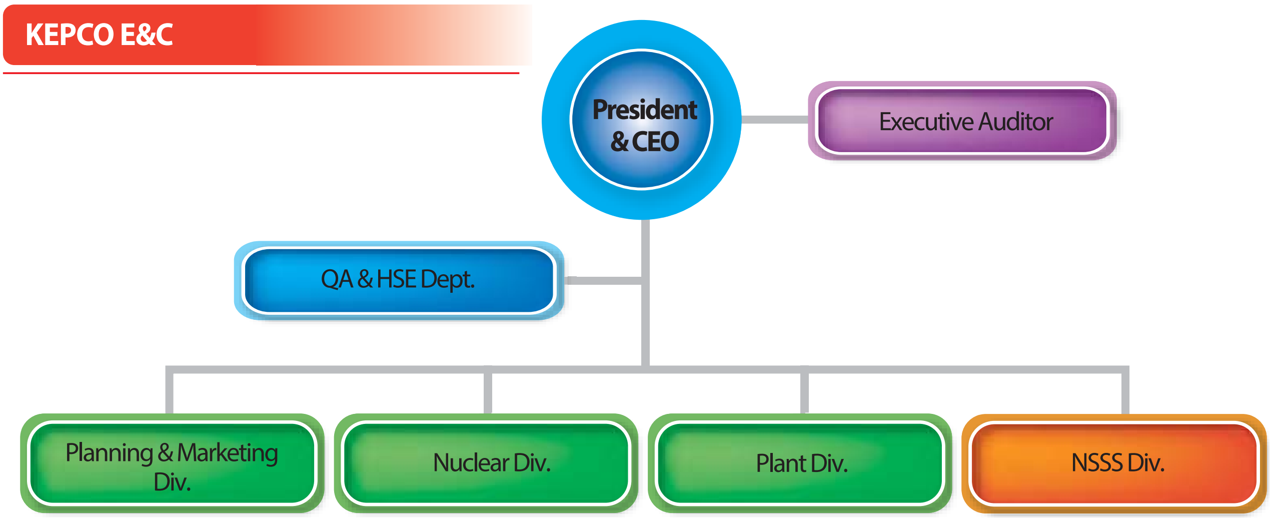
KEPCO E&C NED

Organizational Information

KEPCO E&C



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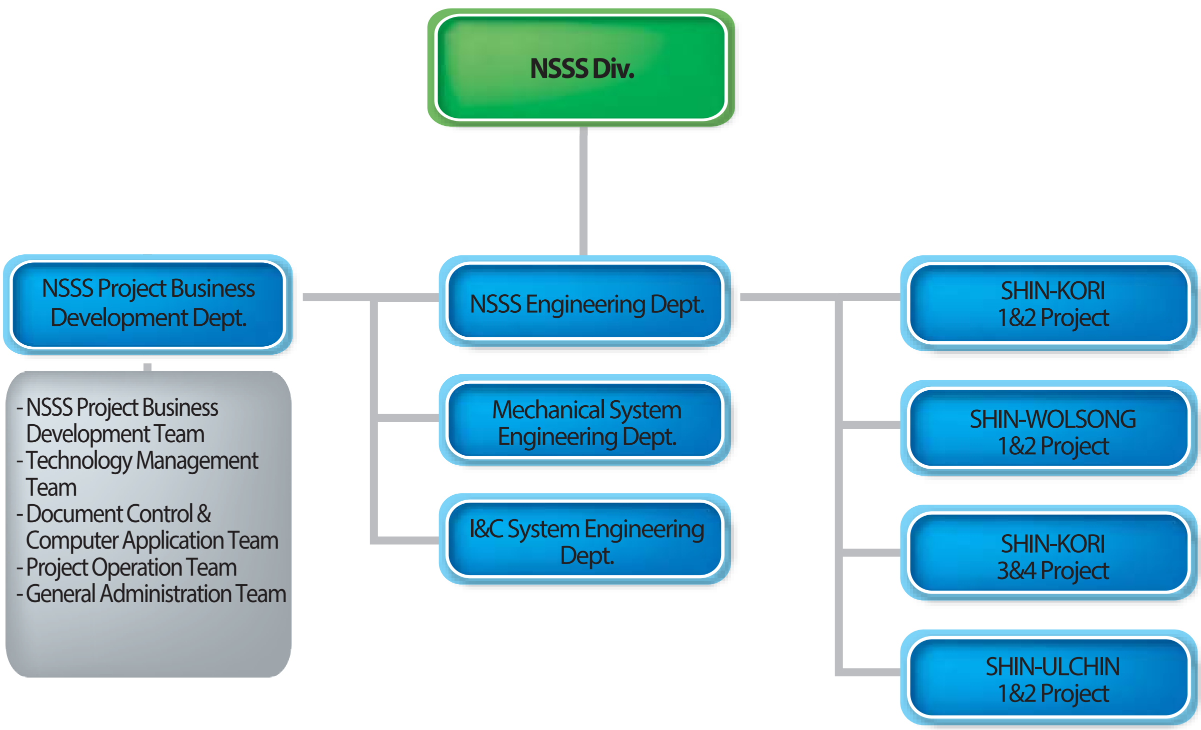

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Brief History for KEPCO E&C NED

KEPCO E&C NED History

Oct.1975 · · ·	KEPCO E&C was founded
Jul.1985 · · ·	Power Reactor System Division (PRSD) was established in the KAERI for NSSS Design
Apr.1991 · · ·	PRSD developed NSSS design for OPR1000
Jan.1997 · · ·	PRSD was merged into KEPCO E&C to form KEPCO E&C NED
Oct.2001 · · ·	KEPCO E&C NED developed NSSS design for APR1400

NPP Development Progress

Nuclear Power Plants
Turn Key Base Contract (1971-1983) [Kori 1&2, Wolsong 1]
Component Base Contract (1979-1990) [Kori 3&4 ~ Ulchin 1&2]
Self-Reliance (Technology Transfer) (1987-1995) [Yonggwang 3&4]
OPR1000 (1991-2005) [Ulchin 3&4 ~ Ulchin 5&6]
Improved OPR1000 (2002-2012) [Shin-Kori 1&2 ~ Shin-Wolsong 1&2]
APR1400 (2006-2016) [Shin-Kori 3&4 ~ Shin-Ulchin 1&2]

1970 1980 1990 2000 2010

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KEPCO E&C

Technology toward an envisioned future

KEPCO E&C NED

NED's Major NPPs Experience

1970's → 1980's → 1990's → 2000's

Introduction | Localization | Self-Reliance | Advanced Reactor

Plant	Reactor Type	Capacity	Commercial Operation	NSSS Supplier
YONGGWANG	OPR1000	1,000		DOOSAN/KEPCO E&C
YGN 3			May 1995	
YGN 4			Jan.1996	
YGN 5			May 2002	
YGN 6			Dec.2002	
ULCHIN	OPR1000	1,000		DOOSAN/KEPCO E&C
UCN 3			Aug.1998	
UCN 4			Dec.1998	
UCN 5			Jul. 2004	
UCN 6			Jun.2005	
KEDO Project	OPR1000	1,000		DOOSAN/KEPCO E&C
KEDO 1			Suspended	
KEDO 2			Suspended	
SHIN-KORI				DOOSAN/KEPCO E&C
SKN 1	OPR 1000	1,000	Dec.2010	
SKN 2	OPR 1000	1,000	Dec.2011	
SKN 3	APR 1400	1,400	Sep.2013	
SKN 4	APR 1400	1,400	Sep.2014	
SHIN-WOLSONG				DOOSAN/KEPCO E&C
SWN 1	OPR 1000	1,000	Mar.2012	
SWN 2	OPR 1000	1,000	Jan.2013	
SHIN-ULCHIN				DOOSAN/KEPCO E&C
SUN 1	APR 1400	1,400	Dec.2015	
SUN 2	APR 1400	1,400	Dec.2016	

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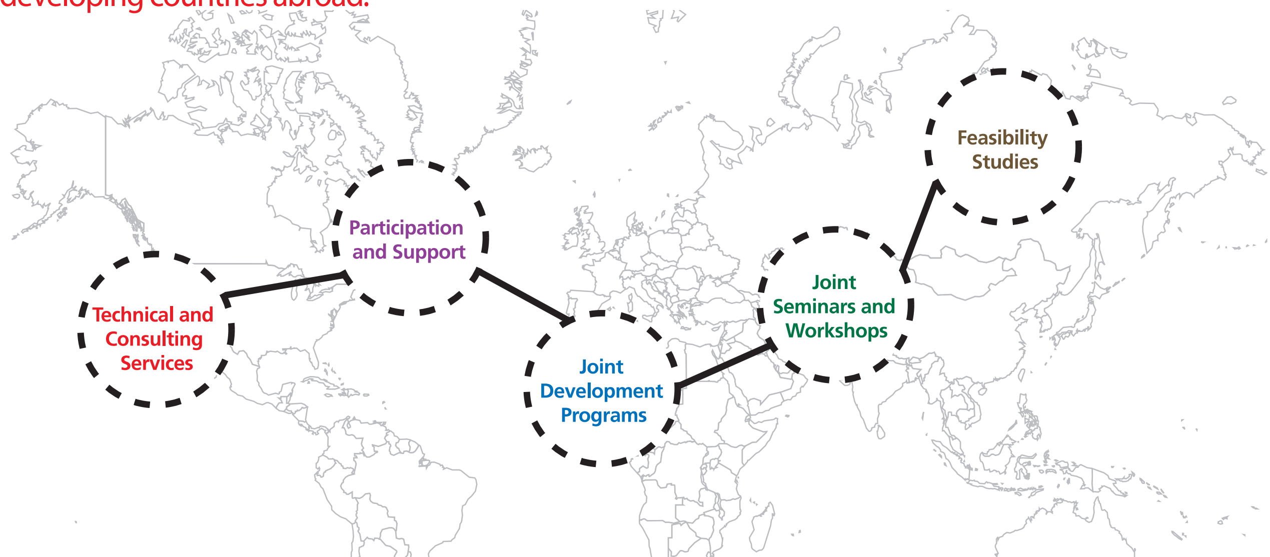
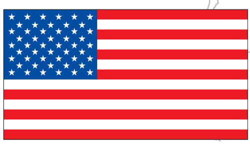
KEPCO E&C NED

KEPCO E&C NED has been actively expanding and plans to further expand international cooperation in NSSS engineering and nuclear services, establishing a network for cooperation linking advanced and developing countries abroad.



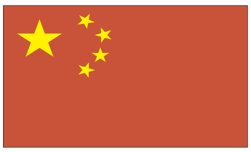


The USA

- Westinghouse Electric Company LLC
- Advent Engineering Services, Inc.
- PaR Systems, Inc

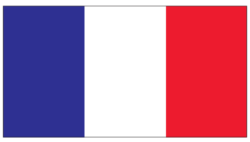
Canada

- AECL (Atomic Energy of Canada Limited)
- ANS [Atlantic Nuclear Services Ltd]



China

- SNERDI (Shanghai Nuclear Engineering Research & Design Institute)
- CNPEC[China Nuclear Power Engineering Corporation]



France

- AREVA (Framatome-ANP)

Germany

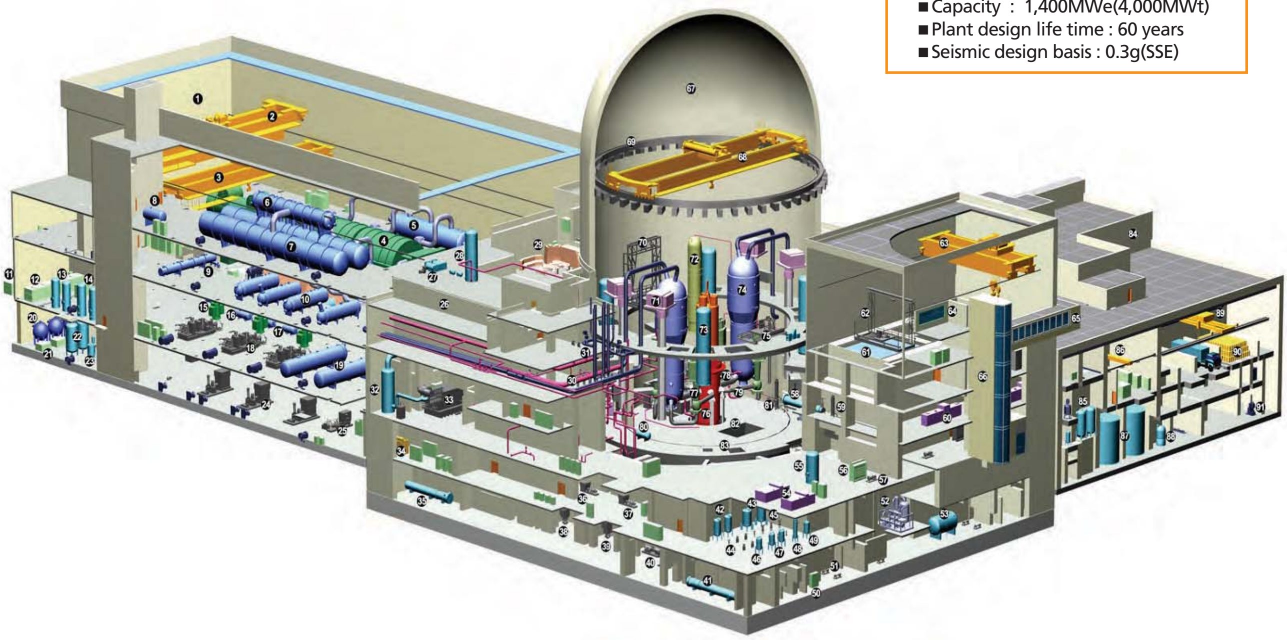
- Siemens
- TÜV Suddeutschland Holding AG

Advanced Power Reactor(APR) 1400

The APR1400, an advanced light water reactor, was developed based on the experience and technology of the Optimized Power Reactor 1000 (OPR1000). The APR1400 provides excellence in terms of both safety and economics as well as technology, to meet the energy requirements of the 21st century. The SHIN-KORI 3&4 Nuclear Power Plants, the first APR1400 units, are currently under construction.

Reactor Type	PWR with 2-loops 2-SG's and 4-RCP's
Plant data	

■ Capacity : 1,400MWe(4,000MWt)
■ Plant design life time : 60 years
■ Seismic design basis : 0.3g(SSE)



Design Features

- ■ Evolutionary standard design
- ■ Pilot operated safety relief valves for stable operation
- ■ Large pressurizer to enhance transient response
- ■ Digital plant protection system and digital control system
- ■ Hot-leg temperature reduction to increase safety margin
- ■ Integrated head assembly to improve maintainability
- ■ Improved steam generator
  - Inconel 690 SG tube material
  - Increased tube plugging margin
  - Enhanced restraint of flow-induced vibration
- ■ High reliability and performance
  - Full digital I&C system
  - Independent four train safety injection system
  - Direct vessel injection of emergency core cooling water
  - Fluidic device in safety injection tank for flow control
  - In-containment refueling water storage tank
- ■ Severe accident mitigation
  - Reactor cavity flooding system
  - Ex-vessel reactor vessel cooling system

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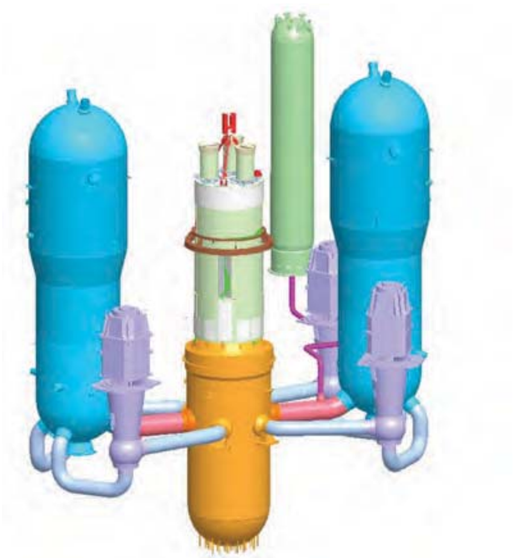
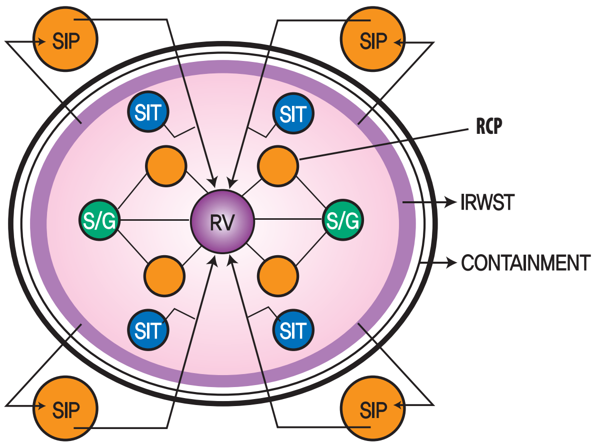
Advanced Power Reactor(APR) 1400

The **Reactor Coolant System** utilizes a well proven 2-loop/4-pump configuration with a large pressurizer, pilot-operated safety relief valves, and proven components and materials for improved safety and reliability



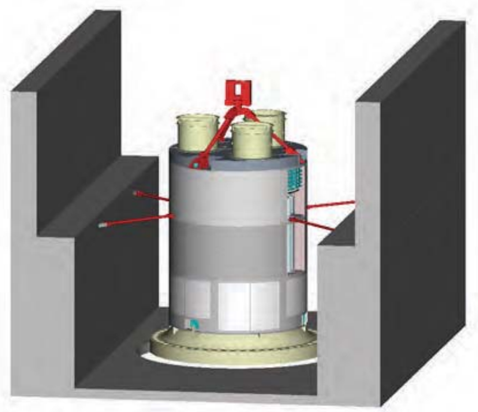
Reactor Coolant System



The **Safety Injection System** consists of four independent trains, taking suction from the incontain-ment refueling water storage tank and discharging it directly into the downcomer of the reactor vessel.

The **Fluidic Device** takes full advantage of the water inventory in the safety injection tank by regulating the injection flow rate in the event of a loss of coolant accident and eliminates the need for low pressure safety injection pumps.

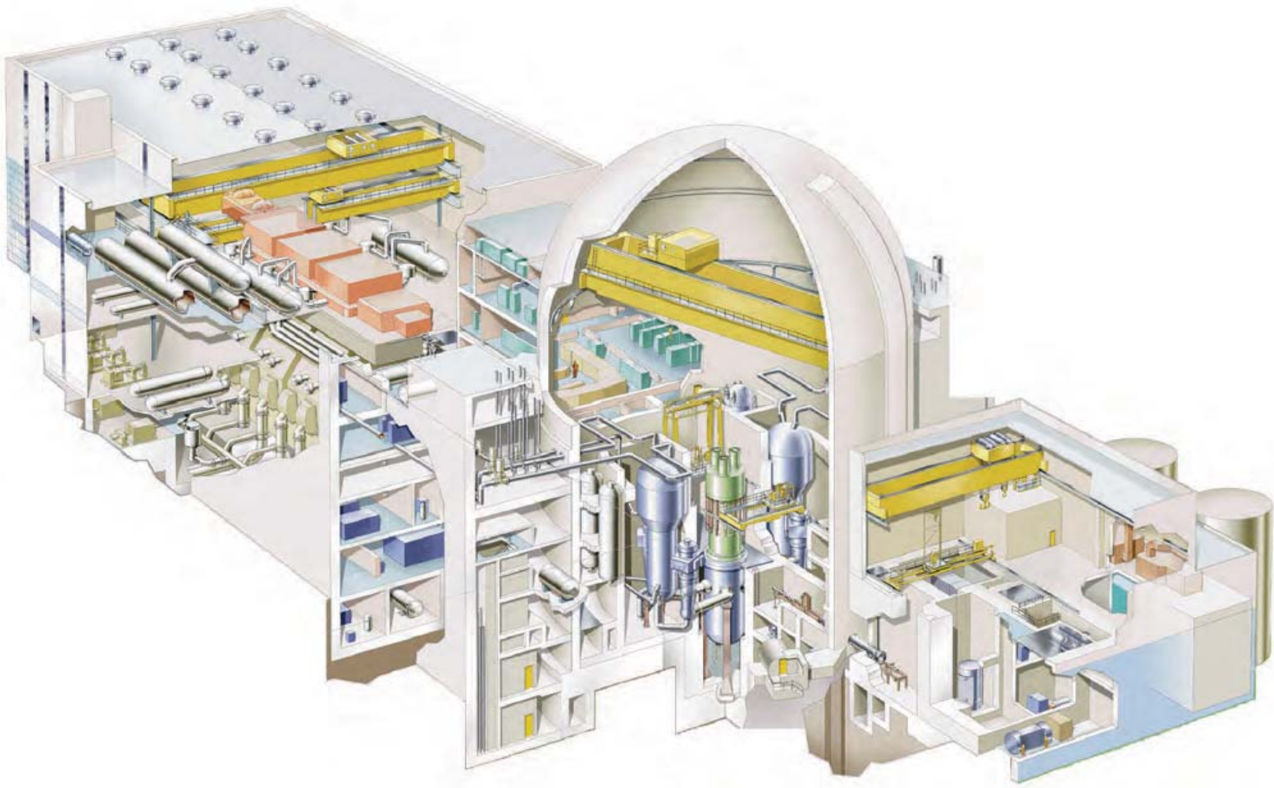
The **Main Control Room** has redundant compact workstations with soft control and a large display panel for plant status awareness and the monitoring of critical safety functions and major systems. A redundant hard-wired safety console for the safety system actuation is provided to cope with the common mode failure of digital I&C systems.



The **Integrated Head Assembly** contains all the components installed in the reactor vessel upper head area. It reduces the number of handling steps and the refueling time, resulting in lower radiation exposure to the maintenance personnel. It also reduces the seismic loads on the control element drive mechanisms and cables.

Optimized Power Reactor(OPR)1000

The design of the Nuclear Steam Supply System (NSSS), Architect Engineering (A/E) and Balance of Plant (BOP) for the OPR 1000 has been carried out by KEPCO E&C.



Design Concept

- Optimization of the design utilizing proven, state-of-the- art technologies
- Feedback of operating and maintenance experiences
- Satisfaction of regulatory requirements
- Improvement of plant economics and safety
- Improvement of man-machine interface
- Standardization of design

Design Characteristics

- Reactor Type : PWR
- Capacity : 1,000MWe(2,825MWt)
- Plant Lifetime : 40 years
- Seismic Design Basis : 0.2g(SSE), 0.1g(OBE)
- Refueling Cycle : 18 months

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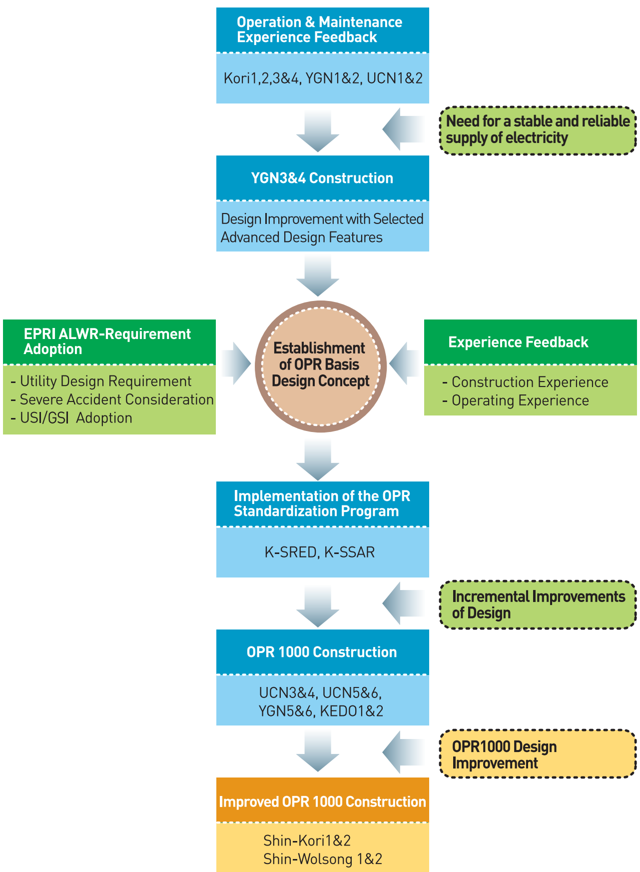
Optimized Power Reactor(OPR)1000

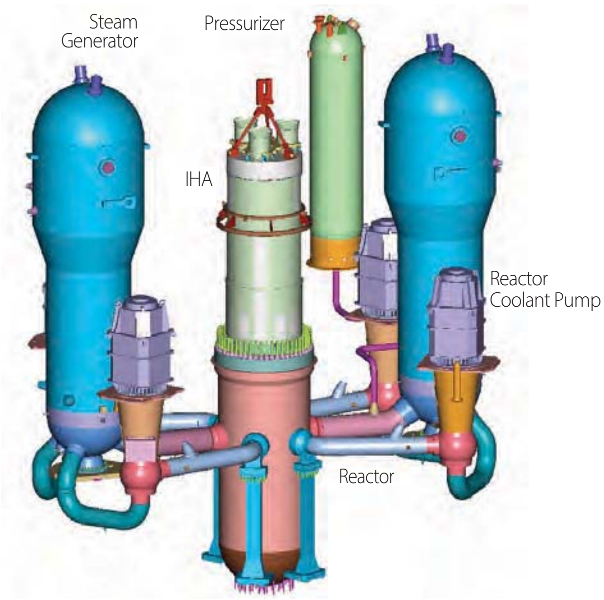
Highlights of OPR1000

- Optimization of plant arrangement
- Adoption of safety depressurization system
- Application of the 'leak-before-break' concept to the reactor coolant system, pressurizer surgeline, shutdown cooling system and safety injection system piping
- Adoption of a digital plant protection system and digital control system
- Enhanced plant safety during mid-loop operation
- Adoption of the Integrated Head Assembly
- Adoption of Inconel 690 steam generator tube material

Development Approach



Reactor Coolant System

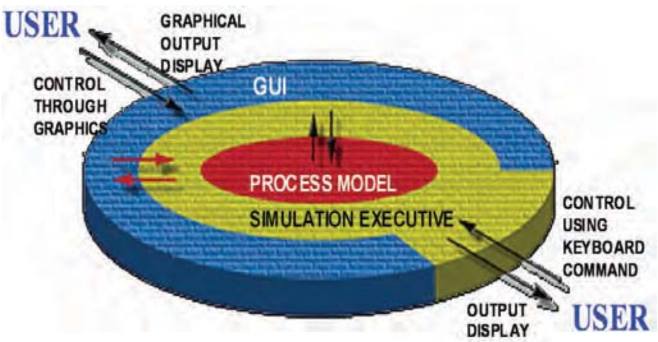


OPR1000 Configuration

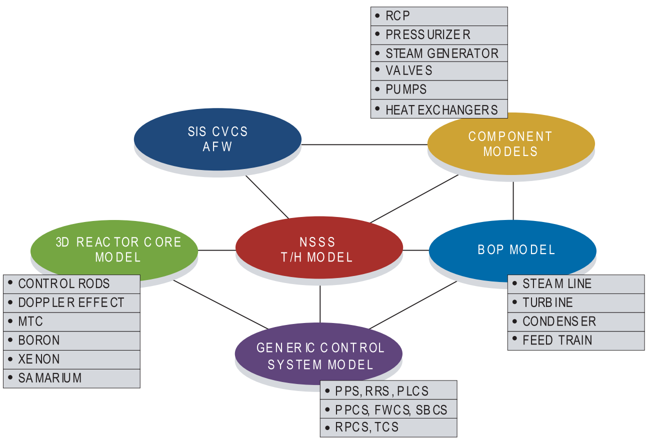
- Reactor Coolant System
- Auxiliary System
  - Chemical and Volume Control System
  - Safety Injection and Shutdown Cooling System
- BOP System
  - Main Steam and Feedwater System
  - Turbine and Condensate System
  - Component Cooling System
- Instrumentation and Control System
  - NSSS and BOP Control System
  - Plant Protection and Monitoring System
- Electric Power System
  - Switchyard and Onsite Power Supply
  - Electric Power Distribution

WINPA

Win-NPA (Nuclear Plant Performance Analyzer)



Win-NPA Structure



Win-NPA Process Model

Verification for Performance of NSSS Control Systems

Development History

- Workstation-Based NPA (1998)
- OPR1000-NPA provided to KINS (2000)
- CANDU-NPA provided to KINS (2001)
- Window-Based NPA (2006)
- Performance Validation Tool for NSSS Control System package (2007)
- Package for training the operator and PR (2008)

Application (Result)

- Improvement of FWCS LPFDL tracking logic for YGN 5&6 (2007)
- Performance validation of changed FWCS H/W for YGN 3&4 (2008)

Application (Plan)

- Performance validation of changed FWCS H/W for UCN 3&4 (2009)
- Training for workers of in-service NPP : Minimizing human errors
- Comparison of control system performance between before and after overhaul : Maintenance verification
- Connection to plant computer system : Performance check for transient condition
- Pre-simulation of power ascension test (PAT) for new plants with connected all NSSS control system finishing the pre-operational test
- Training for the operator of startup test
- Preparation of EOG for new plants
- Verification of full scope simulator software
- PR for export of nuclear power plants

Exposition for Win-NPA

- 2008/1 : UCN 3&4 and 5&6
- 2008/2 : KHNP head office
- 2008/4 : PSA team, KAERI
- 2008/5 : YGN 5&6
- 2008/10 : 16th PBNC, KNS Symposium
- 2008/11 : Workshop on nuclear plant construction

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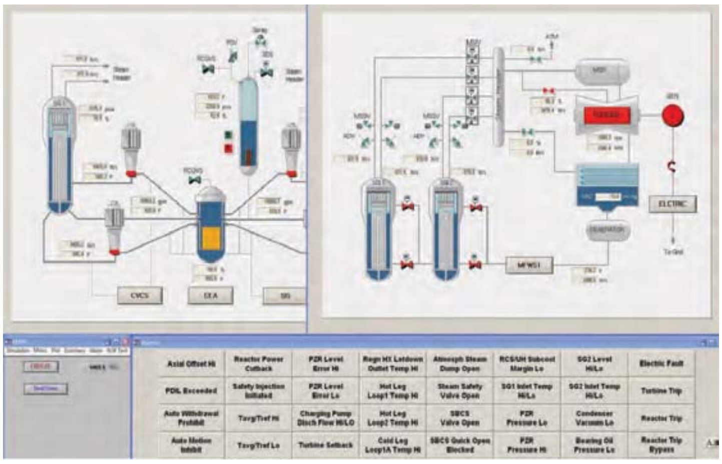
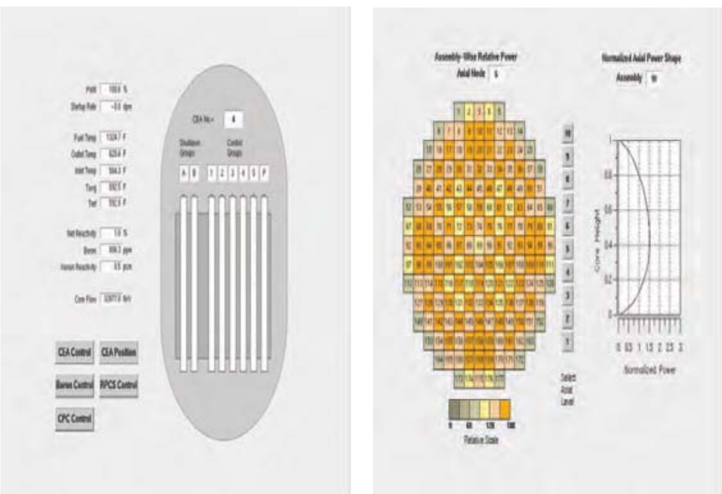
Win-NPA (Nuclear Plant Performance Analyzer)

Win-NPA





Main Display of the Win-NPA

The Win-NPA is an interactive, high fidelity, real-time engineering simulator for nuclear power plants.

The Win-NPA combines the process model for simulating the plant behavior with graphical user interface (GUI) and simulation executive to enhance user interface. Its simulation capability covers a wide range of nuclear power plant operations including normal, abnormal, and accident conditions.

With the Performance Validation Tool for the NSSS Control System package which is a combination of the Win-NPA and a signal interface module, plant transients can be simulated with directly connected actual control system hardware. A comparison between the simulation results of the Win-NPA control system and those of actual hardware, or comparison between result of existing hardware and those of new hardware can validate the performance of the NSSS control system.

Simulation Capability

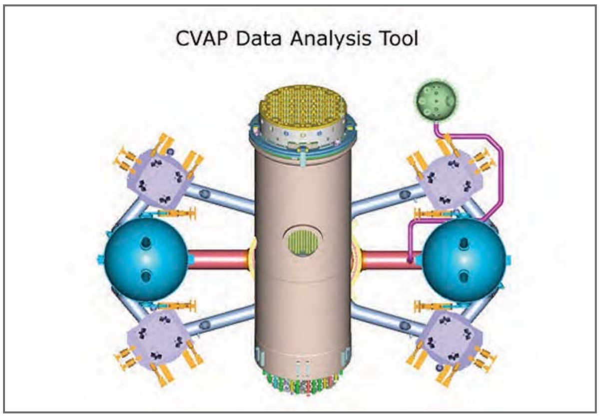
- Normal Operations
  - Steady state
  - Power maneuvering
  - Startup and shutdown
- Abnormal Conditions
  - Reactor or turbine trip
  - Performance-related design bases events
- Accidents
  - Safety-related design bases events
  - Anticipated transient without scram

Software Configuration

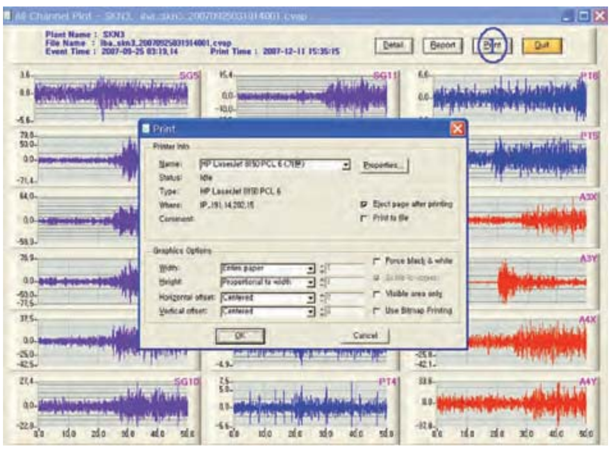
- Process Model
  - Simulation of plant behaviors
  - Detailed models for systems and components
- Graphical User Interface (GUI)
  - Dynamic display
  - Interactive simulation control
- Simulation Executive
  - Simulation control
  - Database management

Reactor Internals Comprehensive Vibration Assessment

Finite Element Model of the Reactor Internals



KCVAP Program Initial Display Mode



Plot of Results from the KCVAP Program

The Comprehensive Vibration Assessment Program (CVAP) assures the structural adequacy of the reactor internals with respect to flow and pump-induced vibrations during a plant lifetime. The CVAP consists of four separate programs-analysis, measurement, inspection, and evaluation. The following technologies were developed to manage all the programs of the CVAP.

Developed Technologies

- Structural Analysis for the selection of measurement locations and the prediction of vibration responses
- Computer program KCVAP for the evaluation of measured signals
- Analysis and evaluation of the measured signals
- Selection criteria for measuring sensors and data processing equipment
- Installation of sensors and cable conduits
- Administration of external supports and interfacing items

Features of the KCVAP

- Analyzes and evaluates measured signals in the graphic user interface environment
- Provides diagnostic information such as APSD, CPSD, phase and coherence of the signals that allow the analyzers to evaluate the CVAP data
- Manages the CVAP data according to the reactor internal components
- Classifies the CVAP data and logs the analysis history

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Replacement of Steam Generator

Ulchin 1&2 nuclear power plants decided in 2007 to replace the steam generators currently in operation, following the replacement of those at the Kori 1 nuclear power plant in Korea. KEPCO E&C performs evaluations and analyses to demonstrate the compatibility of replacing the steam generators with the NSSS components and systems currently installed in the plants.

For the 40 years of the initially licensed period, the steam generators of pressurized water reactors may need to be replaced more than once. Once some 15% of the tubes in a steam generator become plugged, heat transfer performance deteriorates to such an extent that replacement is necessary if the plants are to maintain full power.

KEPCO E&C evaluates the effects of the replacement of steam generators (RSG) on plant components and systems, and conducts accident analyses to demonstrate that the plants continue to comply with currently applicable bases, criteria, and requirements, and are expected to operate acceptably with the RSG in place. Those reanalyzed areas should quantify the available margin following the RSG.

The analyses and evaluations are performed and furnished in accordance with the relevant codes, standards and regulations - including all of the published interpretations thereof - applicable to the current licensing basis of Ulchin 1&2 units .

Replacement of Steam Generator

Technical Services

- Technical support for licensing
- Determination of NSSS design parameters
- Control systems evaluations
- Design transient analysis
- NSSS accident analysis
- NSSS system performance analysis
- NSSS auxiliary system performance analysis
- Structural integrity evaluation

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Core Cooling Monitor

CCM Cabinet

Remote Display Unit

The core cooling monitor (CCM), a computer-based monitoring system designed to monitor the saturation margin of reactor coolant and the core exit temperatures, provides an alarm during abnormal oper- ating conditions.

The CCM receives and processes core exit thermo-couples, RTDs and pressure signals, and displays the calculation results on the remote display unit in the main control room. The CCM also provides core exit temper- atures to the strip chart recorder and the plant computer systems.

The design of the new CCM has undergone many improvements to enhance system re- liability, performance and maintainability.

Design Features

- Full redundant configuration using a safety grade PLC platform ensures continuous operation even during the failure of a PLC.
- The high-speed, high-quality PLC provides enhanced performance.
- PLC platform, modular design, enhanced self-diagno sis, digital calibration and event logging provide easy maintenance.
- The full color touch LCD monitor provides better user interface.
- The safety grade quality assurance program improves hardware and software quality.
- The hardware and software designs comply with the latest regulatory requirements and guidelines.

Applications

- Ulchin unit 1 in Korea (2007)
- Ulchin unit 2 in Korea (2008)

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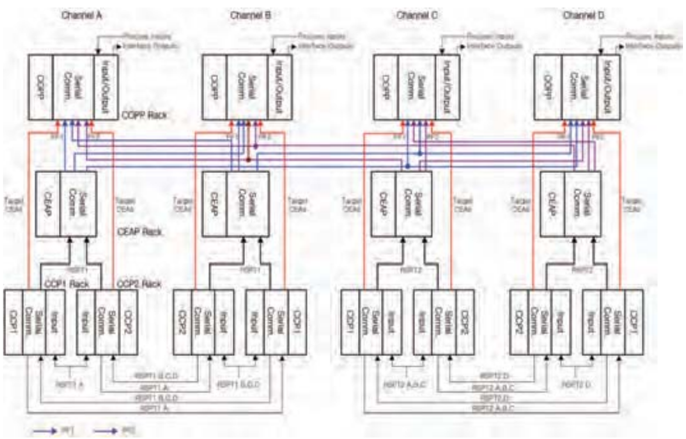
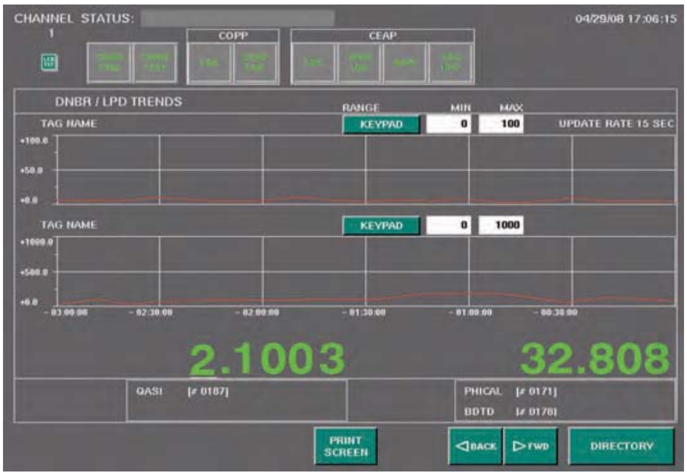
Technology toward an envisioned future

KEPCO E&C NED

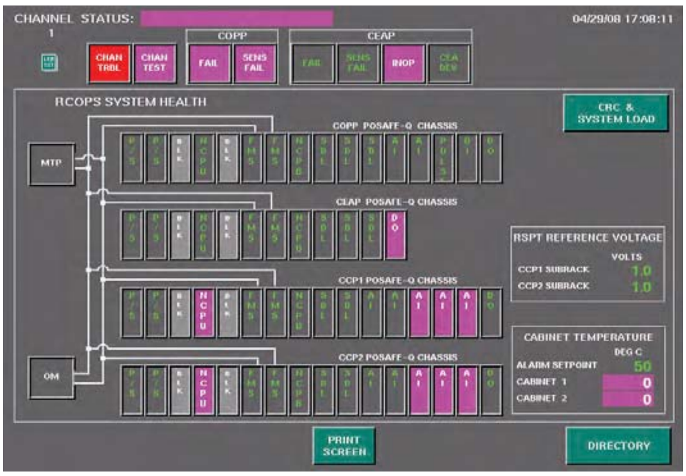
Improved Core Protection Calculator System (ICPCS)



System Configuration



Parameter Trend Displays



System Health Displays

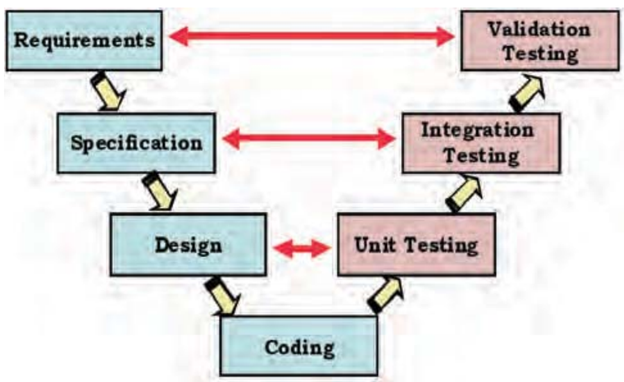
Improved CPCS

-Hardware: PLC-based Class 1E System

-Software: Protection Grade for Nuclear Power Plants

Features

- Continuous on-line calculation and monitoring of the Departure from Nucleate Boiling Ratio (DNBR) and the Local Power Density (LPD) to protect the reactor core from severe accidents
- Best estimate calculation for higher plant availability due to the increase of the operational margin
- Optimized system configuration
- Highly reliable performance
- Deterministic communication between HMI devices and PLC's
- Human-friendly displays and operation
- Strict verification and validation activities for protection grade software
- Complete documentation based on nuclear regulations and standards



Strict Software Verification & Validation Process

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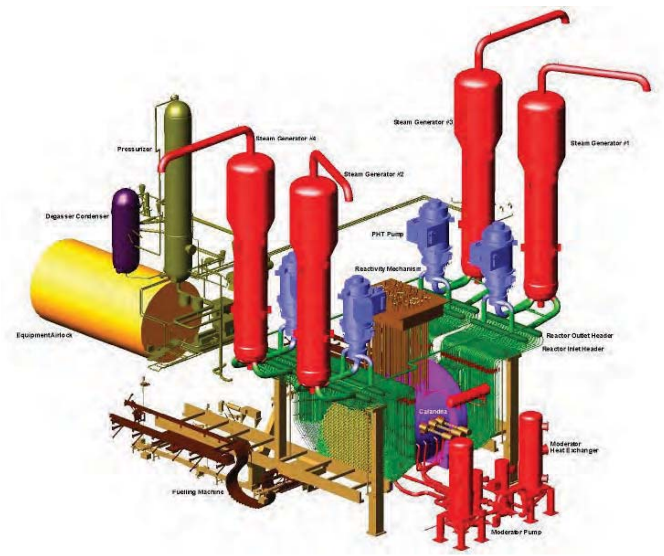
Wolsong Unit 1 Safety Systems Refurbishment

KEPCO E&C has concluded an agreement with KHNP to improve Wolsong unit 1 safety systems.

A total of 20 improvement items that are necessary to extend the operation of Wolsong unit 1 beyond its current design life will be applied to the Shutdown System #1 (SDS1), Shutdown System #2 (SDS2), Emergency Core Cooling System (ECCS) and other safety related systems. The improvement of the safety system will prolong the original design life of the old NPP by 10 or more years, thereby providing the investor with extended returns.



Wolsong unit 1 Primary System

Improvement Features

- Removal of the 3.45 kPa blow-out panel
- Installation of a hydrogen control system in the reactor building
- Addition of a moderator high temperature trip parameter on SDS1
- Automation of the start-up of low pressure ECC
- Addition of valves in series with the ECC dousing tank isolation valves
- Addition of ECC heat exchanger cooling water inlet valves
- Initiation of automatic ECC for very small LOCAs using the lowered reactor building pressure set point
- Improvement of the ECC water tank heating and recirculation path
- Installation of an ECC Tri-Sodium Phosphate (TSP) canisters in the reactor building sump
- Improvement of ECC's unavailability by modifying the ECC pump logic
- Improvement of the SDS2 high log rate neutron power trip coverage
- Addition of the high heat transport system pressure trip parameter on SDS2
- Improvement of the moderator sub-cooling margin
- Monitoring of the poison tank level
- Automation of the PHT pump trip to protect against excessive vibration after a LOCA
- Installation of a demineralized water line to the D2O recovery tank
- Installation of the fire protection system in the reactor building
- Prevention of water hammering in the liquid injection shutdown system
- Improvement of the poison on-line monitoring system
- Addition of the steam generator low level trip parameter on SDS1 & 2

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KEPCO E&C NED

Quality Assurance(QA)

Our Quality Assurance Policy is designed to ensure that we provide defect-free products and services to our customers, both internal and external, on time every time. We believe Quality is an attitude, and our attitude is zero defects. Total customer satisfaction is our measure of quality performance and success. This is achieved by implementing a continually evolving process of evaluation and feedback from our customers.

Certificate of Registration

QUALITY MANAGEMENT SYSTEM

This is to certify that:

Korea Power Engineering Co., Inc.
#360-9, Mabuk-dong
Giheung-gu, Yongin-si
Gyeonggi-do
449-713
South Korea

Holds Certificate No: FS 52926
and operates a Quality Management System which complies with the requirements of ISO 9001:2000 for the following scope:

Project management, engineering and design, procurement, construction and maintenance; construction management and construction supervision services for civil, building & housing, electrical and plant construction industries (including nuclear, coal fired & LNG combined cycle power plant and environmental facilities)

For and on behalf of BSI:

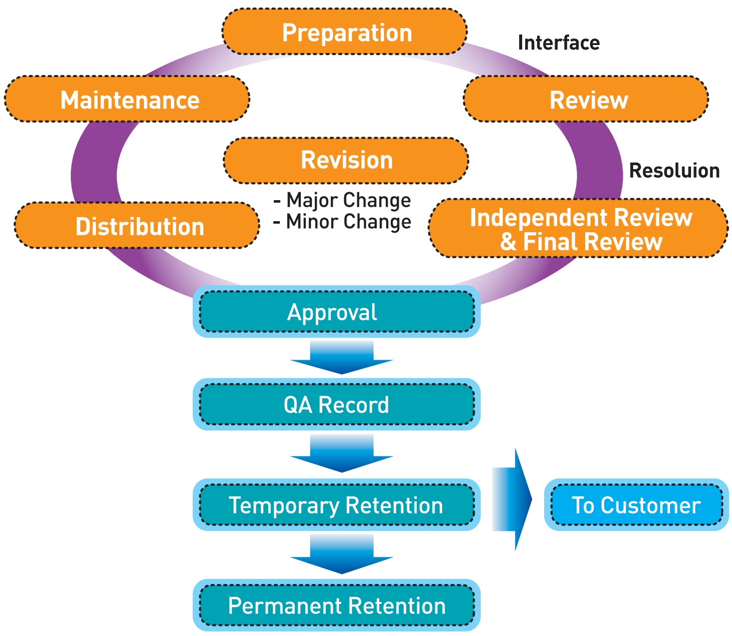
Managing Director Korea, J K Cheon

Originally registered: 25/11/1999 Latest Issue: 11/12/2006

Page: 1 of 2

BSi Management Systems

ISO Certificate of Registration



Design Flow

KEPCO E&C NED has established and implemented a Quality Assurance system which complies with the Atomic Energy Laws of the Republic of Korea and the quality-related requirements of the relevant regulations and standards. As such, all our personnel who are responsible for safety-related activities have been trained to conscientiously follow the quality requirements and achieve our goal of supplying high-quality products and services.

KEPCO E&C NED's outstanding Quality Assurance system was awarded the ISO 9001 certificate by the British Standards Institute, attesting to its excellence in terms of project management, engineering & design, and operation & maintenance for the Nuclear Steam Supply System(NSSS) in the nuclear power plants.
Our Quality Assurance will surely provide confidence in the NSSS design and technology's suitability for its intended purpose, ensuring that products and services satisfy customer requirements in a systematic, reliable fashion.

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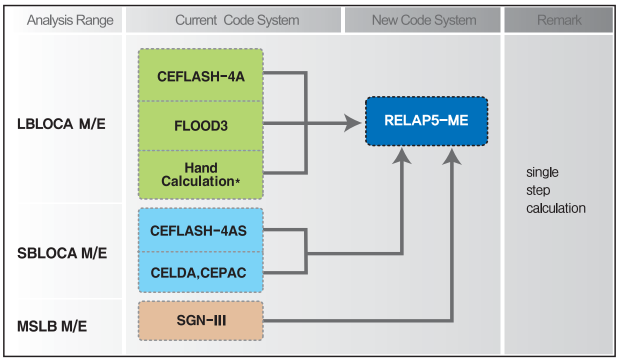
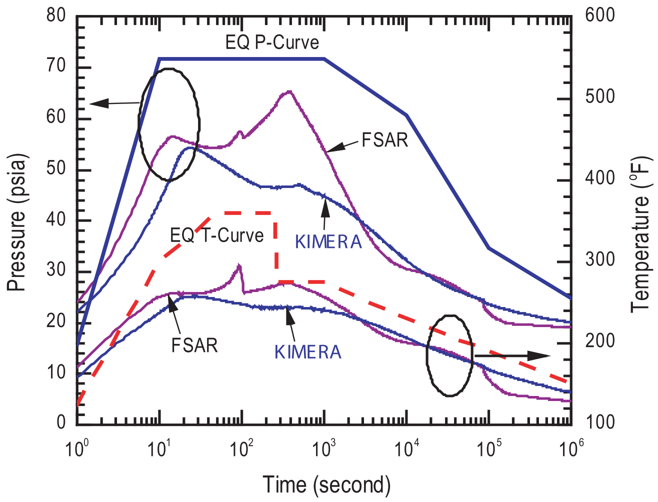
KEPCO E&C Improved M/E Release Analysis Methodology (KIMERA)



Comparison of Computer Code Systems.

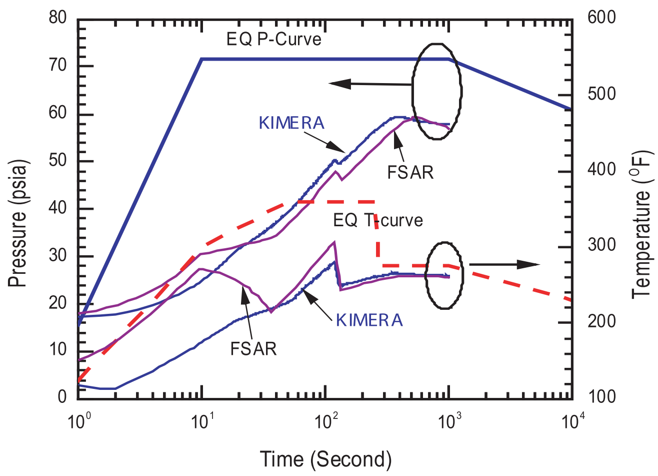
The KEPCO E&C Improved Mass and Energy (M/E) Release Analysis methodology (KIMERA) is a new approach to analyzing the M/E release for the design of containment buildings and structures. The KIMERA methodology acquired licensing approval for OPR1000 and Westinghouse type plants in 2007.



Containment P/T Response to LBLOCA for UCN 3&4

The KIMERA adopts a simplified and integrated code system and performs a single-step calculation for the whole transient. Moreover, the KIMERA has the capability to analyze design basis accidents including LOCAs (Loss Of Coolant Accident) with long-term (LT) cooling and MSLBs (Main Steam Line Break).

The containment pressure and temperature (P/T) responses using the M/E data from the KIMERA provide reasonable results and margins for the containment P/T design and environmental qualification (EQ). This new methodology will be applied to advanced nuclear power plants.



Containment P/T Response to MSLB for UCN 3&4

Features

- Coupled code system of RELAP5/MOD3 and CONTEMPT4/MOD5 (RELAP5-ME)
- Containment back pressure as a boundary condition for RCS Thermal Hydraulic(T/H) analysis
- Best-estimate analysis code for RCS T/H analysis
- Limit value approach for plant operating parameters
- LT cooling model and enhanced M/E model
- Applicable to various PWR type plants
- More containment design margin

newpower, newstandard

KEPCO E&C

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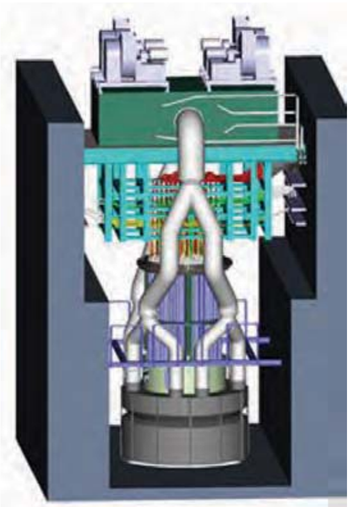
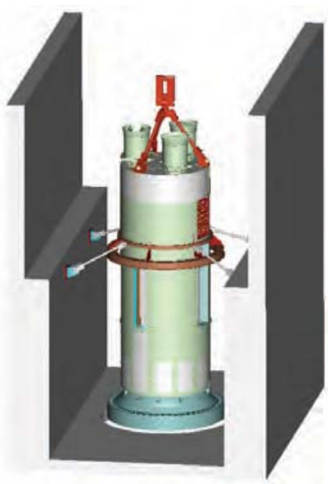
Integrated Head Assembly (IHA)

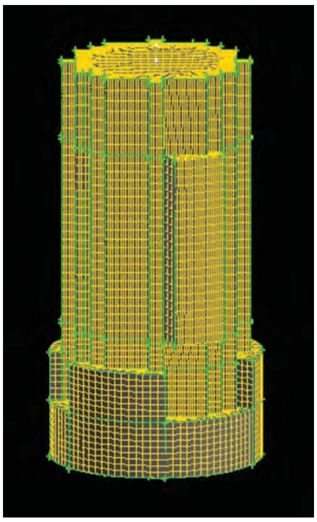
The Integrated Head Assembly (IHA) is a single assembly designed to integrate all conventional head area equipment. The IHA can be lifted together in one step and moved to the storage stand as a single structure during plant refueling.



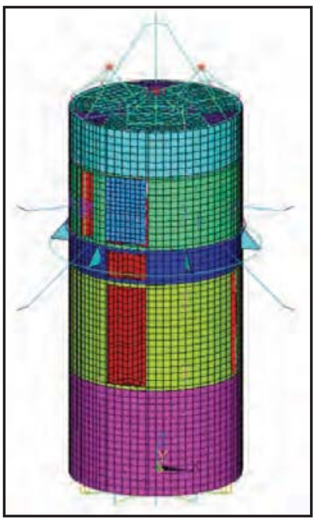
Conventional RV Head Area System



Integrated Head Assembly



Cooling Air Flow Analysis



3D Structural Analysis

The IHA is a mechanical system that assembles the various components required to provide lifting for the reactor vessel closure head, cooling of the CEDMs, missile protection and seismic support for the IHA and CEDMs. The IHA also provides the ability to support and connect the CEDM cables, HJTC (Heated Junction Thermocouple) cables, NIMS (NSSS Integrity Monitoring System) cables, CEDM cooling fans, Stud Tensioner Rail, and the RCGVS (Reactor Coolant Gas Vent System) piping.

Cooling Air Flow Analysis

- To verify the equivalent distribution of CEDM cooling air
- To calculate the temperature for abnormal conditions and the pressure drop

3D Modeling and Structural Analysis

- To check the interference among the IHA components and to ensure the optimal design
- To verify the structural integrity during design basis events

Benefits

- Over 60% reduction of handling steps for the removal and installation of the reactor vessel closure head
- 2 ~ 3 days reduction of refueling outage time
- Safety improvement of maintenance work
- 90% reduction of radiation exposure to personnel
- Reduction of space required for equipment storage

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