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# Development of Environmental Qualification Technology for Motor in Nuclear Power Plants

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## 1. Introduction

EQ (Equipment Qualification) is to qualify a performance of equipment that is to be used nuclear power plant during the operating period under any environmental condition. EQ includes environmental qualification and seismic qualification. Environmental qualification is to estimate integrity of equipment under the two environmental service conditions such as an environment that would at no time be significantly more severe than the environment that would occur during normal plant operation, including anticipated operational occurrences and an environment resulting from a design basis event (DBE), e.g., loss of coolant accident (LOCA). The primary objective of DBE qualification is to demonstrate with reasonable assurance that Class 1E equipment for which a qualified life or condition has been established can perform its safety functions without experiencing common-cause failure before, during, and after applicable design basis events. In this study, focus is on environmental qualification of EQ for class 1E motor used in nuclear power plant to establish the detailed technical standard.

## 2. Experiment

### *2.1 Experimental Procedure*

In preparing EQ for an equipment, all related regulations used industry standards should be basis on following procedures of EQ. The important standards for qualifying class 1E motor are IEEE Std 323, IEEE Std 334 and IEEE Std 112, which are scrutinized in advance , including total 27 document, i.e. regulations, Reg. Guide, etc. IEEE Std 323 describes the basic requirements for qualifying Class 1E equipment and interfaces that are to be used nuclear power generating stations. The principles, methods, and procedures described are intended to be used for qualifying equipment. The qualification requirements in IEEE Std 323 demonstrate and document the ability of equipment to perform safety function under applicable service conditions including design basis events. IEEE Std 334 describes the methods and requirements for qualifying continuous duty class 1E motors for nuclear power generating stations. The purpose of IEEE Std 334 is to provide specific direction for the implementation of the requirements of IEEE Std 323 as they apply to the specific features of continuous duty Class 1E motor qualification. IEEE Std 112 covers instructions for conducting and reporting the more generally applicable and acceptable tests of polyphase induction motors and generators. The instructions are covered to determine the performance and characteristic of polyphase induction motors and generators. Based on above survey, the procedures of the EQ of motor performed in KIMM are shown in Fig. 1. Performance test is to confirm and inspect basic performances of motor, which are winding resistance measurements, temperature test, high-potential test, insulation resistance, over-speed, noise, speed-torque, and vibration test. These tests were performed after every step above in Fig. 1.In this paper, we have mainly described LOCA and temperature & humidity test as representative test among environmental qualification.

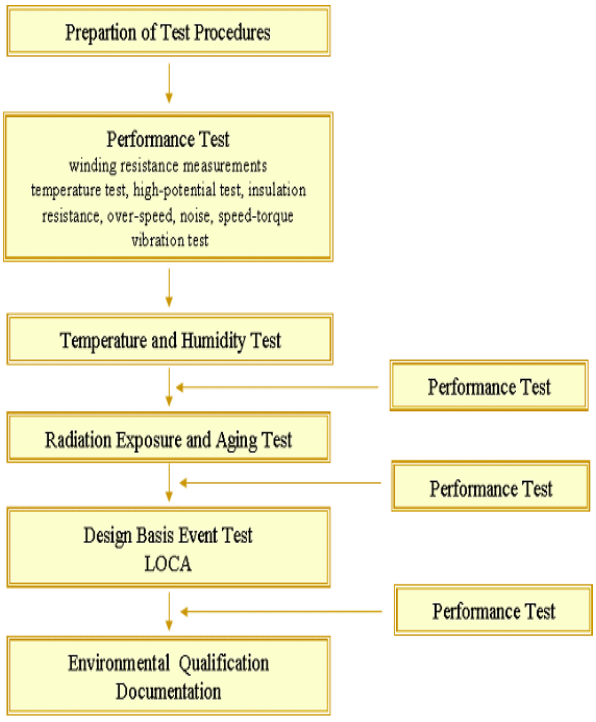


Figure 1. EQ Procedure of Motor

### *2.2 Temperature & Humidity Test*

Temperature & humidity test for motor is to qualify the basic functions of motor under environmental service conditions as shown in Fig. 2. The test chamber employed dimension of 3(W) ×2.5(D) ×2.1(H) m and maintains constant temperature ranging from -70 ℃to 200℃ and constant humidity ranging from 0% to 95%. Figure 2 shows detailed profiles for temperature and humidity with elapsed time in the chamber.

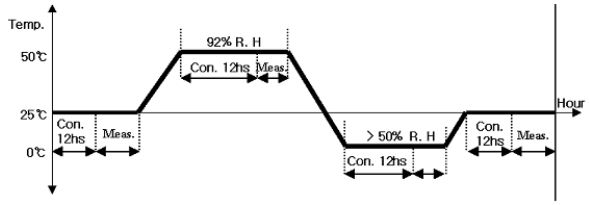


Figure 2. Temperature & Humidity Condition

*2.3 LOCA Test*

Simulated LOCA test for EQ stands for qualification of nuclear equipment under the environmental conditions of DBA. Environmental conditions include pressure, temperature, humidity, chemical spray and radiation. Figure 3 shows the schematics LOCA test system employed, which is consisted of steam generator, accumulator, superheater, chemical spray system, and automatic –control system. Figure 4 shows the detailed pressure and temperature profiles for LOCA test performed by KIMM for 30 days, which profiles are conformable to the ones presented in IEEE Std 323.

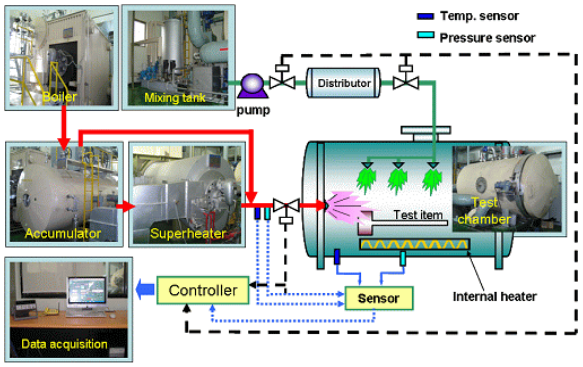


Figure 3. Diagram of LOCA Test System

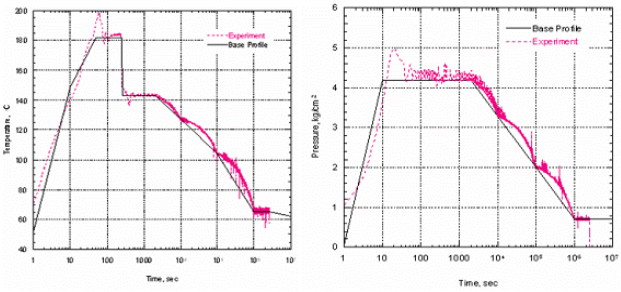


Figure 4. LOCA Pressure and Temperature Profile

### 3. Results and Conclusion

It is necessary for the environmental qualification that its regulations, prescriptions, and standards are analyzed and classified for a specific equipment. Figure 5 shows the classified standards and regulation tree for qualifying motor used in nuclear power plant. It indicates that mother's standard IEEE Std 334 and a lot of daughter' standards as well as IEEE Std 323 are required for qualifying class 1E motor.

Based on standard above, the detailed procedure of environmental qualification for motor was established as shown in Fig. 1. LOCA simulated test as well as performance tests are also performed according to the standard tree in Fig. 5.

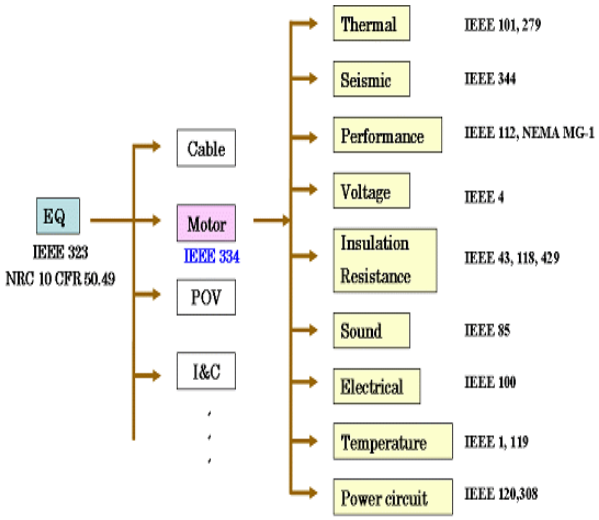


Figure 5. Standards and Regulations Tree for Qualifying Motor

***Acknowledgement***

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### REFERENCES

[1] IEEE Std 334, Qualifying Continuous Duty Class 1E Motors for Nuclear Power Generating Stations
[2] IEEE Std 112, Test Procedure for Polyphase Induction Motors and Generators
[3] IEEE Std 323, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations
[4] Reg. Guide 1.89, Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants.
[5] Reg. Guide 1.40, Qualification Tests of Continuous-Duty Motors Installed Inside the Containment of Water-Cooled Nuclear Power Plants
[6] NRC 10 CFR 50.49, Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants
[7] Reg. Guide 1.129, Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants