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Regulatory Approach for Oversight of APR1400 Constructions

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Overview of Nuclear Power Program

In Operation : 23 units

Under Construction : 4 units

Ulchin

Wolsong

Gyeongju

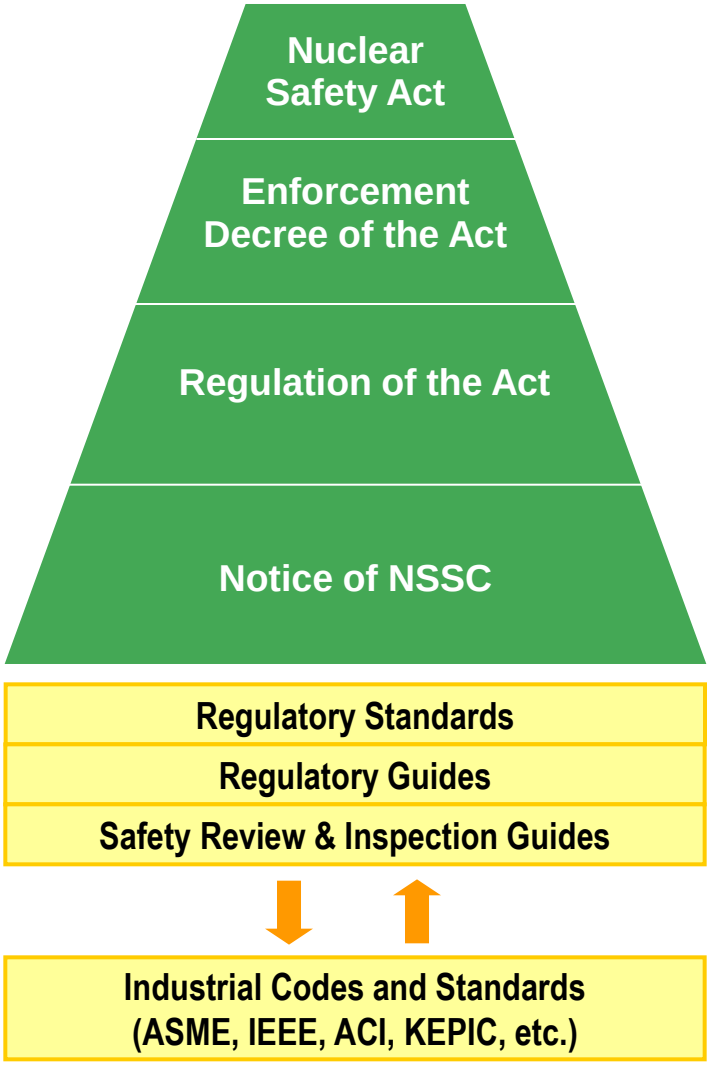
Low- and Intermediate- Level Waste Disposal Facility (Under construction)

Younggwang

Kori

In Operation
Under PSAR Review
Under Construction

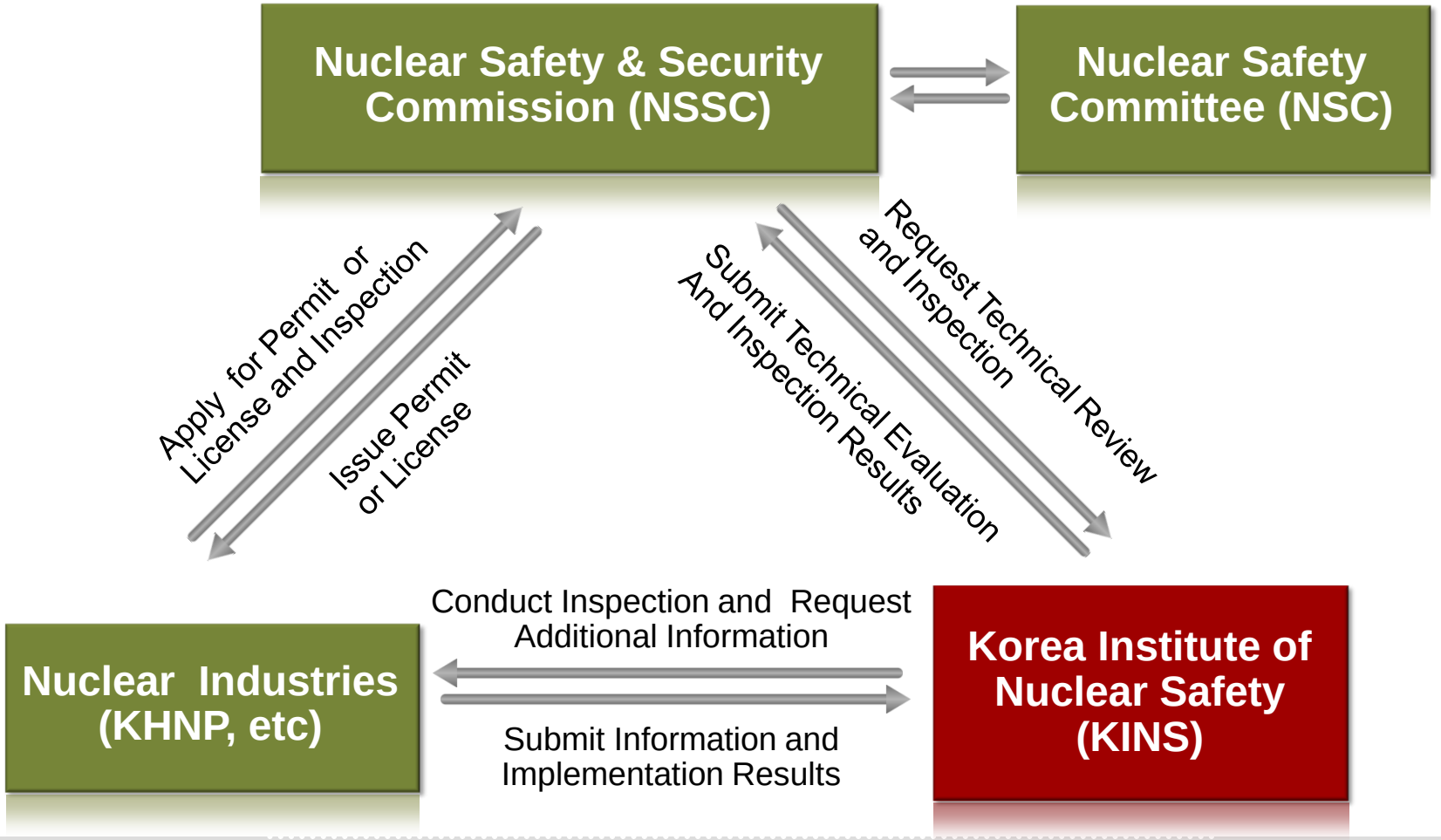
Legal Framework



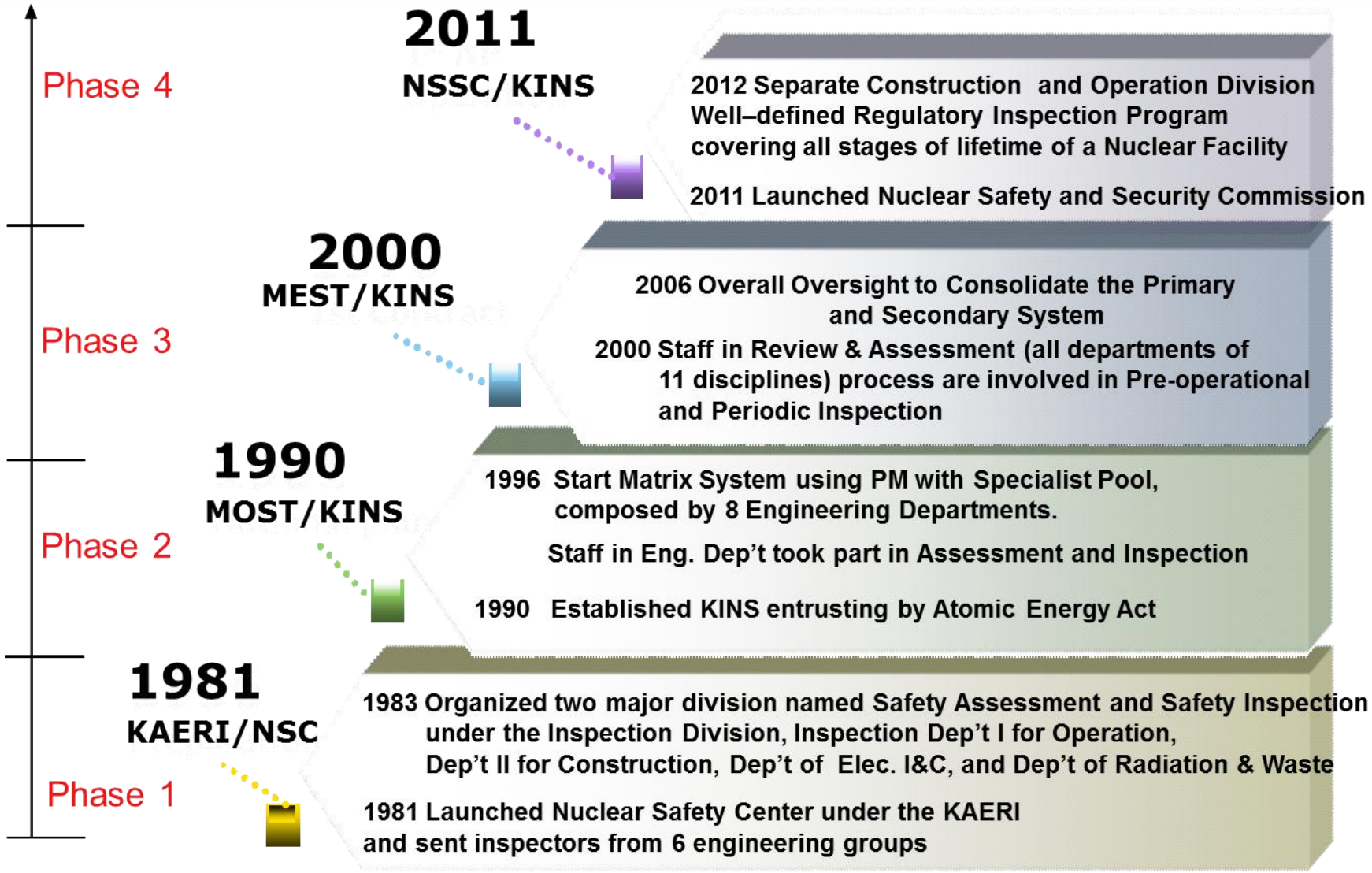
- The Act provides the bases and fundamental matters regarding the development and utilization of nuclear energy and safety regulations
- The Decree provides particulars entrusted by the Act and necessary for the enforcement of the Act
- The Regulation provides the technical standards and particulars entrusted by the Act and the Decree such as detailed procedures and format of documents
- The Notice provides detailed particulars for the technical standards and guidelines
- The Regulatory Standards and Guides provide the interpretation, detailed criteria, acceptable methods, conditions, and specifications of the technical standards.
- The Safety Review & Inspection Guides provides the staff guidance in carrying out regulatory activities.
- Codes and Standards for materials, design, test, and inspection of components and equipment

Regulatory Framework

Interactive Mechanism in Regulation

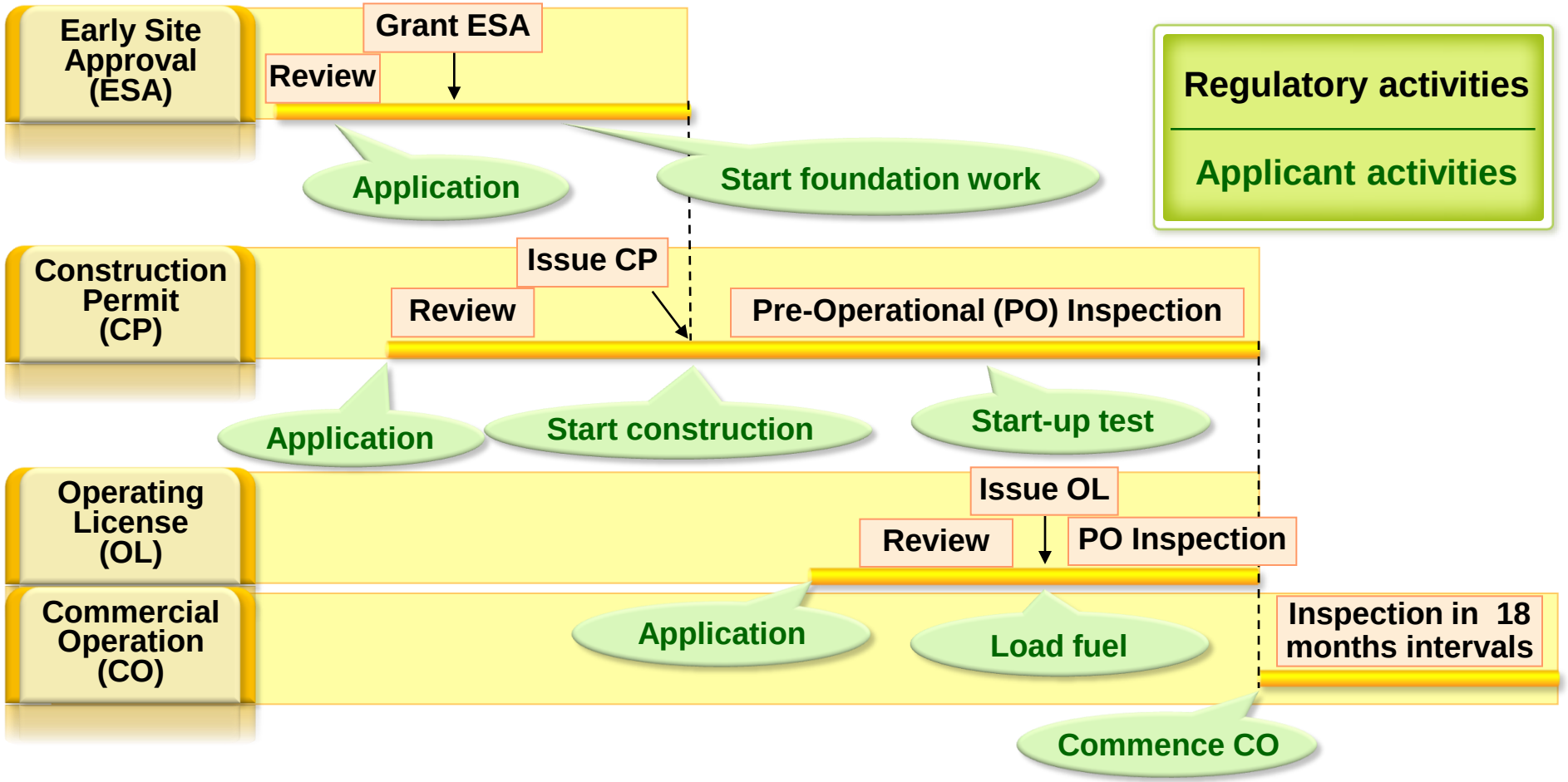


History of KINS Regulation Program



Licensing Process

General Licensing Sequence for NPPs



Licensing Process

Pre-application of Safety Review

- To encourage advanced interaction of applicants with the regulatory body, not only for early identification of regulatory requirements but to provide more timely and effective regulation
- Such early interaction and guidance during the design stage contributes toward minimizing complexity and enhancing stability in the licensing

Standard Design Approval(SDA)

- To improve safety in future plants and promote more efficient reviews
- To certify a standard NPP design for the repeated construction; effective for 10 years
- A legislation of the SDA was completed in January 2001, and was applied to the APR1400 for the first time according to the application from the utility, Korea Hydro and Nuclear Power (KHNP), in July 2001

Licensing Process

Early Site Approval (ESA)

- To allow the applicant to perform a limited civil engineering work for site preparation before CP
- Application documents: Site Survey Report, Detailed Geological Survey Report, etc.

Construction Permit (CP)

- To ensure the adequacy of plant site, design, and construction in accordance with Rules and Regulations, prior to the commencement of construction
- Major application documents
  - Preliminary Safety Analysis Report (PSAR), Quality Assurance Program (QAP) for design and construction, Environmental Report (ER), etc.

Licensing Process

Operating License (OL)

- To confirm the final adequacy of plant design and operational functionality
- To review the operation and accident response capability of the applicant
- Major application documents
  - Final Safety Analysis Report (FSAR), QAP for operation, Technical Specifications for Operation, Radiological Emergency Plan, etc.
- Nuclear fuel loading and commissioning tests upon the issuance of OL

Licensing Process

Approval of Standard Design

- To certify a standard NPP design for the repeated construction; effective for 10 years
- Safety analysis report on the standard design, ITAAC, preparation plan of emergency operating procedures

Amendment of Permit or License

- To modify the contents of approved documents after permit or license
- Supplementary documents to verify the adequacy

Periodic Safety Review (PSR)

- To review, comprehensively and systematically, the safety of each operating NPP in 10 year intervals after the OL
- Physical conditions, safety analysis, equipment verification, aged deterioration, safety performance, experience feedback, operating procedures, etc.

Licensing Process

Continued operation after plant design life

- Continued operation beyond the original design life
- Application 2 to 5 years before the end of design life for additional 10 years of operation
- Periodic safety evaluation report, aging evaluation report of major equipment, radiological environmental report, etc.

Approval of Topical Report

- Safety review on a specific technology expected to be applied repetitively
- Detailed technical background on the application topic

Implementation of Severe Accident Policy

- To secure severe accident prevention and/or mitigation features, and to enhance the capability against the severe accidents
- Pre & final PSA results during CP & OL review periods, respectively, and implementation of the Severe Accident Management Program prior to the commercial operation

Review & Assessment Process

- **R & A is performed to confirm the compliance with Regulatory Requirements and associated Acceptance Criteria**
  - ✓ Standard Review Guideline/Procedure is used
  - ✓ Internal Guidelines
    - ➢ necessary for effective review and assessment of the application documents submitted by applicant
    - ➢ NSSC approves the KINS Rules for Entrusted Regulatory Activities developed in accordance with Article 311 (Approval of Activities) of Enforcement Decree
    - ➢ Administrative procedures for conducting the technical activities

Scheduling and Planning of R & A

- **Processing time of license and notification of review plan**
  - Regulatory process for CP or OL should be completed within 24 months
  - Process within 15 months for the following cases
    - Capacity, Reactor type, and Design Specifications of the Major Components are identical to those for which a CP or OL has already been issued
    - Identical design to the approved standard design
  - Following periods shall not be counted in the process timing:
    - Periods required to supplement or correct the documents
    - Other periods additionally required for excusable reasons
      - to conduct an experiment in order to verify safety
      - period during which the inspection cannot be performed
  - Review plan be notified in advance to enhance the predictability of licensing

- Operating experience, Design changes, Application of the latest technical criteria, First of a kind design issue, and Issues of significant public concern, etc.

Implementation of R & A

- **All of areas considering up-to-dated Experiences & other Factors :**
  - **Proven provisions or Qualification**
    - ✓ EQ, Software Quality of Safety-critical I&C Systems
  - **Consideration of competence and skills and others**
    - ✓ Evaluation of Technical Capability for Operation , Human Factor
  - **Incorporating on the latest experience**
    - ✓ Cyber Security for Digital I&C Systems
  - **Independent confirmatory audit calculation**
    - ✓ Uncertainty and Sensitivity Analysis, Code V & V in Safety Analysis
  - **On-site verification through regulatory inspection**
    - ✓ Electric System Design, ECCS Recirculation Sump Strainer, etc.

Review for OL of SKN Units 3&4

The OL of SKN Units 3&4 applied in June 2011. The operating license application and the affiliated document for SKN Units 3&4 are reviewed:

- Appropriateness of the over-pressure protective facility of the nuclear reactor coolant system
- Design of hydrogen mitigation system
- Appropriateness of the safety instrumentation and control systems designed by domestic products
- Appropriateness of the cyber security of the instrumentation and control systems
- Appropriateness of the integrated design of the soft controller and the engineered safety features-component control system
- Evaluation on the time response for the safety-related operator manual actions in the perspectives on diversity and defense-in depth (D3) design
- Evaluation of human-system interfaces in the main control room

Regulatory Inspection – Type /All Stages

Nuclear Safety Act Articles 16 & 22 (Inspection)

<table>
<tr><th>Type / Stage</th><th>Construction & Commissioning</th><th colspan="2">Operation</th><th>Continued Operation</th><th>Decommissioning</th></tr>
<tr><td rowspan="4">Planned</td><td>Pre-operational Inspection</td><td colspan="3">Periodic Inspection</td><td rowspan="4">Confirm and Check-up</td></tr>
<tr><td colspan="4">Quality Assurance (QA) Inspection</td></tr>
<tr><td colspan="4">Special Inspection (Ad Hoc)
(Safety Issues, Safety Culture, etc.)</td></tr>
<tr><td colspan="4" rowspan="2">Daily Inspection by Region Office
(including Unannounced Inspection)</td></tr>
<tr><td>Reactive</td><td></td></tr>
<tr><td></td><td colspan="4">Special Inspection (Incident)
(Incident Response & Investigation, etc.)</td><td></td></tr>
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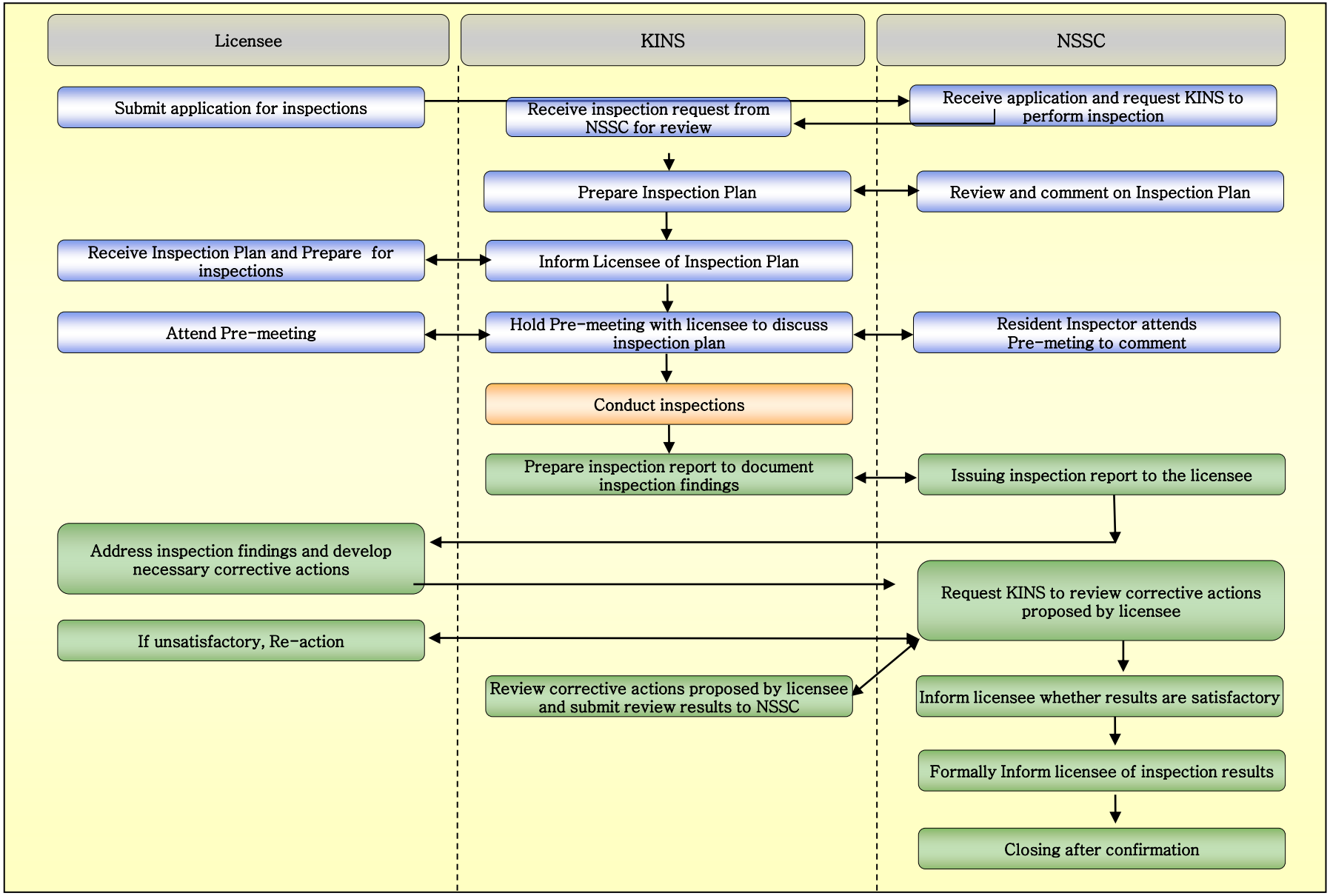
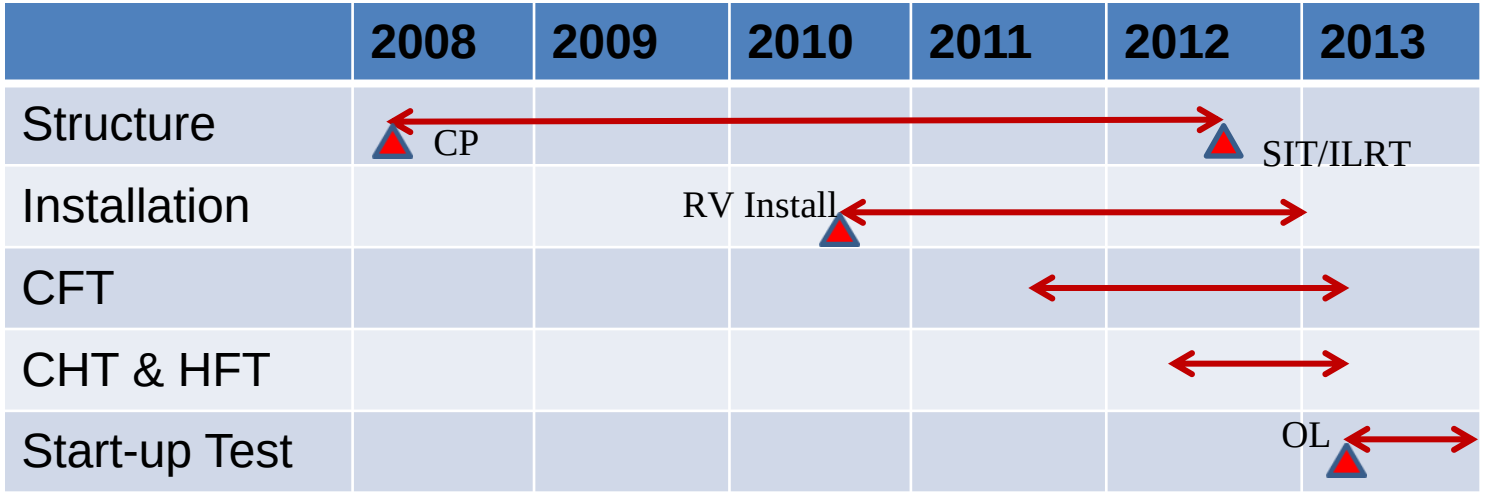
Typical Regulatory Inspection Process



Scope of Pre-operational Inspection

- **Facilities of the safety related functions and important to safety. Safety functions are defined in NSSC Notice No. 2012-18:**
  - Ensuring the integrity of the reactor coolant pressure boundary
  - Safe shutdown of reactor and maintaining shutdown conditions
  - Functions that prevent or mitigate situations that can exceed offsite radiation exposure dose limits

- **Example : Milestone of Shin-Kori Unit 3 (APR1400)**



* CFT: Cold Functional Test, CHT: Cold Hydrostatic Test, HFT: Hot Functional Test

Pre-operational Inspection Items

- **Structure inspection** begins at the early stage of the site construction at the time when the foundation excavation is on the way (specified in NSSC Notice No. 2012-18 for 11 facilities)
- **Installation inspection** begins when the installations, welding, non-destructive test and pressure test are ready (52 items)
- **Cold functional test inspection** is implemented whether components and systems are properly installed and ready to operate in a cold condition (77 items)
- After the **integrity of the primary and the secondary systems** are confirmed, **hot functional tests** at a temperature of normal operating condition (23 items)
- **When the OL is granted**, the operator can proceed to load fuel into the reactor and continue for **core physics and power ascension tests** (33 items)

Structure Inspection

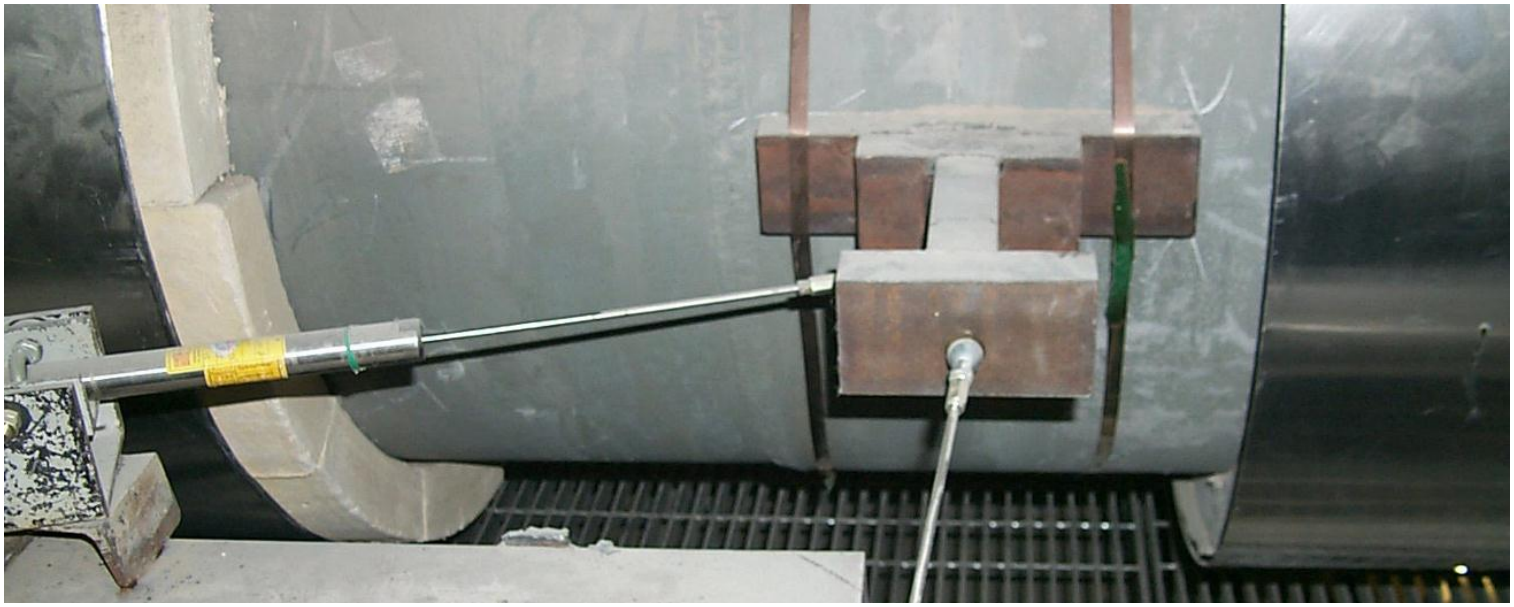
- The structure inspection begins at the early stage of the site construction at the time when the foundation excavation is on the way.
  - Foundation excavation and treatment works,
  - Structure backfill works,
  - Rebar installation works,
  - Concrete works,
  - Containment post tension system works,
  - Steel structure installation works,
  - Concrete anchor bolt installation works,
  - Seismic qualification inspection,
  - Sealing works of safety related openings and penetrations,
  - Permanent dewatering system works,
  - Facility water proof treatment works,
  - Mechanical rebar splice works,
  - Equipment foundation grout works,
  - Containment liner plate installation works,
  - Stainless liner plate installation works,
  - Concrete masonry works,
  - Radiation resistant coating works,
  - Integrated construction test; Structural Integrity Test(SIT), Integrated Leak Rate Test(ILRT)

Installation Inspection

- When the installations, welding, non-destructive test and pressure test are ready (52 items).
  - Reactor pressure vessel
  - Reactor coolant system facility
  - Instrumentation and control facility
  - Fuel handling and storage facility
  - Radioactive waste disposal facility
  - Radiation control facility
  - Reactor containment facility
  - Reactor safety system facility
  - Electric power system facility
  - Power conversion system facility
  - Other facilities related to safety

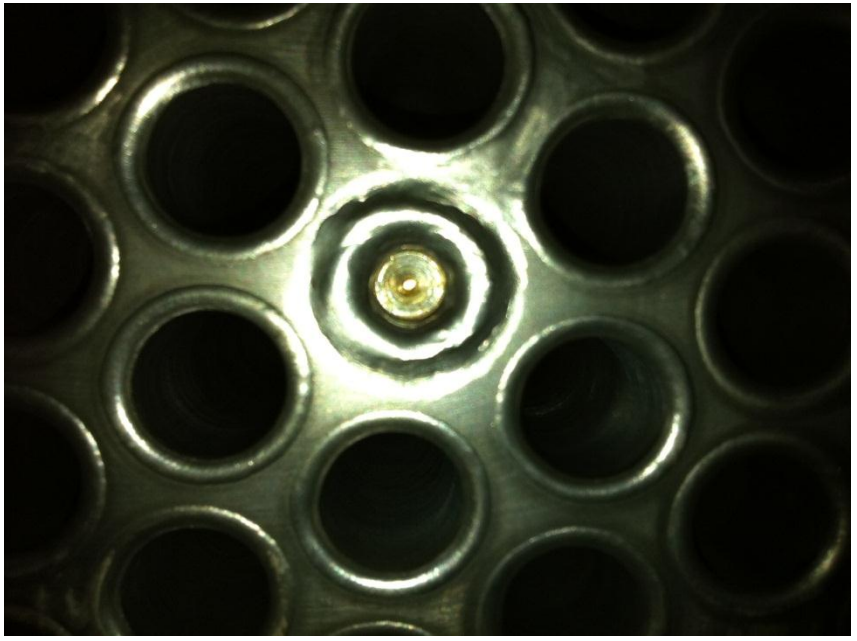
Cold Functional Test Inspection

- Whether components and systems are properly installed and ready to operate in a cold condition (77 items).
  - Reactor pressure vessel
  - Reactor coolant system facility
  - Instrumentation and control facility
  - Fuel handling and storage facility
  - Radioactive waste disposal facility
  - Radiation control facility
  - Reactor containment facility
  - Reactor safety system facility
  - Electric power system facility
  - Power conversion system facility
  - Other facilities related to safety



Hydrostatic Test and Hot Functional Test Inspection

- After the integrity of the primary and the secondary system are confirmed, hot functional tests at a temperature of normal operating condition(23items).
  - Reactor pressure vessel
  - Reactor coolant system facility
  - Instrumentation and control facility
  - Fuel handling and storage facility
  - Radioactive waste disposal facility
  - Radiation control facility
  - Reactor containment facility
  - Reactor safety system facility
  - Electric power system facility
  - Power conversion system facility
  - Other facilities related to safety



Initial Fuel loading and Startup Test Inspection

- When the OL is granted, the operator can proceed to load fuel into the reactor and continue for core physics and power ascension tests(33items).

- Initial fuel loading
- Initial criticality test
- Core performance assessment test
- Axial xenon oscillation test
- Moderator temperature reactivity coefficient
- Rod worth
- Boron reactivity worth measurement
- Initial critical boron concentration
- Power reactivity coefficient assessment and power defect measurement
- Reactor coolant system flow measurement test
- Unit load transient test
- Reactor internal vibration monitoring test
- Loose part monitoring system test
- Acoustic leak monitoring system test
- Reactor coolant pump vibration monitoring system test
- Pressure test of reactor coolant system
- Pressurizer function test
- Natural circulation test
- Post core loading CEDM function test
- Power ascension test and instrument correlation test
- Core function test in case of control rod drop and ejection
- Core protection system test
- Chemical and radiochemistry tests
- Neutron and gamma radiation level measuring and shielding capability test
- Turbine trip test
- Reactor power cutback system test
- Plant shutdown from outside control room
- Loss of off-site power test
- Load rejection test for each power level
- Control system checkout test
- Atmospheric dump valve and steam bypass valve capacity test
- Main feed water control valve transfer test
- Main turbine protective function test

Fukushima Follow-up Measures of Shin Kori Units 3 & 4

- **Special Safety Inspection by Government**
  - SSI performed to 21 operating NPPs, a research reactor and fuel cycle facilities
    - Inspection period : Mar.21 ~ Apr.15, Review of Findings : Apr.16~Apr.30
    - Hearing opinions of residents neighboring site before inspection
- **Objectives of SSI**
  - How well the NPPs are designed against natural hazards;
  - How well they can prevent and mitigate the severe accident;
  - How much effective the emergency response system are in place
    - by assuming the scenario of "earthquake → tsunami → power loss → extreme severe accident" with reference to the causes of the Fukushima accidents
- **Korean Utility(KHNP)'s voluntary inspection**
  - Mar.16~Mar.18, Focused on plant safety against great natural hazards
  - Self-improvement items on waterproofing, emergency power, hydrogen explosion etc.

Major Inspection Points of SSI

Defense-In-Depth Functions	Major Inspection Points
Extreme Natural Hazards	Adequacy of the plant design and facilities against natural hazards - Design against earthquake and seismic capacity - Design against coastal flooding and inundation protection capability
Prevention of Severe Accidents	Adequacy of power supply and cooling functions - Power system and emergency power supply - Cooling capability in case of SBO and inundation
Mitigation of Severe Accidents	Adequacy of countermeasure capabilities against severe accidents - Facilities, guidelines, and strategies against severe accidents
Emergency Response	Adequacy of emergency response - Emergency response to multi-units accidents - Facilities, systems, and infrastructure for the protection of local residents and workers

Inspection Results and Follow-up Action Plan (1)

- Follow-up actions for improvement
  - 1st Phase :
    - Execution of SSI, and follow-up of long- and short-term improvements
    - 50 items mostly cover the lessons-learned from Japanese report to IAEA and IAEA mission report, except some items related regulatory system, safety culture etc.
  - 2nd Phase :
    - Initiation of a project on feedback of lessons-learned from Fukushima ('11.7-)
      - In-depth evaluation of Fukushima accident, and establishment of a plan for review & revision of regulatory requirements
    - Request of licensee's further relevant evaluation, and review by KINS
    - International cooperation for finding and drafting of Lessons-Learned
  - 3rd Phase:
    - Adopting the improvements agreed amongst the international community
    - Applying improvements from the long-term cooperative research programs on severe accidents

Inspection Results and Follow-up Action Plan (2)

- Comprehensive Conclusions
  - 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

- Improvements Review to the APR1400 (33/50)
  - Seismic(4) & Tsunami (3) Resistance
  - Reliability of Power Supply and Cooling System to cope with SBO (10)
  - Response to Severe Accidents (6)
  - Emergency preparedness and medical treatment (10)

Safety Improvements for SKN Units 3&4

Category	No.	Improvements	Remark
Prevention and Mitigation of Beyond Design Basis Accident	1-1	Installation of automatic shut-down system (automatic seismic trip system) in case of earthquake	Dec. '13
	1-2	Improvement of seismic performance for Safe Shutdown System:	Completed
	1-3	Study on maximum earthquake in NPP site	Dec. '12
	1-4	Improvement of seismic resistance including earthquake	
	2-2	Installation of water proofing door & water-proof drainage pump	
	2-3	Study on design criteria on the sea level in NPP sites (Research Project)	
	2-4	Reinforcement of intake cooling water system and preventive facilities against tsunami (Research Project)	Linked with 2-3
	3-1	Addition of mobile generator and batteries	
	3-2	Improvement of design criteria on AAC diesel generator	
	3-3	Design change for anchor bolts of Electrical Transformers(MT, UAT, SAT)	Completed
	3-4	Change of management entity for switchyard	

Safety Improvements for SKN Units 3&4

Category	No.	Improvements	Remark
Prevention and Mitigation of Beyond Design Basis Accident	3-5	Preventive measure to loss of spent fuel pool cooling	
	3-6	Recovery measures to prevent submergence of final heat removal facilities	Linked with 2-1
	3-7	Responsive measure to breaking outdoor tank	
	3-9	Improvement of Fire protection plan and fortification of cooperative system	
	3-10	Improvement of fire protection facilities and self-fire service capability	
	3-11	Introduction of fire-fighting design focusing on NPP performance	
	4-1	Installation of passive hydrogen recombiners (PAR)	Completed
	4-2	Installation of automatic depressurization or vent system for containment building	Completed
	4-3	Installation of emergency cooling water injection loop from the outside	
	4-4	Strengthening training in preparation of severe accident	

Safety Improvements for SKN Units 3&4

Category	No.	Improvements	Remark
Severe Accident Management	4-5	Revision of guideline on severe accident management	
	4-6	Development of Guideline on severe accident management during shutdown or low power operation	
Emergency Preparedness	5-1	Addition of radioactive protection equipment for residents in the vicinity of NPP sites	
	5-2	Revision of radioactive emergency plan such as simultaneous emergency warning issuance for multiple NPP units	
	5-3	Addition of emergency equipment in preparation of long-term emergency warning issuance	
	5-5	Strengthening radioactive emergency exercise	
	5-6	Taking measures to obtain necessary information in the event of long-term power loss	Linked with 3-1
	5-7	Secure protection measure of repair workers	
	5-8	Improvement of emergency preparedness facilities	Completed
	5-9	Revision of information disclosure procedure in the event of radioactive emergency	
	5-10	Protection measure for residents outside of the Emergency Planning Zone	
	5-11	Reinforcement of emergency warning facilities performance (inside NPP)	Completed

Safety Improvements for SKN Units 3&4

In addition, the applicability of the Design Extension Condition (DEC) requirements that is prescribed in the specific safety requirement SSR-2/1 developed by International Atomic Energy Agency (IAEA) are reviewed on the design of SKN Units 3&4.

The reviewed items are:

- The prevention and mitigation capability of the accident conditions
- The design bases for all the facility to prevent and mitigate the accidents
- The facilities for the prevention and mitigation of the accidents
- The reactor containment and the related safety systems to prevent and mitigate the extreme accident scenarios including reactor core melting
- The design to eliminate practically the DEC causing substantial release of radioactive materials, or the protective measures for protection of the public
- The accident conditions due to combination of a series of events considering the possibility of their occurrences

Conclusions

- Standard design and safety approaches of APR1400 satisfied the current safety standard
- Licensing issues identified in both pre-application review and SDA reviews were resolved during the safety review of construction permit for SKN Units 3&4
- As a result of the safety review of the application for construction permit of SKN Units 3&4, the location, structure and equipment of the nuclear reactor and related facilities satisfied the current safety requirements, and the public health and the environment from the impact of the radioactive materials generated from the construction of the facilities can be protected in service.
- The safety improvements according to those recommendations to protect against earthquake and tsunami were reviewed and determined to improve safety and is supposed to be installed during the construction process.

Thank You for Your Attention !!