Transactions of the Korean Nuclear Society Autumn Meeting
Pyeongchang, Korea, October 30-31, 2014

Introduction of Motor Stator Environmental Qualification for Wolsong NPP Primary Heat Transport Pump

Kyung-Heum Park[a*], Keug-Jin Bhang[a], Sun-Chul Jeong[a], Chul-Hwan Yun[a], Tae-Hwan Kim[a]

a Central Research Institute of Korea Hydro & Nuclear Power Co.,
70, 1312 Beon-gil,, Yuseong-daero, Yuseong-gu, Daejeon, Korea 305-343
[*]Corresponding Author : khpark@khnp.co.kr

1. Introduction

The PHT(primary heat transport) system in CANDU6 type NPP(nuclear power plant) consists of two separate loops designed to circulate pressurized heavy water(D2O) coolant through the reactor fuel channels and steam generators in the reactor. The object is to transfer heat from the reactor fuel to light water on the secondary side of the steam generators and produce steam to run the station turbine generator. Each loop contain two steam generators and two primary heat transport pumps and pump motors arranged systematically on each side of the reactor core.

The primary heat transport pump and pump motor set shall be designed for Design Basis Event(DBE). It must start and/or continue to function in the normal plant environment and during and after a DBE, which include one of the following event; Loss of Coolant Accident(LOCA), Loss of Air Cooliers(LOAC), Loss of Emergency Core Cooling(LOECC).

The primary heat transport pump motor is driven by the magnetic forces generated by the stator windings. The magnetic forces are generated by current flowing through the stator windings.

Due to the complexity of the interactions of materials and geometry, testing is the most appropriate method of qualification. In the same manner, this stator is determined to carry out type test. To carry out the type test for motor or motor stator winding insulation system according to IEEE Std 323, IEEE Std 334-2006, IEEE Std 43-2000 and IEEE Std 112-2004 are referred during the whole type test procedure and function test.

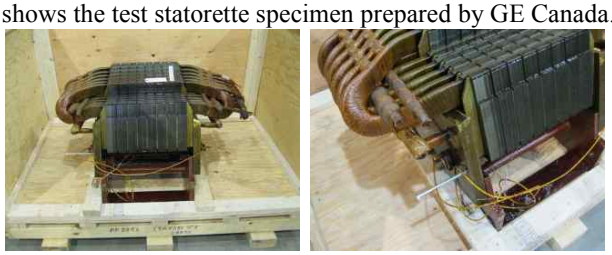
In this paper, I'd like to introduce the environmental qualification of the primary heat transport motor stator winding insulation system for Wolsong NPPs according to IEEE Std 334-2006 made by GE Canada and Kinectrics Inc.

2. Methods and Results

2.1 Stator Specimen for Environmental Qualification Test

Due to the limit of test facilities, it is determined to test the statorette instead of the real size stator. The statorette consists of six windings of the same design as the full stator was tested. Statorettes were fabricated using the same design, material, and methods that were used on the PHT motor stator.

The statorette has six coils of copper conductor, insulated with an insulating materials, and impregnated with epoxy. The six coils are placed in slots in metal punchings, which represent part of the stator. Figure 1 shows the test statorette specimen prepared by GE Canada.



<Figure 1. Test statorette specimen>

2.2 EQ Test Method and Acceptance Criteria for the Statorette

The statorettes were tested to qualify the PHT motor insulation system. The objective is to qualify the motor stator windings for a thirty year life. The qualification was done by the voltage aging, radiation aging, thermal aging, resonance search, mechanical aging, seismic tests and Design Basis Accident(DBA) Test. The test sequence and acceptance criteria shall be as follows:

1. Inspect the test specimen upon receipt to verify that the test specimen description is identical and that there is no shipping damage. Visual Inspection shall not indicate any signs of breach of integrity of the coil insulation, coil connections, ties or blocking.

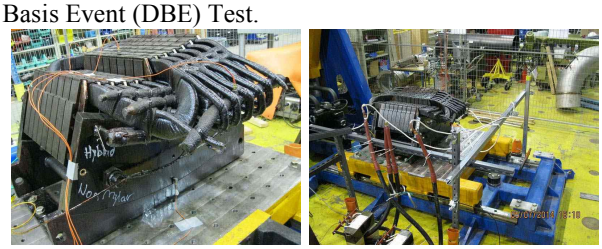
2. Baseline Functional Tests including Coil Insulation Resistance test per IEEE Std 112-2004, Insulation resistance test per IEEE Std 43-2000, Polarization index test per IEEE Std 43-2000, AC Hipot test per IEEE Std 4-2013/IEEE Std 95-2007 and Surge comparison test. The coil insulation resistance(IR) at 500VDC shall be≥5MΩ when corrected to 40°C during all functional tests. The coil insulation polarization index(PI) shall be≥2.0 for all functional tests. All coils must pass a one-minute AC Hipot test at 19,800VAC/60 Hz following the post

radiation functional test and at 16,240VAC during subsequent functional tests with no insulation breakdown.

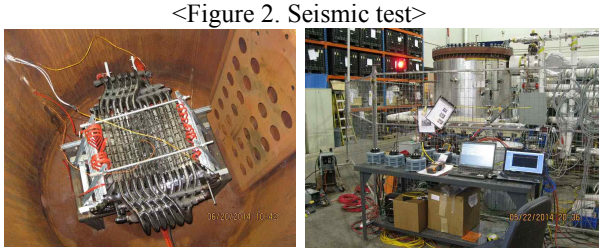
3. Voltage Aging Test of the statorette at 20,000 VAC for 44 hours.
4. Post Voltage Aging Functional Tests.
5. Radiation Aging Test of the test specimen statorette.
6. Post Radiation Aging Functional Tests.
7. Thermal Aging Test to simulate the normal service conditions for 29.3 days at 190 ^{0}C.
8. Post Thermal Aging Functional Tests.
9. Seismic Tests including Resonance search, Mechanical Aging. The statorette must maintain its mechanical and structural integrity and there shall be no insulation breakdown during and following mechanical vibration aging and seismic tests.
10. Post Seismic Test Functional Tests.
11. Design Basis Event (DBE) Test.
12. Final Functional Tests same as baseline function tests.
13. Post-Test Inspection.

2.3 EQ Test Results of the Statorette

Environmental qualification testing performed for the General Electric(GE) Canada statorette on the environmental qualification test program described in the section 2.2. The statorette test specimen successfully completed the required qualification testing program and met the specified acceptance criteria throughout the test program. Figure 2 & 3 shows the seismic test and Design Basis Event (DBE) Test.



<Figure 2. Seismic test>



<Figure 3. Design Basis Event(DBE) Test>

3. Conclusions

EQ type testing were implemented for the statorette represent the primary heat transfort Pump Motor Stator. The stator qualification has been demonstrated by testing a statorette with six sets of windings.

An environmental qualification test program was performed on a GE Canada statorette. The program comprised of voltage aging, radiation aging, thermal aging, mechanical vibration aging, seismic testing and a DBA test. The statorette test specimen successfully completed the required qualification testing program and met the specified acceptance criteria throughout the test program.

The integrity of the insulation system during and following the test demonstrated that the motor stator will perform its safety related function when subjected to a DBA at the end of its service life.

REFERENCES

[1] IEEE Standard, “IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations”, IEEE Std 323-2003
[2] IEEE Standard, “IEEE Standard for Qualifying Continuous Duty Class 1E Motors for Nuclear Power Generating Stations”, IEEE Std 334-2006
[3] K.H.Park, “Determination of the Minimum Acceptable Value of Insulation Resistance for Formwound Motor Winding EQ Test” KEPCO RI, Korean Nuclear Society Spring Meeting, 2009
[4] K.H.Park, “Environmental Qualification of F insulation class Formwound Motor Winding using Vacuum Pressure Impregnation” KEPCO RI, Korean Nuclear Society Spring Meeting, 2011
[5] 10CFR50.49 “Environmental qualification of electric equipment important to safety for nuclear power plants”, 1991
[6] EPRI TR-100516 "Nuclear Power Plant Equipment Qualification Reference Manual", 1992
[7] AECL Technical Specification “Heat Transport Pump Motor Assembly”, 1991
[8] Nuclear Energy "Environmental qualification report for Wolsong 2 PHT motor design", 1995
[9] Kinectrics Inc. “Test report for environmental qualification testing of the General Electric statorette EN219012 to demonstrate qualification of the hybrid insulation system of spare stators EN219014 for the primary heat transport pump motors at KHNP Wolsong NPP”, 2014
[10] Kinectrics Inc. “Test procedure for qualification testing of two general electric statorette to demonstrate qualification of the winding insulation system on the primary heat transport pump motors at Wolsong NPP”, 2013