Report on the Results of the Safety Review for Domestic Korean Nuclear Power Plants

2011.5.4 (Wed.)

Safety Review Team

Korea Institute of Nuclear Safety

목 차
Contents

I. Overview of Safety Review

1. Background

☐ Due to the accident at nuclear power plants in Japan caused by the great earthquake of 2011, public concern about the safety of domestic nuclear power plants increased.

- ○ When severe nuclear power plant accidents caused by large earthquakes and coastal flooding due to tsunamis, storm surges, and the like occur, it is necessary to execute safety review of domestic nuclear power plant facilities to establish countermeasures.
- ○ The sudden shutdown of Kori #1 nuclear power plant (April 12) had the public worried about aging nuclear power plants. In response, Korea Hydro & Nuclear Power Co., Ltd., requested the government to make an accurate inspection (April 20) of this plant.
  - An extra and accurate inspection to confirm the safety of the in-service Kori #1 nuclear power plant was performed.

2. Principles for the Inspection and Report

☐ Confirm safety against the design basis earthquake and coastal flooding.

☐ Secure the cooling capability of the nuclear reactor even against inundation of the power system on the premise of occurrence of natural hazards exceeding the design basis.

☐ Secure the integrity of the containment building in case of severe accidents, assuming loss of reactor cooling functions.

☐ Reinforce the capability of emergency response assuming large emission of radioactive substances.

☐ Perform an accurate inspection of Kori #1 nuclear power plant in terms of age-related deterioration and sudden shutdown.

3. Direction

☐ **Safety review of domestic nuclear power facilities**

- ○ (Subjects of safety review) in-service nuclear power plants, research reactors, nuclear fuel cycle facilities, and the radioactive emergency medical treatment agency

○ (Schedule) March 21 (Mon.) ~ April 30 (Sat.)

○ (Primary objects of safety review) Identified primary objects of safety review by analyzing the nuclear accident in Fukushima, Japan

- Appropriateness of design and facilities against natural hazards
  - · Design protection against earthquake and seismic capacity
  - · Design protection against coastal flooding and inundation protection
- Appropriateness of power supply and cooling functions
  - · Power system and emergency power supply
  - · Cooling capacity in case of blackout and/or inundation
- Ability to cope with severe accidents and appropriateness of emergency response
  - · Facilities, procedures, and strategies for coping with severe accidents
  - · Emergency response to multiple nuclear power plant accidents
  - · Facilities, systems, and infrastructure for the protection of local residents and workers

○ (Contents of safety review) Confirmation of safety of six areas assuming a worst case scenario of the following sequence: 「earthquake event→big tsunami→loss of electric power→severe nuclear accident.」

- (Area 1) Safety of structures and equipment against earthquakes and coastal flooding
- (Area 2) Safety of electrical power, cooling, and fire protection systems in case of inundation
- (Area 3) Severe accident response
- (Area 4) Emergency response systems
- (Area 5) Long-term in-service nuclear power plants and new type of nuclear power plants
- (Area 6) Research reactors, nuclear fuel cycle facilities, and the radioactive emergency medical treatment agency

○ (Safety review team) Consists of a total of 73 industry, academe, and research institute experts (36) from six areas and KINS experts (37), including co-chairman (Seungphil Jang, professor emeritus of Seoul National University, and Youngjin Kim, professor of Sungkyunkwan University)

○ Consolidate the opinions of private organizations (local government, representative of residents, private environmental monitoring organizations) and reflect them in the safety review to secure its objectivity and transparency.

- Kori: March 28, Weolsung: April 4, Uljin: April 7, Youngkwang: April 11, Research reactor, etc: April 14

General committee (Co-chairman)

Area 1	Area 2	Area 3	Area 4	Area 5	Area 6
YangHee Cho (Incheon University)	**BoohyungRyu (Dongkook University)**	**MooHwan Kim (Postech)**	**Moosung Je (Hanyang University)**	**Jaehak Park (Chungbook University)**	**Heesung Ahn (KRIST)**
Earthquake and coastal flooding experts(8)	Electrical Power/Fire/ Cooling Experts (5)	Severe Accidents Experts (2)	Emergency Response Experts (4)	Long-term in-service Nuclear Power Plants Experts (3)	Research Reactor and Nuclear Fuel Cycle Facilities Experts (6)
KINS Experts (5)	KINS Experts (12)	KINS Experts (4)	KINS Experts (6)	KINS Experts (5)	KINS Experts (5)

□ **Accurate safety review of Kori #1 nuclear power plant**

○ (safety review schedule) April 22 (Mon.) ~ May 3 (Tue.)

○ (Primary objects of safety review) Reflecting public concerns on the safety of continuous operation of Korea's oldest nuclear power plant in service

- Made an accurate inspection of the appropriateness of management of aging nuclear power plants, appropriateness of aging deterioration management program, verify integrity of the nuclear reactor vessel, find ways of increasing reliability so as to minimize sudden shutdowns

○ (Contents of safety review) Checked the following matters regarding continuous operation and sudden shutdown

- Reconfirm the safety evaluation of major equipment and facilities, and so on, which was performed when continuous operation was approved (‘07.12), and confirm safety issues announced in press releases, e.g., integrity of the reactor vessel and so on

- Analyze the cause of the sudden shutdown of Kori #1 nuclear power plant (April

12) and confirm and check the appropriateness of quality assurance of supply equipment such as power breakers, etc.

○ (Safety review team) Consists of a total of 56 experts including two team managers (Youngjin Kim, professor of Sungkyunkwan University, Sunggyu Lee, general manager of the nuclear power safety division); 19 experts from the industry, academe, and research institutes, and 37 experts of the Korea Institute of Nuclear Safety (KINS).

II. Results and Means of Improvement

1. Safety of structures and equipment against earthquake

a. Current Status

○ Domestic in-service nuclear power plants are designed with a safety margin of 0.2g above the maximum potential earthquake, taking into account the geologic and seismic characteristics within 320km from the center of the nuclear power plant site.

○ A seismic monitoring system is installed and operated at each nuclear power plant. The nuclear power plant is shut down manually according to the abnormal operating procedure when an earthquake stronger than the operating basis earthquake occurs, and the integrity of structures and equipment is checked.

b. Contents of the safety review

○ Seismic capacity of seismic category I structures and major equipment

- Status of maintenance of main structures and equipment
- Safety effect of design change or additionally installed facilities on existing facilities
- Appropriateness of anchorage of main equipment and possibility of interaction between the main equipment and adjacent facilities

○ Normal or abnormal operation of the seismic monitoring system

- Normal or abnormal operation of the seismic monitoring system and alarm device
- Integrity of input data of shutdown standards

○ Integrity and feasibility of measures when an earthquake occurs

c. Results

○ The integrity of the plant against a design earthquake is secured since the main structures and equipment are managed to maintain the same plant status as that existing at the time of establishment of the plant; this is maintained through periodic check and maintenance.

- Design change and additionally installed facilities are designed not to affect the safety of existing facilities.
- The deterioration of the anchorage of the main equipment is managed properly according to the relevant operation manual.
- Enough separation distance is maintained to prevent interference between the main equipment and adjacent facilities.
- The seismic monitoring system is managed properly through the monthly channel check, the functional test performed every 6 months, and the calibration as part of the scheduled prevention maintenance. The alarm unit and the uninterruptible power supply also meets the requirements.
- The operating basis earthquake as the standard of judgment for a shutdown of the nuclear reactor is 50% of the design earthquake, thus meeting the legal requirements.
- In case of earthquake, the necessary actions, (power plant's trip / shut down and analysis of seismic responses) can be implemented properly according to the abnormal operating procedure (AOP).

○ On the premise that large earthquake exceeding the design basis may occur, 5 more improvements to secure additional safety have been mandated for the near-term.

d. Improvements

[Goals of improvements]

- Securing safe shutdown capability of nuclear reactors even for earthquake exceeding design basis

○ (1-1) Installing an automatic seismic trip system (short-term action, to be finished in 2012)

- Improving facilities such that reactors are automatically shut down (tripped) when detecting an earthquake above a certain seismic level (0.18g) (applied to all NPPs)

○ (1-2) Improving the seismic capacity of the safe shutdown system (mid- &

long-term action, to be finished in 2014)

- In preparation for an earthquake exceeding the design basis, reinforce the seismic capacity of the safe shutdown system to the design earthquake level (0.3g) (the level applied to any new type of nuclear power plant) (this improvement is applied to all NPPs)

○ (1-3) Investigating and researching the maximum earthquake ground motions of NPP sites (mid- & long-term action, to be finished in 2013)

- Conducting a complete reassessment and research on the domestic maximum potential earthquake (applied to all NPPs)

○ (1-4) Improving plant seismic capacity (for example, the seismic event alarm window in the control room) (mid- & long-term action, to be finished in 2013)

- Improving the seismic capacity of the seismic event alarm window in the control room (applied to all NPPs)
- Improving the collapse prevention capacity of ceiling and lighting facilities and fixing of office appliances to protect the operator in the control room (applied to Kori Units 1 through 4)

○ (1-5) Improving the seismic capacity of the entrance bridge in the Weolsung nuclear power plant (short-term action, to be finished in 2012)

- Improving the seismic capacity of the bridge (near the back gate) for access to Weolsung nuclear power plant (action to be applied to Weolsung Units 1 through 4)

2. Safety of structures and equipment against coastal flooding

a. Current status

○ Domestic nuclear power plants calculate the design basis sea water level (probable maximum sea water level and probable minimum sea water level) by evaluating maximum tsunami and storm surge affecting NPP sites.

- The probable maximum sea water level is determined by combining the high tide level and the maximum sea water level following coastal flooding (using the higher sea level from either tsunami or storm surge), and adding the height of wave runup.

- The probable minimum sea water level is determined by combining the low tide level and the minimum sea water level due to tsunami, storm surge, etc (using the lower sea level from either tsunami or storm surge).

b. Contents of the safety review

○ Appropriateness of design in preparation for tsunami and storm surge

- Appropriateness of site elevation in preparation for coastal flooding (considering other natural hazards such as earthquake, storm, etc.)
- resistance ability of safety-related structures against coastal flooding
- capability of intake structure to provide sufficient cooling water in low water conditions

c. Results

○ There is no possibility of inundation of structures in the design basis for possible maximum sea water level condition; while safe water intake is possible even for possible minimum sea water level.

- The possible maximum sea water level of the nuclear power plant's site was calculated conservatively by combining the height of high tide level, maximum sea water level following coastal flooding, and wave runup; there is no possibility of inundation of structures because the possible maximum sea water level is lower than the site elevation (including sea wall).

<Table> Possible maximum sea water level by the nuclear power plant's site and freeboard (m)

	Possible maximum coastal flooding		Maximum possible sea water level	Site elevation*	Freeboard
	Storm	Earth-quake			
Kori NPP	2.5	0.3	7.2	7.5 (Kori #1·#2)	0.3
				9.5 (Kori #3·#4)	2.3
Weolsung NPP	2.0	0.5	7.2	12	4.8
Youngkwang NPP	2.3	-	8.4	10	1.6
Uljin NPP	0.9	3.0	5.7	10	4.3

* Kori Units 1 and 2: site elevation 5.8m + sea wall 1.7m

- The possible minimum sea water level of NPP's site was also calculated conservatively by combining the low tide level and minimum sea water level following coastal flooding; cooling water intake is possible even in minimum sea water level condition by tsunami because the bell mouse of the intake pump is lower than the possible minimum sea water level.

○ On the premise that severe coastal flooding exceeding the design basis might occur, a total of 4 near-term improvements have been mandated for additional safety.

d. Improvements

[Goal of improvements]

- Securing the inundation prevention ability of main safety-related facilities even for coastal flooding exceeding design basis
- Securing the ultimate heat sink even for coastal flooding exceeding design basis

○ (2-1) Extension of sea wall of Kori NPP (short-term action, to be finished in the first half of 2012)

- Extend the height of the sea wall of Kori NPP (whose safe freeboard for coastal flooding is relatively low) to equal the height level (10m) of other

NPP sites (applied to Kori NPP)

○ (2-2) Installation of waterproof gate and waterproof drainage pump (mid- & long-term action, to be finished in 2014)

- Installing waterproof gate and waterproof drainage pump in structures that are seismically designed to cope with the possibility of inundation of the emergency power system and main safety facilities (including the inundation protection measure of penetration such as ventilating opening, etc.) (applied to all NPPs)

○ (2-3) Investigating and researching regarding the design basis sea water level of NPP sites (mid- & long-term action, to be finished in 2013)

- Investigating and researching regarding the design basis sea water level, in particular considering the "conservativeness" (how conservative the estimates actually are, particularly in regard to the simultaneous occurrence of seismic gap, super typhoon, etc.) of input data which was used to evaluate and determine the existing design basis sea water level (applied to all NPPs)

○ (2-4) Reinforcing cooling water intake ability and improving facilities in preparation for possible coastal flooding (mid- & long-term action, to be finished in 2015)

- According to the results of the investigation and research on NPP site's design basis sea water level (improvements 2-3), reinforcing the intake ability of equipment cooling water intake pump (particularly maintaining the minimum sea water level by rearranging the location of the bell mouse of intake pump and installing a submerged dam) (applied to all NPPs)
- Moving the material warehouse to a safe place which is away from inundation to cope with the possibility of damage to the material warehouse (warehouse for spare parts and replacements) in the event of severe coastal flooding (applied to Kori Units 1 and 2)

3. Integrity of electric power, cooling, and fire protection systems when inundation occurs

a. Current status

<Electric power systems>

○ The electric power facilities are designed to have two physically and electrically independent trains in accordance with the relevant nuclear power regulations.

- All nuclear power plants have two emergency diesel generators installed to cope with a loss of offsite power event.
- There is one alternative AC diesel generator per 2 or 4 units to cope with a station blackout event.

<Table> Installation Status of Alternative AC Diesel Generators

NPP	Alternative AC Diesel Generator	Remarks
Kori Units #1~#4	1 (5,500kW)	Installed in 2006
Youngkwang Units #1, #2	1 (5,500kW)	Installed in 2010
Youngkwang Units #3~#6	2 (6,500kW)	Installed at the time of construction
Uljin Units #1, #2	1 (5,500kW)	Installed in 2010
Uljin Units #3~#6	1 (7,000kW)	Installed at the time of construction
Weolsung NPP	2 (2,000kW)	Installed at the time of construction
New Kori (Shin Kori) Units #1, #2	1 (7,200kW)	Installed at the time of construction

<Cooling Systems>

○ Safety-related cooling facilities are designed to have multiple independent trains according to nuclear power regulations.

- Even if one train is out of order, cooling can be performed using the other trains.
- The spent fuel pool (SFP) has multiple secure cooling sources such as water tanks for fuel storage and a pure water storage tank to cope with a loss of cooling function.

<Fire protection>

○ Perform fire hazard analysis (which confirms the safe shutdown functionality) every 10 years according to nuclear power regulations.

- In addition, fire protection plans are established and implemented to prevent and extinguish fires and to secure safe shutdown functionality.

○ Fire-related regulations are divided into nuclear power regulations and firefighting regulations.

b. Contents of the Safety Review

<Electric power systems>

○ Appropriateness of electric power systems against design basis earthquakes and tsunami

- Emergency diesel generators, alternative diesel generators, batteries, etc.

○ Ensuring the functions of electric power systems against earthquakes and tsunami beyond design basis

- Establishment and appropriateness of their restoration plans upon loss of power sources due to a seismic event
- Restoration countermeasures upon flooding of emergency power sources and relevant facilities, such as battery capacity, etc.
- Appropriateness of connection points of electric power supplies vulnerable to inundation

<Cooling Systems>

○ Appropriateness of cooling systems against design basis earthquake and coastal flooding

- Equipment cooling water systems, spent fuel pool cooling systems, etc.

○ Ensuring the functions of cooling systems against earthquakes and tsunami beyond the design basis

- Ensuring the function of the ultimate heat sink (UHS)
- Coping with prolonged loss of cooling function in the spent fuel pool
- Integrity of cooling water sources installed outdoors and integrity of the harmful substances storage tank

<Fire protection>

○ Integrity of NPP fire protection facilities and emergency response ability

c. Results

<Electric power systems>

○ It is not likely that the electric power sources are flooded by design basis earthquakes and their tsunami.

- It is verified that the emergency power sources are capable of coping with seven days loss of offsite power supplies and the alternative diesel generators are capable of supplying emergency power for 8 hours in case of a station blackout event.

○ It is verified that the batteries have the capability to supply sufficient electric power to the connected electric loads upon occurrence of a design basis accident.

<Cooling Systems>

○ Cooling facilities are capable of maintaining safe functionality even on the assumption that one unit is out of order in normal operation and accidental conditions. Facilities that are capable of preventing loss of functions even in abnormal conditions (for example preventing / coping with an intake from clogged with foreign substances) are in place.

○ The spent fuel pool maintains the ability to remove the decay heat of spent fuel even for design basis accidents.

- Various cooling water sources such as fuel exchange water storage tanks, pure water storage tanks, etc. are secured to cope with a prolonged loss of cooling functionality of the spent fuel pool.

○ The refueling water storage tank and condensate storage tank installed outdoors are seismically designed and safe. Likewise, there are facilities that collect and process discharged solutions to cope with damage to the harmful substances tank (sulfuric acid, caustic soda, ethyleneamine, and so on)

<Fire protection>

○ Fire protection facilities are designed and installed according to firefighting and nuclear power regulations.

- Fire protection facilities keep their function of fire extinguishing through conduct of an integrated check according to firefighting regulations.
- Initial firefighting is appropriate since an initial firefighting team and their own fire fighting team exist to cope with fire in a power plant.

○ (Electrical power, cooling, fire protection systems) Assuming the worst case scenario of the NPP site flooded by severe coastal flooding beyond the design basis and all power supplies stop simultaneously in multiple units, a total of 11 improvements are mandated to ensure additional safety.

d. Improvements

<Electric Power Systems>

[Goals of improvements]

- Ensuring the vital electric power sources to secure the core states upon occurrence of natural disasters beyond design basis and station blackout events
- Ensuring alternative electric power sources within 2 hours

○ (3-1) Ensuring the availability of a movable vehicle for generator and batteries, etc. (mid- & long-term action, to be finished in 2014)

- Equipping the NPP site with one vehicle-mounted and portable emergency generator and battery (including charger and cables) in a safe place away from inundation to cope with the inundation of emergency and standby electric power sources and prolonged station blackout, and ensuring temporary points for connecting electric power sources (applied to all NPPs)

○ (3-2) Improving the alternative emergency diesel generator's capacity design basis (mid- & long-term action, to be finished in 2014)

- Improving the alternative emergency diesel generator's design basis (capacity, diversifying its cooling methods, ensuring one day minimum fuel supply) (applied to all NPPs)

○ (3-3) Fastening down the standby transformers with anchor bolts and improving the fuel injection port facilities of Weolsung NPP's emergency power supply system (short-term action, to be finished in 2012)

- Fastening standby transformers with anchor bolts to prevent damage and floating / moving of standby transformers owing to a large earthquake or due to coastal flooding (applied to all NPPs)
- Repositioning the injection port of the fuel storage tank of emergency power supply system to an area higher than the ground surface in Weolsung NPP, which was originally installed in an area lower than the ground surface (applied to Weolsung NPP)

○ (3-4) Improving the management of switchyard facilities (mid- & long-term action, to be finished in 2013)

- Clarifying that there is no problem in safety (preparing procedures for restoring electrical power supply by discussing with KEPCO (Korea Electric Power Corporation) for quick restoration following loss of offsite power supplies due to earthquake or coastal flooding) (applied to all NPPs)

<Cooling Systems>

[Goals of Improvements]

- The cooling function of spent fuel pool and necessary sea water should be restored within 4 days and 2 hours, respectively, upon occurrence of natural disasters beyond design basis.

○ (3-5) Ensuring countermeasures when loss of the cooling function of the spent fuel pool occurs (short-term action, to be finished in 2011)

- When the loss of function of pump and heat exchanger of the spent fuel pool cooling systems occurs, preparing a supplementary method of cooling water using a fire truck and installing a connection point for the truck (applied to all NPPs)

○ (3-6) Preparing the inundation prevention and restoration method for the ultimate heat sink (mid- & long-term action, to be finished in 2013)

- Waterproofing electrical facilities such as motors and power cabinets of equipment cooling water system pump so that they can cope with large storms and tsunamis (applied to all NPPs)
- Securing spare parts of the motor and establishing restoration procedures for loss of function (applied to all NPPs)

○ (3-7) Preparing damage countermeasures for outdoor tanks (mid- & long-term action, to be finished in 2014)

- Installing a wall barrier to cope with damage to the cooling water tank and the chemical substances tank potentially caused by earthquake and coastal flooding (applied to all NPPs)

○ (3-8) Preparing inundation countermeasures for the main steam safety valve room and emergency feed water pump room (mid- & long-term action, to be finished in 2014)

- Preparing inundation prevention and damage countermeasures for the main steam safety valve room of Weolsung Units 2 through 4 and emergency feed water pump room of Weolsung Units 1 through 4, which are installed on the ground (applied to Weolsung NPP)

<Fire protection>

[Goals of improvement]

- Reinforcing the internal and external firefighting team and cooperation systems

○ (3-9) Improving the firefighting plan and reinforcing cooperation systems (short-term action, to be finished in 2012)

- Improving the firefighting plan, e.g., simplifying procedure for supporting the request of external firefighting team, improving the in-out procedure, establishing effective cooperation systems during mobilization, measures planned for a major fire (applied to all NPPs)
- Reinforcing cooperation systems between the internal and external fire stations of the NPP, supplementing the firefighting ability of the adjacent 119 safety center and regional team (applied to all NPPs)

○ (3-10) Improving fire protection facilities and response ability of the NPP's own firefighting team (mid- & long-term, to be finished in 2015)

- In the event that it is impossible to use firefighting water sources in an NPP due to severe coastal flooding, ensuring alternative water sources linked to fire truck (applied to all NPPs)
- Ensuring and maintaining the minimum numbers of experts to operate chemical fire trucks belonging to NPP's own firefighting team (applied to all NPPs)

○ (3-11) Introducing firefighting design focusing on performance to NPP (short-term action, to be finished in 2012)

- Improving NPP management as a facility to which firefighting design focusing on performance is applied, by taking into account the characteristics of the NPP so as to optimize firefighting, considering the frequency and likely effects (applied to all NPPs)

4. Severe accident response

a. Current status

○ Severe accident prevention and mitigation measures are being implemented according to the policy on severe accidents (August, 2001).

- Evaluating the capability of preventing and coping with severe accidents
- Developing the Severe Accident Management Guide
- Probabilistic Safety Assessment (PSA)

○ In case of severe accidents at Kori Unit #1 and NPPs built after the Uljin Units #3 / #4, the facility for removing hydrogen created within the containment building is installed, and all NPPs except Uljin #1 / #2 and Weolsung NPP are equipped with a real-time monitoring system for hydrogen concentration.

<Table> Installation status of domestic NPP's hydrogen control facilities

Kori #1	Kori #2~#4, Youngkwang #1~#4, Uljin #1 · #2	Weolsung #1	Weolsung #2~#4	Youngkwang #5·#6, Uljin #3~#6
Passive Hydrogen Recombiner, 34EA	Thermal Recombiner	None	Ignitor 44EA	Thermal Recombiner, Ignitor 18~20EA

※ Passive Auto-catalytic Recombiner (PAR) is not necessary, but Thermal Recombiner and Ignitor are necessary.

b. Contents of the Safety Review

○ Validity of facilities for preventing and coping with severe accidents

- hydrogen control, nuclear reactor depression and cooling capacity, containment building's depression capacity, etc.
- Viability of equipment and measuring instruments under severe accident environment and conditions

○ Appropriateness of severe accidents strategies and accident management plan

- Applicability of the Severe Accident Management Guide
- Management capability for handling of severe accidents

○ Appropriateness of cooling methods of the nuclear reactor in the event of station blackout (SBO)

- Appropriateness of strategies of feedwater injection of steam generator and cooling methods of nuclear reactors

c. Results of safety review

○ Facilities against severe accidents are continuously supplemented according to TMI follow-up, Policy on Severe Accident (Aug. 2001), and continuous in-service standards for the in-service NPPs; the response capability of the operator is increased by use of the Severe Accident Management Guide.

○ The nuclear reactor cooling facility and a related mitigation procedure in the event of station blackout are in place such that reactor core cooling is maintained for a certain period after accidents.

- A nuclear reactor cooling procedure using the turbine-driven auxiliary feedwater pump and related equipment exists; sufficient electrical power for equipment and instruments for use during severe accidents can be supplied for more than 2 hours.

○ Currently, Korean response strategies of the Severe Accident Management Guide are established on the premise that a power supply is available for the cooling of nuclear reactor, hydrogen control, water sprinkling, and ventilation of the containment building.

○ On the premise that nuclear fuel melts due to the total loss of cooling function as a worst case scenario, 6 improvements to ensure additional safety are mandated.

d. Improvements

[Goal of improvements]

- Preventing severe accidents when natural hazards beyond the Design Basis occur
- Ensuring the cooling function such as reactor cooling and depression, etc. to prevent reactor core damage
- Securing the ability to monitor major safety parameters when severe accidents occur
- Maintaining the integrity of the containment building despite hazards such as hydrogen explosion and ensuring the control functions for the release of radioactive materials into the environment

○ (4-1) Installing passive hydrogen removal equipment (mid- & long-term, to be finished in 2013)

- Install passive hydrogen removal equipment that can be operated without any power supply (applied to all NPPs except existing Kori Unit #1).
- Install real-time hydrogen monitoring equipment within the containment buildings (applied to Uljjin #1 / #2, Weolsung #1 through #4) (to be finished in 2015).

○ (4-2) Install ventilation or depressurizing facilities in the containment buildings (mid- & long-term, to be finished in 2015).

- Install filtered vent or depressurizing facilities within the containment buildings to prevent the excessive rise of pressure in preparation for severe accidents (applied to all NPPs).

○ (4-3) Install conduits for injecting nuclear reactor emergency cooling water from external sources (mid- & long-term, finished in 2015).

- Install primary and secondary injection conduits for emergency cooling water in preparation for prolonged loss of cooling function (applied to all NPPs).

○ (4-4) Reinforcing education and training for severe accidents (short-term action, immediately application)

- Training the operators using various severe accidents scenarios of the Severe Accident Management Guide and severe accident Simulator, extending the training time from 8 hours for 2 years to yearly 10 hours (applied to all NPPs)

○ (4-5) Amending the Severe Accident Management Guide to reinforce the effectiveness of accident management strategies (short-term action, finished in 2012)

- Evaluating the validity of availability of make-up water flow and cooling capacity in terms of the current strategies for the reactor cavity cooling water make-up, reflecting them on the Severe Accident Management Guide (applied to all NPPs)
- Evaluating viability considering the long-term loss of off-site power for the necessary equipment and instruments, establishing the power supply procedure based on the priority of power recovery (applied to all NPPs)

○ (4-6) Developing Low-Power Shutdown Severe Accident Management Guides (short-term action, finished in 2012)

- Developing the Severe Accident Management Guide by evaluating the low-power shutdown severe accident (applied to all NPPs)

5. Emergency Response and Emergency Medical Systems

a. Current Status

○ The radioactive emergency response for NPPs is implemented according to the radiation emergency plan that is prepared and approved based on the 「The Act on Physical Protection and Radiological Emergency (APPRE)」.

○ The emergency response facilities located in and out of the power plant are appropriately secured, checked and managed periodically.

○ To check the effectiveness of the radiation emergency plan and implementing procedure and to enhance emergency response ability conduct: full training (on-site emergency exercise) every single year, joint training (integrated emergency exercise) supported by the local government every 4 years, and allied training (unified emergency exercise) supported by the central government every five years.

	Unified Emergency Exercise	Integrated Emergency Exercise	On-site Emergency Exercise	Drill
Organized by	Central government (every 5 years)	Local government (every 4 years by site)	Korea Hydro & Nuclear Power Co., Ltd. (every year by power plant)	Korea Hydro & Nuclear Power Co., Ltd. (every quarter by power plant)
Range of participation	Nation-wide disaster organization	All local disaster organizations	Power plant's disaster organization	Power plant working group

○ With the Korea Institute of Radiological & Medical Sciences (KIRAMS) at the center, primary organizations around NPP, and secondary organization by "shi" (city) and "do" (county), a total of 22 organizations and 400 emergency medical treatment agents are designated and operated to cope with radiation disasters.

Division	No. of Organizations	Role
Primary designated organization	9	Initial medical response (classifying injuries and first aid/decontamination)
Secondary designated organization	12	Medical treatment for excessive radiation exposure, burn, serious trauma, etc.
Korea Institute of Radiological & Medical Sciences	1	Medical treatment for acute radiation syndrome and contaminated internal person

○ Current status of reserved potassium iodide (KI) and gas mask for residents around NPP

- Reserved KI quantity: Available at KIRAM, local government around NPP; sufficient for about 120,000 people
- Reserved gas mask quantity: Available at local government around NPP; sufficient for about 61,700 people

b. Contents of the Safety Review

○ Emergency plan related to standards, procedures, and organization for issuing emergency alert

- Whether the plan adequately secures standards and procedure for issuing emergency alert in preparation for issuing emergency alert, organizing emergency agents, launching an emergency organization, and securing command and control system
- Whether management standards for emergency recovery workers and protection workers are appropriate

○ Emergency response facilities and equipment
- Emergency response facilities of the NPP and the local government
- Emergency communication alarm facilities in and out of the station
- Securing status of protective appliances such as protective clothing, radiation monitor

○ System operating status for protecting residents in case of emergency
- Operating SPDS (Safety Parameter Display System) and environmental radiation monitor
- Connectivity with the environmental radiation monitoring center in the event of a blue-level or red-level emergency
- Need for additional installation of environmental radiation detectors
- Information disclosure procedure

○ Emergency medical systems
- Indoor response manual for emergency patients
- Managerial book for training course for emergency agents and status of course completion, facilities, equipment, goods, and medicine for emergency response

○ Training for confirming emergency response ability
- Status of conducting training such as training scenario and training performance

c. Results

○ The standards and procedures for issuing emergency alerts, organizing emergency agents, and securing the command and control system and functions, duties, and launching time of the emergency response organization, etc., are clearly described in the radiation emergency plan and implemented accordingly.

- Contents include items such as the protection measures for residents and evacuation of personnel within the power plant, protection measures for thyroid, entrance control in emergency, limitation of food intake, agreement with the designated radiation emergency medical treatment hospital, meeting related standards

○ In case an emergency is prolonged, preparations such as support by other NPP's headquarters, operating shift work, and worker support plans according to the shift work organizing and operating procedure are established properly.

○ TSC (Technical Support Center), OSC (Operating Support Center), and EOF (Emergency Operation Facility) as emergency response facilities are secured and managed properly so that they are able to start and respond quickly in the event of an emergency.

- Each emergency operation facility has radiation prevention equipment; and checks and manages the equipment periodically (monthly, etc.).

○ Major operating variables are provided to related emergency response organizations such as the Ministry of Education, Science, and Technology and Korea Institute of Nuclear Safety through CFMS (Critical Function Monitoring System) and SPDS (Safety Parameter Display System), which are supplied with electrical power by battery (2~10 hours' capacity) in case of station blackout.

○ An emergency broadcasting network is installed and operated properly 2km around the NPP including a dedicated telephone network and satellite phone for emergency telecommunication with related organizations in and out of the station.

○ Each power plant has operating radiation safety management procedures for abnormal radiation conditions and urgent tasks.

○ There are contract provisions for use of staff of the maintenance partner, KEPCO KPS, in the event of a radiation emergency; currently, prevention education and training are conducted for some staff of the partner designated as a prevention agency.

○ The ERMS (Environmental Radiation Monitoring System) installed on the shoreline around the NPP contains a battery whose capacity is 4 hours in preparation for loss of electrical power.

○ The primary and secondary emergency medical treatment organizations with the NPP as the center are properly organized and operated.

- Local government around the NPP, Korea Institute of Radiological & Medical Sciences, and emergency medical treatment organizations have facilities and medicine for radiation-contaminated patients.
- With the emergency medical treatment organization by region as the center, response training for emergency medical treatment is conducted every year so that proper medical treatment response can be executed.

○ A total of 11 improvements to respond to the worst radiation disasters such as simultaneous issuing of emergency alert at multiple units are mandated.

d. Improvements

[Goals of improvements]

- Securing emergency response ability considering natural hazards beyond the design basis
- Maintaining the emergency response function even for the event of simultaneous issuance of emergency alert at multiple units

○ (5-1) Securing additional radiation protection equipment for protecting residents near NPP (short-term action, to be finished in 2012)

- Securing a supply of potassium iodide (KI) increased from 120,000 portions to 500,000 portions and gas mask from 60,000 EA to 480,000 EA for protecting residents near NPPs in preparation for large accidents (applied to all NPPs)

※ (Securing standards) Increasing population basis from residents within 10km around NPP -> to population within 16km around NPP

○ (5-2) Amending the radiation emergency plan to include such events as simultaneous issuing of emergency alert at multiple units (short-term action, to be finished in 2011)

- Reflecting on the radiation emergency plan measures such as composing the emergency response organization applicable to simultaneous natural disaster emergencies at multiple units, including operating methods, standards for issuing emergency alerts reflecting the scale of coastal flooding, and starting times of emergency response organization (applied to all NPPs).

○ (5-3) Securing additional equipment in preparation for an event wherein the emergency is prolonged (short-term action, to be finished in 2012)

- Securing additional protection devices such as protective clothing and gas mask filter at more than 200% of the current inventory levels and storing them in a secure place that will not flood (applied to all NPPs)

○ (5-4) Expanding the equipment of the emergency medical treatment organization (mid- & long-term, to be finished in 2013)

- Expanding emergency medical treatment facilities and medical equipment and designating the emergency medical treatment organization (Korea Institute of Radiological & Medical Sciences) for quick initial medical treatment in case of radiation disasters

○ (5-5) Reinforcing the radiation emergency training (short-term action, to be finished in 2012)

- Developing a practical scenario for earthquake and coastal flooding and using it for prevention training and further increasing emergency response capabilities through sudden training (applied to all NPPs)

○ (5-6) Devising a means of securing necessary information in case of prolonged loss of electrical power (mid- & long-term, to be finished in 2013)

- Reinforcing the electrical power equipment of CFMS and SPDS to provide the necessary safety variables of the power plant as needed to protect residents (applied to all NPPs)
- Establishing inundation prevention measures for environment monitors near nuclear power plants in case of major coastal flooding and securing additional emergency electrical power in preparation for prolonged loss of electrical power (applied to all NPPs)

○ (5-7) Securing countermeasures for protecting maintenance workers (short-term action, to be finished in 2012)

- Including the maintenance workers of the partners in the emergency organization of Korea Hydro & Nuclear Power Co., Ltd., and amending the radiation emergency plan so that these people can receive preventive education and training (applied to all NPPs)

- Preparing standardized procedures (deciding the urgent work, approval procedures, etc.) so that there is no confusion in protecting workers performing urgent work in case of a radiation emergency situation (applied to all NPPs)

○ (5-8) Improving the emergency response facilities (mid- & long-term, to be finished in 2015)

- Improving the seismic capacity of TSC and OSC (applied to Kori NPP) and ability to prevent inundation (applied to Kori NPP, Youngkwang Units #1, #2) in preparation for coastal flooding and earthquakes exceeding site elevation
- Securing the proper area of TSC and OSC (applied to Kori NPP, Uljin Units #1, #2, Weolsung NPP) and emergency electrical power (applied to all NPPs)

○ (5-9) Amending the information disclosure procedure in the event of radiological emergency (short-term action, to be finished in 2012)

- Amending the radiation emergency plan and related manual (risk response manual, etc.) so that concrete information (real-time information disclosure list, radiation contamination, guide to protecting residents) and the period of information disclosure provided to the press, people, and residents are included (applied to all NPPs).

○ (5-10) Evaluating protective measures for residents who live beyond the emergency plan area (mid- & long-term, to be finished 2014)

- Evaluating protective measures for residents who live outside the emergency plan area, considering the same site and simultaneous accidents at multiple units (applied to all NPPs)

○ (5-11) Reinforcing the performance of emergency alarm facilities (mid- & long-term, to be finished in 2014)

- Securing emergency electrical power for alarm facilities installed to protect staff and residents who reside within the power plant and within the 2km radius of the NPP in preparation for natural hazards beyond the design basis (applied to all NPPs)

6. Kori Unit #1 and Long-term, in-Service NPP

a. Current status

<Kori Unit #1>

○ Kori Unit #1 is the first domestic commercial operation nuclear reactor, and its major aged parts are replaced after it commenced commercial operation in 1978; it has been operated continuously since Dec. 2007.

- A total of 26 main systems have been secured such as main condenser replacement (in 1988), low pressure turbine replacement (in 1997), steam generator replacement (in 1998), main transformer replacement (in 2002), reactor coolant pump internal replacement) (in 2005), AAC diesel generator newly established (in 2006), PAR (Passive Autocatalytic Recombiner) newly established (in 2010), etc.
- Aging management program and life evaluation for major SSCs (structure, system, & components) such as steel containment building, reactor vessel, safety class piping, etc. are implemented according to relevant requirements.

<Long-Term In-Service NPP>

○ Monitoring decomposition, assembly, leakage, and foreign objects of the reactor of long-term in-service NPP, these are managed according to appropriate procedures.

- A surveillance program to check the neutron irradiation embrittlement of the reactor vessel is operated according to notice #2009-37 (MEST.Reactor.014) of the Ministry of Education, Science, and Technology.
- A long-term, in-service inspection plan is prepared to confirm the integrity of reactor vessel welds, upper and lower head penetrations, heavy water reactor, and pressure tube.

○ A long-term, in-service inspection plan is established and implemented to confirm the integrity of the piping of major systems such as the reactor coolant system.

- According to the inspection results of the steam generator tube, indications exceeding the allowable levels of aging were confirmed, and aging management (plugging) is performed accordingly.

○ Performance testing for the major active components (pumps and valves) of long-term, in-service NPPs is conducted according to the in-service test plan and technical specifications

- Operability is confirmed through the fixed cycle test for pumps and valves as safety-related active equipment

○ A hydrogen controller is installed in long-term, in-service NPPs (Kori Units #1~#4, Youngkwang Units #1 / #2, Uljin Units #1 / #2) to guard against hydrogen explosions

b. Contents of Safety Review

<Kori Unit #1>

○ Overall reexamination of the "continued operation" evaluation item

- Fatigue integrity and life assessment of equipment and piping
- Life assessment of steel containment building and penetrations
- Validation of environmental qualification and life assessment of safety-related electrical equipment
- Conducting an on-site inspection for equipment subject to evaluation of seismic adequacy
- Evaluation of appropriateness of reinforcement measures for reinforced seismic equipment
- Confirming the performance of the PAR

○ Adequacy of implementation of the aging management program

- Appropriateness of implementation status of aging management by area

○ Integrity of the reactor vessel

- Analyzing and evaluating the surveillance capsule
- Analyzing and evaluating the inspection records of the weld zone of the reactor vessel

○ Evaluating sudden shutdown, managing human factors, quality assurance/control activity

○ Automatic reactor trip event (4.12) reason: caused by ripple effects due to the burnout of a circuit breaker for the power supply in the station and connection point to external power supply, this occurred during normal operation and under full power

<Long-term, In-Service NPP>

○ Appropriateness of management of the aging of long-term, in-service NPPs

○ Aging monitoring (reactor vessel, steam generator, piping and support, emergency diesel generator, etc.) of long-term, in-service NPPs

○ Appropriateness of management of major active components (pumps and valves) of long-term, in-service NPPs

○ Determine whether or not facilities to cope with severe accidents are installed and normally operated

- Whether the hydrogen controller is operated or not, and appropriateness of operation

c. Results

<Kori Unit #1>

○ The fatigue life evaluation of components and piping, and the reliability assessment of the emergency diesel generator, as major items for the assessment of continued operation, are conducted properly.

- For the fatigue life evaluation of safety class 1 components and piping, the fatigue monitoring system is used and cumulative fatigue usage factor meets the acceptance criteria of KEPIC (Korea Electric Power Industry Code).
- All electrical components (891 EA) whose remaining life was less than 10 years, were replaced (in 2007); 789 lines of cable are now being replaced as scheduled.

- The design capacity of the emergency diesel generator is 2,920 kW, but the current necessary electrical load is 2,763 kW, thus with a margin of about 6%. The operating reliability is more than 0.99%, thus meeting target value of 0.975.

○ The steel containment building and penetrations during continued operation are verified as maintaining their integrity in regard to fatigue.

- For the steel containment building, the number of repetitions between air pressure and operational pressure, pressure change during normal operation, temperature difference according to start and stop, and every mechanical load change except pressure, are verified to meet the requirements of KEPIC.

- The estimated number of transient state (heating and cooling) for the penetrations of the main steam line and feeder water line (as piping penetrations that are most vulnerable to temperature and pressure change) is verified to be less than the number considered in the design.

○ The maintenance status of components as the subject of evaluation of seismic adequacy is good, and seismic reinforcing and replacement construction are appropriate.

○ The status of PAR located in the accessible zone within the containment building is good; it meets the performance criteria (responding temperature) after testing the performance of the hydrogen removal ability of the catalytic plate.

○ The aging management program is properly established and implemented by the subjects of evaluation according to MEST Notice No. 2009-37 (MEST. Rector.035) and continued operation review guidelines (KINS/GE-N8).

○ The integrity of the reactor vessel is assured during continued operation because the result of the monitoring test for reactor vessel meets the acceptance criteria of MEST Notice No. 2009-37(MEST.Reactor.014) and U.S. Federal Law (10 C.F.R. 50).

- For low upper shelf energy, safety margin is verified through the fracture toughness test and interpretation; the absence of cracking is verified based on 100% volumetric non-destructive examination of beltline region welds.

- For pressurized thermal shock, the reference temperature of PTS, RT_{PTS} (127℃) of the pressurized thermal shock is verified to meet the acceptance criteria (below 149℃), which use precise destructive examination according to the ASME Code procedure (Master Curve method).
  - ※ This method is regulated in 10 C.F.R. 50 (US Regulation) and IAEA TECDOC-1631, etc.
- The Pressure-temperature limit curve is drawn properly according to the method provided in the domestic law and KEPIC and ASME Code, and enough safe operating area is secured.
- In terms of the objective integrity assessment for a nuclear reactor vessel, external experts conducted independent verification interpretation for the upper shelf energy, pressurized thermal shock, and pressure-temperature limit curve. As a result, related requirements are confirmed to have been met.

○ The in-service inspection of reactor vessel welds was conducted properly according to MEST Notice No. 2009-37 (Mest.Reactor.016) and KEPIC, and the results of ultrasonic testing meet the acceptance criteria without cracks, etc.

- Selection of examination subjects, examination method, examination contents, and examination results are verified to be appropriate based on re-evaluation by domestic and overseas experts.

○ Fire protection facilities were properly managed according to MEST Notice No. 2010-27 (Mest.reactor.031), 2009-37 (Mest.reactor.032), and KEPIC; they are also managed properly because improvements to increase fire safety are identified and implemented every ten years in the fire hazard analysis re-evaluation and periodic safety evaluation.

○ Evaluating the reactor's sudden shutdown factors, managing human factors, quality assurance, and control activity

- Trip-inducing equipment management systems that especially manage the reactor's shutdown factors and operation improvement program that traces and manages shutdown prevention countermeasures have been operated since 2007; they were verified to try to prevent sudden shutdown again and again through equipment improvement.

- Human factors were verified to have been considered properly according to standard implementation procedure and HFE (Human Factors Engineering) instruction in the recent 10-year design changes and maintenance performed for human-machine connection facilities in the main control room and remote shutdown console.
- To assure the quality of replacements, general standardized products quality examination program for discontinued models is established as a company-wide standard implementation procedure; training for resident workers of partners is conducted to assure maintenance quality.

○ The sudden shutdown of the Kori Unit #1 nuclear reactor (4.12) was caused by overheating due to the lack of tension in a spring for breaker terminal connection; poor management of spring-related quality is thus a cause of the accident.

- Due to the problem of use of a non-safety class breaker, the problem of blocked off-site power with regards to power supply for safety-class systems occurs, and improving this is necessary.
- Need to prepare a means of reflecting the facilities improvements after installing the supplied items

<Long-Term In-Service NPP>

○ The aging of long-term, in-service NPP is evaluated according to the nuclear law enforcement regulations (details of periodic safety evaluation).

○ The Surveillance Test to monitor the radiation embrittlement of the reactor vessel of the long-term, in-service NPP is conducted appropriately according to MEST Notice No. 2009-37 (Mest.reactor.014); in-service inspection for the components and piping of the main system such as reactor vessel welds, upper head penetrations, heavy water reactor, pressure tube and reactor coolant system, etc. is conducted appropriately according to MEST Notice No. 2009-37 (Mest.Reactor.016).

○ The performance test for the main active components (pumps and valves) of the long-term, in-service NPP is conducted appropriately according to the in-service test plan and technical specification established by MEST Notice No. 2009-37

(Mest.reactor.033), with operation availability confirmed through the fixed cycle test.

○ Comprehensive results

- 8 improvements to reinforce the safety of the long-term, in-service NPP including Kori Unit #1 are deduced and mandated.
- 2 further improvements to prevent the occurrence of any other cases similar to Kori Unit #1 automatic trip (4.12) are also mandated

d. Improvements

[Goals of improvements]

- Preventing the deterioration of safety margins due to aging
- Preventing the occurrence of the same type of sudden shutdown by reinforcing the maintenance quality of long-term, in-service NPPs

<Long-Term, In-Service NPPs Including Kori Unit #1>

○ (6-1) Drastically reinforcing the safety examinations, such as regular examination (short-term action, to be finished in 2012)

- Establish and implement mitigation measures and management plans for aging and verify its appropriateness during the periodic inspection. (applied to Kori #1 to #4, Youngkwang #1 & #2, Uljin #1 & #2, and Weolsung #1)
- Add to the existing periodic inspection items new items such as "monitoring the life of the main components" related to continued operation; if necessary, extend the inspection period. (applied to Kori #1)

○ (6-2) Reinforcing the in-service inspection of the main components and pipes (short-term action, immediate application)

- Shorten the period of inspection of the reactor vessel beltline welds (from 10 years to 5 years) (applied to Kori #1)
- Expand the in-service inspection scope for class 1 piping (from 25% to 50%). (applied to Kori #1)

○ (6-3) Establishing and implementing an integrated management method for the aging management program (short-term action, to be finished in 2012).

- Establish and implement an integrated management method for establishing, amending, and implementing the aging management program (applied to Kori Unit #1).
- Install and operate a dedicated organization for the total management of the aging management program (applied to Kori Unit #1).

○ (6-4) Reinforcing the management of performance parameter of the main active components (short-term action, to be finished in 2012).

- Analyze the trend of performance parameters of safety-related pumps and valves and reinforce management thereof (applied to Kori #1 & #2, Uljin #1 & #2, Youngkwang #1 & #2, Weolsung #1 to #4).

○ (6-5) Install a fatigue monitoring system to reinforce quantitative fatigue management. (mid- & long-term, to be finished in 2015)

- Install a fatigue monitoring system in the long-term, in-service NPP and reinforce quantitative fatigue management. (applied to Kori #2, #3, #4, Youngkwang #1 & #2, Uljin #1 &#2).

○ (6-6) Reinforcing the fatigue integrity of the pressurizer lower head (short-term action, to be finished in 2012).

- According to the reactor coolant's inflow and outflow, reinforcing fatigue integrity of the pressurizer lower head (applied to Kori #2, #3, #4, Youngkwang #1 & #2, Uljin #1 & #2).

○ (6-7) Increasing the reliability of trip-inducing equipment (short-term action, to be finished in 2012).

- To increase the reliability of trip-inducing equipment, reflect past fault cases and fundamental reason for faults on the preventive maintenance program (applied to all NPPs).
- To prevent the human errors of partners and service companies and to secure maintenance service quality, reinforce education and training for workers (applied to all NPPs).

○ (6-8) Evaluating the appropriateness of operators (mid- & long-term, to be finished in 2013).

- Evaluate the appropriateness of staff by analyzing the duty, reflecting the organization change and subcontracts for current operators whose staffing number limit decreased 15% compared to staffing in 2007; based on the results, take actions such as recruiting (applied to Kori Units #1, #2).

<Kori Unit #1 Automatic Trip (4.12) Similar Case Occurrence Prevention>

○ (6-9) Increase reliability of station power supply systems (mid- & long-term, to be finished in 2013)

- Considering the fact that breaker damage affects the systems supplied with external electric power, review the design wherein unsafe bus and safe bus are divided, so that the unsafe bus fault does not to affect the safe bus, and to increase the reliability of the station power supply systems. (applied to Kori Unit #1)

○ (6-10) Reinforcing the examination of the purchase quality assurance system (short-term action, to be finished in 2011)

- Reinforce quality requirements in the purchaser specification to avoid using defective parts for equipment that can induce the reactor's shutdown; in cases of design changes by manufacturers, specify such in the equipment supply contract for feedback. (applied to all NPPs)

7. Research reactor, nuclear cycle facilities

a. Current status

○ Hanaro consists of a reactor building and stack with 0.2g (design earthquake); a radiation emergency plan has been established, so possible domestic earthquake and emergency response is prepared. Hanaro is not located in a coastal area, so tsunami damage is not an issue.

○ The radiation emergency plan of NPP fuel processing facilities is made and classified by standards for issuing emergency alert, according to the type of event.

b. Contents

○ Appropriateness of earthquake, inundation, and fire preparedness

○ Appropriateness of the emergency plan and related manual against earthquake

c. Results

○ Appropriateness of earthquake, inundation, and fire preparedness

- The reactor building and stack are seismically designed based on the design earthquake (0.2g), and integrity is secured for the design earthquake.
- Hanaro reactor building, IMEF (Irradiated Materials Examination Facility), and PIEF (Post Irradiation Examination Facility), and nuclear waste processing facilities building are verified to be maintained properly.
- The absence of leaks in the Hanaro reactor pool, working pool, and spent fuel pool is verified.
- The firefighting and fire responding system is verified to be appropriate in the event of a loss of function of firefighting water supply systems due to an earthquake.

○ Appropriateness of the emergency plan and related manual against earthquakes

- "White-level" of issuing emergency criteria is established for the Hanaro facilities in case of natural disasters (earthquakes, etc.).
- After checking the emergency response organization, the number of staff of the prevention organization is 4 during normal conditions, but over 200 staff are designated as prevention staff in radiological emergency conditions; thus, the composition of emergency organization and agents are appropriate.

○ 3 improvements for Hanaro and nuclear cycle facilities to respond effectively to very large localized heavy rain beyond the design basis have been mandated.

d. Improvements

[Goal of improvements]

- Preventing radiation leakage accident due to natural disaster and fire
- Increasing the effectiveness of emergency response

○ (7-1) Evaluate the seismic capacity of structures and improve the main control room (short-term action, to be finished in 2012).

- Evaluate the seismic capacity of the Hanaro nuclear reactor building and stack for earthquakes beyond the design basis.
- Prevent ceiling and lighting equipment from collapsing and fix office appliances to protect the operators in the reactor control room in case of earthquake.

○ (7-2) Re-evaluate the site's inundation depth of Hanaro and additional facilities (short-term action, to be finished in 2011).

- Calculate the possible maximum rainfall considering the change of rainfall intensity according to the recent global climate change and re-evaluate the site's inundation depth of Hanaro (if necessary, improve facilities)

○ (7-3) Amend the radiation emergency plan, reflecting the complicated radiological emergency condition (short-term action, to be finished in 2011)

- Evaluate complicated radiological emergency conditions (simultaneous accidents at multiple facilities, various radioactive materials release) and reflect the results on the radiation emergency plan (applied to Hanaro, NPP fuel processing facilities)

III. Comprehensive Conclusions

☐ It is verified that Korean NPPs are safe for expected maximum potential earthquake and coastal flooding based on investigation and research to date.

○ Implementation of 50 long- & short-term improvements for earthquake, coastal flooding, and severe accidents to secure safety even for natural hazards beyond the design basis such as the recent natural disaster at Japanese NPPs

☐ The continued operation of the Kori Unit #1 is re-verified not to have safety-related problems.

○ Unlike other NPPs, however, the examination period of the Kori Unit #1 regular safety examination needs to be extended / conducted every one year; examination items (main components' life cycle monitoring, etc.) related to continued operation should be added, and differentiated safety examination, conducted vigorously.

IV. Future Plans

☐ Reviewing the semiannual performance of implementation by Korea Hydro & Nuclear Power Co., Ltd. and site checking

☐ Holding a briefing session on safety review for residents

○ Presentation of results to the local government, residents, and private environment monitoring organizations

[Appendix] List of Improvements

Management No.	Improvements	Action※
1-1	Installing automatic seismic trip system	short-term
1-2	Improving the seismic capacity of the safe shutdown system	mid- & long-term
1-3	Investigating and researching on the maximum potential earthquake in NPP	mid- & long-term
1-4	Improving the seismic capacity of the main control room, e.g., seismic event alarm window	mid- & long-term
1-5	Improving the seismic capacity of the entrance bridge of Weolsung NPP	short-term
2-1	Extending the height of the sea wall of Kori NPP	short-term
2-2	Installing waterproof gate and drainage pump	mid- & long-term
2-3	Investigating and researching on NPP site's design basis sea water level	mid- & long-term
2-4	Reinforcing the intake ability of cooling water and improving facilities to cope with coastal flooding	mid- & long-term
3-1	Securing a movable generating vehicle as well as batteries	mid- & long-term
3-2	Improving the design basis of the alternative emergency diesel generator	mid- & long-term
3-3	Fastening standby transformers with anchor bolt and improving the fuel injection port facilities of Weolsung NPP's emergency power supply system	short-term
3-4	Improving the management of switchyard facilities	mid- & long-term
3-5	Ensuring countermeasures when loss of the cooling function of spent fuel pool occurs	short-term
3-6	Preparing inundation prevention and restoration countermeasures for the ultimate heat sink	mid- & long-term
3-7	Preparing damage countermeasures for outdoor tank	mid- & long-term
3-8	Preparing inundation countermeasures for the main steam safety valve room and emergency feed water pump room	mid- & long-term
3-9	Improving the firefighting plan and reinforcing the cooperation system	short-term
3-10	Improving fire protection facilities and response ability of the NPP's own firefighting team	mid- & long-term
3-11	Introducing firefighting design mainly with NPP performance	short-term
4-1	Installing passive hydrogen removal equipment	mid- & long-term
4-2	Installing containment building ventilation or depression facilities	mid- & long-term
4-3	Installing conduits for injecting nuclear reactor emergency cooling water from external sources	mid- & long-term
4-4	Reinforcing education and training for severe accidents	short-term
4-5	Amending the Severe Accident Management Guide to reinforce the effectiveness of accident management strategies	short-term
4-6	Developing Low-power Shutdown Severe Accident Management Guides	short-term

Management No.	Improvements	Action※
5-1	Securing additional radiological protection equipment for residents near NPP	short-term
5-2	Amending the radiation emergency plan such as simultaneous emergency issuing at multiple units	short-term
5-3	Securing additional emergency equipment in preparation for long-term emergency issuing	short-term
5-4	Expanding the additional equipment of the emergency medical treatment organization	mid- & long-term
5-5	Reinforcing radiological emergency exercise	short-term
5-6	Devising a means of securing the necessary information in case of prolonged loss of electrical power	mid- & long-term
5-7	Securing protection countermeasures for maintenance workers	short-term
5-8	Improving the emergency response facilities	mid- & long-term
5-9	Amending the information disclosure procedure in case of radiological emergency	short-term
5-10	Public protective action beyond the emergency planning zone	mid- & long-term
5-11	Reinforcing the performance of emergency alarm equipment	mid- & long-term
6-1	Drastically reinforcing the safety examination such as regular examination	short-term
6-2	Reinforcing the in-service examination of main components and pipes	short-term
6-3	Establishing and implementing an integrated management method for the aging management program	short-term
6-4	Reinforcing the management of performance parameter of main active components	short-term
6-5	Installing the fatigue monitoring system for reinforcing quantitative fatigue management	mid- & long-term
6-6	Reinforcing the fatigue integrity of pressurizer lower head	short-term
6-7	Increasing the reliability of trip-inducing equipment	short-term
6-8	Evaluating the appropriateness of operators	mid- & long-term
6-9	Increasing the reliability of station power supply systems	mid- & long-term
6-10	Reinforcing the examination of purchase quality assurance system	short-term
7-1	Evaluating the seismic capacity of structures and improving the main control room	short-term
7-2	Re-evaluation of the site's inundation depth of Hanaro and additional facilities	short-term
7-3	Reflecting complicated radiological emergency conditions, amending the radiation emergency plan	short-term
Total	50 improvements	

※ short-term: to be finished in 2012, mid- & long-term: to be finished in 2013~2015