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UK ABWR Generic Design Assessment

Generic PCSR Sub-chapter 16.4 : Other Auxiliary Systems

Hitachi-GE Nuclear Energy, Ltd.

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16.4.1 Fire Protection Systems

16.4.1.1 General Comments

The fire protection system is not the principle means of protecting the plant against the internal fire effect, but this system are installed as a defence-in depth measure.

16.4.1.2 Fire Detection and Alarm Systems

16.4.1.2.1 System Summary Description

This section is a general introduction to the fire detection and alarm systems where the system roles, system functions, system configuration are briefly describes.

16.4.1.2.2 System Roles

Fire detection and alarm systems serve to detect a fire and provide warning to occupants in the vicinity of a fire and the main control room (MCR). Detection and notification of a fire in an area containing important equipment that performs a safety function allow operators to take actions to mitigate the effects of fire.

The detection system is designed to continuously monitor the environment across locations as appropriate in the plant, early detection and alerting of a fire can ensure safe evacuation of personnel, suppression systems to operate, and other measures to operate, such as fire dampers to protect people and safety functions of UK ABWR.

16.4.1.2.3 Functions Delivered

The functions of the fire detection and alarm system are to detect a fire and send signals to the fire alarm main control panel. The detection system is analogue addressable, allowing the location of each detector operating to be identified at the fire alarm panel. This then leads the fire alarm sounders in the appropriate area and other fire protection measures including fixed suppression systems to be activated, as required.

The fire detection system provides audible and/or visual alarms and system trouble annunciation in the MCR.

16.4.1.2.4 Basic Configuration

The fire detection and alarm system consist of detectors and manual call point in appropriate detection zone, local fire alarm panels on each floor of the building, main fire alarm main control panel in main control room and local sounder.

16.4.1.2.5 Design Basis

Fire detector and alarm systems serve to detect a fire and provide warning to occupants in the vicinity of a fire and the MCR. [FPS_SFC_5-14.1] This safety function is a Category C function,

and the components necessary to deliver this function are classified as Class 3 safety components according to the safety categorization and classification of UK ABWR.

16.4.1.2.6 System Design

This section describes the design of the Fire Detection and Alarm Systems to support the safety functions described in section 16.4.1.2.5.

16.4.1.2.6.1 Overall Design and Operation

This system mainly consists of fire detector, local sounding system, fire alarm panel and cables. Signals from detectors are sent to the local alarm panel. The local alarm panel displays the location of fire as transmitting the signal to the fire alarm main control panel, and actuates main/local sounders. Also the local fire alarm panel actuates the operation of fixed fire suppression system. The fire alarm main control panel displays the location of fire occurrence.

16.4.1.2.6.2 Equipment Design

16.4.1.2.6.2.1 Fire alarm main control panel

(1) Alarm area map is displayed on the colour monitor.
(2) Alarm from interlocking fire door and damper is displayed on the colour monitor.
(3) Status of fixed suppression system is displayed on the colour monitor.
(4) Failure signal from detectors is displayed on the colour monitor.

The fire alarm main control panel is placed to maintain constant monitoring in the main control room.

16.4.1.2.6.2.2 Local fire alarm panel

Appropriate alarm area map is displayed on the monitor.

16.4.1.2.6.2.3 Manual call points

Manual call points have a function to send a fire signal by pushing buttons.

16.4.1.2.6.2.4 Local sounders

Local sounders sound with either a fire signal from the fire detector or from the manual call point.

16.4.1.2.6.2.5 Fire detectors

The type of detector at each location is chosen with regard to the particular fire phenomena applicable to the equipment or location being monitored (heat, flame, smoke, product of combustion, etc.) and to the specific conditions of its installation (accessibility, atmosphere: humidity, temperature, radiation, corrosive or explosive gases and pressure at the location).

16.4.1.2.6.3 Main Support Systems

The fire detection and alarm system is supplied from the commercial electrical supply system.

16.4.1.2.6.3.1 Instrumentation and Control Systems

Fire indication:
When fire signal is received from a fire detector or a manual call point, the indication lamps on the fire alarm main control panel and local fire control panel are turned on, and the detection zone of fire incidence is indicated.

The indication functions of fixed fire extinguishing system:
A signal indicating actuation of a fixed fire extinguishing system or a push button of the local control panels is sent to the fire alarm main control panel.

The indication functions of fire damper:
The fire alarm main control panel indicates the status of fire dampers.

16.4.1.3 Fire Fighting Water Supply System

16.4.1.3.1 System Summary Description

This section is a general introduction to the fire fighting water supply system where the system roles, system functions, system configuration are briefly described.

16.4.1.3.2 System Roles

The main role of the fire fighting water supply system is to minimize the damage caused by fire by providing a dedicated supply to the Fire Fighting system. The fire fighting water supply is to both provide the appropriate system pressure and water volume.

16.4.1.3.3 Functions Delivered

The fire fighting water supply system is designed to function in the case of a fire and provides supply of pressurised water to the fire fighting systems across the site for an extended period of time.

16.4.1.3.4 Basic Configuration

The fire fighting water supply system provides dedicated fire fighting water. Water for the system is stored in outdoor water tanks and fire pumps connect them to a looped fire mains. This allows water to be provided from two directions, which provides redundancy against failure in the looped fire mains.

16.4.1.3.5 Design Basis

The fire fighting water supply system provides the water to the fire fighting systems. [FPS_SFC_5-14.2] This safety function is a Category C function, and the components necessary to deliver this function are categorized as Class 3 safety components according to the safety categorization and classification of UK ABWR.

16.4.1.3.6 System Design

This section describes the design of the Fire Fighting Water Supply System to support the safety functions described in section 16.4.1.3.5.

16.4.1.3.6.1 Overall Design and Operation

The fire pumps, fire water and fire mains piping are dedicated to the fire water supply.
Fire water system consists of a fire main loop and it is supplied by dedicated pumps and connected to water tanks, as shown in Figure 16.4 -1.
Fire water for the main loop is supplied by four fire pumps with 50 percent flow capacity respectively.

Two fire water tanks for main loop have 100% capacity respectively. The capacity for water supply system is determined as maximum water consumption rate of most demanding fixed suppression system added to the manual suppression requirement.

16.4.1.3.6.2 Equipment Design

16.4.1.3.6.2.1 Water Distribution Network

(1) Configuration
The fire water distribution network consists of a fire main loop.
It supplies water to:
- Outdoor hydrant system and indoor wet hydrant system in reactor building
- Foam extinguishing system
- Fixed water spray systems in the buildings

Isolation valves are located throughout the fire mains.

(2) Performance
Water flow rate of fire pumps and capacity of fire water tanks are determined by maximum water consumption of the most demanding fixed extinguishing system plus the manual suppression requirement.

16.4.1.3.6.2.2 Fire Pump

(1) Configuration
One fire pump can supply 50 percent of the requirement of water for the most demanding fixed suppression system and the hydrant requirements.
A pair of electrically driven fire pumps is provided as the primary pumps and a pair of secondary diesel driven pumps provides diversity. Fire pump discharge header piping is pressurized by one jockey pump to maintain appropriate pressure.

(2) Performance
Water head pressure is determined by required pressure at the farthest nozzle of the most demanding extinguishing system.

16.4.1.3.6.2.3 Fire Water Tank

(1) Configuration
The fire water tanks are filled through a connection from the towns water. The capacity of fire water is dedicated to supply water to the fire fighting systems.

(2) Performance
The fire water tanks capacities are determined based on the flow requirements of the most demanding fixed extinguishing system plus the manual suppression requirements.

16.4.1.3.6.3 Main Support Systems

The major support systems related to the delivery of the fire fighting water supply system safety functions are briefly described as follows.

(1) Control
In normal operating condition of power station, a jockey pump maintains the required pressure, and fire pumps are in standby condition. The fire pumps can be started either automatically by detecting low pressure in fire pump discharge header piping, or manually in the MCR or by the local pump control panel.

If the fire pump cannot operate due to loss of power or other possible failures, the secondary fire pump automatically starts.

(2) Interlock

To prevent cavitations occurring in the jockey pump and fire pumps due to the lowering of water level in fire protection water tanks, water level in the tanks is monitored and a low level causes each fire pump to trip.

(3) Power source

The primary pumps on the fire main loop are a pair of motor driven pumps. And the secondary pumps are a pair of diesel driven pumps.

Measurement

The following items are measured and monitored in the fire water supply system:

(a) Water level at fire water tank
(b) Water pressure of water supply (fire pump discharge header pressure)

(4) Alarm

In order to maintain this system's functions, following alarms are provided.

(a) High level of fire water tank (before overflowing)
(b) Low level of fire water tank (before pump trips)
(c) Low pressure of water supply header piping
(d) Fire pump operation
(e) Fire pump failure
(f) Fire detection in fire pump house.

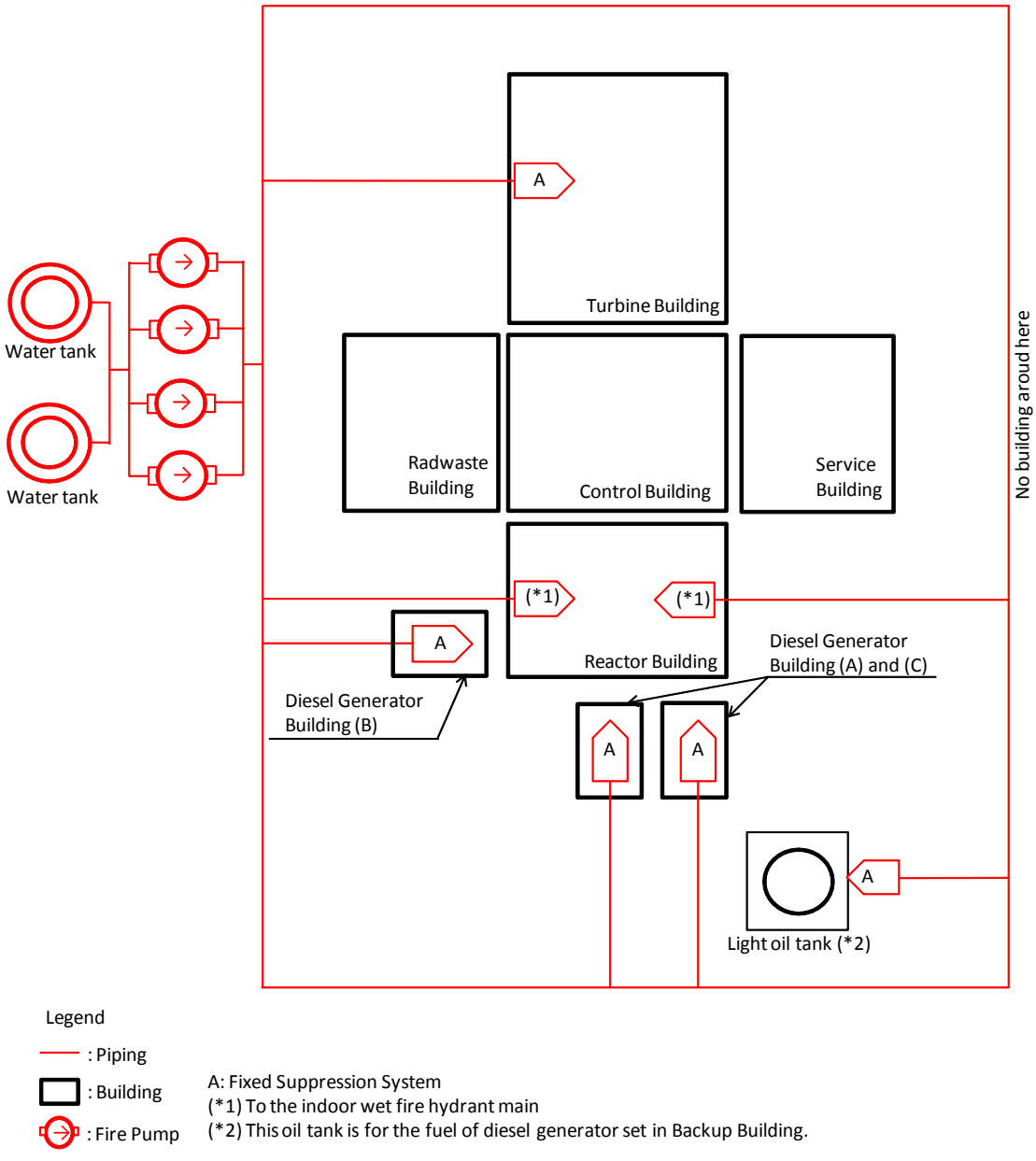

Figure 16.4-1 : Outline of the Fire Fighting Water Supply System

16.4.1.4 Fixed Fire Suppression Systems

16.4.1.4.1 System Summary Description

This section is a general introduction to the fixed fire suppression systems where the system roles, system functions and system configuration are briefly described.

16.4.1.4.2 System Roles

The main role of the fixed fire suppression systems is to operate in the case of a fire to limit its growth and spread following ignition.

16.4.1.4.3 Functions Delivered

The fixed fire suppression systems are designed to function in the case of a fire and provide fire suppression in areas of high fire risk.

16.4.1.4.4 Basic Configuration

Fixed suppression systems are provided in areas of high fire risk, and are supplied water from fire fighting water supply system.

16.4.1.4.5 Design Basis

The fixed fire suppression systems limit fire growth and spread following ignition. [FPS_SFC_5-14.3] This safety function is a Category C function, and the components necessary to deliver this function are categorised as Class 3 safety components according to the safety categorisation and classification of UK ABWR.

16.4.1.4.6 System Design

This section describes the design of the fixed fire fighting system to support the safety functions described in section 16.4.1.4.5.

16.4.1.4.6.1 Overall Design and Operation

Water spray extinguishing systems and foam extinguishing systems are designed to extinguish fires in areas of where there is the potential for oil fire.

Each fixed fire suppression system has a separate direct connection to the fire main loop.
Fixed fire suppression system actuation decreases the pressure in the fire fighting water supply system and causes the fire pumps to operate.

16.4.1.4.6.2 Equipment Design

For all pipe work associated with the fixed fire fighting systems, isolating valves are installed to enable individual systems to be isolated and repairs to be carried out. Each of the fixed fire fighting systems has a fire main connecting it to the water supply distribution network. The fixed fire suppression systems are made up of the following:

16.4.1.4.6.2.1 Water Spray Extinguishing System

(1) Configuration
Water spray systems are designed to extinguish fires in areas of where there is the potential for oil fire. The piping network contains water spray nozzles open to atmosphere. The water is held back by deluge valves. The deluge valves are opened by two different types' detectors (such as heat and smoke) allowing water to flow into the piping network. The deluge valves can also be operated manually.

(2) Performance
The system is designed to suppress oil pool fires and calculated based on a nominal application rate and duration based on appropriate standard.

16.4.1.4.6.2.2 Foam Extinguishing System

(1) Configuration
The foam extinguishing systems are designed to extinguish fires in areas of where there is the potential for oil fire. The piping network is connected to the foam concentrate tank. The foam extinguishing system is also designed for the bunded area to put out the fire may cause from leaked oil.

(2) Performance
The system is designed to suppress oil pool fires and calculated based on a nominal application rate and duration based on appropriate standard.

16.4.1.4.6.3 Main Support Systems

16.4.1.4.6.3.1 Water Spray Extinguishing System

Water spray systems are supplied water from fire fighting water supply system, and fire detectors are provided to detect fire that may occur in protected rooms. Fire detectors are connected to the local control panel of water spray system in order to activate the system operation automatically.

16.4.1.4.6.3.2 Foam Extinguishing System

The foam extinguishing system is supplied with water from fire fighting water supply system, and fire detectors are provided to detect fire may that occur in protected rooms. The power source is supplied from normal power supply system.

16.4.1.5 Fire Brigade Equipment

16.4.1.5.1 System Summary Description

This section is a general introduction to the fire brigade equipment where the system roles, system functions, system configuration are briefly described.

16.4.1.5.2 System Roles

The main role of the fire brigade equipment is to provide the fire brigade with the necessary equipment to manage a fire in order to limit its growth and spread following ignition.

16.4.1.5.3 Functions Delivered

The fire brigade equipment is designed to be available in case of a fire and provides:
(1) Access to outdoor hydrants on site;
(2) Indoor piping network and outlets with hoses for fire water to reach any room

16.4.1.5.4 Basic Configuration

The fire brigade equipment consists of fire mains (internal and external), fire hydrants (internal and external).

16.4.1.5.5 Design Basis

The fire brigade equipment limit fire growth and spread following ignition. [FPS_SFC_5-14.4]This safety function is a Category C function, and the components necessary to deliver this function are categorized as Class 3 safety components according to the safety categorisation and classification of UK ABWR.

16.4.1.5.6 System Design

This section describes the design of the fire brigade equipment to support the safety functions described in section 16.4.1.5.5.

16.4.1.5.6.1 Overall Design and Operation

Primary suppression coverage for inside of buildings is provided by dry fire mains to which water is supplied from connections on outside building wall and hydrants except in the secondary containment area of reactor building where wet fire main loop and hydrants are provided.

The suppression coverage of the outside of buildings and their surroundings is provided by outdoor fire hydrants.
Both inside and outside fire hydrants can be used by the fire brigade.

16.4.1.5.6.2 Equipment Design

16.4.1.5.6.2.1 Outdoor Fire Hydrants

(1) Configuration and operation
Fire hydrants are placed adequately in order for the fire brigade to attempt to suppress fires. Water is supplied by external fire mains.
(2) Performance design
A fire hydrant outlet is capable of providing a minimum of 750 L/min.

16.4.1.5.6.2.2 Indoor Fire Mains and Hydrants

(1) Configuration and operation
The dry indoor fire mains and hydrants are placed in all fire fighting shafts and other locations in order to suppress fire may occur inside of buildings except in the secondary containment of reactor building where wet indoor fire main loop and hydrants are provided.
(2) Performance Design
A fire hydrant outlet is capable of providing a minimum of 750 L/min.

16.4.1.5.6.2.3 Main Support Systems

Water for the indoor fire mains are designed to be supplied from the outdoor fire mains. The indoor fire mains of other than secondary containment of reactor building are connected to the outdoor fire mains indirectly.

16.4.1.6 Smoke Control Systems

16.4.1.6.1 System Summary Description

This section is a general introduction to the smoke control system where the roles, functions, configuration and modes of operation are briefly described.

16.4.1.6.2 System Roles

The roles of the smoke control systems as described in the fire strategy report are as follows:
(1) Protect personnel and SSCs
(2) Prevent the spread of smoke when a fire has initiated in one plant room
(3) Remove smoke from a plant room through ventilation
(4) Ensure basement areas are sufficiently ventilated and any smoke can be vented out
(5) Prevent spread of airborne radiological contamination
(6) Allows occupants to escape
(7) Allows manual fire fighting and rescue activities to take place
There is also a requirement for emergency stairways to be isolated from smoke and ventilated, to provide personnel a safe means to escape.

16.4.1.6.3 Functions Delivered

The smoke control system provides two functions: smoke extraction and overpressure.

For the non-controlled areas in the safety divisions, smoke extraction is required to extract smoke from one of the fire sectors, which is already isolated from the ventilation system by fire dampers. In controlled areas, such as reactor building, turbine building, on the basis that main functional requirement of ventilation systems serving radiation controlled areas within UK is to provide containment, smoke extraction serving the controlled areas is not provided. [Ref-4]

A pressure differential system is used to minimise the spread of smoke in the staircase during means of egress and firefighting operation.

16.4.1.6.4 Basic Configuration

Every fire safety sector emergency stairway in non-controlled areas has blower fans to form an overpressure and keep smoke in a fire-affected area.

Extractor fan circuits with vents are provided for all non-controlled areas.

Every fire barrier with ventilation across it has fire dampers to prevent the spread of smoke.

16.4.1.6.5 Safety Design Basis

The smoke control system is designed to meet the following safety function claim (SFC). The relation between the SFC put on this system and the high level claims is shown in Appendix-1.

The smoke control system contributes fire containment by controlling the spread of smoke, enabling a rapid response to a fire. [FPS_SFC_5-14.5] Plant rooms are compartmentalised to prevent spread

of fire and smoke, and this is further mitigated by the use of smoke dampers as fire barriers. Several plant rooms are connected together via a common smoke extraction duct equipped with smoke dampers.

Excluding the smoke control across the controlled areas in the safety divisions, which have radiological containment significance, there are no nuclear safety claims on the smoke control system.
This safety function is a Category C function, and the components necessary to deliver this function are categorized as Class 3 safety components according to the safety categorization and classification of UK ABWR.

16.4.1.6.6 System Design Description

16.4.1.6.6.1 Overall Design and Operation

All of the safety division train has connections to the smoke ducts that vent the smoke out in the event of a fire. Overpressure is provided through blower fans in the emergency stairways and exits. The HVAC system is also available to purge cold smoke from logged and non-radiological areas after fires have been extinguished as described in the fire strategy report.

Fire fighting shafts are also provided with smoke control to assist in fire brigade operations, by preventing them becoming completely smoke logged. However, the smoke control design has to take into account the need for radiological containment, the degree of internal separation in the buildings, the configuration of all elements of the SSCs and the interaction of the systems.

Generally, smoke extract systems are designed in accordance with BS EN 12101.

16.4.1.6.6.1.1 System Operation Conditions

Fire dampers automatically close upon alarms received by the main control panel.

16.4.1.6.6.1.2 Design Features of the Smoke Control System

Each division of the non-controlled safety division train, and each stairway and protected exit in the Power Block has smoke control provided by an independent sub-system. Each smoke extraction circuit is made up of:

- One or more smoke extraction dampers valves,
- One extractor fan per circuit, whose capacity is regulated according to the under-pressure achieved in the sector from which the smokes have been extracted.

The fire zones involved in fume extraction in the non-controlled areas of the safety divisions are:

- The instrumentation and control cabinet rooms.
- The switchboards rooms.
- The Main Control Room.

All these stairways and protected emergency exits are used to evacuate staff and to give access for the fire brigade. They are remained smoke-free.

The smoke control system and corresponding sub-systems are on permanent load if a fire starts in a fire sector in the Power Block buildings.

If the affected sector is involved in smoke extraction (non-controlled area of the safety divisions), additional measures are required.

- Fire in a fire sector with smoke extraction (safety divisions electrical rooms)

When the fire detection system gives the alarm in the Main Control Room, the fire dampers in the normal ventilation of the sector involved are closed automatically.

The smoke extraction dampers flaps in the affected sector open automatically. The extractor fan in the sector is started manually from the Main Control Room or locally, after the existence of a fire has been established together with confirmation that all staff in the sector has been evacuated.
The stairways are over-pressurised, by starting the fan. This enables the fire sector to be approached or to be evacuated.

- Fire in a fire sector without fume extraction

The fire detection system triggers the alarm in the Main Control Room. The fire dampers in the normal ventilation system of the sector involved are closed automatically.

16.4.1.6.6.2 Equipment Design

The smoke control system is designed as part of the HVAC systems, for the dual purpose of HVAC requirements and fire protection. The major plant features of the equipment design are:

- Venting of fire areas to prevent undue build up of pressure due to a fire.
- Pressure control across the fire barriers to assure that any leakage is into the fire area experiencing the fire.
- Pressure control and purge air supply to prevent back-flow of smoke and hot gases when fire barrier doors are maintained open for access for manual fire suppression activities.
- Augmented and directed clean air supply to provide a clean air path to the fire for fire suppression personnel.
- Smoke control by fans and systems external to the fire area experiencing the fire.
- Removal of smoke and heat from the fire by exhaust fans and operating supply fans to provide clean, cool air.
- Manually reset position of fire dampers in the smoke removal path.

16.4.1.6.6.3 Main Support Systems

16.4.1.6.6.3.1 Instrumentation and Control Systems

The instrumentation and control processing is located in the same electrical division as the actuators being controlled.

16.4.2 Emergency Power Supply System

16.4.2.1 Emergency Diesel Generator

16.4.2.1.1 System Summary Description

This section is a general introduction to the Emergency Diesel Generator (EDG) where the system roles, system functions, system configuration and modes of operation are briefly described. [Ref-1]

16.4.2.1.1.1 System Roles

The role of the EDGs is to supply power needed to shut down the reactor safely when the off-site power is lost, and to supply power to the electrical systems supporting the delivery of safety functions when a Loss of Coolant Accident (LOCA) should occur simultaneously.

16.4.2.1.1.2 Functions Delivered

The EDGs are designed to perform the following main function:

(1) The EDGs supply power to loads necessary to safety shut down the reactor in the event of Loss of Off-site Power (LOOP) and Loss of Coolant Accident (LOCA) associated with LOOP.

16.4.2.1.1.3 Basic Configuration

The EDGs consist of three independent divisions, A, B, and C. Each division consists of the following main components.

(1) Engine
(2) Generator
(3) DG Fuel Oil System
(4) DG Cooling Water System
(5) DG Lubricant Oil System
(6) DG Compressed Air System
(7) DG Air Intake and Exhaust Gas System

16.4.2.1.1.4 Modes of Operation

Modes of operation of the EDGs are summarised as follows.

16.4.2.1.1.4.1 Emergency operating mode

The EDGs supply power to loads necessary to safety shut down the reactor in the event of Loss of Off-site Power (LOOP) and Loss of Coolant Accident (LOCA) associated with LOOP.

16.4.2.1.1.4.2 Stand-by mode

During stand-by mode, it can be started-up immediately by start-up signal at any time. To achieve this, the engine is pre-lubricated and pre-heated by DG Lubricant Oil System, DG Cooling Water System.

16.4.2.1.2 Design Bases

This section describes the design basis for the EDGs.

16.4.2.1.2.1 Safety Functions

The EDGs have been designed to meet the following Safety Functional Claims (SFC).

(1) The EDGs supply power to loads necessary to secure functions of engineering safety facilities and necessary to safety shut down the reactor in the event of LOOP and LOCA associated with LOOP. This function is categorized as Category A and the components to deliver it are designed to meet Class 1 requirements. [EPS_SFC_5-2.1]
The kind of main loads connected to each of EDGs are described in Generic PCSR Chapter 15.4 “Electrical Equipment and systems” (GA91-9101-0101-15004).

16.4.2.1.3 System Design Description

This section describes the design of the EDGs to support and justify the delivery of EPS_SFC_5-2.1. [Ref-1]

16.4.2.1.3.1 System Design and Operation

The EDGs are composed of three electrical and mechanical independent divisions designated A, B and C. Each division contains the necessary equipment.

16.4.2.1.3.2 Equipment Design and Operation

16.4.2.1.3.2.1 Engine

(1) Purpose
The engine supplies drive power to the generator.

(2) Configuration and Operation
EDGs are provided with an exhaust turbocharged engine. The engine is designed to be started by compressed air automatically. The engine is able to be started up and shut down by remote manual operation from the main control panel or local control panel [EPS_SFC_5-2.1].

(3) Performance
The engine is designed to be able to continuously operate at rated power under the specified operating condition. The rate of engine speed variance is lower than specified value [EPS_SFC_5-2.1].

16.4.2.1.3.2.2 DG Fuel Oil System

(1) Purpose
The DG Fuel Oil System (DGFO) is intended to supply fuel oil to the engine for generate the electrical power.

(2) Configuration and Operation
Each engine is supplied with fuel oil from the independent DGFO. The DGFO consists of tanks, pumps, piping and valves. The fuel oil day tank, which holds enough fuel for eight hours of engine operation, will be installed in each DGFO. Fuel oil will be filled to the fuel oil day tank from the light oil tank when it is detected that the fuel oil level falls below the specified height [EPS_SFC_5-2.1].

(3) Performance
The storage capacity of DGFO is sufficient for operation each engine for seven days at rated power [EPS_SFC_5-2.1].

16.4.2.1.3.2.3 DG Cooling Water System

(1) Purpose
The DG Cooling Water System (DGCW) is configured to perform cooling and warming around the diesel engine cylinder for shortens the start-up time and efficient operation of the EDGs.

(2) Configuration and Operation
Each engine is supplied cooling water from the independent DGCW. The DGCW consists of tanks, pumps, heat exchanger, piping and valves. The water consumption of the DGCW is supplied automatically from the Makeup Water Purified System (MUWP). The DGCW is cooled by Reactor Building Cooling Water System (RCW) [EPS_SFC_5-2.1].

(3) Performance
The cooling capacity of the DGCW is sufficient for operation at rated power. In order to facilitate the rapid starting of the engine, the engine should be pre-heated [EPS SFC 5-2.1].

16.4.2.1.3.2.4 DG Lubricant Oil System

(1) Purpose
The DG Lubricant Oil System (DGLO) lubricates the part requiring lubrication and cooling such as main bearing of diesel engine and pre-lubricates and warm up the system to shorten the start-up time of the EDGs.

(2) Configuration and Operation
Each engine is supplied with lubricant oil from the independent DGLO. The DGLO consists of tanks, pumps, heat exchanger, piping and valves [EPS_SFC_5-2.1].

(3) Performance
The lubricating capacity of the DGLO is sufficient for continuous operation at rated power. In order to facilitate the rapid starting of the engine, the engine should be pre-heated and pre-lubricated [EPS_SFC_5-2.1].

16.4.2.1.3.2.5 DG Compressed Air System

(1) Purpose
The DG Compressed Air System (DGCA) is intended to store the compressed air required to start-up the engine.

(2) Configuration and Operation
The DGCA provides a supply of compressed air for starting the engine without external power. The DGCA consists of starting air receiver, air compressor, piping and valves. The DGCA has two lines from starting air receiver to engine [EPS_SFC_5-2.1].

(3) Performance
Each compressed air system has enough air storage capacity for 5 times starts. The EDGs shall be able to achieve the prescribed values of frequency within specified times until specified number of times engine starts. The capacity of air compressor is sufficient to recharge the storage of air receiver within specified times [EPS_SFC_5-2.1].

16.4.2.1.3.2.6 DG Air Intake and Exhaust Gas System

(1) Purpose
The DG Air Intake and Exhaust Gas System (DGAE) intake the combustion air from outside of EDG Building (EDG/B) and exhausts the combustion gas to outside.

(2) Configuration and Operation
Each engine is supplied with combustion air, and discharge exhaust gas by the independent DGAE. The DGAE consists of an expansion joint, an exhaust silencer, piping and valves. The exhaust gas drives turbocharger to increase amount of intake air [EPS_SFC_5-2.1].

(3) Performance
The air intake is from the piping through the outside of EDG/B, and exhaust gases are released atmosphere via exhaust silencer on the EDG/B roof [EPS_SFC_5-2.1].

16.4.2.1.3.2.7 Generator

(1) Purpose
Generator generates electricity is needed to safely shut down reactor in the event of LOOP and LOCA associated with LOOP.

(2) Configuration and Operation
The generator is a synchronous generator and direct coupled with engine [EPS_SFC_5-2.1].

(3) Performance
The generator shall be able to continuously operate with rated load. The capacity of generator is sufficient to supply power to necessary load (such as a load for fuel cooling) in the event LOOP or LOCA associated with LOOP.
Rate of generator voltage variance is lower than specified value [EPS_SFC_5-2.1].

16.4.2.1.3.3 Main Support Systems

The main systems supporting SSCs for the delivery of the safety functions are briefly described as follows.

16.4.2.1.3.3.1 Reactor Building Cooling Water System (RCW)

The RCW supplies cooling water to the Heat Exchangers of EDGs. In these heat exchangers, the heat of DGCW is removed. The EDGs are connected to independent and separated RCW divisions.

16.4.2.1.3.3.2 Makeup Water Purified System (MUWP)

The MUWP supplies cooling water to the cooling water expansion tank of DGCW. The liquid level of tank is monitored and cooling water is automatically supplied by MUWP when the liquid level is lower than specified value.

16.4.2.2 Back-up Building Generator

16.4.2.2.1 System Summary Description

This section is a general introduction to Back-up Building Generator (BBG) where the system roles, system functions, system configuration and modes of operation are briefly described. [Ref-1]

16.4.2.2.1.1 System Roles

The role of the BBGs is to supply power to diverse provisions which is necessary for reactor safety in the event of Loss of Off-site Power (LOOP) and LOCA associated with LOOP.
The BBGs have also role as the source of electricity at the situation of severe accident.

16.4.2.2.1.2 Functions Delivered

The BBGs are designed to perform the following main functions:
(1) The BBGs supply power to diverse provisions which is necessary for reactor safety in the event of Loss of Off-site Power (LOOP) and Loss of Coolant Accident (LOCA) associated with LOOP.
(2) The BBGs become power supply equipment in the event of severe accidents.

16.4.2.2.1.3 Basic Configuration

The BBGs consist of two independent divisions, system 1 and system 2. Each division consists of the following main components.
(1) Engine
(2) Generator
(3) BBG Fuel Oil System
(4) BBG Cooling Water System
(5) BBG Lubricant Oil System
(6) BBG Compressed Air System
(7) BBG Air Intake and Exhaust Gas System

16.4.2.2.1.4 Modes of Operation

Modes of operation of the BBGs are summarised as follows.

16.4.2.2.1.4.1 Emergency operating mode

The BBGs supply power to diverse provisions which is necessary for reactor safety in the event of Loss of Off-site Power (LOOP) and Loss of Coolant Accident (LOCA) associated with LOOP.

16.4.2.2.1.4.2 Stand-by mode

During stand-by mode, it can be started up immediately by start up signal at any time. To achieve this, the engine is pre-lubricated and pre-heated by BBG Lubricant System and BBG Cooling Water System.

16.4.2.2.2 Design Bases

This section describes the design basis for the BBGs.

16.4.2.2.2.1 Safety Functions

The BBGs have been designed to meet the following SFC.

(1) The BBGs supply power to diverse provisions which is necessary for reactor safety in the event of a LOOP and a LOCA associated with a LOOP. This function is categorized as Category A and the components to deliver it are designed to meet Class 2 requirements. [EPS_SFC_5-3.1]
The kind of main loads connected to each of BBGs are described in Generic PCSR Chapter 15.4 "Electrical Equipment and systems" (GA91-9101-0101-15004).

(2) The BBGs supply power in the event of severe accidents. This function is categorized as Category B and the components to deliver it are designed to meet Class 2 requirements. [EPS_SFC_5-3.2]

16.4.2.2.3 System Design Description

This section describes the design of the BBGs to support and justify the delivery of EPS_SFC_5-3.1 and EPS_SFC_5-3.2. [Ref-1]

16.4.2.2.3.1 System Design and Operation

The BBGs are composed of two electrical and mechanical independent divisions designated system 1 and system 2. Each division contains the necessary equipment.

16.4.2.2.3.2 Equipment Design and Operation

16.4.2.2.3.2.1 Engine

(1) Purpose
The engine supplies drive power to the generator.

(2) Configuration and Operation
BBGs are provided with an exhaust turbocharged engine. The engine is designed to be started by compressed air automatically. The engine is able to be started up and shut down by remote manual operation from the main control panel or local control panel [EPS_SFC_5-3.1 and EPS_SFC_5-3.2].

(3) Performance
The engine is designed to be able to continuously operate at rated power under the specified operating condition. The rate of engine speed variance is lower than specified value [EPS_SFC_5-3.1 and EPS_SFC_5-3.2].

16.4.2.2.3.2.2 BBG Fuel Oil System

(1) Purpose
The BBG Fuel Oil System (BBGFO) is intended to supply fuel oil to the engine for generating the electrical power.

(2) Configuration and Operation
Each engine is supplied with fuel oil from the BBGFO. The BBGFO consists of tanks, pumps, piping and valves. The fuel oil day tank, which holds enough fuel for eight hours of engine operation, will be installed in each BBGFO. Fuel oil will be filled to the fuel oil day tank from the light oil tank when it is detected that the fuel oil level falls below the specified height [EPS_SFC_5-3.1 and EPS_SFC_5-3.2].

(3) Performance
The storage capacity of BBGFO is sufficient for operation one engine for seven days at rated power [EPS_SFC_5-3.1 and EPS_SFC_5-3.2].

16.4.2.2.3.2.3 BBG Cooling Water System

(1) Purpose
The BBG Cooling Water System (BBGCW) is configured to perform cooling and warming around the diesel engine cylinder for shortening the start-up time and efficient operation of the BBGs.

(2) Configuration and Operation
Each engine is supplied with cooling water from the independent BBGCW. The BBGCW consists of tanks, pumps, heat exchanger, piping and valves. The BBGCW is cooled by Emergency Equipment Cooling Water System (EECW) [EPS_SFC_5-3.1 and EPS_SFC_5-3.2].

(3) Performance
The cooling capacity of the BBGCW is sufficient for continuous operation at rated power. In order to facilitate the rapid starting of the engine, the engine should be pre-heated [EPS_SFC_5-3.1 and EPS_SFC_5-3.2].

16.4.2.2.3.2.4 BBG Lubricant Oil System

(1) Purpose
The BBG Lubricant Oil System (BBGLO) lubricates the part requiring lubrication and cooling such as main bearing of diesel engine and pre-lubricates and warm up the system to shorten the start-up time of the BBGs.

(2) Configuration and Operation
Each engine is supplied with lubricant oil from the independent BBGLO. The BBGLO consists of tanks, pumps, heat exchanger, piping and valves [EPS_SFC_5-3.1 and EPS_SFC_5-3.2].

(3) Performance
The lubricating capacity of the BBGLO is sufficient for continuous operation at rated power. In order to facilitate the rapid starting of the engine, the engine should be pre-heated and pre-lubricated [EPS_SFC_5-3.1 and EPS_SFC_5-3.2].

16.4.2.2.3.2.5 BBG Compressed Air System

(1) Purpose
The BBG Compressed Air System (BBGCA) is intended to store the compressed air required to start up the engine.

(2) Configuration and Operation
The BBGCA provides a supply of compressed air for starting the engine without external power. The BBGCA consists of starting air receiver, air compressor, piping and valves. The BBGCA has two lines from starting air receiver to engine [EPS_SFC_5.3-1 and EPS_SFC_5.3-2].

(3) Performance
Each compressed air system has enough air storage capacity for 5 times starts. The BBGs shall be able to achieve the prescribed values of frequency within specified times until specified number of times engine starts. The capacity of air compressor is sufficient to recharge the storage of air receiver within specified times [EPS_SFC_5.3-1 and EPS_SFC_5.3-2].

16.4.2.2.3.2.6 BBG Air Intake and Exhaust Gas System

(1) Purpose
The BBG Air Intake and Exhaust Gas System (BBGAE) intake the combustion air from outside of the Backup Building (B/B) and exhausts the combustion gas to outside.

(2) Configuration and Operation
Each engine is supplied with combustion air, and discharges exhaust gas by the independent BBGAE. The BBGAE consists of an expansion joint, an exhaust silencer, piping and valves. The exhaust gas drives turbocharger to increase amount of intake air [EPS_SFC_5-3.1 and EPS_SFC5-3.2].

(3) Performance
The air intake is from the piping through the outside of the B/B, and exhaust gases are released atmosphere via exhaust silencer on the B/B roof [EPS_SFC_5-3.1 and EPS_SFC_5-3.2].

16.4.2.2.3.2.7 Generator

(1) Purpose
Generator generates electricity needed to safely shut down reactor in the event of LOOP and LOCA associated with LOOP.

(2) Configuration and Operation
The generator is a synchronous generator and direct coupled with engine [EPS_SFC_5-3.1 and EPS_SFC_5.3-2].

(3) Performance
The generator shall be able to continuously operate with rated load. The capacity of generator is sufficient to supply power to necessary load (such as a load for fuel cooling) in the event LOOP or LOCA associated with LOOP.
Rate of generator voltage variance is lower than specified value [EPS_SFC_5-3.1 and EPS_SFC_5-3.2].

16.4.2.2.3.3 Main Support Systems

The main systems supporting SSCs for the delivery of the safety functions are briefly described as follows.

16.4.2.2.3.3.1 Emergency Equipment Cooling Water System (EECW)

The EECW supplies water to the Heat Exchanger of BBG. In these Heat Exchangers, the heat of BBGCW is removed.The BBG is connected to independent and separated EECW divisions.

16.4.2.3 Diverse Additional Generator

16.4.2.3.1 System Summary Description

This section is a general introduction to the Diverse Additional generator (DAG) where the system roles, system functions, system configuration and modes of operation are briefly described. [Ref-1]

16.4.2.3.1.1 System Roles

The role of the DAG is to supply power needed to shut down the reactor safely when the off-site power is lost, and to supply power to the electrical systems supporting the delivery of safety functions when a Loss of Coolant Accident (LOCA) should occur simultaneously and EDGs CCF (Common Cause Failure).

16.4.2.3.1.2 Functions Delivered

The DAG is designed to perform the following main functions:
The DAG supplies power to loads necessary to safely shut down the reactor in the event of Loss of Off-site Power (LOOP) and Loss of Coolant Accident (LOCA) associated with LOOP.

16.4.2.3.1.3 Basic Configuration

The DAG consists of the following main components.
(1) Motor
(2) Generator
(3) DAG Fuel Oil System
(4) DAG Lubricant Oil System
(5) DAG Air Intake and Exhaust Gas System

16.4.2.3.1.4 Modes of Operation

Modes of operation of the DAG are summarised as follows.

16.4.2.3.1.4.1 Emergency operating mode

The DAG supplies power to loads necessary to safety shut down the reactor in the event of Loss of Off-site Power (LOOP), Loss of Coolant Accident (LOCA) associated with LOOP and when EDG does not function.

16.4.2.3.1.4.2 Stand-by mode

During stand-by mode, it can be started-up by start-up signal at any time. To achieve this, the motor is pre-lubricated by DAG Lubricant Oil System.

16.4.2.3.2 Design Bases

This section describes the design basis for the DAG.

16.4.2.3.2.1 Safety Functions

The DAG has been designed to meet the following SFC.
The DAG supplies power to loads necessary to secure functions of engineering safety facilities and necessary to safely shut down the reactor in the event of LOOP, LOCA associated with LOOP and when EDG does not function. This function is categorized as Category C and the components to deliver it are designed to meet Class 3 requirements. [EPS_SFC_5-3.3]

16.4.2.3.3 System Design Description

This section describes the design of the DAG to support and justify the delivery of EPS_SFC_5-3.3. [Ref-1]

16.4.2.3.3.1 System Design and Operation

The DAG contains the necessary equipment as follows.

16.4.2.3.3.2 Equipment Design and Operation

16.4.2.3.3.2.1 Motor

(1) Purpose
The motor supplies drive power to the generator.

(2) Configuration and Operation
The DAG is provided with a different device from EDG and BBG. The motor is designed to be started by an electrical signal automatically. The engine is able to be started up and shut down by remote manual operation from the main control panel or local control panel [EPS_SFC_5-3.3].

(3) Performance
The motor is designed to be able to continuously operate at rated power under the specified operating condition. The rate of engine speed variance is lower than specified value [EPS_SFC_5-3.3].

16.4.2.3.3.2.2 DAG Fuel Oil System

(1) Purpose
The DAG Fuel Oil System (DAGFO) is intended to supply fuel oil to the motor for generating the electrical power.

(2) Configuration and Operation
The motor is supplied with fuel oil from the DAGFO. The DAGFO consists of tanks, pumps, piping and valves. The fuel oil day tank, which holds enough fuel for eight hours of engine operation, will be installed in each DAGFO. Fuel oil will be filled to the fuel oil day tank from the light oil tank when it is detected that the fuel oil level falls below the specified height [EPS_SFC_5-3.3].

(3) Performance
The storage capacity of DAGFO is sufficient for operation engine for seven days at rated power [EPS_SFC_5-3.3].

16.4.2.3.3.2.3 DAG Lubricant Oil System

(1) Purpose
The DAG Lubricant Oil System (DAGLO) lubricates the part requiring lubrication and cooling such as main bearing of motor and pre-lubricates and warm-up the system to shorten the start-up time of the DAG.

(2) Configuration and Operation
The engine is supplied with lubricant oil from the DAGLO. The DAGLO consists of tanks, pumps, heat exchanger, piping and valves [EPS_SFC_5-3.3].

(3) Performance
The lubricating capacity of the DAGLO is sufficient for continuous operation at rated power. In order to facilitate the rapid starting of the engine, the engine should be pre-heated and pre-lubricated [EPS_SFC_5-3.3].

16.4.2.3.3.2.4 DAG Air Intake and Exhaust Gas System

(1) Purpose
The DAG Air Intake and Exhaust Gas System (DAGAE) intakes the combustion air from outside of DAG Building (DAG/B) and exhausts the combustion gas to outside.

(2) Configuration and Operation
The motor is supplied with combustion air, and discharge exhaust gas by the DAGAE. The DAGAE consists of an expansion joint, an exhaust silencer, piping and valves[EPS_SFC_5-3.3].

(3) Performance
The air intake is from the piping through the outside of DAG/B, and exhaust gases are released atmosphere via exhaust silencer on the DAG/B roof [EPS_SFC_5-3.3].

16.4.2.3.3.2.5 Generator

(1) Purpose
Generator generates electricity needed to safely shut down reactor in the event of LOOP, LOCA associated with LOOP and when EDG does not function.

(2) Configuration and Operation
The generator is a synchronous generator and direct coupled with engine [EPS_SFC_5-3.3].

(3) Performance
The generator shall be able to continuously operate with rated load. The capacity of generator is sufficient to supply power to necessary load (such as a load for fuel cooling) in the event LOOP or LOCA associated with LOOP.
Rate of generator voltage variance is lower than specified value [EPS_SFC_5-3.3].

16.4.3 Suppression Pool Cleanup System

16.4.3.1 System Summary Description

This section is a general introduction to the Suppression Pool Clean-up System (SPCU) where the system roles, system functions, system configuration and modes of operation are briefly described. Further detail design information is shown in related supporting documents. [Ref-5][Ref-6]

16.4.3.1.1 System Roles

The purpose of the SPCU is to clean the water in the Suppression Pool (S/P) by transferring the pool water through the Fuel Pool Cooling and Clean-up System Filter Demineraliser (FPC F/D) and returning it back to the S/P. The treated water can be used for water-filling of the upper pools as well (Reactor Well and Steam Dryer, Steam Separator Pit (D/S Pit)) during preparation for re-fuelling outage.
Moreover, the SPCU is capable of drawing water from the Condensate Storage Tank (CST) or the S/P to supply water to the Spent Fuel Storage Pool (SFP) as required.

16.4.3.1.2 Functions Delivered

(1) The primary function of the SPCU is to provide continuous purifying water treatment for the S/P. The SPCU removes miscellaneous impurities by filtration, adsorption, and ion exchange processes. Moreover, it maintains the S/P water quality within the specification.
(2) The SPCU provides water-filling to the upper pools prior to refuelling.
(3) The SPCU provides makeup water to the Spent Fuel Pool (SFP) from the Condensate Storage Tank (CST) or the S/P. SPCU is also capable of providing makeup water to the SFP as a backup in the event that Residual Heat Removal System (RHR) and regular makeup water systems failed.

16.4.3.1.3 Basic Configuration

The SPCU consists of the following components:
(1) SPCU Pump
(2) FPC F/D (installed on the FPC)
(3) Piping and Valves
(4) Instrumentation and Controllers
Figure 16.4-2 shows an outline of the SPCU.

16.4.3.1.4 Modes of Operation

The SPCU can deliver the following operation modes by switching the position of the valves.

16.4.3.1.4.1 Suppression Pool Water Clean-up Mode

Water from the S/P is drawn by the SPCU Pump, treated by the FPC F/D (A), and returned to the S/P. The operation is initiated and stopped by the operator. Since this operation mode is not a continuous operation mode, only one of the two F/D units (F/D (A)) is designed to be utilized, and is capable of operating in parallel with F/D unit B performing clean-up of the SFP.
This mode is operated sufficiently to satisfy the specified water quality requirements before refuelling outage.

16.4.3.1.4.2 SFP Water-Filling and Drainage Mode

Water from the S/P is transferred to the upper pools prior to fuel replacement on this mode to fill up the pools for shielding during fuel and components handling. The outlet valve on the water supply line to the Dryer/Separator (D/S) Pit (from downstream of the F/D (A)) is opened and the valve on the return piping to the S/P is closed to transfer water. The flow rate is equal to that of the S/P Water Clean-up Mode to facilitate operation of the F/D. This operating mode is initiated and stopped by the operator.

This operation mode is also to drain water in the SFP after fuel replacement operation. Water is cleaned up by the FPC F/D and directly drained through the SPCU return line to the S/P. This operation mode can perform clean-up with one FPC F/D or both FPC F/Ds.

16.4.3.1.4.3 SFP Makeup Mode

Feed-water to the SFP is performed by initiating the SPCU Pump and opening each inlet valve. Water can be drawn from the CST or the S/P by the SPCU Pump, and is directly transferred to the SFP without passing through the FPC F/D. The S/P is used as a backup water source instead of the CST. However, The S/P water is supplied only during events that do not involve Loss of Coolant Accident (LOCA). This operating mode is initiated and stopped by the operator.

16.4.3.2 Design Bases

This section describes the design bases for the SPCU. [Ref-5]

16.4.3.2.1 Safety Functions

The SPCU has been designed to meet the following SFCs. The relation between the SFCs put on this system and the high level claims is shown on Appendix-3.

Normal Operations

(1) The SPCU provides purifying water treatment for the S/P in plant normal operation. It removes various impurities by filtration, adsorption, and ion exchange processes.
This function is categorized as Category C and the components to deliver it are designed to meet Class 3 requirements. [SPCU_SFC_5-9.1]

(2) The SPCU piping outside the PCV boundary contains radioactive material. Rupture of this piping could lead to a release of radioactive material of dose consequences relatively low. This function is categorised as Category C and the components to deliver it are designed to meet Class 3 requirements. [SPCU_SFC_4-3.1]

Fault Conditions

(3) The SPCU is capable of supplying makeup water to the SFP even if it is under the environmental conditions post LOCA.
This function is categorized as Category C and the components to deliver it are designed to meet Class 3 requirements. [SPCU_SFC_2-5.1]
This safety function is developed and justified in the section related to the Spent Fuel Pool Cooling in Generic PCSR Chapter 19 “Fuel Storage and Handling” (GA91-9101-0101-19000).

(4) The SPCU components within the PCVB are completely isolated by the PCIS in order to form barrier to confine the radioactive material within the containment boundary and prevent its dispersion to the environment in the event of faults.
This function is categorized as Category A and the components to deliver it are designed to meet Class 1 requirements. [PCIS_SFC_4-7.17]
This safety function is developed and justified in the section related to the Primary Containment Facility in Generic PCSR Chapter 13.2 "Containment System" (GA91-9101-0101-13002).

16.4.3.3 System Design Description

This section describes the design of the SPCU to support and justify the delivery of SPCU_SFC_5-9.1. Additional design description can be found in [Ref-5][Ref-6].

16.4.3.3.1 Overall System Design and Operation

FPC F/D unit A is separated from the SFP clean-up mode and used for S/P Water clean-up mode. Water from the S/P is drawn by the SPCU Pump, treated by the FPC F/D (A), and returned to the S/P. The operation is initiated and stopped by the operator. However, this operation mode will be automatically shut off to isolate systems from the S/P upon Primary Containment Vessel (PCV) isolation signal. Since this operation mode is not a normal operation mode, only one of the two F/D units (F/D (A)) is designed to be utilized, and is capable of operating in parallel with F/D unit B performing clean-up of the SFP. Therefore, in the event that F/D (A) was operating as a SFP clean-up filter, it is switched to the F/D (B) and F/D (A) is used on S/P clean-up mode. This mode is sufficiently operated to satisfy the specified water quality requirements before refuelling outage.

16.4.3.3.2 Equipment Design and Operation

16.4.3.3.2.1 SPCU Pump

(1) Purpose
The SPCU pump provides flow of the water from the S/P to circulate it through the FPC F/D in order to deliver SPCU_SFC_5-9.1.

(2) Configuration
One SPCU Pump capable of continuous operation is provided. The SPCU Pump is located on the bottom floor of the reactor building and close to the S/P so that adequate suction head is assured during all the operating modes and the pump suction line remains flooded.

(3) Performance
The flow rate of the SPCU Pump is the same as the FPC F/D flow. The SPCU Pump total head is such that the pump is capable of drawing water from the S/P and transferring it to the upper pools passing through the FPC F/D. The SPCU Pump is designed to have sufficient suction head under the most demanding conditions during all operation modes. The Specification of SPCU Pump required for the delivery of SPCU_SFC_5-9.1 is shown as follows:

(a)	Number	1 unit
(b)	Pump type	Turbo
(c)	Rated Flow	approx.250 m^3/h
(d)	Design Pressure	1.57 MPa[gauge]

16.4.3.3.2.2 FPC Filter-demineraliser

(1) Purpose
The FPC F/D purifies the water from the S/P by removing the various impurities through filtration, adsorption and ion exchange processes in order to deliver SPCU_SFC_5-9.1.

(2) Configuration
During normal plant operation, the SPCU is designed to recirculate approximately 250m^3/h of suppression pool water through one of the FPC Filter-demineraliser.

(3) Performance
(a) Number 1 unit
(b) Capacity approx. 250m^3/h

16.4.3.3.3 Main Support Systems

16.4.3.3.3.1 Instrumentation and Control Systems

(1) Instrumentation
(a) A flow element and a flow transmitter are provided on the SPCU Pump discharge line in order to measure the flow and inform the main control room. A switch is provided with an interlock to protect the SPCU Pump and warn the main control room that the discharge flow is low.
(b) A pressure switch is provided on the suction side of the SPCU Pump, to protect the pump with an interlock and warn the main control room that the suction pressure is low.
(c) The statuses of all motor operated valves are indicated in the main control room.

(2) Interlock
(a) The SPCU Pump is not operable unless the suction valve, on the S/P or the CST side, is fully opened.
(b) The SPCU Pump is tripped upon low suction pressure or low discharge flow signals. In addition, the pump is tripped upon Low Water Level in the S/P.

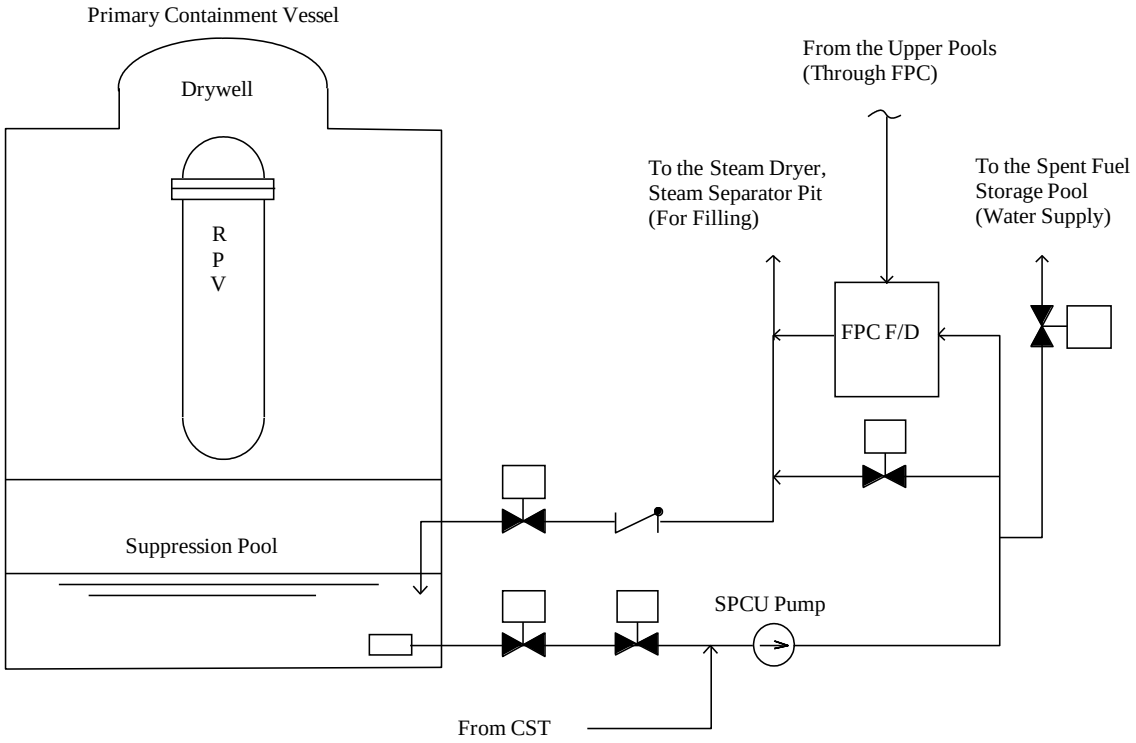

Figure 16.4-2 : Outline of SPCU configuration

16.4.4 Claims and Link to High Level Safety Functions

The list of claims in this sub chapter and the linkage to corresponding High Level Safety Functions is shown in Appendixes 1 to 3. A short description on the application of High Level Safety Fucntions in the development of the claims, arguments and evidence is provided in Generic PCSR Chapter 1 “Introduction “(GA91-9101-0101-01000).

16.4.5 References

[Ref-1] Hitachi-GE Nuclear Energy, Ltd., *"Basis of Safety Cases on Emergency Power Supply System"*, GA91-9201-0002-00042 (VDE-GD-0001) Rev. 1, February 2015.

[Ref-2] Hitachi-GE Nuclear Energy, Ltd., "*Fire Protection System Basic Design Plan*", GA26-1001-0002-00001 (BKD-GD-0002) Rev.0, Mar 2014.

[Ref-3] Hitachi-GE Nuclear Energy, Ltd., "*Topic Report on Departures from Conventional Fire Regulation*", GA91-9201-0001-00001, Rev.2, May 2015

[Ref-4] Hitachi-GE Nuclear Energy, Ltd., "*Basis of Safety Cases on Heating Ventilating and Air Conditioning System*", GA91-9201-0002-00041(HPE-GD-H006) Rev.1, February 2015.

[Ref-5] Hitachi-GE Nuclear Energy, Ltd., *"Suppression Pool Clean-up System System Design Description"*, GG51-1001-0001-00001 (SD-GD-0011) Rev. 0, May 2013.

[Ref-6] Hitachi-GE Nuclear Energy, Ltd., *"Suppression Pool Clean-up System P&ID"*, GG51-2101-0001-00001 (310QC98-326) Rev.0, Mar 2014.

16.4.6 Appendixes

Appendix-1: Claim tree for Ch. 16.4.1 (FPS)
Appendix-2: Claim tree for Ch. 16.4.2 (EDG, BBG and DAG)
Appendix-3: Claim tree for Ch. 16.4.3 (SPCU)

16.4.6.1 Appendix-1: Claim tree for Ch. 16.4.1 (FPS)

	Top Claim for mechanical system						Safety Functional Claim (SFC) for the mechanical system and components		
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)				
	Generic PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.2 Identification of ABWR Safety Functions)		Generic PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.6 Summary of Safety Category and Classification)		Topic Report on Fault Assessment (UE-GD-0071) Table.4.2-1 Fault Schedule		State	Claim ID	Claim Contents
1	5	Others	5-14	Functions important to emergency measures and monitoring of abnormal conditions	-	No Claim	Fault Scenarios	FPS_SFC_5-14.1	Fire detector and alarm systems serve to detect a fire and provide warning to occupants in the vicinity of a fire and the MCR.
2	5	Others	5-14	Functions important to emergency measures and monitoring of abnormal conditions	-	No Claim	Fault Scenarios	FPS_SFC_5-14.2	The firefighting water supply system provides the water to the firefighting systems.
3	5	Others	5-14	Functions important to emergency measures and monitoring of abnormal conditions	-	No Claim	Fault Scenarios	FPS_SFC_5-14.3	The fixed fire suppression systems limit fire growth and spread following ignition.
4	5	Others	5-14	Functions important to emergency measures and monitoring of abnormal conditions	-	No Claim	Fault Scenarios	FPS_SFC_5-14.4	The fire brigade equipments limit fire growth and spread following ignition.

	Top Claim for mechanical system						Safety Functional Claim (SFC) for the mechanical system and components		
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)				
	Generic PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.2 Identification of ABWR Safety Functions)		Generic PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.6 Summary of Safety Category and Classification)		Topic Report on Fault Assessment (UE-GD-0071) Table.4.2-1 Fault Schedule		State	Claim ID	Claim Contents
5	5	Others	5-14	Functions important to emergency measures and monitoring of abnormal conditions	-	No Claim	Fault Scenarios	FPS_SFC_5-14.5	The smoke control system contributes fire containment by controlling the spread of smoke, enabling a rapid response to a fire. Plant rooms are compartmentalised to prevent spread of fire and smoke, and this is further mitigated by the use of smoke dampers as fire barriers. Several plant rooms are connected together via a common smoke extraction duct equipped with smoke dampers. Excluding the smoke control across the controlled areas in the safety divisions, which have radiological containment significance, there are no nuclear safety claims on the smoke control system.

16.4.6.2 Appendix-2: Claim tree for Ch. 16.4.2 (EDG, BBG and DAG)

	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)		
	Fundamental Safety Function (FSF)			High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)			
	Generic PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.2 Identification of ABWR Safety Functions)			Generic PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.6 Summary of Safety Category and Classification)		Topic Report on Fault Assessment (UE-GD-0071) Table.4.2-1 Fault Schedule	State	Claim ID	Claim Contents
1	5	Others	5-2	Supporting functions especially important to safety	-	See chapter 15	Fault Scenarios	EPS_SFC_5-2.1	The EDGs supply power to loads necessary to secure functions of engineering safety facilities and necessary to safety shut down the reactor in the event of LOOP and LOCA associated with LOOP. The kind of main loads connected to each of EDGs are described in Generic PCSR Chapter 15.4 “Electrical Equipment and systems” (GA91-9101-0101-15004).
2	5	Others	5-3	Function of alternative supporting system	-	See chapter 15	Fault Scenarios	EPS_SFC_5-3.1	The BBG supplies power to diverse provisions which is necessary for reactor safety in the event of a LOOP and a LOCA associated with LOOP. The kind of main loads connected to each of BBGs are described in Generic PCSR Chapter 15.4 “Electrical Equipment and systems” (GA91-9101-0101-15004).
3	5	Others	5-3	Function of alternative supporting system	-	See chapter 15	Beyond Design Basis Fault Conditions	EPS_SFC_5-3.2	The BBG supplies power in the event of severe accidents.
4	5	Others	5-3	Function of alternative supporting system	-	See chapter 15	Fault Scenarios	EPS_SFC_5-3.3	The DAG supplies power to loads necessary to secure functions of engineering safety facilities and necessary to safety shut down the reactor in the event of LOOP and LOCA associated with LOOP and when EDG does not function.

16.4.6.3 Appendix-3: Claim tree for Ch. 16.4.3 (SPCU)

	Top Claim for mechanical system						Safety Functional Claim for the mechanical system and components (SFC)		
	Fundamental Safety Function (FSF)		High Level Safety Function (HLSF)		Fault Schedule (Bounding Fault)				
	Generic PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.2 Identification of ABWR Safety Functions)		Generic PCSR Ch.5.4 (List of Safety Category and Class for UK ABWR (AE-GD-0224) 3.6 Summary of Safety Category and Classification)		Topic Report on Fault Assessment (UE-GD-0071) Table.4.2-1 Fault Schedule		State	Claim ID	Claim Contents
1	5	Others	5-9	Functions to clean up other than reactor coolant	-	No claim	Normal Operations	SPCU_SFC_5-9.1	The SPCU provides purifying water treatment for the S/P in plant normal operation. It removes various impurities by filtration, adsorption, and ion exchange processes.
2	2	Fuel cooling	2-5	Functions to make up water for spent fuel pool	-	No claim	Fault Conditions	SPCU_SFC_2-5.1	The SPCU is capable of supplying makeup water to the SFP even if it is under the environmental conditions post LOCA.
3	4	Confinment/Containment of radioactive materials	4-7	Functions to confine radioactive materials, shield radiation, and reduce radioactive release	1.4	Feedwater controller failure - Maximum demand	Fault Conditions	PCIS SFC 4-7.17	The SPCU components within the PCVB are completely isolated by the PCIS in order to form barrier to confine the radioactive material within the containment boundary and prevent its dispersion to the environment in the event of faults.
					2.1	Inadvertent MSIV closure			
					2.2	Reactor pressure regulator failure in the open direction			
					2.3	Loss of main condenser vacuum			
					3.1	Loss of all feedwater flow			
					5.1	Short term LOOP			
					5.1.1	Short-term LOOP with CCF of EDGs			
					5.2	Medium term LOOP			
					5.2.1	Medium term LOOP with CCF of EDGs			
					5.3	Long-term LOOP			
					5.3.1	Long-term LOOP with CCF of EDGs			
					7.1	LOCA - RPV bottom drain line break			
					8.1	LOCA - HPCF line break			
					8.2	LOCA - LPFL line break			
					9.1.1	LOCA - FWD line (LPFL connected) break			
					9.1.2	LOCA - FWD line (RCIC connected) break			
					9.2	LOCA - MS line break			
					9.3	LOCA - RHR line break			
4	4	Confinment/Containment of radioactive materials	4-3	Functions to contain radioactive materials	-	No claim	Normal Operations	SPCU_SFC_4-3.1	The SPCU piping outside the PCV boundary contains radioactive material. Rupture of this piping could lead to a release of radioactive material of dose consequences relatively low.