ONSITE INSPECTION EXPERIENCE OF ELECTRIC EQUIPMENT IN LICENSE PROCESS OF THE CONTINUED OPERATION OF KORI UNIT ONE

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Abstract

The methods of equipment qualification for the continued operation of Kori unit one are qualification by type test report, analysis, operating experience and by the combined qualification. The original licensed document did not include a full featured Environmental Qualification Reports due to either a turn-key based project or early 70's requirements. Additional EQ for license of the continued operation is performed such as following actions; Replacement with qualified equipment, Re-analysis, Laboratory partial type test and Relocation to mild environmental condition area. Most of replacement and relocation will be completed by December 2007. It should be required to finish the regulatory review within 18 months after submission on June 2006. As an operating experience approach qualified for normal environments, an additional material degradation analysis is performed to qualify the equipment for DBE. Partial type tests on vital components, such as MOVs, are being provided in support of the operating experience method, in addition to on a passive and long-lived items- PVC cables. The inspection of the continued operation will be performed in three stages. The 2nd onsite inspection was completed in May 2007. The inspection activities after the 2nd onsite inspection, which would be incorporated with periodic safety inspection, in the field of electric equipment installed, are 1) scoping and screening of submitted/ supporting documents, 2) walk-down of electric systems, and 3) reviewing the onsite procedure of AMP. With respect to the integrated plant assessment, an improved performance of emergency diesel generator with replacement of key components, such as governor and AVR, will be inspected according to the current licensing basis standards. The inspection will be completed by December 2007.

1. INTRODUCTION

Kori unit 1 is 30 years old in June 2007, reaching its design lifetime. As did many other countries, the licensing period was not granted in Korea when the Operating License was issued. The continued operation is based on two key principles- Current licensing basis (CLB) and acceptance of the updated standards. In principle, the scoping process should be focused on the selection of the SSCs that are screened as "passive" and "long-lived"[1]. The scoping and screening methodology for aging management should be done in accordance with KINS' safety review guidelines[5] developed based on NUREG-1800[1]. The following are the examples of replacement or refurbishment for the I & C and Electrical system .

- Anticipated Transient Without Scram mitigation system
- Process control protection and monitoring instruments improvement
- 4.16 kV switch gears, 125V Class 1E Battery banks
- AAC diesel generator in Kori site.
- Main and auxiliary transformers

- Main generator and excitation system
- Generator Circuit Breaker

1.1 LEGAL FRAMEWORK OF CONTINUED OPERATION

The licensee to operate a nuclear power plant beyond its design life time should submit the periodic safety review (PSR) report based on the eleven safety factors required by Korean Enforcement Decree of the Atomic Energy Act[2]. According to the Notice of the MOST[3] Aging management program (AMP) should provide the information as follows:

- Scoping and screening results of aging management
- Aging management program
- TLAA including the continued operation term
- Operation experience feedback and important safety research results

1.2 LEGAL FRAMEWORK OF ONSITE INSPECTION OF CONTINUED OPERATION

The inspection should be conducted to verify whether the information in the application is consistent with the licensee's implementation of continued operation activities. In general, the onsite periodic safety inspection(PSI) conducted at the request of the licensee every refueling & planed overhaul stage would be to make sure that the plant maintains an appropriate safety level because the objective of PSI is to confirm both whether the NPP is in compliance with the applicable codes & standards as committed when the operating license was issued and whether the safety related components and systems are maintaining appropriate performance level as accepted in the pre-operational safety inspection.

The technical safety standards for continued operation should be updated for taking the aging effects and operating experiences into account as provided in the Notice of the MOST[3]. It means that the current licensing bases(CLB) are updated for continued operation. The inspection for continued operation will be composed of two parts. The one is the periodic safety inspection(PSI) in compliance with the Notice of the MOST No.2005-10[4] confirm whether the ‘existing licensing bases’ are met properly. The other is the inspection based on Notice of the MOST No.2005-31[3] to confirm that the measures and the implementation activities of the licensee are appropriate in view of newly upgraded standards ,‘CLB’, which is called continued operation inspection (COI). The inspection scope and items for the PSI have been well defined in the past experience and regulations since 1977 whereas those for the COI are rather new, review-oriented and dependent on inspectors' expertise. The onsite COI would focus on both scoping & screening documentation and aging management programs in particular for the time of the1st and 2nd inspection in order to verify that the licensee has properly included the systems, structures, and components within the scope of continued operation and aging management program. The aging management program inspection on site was focused to verify that the aging management programs should manage aging effects . The safety review as well as onsite inspection for continued operation under the framework of PSR would be followed by more rigorous safety requirements than that for the normal PSR within design life.

1.3 THE REQUIREMENT FOR AGING MANAGEMENT PROGRAM

The aging management program (AMP) shall contain ten elements: In addition to these elements, special considerations should be provided for operating experiences and safety research results as required in the safety review guidelines[5]. The AMP should provide the information about the items to be reviewed for continued operation, measures to be taken prior to continued operation, additional measures to be taken posterior to the start of continued operation in consideration of characteristics of design and operation, and operating experiences. The detailed items, a total of 39 items, included in the AMP are provided in the Notice of the MOST[3] and NUREG-1801[6]. In addition, in case when the AMP needs to reflect the specific characteristic of the reactor design or operation experiences, those items should be included.

1.4 THE REQUIREMENT FOR TIME LIMITED AGING ANALYSIS

The time-limited aging analysis (TLAA) is to address plant specific safety analyses that are based on plant design life. The licensee is required to provide a list of TLAAs according to the Notice of the MOST[2,3]. The seven items subject to TLAA are provided in table 3 of the above notice. The licensee shall demonstrate one of the followings:

- The analyses remains valid for the period of continued operation : category I
- The analyses have been projected to the end of the continued operation : II
- The effects of aging on the intended functions will be adequately managed for the period : III

1.5 THE REQUIREMENT FOR OPERATIONAL EXPERIENCE FEEDBACK

The operational experience feedbacks are those items that have not been covered during the safety review of initial operating license but that have been selected to be important from operational experiences and safety research results, whether they are based on our own experiences or other countries' ones.

2. ENVIRONMENTAL QUALIFICATION

Kori Unit 1 did not establish plant specific EQ program and time limited aging analysis (TLAA), for there were no rigorous requirements for EQ in 1977. This review was conducted based upon the codes and standards in related laws and applied various codes and standards applicable to Kori Unit 1. Implementation of the safety improvements on the 1st PSR was confirmed that the unit can operate safely during the continued operation period. 10CFR50.49 stipulates that the SSCs subjected to environmental qualification are safety-related electrical equipment, electrical equipment whose failure affects safety-related electrical equipment, and electrical equipment of the post-accident monitoring system.

TLAA of Kori classifies the EQ equipments such as 18 items; such as Electrical Actuator, e.g. Turbine Driven Auxiliary Feed-water Pump Discharge Valve Actuator , Electrical Motors, e.g. Containment Vessel Recirculation Fan Motors , Electrical Motor Operated Valves, e.g. Main Steam Isolation Valve Motor, Air Operated Solenoid Valves, Instrumentation/ Air Operated Solenoid Valves, Electrical/ Instrument Panels/ Splices, Electrical Penetration Assemblies, Electrical/ Instrument Terminal Blocks, Instrumentation Converters, Instrumentation Seals/ Leak Detectors/ Junction Boxes/ Limit Switches/Elements and Instrumentation Transmitter

2.1 REQUIREMENTS OF EQUIPMENT QUALIFICATION

According to the standards in 10CFR50.49(d), the licensee of nuclear power plants have to select equipment located under adverse circumstances to be subjected to environmental qualification and shall have their list updated. Kori Unit 1 keeps the list of equipment subjected to environmental qualification according to the requirements of 10CFR50.49(d) and has the Procedure to maintain the list. The EQ test of Kori Unit 1 had been completed only one third of equipment to be qualified, applying Westinghouse's environmental qualification test standard. Kori Unit 1 has applied the codes and standards , e.g. IEEE323 as the standard for the environmental qualification of Kori Unit 1 delineated in FSAR 3.11[9].

Recently replaced equipments including 740 items subjected to environmental qualification have applied IEEE323[7] as the qualification test standard. FSAR 3.11 [9] to apply the latest environmental qualification standard to the equipment to be replaced after their life. Temperature/pressure, moisture, effects of chemical materials, radiation, aging, submergence, synergistic effect and margin should be considered as the environmental qualification factors. The environmental qualification plan of Kori Unit 1 according to Regulatory Guide 1.89 [8] should be applied to 740 items to be replaced. Kori Unit 1 has a list of local DBA environmental conditions prepared through the analysis of mass and energy of LOCA and MSLB

2.2 MONITORING FOR THE PROTECTION OF QUALIFIED EQUIPMENT FROM ADVERSE ENVIRONMENTAL CONDITION

Some of equipment qualified less than 10 years shall be verified with on-line monitoring system during operation , while other of equipment conditionally qualified more than 10 years by on-line monitoring verification. Temperature data used in aging evaluation should be conservative enough as well as based either on plant design temperature data or on plant actual data collected from temperature monitors. Kori unit 1 installs the temperature on-line

monitoring system to acquire the plant actual data to reduce an assumed conservatism in the real equipment service conditions. EQ qualified lifetime could be extrapolated and extended if used in proven technology that an actual service conditions are milder than expected in the design stage or in the type test condition. The figure 1 shows an on-line temperature monitoring system for cables and motors in connection to conduit of radiation gamma ray monitor instrumentation.

FIG. 1. On-line temperature monitoring system for cables and motors

The on-line temperature monitoring system consists of semi-conductor temperature sensors, flash-ROM memories, infra-red data communication cables and hand hold PDAs for data communication as shown figure 2.

FIG. 2. Hand hold PDAs for data communication

The figure 3 shows an one year record of on-line temperature monitoring system for power cable from March 2005 to March 2006 in the location Room E30-01.

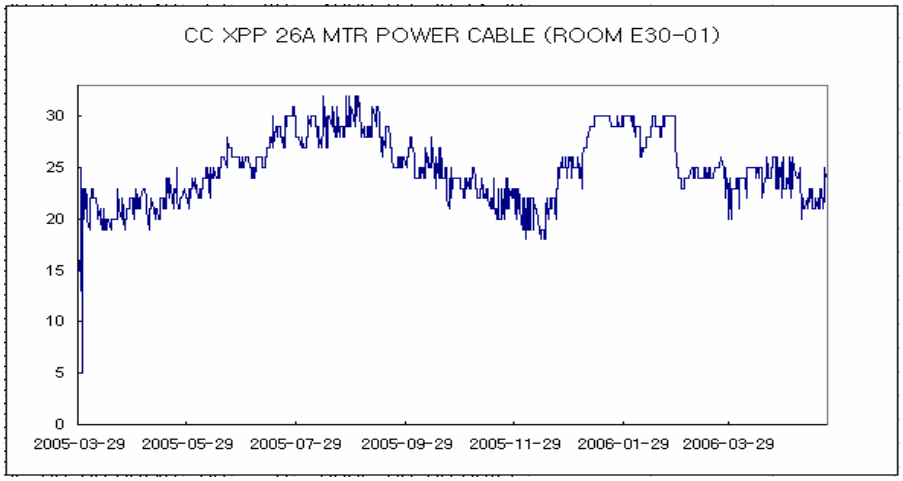

FIG. 3. One year record of on-line temperature monitoring system for cables

2.3 METHODS OF QUALIFICATION

2.3.1 QUALIFICATION BY ANALYSIS

If qualification documentation of another equipment is available, it is reviewed to determine whether the organic component qualified is identical to that to be qualified through the similarity analysis. If qualification does not exist, a material aging analysis is performed. Partial type tests on vital components or material of the equipment under qualification are provided in support of this method. In the case of Kori Unit 1, there are 240 items including BA No.2 tank recirculation control valve IP, that are subjected to environmental qualification by a partial type test, 24 items, and can be qualified by analysis. Those are included the electrical actuators and MOV motors with a laboratory partial type test. Their aging management review is completed through the examination of similar equipment and the analysis of material.

2.3.2 QUALIFICATION BY FULL TYPE TEST

While testing, the specimen is subjected to accelerated aging using Arrhenius methodology and other aging methods which are supported by type tests. Synergistic effects have been identified on materials that are included in the equipment being qualified. Those are 764 items including RCDT pump discharge outside containment isolation valve limit switch, that are subjected to environmental qualification and can be qualified by EQ full type test. They are to be replaced with those having qualification test reports through the planned preventive maintenance to be implemented in May 2006. It is planned to complete the environmental qualification test of the equipment for the test by Dec. 2007.

2.3.3 OPERATING EXPERIENCE

Qualification of equipment using operating experience is a basis for environmental qualification. This type of qualification may be used for equipment for which testing is not feasible due to the equipment physical size. This evaluation is done using similar equipment with a successful operating history in a service environment equal to or more sever than the environment for the equipment in question. The validity of operating experience as a means of qualification is determined from the type and amount of available supporting

documentation, the service conditions and equipment performances. Partial type tests on vital components of the equipment under qualification are provided in support of this method.

2.3.4 COMBINED QUALIFICATION

Combined qualification is used for any equipment which cannot be qualified through a full type test. Combined qualification is usually any combination of type test, previous operating experience, and analysis. Partial type tests with extrapolation or analysis, operating experience with extrapolation or analysis, and type tests supplemented with tests of components and analysis are examples of the use of combined qualification.

2.4 REPLACEMENT WITH QUALIFIED EQUIPMENT

In Kori Unit 1, there are a total of 740 items including Feed water HDR to SG A isolation valve actuator that are subjected to environmental qualification and need to be replaced with qualified equipment. They are to be replaced with qualified equipment through the planned preventive maintenance to be implemented during the outage period of 2007.

2.5 QUALIFICATION OF REPLACED EQUIPMENT LOCATED IN HARSH/MILD ENVIRONMENTS

In Kori Unit 1, there are 11 items including 120V vital instrument panel 18A that are subjected to environmental qualification and are to be excluded from the list of equipment subjected to qualification when their environmental condition is improved. They are to go through environmental condition improvement through the planned preventive maintenance to be implemented during the outage period of 2007.

Currently, it is completed to draw up environmental qualification review documents of those equipment for which qualification test reports are acquired. Kori Unit 1 has developed the qualification maintenance procedure to analyze whether the failure of equipment affect initial qualification. Table 1 shows examples of the procedure to replace or to improve the new qualified equipments.

Table 1. Kori unit 1 maintenance procedures for continued operation

Number of procedure	Title of procedure	Title of work	Year 2007 schedule
K1-EQ-11.2	Implementation of EQ	Replacement of electrical cables against non-compliance EQ requirements	July-Sept.
K1-AG-14.3	Improvement AMP for electrical and I &C system	Replacement of large motors	July-Aug.
K1-AG-17.2	Improvement/Modification for heat exchanger and cooler	Replacement of 4.16kV Switch Gears (Non-1E)	July-Sept.
K1-AG-17.2	Improvement/Modification for heat exchanger and cooler	Replacement of Switch Gears of 480V Motor Control Center	July-Sept.

K1-AG-17.4	Implementation of EQ	Replacement of fuse holders of 480V Motor Control Center	July-Sept.
K1-EQ-10.2	Implementation of EQ	Replacement of relays against non-compliance EQ requirements	July-Aug.
K1-EQ-11.2	Implementation of EQ	Replacement of I & C cables against non-compliance EQ requirements	July-Sept.
K1-SA-7.4	Interconnection with PSA	Replacement of Class 1E Battery banks	July-Sept.
K1-EQ-10.2	Implementation of EQ	Replacement and improvement of follow-up action of EQ	June-Sept.

Qualification tests and analysis performed on instrumentation and electrical equipment located in harsh environment fulfill the requirements of IEEE Standard 323 as endorsed by Regulatory Guide 1.89 [8] and "Category I" of NUREG 0588. Some of those equipments should be re-qualifed and the EQ list has been revised either by emigration from harsh environment zone to mild one or by installing 3 hour rating fire walls/ barriers.

Equipment located in mild environment is designed for the designated lifetime in the temperature, pressure, humidity, and radiation environment that exists at the equipment location during normal operation, assuming proper routine preventive maintenance is performed, such as periodic replacement of seals and packing. No further qualification is required for equipment located in mild environments[9]. For example, while the figure 4 shows the original layout of the harsh environmental area, the figure 5 does show an improved one by installing curbs, holes for pressure relief, dikes, steel concrete wall and pressure tightening doors,

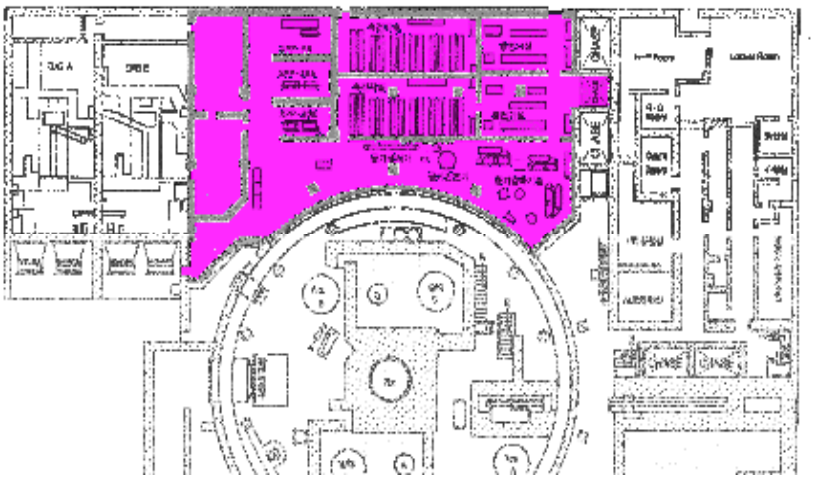

FIG. 4. Intermediate Building Environment Improvement from Harsh Zone[Before]

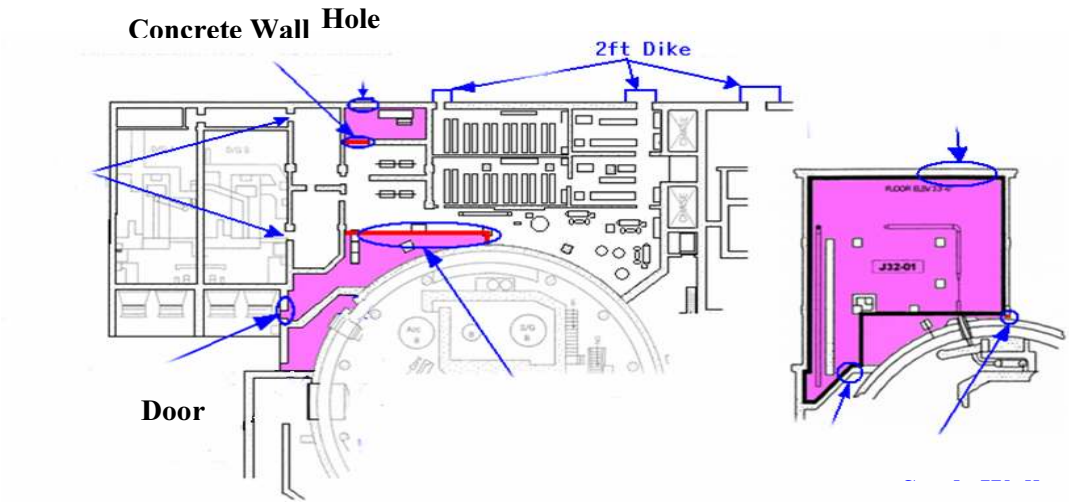

FIG. 5. Intermediate Building Environment Improvement from Harsh Zone to Mild Zone[After]

3. TIME LIMITED AGING ANALYSIS AND ENVIRONMENTAL QUALIFICATION

TLAA(1) is category I for the equipment qualified more than 10 years. Two third of class 1E equipments did not have EQ document. Most of them are replaced with new equipments qualified. 24 items of 764 items in category I should be qualified with a partial type test in table 2. Those are both electrical actuators and MOV motors, which have been tested in environmental & energy research laboratory of Korea Institute of Machinery and Material. TLAA(2) is category II for the equipment qualified less than 10 years but should be achieved conditionally more than 10 years by on-line monitoring of environment temperature during operation TLAA(3) is category III for the equipment qualified less than 10 years but shall be continuously monitored by on-line monitoring of enviroment temperature during operation

Table 2. Number of TLAA classification of equipment

		TLAA(1)	TLAA(2)	TLAA(2)	SUM
1	E_ACT	26	40	0	66
2	E_MOTOR	6	18	0	24
3	E_MOV	26	40	0	66
4	E_PNL	0	9	10	19
5	E_SPLC	8	6	0	14
6	EPA	0	48	0	48
7	E_TMBLK	59	12	0	71
8	I_CNVRT	0	9	0	9
9	I_SEAL	185	60	0	245
10	I_LKDCTR	0	4	0	4
11	I_JNBC	0	26	0	26
12	I_LMSW	126	50	1	177
13	I_ELEM	46	48	0	94
14	AIR_SOL	37	57	0	94
15	I_SPLC	153	20	0	173

16	I_SOL	0	15	0	15
17	I_TMBLK	88	4	0	92
18	I_TRSMTR	4	57	0	61
SUM		764	523	11	1298

NOTE:
E_ACT: Electrical Actuator, e.g. Turbine Driven Auxiliary Feed-water Pump Discharge Valve Actuator
E_MOTOR: Electrical Motors, e.g. Containment Vessel Recirculation Fan Motor
E_MOV: Electrical Motor Operated Valve, e.g. Main Steam Isolation Valve Motor
AIR_SOL: Air Operated Solenoid Valve, I_SOL: Instrumentation Solenoid Valve
E_PNL: Electrical Panel, E_SPLC: Electrical Splice
I_SPLC: Instrumentation Splice, EPA: Electrical Penetration
E_TMBLK: Electrical Terminal Block, I_TMBLK: Instrumentation Terminal Block
I_CNVRT: Instrumentation Converter, I_SEAL: Instrumentation Seal
I_LKDCTR: Instrumentation Leak Detector, I_JNBC: Instrumentation Junction Box
I_LMSW: Instrumentation Limit Switch, I_ELEM: Instrumentation Element
I_TRSMTR: Instrumentation transmitter

There were several issues during the 1st onsite inspection and review stage, however it has been resolved through discussion with utility. The use of PVC cable and coaxial cable was identified and they should be qualified through partial type test.

The metal enclosed bus duct and fuse holder is located between downstream of reactor trip breaker 3 phase 260VAC bus and upstream of power panel of control rod drive mechanism DC bus. This bus duct is included in scoping process for continued operation but excluded in screening process because of not related with ATWS and SBO. However it is necessary to perform ONE time inspection with two rationales; First, power through this bus duct is essential for stable power production because if power for CRDM is lost, the control rod is shut off for reactor trip. Secondly, this bus has never been inspected since installed. One time inspection is scheduled with a maintenance procedure on planned overhaul period, June to Sept. 2007.

4. FUTURE PLAN FOR ONSITE INSPECTION FOR CONTINUED OPERATION

The 1st/2nd onsite inspection was completed in Jan./May 2007. The inspection activities after the 2nd onsite inspection, which would be incorporated with periodic safety inspection(PSI), in the field of electric equipment installed are 1) scoping and screening of submitted/ supporting documents, 2) walk-down of electric systems, and 3) reviewing the onsite procedure of AMP .

Table 3. Overall Schedule for On-site Inspection

Title of Inspection	Items to cover	Schedule 2007
IAEA Peer Review	Review of Submitted Documents for CO and Onsite walk-through inspection.	23 July - 3 Aug.
The 3rd On-site Team inspection	39 items of AMP, inspection of works of CO with the procedures Table 1	6 August - 10 August

The 4th On-site Team inspection	39 items of AMP, inspection of 47 item works of CO with the procedures Table 1	3 August - 10 August
Onsite inspection for Modification for CO	Inspection of Generator Circuit Breaker	3 Sept. - 7 Sept.
Onsite inspection for Modification for CO	Inspection of Emergency Diesel Generators	30 Sept. – 6 Oct.
Onsite inspection for Modification for CO	Inspection of Fire Protection System Improvement	1 Oct. – 12 Oct.
Onsite inspection for Modification for CO	Inspection of Follow-up Action for EQ	8 Oct. – 12 Oct.

REFERENCES

[1] NUREG-1800 : US-NRC, Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants

[2] Enforcement Decree of the Atomic Energy Act, Article 42-3 (Contents of Periodic Safety Review) , Article 42-4 (Methods and Standards of Periodic Safety Review) Enforcement Regulation of the Atomic Energy Act, Article 19-2 (Details of Periodic Safety Review), Article 19-3 (Criteria for Periodic Safety Reviews)

[3] Notice of the MOST for CO (No. 2005-31), “Guidelines on Application of Technical Standards for Assessment of Continued Operation of Nuclear Reactor Facilities Beyond Design Life”

[4] Notice of the MOST No.2005-10, "Regulation on items and Method of Periodic Inspection for Nuclear Facilities"

[5] KINS/GE-N8, “Review Guidelines for Continued Operation of PWR Plants”, March 2006

[6] NUREG-1801 : Generic Aging Lessons Learned Report

[7] IEEE std 323, “IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations”

[8] Regulatory Guide 1.89, Rev 1, “Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants, 1984”

[9] Kori Unit 1, FSAR Sec.3.11., “Environmental Design of Mechanical and Electrical Equipment”