Environmental Qualification Program of CANDU Nuclear Power Plant

Kim, YunHo
Nuclear Power Lab, KEPRI.
103-16 Munjidong Yuseong-gu Daejon, kyunho@kepri.re.kr

1. Introduction

A primary condition in the operating license of nuclear power plants is the need to protect the health and safety of the station staff and the general public out side the plants. For this purpose it is essential that at all times during the operating life of the station, the safety function of all safety and safety related equipments must be maintained. Although integrity of equipment's safety function under normal operating condition was kept by manufacture's test and routine maintenance activity in plants, aging sensitive equipment can not tolerate under harsh environmental condition arising from accident. As a follow-up measure of Wolsong-1 Periodic Safety Review(PSR), environmental qualification program for CANDU nuclear power plant is under development.

2. Environmental impact on equipment

2.1. Safety function

Four basic safety functions which special safety system and safety related system must to have are as follows.

- control of the reactor power
- cooling of the heat transport system
- containment of radioactive isotopes release
- monitoring of critical safety parameters to assure safe shutdown condition.

2.2. Environmental stressors

Environmental parameters such as temperature, pressure, radiation, humidity undergo significant change as a result of design basis accident which causes common cause failures. All equipment exposed to these kinds of harsh environment and which is credited with performing a safety function, or which by its failure can impede the execution of safety function, falls within the scope of the EQ program.

- Temperature : The indirect effect of temperature on altering material properties by assisting chemical and physical process is called thermal aging. It changes mechanical properties like hardness, elongation, tensile and compressive strength, as well as electrical properties like insulation resistance, high-potential dielectric withstand strength.
- Radiation : The atomic and molecular structure of material changes when it is exposed to radiation. This is more significant in organic compounds such as those used for mechanical seals and electrical insulation.
- Pressure : An ambient pressure increase can change operation of device such as pressure regulators and diaphragm actuators or cause structural failures of seal.
- Humidity : Moisture causes corrosion of metal surfaces, galvanic effects at the interfaces of dissimilar metal, degradation of electrical terminations and contact surfaces, reduction of the resistivity withstand potential of insulating surface that can lead to required performance levels not being met when demanded.
- Cyclic operation : Cyclic operation both mechanically and electrically degrades functional performance. O-ring seals, airlock door seals and relays are typical example.

2.3. Harsh environment

Harsh environment shall be identified by a significant change in the ambient value of at least one of the following parameter conditions

- Temperature : 10°C above normal and 50°C
- Pressure : above or below normal from a DBA
- Radiation : total integrated dose(TID) > 1.7×10^4 Rads
- Humidity : 100% relative humidity or condensing steam condition
- Submergence : any

3. Environmental condition

Environmental condition is based on design basis accidents evaluated in safety report that produce harsh environments. Considering pipe break size, location of credible breaks, accident scenario, bounding environment condition is generated. Bounding design basis accidents are large LOCA, small LOCA and main steam line break accident.

3.1. Analysis code

For the thermal hydraulic analysis, CATHENA is used and for containment behavior analysis PRESCON-2 is used. Containment of wolsong-1 is modeled as 9 nodes.

3.2. Environmental condition

The highest temperature and pressure environment develops for main steam line break accident with loss of dousing system [Figure1, 2]. But the equipment which does safety function for only large break LOCA has to be qualified for the environment condition induced from large break LOCA.

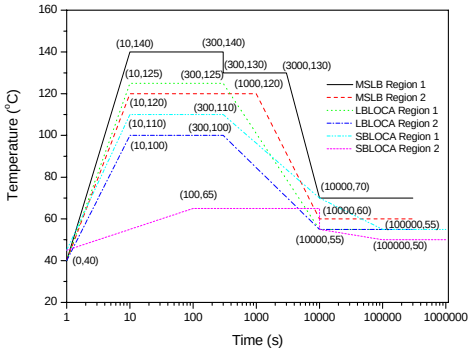

Figure 1. Temperature condition for wolsong-1

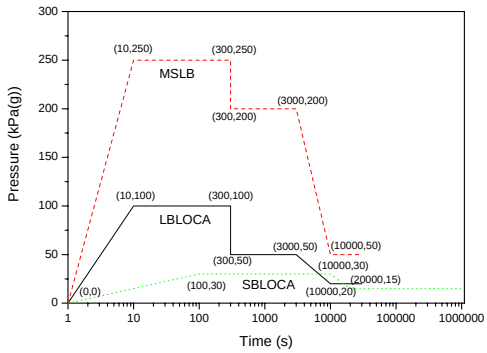

Figure 1. Pressure condition for wolsong-1

3.3. Mission time

The minimum time interval during which safety function of equipments shall be required is called mission time. Mission time is dependent on location of equipment and DBA the equipment is exposed to. It is categorized into 3 groups from review of safety analysis. Reactor shutdown system and poison addition system usually need less than 2 hours' mission time. Emergency core cooling system and moderator system and post accident monitoring system are required to keep safety function as long as more than 1 months. Dousing system and D_2O storage, transfer and recovery system are needed to function for around 1 day.

4. Environmental qualification component list (EQCL)

All equipment and components that perform essential safety functions in the line of defense against DBAs that produce harsh environments shall be identified for inclusion in EQCL. In addition, equipment and components that do not perform essential safety functions are also included in EQCL, if their failure under DBA conditions can defeat the accomplishment of a credited system function. Detailed procedure for the selection of equipment to be environmentally qualified is developed as in Figure 3. Detailed location, model and manufacturer of the equipment was checked through site walk-down and filed in EQDB[Figure 4].

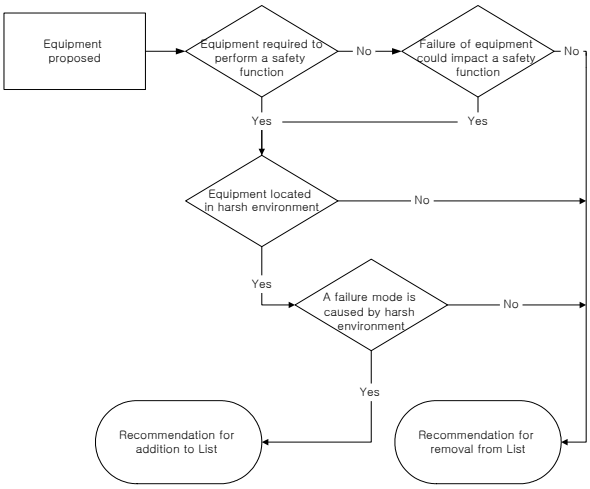

Figure 2. An addition to or removal from EQCL

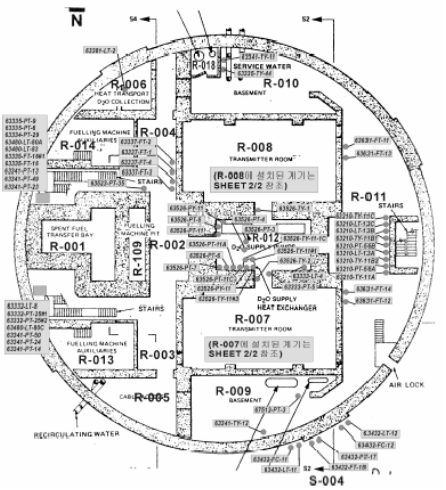

Figure 4. Transmitter location information

5. Conclusion

EQ program for wolsong-1 nuclear power plant is under development. Construction of systematic EQ program can be a foundation for implementation of consistent EQ activity in plant site. Qualification of the safety and safety-related equipment is preserved throughout plant life time.

The environmental condition and mission time for qualification are generated for three main accidents inside containment. Equipments to be qualified are identified through the selection procedure and maintenance of qualification is achieved through EQ program.

REFERENCES

[1] 10CFR50.49, Environmental qualification criteria for nuclear power plant, 2002.

[2] C-6, Requirements for the Safety Analysis of CANDU NPPs, 1980.

[3] R-8, Requirements for Shutdown Systems for CANDU NPPs, 1991.

[4] CAN/CSA-N290.13, Requirements for Environmental Qualification of Equipments for CANDU NPPs, 2005.