Advanced Boiling Water Reactor

The first Generation III+ Reactor in Operation today

Hitachi-GE Nuclear Energy, Ltd.

Energy production technologies for sustainable future

Advanced Boiling Water Reactor - The first Generation III+ Reactor in Operation today - with Enhanced Safety, Performance and Cost Efficiency.

Shimane 3 , The Chugoku Electric Power Co., Inc.

- Nuclear Energy -

Nuclear Plant Technologies

ABWR Structure, System and Component

Project Management Organizations

Research and Development

Achievements

Boiling Water Reactor History and Line-UP

Simple & Reliable Nuclear-Power Generation System

One of the world's most common types of nuclear power generating plants, boiling water reactors, are characterized by a system wherein steam generated inside the reactor is directly passed to the turbine to simplify the process and equipment.
Since the introduction of the boiling water reactor technology, from General Electric in the 1960s, Hitachi has participated in the design, development and construction of over 20 nuclear power plants within Japan.

The Chugoku Electric Power Co., Inc. Shimane 1

Tokyo Electric Power Company Holdings, Inc. Kashiwazaki-Kariwa 5
【Source：Tokyo Electric Power Company Holdings, Inc.】

Introduction of Technology from US in 1960s

Tsuruga 1 (The Japan Atomic Power Co.)
Fukushima Ⅰ-1 (Tokyo Electric Power Company Holdings, Inc.)
Hamaoka 1 (Chubu Electric Power Co., Inc.)
Fukushima Ⅰ-4 (Tokyo Electric Power Company Holdings, Inc.)
Tokai Ⅱ (The Japan Atomic Power Co.)
Hamaoka 2 (Chubu Electric Power Co., Inc.)

Promotion of Domestic Plant

Shimane 1 (The Chugoku Electric Power Co., Inc.)

BWR-2 ▶ BWR-3,4,5

Primary Improvement

Promotion of Improvement and Standardization Program (1975 to 1977)

Fukushima Ⅱ-2 (Tokyo Electric Power Company Holdings, Inc.)
Fukushima Ⅱ-4 (Tokyo Electric Power Company Holdings, Inc.)
Hamaoka 3 (Chubu Electric Power Co., Inc.)
Shimane 2 (The Chugoku Electric Power Co., Inc.)
Kashiwazaki-Kariwa 5 (Tokyo Electric Power Company Holdings, Inc.)

BWR-5
Improved Version

Promotion of Secondary Improvement and Standardization Program (1979 to 1980)

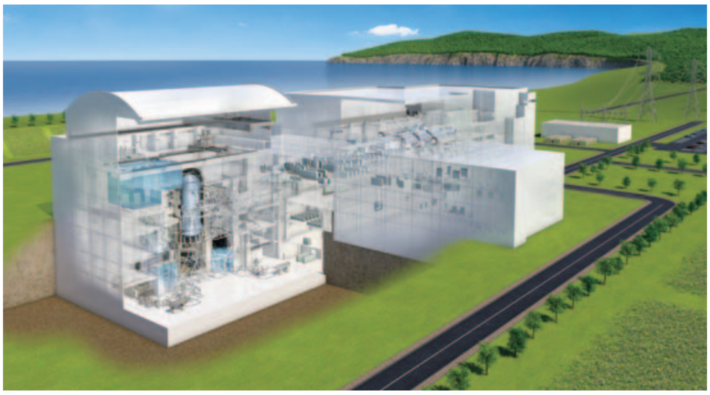
Shika 1 (Hokuriku Electric Power Co., Inc.)
Hamaoka 4 (Chubu Electric Power Co., Inc.)
Kashiwazaki-Kariwa 4 (Tokyo Electric Power Company Holdings, Inc.)
Onagawa 3 (Tohoku Electric Power Co., Inc.)

Our highly reliable products, based on proven design, are leading nuclear technology that enhance the safety of nuclear power plants.

ABWR Development concept

- Enhanced Safety
- Higher Operability
- Reduced Dose Equivalent
- Enhanced Cost Efficiency (Construction/Operation)

The Chugoku Electric Power Co., Inc. Shimane 3



UK-ABWR

ABWR

Application of Evolutional Design and Standardization

The first and second ABWR in the world (Twin plant)

Kashiwazaki-Kariwa 6 (Tokyo Electric Power Company Holdings, Inc.)
Kashiwazaki-Kariwa 7 (Tokyo Electric Power Company Holdings, Inc.)

Succeeding ABWR plants

Hamaoka 5 (Chubu Electric Power Co., Inc.)
Shika 2(Hokuriku Electric Power Co., Inc.)
Shimane 3 (The Chugoku Electric Power Co., Inc.)
Ohma (Electric Power Development Co., Ltd.)
Higashidori 1(Tokyo Electric Power Company Holdings, Inc.)

Completed Generic Design Assessment(GDA) for UK-ABWR in December 2017.

Advanced Boiling Water Reactor

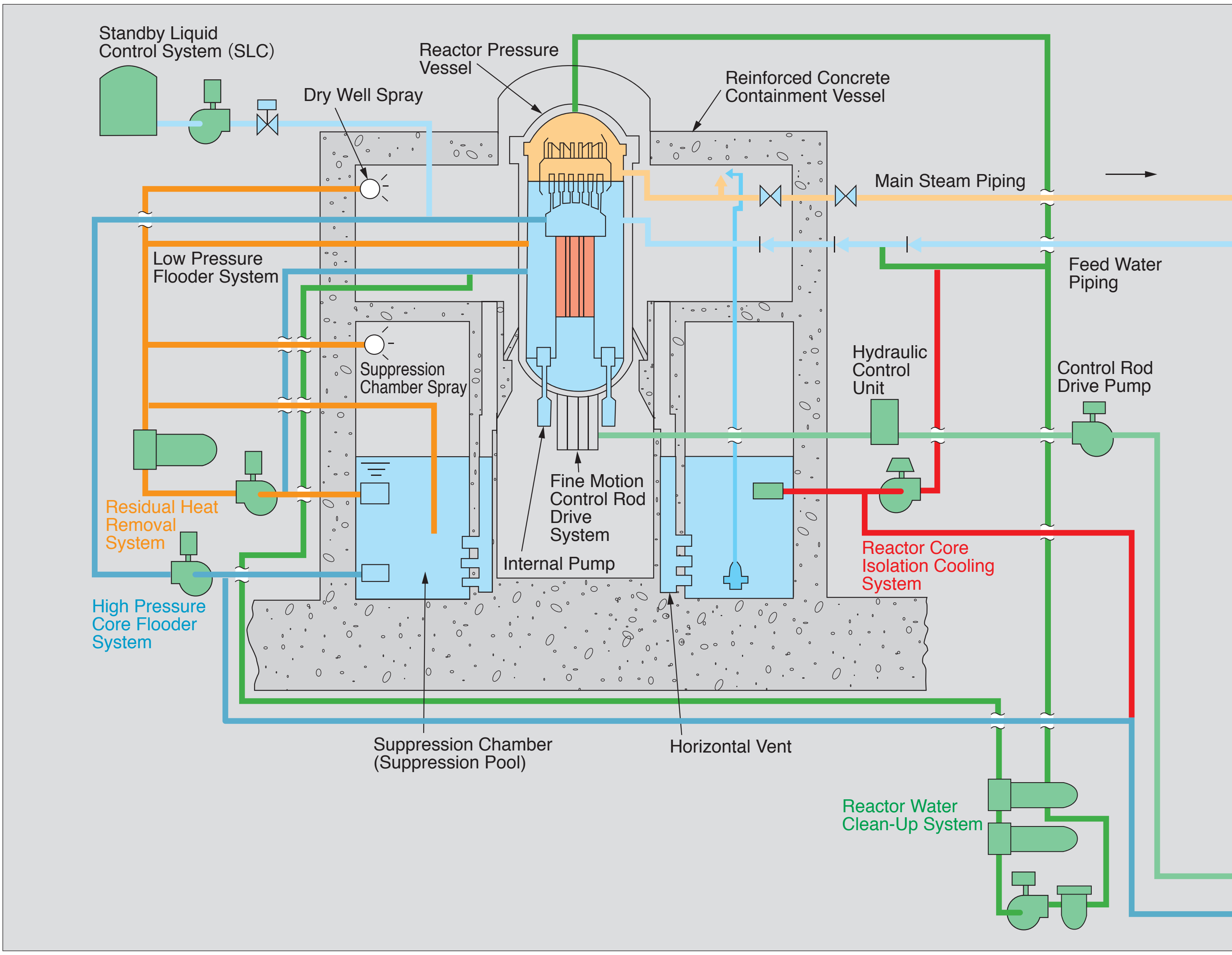
ABWR Plant Realized through International Joint Development

Hitachi developed the ABWR in 1985, in collaboration with various international partners and support from power companies with experience in operating BWR plants. The main technological features employed are as follows:

(1) Large scale, highly efficient plant
(2) Highly economical reactor core
(3) Reactor coolant recirculation system driven by internal pumps
(4) Advanced control rod drive mechanism
(5) Overall digital control and instrumentation
(6) Reinforced concrete containment vessel

These features constitute a highly functional, enhanced safety nuclear reactor systems, with a compact, easy-to-operate, and efficient turbine that offers excellent performance.

■Schematic Diagram of Advanced Boiling Water Reactor (ABWR)



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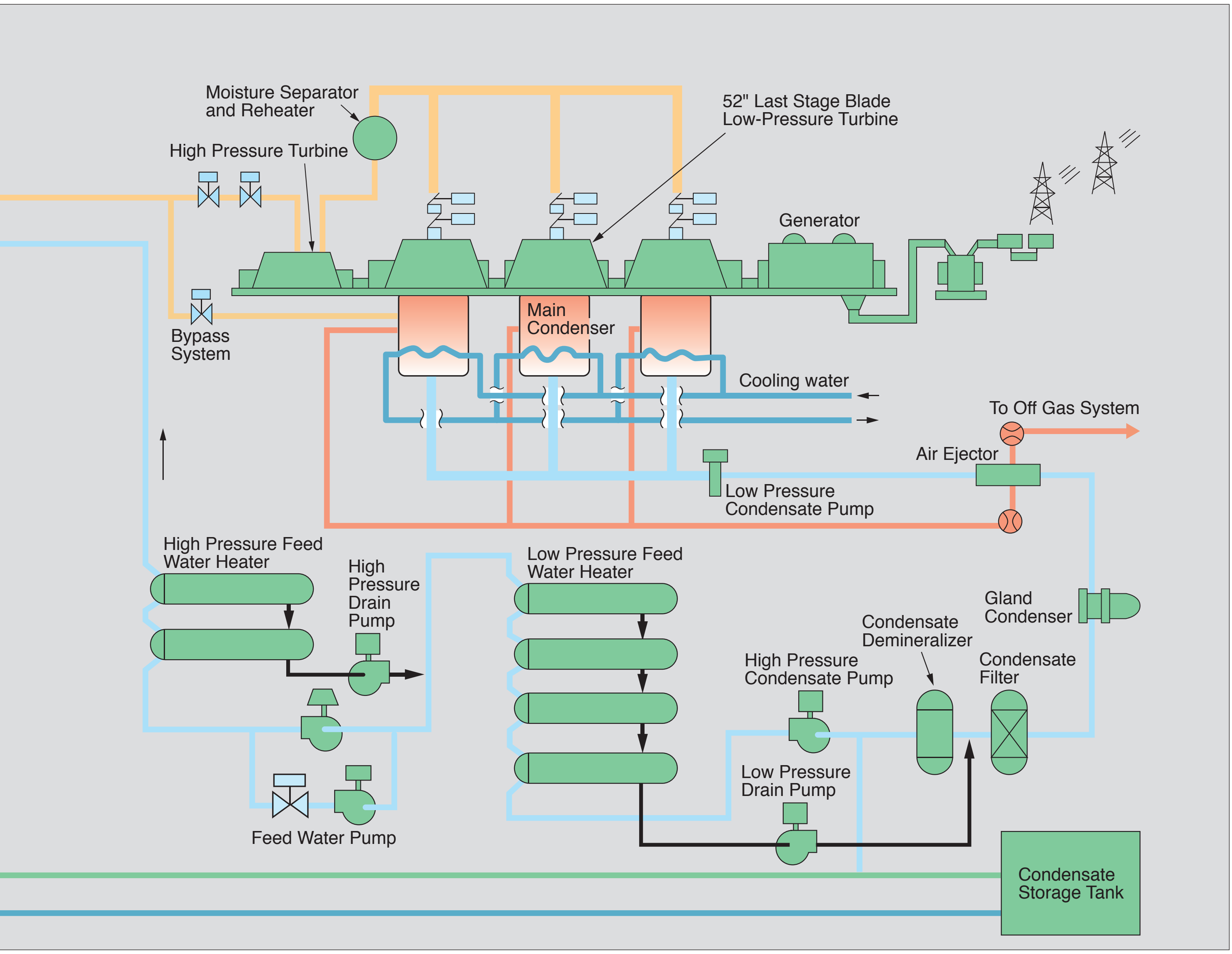
■Key Specifications of BWR Nuclear Power Plants

	Item	ABWR	BWR-5
Output	Plant Output	1,350 MWe	1,100 MWe
	Reactor Thermal Output	3,926 MWt	3,293 MWt
Reactor Core	Fuel Assemblies	872	764
	Control Rods	205 rods	185 rods
Reactor Equipment	Recirculation System	Internal pump method	External recirculation type
	Control Rod Drive	Hydraulic / electric motor drive methods	Hydraulic drive
Reactor Containment Vessel		Reinforced concrete with built-in liner	Free-standing vessel
RHR* System		3 systems	2 systems
Turbine Systems	Thermal Cycle	Two-stage reheat	Non-reheat
	Turbine (final blade length)	52 inches	43 inches
	Moisture Separation Method	Reheat type	Non-reheat type
	Heater Drain	Drain up type	Cascade type

*Residual Heat Removal System

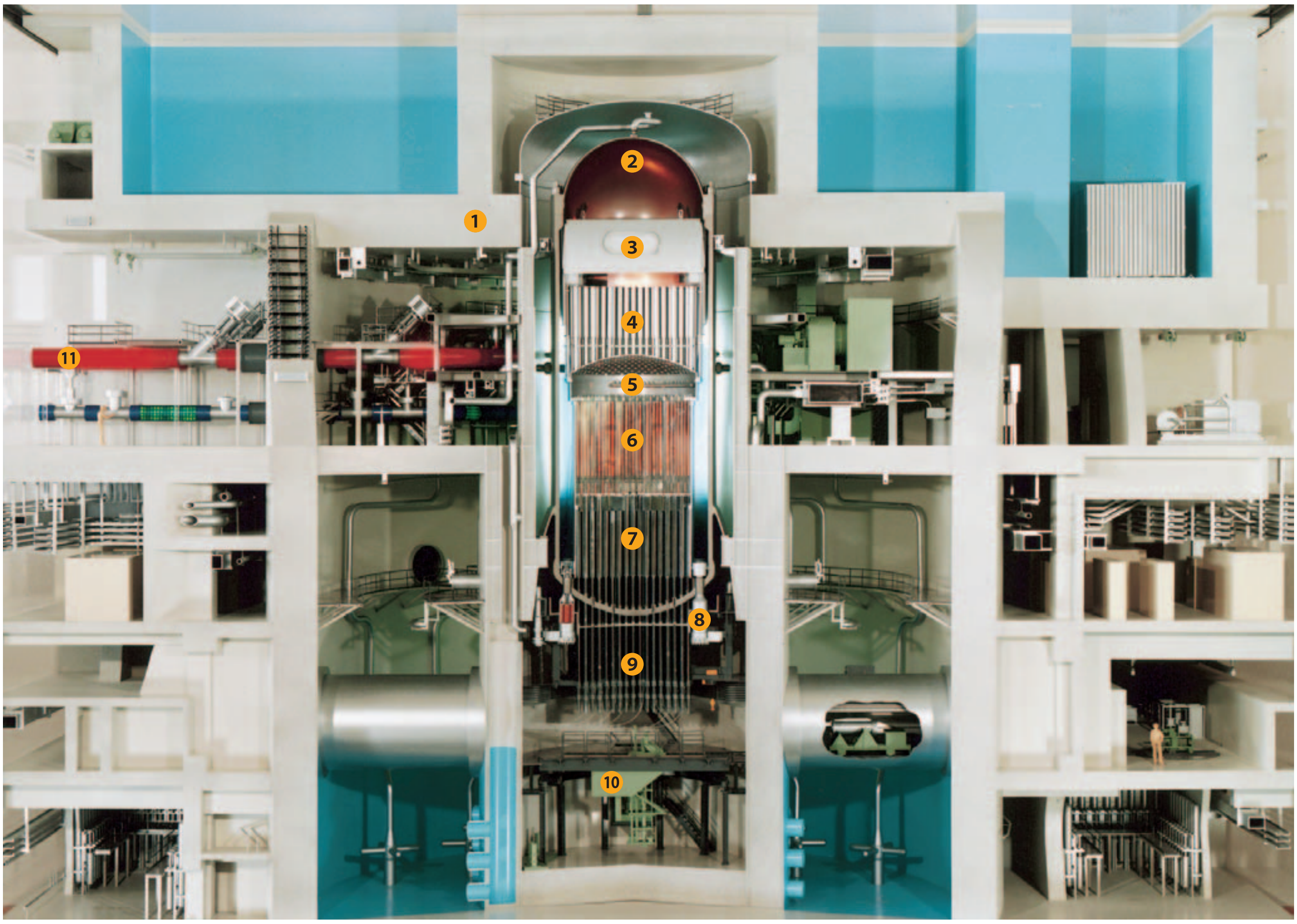


Advanced Boiling Water Reactor

Application of "Evolutional Designs"

- Large capacity, high efficiency plant systems
- Emergency Core Coooling Systems with enhanced safety
- Highly economical reactor core
- Reactor recirculation system applying internal pumps
- Advanced Fine Motion Control Rod Drive System
- Advanced Main Control Room with Full Digital system and improved Human- Machine Interface & Automatic Operation
- Reinforced Concrete Containment Vessel

■ABWR Reactor Building section view



1 Reinforced Concrete Containment Vessel
2 Reactor Pressure Vessel
3 Steam Dryer
4 Steam Separator
5 High Pressure Core Flooder Sparger
6 Fuel Assembly
7 Control Rod
8 Reactor Internal Pump
9 Fine Motion Control Rod Drive System
10 Control Rod Drive Mechanism Handling Machine
11 Main Steam Piping

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■Hitachi's continuous involvement in construction of ABWR power plants

(C/O:Commercial Operation)

1st, 2nd ABWRs **Kashiwazaki-Kariwa 6&7 (C/O:1996,1997)**

【Source：Tokyo Electric Power Company Holdings, Inc.】

3rd ABWR **Hamaoka 5(C/O:2005)**

4th ABWR **Shika 2(C/O:2006)**

5th ABWR **Shimane 3** (Under Construction)

6th ABWR **Ohma 1** (Under Construction)

7th ABWR **Higashidori 1** (Under Construction)

Reference: http://www.tepco.co.jp/nu/hd-np/plan/plan-j.html

ABWR Countermeasures Against Fukushima Accident

Enhanced Safety Features regarding Fukushima-daiichi NPP※ accident

ABWR safety are based on the Defense in Depth (DiD) concept wherein multiple layers of protection are provided with each layer designed to provide the safety function with no reliance on the other layers.
ABWR design is compliant with the international criteria by well-designed Safety Systems to achieve a sufficiently low core damage frequency.
Furthermore, to accomplish an enhanced level of nuclear safety, supplementary safety enhancements against severe conditions have been incorporated. These enhancements on further layer in DiD are designed to address the Fukushima-daiichi NPP accident caused by the huge earthquake and subsequent tsunamis on March 11, 2011.
The major enhancements are the further prevention of Station Black Out (SBO) and/or Loss of Ultimate Heat Sink (LUHS). Moreover, the enhanced functions ensure water supply into the reactor, PCV integrity, and SFP water level is maintained even in the event of SBO and/or LUHS.
These enhancements, based on lessons learned from Fukushima Accident, provision and maintenance of Severe Accident Management Guidelines, ensure that the integrity of inherent safety features of the ABWR is retained even in the event of a severe accident.

※NPP : Nuclear Power Plant

ABWR Safety

- Diversified water injection methods
- Large capacity of heat sink (pool)
- Inactivated PCV
- High seismic resistance
- No large bore pipes lower than the top of fuel assemblies

➡ Core Damage Frequency (CDF):1.6×10^{-7}

(1) Secure Power Source
- Alternative DC Power Source
- Diversity of Power Source (Water-cooled DG, Air-cooled DG)
- Sealed building structure to secure components and power panels in case of flooding

(2) Secure water injection systems and ultimate heat sink
- Diversity of alternate water injection capabilities
- Enhancement of mobility by applying portable pumps
- Diversity of heat sink through use of portable heat removal system

(3) Prevention of PCV damage
- Prevention of PCV damage caused by elevated temperatures by enhancing the PCV cooling system

(4) Secure Spent Fuel Pool Cooling function
- Diversity of pool water injection method
- Accident Management operability enhancement by applying external water injection filler
- Incorporation of additional SFP temperature and water level monitoring systems in case of severe accident

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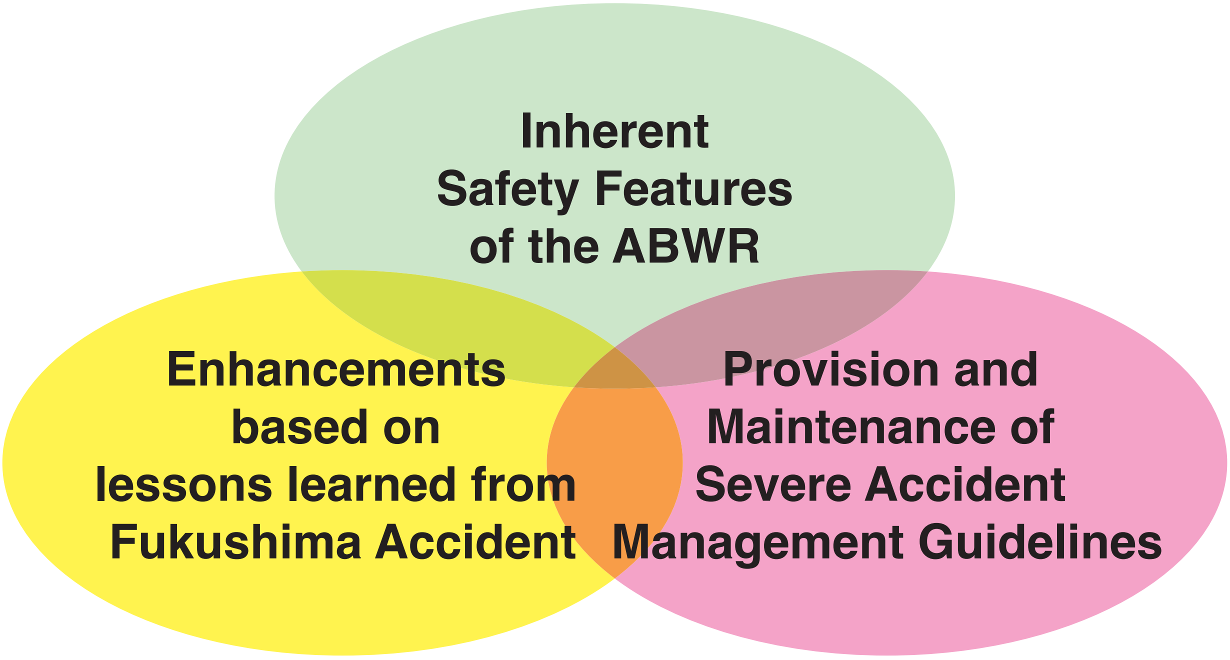
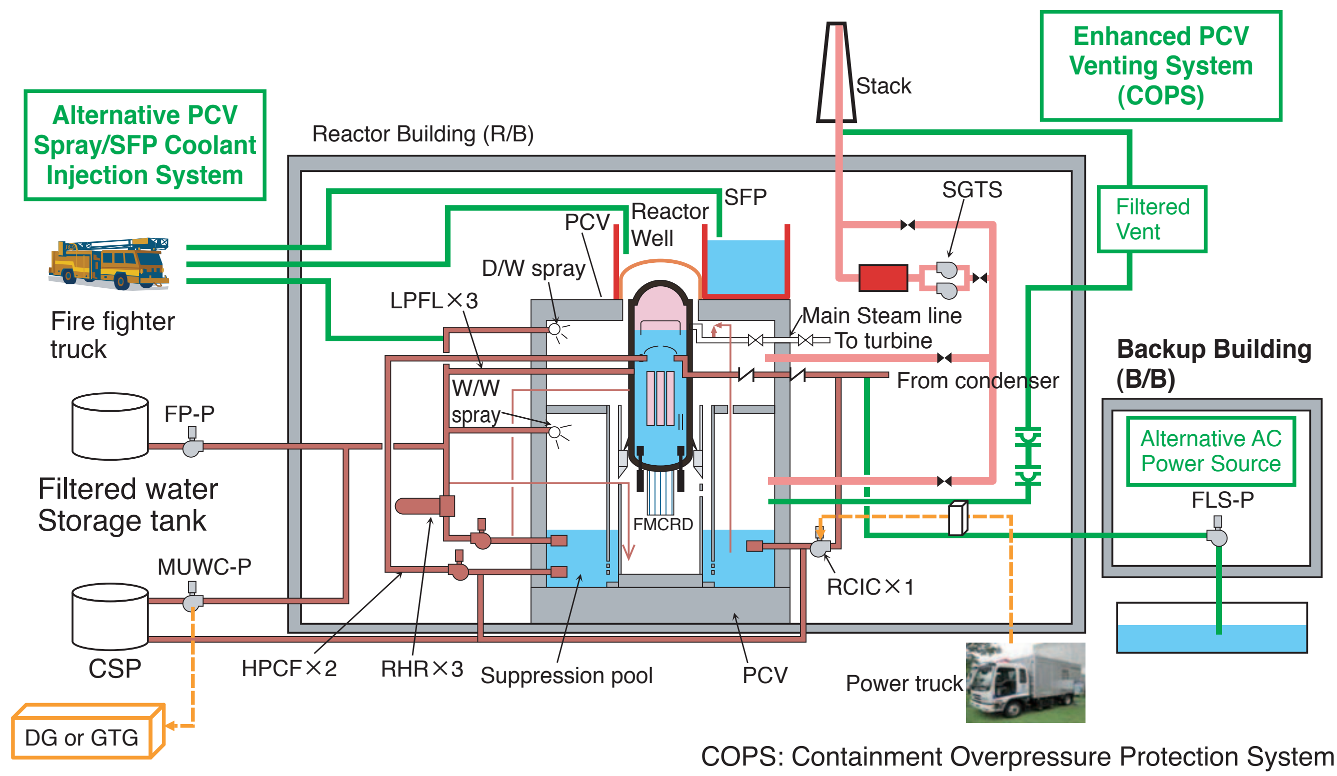


■Overview of Enhanced Safety Systems for Severe Accident



PCV: Primary Containment Vessel
SFP: Spent Fuel Pool
FP: Fire Protection System
MUWC: Make Up Water System (Condensate)
CSP: Condensate Storage Pool
D/W: Dry Well
W/W: Wet Well

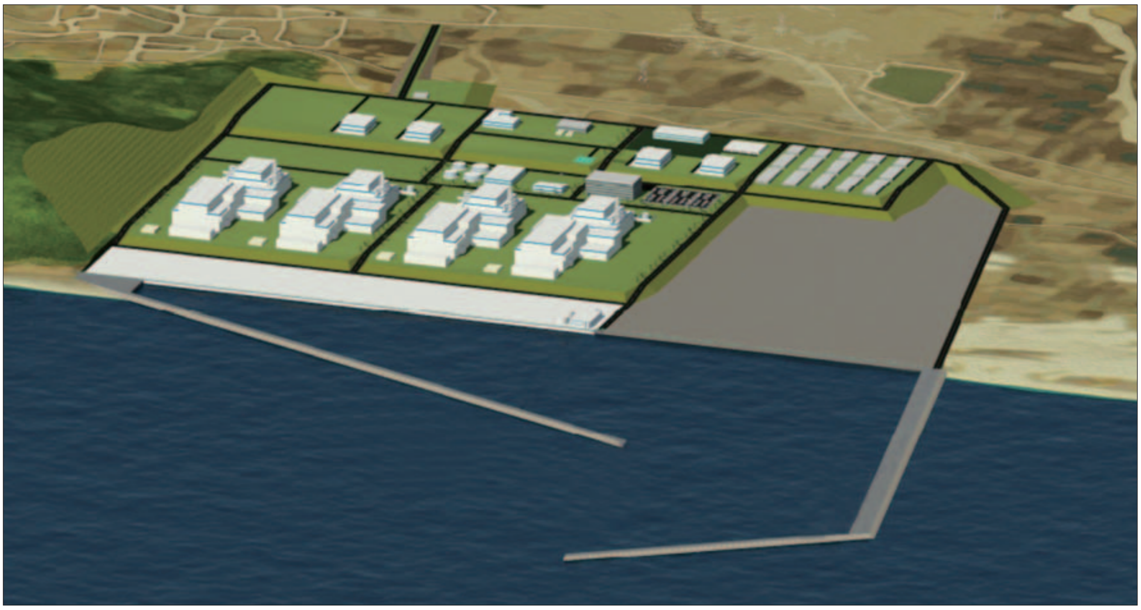
COPS: Containment Overpressure Protection System
LPFL: Low Pressure Core Flooder System
HPCF: High Pressure Core Flooder System
RHR: Residual Heat Removal System
RCIC: Reactor Core Isolation Cooling System
SGTS: Standby Gas Treatment System
FLS: Flooder System

ABWR Countermeasures Against Fukushima Accident

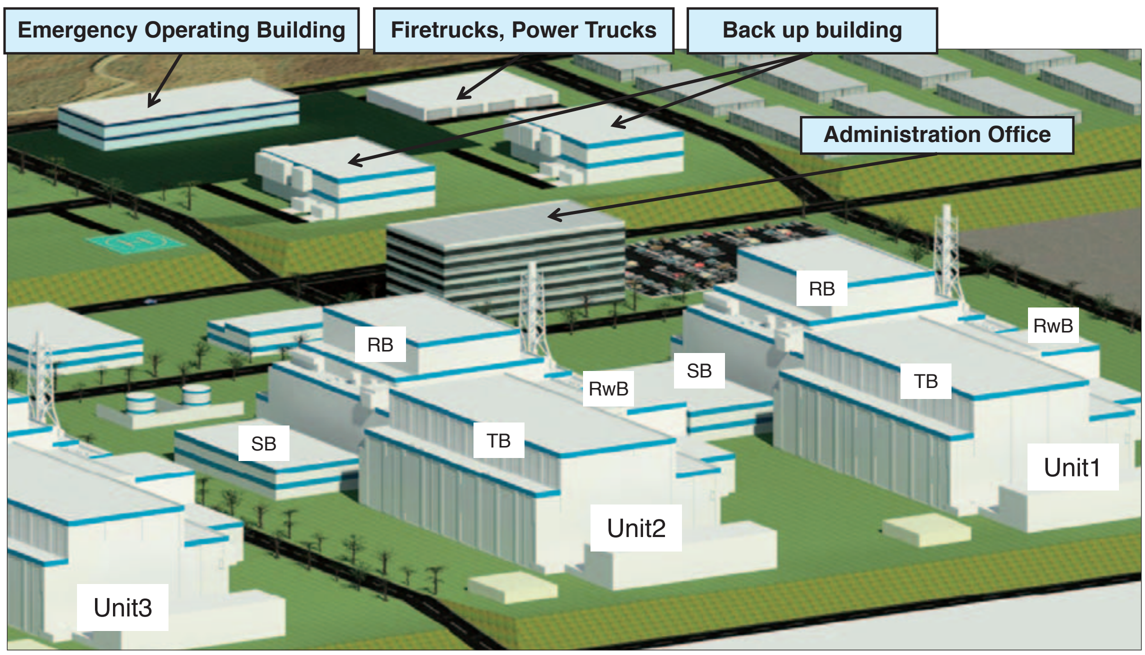
Plant Layout Design with backup water injection systems, Mobile/Portable components for water injection and sources of power

ABWR, which is the Generation III+ reactor operating in the world, has achieved an incomparable level of safety with additional facilities for safety enhancement as well as plant layout designs to mitigate site specific external hazards.

■**Site Layout example (1)** Full View



■**Site Layout example (2)** Closeup View



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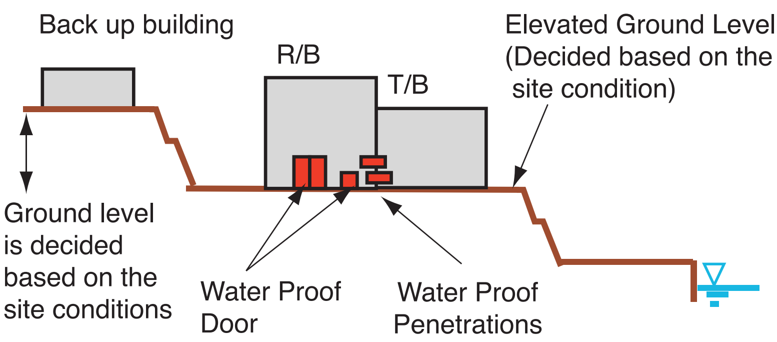
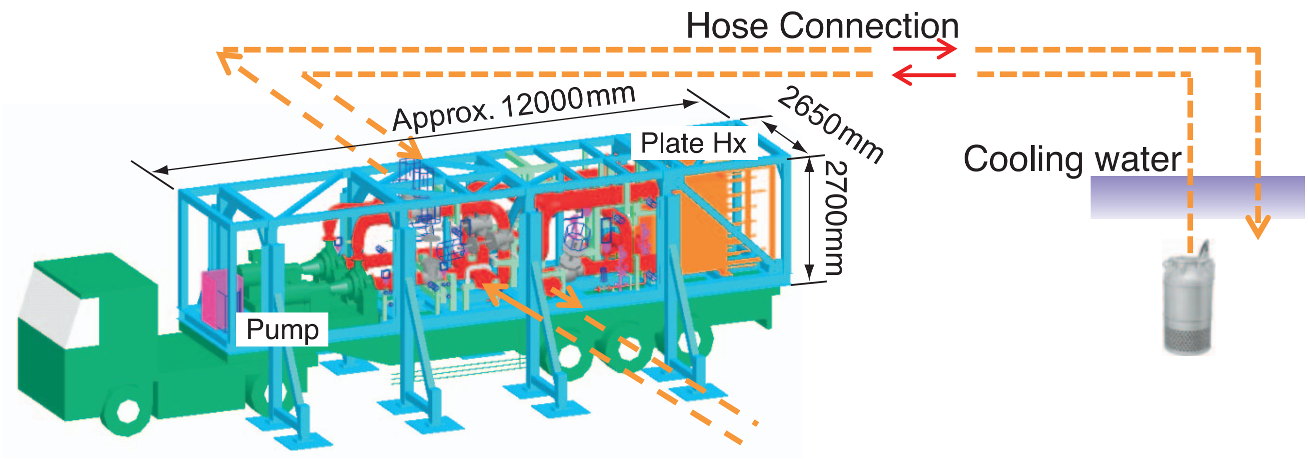
Countermeasures for flooding



Water Proof Door

Example of Alternative Heat Removal System (Portable)



Mobile Equipment

Fire Truck

Power Truck

Construction Machinery

Reinforced Concrete Containment Vessel (RCCV)

ABWR has increased its power output while also decreasing its containment size

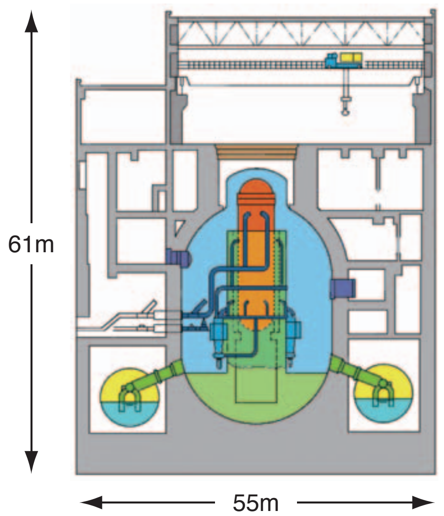
RCCV consists of a steel liner inside of a reinforced concrete structure. The RCCV has two functions: contain pressure and prevent leakage.
The concrete handles the functions of pressure containment and shielding, and the liner handles the function of leakage prevention.
The RCCV is divided into a drywell and a suppression chamber by the diaphragm floor and the RPV※1 pedestal.
The suppression chamber contains a pool and an air space. Vapor flows, which are generated from a LOCA flow from the drywell space to the suppression pool through horizontal vent pipes embedded into the RPV pedestal.
The design pressure of RCCV is 310kPa. The RCCV design temperature is 171°C for the drywell and 104°C for the suppression chamber.
The RCCV is cylindrical and consists of a top slab, a shell and a foundation. The inside diameter of the RCCV is 29m, and the height from upper surface of the foundation to upper surface of the top head is 36m.
The thickness of the RCCV shell is 2m and attached to the foundation.

- Reinforced Concrete Containment Vessel (RCCV) contains reactor pressure vessel.
- RCCV has reduced its volume and height to improve seismic resistancy.
- The RCCV compact structure and reactor building integration improves cost effectiveness.
- In case of RCCV pressure increase, steam is condensed in the Suppression Pool water and a nitrogen atmosphere can be developed in the PCV※2 to prevent a hydrogen explosion.

※1 RPV : Reactor Pressure Vessel , ※2 PCV : Primary Containment Vessel

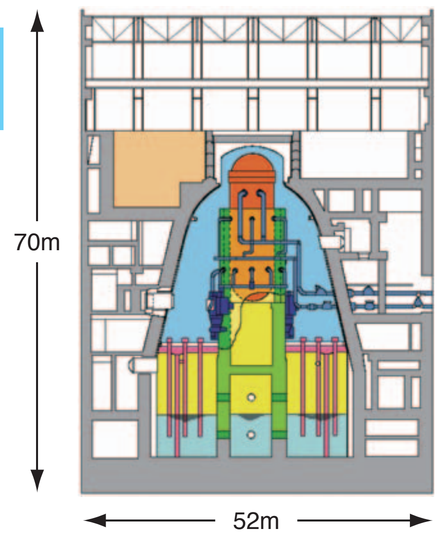
More cost-effective

MARK Ⅰ
(BWR-3/4)



Output power : 780MWe

MARK Ⅱ
(BWR-5)



Output power : 1,100MWe

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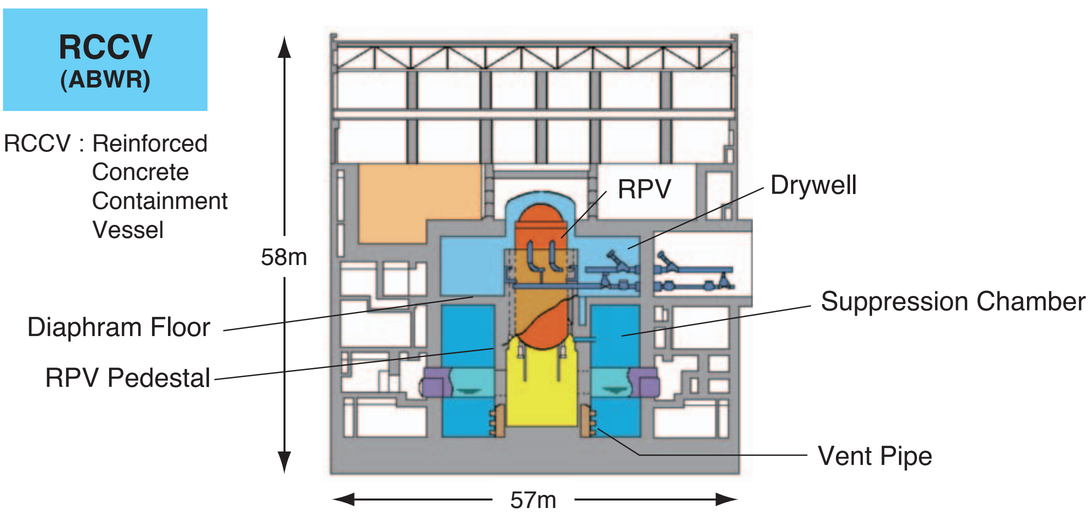
Shimane 3 RCCV Liner module Installation

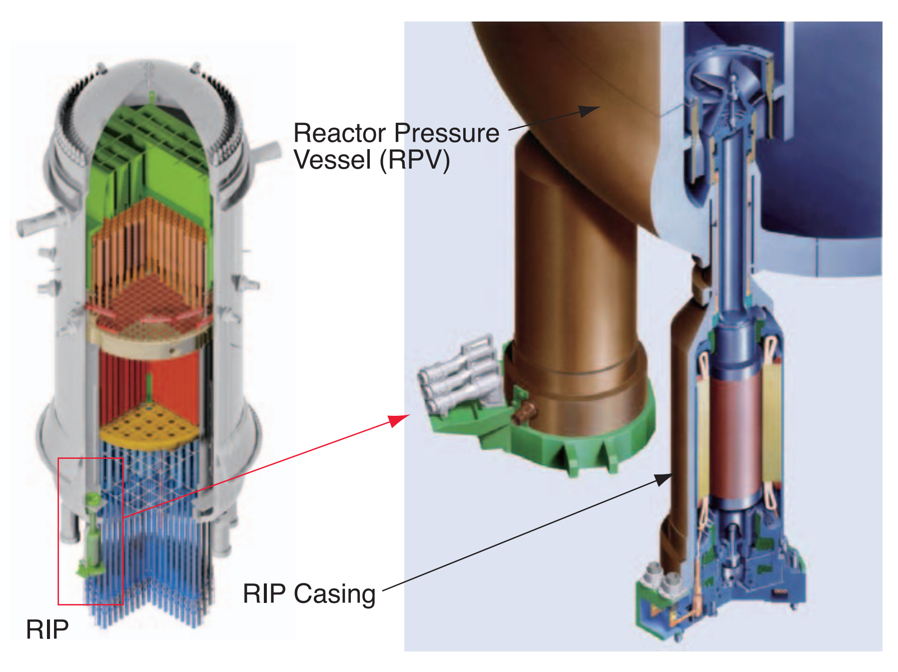


Output power : 1,350MWe (ABWR)

Reactor Internal Pump (RIP)

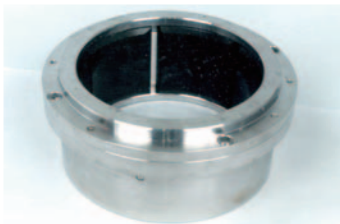
Reactor Internal Pump—High Reliability, High Performance

- The Reactor Internal Pump is directly mounted to the bottom of the nuclear reactor pressure vessel (as shown in figure below) and supplies coolant (water) to the reactor core.
- By controlling Reactor Internal Pump's rotational speed, the reactor core flow and void coefficient are changed, thus controlling the nuclear power plant's power output.
- In comparison to BWR's with external pumps, motor driving power and radiation exposures can be reduced due to the elimination of external recirculation pipes.

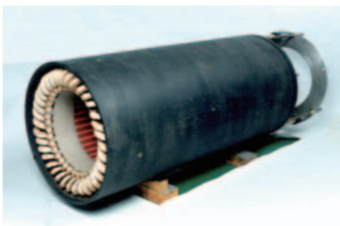


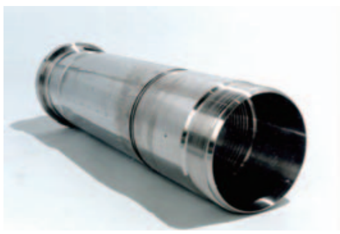

Impeller and Shaft

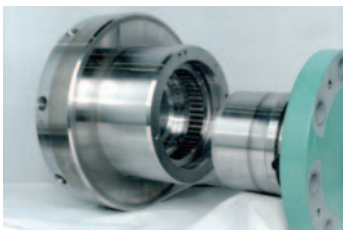

Impeller and Diffuser


Tilting Pad Radial Bearing


Rotor


Stator


Stretch tube


Thrust Disk and Auxiliary Cover


Motor Cover

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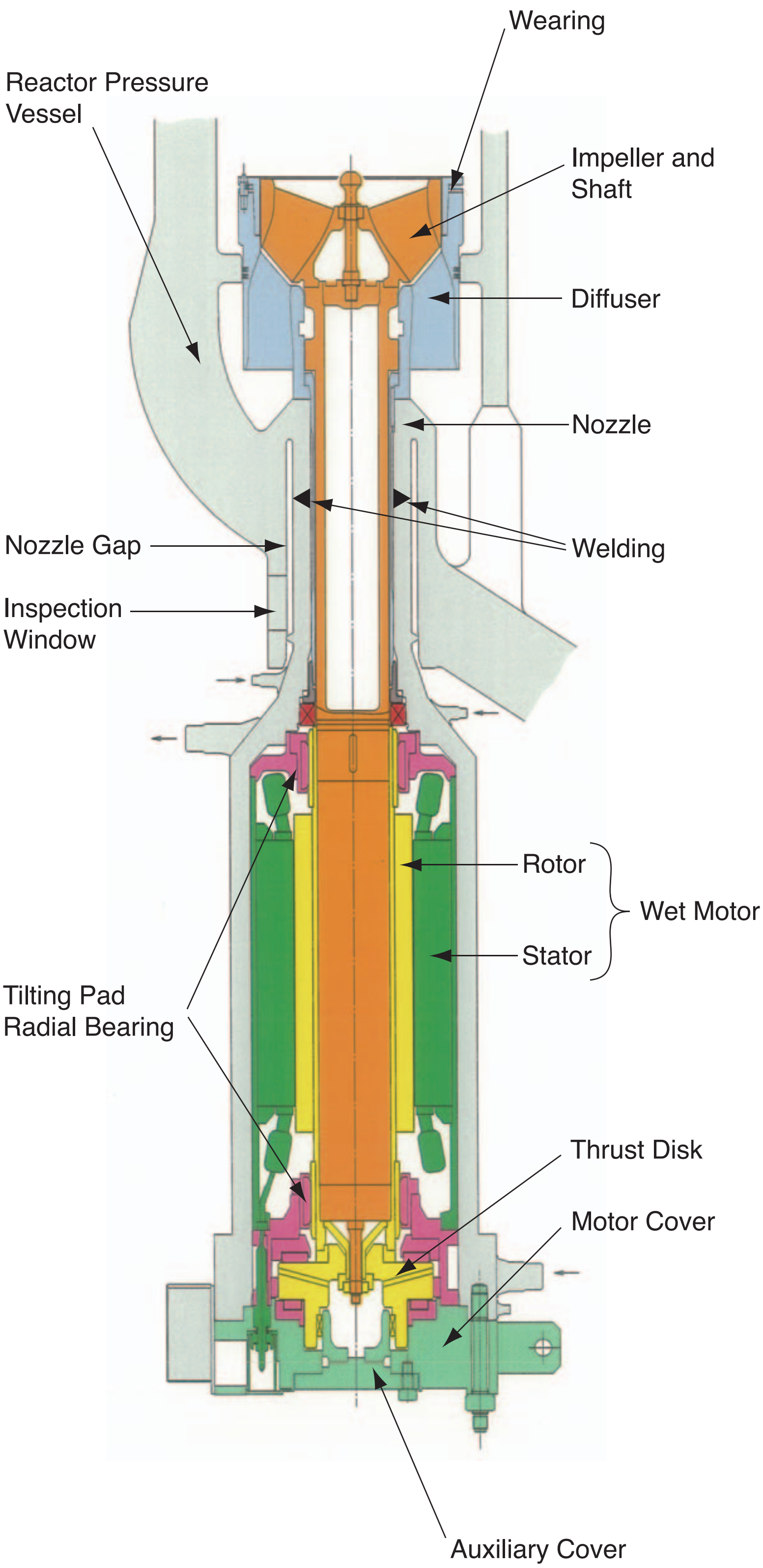
■Hitachi Reactor Internal Pump Features



Technical Data	
Number of Pumps	10
Capacity	Approx. 8,300 m^3/h*
Total Head	Approx. 46 m*
Speed	Approx. 1,600 min^{-1}*
Design Temp.	302 °C
Design Pressure	8.62 MPa

*Maximum at 120% core flow

High Reliability:

- Adoption of Tilting Pad Bearing helps vibration stability.
- Thicker nozzle yields high earthquake resistance. (Actual results from past nuclear power plants.)
- The nozzle gap and the inspection window enable inspection of the welded area.
- There is a testing facility to test the Reactor Internal Pump under the same conditions in an actual nuclear power plant.
- In order to eliminate the shaft seal, the wet motor was adopted to connect the pump and motor using one shaft.

High Performance:

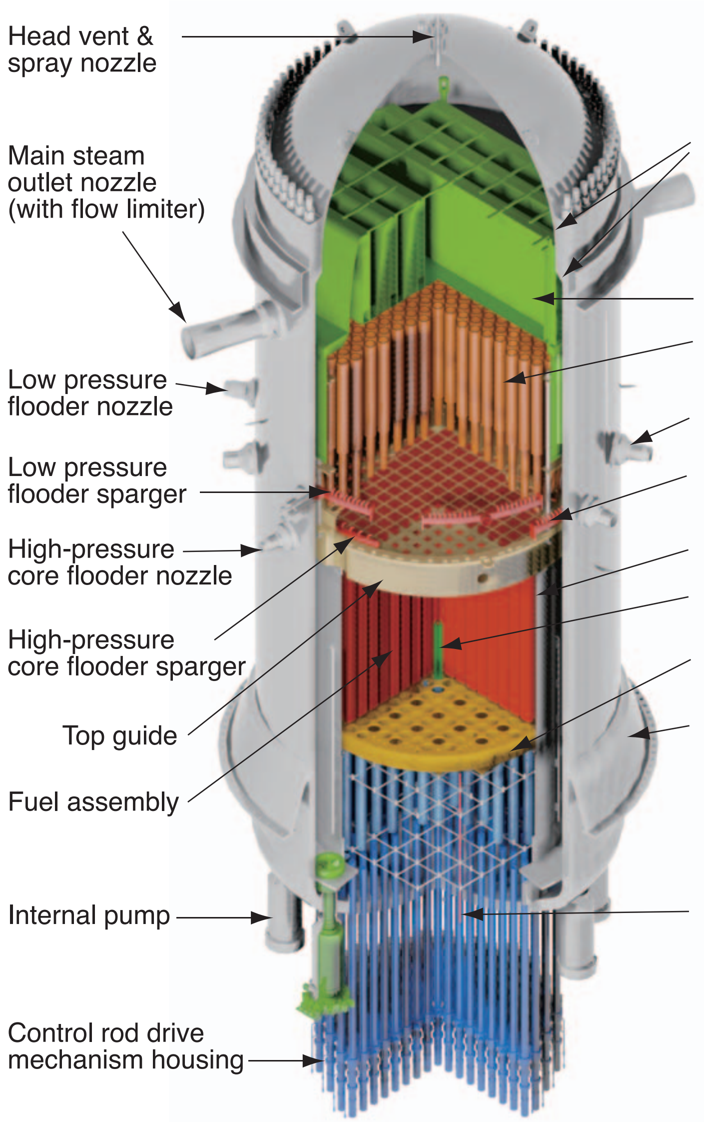
- 100% core flow is maintained even with only 9 pumps working.
- High voltage motor is used to correspond to the high capacity needs.

Reactor Pressure Vessel (RPV)

Reactor Pressure Vessel Contains the Core of the Nuclear Power Plant

The reactor pressure vessel contains fuel assemblies, control rods, steam dryer, steam separator, and other components. With a large separation between the reactor and pressure vessel walls, BWRs feature low neutron irradiation embrittlement. Hitachi uses highly reliable vessel materials that further reduce irradiation embrittlement, by reducing the content of copper, sulfur, and phosphorous in these materials. Additionally, the single-block forging of bottom head and other components greatly reduces weld-line length to be covered by in-service inspections.

Reactor Pressure Vessel of Shika Power Station
Unit No. 2 Being Lifted into Building



Reactor pressure vessel schematic view

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RPV Under Fabrication

RPV off loaded at construction site

Flanges

Steam dryer

Steam separator

Feed water inlet nozzle

Feed water sparger

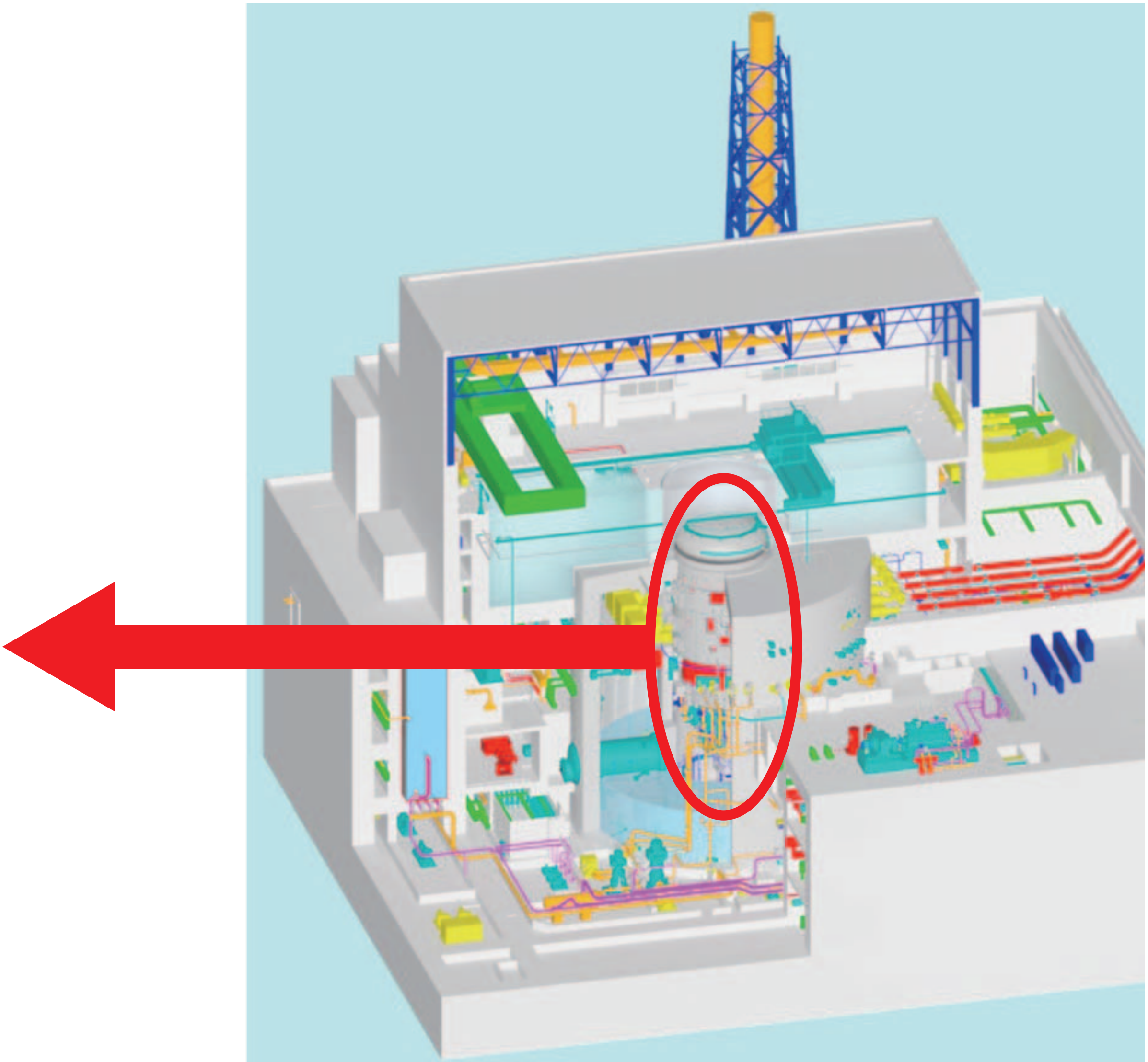
Core shroud

Control rods

Core plate

Reactor pressure vessel support skirt

In-core monitor housing



Section view of ABWR reactor building

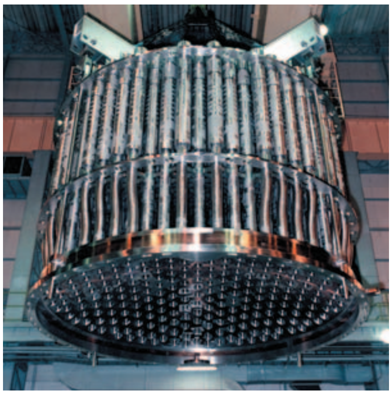
Reactor Internals

Key Components made by high accuracy manufacturing techniques

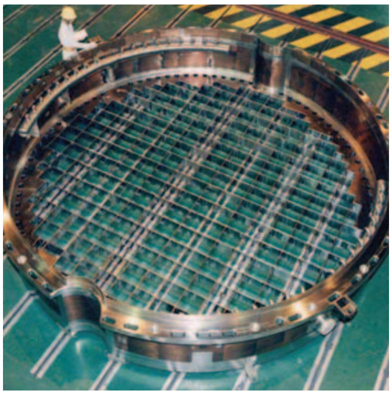
Hitachi has designed and manufactured a large number of reactor pressure vessels (RPV) and reactor internal components. Stringent quality control standards guarantee the highest reliability possible. The expertise acquired to date in design, manufacturing and quality control ensures that the reliability of the RPVs and reactor internal components for ABWR facilities will continue to be every bit as in the past.

■Design & Manufacturing

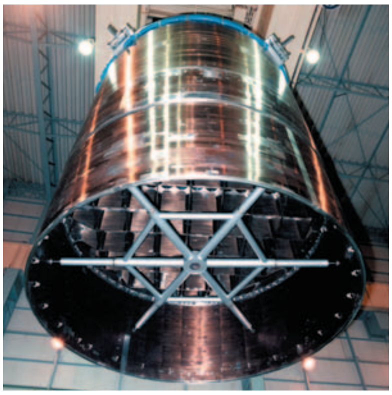
From small precisely machined components to large welded components, a wide variety of nuclear core equipment has been designed and manufactured by Hitachi.



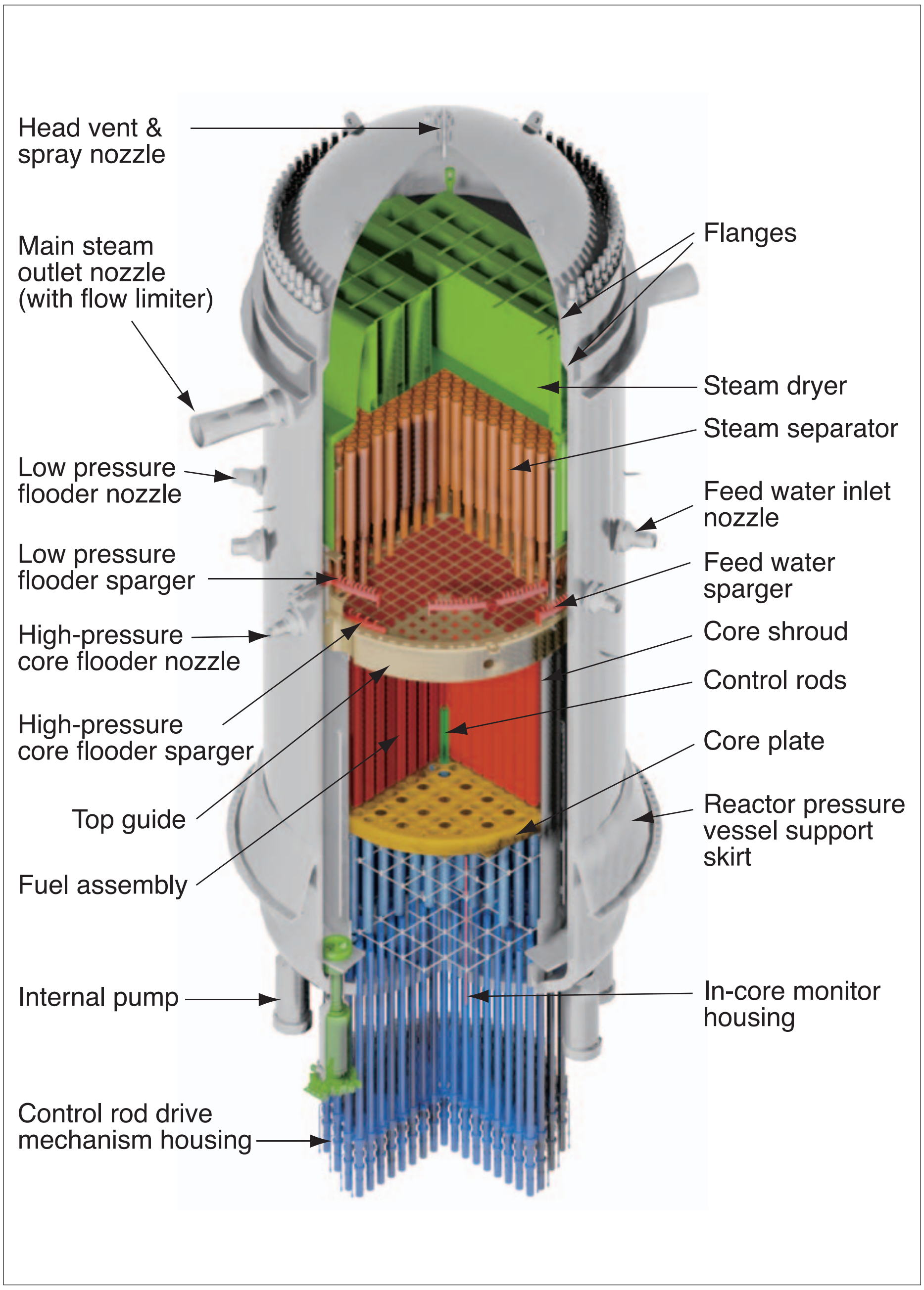
Steam Separator



Top Guide



Shroud



Structural sketch of reactor pressure vessel and reactor internal components

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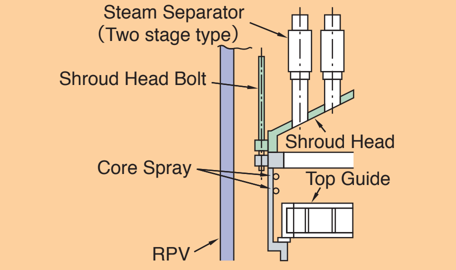
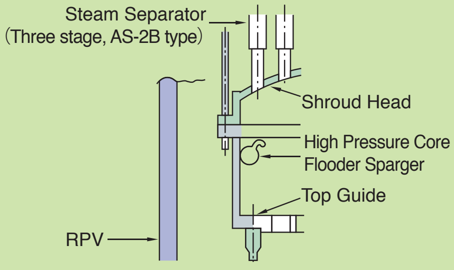
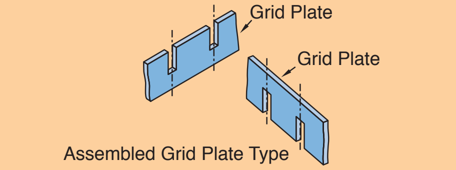
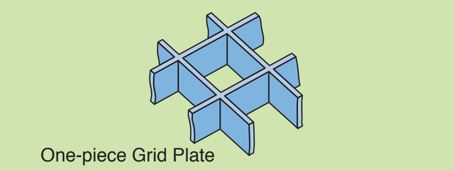
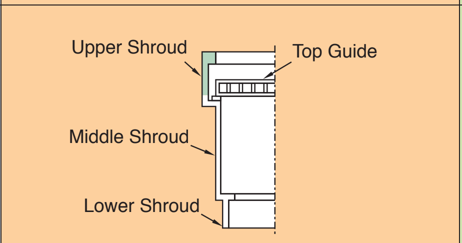
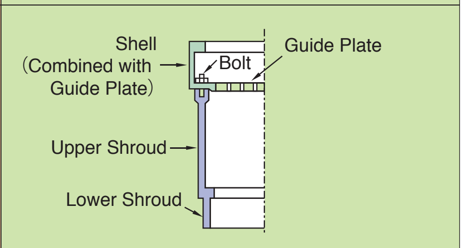
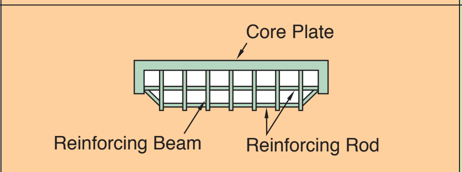
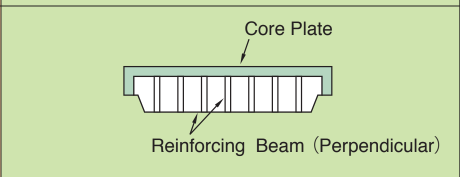
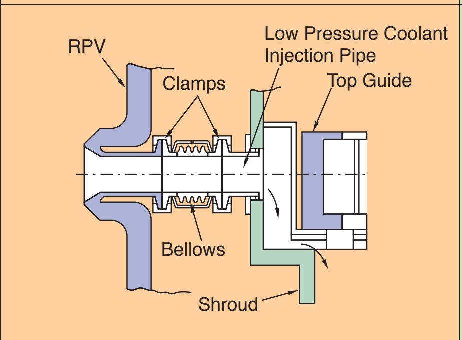
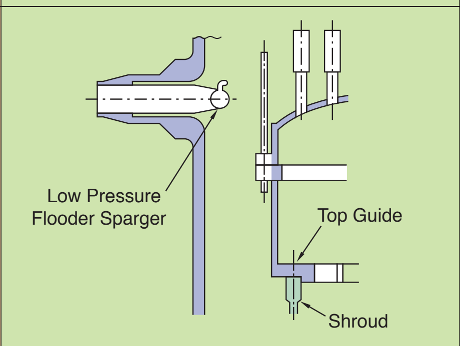
■Reactor Internal Components of ABWR

The ABWR reactor internal components are based on the design of the BWR-5 components which are the evolutionary improvement over the BWR-5 reactor internal components. A number of improvements were made to enhance the structural strength and higher performance. In particular, a square hole machining device utilizing extra-high precision technology was used on the grid plate to manufacture the component from one piece, ensuring outstanding structural strength.

Structural Comparison of BWR-5 and ABWR

No.	Changes	BWR-5	ABWR
1	• Steam separator changed from two stage to low pressure-loss three stage type (AS-2B) • Adoption of internal pumps eliminates large-diameter pipe breaks in bottom of reactor. This enables core to be constantly covered in water, allowing cooling system to be changed from spray to simple sparger type.		
2	**Top Guide** • Top guide structure was changed from assembly of individual matching plates to one-piece high-structural-strength one-piece machined type.		
3	**Core Shroud** • Inner diameter of core shroud has been increased to accommodate a larger number of fuel assemblies. • Top guide and upper shroud are now integral.		
4	**Core Plate** • A structure with reinforcing beams and perpendicular reinforcing rods was changed to all reinforcing beams to increase strength.		
5	**Lower Pressure Flooder System** • Adoption of internal pumps eliminates large diameter pipe breaks in bottom of reactor, ensuring a constant core coverage under water. This eliminates the necessity of supplying water to the inside of the shroud, allowing cooling system to be changed to sparger type of outside of shroud.		
6	**Reactor Recirculation System**	**Jet Pump**	**Internal Pump**

Control Rods, Control Rod Drives

Contributing to reduction of plant start-up time, and low radiation exposure during maintenance

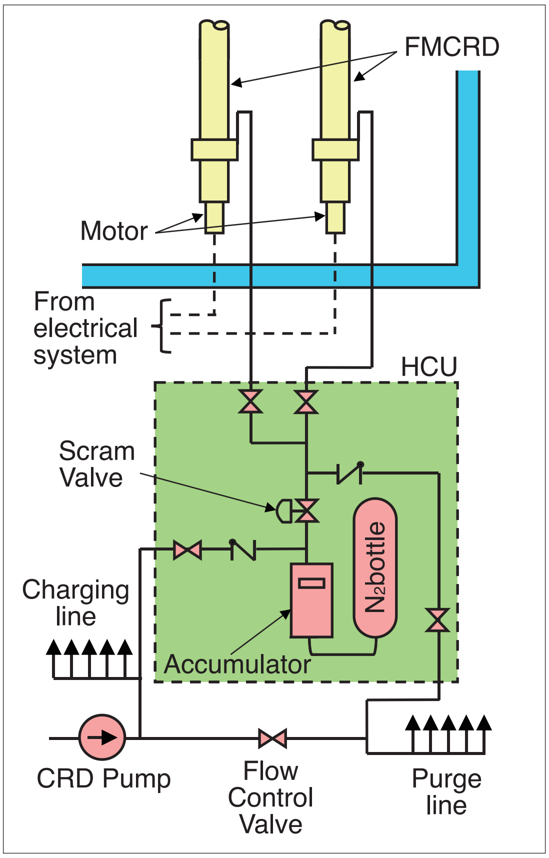
- Fine Motion Control Rod Drive (FMCRD) system utilizes two different power sources:
  -Electric motor drive for normal operation
  -Conventional hydraulic accumulator for emergency insertion (scram)
- Diversification of the power source enhances reliability.
- One way water purge system minimizes the contamination of FMCRD and Hydraulic Control Unit (HCU) and reduces radiation dose during maintenance.
- Fine control of control rod position by the electric motor reduces mechanical and thermal loads to fuel bundles, thereby increasing fuel reliability.
- Fine control of Control Rod position by the electric motor improves the load following capability of the plant electric power output.
- Simultaneous drive operation of control rods (gang mode operation) shortens the start up time of the plant.
- Reduction of the number of FMCRDs to be inspected shortens the time required for periodical inspection and radiation dose at refueling outages.

Control Rods

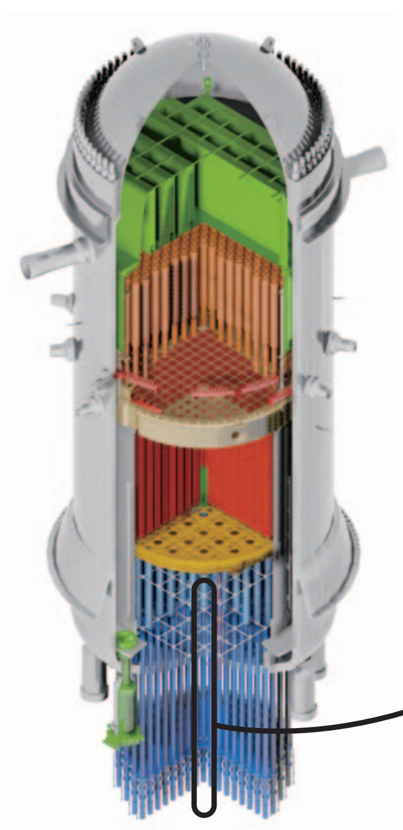
FMCRD before assembling

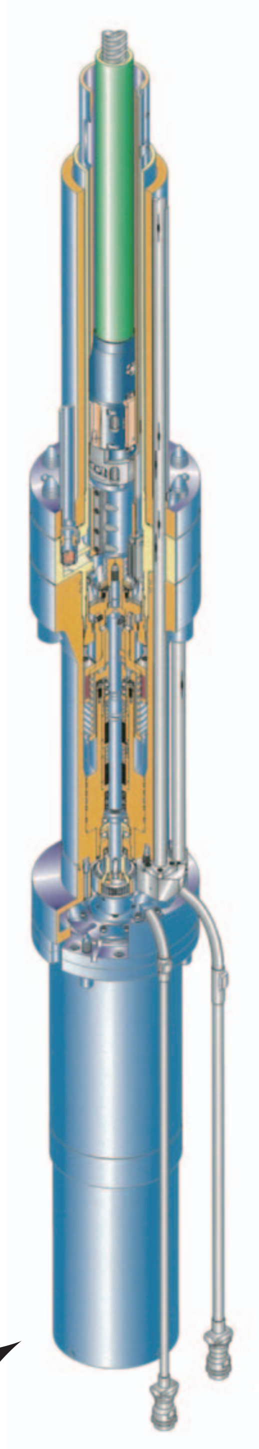
Hydraulic Control Units

Our highly reliable products, based on proven design, are leading nuclear technology that enhance the safety of nuclear power plants.

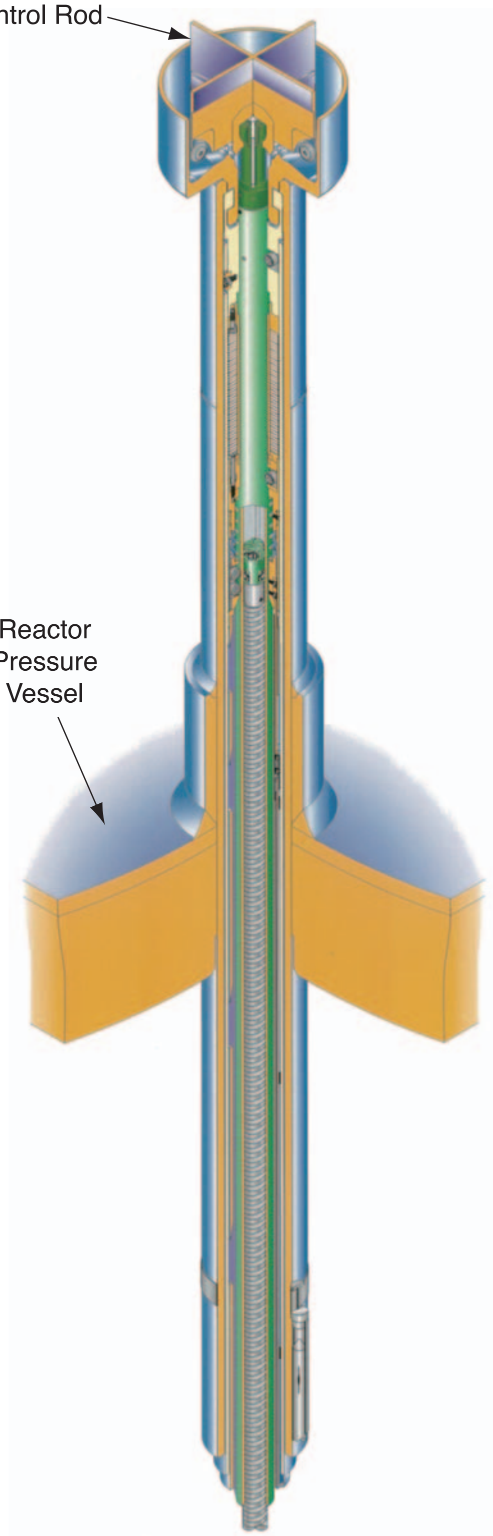


CRD System Configuration





FMCRD Lower Portion



FMCRD Upper Portion

Nuclear Fuel

Optimized Design and Performance

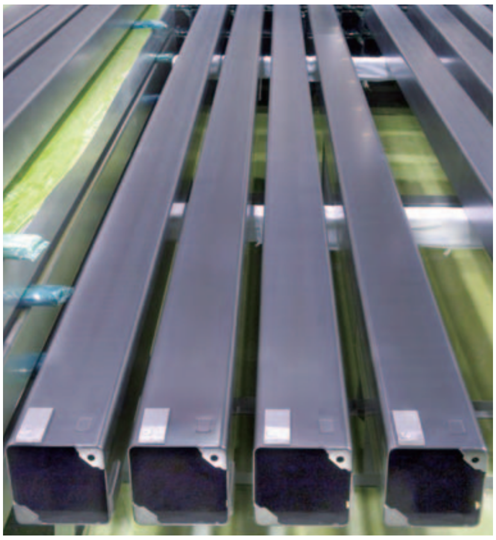
The enhanced design of the GNF2 fuel assembly — based on pioneering technologies developed by GNF — provides customers with improved fuel utilization and increased performance and reliability.
In addition to increased output and reduced fuel costs, the GNF2 advanced design offers the latest technology in corrosion and debris resistance. The advanced debris filter, the Defender™, is now standard on the GNF2 fuel assembly — increasing reliability and filtration to the best available in today's market.
The GNF2 fuel assembly has undergone rigorous testing and is expected to be even more reliable than other fuel designs — preventing more fuel failures than any other design due to the standard Defender™ filter.

Increased Energy
・Supports 24 months operation at 120% power
・High exposure capability(up to bundle average 60MWd/t)
・High Energy Bundle(High Fuel mass, High Enrichment pellet)

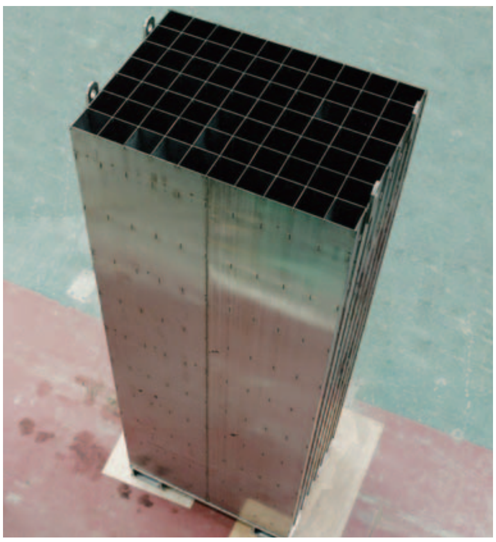
Operating Flexibility
・Increased Critical Power(High performance spacer design)
・Increased Mechanical Power Margin
・Low Pressure Drop(Low pressure drop UTP※1 design)

Fuel Reliability
・Debris Resistance(Advanced Debris Filter - Defender™ LTP※2-)
・Hydrogen Resistance(Corrosion Resistance Cladding -GNF Ziron-)

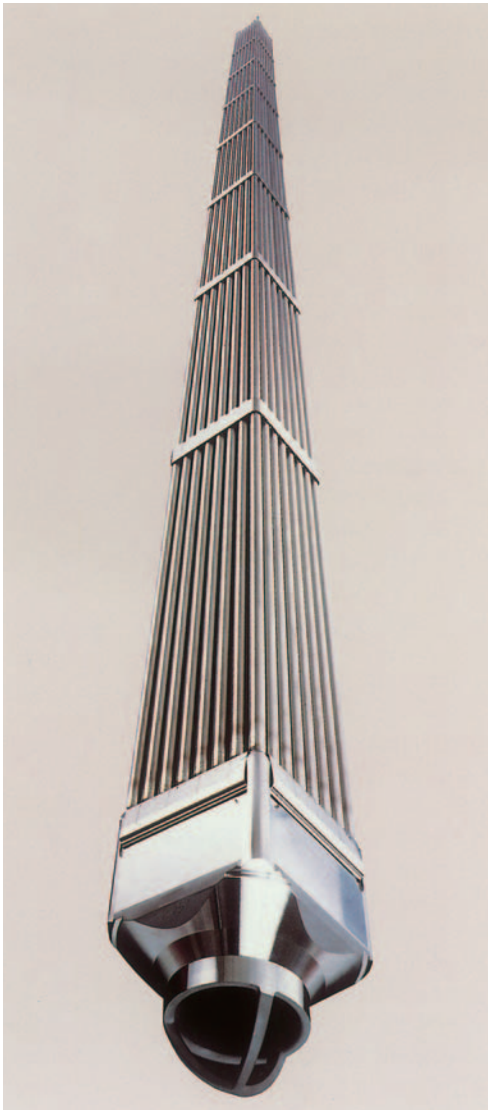
※1 UTP : Upper Tie Plate , ※2 LTP : Lower Tie Plate



Fuel Assembly Channel Box



Spent Fuel Storage Rack



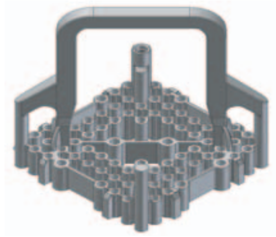
Fuel Assembly(Step2)

Our highly reliable products, based on proven design, are leading nuclear technology that enhance the safety of nuclear power plants.

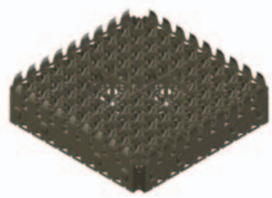
Evolution of BWR Fuels

GE14

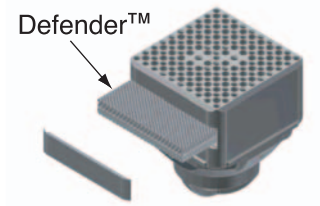
GNF2



GNF2 Low Pressure Drop UTP



GNF2 High Performance Spacer



GE14 & GNF2 Defender™ LTP
Improved Debris Protection

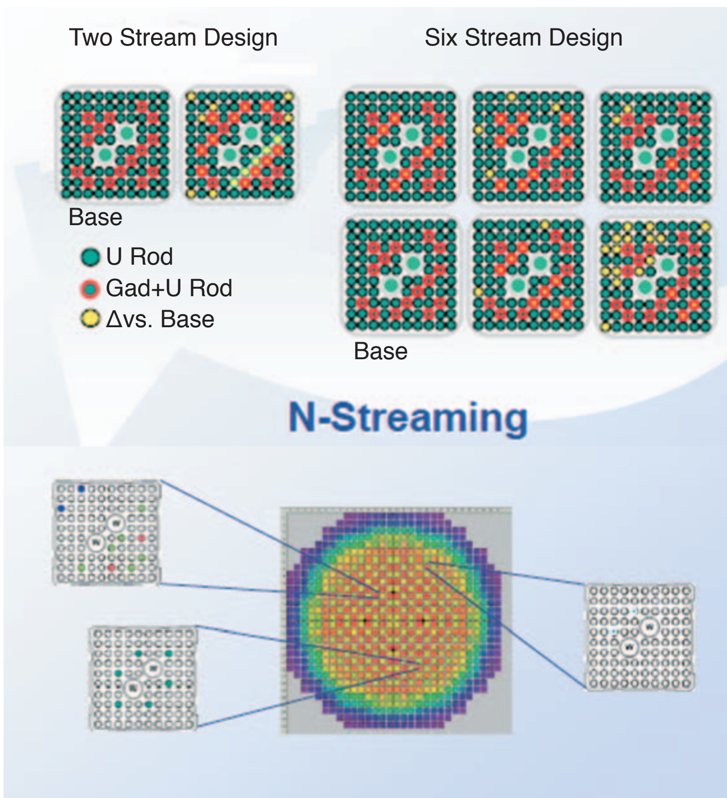
Operational Optimization - N-Streaming -

Recognizes Current Design Limitations

- Traditional designs use 1-2 bundle types
- Local design requirements dictate bundle characteristics
- Same bundle uses in non-limiting locations

Expands Design Space

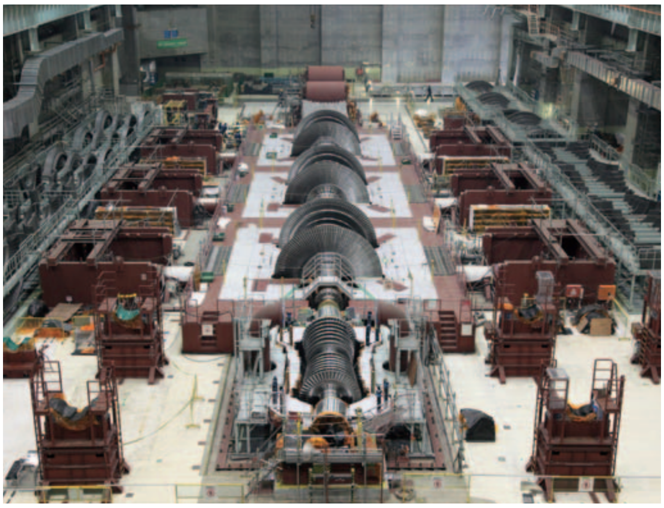
- Generate numerous bundle types from an equivalent set of rod types
- Perform core design using fuel rods versus the fuel bundles
- Solve local problems with unique designs



Turbine and Generator

Hitachi Turbine and Generator, Responsive to the World's Needs

Since manufacturing the first unit in 1933, Hitachi, Ltd. has supplied numerous turbine generators to power stations throughout the world. These turbine generators are known for their high levels of efficiency and reliability.
Hitachi has the integrated capacity to supply power stations with all critical deliverables from materials for construction to equipment for operations.
Experts in power and electrical equipment, Hitachi not only provides turbine generators but also instrument and control equipment. Further, Hitachi is able to manage and control turnkey projects of power stations, including basic planning, design engineering, transportation, construction work, operations and other related work.
We believe that Hitachi's total capacity of supplying turbine generators and other equipment is of great benefit to the customers throughout the world.


Shimane 3, Nuclear Turbine

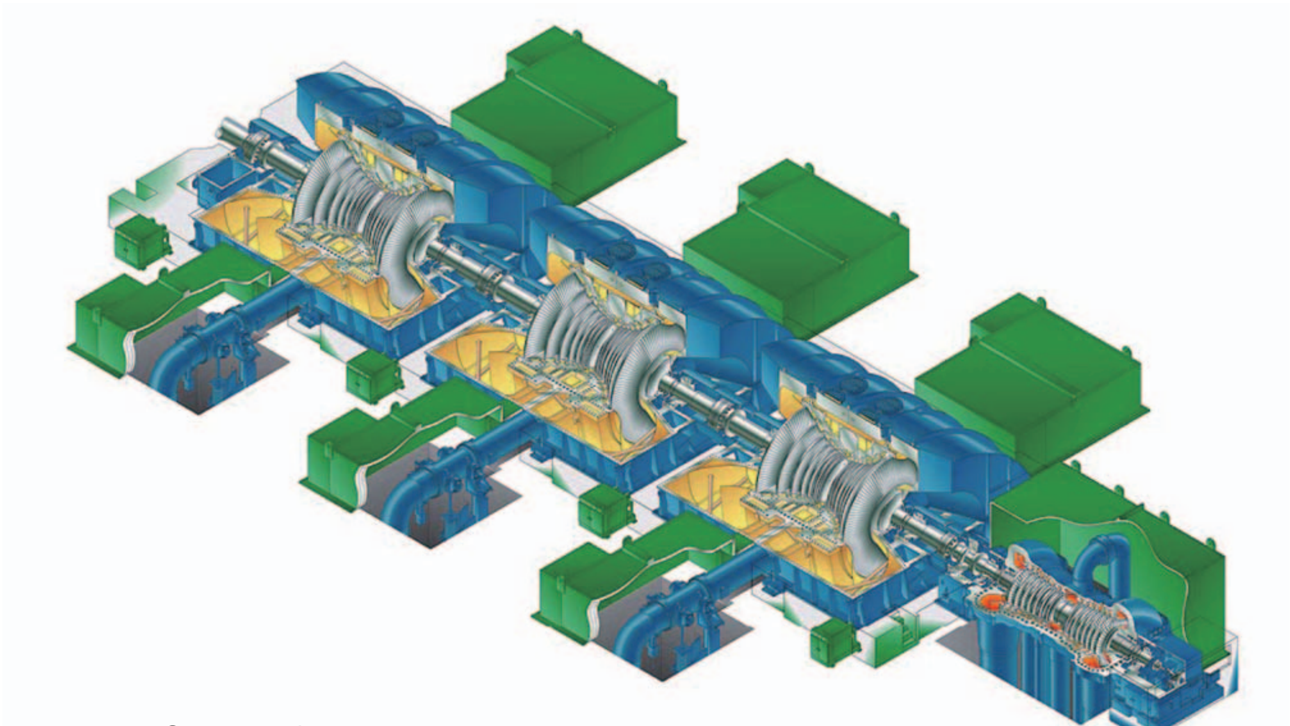

Installation of Turbine


Shimane 3, Nuclear Turbine

Our highly reliable products, based on proven design, are leading nuclear technology that enhance the safety of nuclear power plants.

■Hitachi Steam Turbines

Hitachi Steam Turbines play an important role as a main facility of the electricity generation business. Hitachi Steam Turbines lead the business with many superior features such as high-performance long blades by loss reduction technologies and the Ultra Super Critical Steam Conditions (Steam pressure of 25MPa and Steam temperatures at 600°C/620°C).



ABWR 60Hz TC6F-52 Turbine

■Hitachi Large Generator

It is now more than 90 years since Hitachi's reliable generators first debuted, yet Hitachi innovation has never slowed.
Today Hitachi produces broad range of superior generators up to 1.6GVA class nuclear turbine generators.

Shimane 3, Generator Stator

Shimane 3, Nuclear turbine Generator

Advanced NUCAMM-90ABWR Instrumentation & Control Systems

Hitachi's High Reliability Supports the Stable Operation of Nuclear Power Plants

Hitachi is committed to continuous improvements in the ease of operation and reliability of its nuclear power plant monitoring and control systems. We are working on increased reliability in the form of standardization of our digital control panels, and the increased utilization of multiple technologies and fault tolerance improvement technologies, as well as the use of optical multiple transmission technology in the creation of hierarchical information networks.
Our integrated digital monitoring control system, NUCAMM-90, incorporates a background of digital technological development and expanded calculation capacity with a high level human interface and increased scope of automation.

Main Control Room Overview

Our highly reliable products, based on proven design, are leading nuclear technology that enhance the safety of nuclear power plants.

Advanced NUCAMM-90 ABWR Instrumentation & Control Systems

(NUCAMM-90 : Nuclear Power Plant Control Complex with Advanced Man-Machine Interface 90)

●Large-Scale Display Board Facilitates Sharing of Information

Overall plant status supplied as shared information.
Warnings are displayed using hierarchies, for improved identification.

●Compact Main Control Board

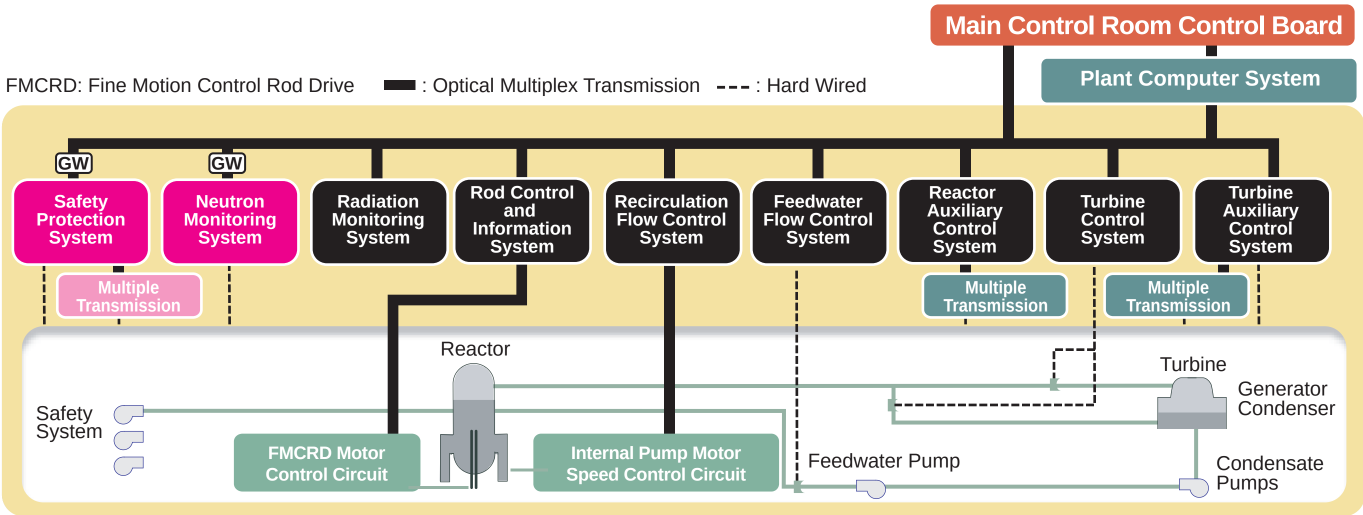
Main monitoring operations consolidated into a compact console.

●Expanded Automation Reduces Load on Operator

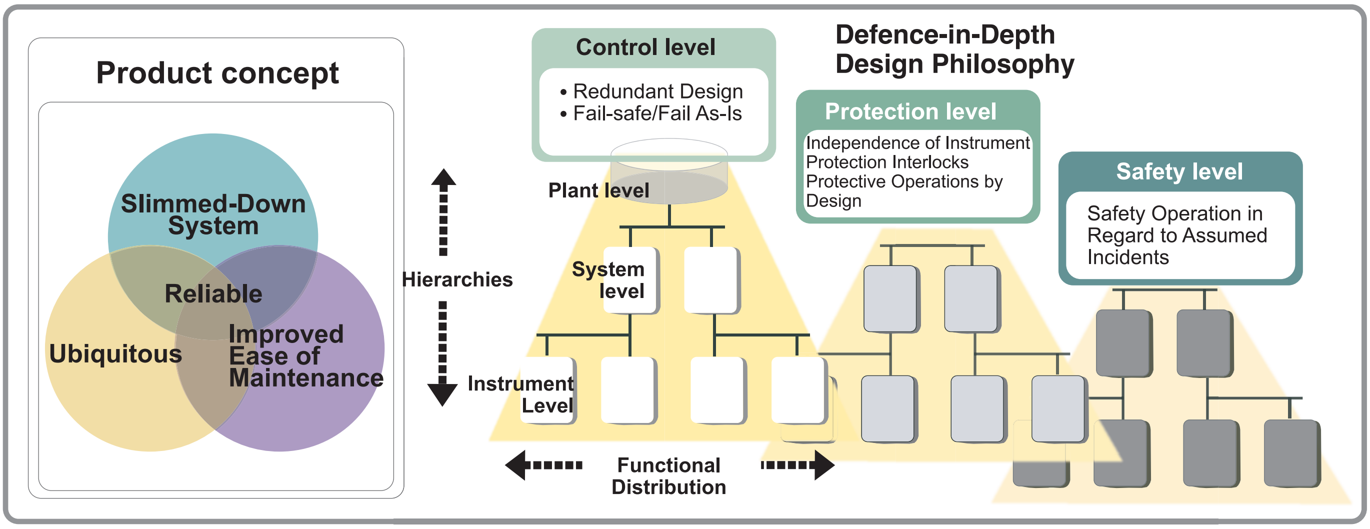
Expanded automatic operations, including control rod operation, allows operators mainly overall plant monitoring operations.

●Integrated Digital Control System

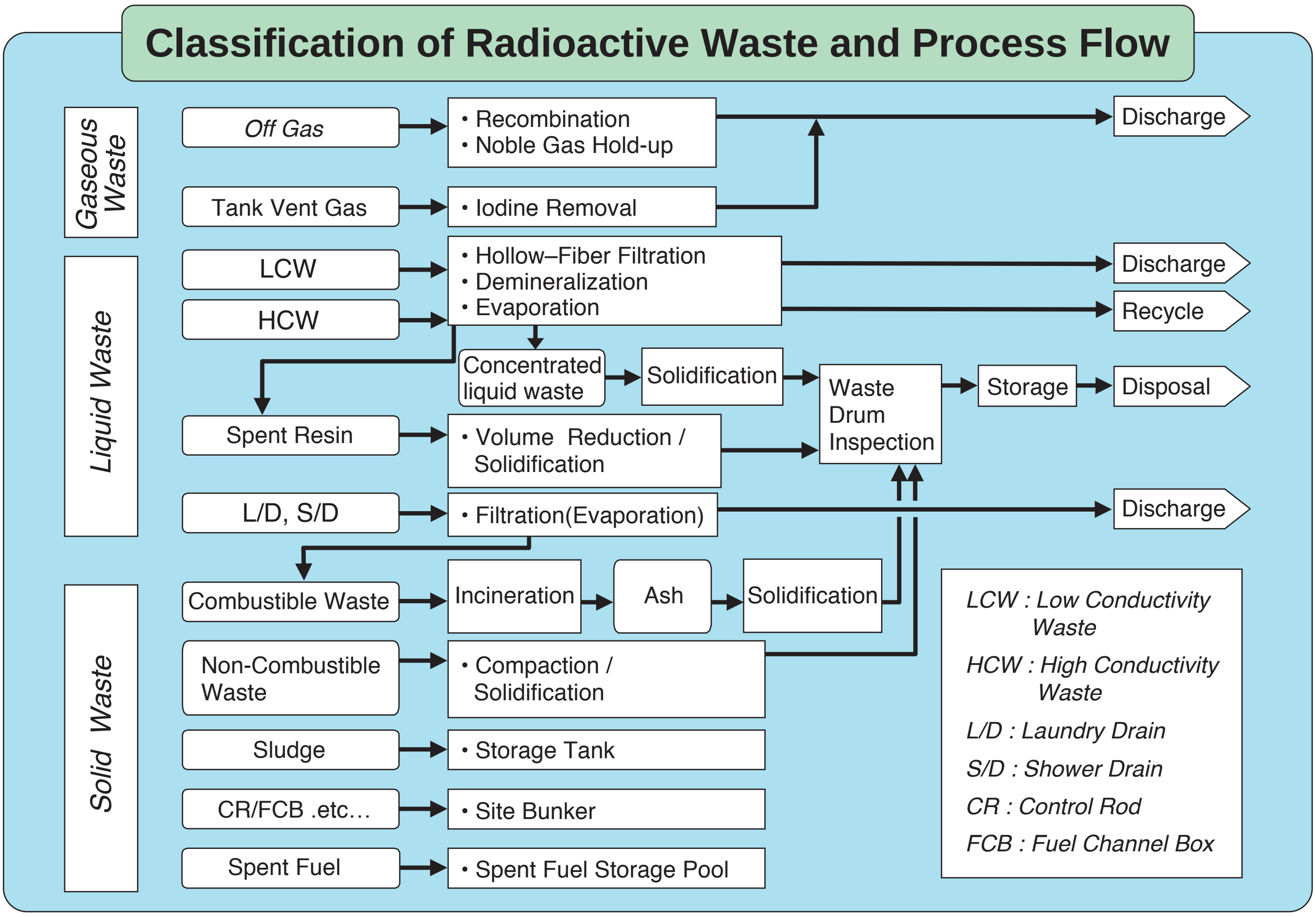
Improved reliability and ease of maintenance as a result of integrated digitalization, Electrical and physical separation between safety systems and non-safety systems



GW : Gateway

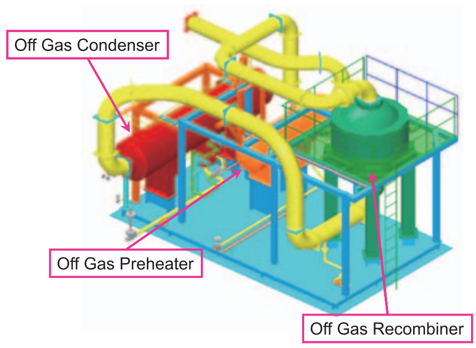


Radioactive Waste Processing Systems



■Gaseous Waste Processing System

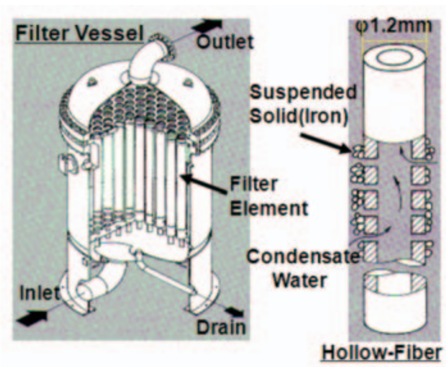
- Off Gas Recombiner fitted with a Sponge-Metal Catalyst to achieve high recombination efficiency
- Noble Gas Hold-up unit with a simplified and compact design
- Silver-Alumina Adsorbent used to achieve high Iodine removal efficiency



Off Gas Recombiner Module
＊This figure shows an example of existing Japanese plant module
＊Two recombiners are installed in the latest ABWR design

■Liquid Waste Processing System

- Hollow Fiber Filter with high processing capability
- Secondary waste generation reduced by half
- By combining Hollow Fiber Filtration with a Demineralizer, processed liquid can be reused or discharged to the environment



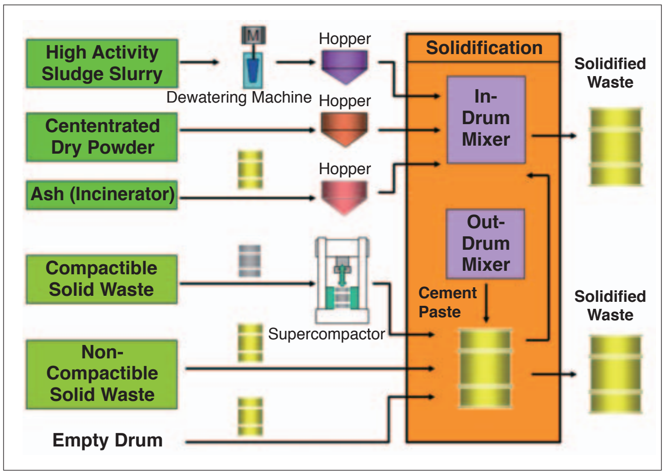
Hollow Fiber Filter Element

Our highly reliable products, based on proven design, are leading nuclear technology that enhance the safety of nuclear power plants.

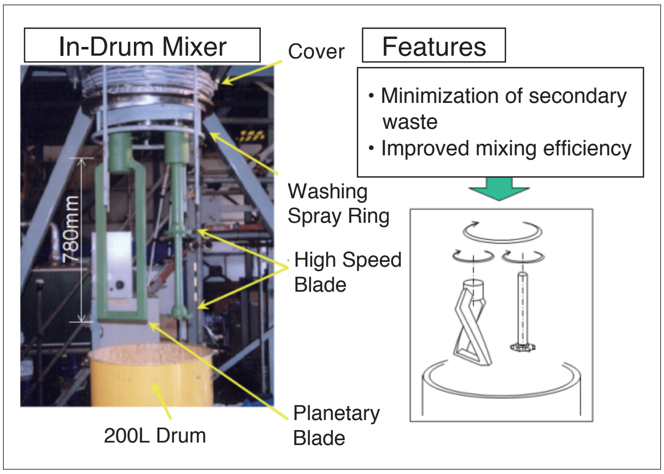
Waste Solidification System

- Cement based solidification materials, improved mixer efficiency to achieve stable solid waste

Overview of Solidification System



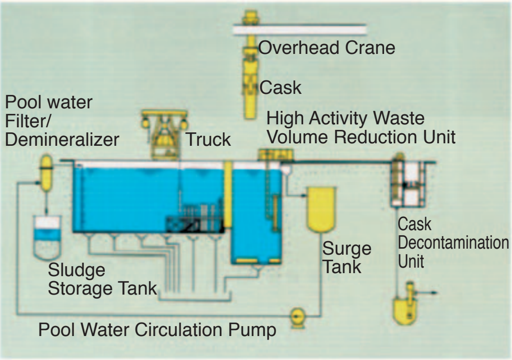
In-Drum Mixer



Site Bunker Facility

Features

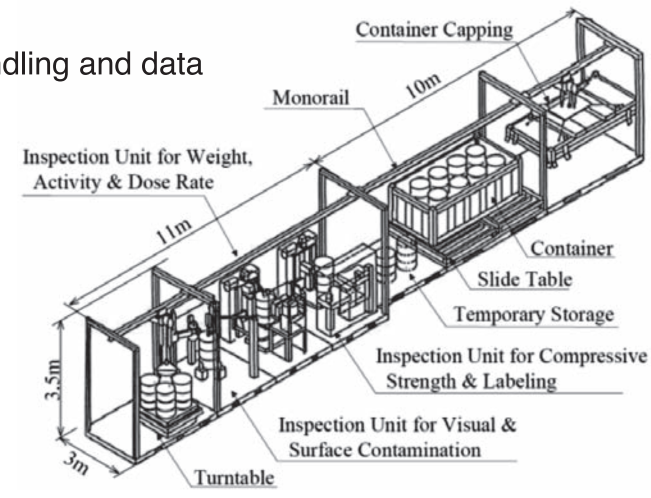
- Stainless Steel Lined Pool
- High Density Storage Rack
- Fitted with a high-level waste Volume Reduction Equipment
- Diversified Pool Water Cleanup System



Waste Drum Inspection System

Features

- Proven performance in BWR/PWR plants
- Compact System
- Fully automated handling and data processing
- High maintainability



Weight, Activity and Dose rate Measurement Units

Automatic Equipment

Remote-Automatic Equipment to Reduce Radiation Exposure and Manpower

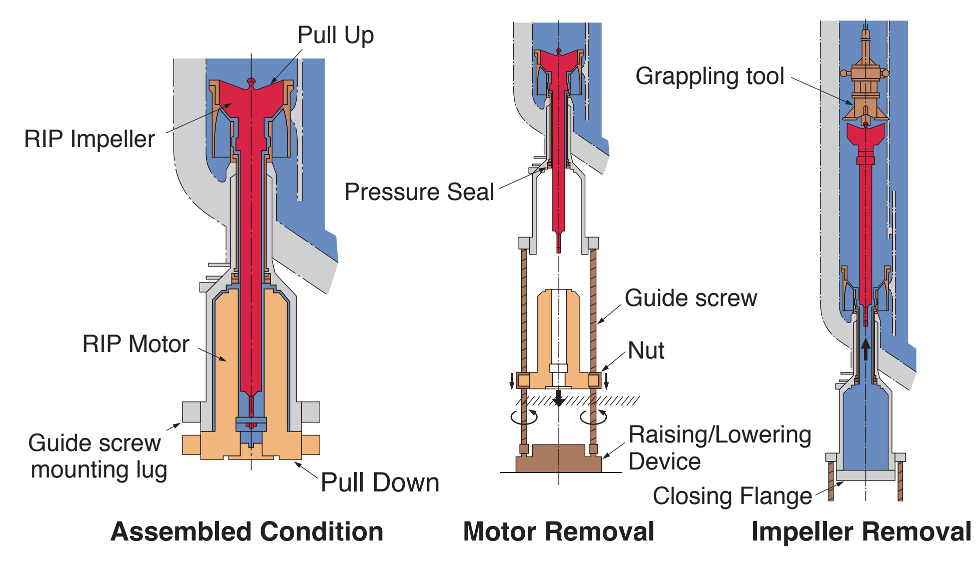
To reduce radiation exposure and manpower, Hitachi has developed many remote-automatic maintenance and inspection equipment based upon proven robotic technologies.

■Refueling Machine

Nuclear fuel is exchanged with new fuel during reactor shutdown to form the new reactor core. The refueling machine that performs this fuel exchange operation travels or moves laterally over the reactor well and spent fuel storage pool to move the fuel.

The automatic refueling machine, developed by Hitachi, performs this operation with high precision by using a process computer that automatically controls the speed and position of the refueling machine in four-dimensions; bridge travel, trolley travel, grapple vertical and rotational. By simple operation instructions from the remote control room, the refueling operation can be done swiftly and safely.

■RIP (Reactor Internal Pump) Maintenance Equipment



RIP Maintenance Equipment is roughly divided into the Elevator with guide screw under vessel and the grappling tool on the refueling floor. The elevator is driven by electrical motor that raises and lowers RIP motors.
Grappling tool is connected to RIP hoist of Refueling machine to handle the Impeller.

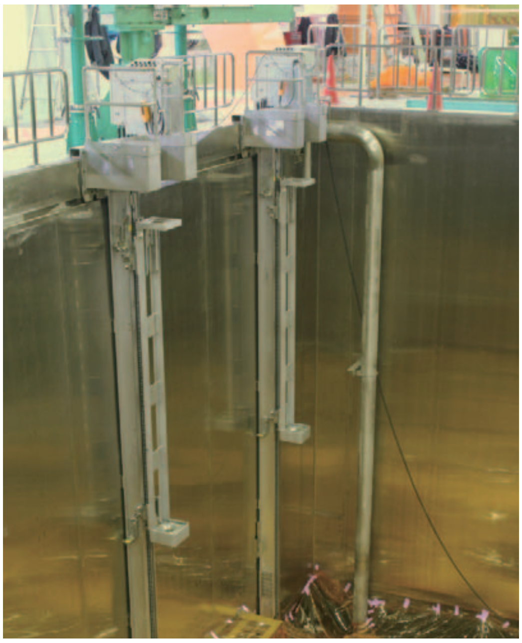
Our highly reliable products, based on proven design, are leading nuclear technology that enhance the safety of nuclear power plants.

■CRD Handling Equipment

During the periodic reactor inspection, the FMCRD is inspected and maintained.
FMCRD handling work is performed with the CRD Handling Equipment installed undervessel for it's assembling/dis-assembling. Then, the dis-assembled FMCRD is inspected/maintained with Maintenance Equipment.

■Fuel Preparation Machine

Loading preparations of new fuel and inspections of used fuel are performed under water using a fuel preparation machine. At Hitachi, development and practical use have been accomplished of an Improved Fuel Preparation Machine, not only with remote control and electric motor drive, but also with a new structure for ease of maintenance and inspection.



■In-Service Inspection Equipment

This equipment is used to detect defects on the outer RPV (body, support skirts, flanges, nozzles and their corners), pipes and RIP nozzles by using ultrasonic probes.
In consideration of the broad range of thicknesses and number of steel grades to be inspected in the RPV and pipe, an incidence angle fixation probe is utilized. However, for the RIP nozzle, a phased array probe is used.

Organization for Hitachi's Nuclear Buisiness

Hitachi's Unified Company-Wide Nuclear Business System Based on Hitachi Technology

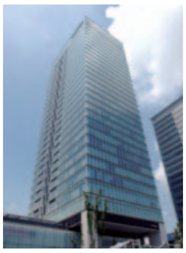
Together with all partners in the Hitachi group, Hitachi-GE Nuclear energy has established a comprehensive line-up of nuclear power service including planning, design, manufacturing, installation and maintenance of nuclear power generation plants; furthermore, we also provide training programs for plant operators. At present, Hitachi is making diligent efforts to further improve the related technology through the introduction of economically efficient light water reactor and the practical use of fast reactor while continuing to promote research and development.

Hitachi-GE Nuclear Energy,Ltd.

Registered Office

Hitachi Works

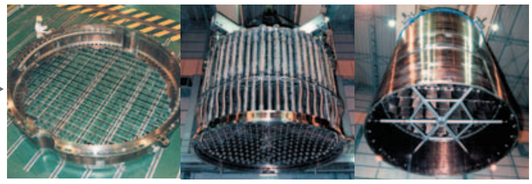
Tokyo HQ



Akihabara Daibiru

Rinkai Factory
Nuclear power plant components

Internals



Hitachi, Ltd. Power Business Unit

power transformers, breakers, etc.

Power Production Management Division (Kokubu Production Division)

Transformer

Service & Platforms Business Unit

Instrumentation and controls, control panels, control computers, etc.

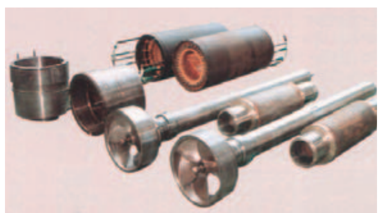
Control System Platform Division (Omika Works)

Main Control System

Industrial Products Business Unit

Pumps

Machinery Systems Division (Tsuchiura Works)

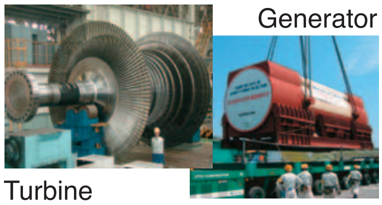


Reactor Internal Pump

Our highly reliable products, based on proven design, are leading nuclear technology that enhance the safety of nuclear power plants.

Affiliated Companies

Steam turbines, generators



Generator

Turbine

Reactor pressure vessel, etc.

Reactor Pressure Vessel

Mitsubishi Hitachi Power Systems, Ltd.

Hitachi Plant Construction, Ltd.	Planning and execution of site installation
Global Nuclear Fuel-Japan Co., Ltd.	Fabrication work of nuclear fuel
BWR Operator Training Center Inc.	Training of operators
Nippon Nuclear Fuel Development Co., Ltd.	Development of nuclear fuel and related technology
Hitachi Industrial Equipment Systems Co., Ltd.	Switch boards

R & D

Hitachi Reseach Laboratory

Energy and Environmental Systems Research Center

Studies concerning reactor safety analysis, waste treatment, instrumentation, and control

Materials Research Center

Development of materials

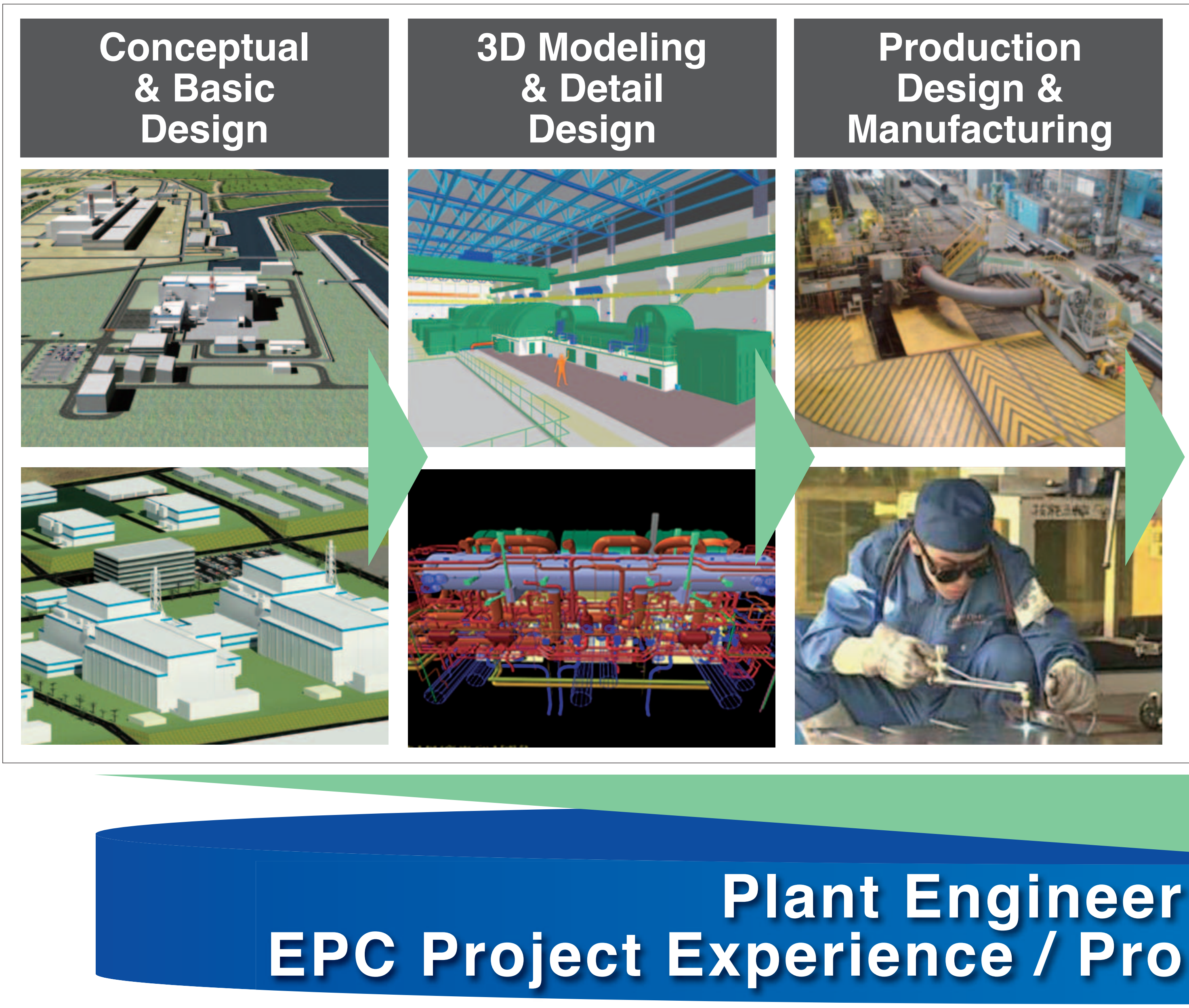
Mechanical Engineering Research Center

Studies concerning seismic design

Engineering Technologies

Concept to Reality
- HITACHI's IT Technologies Streamline Nuclear Plant Life-long Management

The design stage of nuclear power plant requires overall coordination of broad range of engineering tasks, including conceptual design, layout design, equipment carry in/out plan, shielding plan, as well as the plant construction, operation and maintenance plan.
Schedule management, workforce management and QA/QC management are also important during each task phase.
In order to perform these tasks efficiently, Hitachi has developed an "Advanced Integrated CAE System" to actualize high-quality and efficient works.
This system works based on not only the plant engineering database but also the accumulated experiences and management know-how of the previous projects.
Also, it is enhanced day by day through the actual projects as our core in-house engineering system.

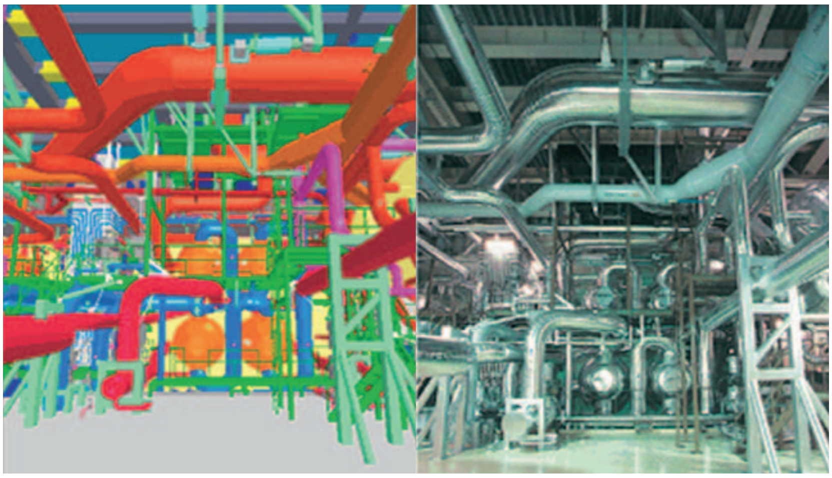


Our highly reliable products, based on proven design, are leading nuclear technology that enhance the safety of nuclear power plants.

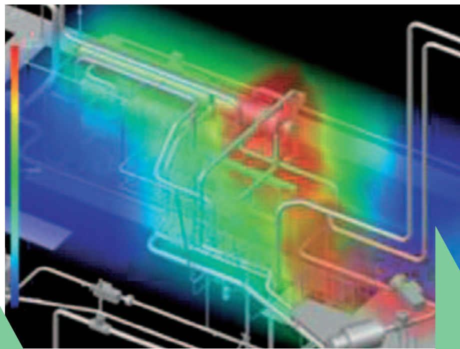
Our Policies

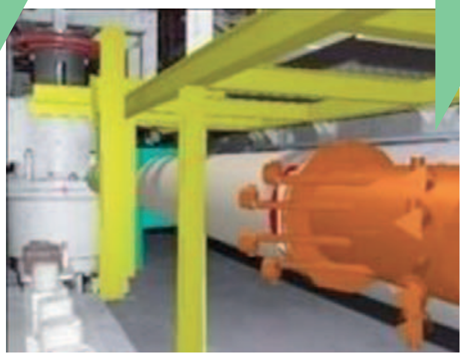
- Execute as planned
- Simulate in advance

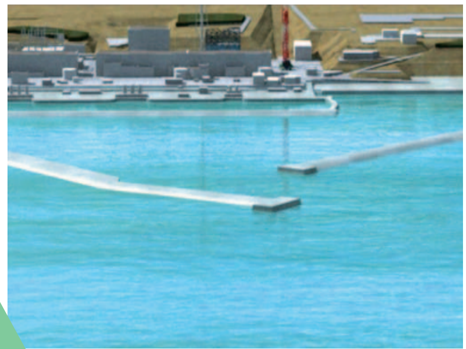
- Highest quality and safety
- On schedule/on budget
- Ultimate plant usability;
  - -Constructability
  - -Operability
  - -Maintainability

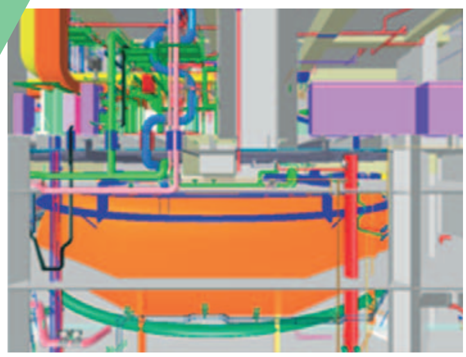


Construction & Start Up	Operation & Maintenance	Reactor Decommission-ing plan







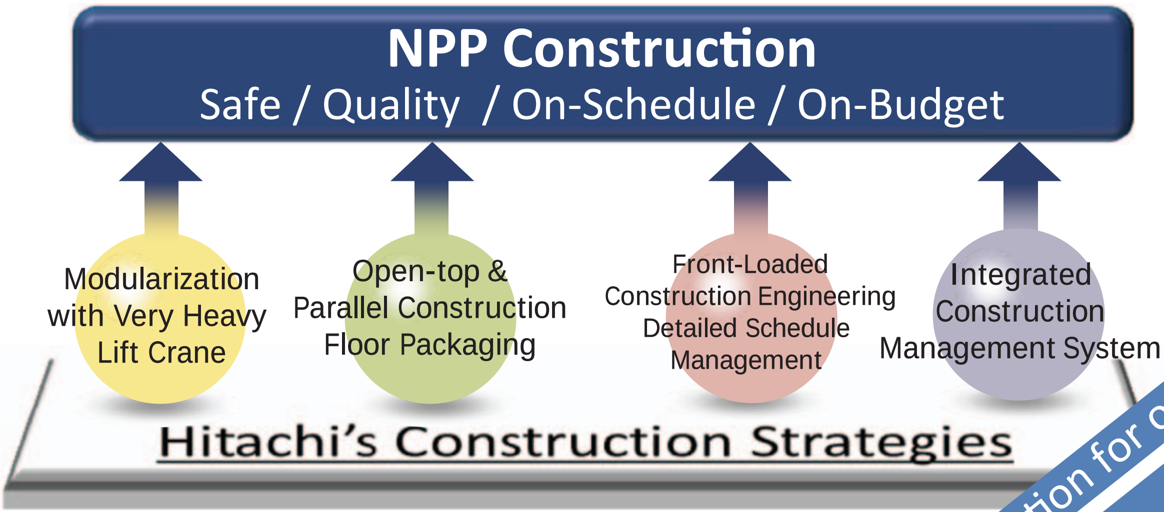


ing Database
ject Management Know-How

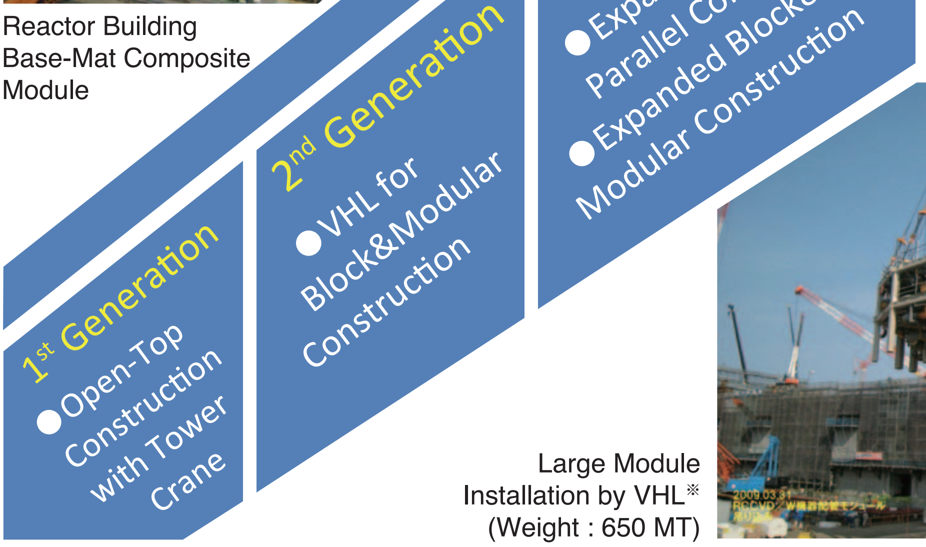
Construction

Hitachi's Proven NPP Construction

To improve the construction period, safety and quality, Hitachi has continuously improved its construction technologies since the first BWR Nuclear Power Plant (NPP) construction in 1970's. Now, Hitachi has 4 main construction strategies.
These strategies contribute to Hitachi's excellent execution of NPP projects.



Reactor Building Base-Mat Composite Module



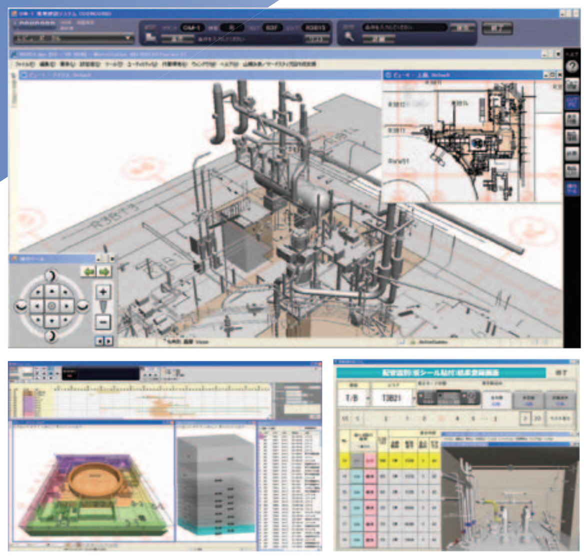
Large Module Installation by VHL※ (Weight : 650 MT)

※VHL : Very Heavy Lift

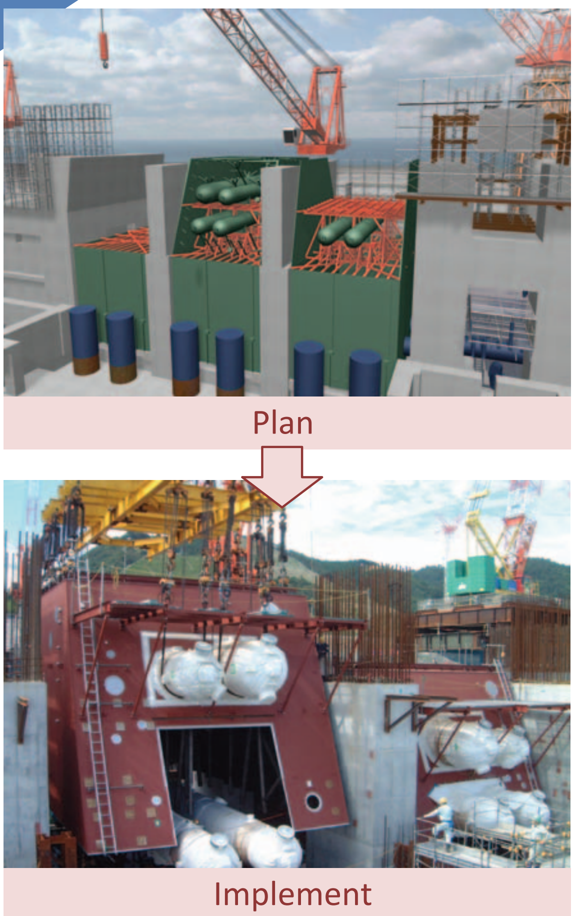
Our highly reliable products, based on proven design, are leading nuclear technology that enhance the safety of nuclear power plants.

5th Generation

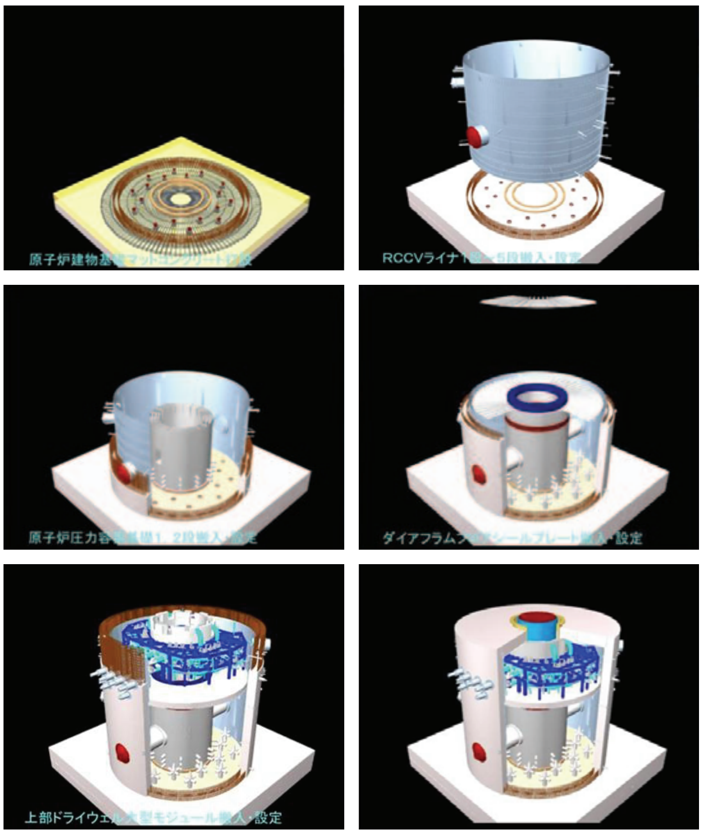
- Composite-Module and Block & Module's Enlargement
- Fully Integrated Design & Engineering & Management
- Real-time Technology for Logistics and Progress Control



4D Visual Construction System



Open-Top Construction

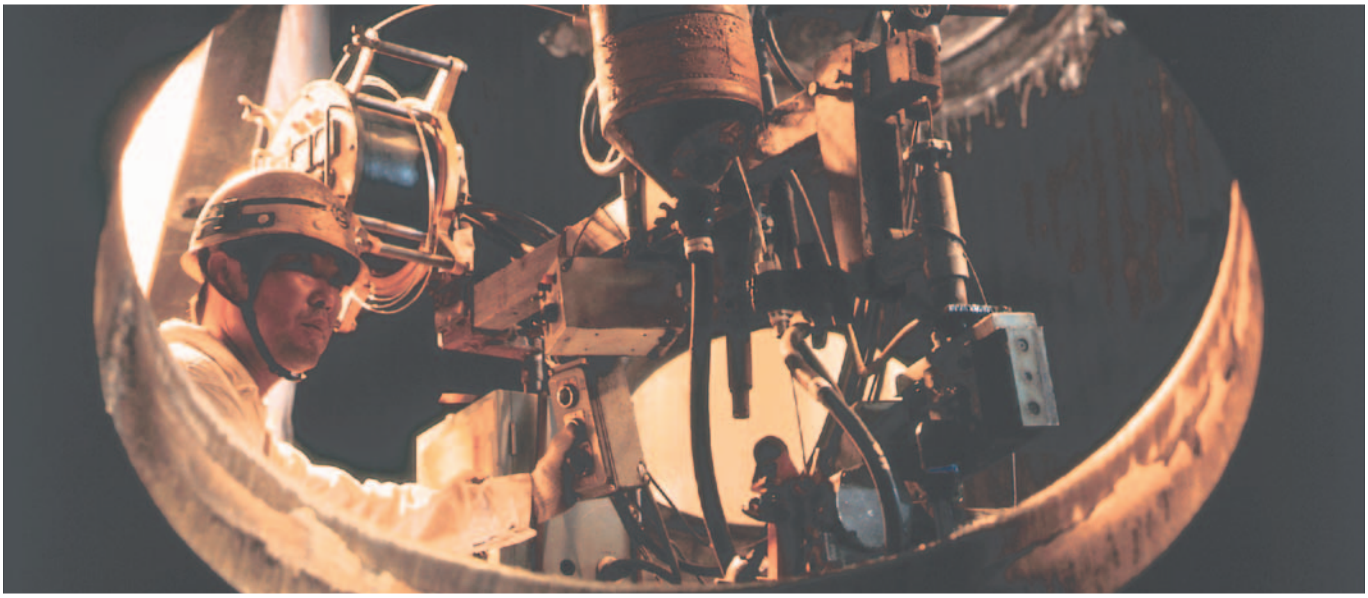


Visualized Construction Sequence
(Front-Loaded Engineering)

Quality Assurance System

Hitachi Guarantees the High Quality of the Products, which are Supported by Hitachi's Time-Tested Array of Technologies

In order to ensure construction of high quality, highly reliable nuclear power plants, Hitachi has established a consistent quality assurance system, which extends to design, manufacture, inspection, installation, and even preventative maintenance after delivery.
In addition, ISO9001 certification was first obtained in 1999.



The Manufacture of Nuclear Power Equipment Requires Advanced Technology

■Nuclear Power Quality Assurance System

- **Hitachi-GE Nuclear Energy, Ltd. Nuclear Systems Quality Assurance Division**
  - Hitachi-GE Nuclear Energy, Ltd. Hitachi Works
    - Local Construction Site / Office
  - **Hitachi, Ltd.**
    - Power Systems Company
      - Thermal Power Systems Division
      - Power & Industrial Systems Division
    - Infrastructure Systems Company
    - ⋮
  - **Research Institutes**
  - **Related Companies, etc.**

Various Quality Assurance Departments

⋮

Various Quality Assurance Departments

■Nuclear Power Quality Assurance Activities

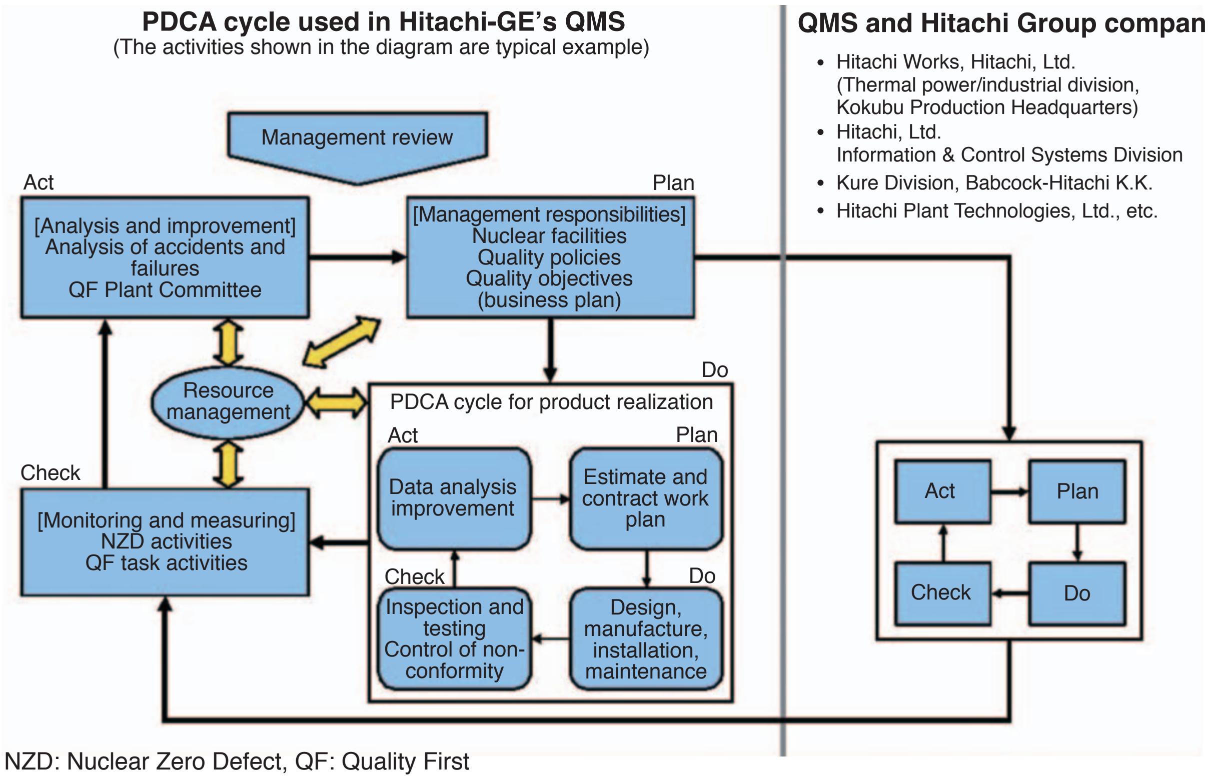
Nuclear Power Quality Assurance Committee

- Nuclear Power Project Administration Regulations
- Nuclear Power OCHIBO Committee
- Nuclear Equipment Accident Prevention Committee
- Construction Plant Reliability Activities
- Operation Plant Reliability Activities
- Various Reliability Improvement Activities

Our highly reliable products, based on proven design, are leading nuclear technology that enhance the safety of nuclear power plants.

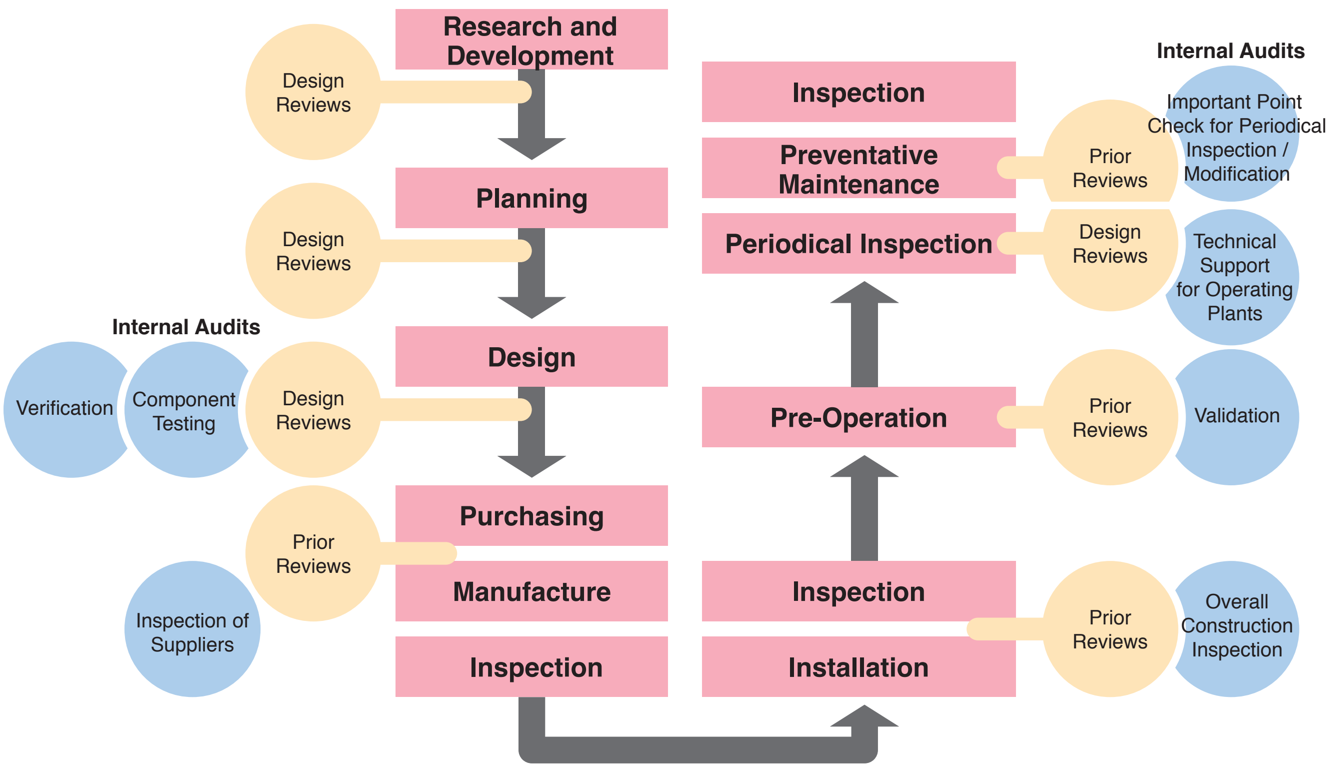
■QMS operation for Plant Delivery

Quality management system at Hitachi-GE and the Hitachi Group



Note) NZD: Nuclear Zero Defect, QF: Quality First

■Quality Control Activities

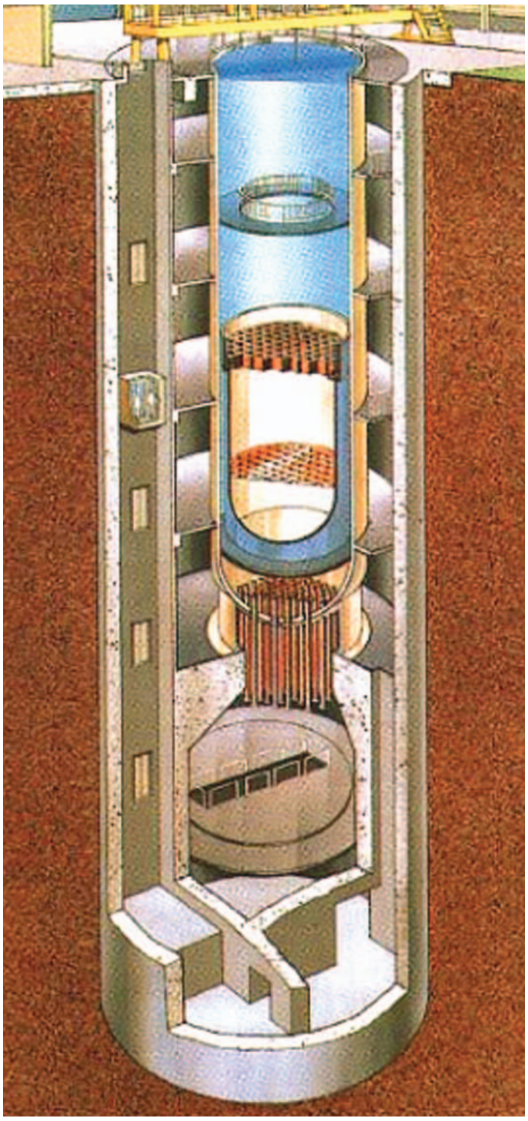


Preventive Maintenance

Hitachi's Preventive Maintenance Technologies ensure Optimum Performance

Hitachi offers high valued service with the most advanced inspection, stress relaxation, and repair technologies, utilizing our abundant product manufacturing experience and IT in order to contribute to the high reliability of nuclear power plants.

■Hitachi BWR Reactor Preventive Maintenance Technology Center



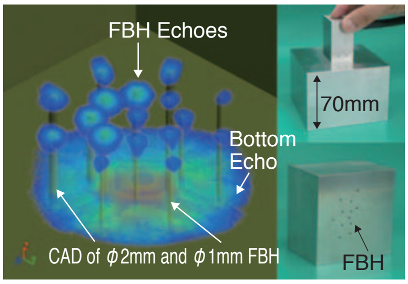
Cut View of Pit
Hitachi's underwater technicians can train the maintenance works remotely 20 meters above the bottom of RPV or below a forest of structures under RPV in the simulated facility.

■Inspection Technologies

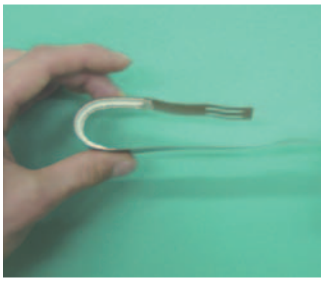
Hitachi has developed various inspection technologies and systems.

Sensing Technologies (UT, ECT, RT)

Developing many sensors and inspection systems adapted for various materials, shapes and environments, and use them in the real plants.



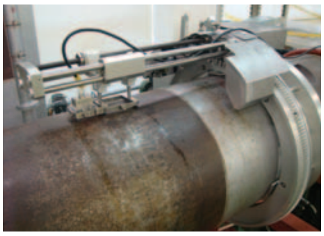
FBH : Flat Bottom Holes



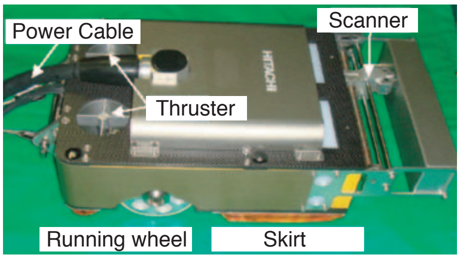
Flexible Multi Coil ECT Sensor

Inspection Mechanics and Systems

Developing and use remote and automated inspection equipment for the nuclear power plant facilities.



Pipe Inspection System



Remotely Operated Underwater Vehicle (Extraction Type)

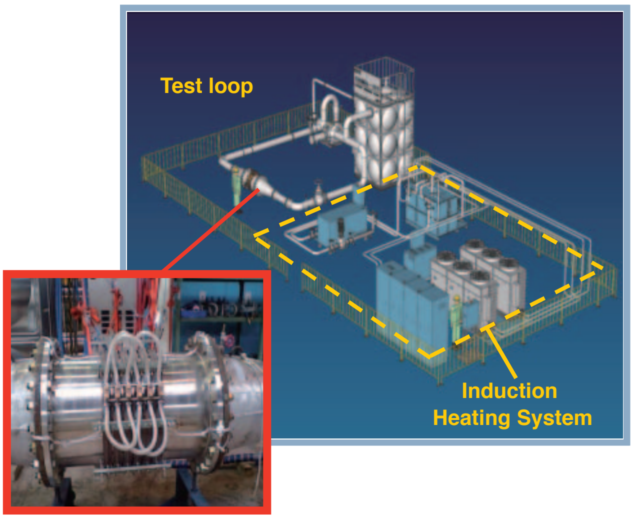
Remotely Operated Underwater Vehicle (Swimming Type)

Our highly reliable products, based on proven design, are leading nuclear technology that enhance the safety of nuclear power plants.

■Stress Relaxation Technologies

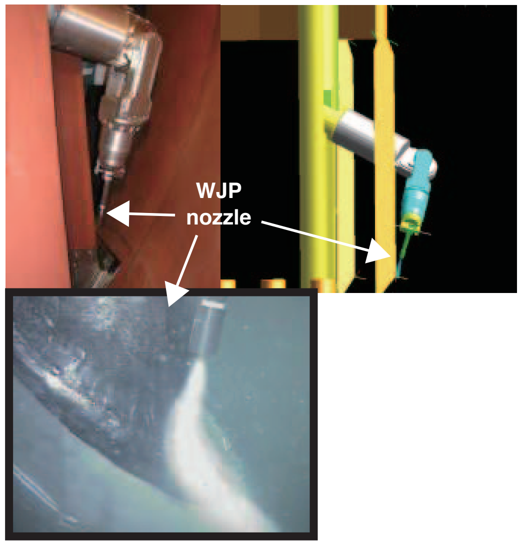
Hitachi's stress relaxation technologies improve the reliability of nuclear power plants.

Stress Improvement of Inner surface of pipes by Induction Heating Stress Improvement (IHSI)



Heating coil

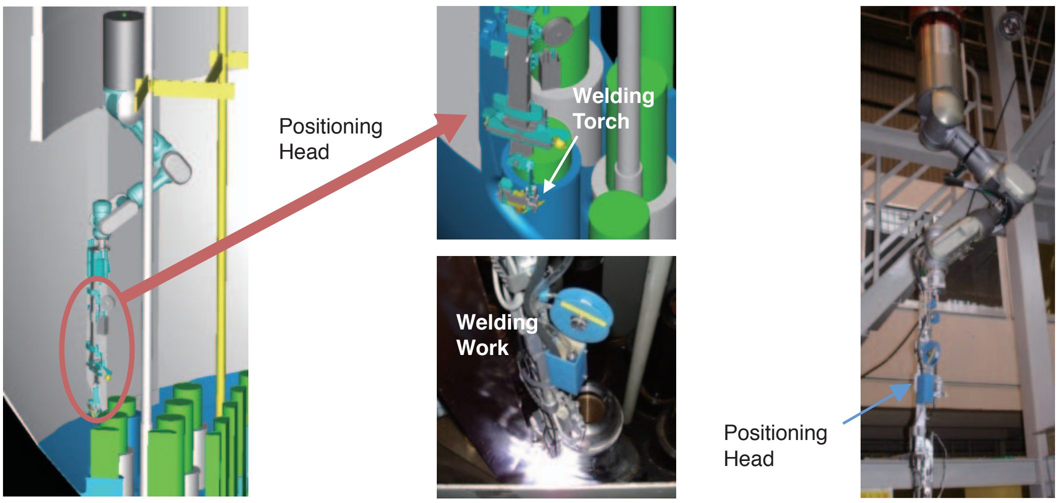
Stress Improvement of RPV Internals by Water Jet Peening (WJP)



■Repair Technologies

Hitachi has developed and applied various repair technologies and systems.

Remote Repair Technology of RPV Bottom Head Equipment



3-D simulation

Manipulator

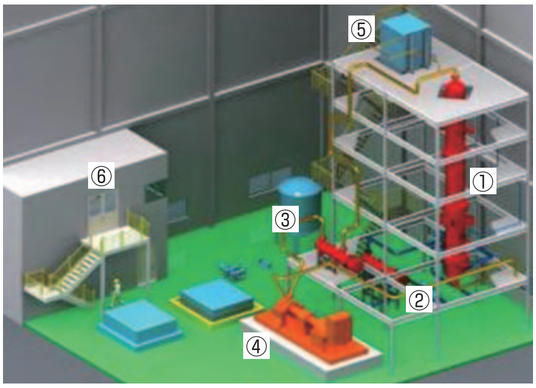
Research and Development

Multi-purpose steam source test facility (HUSTLE)

Hitachi is accelerating R & D to develop superior technology and products in its key nuclear businesses of new plants, components, maintenance, and uprates, making full use of the test facility which provides two phase flow under BWR's actual pressure and temperature.

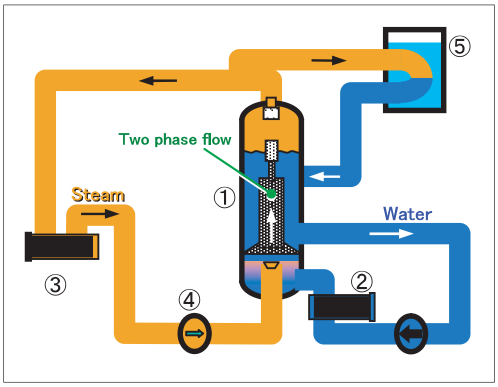
■**Features**

- One of the biggest facilities in Japan
- BWR's actual operating condition (Up to 7MPa/290℃)
- Two-phase flow
- Steam recirculation with steam compressor



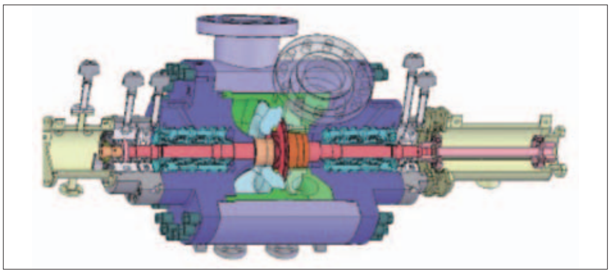
Layout of the facility

①Test section
②Water heater
③Steam heater
④Steam compressor
⑤Condenser
⑥Control room



System configuration

Test center of HUSTLE



3D Cut Model of the Steam compressor

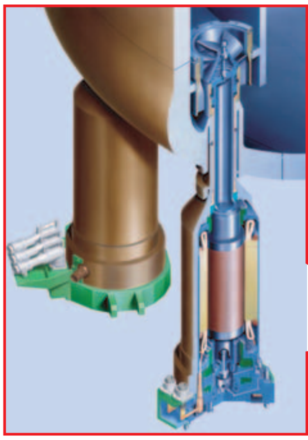
HUSTLE:Hitachi Utility Steam Test Leading facility

Our highly reliable products, based on proven design, are leading nuclear technology that enhance the safety of nuclear power plants.

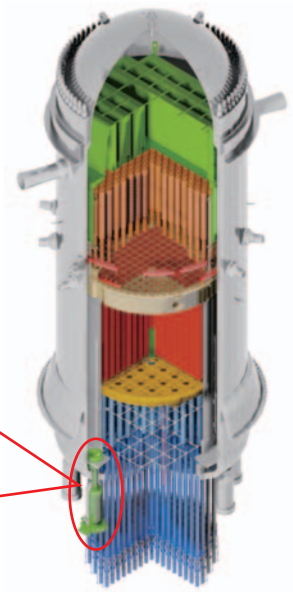
■Testing

Various tests are performed to confirm performance and quality of nuclear core equipment.

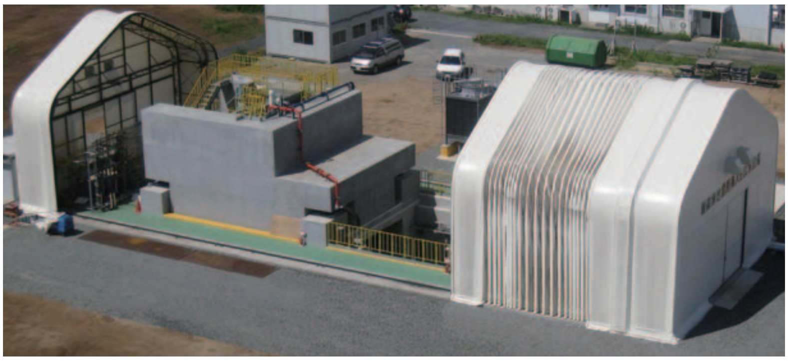
Reactor Internal Pump Test Facility



Reactor Internal Pump

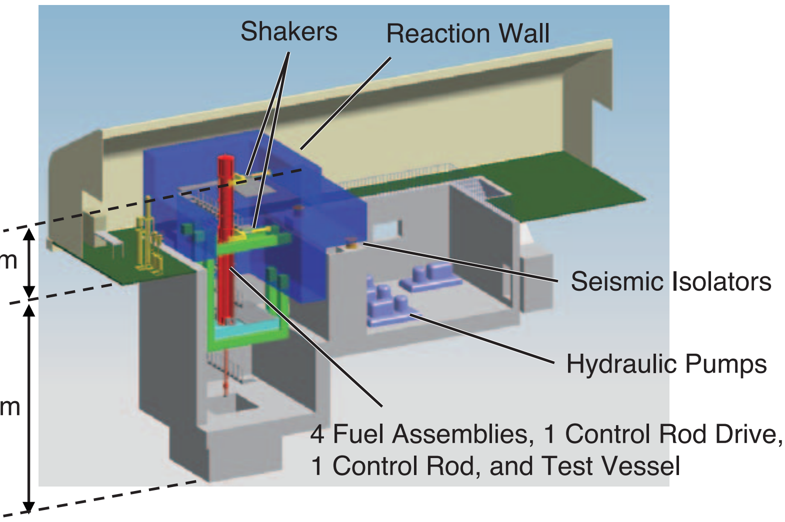


Reactor Pressure Vessel



High-Performance Test Facility of Control Rod Scrammability under Seismic Conditions

High-Performance Control Rod Seismic Scrammability Test Facility



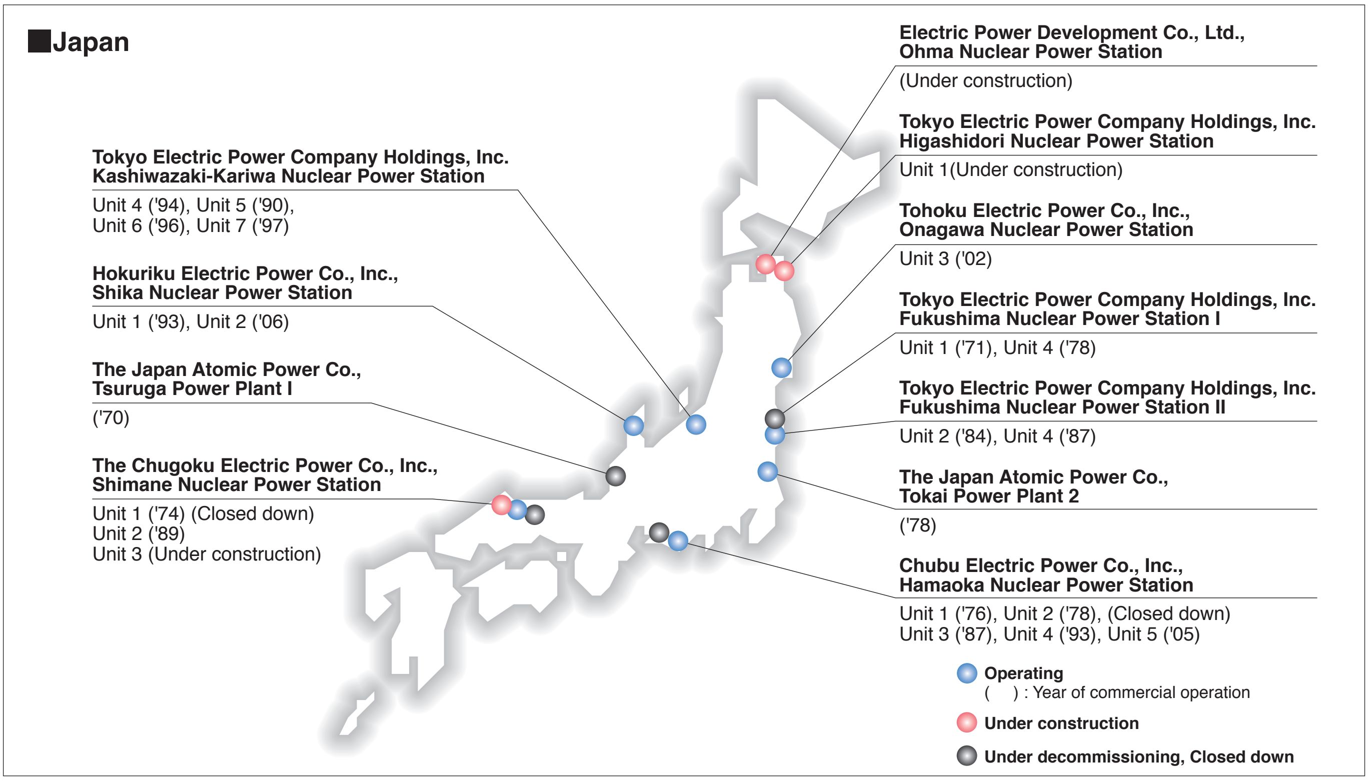
- This test facility can perform seismic scrammability tests for all BWR type reactors.
- Parallel and horizontal excitation by two hydraulic shakers can demonstrate seismic response behavior.
- Seismic isolators are used for supporting the reaction wall in order to minimize the vibration influence to the surrounding areas.

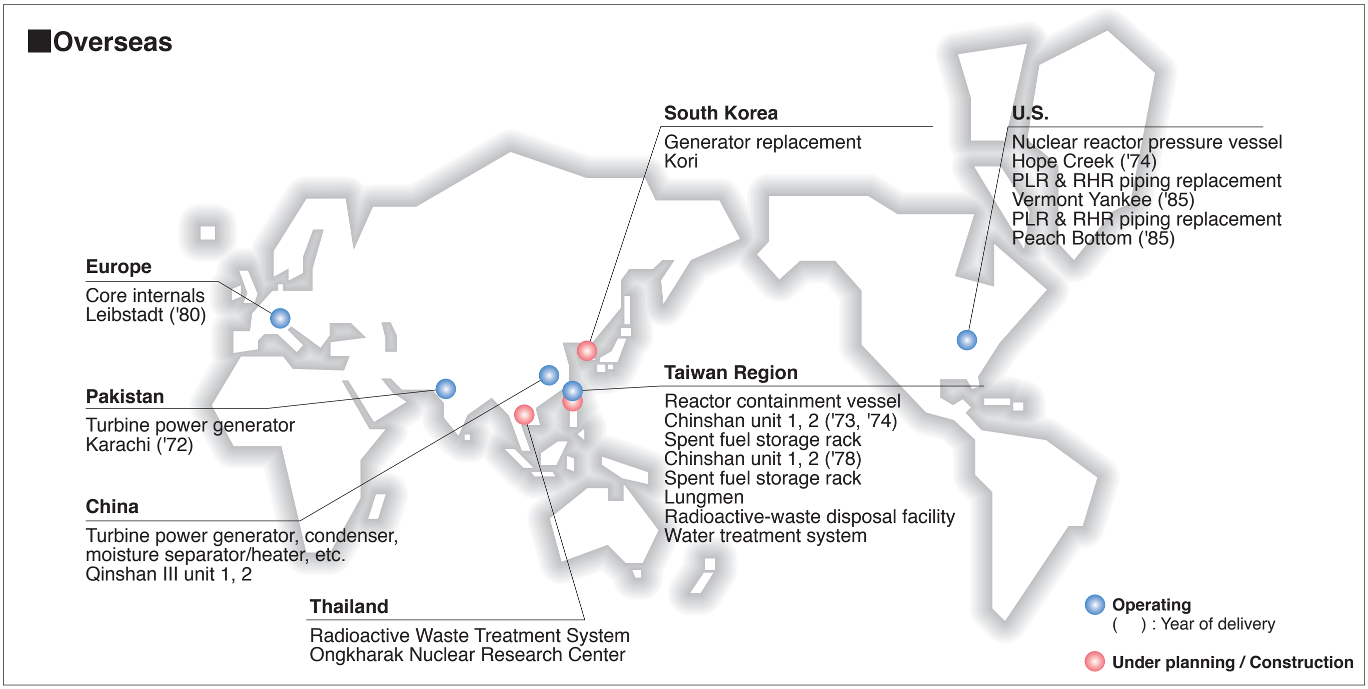
Hitachi's Achievements in Nuclear Power

Hitachi is Committed to Apply the Latest Technology to Construct Advanced Power Stations

Since we took part in the construction of Japan's first light water reactor -The Japan Atomic Power Co.'s Tsuruga Nuclear Power Station Unit No.1- Hitachi has installed 20 nuclear power plants in total. We are also in the process of constructing a further three plants.

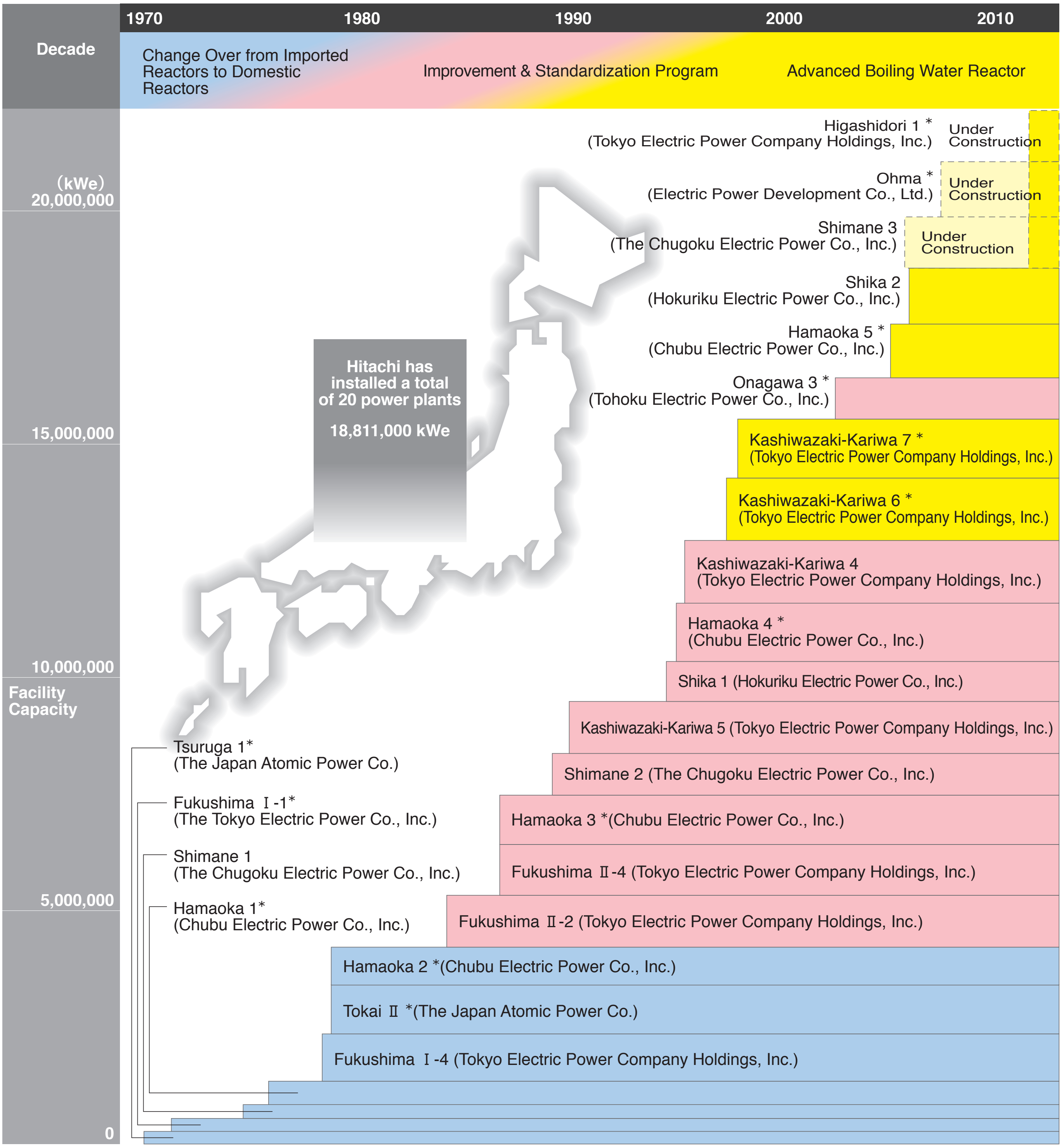
■Achievements in Nuclear Power Plant Delivery





Our highly reliable products, based on proven design, are leading nuclear technology that enhance the safety of nuclear power plants.

History of Hitachi's Nuclear Power Plant Construction



* : Joint construction project

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FSC® C015138
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Catalog No. : 83Z-Z1-0022 R5
Reprint without Permission Prohibition
Printed in Japan 2018.05