

Performance Assessment of Wolsung Unit 2 Safety Grade Pumps using In-Service Test

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1. Introduction

Nuclear power plant has several safety features and each safety feature is based on the operation of pumps and valves. Therefore, it is an essential basis for the safety of nuclear power plant to keep operational readiness of pumps and valves by In-Service Test (IST).

According to Ministry of Education, Science and Technology (MEST) Bulletin 2008-14[1], the safety functioned pumps and valves of all nuclear power plants of Korea Hydro and Nuclear Power Co. Ltd.(KHNP) have been tested to verify their performance of safety function. Each safety grade pump has own design requirement and should be tested to identify whether it could meet the requirement.

Design requirements and test references of all safety grade pumps of Wolsung Nuclear Power Plant Unit 2 (Wolsung Unit 2) were examined in this study. And the results of the performance test of the pump were also compared to the design requirements of each pump.

2. Methods and Results

2.1 Design Requirement of the safety grade pumps

In Wolsung Unit 2, 31 pumps were tested according to the IST program [2]. And the design requirements of the each pump were examined to compare it to the each performance variable (i.e. flow rate, developed head) of the test. If the references and permissible ranges of the test variables of the pumps meet their requirement, it is obvious that these pumps were tested appropriately. The design requirements were referred to the Final Safety Assessment Report (FSAR)[3] or design manual of each system of Wolsung Unit 2. Table 1 shows the result of the examination of the test variable and requirement and performance assessment.

For the tests using recirculation flow paths of pumps, such as Emergency Core Cooling (ECC) pumps (3432-P01 & P02), the test flow rate is less than design flow rate since the main flow paths could not be used for the tests during normal operation of nuclear power plant. In these cases, we used pump performance curves to perform the assessments. Even though the test flow rate is quite less than the design flow, the test result could be considered as adequate when the developed head by the pump at the test flow rate was on the performance curve.

Table 1 Performance Assessment Results of Wolsung Unit 2 Safety Grade Pumps

Pump	Reference and Permissible Range	Design Requirement	Assessment Result
3331-P01	Q: 7.65 ℓ/s ΔP: 13.34 MPa(d) ΔP Range: 12.01~14.67 MPa(d)	Q: 7.12 ℓ/s ΔP: 12.7 MPa	Accepted
3331-P02	Q: 7.65 ℓ/s ΔP: 12.78 MPa(d) ΔP Range: 11.50~14.06 MPa(d)		Accepted
3341-P01	Q: NA (wolsung2-RP-02) ¹⁾ ΔP: 0.787 MPa(d) ΔP Range: 0.708~0.866 MPa(d)	Q: 181 ℓ/s ΔP: 0.724 MPa	Accepted
3341-P02	Q: NA (wolsung2-RP-02) ¹⁾ ΔP: 0.771 MPa(d) ΔP Range: 0.694~0.848 MPa(d)		Accepted
3432-P01	Q: 180 ℓ/s ΔP: 0.925 MPa(d) Range: 162~198 kg/s	Q: 606 ℓ/s ΔP: 0.687 MPa	Accepted
3432-P02	Q: 180 ℓ/s ΔP: 0.925 MPa(d) Range: 162~198 kg/s		Accepted
4321-P103	Q: 15.4 kg/s ΔP: 1100 KPa(d) ΔP range: 990~1210 KPa(d)	Q: 44.1 kg/s ΔP: 921.6 KPa	Accepted
4323-P104	Q: 20.1 kg/s ΔP: 7.05 MPa(d) ΔP range: 6.345 ~ 7.755 Mpa(d)	Q: 41.9 kg/s ΔP: 5.3 Mpa minimum flow: 10.51 kg/s	Accepted
	Q: 41 kg/s ΔP: 5.67 MPa(d) ΔP range: 5.1 ~ 6.24 MPa(d)		Accepted
3211-P03	Q: NA (wolsung2-RP-06) ¹⁾ ΔP: 44 kPa(d) ΔP range: 36.9 ~ 48.8 kPa(d)	Q: 235 ℓ/s @ ΔP: 33.3 KPa	Accepted
3211-P04	Q: NA (wolsung2-RP-06) ¹⁾ ΔP: 45 kPa(d) ΔP range: 40.5 ~ 49.5		Accepted
3231-P01	Q: 0.34 ℓ/s ΔP: 77 kPa(d) Q range:: 0.306 ~ 0.374 ℓ/s ΔP range: 69.3 ~ 84.7 kPa(d)	Q: 0.76 ℓ/s ΔP: 181 KPa	Accepted
3231-P02	Q: 0.37 ℓ/s ΔP: 74 kPa(d) Q range:: 0.333 ~ 0.407 ℓ/s ΔP range: 66.6 ~ 81.4 kPa(d)		Accepted

¹⁾: Relief Request for measuring flow rate [4]

Figure 1 is the performance curve of 3432 P-01. The marked point on the performance curve in the center of figure 1 is design requirement. But the test conditions exist on the total head curve corresponding to the flow

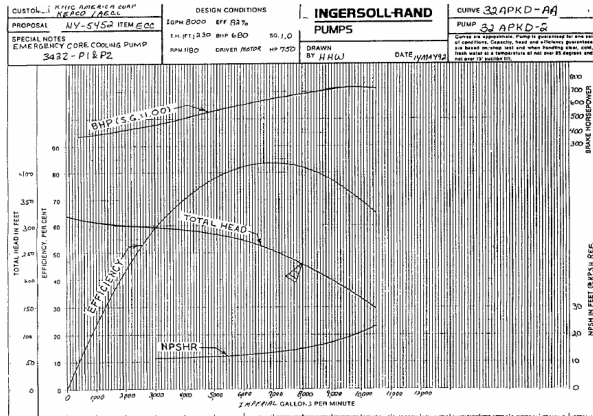


Fig. 1. ECC Pump (3432-P01) performance curve.

rate. Therefore, the test with the flow rate quite less than design flow could be verified the adequacy of the test variable by pump performance curve. However, the maximum flow rate test should be performed when the test would be possible in the plant condition.

As mentioned above, the 31 pumps were examined and proved that the test references and admissible range meet the requirement and all the tests of the pumps were allowable to verify the safety function of pumps.

2.2 In-Service Test Result Analysis

In this study, the IST result of Wolsung Unit 2 safety grade pumps for last 7 years were collected and analyzed. All the test variables including vibration of the pumps were investigated. Figure 2 represents the IST results of ECC Pump (3432-P01) for last 7 years. As shown in figure 2, test failure was not occurred in the period of time. And the vibration of the pump is not shown in figure 2, but there were not test failures caused by vibration.

The test failure was occurred twice at Raw Cooling Water (RCW) Pump in this period of time. Figure 3 shows the IST result of RCW Pump(7134-P7002) caused by low differential pressure. The other test failure was occurred at RCW Pump(7134-P7004) caused by drift of the measuring instrument. But the test failure was not any effect on safety or performance of the pump since corrective action was suitably conducted such as breakdown maintenance etc.

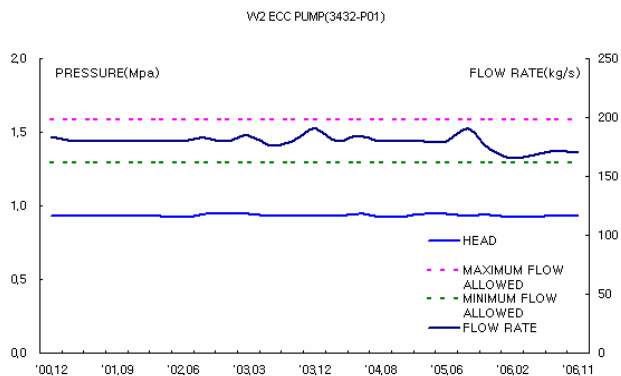


Fig. 2. IST Result of ECC Pump (3432-P01)

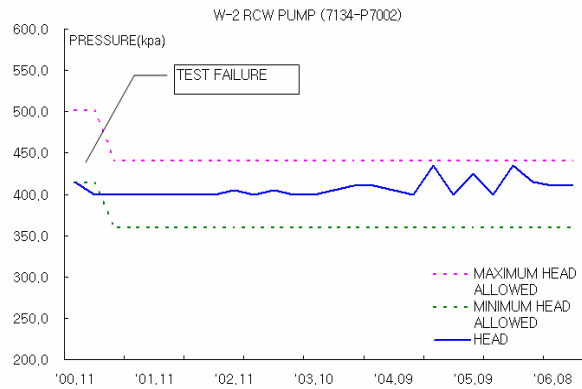


Fig.3. IST Result of RCW Pump (7134-P7002)

For seven years, the only two times test failure on 31 pumps strongly demonstrated that Wolsung Nuclear power plant unit 2 has been operated very safely.

3. Conclusion

For the performance assessment of the pumps of Wolsung Unit 2 approaches to verify the tests and the safety performance on a total of 31 pumps were used in this study. It was clearly proved that all the test on the safety grade pumps were performed with the proper references and permissible ranges to verify their own safety functions. In addition, it was verified that safety grade pumps of Wolsung Unit 2 are ensured against risks(i.e. low failure frequency, proper corrective action).

REFERENCES

- [1] Ministry of Education, Science and Technology Bulletin 2008-24 "Provision on In-Service Test of Safety Functioned Pumps and Valves", Ministry of Education, Science and Technology, 2008.
- [2] Korea Hydro and Nuclear Power Co. Ltd. Wolsung Nuclear Power Plant, "In-Service Test Program of Wolsung Nuclear Power Plant Unit 1&2", KHNP, 2003
- [3] Korea Hydro and Nuclear Power Co. Ltd. "Final Safety Assessment Report on Wolsung Nuclear Power Plant Unit 2", rev. 36, KHNP, 2006
- [4] Korea Hydro and Nuclear Power Co. Ltd. Wolsung Nuclear Power Plant, "In-Service Test Program of Wolsung Nuclear Power Plant Unit 1&2, Appendix III-1", KHNP, 2003