1 000 MW USC Steam Turbine Generators Shipped to Korea

Toshiba shipped two steam turbine generators (STGs) to Korea between the end of October 2013 and February 2014 for Units 1 and 2 of the coal-fired Samcheok Green Power Plant. These 1 000 MW ultra-supercritical (USC) STGs were ordered by Korea Southern Power Co., Ltd. in May 2011.

The main features of these STGs are as follows.

- Steam turbine: The turbine has the largest capacity among Toshiba's turbines for overseas thermal power plants and is the first to be equipped with 48-inch titanium last-stage blades. It incorporates highly sophisticated technologies due to the use of the latest three-dimensional (3D) design methodologies.
- Generator: The generator also has the largest capacity (1 230 MVA) among Toshiba's generators for overseas power plants, and attains a high efficiency exceeding 99%. Similarly to the steam turbine, it was designed using the latest 3D approach.
- Turbine for feedwater pump drive: Cost reduction was achieved by overseas production through technical cooperation with China Chang Jiang Energy Corp.
- Others: A new STG startup procedure capable of handling a number of startup patterns was adopted using two sets of 500 MW one-through type boilers.

We took advantage of local procurement to build these units in Korea, which allowed us to control the cost as well as delivery risks. For the installation and commissioning of the STG equipment, we formed a consortium with Hyundai Engineering & Construction Company (HDEC) of Korea to complete the necessary work. HDEC is mainly in charge of the installation of Units 1 and 2, which is currently underway.

Units 1 and 2 are respectively scheduled to start commercial operation in December 2015 and June 2016. There is also a plan to build Units 3 and 4 at the Samcheok Green Power Plant. We are aiming to build more STGs based on their performance at Units 1 and 2.

Low-pressure (LP) turbine rotor

Generator

Generator Stator Rewinding Project for OEM Unit in North America Completed in Short Time

In November 2013, Toshiba succeeded in completing rewinding of the generator water-cooled stator for Unit 3 (output rating: 389 MVA) of the Weston Power Plant in Wisconsin, U.S.A., in only 27 days. This original equipment manufacturer (OEM) unit went into commercial service in 1981. The owner, Wisconsin Public Service Corporation, placed an order for this work with Toshiba in 2009.

We had required 35 days to complete generator and stator rewinding work in North America in the past. However, by combining our capabilities with those of our local service center, Toshiba International Corporation Milwaukee Service Center (TIC-MSC), in the U.S.A., we were able to complete the project in a short time.

A key to the success of this rewinding project was thorough preparation and planning for the work, including arrangement of the necessary tools and development of the site work procedures. These preparatory activities helped to ensure the quality of the work and improve work efficiency at the site. We used a low-temperature-curing material for hose molding. Moreover, some of the tasks were combined and performed in parallel to accelerate the work schedule.

In thermal fleet projects in North America, customers often require rewinding work to be completed within 28 days. The satisfactory outcome of this project demonstrated our ability to complete rewinding work within tight time constraints.

Rewound generator stator for Weston Power Plant Unit 3, U.S.A.

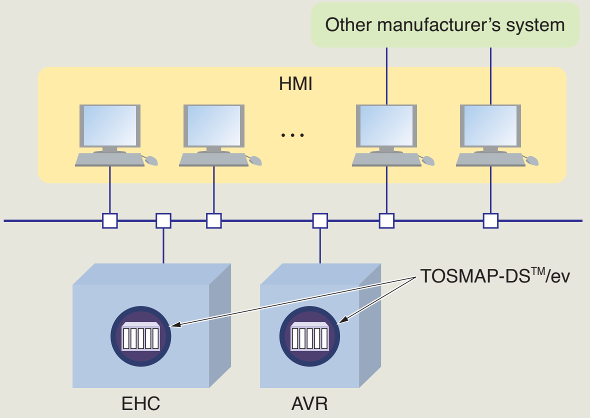
Efforts to Accelerate On-Site Work for Upgrading Forney Power Plant, U.S.A.

A project to upgrade the control systems of Units 1 and 2 of the Forney Power Plant, U.S.A., was successfully completed in November 2013. The project was executed by Toshiba in cooperation with Toshiba International Corporation (TIC), U.S.A. Although we were given seven days to complete the work for each unit, which was shorter than the period that we had required for a similar project, we finished the work in 4.5 days for Unit 1 and in 4 days for Unit 2.

The controllers of the automatic voltage regulator (AVR) and electrohydraulic control (EHC) systems were replaced with TOSMAP-DS™/ev series controllers. The AVR is the excitation control system for the turbine generator, while the EHC system controls, protects, and monitors the steam turbine. The human-machine interface (HMI) software for operation and monitoring was upgraded to the TOSMAP-DS™ SR22 series.

We formulated and implemented the three strategic plans outlined below so as to complete the upgrading project well within the seven-day deadline for each unit, as mentioned above:

- minimization of the on-site work (accumulation of small improvements such as parts arrangement optimization, equipment modularization, etc.)
- optimization of the on-site work plan
- interface testing at TIC's factory with the distributed control system (DCS) built by another manufacturer and a system provided by the customer before starting the on-site work.



Upgrade of AVR and EHC systems with TOSMAP-DS™/ev controllers at Forney Power Plant, U.S.A.

Generator Protection Relay Complying with IEEE C37.102 Standard

Toshiba has developed a generator protection relay unit that complies with the protective functions specified in the IEEE C37.102 standard. This relay is available for communication with generator excitation and steam turbine control systems, such as AVR and EHC systems, based on the IEC 61850 standard protocols.

With the development of this relay, Toshiba can supply a total control package and protection system for a thermal power plant as a whole.

IEEE: Institute of Electrical and Electronics Engineers
IEC: International Electrotechnical Commission

Relay unit complying with IEEE C37.102 standard

Successful Testing of Novel Combustor for Supercritical CO_2 Turbine System

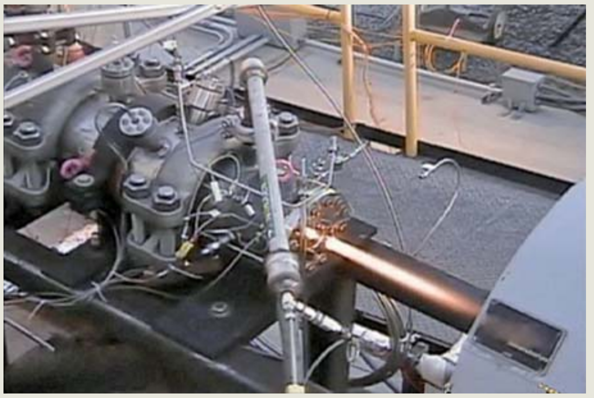
Step-by-step testing of a new combustor was initiated at a facility in the U.S.A. in January 2013. Its purpose was to demonstrate and verify the operation of the combustor under the environment required by a supercritical carbon dioxide (CO_2) turbine system. The combustor worked under the highest operating pressure ever recorded during such tests[*].

The supercritical CO_2 turbine system is designed to operate at a very high pressure of 300 atm, and the development of a new combustor was a critical challenge. In July, the test program broke new scientific ground by confirming stable operation at the system's target pressure of 300 atm.

The successful testing of the combustor is a major step toward the realization of a new thermal power generation system. This system burns a mixture of fossil fuel and oxygen combined with CO_2 to produce a working fluid, mainly consisting of CO_2 and water vapor. The fluid is used to drive the turbine generator, and separates and collects CO_2 without the need for any carbon capture system.

These features will make it possible to build high-efficiency thermal power plants with near-zero emissions.

(*) As of July 2013 (as researched by Toshiba)



Combustor undergoing combustion test for supercritical CO_2 turbine

Commercial Operation of All Six Units of Shihutang Hydropower Plant, China

Toshiba Hydro Power (Hangzhou) Co., Ltd. (THPC), a subsidiary of Toshiba, was awarded a contract to supply hydroelectric equipment for the Shihutang Hydropower Plant, China, in August 2009. Within the short period of three and a half years, all six units were completed and commercial operation started in April 2013.

The plant is operated under a high head during the dry season and a low head during the flooded season. Hence, in order to maximize the power generated by the plant, two types of bulb turbines were designed and manufactured by THPC, using models developed by Toshiba. These two types of bulb turbines are a four-blade type (two units) that provides superior performance for the high head, and a three-blade type (four units) that is suitable for the low head.

The ratings of the turbine and generator are as follows:

- Turbine: 20.62 MW-6.25 m-68.2 min^{-1} (two units); 20.62 MW-5.65 m-79 min^{-1} (four units)
- Generator: 22.22 MVA-10.5 kV-68.2 min^{-1}, 50 Hz (two units); 22.22 MVA-10.5 kV-79 min^{-1}, 50 Hz (four units).

Runner assembly at site of Shihutang Hydropower Plant, China

Start of Commercial Operation of Grand Poubara Hydropower Station, Gabon

The Grand Poubara Hydropower Station is located in the southeastern region of the Gabonese Republic in Central Africa. The station consists of four Francis turbines and generators and has the nation's largest capacity of 160 MW. The initial unit started commercial operation in August 2013 and the remaining units started operation within a month after that.

Toshiba Hydro Power (Hangzhou) Co., Ltd. (THPC), one of Toshiba's major overseas bases, concluded a contract for this project for the first time outside of China. The customer requested that the project be completed in only four years from the date of the contract in August 2009. THPC designed and manufactured all of the turbines and generators with technical support from Toshiba and completed them on time. The turbines and generators are operating as planned.

The ratings of the turbine and generator are as follows:

- Turbine: 42.6 MW-103.4 m-272.7 min^{-1} (4 units)
- Generator: 57.2 MVA-10.5 kV-272.7 min^{-1}, 50 Hz (4 units).

Interior view of Grand Poubara Hydropower Station, Gabon

Installation of generator rotor (left) and runner (right)

Shipment of First Pump-Turbine Runner for Ludington Pumped Storage Power Plant, U.S.A.

The first of six pump-turbine runners for the Ludington Pumped Storage Power Plant in Michigan, U.S.A., was completed and shipped in June 2013.

The contract was concluded for the purpose of improving the capacity of the pump-turbine and generator-motor, which were built by another manufacturer about 40 years ago. Design and engineering of the new pump-turbine runner were conducted in Japan, and the pump-turbine runner was manufactured by Toshiba Hydro Power (Hangzhou) Co., Ltd. (THPC) in China.

The runner weighs approximately 270 tons and has a diameter of approximately 8.4 m, which are the world's largest-class pump-turbine runner(*).

Toshiba employed a state-of-the-art model testing facility and computational fluid dynamics (CFD) technology to optimize the pump-turbine runner profile. As a result, the output capacity of the pump-turbine at the rated net head has been raised to approximately 360 MW from the current output of 312 MW.

The ratings of the pump-turbine are as follows:

- 359 MW-98/111 m-112.5 min^{-1} (6 units)

(*) As of May 2013 (as researched by Toshiba)

Replacement pump-turbine runner for Ludington Pumped Storage Power Plant, U.S.A.

Delivery of Steam Turbine Generator for Olkaria Geothermal Power Station, Kenya

Toshiba completed delivery of steam turbines, generators, and auxiliaries for Units 4 and 5 of Olkaria Geothermal Power Station I and Units 1 and 2 of Olkaria Geothermal Power Station IV in June 2013. These facilities are being constructed by Hyundai Engineering & Construction Company (HDEC) in the Olkaria geothermal region of Kenya. Toshiba succeeded in accelerating delivery by two to three months in accordance with the customer's requirement.

The Olkaria Geothermal Power Station is located about 120 km northwest of Nairobi. The rated output of the newly supplied turbine generators is about 75 MW. The new units are scheduled to start commercial operation in succession from July 2014, with the last unit starting operation in November 2014. At that time, the power generated by this station will account for about 25% of Kenya's overall generation capacity. Toshiba has sent technical advisors to the site to support the construction and commissioning work.

The main equipment for each unit supplied by Toshiba is as follows:

- main steam turbine
- main stop valve and control valve
- lubrication and control oil system
- air-cooled type generator.

Turbine rotor for Olkaria Geothermal Power Station, Kenya

Turbine Upgrade for Unit 19-2 of Calistoga Geothermal Power Plant, U.S.A.

Toshiba has supplied a second-generation super-rotor and related technical support for the upgrading project for Unit 19-2 of the Calistoga Geothermal Power Plant, located in The Geysers region of California, U.S.A. The project further improved the reliability and performance of the turbine.

As a countermeasure against stress corrosion cracking, which is often found in corrosive environments like that of a geothermal plant, the first-generation super-rotor technology was developed and applied for the first time in 2002. The second-generation super-rotor was introduced as the successor to this technology. Examples of the improvements realized by this second-generation technology include blades equipped with a drainage discharge structure to boost performance, and the use of a larger last-stage blade of 26 inches to reduce exhaust loss. Furthermore, a newly designed steam path was provided to match the geothermal steam conditions, which had deteriorated after almost 30 years of operation.

As a result of these features, the second-generation super-rotor has achieved a 3% improvement in efficiency compared with the first-generation equipment and contributed to the successful completion of this project.

Second-generation super-rotor for Unit 19-2 of Calistoga Geothermal Power Plant, U.S.A.

PV Systems with Capacity of 3 MW Installed on Apartment Building Roofs in Germany

Toshiba photovoltaic (PV) systems have been installed on the roofs of a number of apartment buildings owned by Gagfah S.A., a real estate company that leases rooms to 180 000 households in Germany.

Starting with a 250.32 kW system for the roofs of 12 houses in the city of Ostfildern, PV systems capable of generating a total of 3 MW have been installed in 25 cities around the country.

The main features of these PV systems are as follows:

- Optimization of PV system capacity
  PV inverters with a capacity of 13 kW, 17 kW, or 20 kW are selected and combined to match the roof size.
- Operation and maintenance
  The power generation facility and its output are remotely monitored based on data provided by irradiance and ambient temperature sensors in each area. This mechanism ensures reliable operation and maintenance of the PV systems.

The first system commenced operation in March 2014, and the installed capacity is planned to be expanded to 100 MW throughout Germany by 2016.

PV system on apartment buildings in Villingen-Schwenningen, Germany

BESS and EMS for Kurimajima Project in Miyakojima City Commence Operation

A field demonstration project of Toshiba's SCiB™-based battery energy storage system (BESS) and energy management system (EMS) commenced operation in January 2014, led by Miyakojima City and The Okinawa Electric Power Co., Inc.

The objective of the project is to demonstrate that 100% of the energy consumed on Kurimajima Island can be supplied by PV generation and the BESS installed on the island, while maintaining the stability of the electricity supply grid.

The BESS, with a rating of 100 kW-176 kWh, is installed in a compact package together with a switchgear, and is connected to the 6.6 kV grid on Kurimajima Island. The EMS (referred to as the Kurima-EMS) controls the charging and discharging of the BESS to maintain the tie-line power flow between Miyakojima Island and Kurimajima Island at or around zero.

100 kW-176 kWh BESS installed on Kurimajima Island, Miyakojima City, for EMS demonstration project

First CCU Plant in Japan to Incorporate Chemical Absorption CO_2 Capture Technology for Waste Incineration Plant

Toshiba has joined an incineration plant biomass energy utilization project being promoted by Saga City, and installed a CO_2 capture and utilization (CCU) test plant adjacent to the Saga Municipal Waste Incineration Plant in October 2013.

This is the first CCU test plant in Japan to adopt chemical absorption CO_2 capture technology for a waste incineration plant. The plant operates fully automatically and has the capacity to capture 10 to 20 kg of CO_2 per day from flue gases at the incineration plant using an amine-based solvent.

Saga City is planning to establish a system in which CO_2 is utilized for crop cultivation, algae culture, and other purposes. We plan to identify and verify the purity of the captured CO_2 and the durability of the solvent. We are also analyzing the techno-economics of the system in order to realize commercial applications for the system with Saga City.

CCU test plant at waste incineration plant for biomass energy utilization project of Saga City

Saga Municipal Waste Incineration Plant

New Model of ENE-FARM Residential Fuel Cell System Released

Since the residential fuel cell system was first commercialized in 2009 under the name “ENE-FARM,” the market for such systems has grown steadily and Toshiba has delivered more than 30 000 units of the system as of March 2014. Our system offers a number of industry-leading technologies, providing features such as enhanced durability that eliminates the need to replace components, including cell stacks, during the 10-year lifetime of the system. In addition to its superior durability, the system is equipped with a grid-independent function that requires no rechargeable batteries, in order to respond to the needs of the market. The system can also operate on various types of fuel.

In March 2014, we released a new model of the system that realizes a total efficiency of 95%, the smallest maintenance space in the world(*), a noise level of 37 dB(A), and reduced cost. This model also offers new functions to enhance its added value.

We are making efforts to further disseminate ENE-FARM systems in new areas of application, including models installable in housing complexes, models with blackout-recovery capability, and models suitable for overseas markets.

(*) As of December 2013 (as researched by Toshiba)

New model of ENE-FARM residential fuel cell system

Commencement of Operation of Large-Scale Integrated SCADA System Utilizing Private Cloud Computing for Hokkaido Electric Power Co., Inc.

Toshiba and Hokkaido Electric Power Co., Inc. (HEPCO) have developed a large-scale integrated supervisory control and data acquisition (SCADA) system for an electric power system to integrate distributed platforms connected to a wide-area network via private cloud computing.

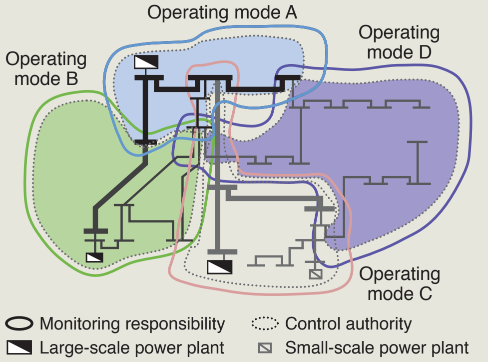
The development of this system was undertaken with the following objectives:

- To realize adaptable supervisory control, allowing each control center to conduct operations flexibly according to the situation.
- To improve disaster tolerance and operating continuity in the event of a catastrophic natural disaster.

In order to achieve these purposes, we have introduced a new "multi-access" concept. This concept gives the operating divisions a certain amount of freedom in the monitoring and control of the power system equipment.

This system is capable of performing supervisory control over the power equipment in HEPCO's entire operating region. The system has commenced operation at each of the company's control centers in succession, starting with the Hakodate Control Center on March 25, 2013, followed by the Asahikawa, Tomakomai, and Kushiro control centers as of March 2014.

HMI of integrated SCADA system installed in control room



Multi-access concept for sharing of control and monitoring in each operation mode

Shipment of Generator Step-up Transformers for Nuclear Power Stations in U.S.A.

In 2009, Toshiba received an order for 12 sets of 26-230/$\sqrt{3}$ kV-1380/3 MVA and four sets of 26-525/$\sqrt{3}$ kV-1380/3 MVA generator step-up transformers (including four spare transformers) for Units 3 and 4 of the Vogtle Nuclear Station and Units 2 and 3 of the V.C. Summer Nuclear Station, U.S.A., which are equipped with AP1000™ reactors. The AP1000™ is a cutting-edge pressurized water reactor (PWR) developed by Westinghouse Electric Company.

We have shipped eight sets in total for Vogtle Unit 3 and V.C. Summer Unit 2 so far. At each plant, three transformers are used for 3-phase power supply and one spare transformer is installed as a standby to promptly serve as a replacement in the event of any abnormality. Since we have abundant experience in manufacturing transformers for nuclear power stations in Japan and performs thorough step-by-step inspections to ensure that the level of quality is maintained, it can satisfy Westinghouse's strict quality requirements and has received positive feedback from Westinghouse.

Operation of Vogtle Unit 3 is scheduled to start in 2016, while V.C. Summer Unit 2 is expected to start operation in 2018. The remaining eight sets for Vogtle Unit 4 and V.C. Summer Unit 3 will be shipped by February 2015.

These transformers have been designed to match the design concept of the AP1000™, and we are planning to widen their applications in the future.

230 kV generator step-up transformer for U.S. nuclear power stations

AP1000™ Plant Construction in Progress in China and U.S.A.

Westinghouse Electric Company's AP1000™ nuclear power plant is the most advanced PWR available in the commercial nuclear energy market. The construction of eight AP1000™ units is currently underway in China and the U.S.A.

In China, the passive containment cooling water storage tanks were installed on top of the shield building of Unit 1 of the Sanmen Nuclear Power Plant and Unit 1 of the Haiyang Nuclear Power Plant, respectively, in January and March 2014. The exterior construction work for the nuclear islands is in its final stage at these plants. With regard to the instrumentation and control system, the main control room of Sanmen Unit 1 was declared operational in March 2014.

In the U.S.A., auxiliary building modules were installed at Vogtle Unit 3 in March 2014 and at V.C. Summer Unit 2 in May 2014. This is the largest module for the AP1000™ plant, which is approximately five stories high. The use of such large modules maximizes the benefit of the modular-construction techniques, which allow a number of construction activities to proceed in factories in parallel with the on-site construction.

Westinghouse continues to focus on the successful delivery of these AP1000™ units.

Shield building with cooling water tank at Sanmen Unit 1, China

Installation of largest module at Vogtle Unit 3, U.S.A.

Westinghouse Receives Final Safety Evaluation Report from U.S. NRC for Next-Generation Instrumentation and Control Platform for Safety Systems Utilizing FPGA Technology

In September 2013, Westinghouse Electric Company received a safety evaluation report from the U.S. Nuclear Regulatory Commission (NRC) for its next-generation instrumentation and control (I&C) platform for safety systems utilizing field-programmable gate array (FPGA) technology.

While a conventional digital I&C system is an architecture using a central processing unit (CPU), an operating system (OS), and software for operation, the new platform is simple architecture and utilizes logic implemented using FPGA technology instead of a CPU and OS. As a result, the platform provides the high reliability required for safety systems.

This platform incorporates advanced features to allow diagnosis, testability, and modularity. Diagnosis and testing capabilities are designed into the platform to provide a systematic approach to maintaining and testing the system. In addition, there are several types of primary boards in the new platform, which can be combined according to the applications. The platform is designed not only to be at the appropriate level of complexity to achieve high reliability and integrity, but also to allow flexibility to target a number of safety applications in a given plant.

This platform presents significant opportunities for Westinghouse, as it is designed to provide safety system solutions for both operating plant safety system upgrades and new nuclear plants, including AP1000™ nuclear plants.

I&C platform for safety systems using FPGA technology

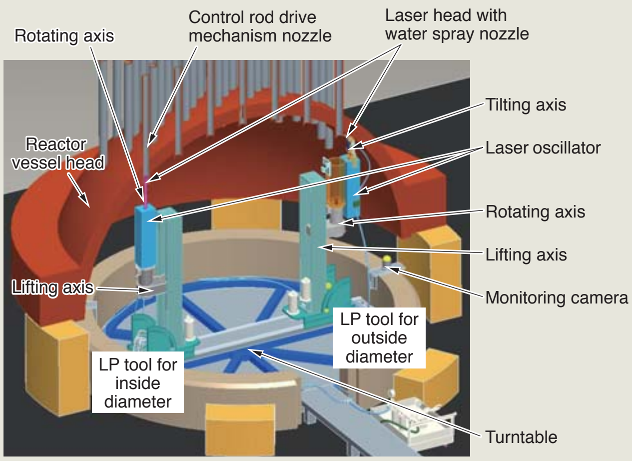
Laser Technology for Prevention of Stress Corrosion Cracking in PWR Closure Heads

Toshiba has succeeded in applying laser peening (LP) technology to the reactor vessel closure head nozzles of a PWR as a preventive maintenance measure against stress corrosion cracking. LP technology can reduce the maintenance cost and generation of radioactive waste dramatically compared with the conventional closure head replacement method.

LP technology reduces residual stresses on the metal surfaces of aged nuclear plants using the effect of high-pressure plasma created by underwater laser irradiation. The inertia of the water acts to confine the plasma so that the plasma pressure grows sufficiently large to deform the metal surface. LP technology has been applied to components inside reactor vessels, which are generally filled with water to protect workers from radiation. However, the closure head is normally laid down on the refueling floor outside, which is in the ambient air.

We have developed a technology to implement LP in a water spray, which has the same effect as LP performed underwater, and have established the concept of equipment with which LP can be performed on closure head nozzles. About 70 closure head nozzles inside and outside a reactor vessel can be peened in about 30 days.

We are planning to further expand the range of applications for peening to meet various needs in overseas markets.



LP system for PWR closure head nozzles

Backup Power Supply Panel Incorporating Lithium-Ion Battery Modules for Nuclear Power Plants

Toshiba has developed a power supply panel that incorporates lithium-ion battery modules.

The SCiB™ is a type of lithium-ion battery having superb safety features and a high energy density. The size of the newly developed power panel with built-in SCiB™ battery modules is approximately one-thirds that of a lead-acid battery type panel, allowing it to be installed in a small space within a nuclear power plant.

The panel enclosure is designed to withstand earthquakes for application to nuclear facilities and is capable of functioning as a backup power source even in the event of a station blackout caused by an earthquake. It is also capable of supplying AC power through an inverter.

Since the panel is classified as commercial power supply equipment, we are developing an emergency power supply panel for reactor cooling, protection control systems, and other critical missions. Through these efforts, we are working to further improve the safety of nuclear power plants by enhancing the reliability of their power supply systems.

Backup power supply panels incorporating SCiB™ battery modules for nuclear power plants

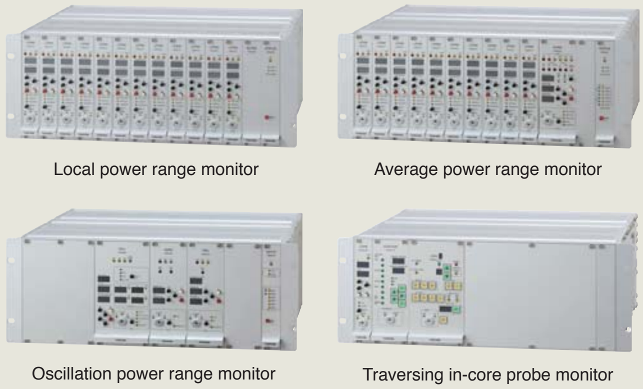
Application of FPGA-Based Neutron Monitors to Overseas Boiling Water Reactors

Toshiba has developed FPGA-based neutron monitors for use in boiling water reactors (BWRs). FPGA-based neutron monitors have a longer product life cycle than CPU-based products.

We have applied the newly developed monitors not only to Japanese BWRs but also to the Cofrentes Nuclear Power Plant in Spain. The monitors have shown good performance since their installation at these facilities.

In 2013, we prepared a design verification report for FPGA-based neutron monitors in accordance with U.S. regulatory requirements for nuclear safety systems. The report has been submitted to the NRC for type certification.

By obtaining type certification at an early stage, we intend to further promote the application of FPGA-based neutron monitors to overseas BWRs.



FPGA-based neutron monitors for BWRs

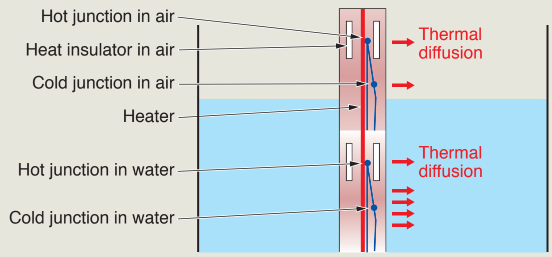
Reactor Water Level Monitoring Instrument Capable of Withstanding Severe Accident

To make it possible to monitor the water level of a reactor in the event of a severe accident, Toshiba has developed a new water level monitoring instrument for installation in the reactor pressure vessel of a BWR. This instrument can directly measure the reactor water level without the use of instrument piping such as that required by differential pressure type measuring instruments.

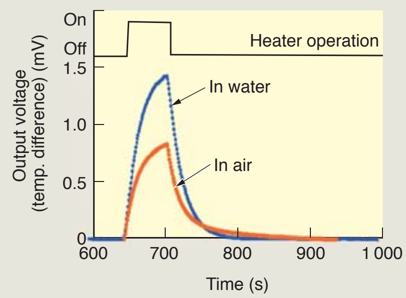
The newly developed instrument has several sensors comprising one heater and several differential thermocouples. Each sensor also has a hot junction with a heat insulator and a cold junction with no heat insulator.

The instrument can determine whether each sensor is situated in water or in air based on the difference in differential thermal diffusion. The differential thermal diffusion rate between the hot and cold junctions is larger in water than in air. As a consequence of this property, the output voltage of a sensor in water is higher than that of a sensor in air when the heater is turned on.

The metal and ceramic materials used for the construction of the instrument make it highly durable and reliable, with the capability to measure the water level inside a reactor even in the event of a severe accident.



Measurement principle



Transient response of sensors to heater operation

Reactor water level monitoring instrument capable of withstanding severe accident

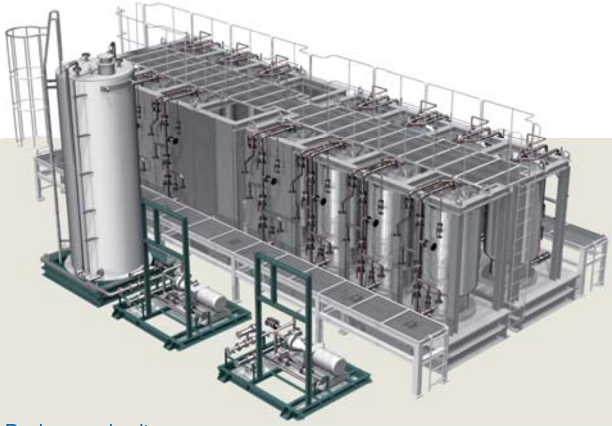
Multi-Radionuclide Removal System (MRRS) for Fukushima Daiichi Nuclear Power Station

Toshiba has supplied Tokyo Electric Power Co., Inc. with the world's first multi-radionuclide removal system (MRRS)(*) to remove 62 types of radionuclides from the huge amount of contaminated water stored at the Fukushima Daiichi Nuclear Power Station.

The MRRS, which is undergoing hot testing for full operation, consists of three trains and has the capacity to treat 500 m^3 of water per day. This system is based on a conceptual design by the U.S. company EnergySolutions, and we took on the roles of detailed design, manufacturing, and installation. Trial operation of the system to treat contaminated water started in March 2013 and continued while reflecting improvements made during operation. The total amount of water treated reached 30 000 m^3 by the end of November 2013, with the concentrations of most radionuclides reduced to levels lower than the regulatory limits.

These results have demonstrated that the MRRS can make a significant contribution to reducing the risk posed by contaminated water. The system is expected to become fully operational soon. We are also planning to build a new MRRS to reduce secondary waste, which will start operation in 2014.

(*) As of March 2013 (as researched by Toshiba)


Resin vessel unit


MRRS at Fukushima Daiichi Nuclear Power Station

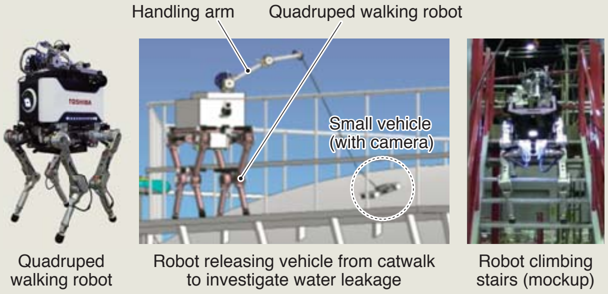
Quadruped Walking Robot to Investigate High Radiation Areas at Fukushima Daiichi Nuclear Power Station

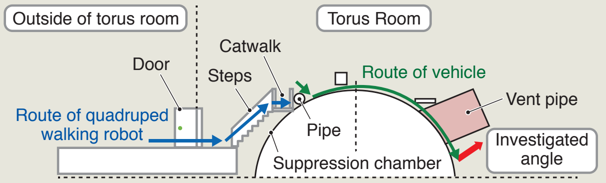
At the Fukushima Daiichi Nuclear Power Station, contaminated water leakage from primary containment vessels (PCVs) needs to be identified under a high radiation environment before the removal of debris can take place.

Toshiba investigated suspected leakages from eight vent pipes connected to the PCV of Unit 2 of the Fukushima Daiichi Nuclear Power Station using a sophisticated quadruped walking robot developed by our company. The remote-controlled robot climbed stairs and walked while avoiding obstacles in its path, carrying in its handling arm a vehicle that can pass through a 50 mm gap. The robot used its arm to place the vehicle on the suppression chamber and approached the vent pipes to investigate their condition.

The investigation of this high radiation area was successfully completed using the quadruped walking robot, and no water leakages were found to have occurred on or around the lower parts of the vent pipes.

We are continuing to operate the robot for restoration of the Fukushima Daiichi Nuclear Power Station, and plan to broaden its application to a wide variety of areas.





Routes of robot and vehicle for investigation

Investigation of water leakage points using quadruped walking robot

Contribution of Toshiba to JT-60SA Construction

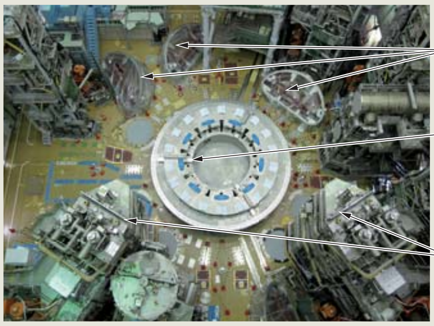
The Japan Atomic Energy Agency is building the JT-60SA Tokamak(*) device for plasma experiments in cooperation with the European Union.

As a part of this project, Toshiba has received an order to manufacture a torus type vacuum vessel to confine plasma and built a 360°-structured vessel divided into 10 sectors. The device is currently in the process of being assembled and the cryostat base, built in Spain as the first component of this device, was installed in March 2013. Using a laser tracker, the cryostat was installed at the center of the base, which is 11 m in diameter, with an accuracy of 2 mm.

The assembly of the vacuum vessel is now underway. An automatic welding robot that was developed exclusively for this project is being used to weld the vacuum vessel sector connections. The robot detects the status of welding grooves and the positions for welding by means of a sensor, and determines the welding conditions automatically.

At present, we are working on groove alignment of the sectors that will be welded first. Welding started in July 2014 and we plan to weld-connect the vacuum vessel to the 340° level in about one year.

(*) A type of fusion plasma confinement system



Assembly of cryostat base

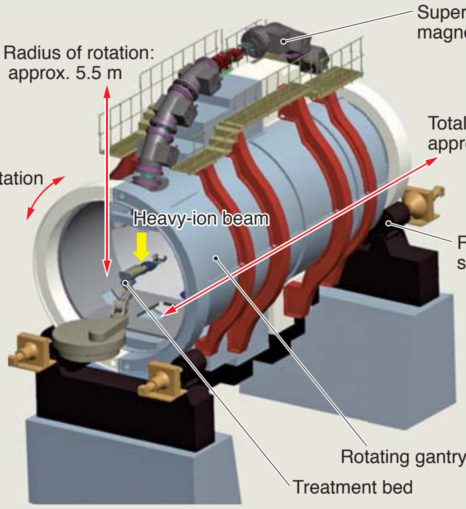
Correction of vacuum vessel welding grooves

Precise Control System for Superconducting Rotating Gantry Used in Heavy-Ion Radiotherapy

Toshiba has been awarded a contract by the National Institute of Radiological Sciences (NIRS) for a superconducting rotating gantry to be used in heavy-ion radiotherapy, and has developed a precise control system for this gantry.

The rotating gantry allows heavy-ion beams to irradiate a tumor from any direction. As a result, the radiation dose accumulated in normal tissues can be reduced in the process of implementing a treatment plan. In addition, patients can undergo the therapy more comfortably because they do not have to change their position during treatment. On the other hand, the rotating gantry, which incorporates superconducting technology, is a large device but requires highly precise rotation control such as position control accuracy (within ±0.2°) and generated acceleration (less than 1 G). These requirements are achieved by the use of a frictional drive system and fully closed loop feedback control.

The successful development of this control system represents a significant step toward the completion of the world's first superconducting rotating gantry at NIRS. We are now manufacturing the machine, and aim to win further contracts for the superconducting rotating gantry from heavy-ion radiotherapy centers in Japan and overseas.



Superconducting rotating gantry for heavy-ion radiotherapy at NIRS