

Procedure and Method of Equipment Qualification(EQ) for EPA in NPP

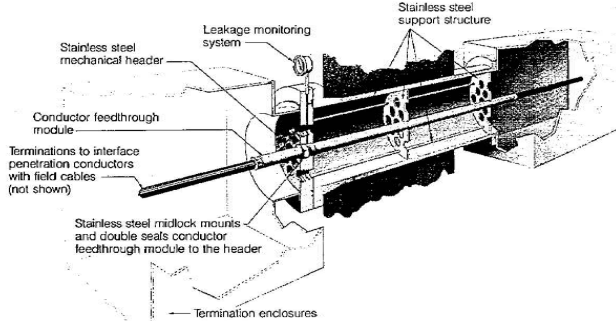
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1. Introduction

The Electric Penetration Assemblies(EPAs) for NPP are usually used for medium-voltage power, low-voltage power, low-voltage control and instrumentation. Field cables either interface with the EPAs using electrical connectors or are terminated to penetration lead wires using splices or terminal blocks. These EPAs provide two critical and distinct functions, which are the electrical continuity, insulation and the containment pressure integrity. EPAs insulation resistance or impedance characteristics may be critical in instrument applications. The following design shows a typical modular unit design. In this paper, we analyze the codes and procedures of the equipment qualification test and propose test items, conditions, and acceptance criteria more specifically.



<Figure 1> A typical modular unit design of EPA

2. Analysis of the test regulations for EQ

EQ tests for EPAs are presented in a variety of regulations, guides, and codes including Nuclear Safety Law, NSSC rule of technical requirements applying to the nuclear installations, regulatory standard, KEPIC, 10CFR50.49, regulatory guide, IEEE. To summarize, the major points are shown in table 1.

<Table 1> Major technical standards of EQ for EPA

Technical standard		Application
KOREA	U.S.A	
Nuclear Safety Law Enforcement Regulation NSSC rule No.3	10CFR50.49	Legal requirements for qualifications
Ministerial Ordinance of technical requirements applying to the nuclear installations article 24, article 15, 40, 70	Reg. 1.63 Guide	Regulatory qualifications requirements
Regulatory standard and guideline for PWR	Reg. 1.89 Guide	

KEPIC END 1100[1]	IEEE 323	Comprehensive test requirements for qualifications
KEPIC END 2000[2]	IEEE 344	Test requirements for seismic
KEPIC ENB 6430[3]	IEEE 317	Test requirements for EPA
KEPIC ENB 5000[4]	IEEE 741	Power system protection standards

Nuclear Safety Law and NSSC Rule No.3 considered as the high-level basis for equipment qualification describe the qualification program for the safety related electric equipments. KEPIC END 1100 prescribes the test requirements of equipment qualification for all the safety related electric equipments describing the purpose, object, test plan, and filling out paperwork in detail. Especially, KEPIC END 6430 is the most detailed requirement for the qualification test of EPA.

However, the external circuit protection of EPA is covered by KEPIC ENB 5000. Therefore, the representative regulations for the EPA qualification test are KEPIC END 1100 as the basis, KEPIC END 2000, KEPIC ENB 6430, and KEPIC ENB 5000.

3. Test procedures and methods

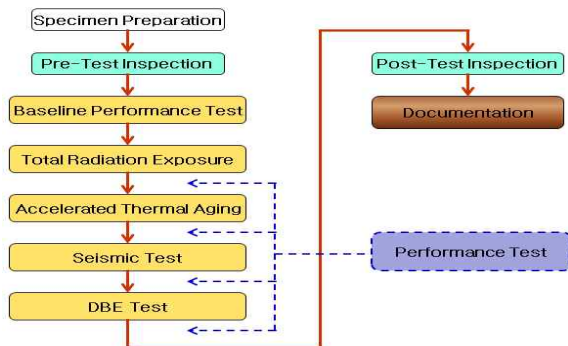
3.1 Test procedures

The qualification test is divided into the function & performance tests, and the aging test in normal & accident environments. According to the type of the qualification equipment, the test items of the aging test in normal and accidental environment are similar to each other, but the function and performance tests are different. The function and performance tests are conducted to determine whether the equipment maintains the function and performance appropriately with acceptable standards during the test.

Normal environment aging tests are thermal, cycling and radioactive aging tests during design life time in service location. Accidental environment aging tests of so-called Design Basis Event(DBE) are seismic and LOCA simulation tests for 1 year period after design life time. The procedure of the equipment qualification for the EPA is shown in figure 2.

Qualifications shall include design test and qualified-life test. The design test will demonstrate the adequacy of design to meet requirements, which are unrelated to aging. And the qualified-life test will address aging and establish the qualified life of the assembly. Design tests may be performed in any sequence on different test

specimens. Qualified life tests shall be performed on preconditioned test specimens in the sequence and may be performed on test specimens that have not been subjected to design tests.



<Figure 2> Test procedures (KEPIC END 1100)

3.2 Design test

The unique function and performance parameters on EPAs are in accordance with the test requirements of KEPIC ENB 6430. And the items of design test are the gas-leak test, the pneumatic pressure test, the dielectric-strength test, the insulation resistance test, partial-discharge(corona) test, the rated continuous test, the rated short-time overload current test, the rated short-circuit current test, the rated short-circuit thermal capacity test, the seismic test, and the installation welding test. The tests may be performed in any sequence on different test specimens. The design tests shall be performed for each generic design.

3.3 Qualification test

Qualification test shall be performed on the test specimen passing the design test. Each test specimen shall be subjected to preconditioning(i.e. Shipping and Storage Simulation, Thermal Operating Cycle Simulation, Thermal Conditioning, and Radiation Exposure Simulation) prior to performing the tests.

For Shipping and Storage Simulation, the test specimen shall be exposed to not less than 5 cycles of ambient temperature changes where each cycle varies from -28°C to 65.5°C and the duration of each temperature extreme is not less than 2 hours. For Thermal Operating Cycle Simulation, the test specimen shall be subjected to not less than 120 cycles of temperature changes in the specimen of not less than 55°C for each cycle. One cycle equates to a temperature change of $100^{\circ}\text{F}(74\pm 19^{\circ}\text{C})$. For Thermal Age Conditioning, the test specimen shall be thermally age conditioned to simulate operation at design normal service temperature for the installed life. Accelerated thermal aging time and temperature derived from Arrhenius data or other methods. For Radiation Exposure Simulation, the test specimen shall be exposed to radiation simulating the design normal service environment radiation for the installed life.

After preconditioning the following tests shall be performed in the sequence given with the test set-up

simulating the actual installed condition. Those tests are short-circuit Current and thermal capacity tests, seismic test, simulation test of the most severe DBE environmental conditions. This simulation test includes a rated short-time overload current & duration test, rated short-circuit current test and rated short-circuit thermal capacity test at the same time. Remaining of the test sequence is similar to above tests.

4. Criteria for Test

The acceptance criteria satisfied with the test conditions shall be used to determine whether the test is qualified or not. After all, the qualification shall be considered to be completed if the acceptance criteria of the performance are accepted. The key items of performance tests are conductor continuity, insulation resistance, leakage current and the containment pressure integrity. These performance values are compared between initial values and aging values. Especially, the acceptance criteria of the performance test shall depend on the requirements of either the service condition or the manufacturer specifications.

5. Results

Through these tests, we analyze the test codes and procedures of the qualification test for the EPA which are used in NPP and systematize the test items, methods, and test equipments. The standards of the qualification for the EPAs are laws, regulatory guidelines, industry standards in order, and the test codes are subdivided depending on the test items. The regulations and guidelines are Nuclear Safety Law Enforcement Regulation and NSSC rule No.3. The industry standards are KEPIC END 1100, 2000, 5000, and 6430. After the completion of the test, the equipment qualified depends on whether the performance standards meet the acceptance criteria or not.

EPA manufacturer shall do appropriate nonmetallic materials selection, design and test. The nonmetallic materials are selected against thermal and radioactive weak materials. This study is using for localization of EPA development, design qualification and equipment qualification test

REFERENCES

- [1] KEPIC END 1100, "Qualifying Class 1E Equipment for Nuclear Power Generating Stations", 2010
- [2] KEPIC END 2000, "Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations", 2010
- [3] KEPIC ENB 6430, "Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations", 2010
- [4] KEPIC ENB 5000, "Criteria for the Protection of Class 1E Power Systems and Equipment for Nuclear Power Generating Stations", 2010