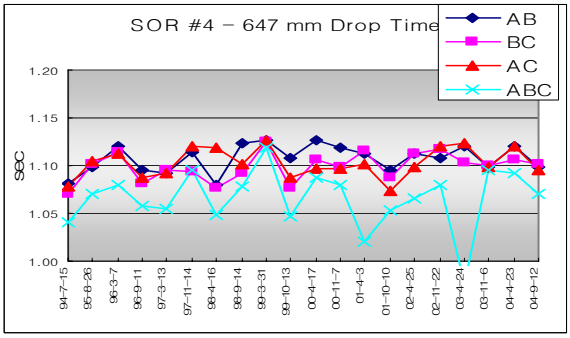

Fig.1 Drop Time History for SOR#4

2.3 Ageing of Drop Cycles

The reactor power has been gradually increased to 30 MWth through the service period. Therefore the reactor age is very young from the viewpoint of the ageing effect on the reactor structure and components by a neutron irradiation when considering the expected reactor lifetime. Nevertheless, the shutoff units have aged more rapidly than the other components because the number of rod drop cycle was much higher than that that expected at the design stage. The system commissioning tests, periodic performance tests, and the short operation cycles for the first decade have contributed to the high frequency of the rod drop. As of the end of 2004, the drop cycles of SOR reached 1091, 73% of the endurance-

verified number. Figure 2 shows the operation history as a percentage of the lifetime of the shutoff units to compare it with the reactor lifetime from the viewpoint of ageing by neutron irradiation. It is certain that the number of drops will reach the verified numbers far before the end of the reactor life. It is thought that the high cycles of impact loads by the drop of the shutoff rods are of more concern from the safety point of view rather than by the wear of the moving system which can be detected by the change of the drop performance.

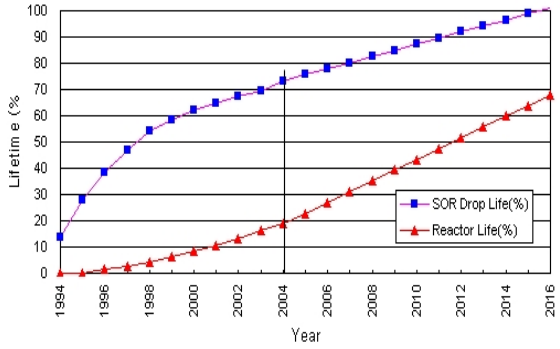

Fig.2 Ageing History of SOR Drop

3. Life Extension Program for Shutoff Units

. Therefore, we have a program on going to extend the lifetime of the shutoff units [1]. The program means an additional endurance test for the extended number of drops with a spare unit at an out-pile test facility in 2005. For the spare unit which had been tested up to 1500 cycle's drop during the endurance test at the design verification stage, more than 4000 cycle's drop test will be added to verify the validity of the use of the current shutoff units for the expected lifetime of the reactor, 30 more years. For the endurance test, we prepared a complete set of test facility composed of a 1/2- core test loop of Hanaro, a full system of shutoff unit, and an automatic measurement system. The 1/2-core test loop was built to simulate the flow pattern of Hanaro reactor with a full sized half core. A full set of shutoff unit was installed in the test facility according to the design drawing and installation procedure of the Hanaro shutoff units. For the test and evaluation of the performance for thousands of drop and withdrawal, we developed the automatic control system [2] to actuate the shutoff system and to record the all data of performance and test parameters. The performance of the all the systems have been verified through the commissioning test in 2004.

4. Conclusion

For the 10 years of the HANARO operation, we confirmed that the performance and integrity of the shutoff units are being maintained well with a few replacements of the off-the-shelf items. There is no problem on mechanical components installed in the reactor structure, but the drop cycles for shutoff rods are much higher than the expected number. Therefore we have an endurance test program on going to verify the performance and integrity for the increased drop cycles for the life extension of the existing shutoff units to use up to 30 more years.

References

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2. Yun-Hang Choung , Y.G. Cho, Y.S. Choi, J.S. Wu, "Development of a Performance Evaluation and Automatic Control Program for the Shutoff Units", Proceedings of KNS Autumn Meeting, 2003