Testing Equipment

Research Service

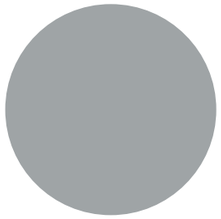
3D Design and Miniature

R&D PARTNER

Testing Equipment Specialist, KLES

KLES strives to be your reliable R&D partner

KLES



Customizable Testing Equipment Specialist, KLES

KLES provides high-quality, customizable testing equipment that suits customer's needs

01 Testing Equipment

1. Universal Testing Machine
2. Impact Tester
3. Corrosion Tester
4. Creep Tester
   - Small Punch Creep Tester
5. Insulation Performance Tester
6. High-Temperature, High-Pressure Water Chemistry Loop System

Universal Testing Machine

The universal testing machine is used to evaluate the strength of materials through tensile, compression, bending, and shearing tests. This testing equipment provides a static-proof stress test environment for industries and research and education institutes that require highly precise and repetitive material tests. It also meets the specific requirements of developers in regards to high reliability, operation time, and price and quality competitiveness.

Features

- Load measurement precision
  - Measurement up to 1/500 of capacity of load cell, with customizable specifications
- Data acquisition speed
  - Up to 1kHz for the load, displacement, and elongation channels simultaneously
  - Service channels and additional sensors can be installed to obtain additional data
- Test speed
  - 0.001~3,000mm/min(0.00004~120in/min)
- Auto sensor recognition function for load cells and extensometers
- Crack growth measurement, using DCPD
- Dedicated grips and jigs

Specifications

Class.	Electromechanical	Static-hydraulic
Force capacity	10, 30, 50, 100KN	10, 30, 50, 100, 200, 500, 1,000KN
Force resolution	0.02%	0.02%
Stroke	Max. 200mm (optional)	Max. 200mm (optional)
Stroke resolution	0.001mm	0.001mm
Safety device	· Up/Down limit · Load limit · Stroke limit	· Up/Down limit · Load limit · Stroke limit · Hydraulic pressure limit
Frequency	0.1 ~ 5Hz (sine wave)	0.1 ~ 60Hz (sine wave)

Track records

2016 KAIST
Korea Hydro & Nuclear Power Co., Ltd.

2015 KAIST
Korea Hydro & Nuclear Power Co., Ltd.

2007 KAIST

2004 KAIST

UI Design

Impact Tester

The impact tester is used to evaluate the impact resistance of materials. The toughness and brittleness of materials can be obtained by crushing a specimen and measuring the energy it can withstand until it fractures. This equipment can be fabricated in mechanical or hydraulic. The mechanical impact tester takes the form of a pendulum and is mounted with an anti-rebound device to enable to simulate the impact according to actual load. The hydraulic impact tester can test high loads with more precise impact control than the mechanical type.

Features

- Test frame with a belt drive and electric system
- Convenient control system with automatic angle measurement
- Modular cross head for quick and safe weight replacement
- Software for detailed impact performance data acquisition, analysis, and report
  – Simultaneous sampling of speed, acceleration, and impact at 2MHz
- Optional anti-rebound device and environment chamber

Specifications

Class.	Mechanical	Hydraulic
Impact speed	Max. 6.0m/s	Max. 10.0m/s
Acceleration	Max. 100 ~ 3,000m/s^2	Max. 100 ~ 3,000m/s^2
Pulse duration range	1 ~ 100ms	100ms

▪ Accessory: Heater

Class.	Mechanical	Hydraulic
Electric energy	6kW	12kW
Voltage	380Vac, 1phase	380Vac, 3phase
Temperature	Max. 400℃ (±5℃)	Max. 400℃ (±5℃)
Heating rate	10℃/min	10℃/min

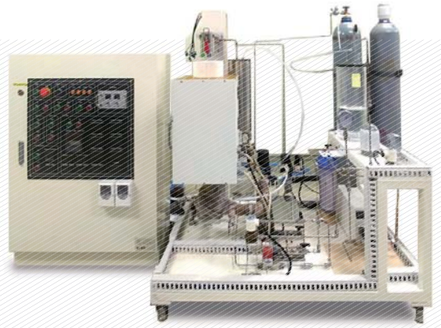
Track records

2015 KEPCO Nuclear Fuel

UI Design

Corrosion Tester

The corrosion tester is used to evaluate the corrosion resistance of a material in particular environments that can physically or chemically alter the material. This equipment can simulate the general corrosive environment, as well as the primary system environment of a pressurized water reactor at high temperature and pressure in a nuclear power plant, the turbine environment of a thermal power plant, and even the salt water and high-temperature gas environment where serious damage can be caused to materials.



Features

- Autoclave for safe experiments with the conditions of a nuclear (350℃, 15MPa) or thermal (600℃, 25MPa) power plant
- Diverse heating system to meet the temperature conditions for hot steam oxidation corrosion (Max: 1,300℃) (with IR Lamp, furnace, etc.)
- High-temperature hydrogen corrosion tester
  - Experiments available in the hydrogen environment of 600℃, 20Mpa.
- High-temperature gas corrosion tester
  - Experiments available with very corrosive gases such as H_2S, CO, or NOx
- Tester customization for different experiment conditions

Specifications

Class.	Primary system condition of nuclear power	Condition of thermal power	Nuclear power fuel rod condition	CO_2 high-temperature corrosion
Temperature	Max. 350℃ (Option : 600℃ or more)	Max. 600℃ (Option : 1,300℃ or more)	Max. 1,200℃	Max. 400℃ (Option : 600℃ or more)
Pressure	Max. 15MPa (Option : 25MPa)	Max. 25MPa	Max. 20MPa	Max. 25MPa
Atmosphere	N/A	N/A	N/A	CO_2
Vacuum	N/A	N/A	$2*10^{-6}$torr	N/A
Electrical conductivity	0.02 ~ 2,000mS/m (Resolution : ±1%)	0.02 ~ 2,000mS/m (Resolution : ±1%)	N/A	N/A
DO	0 ~ 20ppb (Resolution : 0.1)	0 ~ 20ppb (Resolution : 0.1)	0 ~ 20ppb (Resolution : 0.1)	N/A
pH	1.0 ~ 11.0pH (Resolution : 0.1)	1.0 ~ 11.0pH (Resolution : 0.1)	1.0 ~ 11.0pH (Resolution : 0.1)	N/A
DH	0 ~ 80cc/kg Adjustable	0 ~ 80cc/kg Adjustable	N/A	N/A

Track records

2016 Korea Hydro & Nuclear Power Co., Ltd.
2015 Iljin Steel
KEPCO Nuclear Fuel
Doosan Heavy Industry
2014 Korea Hydro & Nuclear Power Co., Ltd.
2013 KAIST
2012 Doosan Heavy Industry

Autoclave

High temperature steam oxidation corrosion

High-temperature gas corrosion

Creep Tester

The creep tester is a test equipment to evaluate creep fractures in materials by applying specific tensile or compression load at a certain temperature for an extended period of time, which shows off exceptionally excellent stability and durability even for long time experiments at high temperature (over 1,000℃). After applying specific tension or compression load to the material for a long period of time, the alteration in length of the specimen is measured. When fracture occurs on the way, the test is to be automatically knocked off, and then the creep curve and data are analyzed. At the time, the heating device (furnace chamber) is deactivated to reassure the safety.

Features

- Heating system stably controlled by PID even at high temperatures (1,000℃ or more) (Error: ± 2℃)
- System with the accuracy of load application through its automatic leveling controller
- Safe system to automatically detect any fractures, overheating, etc. of the specimens and terminate the test at once, warning the user of such incidents.
- Structure in which a weight can be instantly and safely replaced.

Specifications

Class.	Lever type	Dead type
Force capacity	0 ~ 20KN	0 ~ 1KN
Temperature	Max. 1,400℃	Max. 1,400℃
Lever ratio	20:1, 15:1	N/A
Stroke	100mm	100mm

Track records

2016 KAIST
Hanyang University

2015 KAIST
Hanyang University

2014 KAIST

2012 Hanyang University

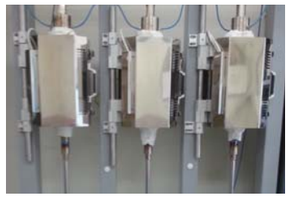
2011 Dongguk University
KAIST

2010 KEPCO Research Institute
Chungnam National University

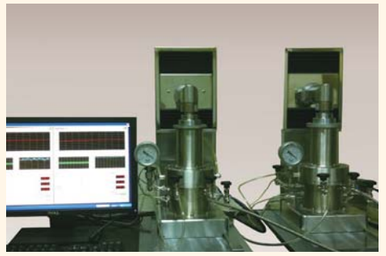
2009 Sungkyunkwan University

UI Design

Multi-creep Tester



Small Punch Creep Tester



The small punch creep tester is used to evaluate characteristics for fracture toughness (transient temperature, elastic-plastic fracture tension, etc.) of the equipment by cutting out a small piece of specimen directly from a base material to the extent that the integrity of the subject equipment is maintained.
The small punch test has been emerging as a pseudo-nondestructive material-degradation evaluation method because the equipment does not have to be demobilized to collect the specimen piece and remedial treatment is not required after sampling. The fracture tension of the base metal that has been degraded during operation can be directly obtained, and additional welding maintenance is not required for the base metal after collecting the sample. It has the advantages not only facilitating to obtain directly the fracture toughness of the base material going through degradation by the operation, but also being processible to go without additional welding repairs to the base material after sampling.

Features

- Evaluation possible with a tiny specimen (0.5mm thick x 6.5mm diameter) taken from a base material
  - No welding maintenance after collecting a specimen
- Embrittlement and damage speed data monitoring for member of framework, and direct evaluation of tension after long-term use
- Reproducibility of test results

Specifications

Class.	Electronic	Mechanical
Force capacity	Max. 3.5KN (option : 6kN)	Max. 3.5KN (option : 6kN)
Force resolution	0.03%	N/A
Specimen jig	Super heat resisting alloy	Super heat resisting alloy
Stroke	100mm	N/A
Stroke resolution	0.001mm	N/A
Temperature	Max. 600℃ (option : 1,050℃)	Max. 600℃ (option : 1,050℃)

Track records

Electronic

2016 KAIST

2011 KEPCO Research Institute

Mechanical

2010 Sungkyunkwan University

UI Design

Insulation Performance Tester

The Insulation performance tester is used to evaluate the heat transfer efficiency of insulators, which can evaluate the performance of general insulators and Reflective Metal Insulation (RMI) used in nuclear power plant as well. In addition, it is configured in the shape of a planar type and a pipe type in order to evaluate the changes in insulation performance according to the insulation shapes.

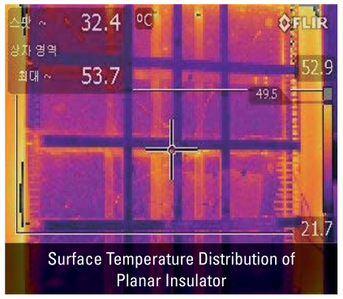
Features

- Effective value measurement
  - Uses a power analyzer with a precision of 0.1%
  - All heaters use rectified AC power.
- Guard box maintains the temperature with PID temperature control
- Power regulator is employed to regulate temperatures through power control method
- Measurement reliability for insulation test part (Power: WT330, Temperature: NI cDAQ 9188)

▪ Planar Type

- Test for insulators in the size to the extent of an area of 930~1,480mm and a thickness of 105mm
- This is a guarded hot box test device to measure thermal properties such as thermal transmission, conductivity, and resistance
- Angle adjustments of 45° or 90° so as to observe the change in insulation performance depending on angle.

Planar-Type Insulation Performance Tester

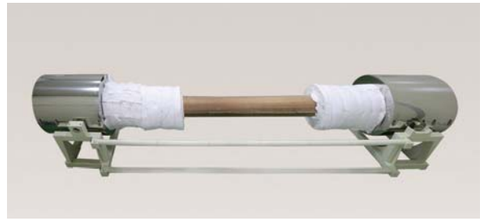


Surface Temperature Distribution of Planar Insulator

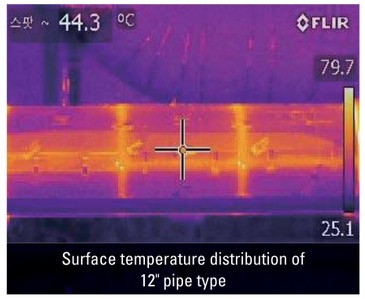
▪ Pipe Type

- Test for insulators with an internal diameter of 324mm or more and a length of 1~4m
- Measurement of thermal properties, such as thermal transmission, conductivity, and resistance, with device configuration according to ASTM C335 standard:
- Insulation performance evaluation for the shape of onsite plant pipe (12", 30")

12" pipe insulator



30" pipe insulator



Surface temperature distribution of 12" pipe type

UI Design

High-Temperature, High-Pressure Water Chemistry Loop System

The system is used to simulate the critical operation environments of high-temperature and high-pressure in nuclear and thermal power plants. The levels of dissolved oxygen and dissolved hydrogen are adjusted to simulate the optimal experiment conditions similar to that of a power plant.

Features

- System for safe simulation of the condition's of a nuclear (350℃, 15MPa) or thermal (600℃, 25MPa) power plant
- Program for real-time measurement and storage of temperature, pressure, and water chemistry conditions (DO, DH, and pH)
- Safety system to prevent excessive pressure, overheating, gas leakage, and cooling issues
- System with stable operation for over one year
- System for precise and safe control (mass flow controller [MFC]) of argon, hydrogen, and other gases

Specifications

Class.	Description	Remarks
Temperature	Max. 400℃	Option : 600℃
Pressure	Max. 25MPa	N/A
DO	0 ~ 20ppb, 0 ~ 1,000ppm	N/A
DH	0 ~ 80cc/kg	Adjustable
Electrical conductivity	0.02 ~ 2,000mS/m	Resolution : ±1%
pH	1.0 ~ 11.0pH	Resolution : 0.1

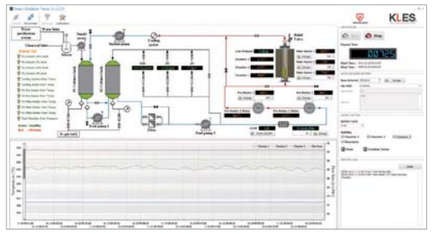
Track records

2016 Korea Hydro & Nuclear Power Co., Ltd.

2015 Korea Hydro & Nuclear Power Co., Ltd.
KEPCO Nuclear Fuel
KAIST
Iljin Steel

2014 KAIST
Dongseo Industry
Doosan Heavy Industry

UI Design



02 Research Service

1. Ball-Bearing Durability Evaluation Test
2. Wear Test
3. Residual Stress Measurement
4. Thermo Mechanical Fatigue (TMF)
5. Corrosion Fatigue Test
6. Selective Fatigue Test

Ball-Bearing Durability Evaluation Test

Evaluation of bearings operating
in a water-lubricated environment
by applying a load in the axial direction

Description

• Bearing wear test

· Fabrication of tester to simulate axial load and water lubricated environment

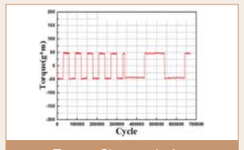
· Wear test with a maximum of 670,000 rotations

• Bearing drop impact test

· Impact test to simulate an emergency while using the ball bearing

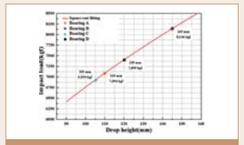
Records

2011 Seoul National University of Science and Technology



Torque Change during Experiment

High-Load and Water Lubrication Test



Break Impact Load by Candidate Group

Damaged Bearing after Drop impact test

Wear Test

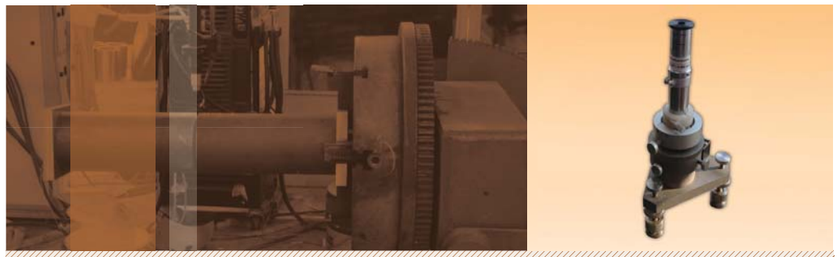
Evaluation of wear characteristics in extreme conditions such as vertical load, sliding distance, temperature, or pressure applied to the material

Description

- **Wear characteristic review and test condition setting**
  - · Prior technology data collection and analysis
  - · Wear life evaluation model analysis
  - · Base experiment to define worn apparatus
- **Main test**
  - · Room-temperature wear test
  - · High-temperature and high-pressure wear test
  - · Quantitative analysis (wear amount, depth, and volume)
  - · Deduction of wear coefficient

Records

2007 KEPCO Research Institute



Residual Stress Measurement

Nondestructive and semi-nondestructive residual stress measurement

Description

- **Specimen fabrication to verify finite element analysis**
  - · Fabrication of dissimilar metal welding model
  - · Data collection to calculate heat input while welding (voltage, current, and temperature)
  - · Heat treatment (HT)
- **Residual stress measurement**
  - · Drilling, indentation, and X-ray diffraction
- **Others**
  - · Welding hardness and tissue analysis

References

- · ASTM E837
- · ASTM E1426
- · Specification (WPS)

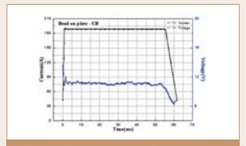
Records

2013 Korea Hydro & Nuclear Power Co., Ltd.

Specimen Fabrication

Nozzle Mock-Up

Drilling



Data Collection while Welding (Voltage and Current)

Thermo Mechanical Fatigue (TMF)

High-temperature, low-cycle, and thermal fatigue characteristic test and evaluation

Description

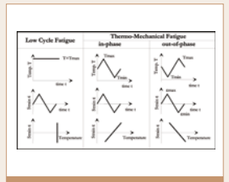
- **Wear characteristic review and test condition setting**
  - · High-temperature low-cycle and thermal fatigue test data survey and analysis
  - · Thermal fatigue tester operation, equipment inspection and maintenance
  - · High-temperature and low-cycle fatigue and thermal fatigue test condition setting through preliminary test
- **Test and analysis**
  - · Comparison of thermal fatigue characteristics by bearing of material
  - · Comparison of thermal fatigue characteristics by thermal stress mode
  - · Comparison of thermal fatigue characteristics by high-temperature retention time

References

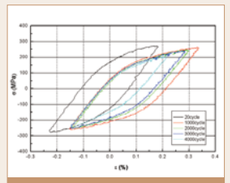
· ASTM E8M

Records

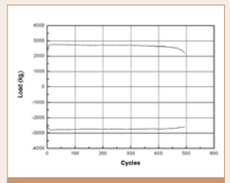
2011 KEPCO Research Institute



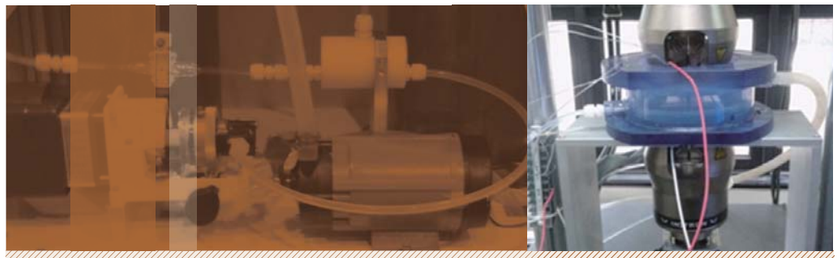
Type of Thermal Fatigue Cycle



Load-Cycle Curve



Stress-Strain Curve

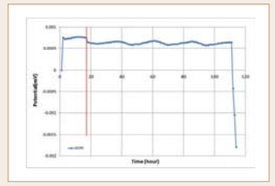


Corrosion Fatigue Test

Fatigue Characteristic Evaluation under Corrosive Environment

Description

- **Wear characteristic review and test condition setting**
  - · Corrosion damage and fatigue test data survey
  - · Basic physical properties test
  - · EPR test
- **Main test**
  - · Corrosion fatigue test (crack growth measurement of an object with DCPD)
  - · Interrupt test
- **History of potential over time**



References

· ASTM E8M
· ASTM G108
· ASTM G5
· ASTM E647
· Specifications

Records

2012 KEPCO Research Institute

Selective Fatigue Test

Evaluation of mechanical characteristics with selective leaching experiments and measurements of valve materials and laid piping materials for the system to supply firewater in a nuclear power plant

Description

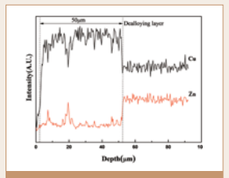
- **Selective leaching test**
  - · Deduction of selective leaching conditions by brass, gray cast iron, Al-bronze, and Cu-Ni alloy
  - · Deduction of accelerated test conditions (temp., time)
- **Test and analysis**
  - · Visual inspection
  - · Hardness
  - · SEM / EDS
  - · Tensile strength

References

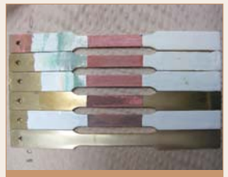
· ASTM E8M

Records

2010 KEPCO E&C



Leaching Depth Measurement with EDS



Leaching Specimen

03 3D Design and Miniature

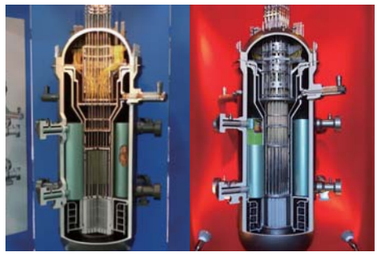
1. 2D drawing, 3D design, and miniature (1st - 5th) for Smart nuclear reactor assembly
2. 3D modeling and video of Smart major devices (CEDM, SG, and MCP)
3. 3D modeling and miniature for Jordan Research & Training Reactor
4. Model and video contents for the promotion and training of the Yeongheung Thermal Power Plant
5. Model and video contents for the promotion and training of the Samcheonpo Thermal Power Plant
6. Portable display model of a Very High Temperature Reactor (VHTR)
7. Integrity diagnosis model for the heat-transfer pipe of steam generator
8. Pressure vessel structure material model
9. Block diagram and model of main component materials of a nuclear power plant
10. 3D modeling of the RVA nuclear reactor assembly
11. Concept and basic design of the PALLAS reactor and CRDM

3D Design and Miniature

1 2D drawing, 3D design, and miniature (1st-5th) for Smart nuclear reactor assembly

Client Korea Atomic Energy Research Institute

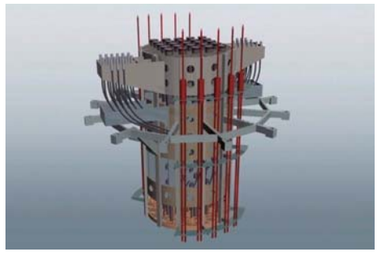
- 2D drawing of the Smart reactor assembly
- 3D modeling of the Smart reactor assembly
- Evaluation of space requirements and implementation for developed design concept (CAD model development) and placement of nuclear reactor assemblies
- Smart nuclear reactor display model fabrication
- Development (1994 ~ 2011), UAE 330MW Nuclear Reactor



2 3D modeling and video of Smart major devices (CEDM, SG, and MCP)

Client Korea Atomic Energy Research Institute

- Smart major device design technology development project
- CEDM (control rod drive)
- SG (steam generator)
- MCP (coolant circulation pump)



3 3D modeling and miniature for Jordan Research & Training Reactor

Client Korea Atomic Energy Research Institute

- Jordan Research & Training Reactor 5MW Research Reactor ~ 2015, Jordan

4 Model and video contents for the promotion and training of the Yeongheung Thermal Power Plant

Client Korea South East Power Co. Ltd.

- System model fabrication for boiler, turbine, piping, and other structures
- Fabrication of actual mockup and video contents for publicity of power plant along with self-explanatory descriptions and understandings on coal-fired power.
- New employee training and publicity for power plants
- Training video contents in five languages

5 Model and video contents for the promotion and training of the Samcheonpo Thermal Power Plant

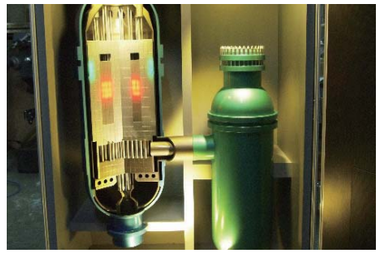
Client Korea South East Power Co. Ltd.

- System model fabrication for boiler, turbine, piping, and other structures
- Screening of video and contents with PDP screen connected to PC and user interface program
- LED lighting flow and video control of model piping system by directly operating KIOSK touch monitor
- New employee training and publicity for power plants
- Training video contents in five languages

6 Portable display model of Very High Temperature Reactor (VHTR)

Client Korea Atomic Energy Research Institute

- Model to maximize the effects of exhibition and publicity by realistically simulating each assembly constituting High-Temperature Gas-cooled Reactor, and lively visualizing the flow of each system



7 Integrity diagnosis model for the heat-transfer pipe of steam generator

Client Korea Atomic Energy Research Institute

- 2012 Nuclear Power R&D Project Performance Exhibition
- Model to realize the actual mechanism of new probe to diagnose the integrity of heat-transfer pipes in a steam generator

8 Pressure vessel structure material model

Client Korea Atomic Energy Research Institute

- 2012 Nuclear Power R&D Project Performance Exhibition
- Model to introduce shape and material of dissimilar welding between the pressure vessel and nozzle of a running nuclear reactor

9 Block diagram and model of main component materials of a nuclear power plant

Client Korea Atomic Energy Research Institute

- 2012 Nuclear Power R&D Project Performance Exhibition
- Block diagram and model of materials for NSSS units of light-water reactor of running nuclear power plant

10 3D modeling of the RVA nuclear reactor assembly

Client Korea Atomic Energy Research Institute

- 3D modeling of Reactor Vessel Assembly

11 Concept and basic design of PALLAS reactor and CRDM

Client Korea Atomic Energy Research Institute

- Concept design phased I and II for research nuclear reactor and CRDM to bid for the Netherlands' PALLAS Research Reactor.
- 2007 ~ 2016, the Netherlands 800MW Research Reactor

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