Experimental Study for Effects of Pressure Condition on Equipment Integrity in LOCA Simulation Test

Byung-ju Lim, Chang-dae Park, Chi-sung Song
Korea Institute of Machinery and Materials
bzoo77@kimm.re.kr

1. Introduction

In LOCA(Loss Of Coolant Accident) simulation test of EQ(Equipment Qualification), test profile is specified by accident environmental conditions of NPPs(Nuclear Power Plants). General duration of LOCA environment is one year in domestic NPPs. To shorten this long test profile, most test laboratories usually apply aging assessment method presented in IEEE Std. 1205-2000 [1]. This method defines that degradation of equipment is a function of temperature, and aging time and temperature can be changed into equivalent time and temperature by Arrhenius equation. Although some limitations such as constancy of activation energy of specimen and disregard of pressure effects are included, the method is generally used as the most reasonable solution for shortening long test period [2].

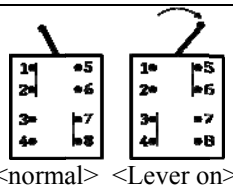
Although this method conveniently modify long profile(one year) into shortened profile(less than 30 days), it may be justified under the assumption that the pressure condition has no effects on performance of equipment. In case of equipment which sealing part plays an important role in its performance maintenance, the effects of pressure condition on the equipment performance will be as significant as the temperature condition.

In this paper, we examine the pressure effects on the equipment integrity during LOCA test by applying different pressure profiles to two identical limit switches.

2. Experiment

Test specimens are two limit switches named LS-R and LS-T. The limit switch transfers electrical current to another point by moving lever as presented in Table 1. In performance test, one example of acceptance criteria of the limit switch is as follows.

Table 1 Operation principle of limit switch

Contact point	Connecting status		Schematic
	Normal	Lever on	
1-2	O	X	
3-4	X	O	
5-6	X	O	
7-8	O	X	<normal> <Lever on>
O: connecting, X: disconnecting			

- Insulation resistance between each contact point and ground: over 10 MΩ applying 500 Vdc
- Dielectric strength between each contact point and ground: endurance in applying 2,500 Vac during 1 minute
- Electric continuity of contact points: contact resistance less than 1 Ω

EQ test procedure for a limit switch is presented in Fig. 1. Prior to the LOCA test, two limit switches were prepared in exactly same aging conditions such as test day, chamber, and tester until seismic qualification test. The functional test is followed by seismic qualification test, and LOCA simulation tests are respectively performed in two different pressure profiles under identical temperature and chemical spray conditions.

2.1 LOCA Test condition

Required test profiles are presented in Fig. 2. By aging assessment method, we shortened the required LOCA profiles of one year to test profile of 7 days as shown in Fig. 3. The test profile for temperature and pressure is accelerated from 1001 second at 128.0 ^{o}C and 252.0 kPa, respectively. In case of pressure profiles, the specimen LS-R is exposed to the required LOCA profile in Fig. 2 and LS-T to the test profile in Fig. 3. In case of temperature profiles, both specimens are exposed to the same test profile in Fig. 3.

2.2 Test Facilities

Figure 4 shows schematic diagram of the test facility. It mainly consists of steam generator such as boiler, accumulator and superheater, spraying system of chemical solution such as mixing tank and spray pump, several control valves, and data acquisition system such

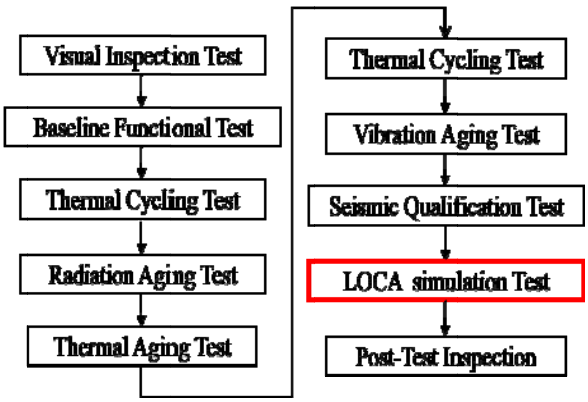


Fig. 1 EQ test procedure of limit switch

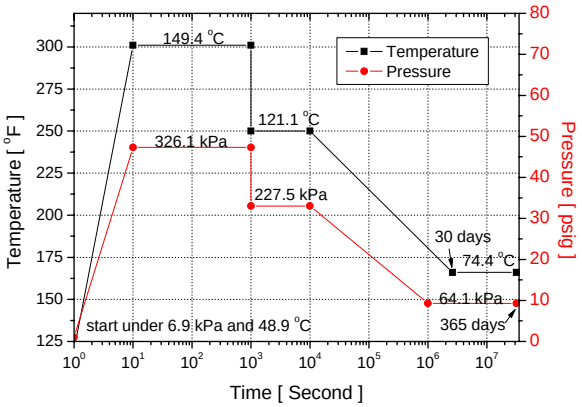


Fig. 2 Required LOCA profile

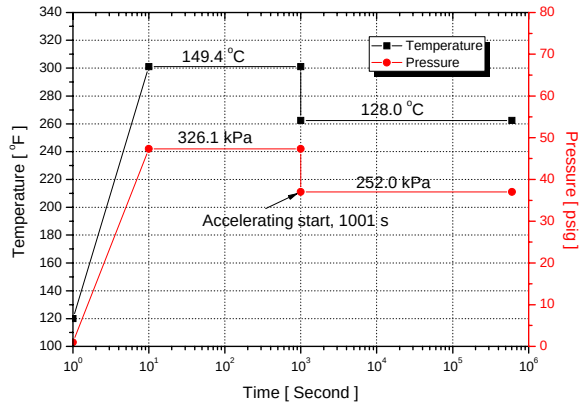


Fig. 3 Test profile

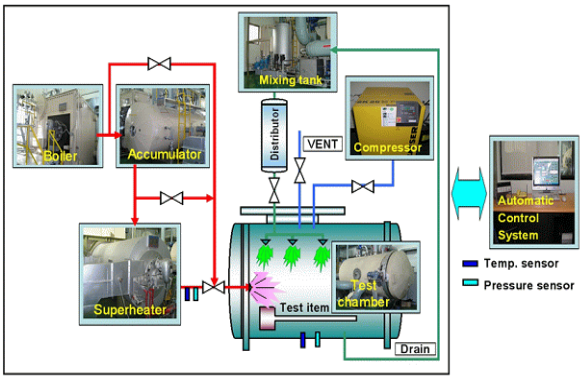


Fig. 4 Schematics of LOCA test facility

as PLC and LabVIEW software.

3. Results

The functional test is performed for two limit switches aged in different LOCA pressure condition. The test results of the functional test before, during, and after the LOCA test are presented in Table 2. Considering the acceptance criteria stated previously, the specimen LS-R maintained its integrity in performance and had no damages except for thermally aged stain. On the other hand, the specimen LS-T tested in higher pressure condition did not need the requirement of acceptance criteria. For electric continuity test, contact resistances of contact points displayed in Table 1 have to maintain less than 1 ohm. However, the resistances of the contact points were not satisfied with this criterion in functional test after the LOCA test. When disassembling the specimens, contact points of the specimen LS-T was intensely contaminated by steam and chemicals due to leakage of seal of limit switch case.

4. Conclusion

In LOCA simulation test of EQ, most test laboratories usually shorten test profile using aging assessment method which considers degradation related to temperature effect and regards that pressure condition has no effects on performance of a specimen. However, our test results in Table 2 show that higher test pressure may cause the critical failures in equipment performance after the LOCA simulation test. Therefore, pressure as well as temperature condition in LOCA simulation test should be considered as important factor in case of pressure-vulnerable equipment which sealing status has a critical effect on performance.

Table 2. Results of performance test for limit switches

Performance		Before test	During test	After test
Insulation resistance	LS-R	29.9 GΩ	-	34.9 MΩ
	LS-T	29.9 GΩ	-	-
Dielectric strength	LS-R	Pass		
	LS-T	Pass	-	-
Electric continuity, [mΩ]	LS-R	60.9	57.8	64.2
	LS-T	Pass	Pass	Fail

REFERENCES

[1] IEEE Std 1205, "Assessing monitoring, and mitigating aging effects on Class 1E equipment used in nuclear power generating stations" (2000).
[2] C.D Park, B.J Lim, C.S Song, "Methodology for modification of LOCA environmental test profile", NTHAS5, (2006).