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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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Table of Contents

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 equipments that perform a safety function allows 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 function of the fire detection and alarm system is to detect a fire and send a signal 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 activate, 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 consists 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, 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. 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 point

Manual call point has a function to send a fire signal by pushing a button.

16.4.1.2.6.2.4 Local sounder

The local sounder sounds 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 power source for the alarm system is supplied commercial supply system.

16.4.1.2.6.3.1 Instrumentation and Control

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 turn 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 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 these to a looped distribution network. This allows water to be provided from two directions.

16.4.1.3.5 Design Basis

The fire fighting water supply system provides the water to the fire fighting systems. 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.

16.4.1.3.6 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, water tanks and distribution network piping are dedicated to the fire water supply. Fire water system consists of an external main loop and an internal main loop, both of which are supplied by dedicated pumps and tanks and connected to each other, as shown in Figure 16.4 -1. Fire water for external main loop is supplied by two fire pumps with 100% pressure and flow capacity respectively.

Two fire water tanks for external 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 the internal main loop and the external main loop.
The internal loop supplies water to:
- Outdoor hydrant system and indoor wet hydrant system in reactor building
- Foam extinguishing system
- Fixed water spray systems in the buildings

The external loop supplies water to:
- Outdoor hydrant system

The external loop supplies water to external hydrants, as well as to the internal loop. The connections between the external loop and the internal loop are open with valves which can be manually closed if they need to be isolated.
Isolation valves are located throughout the distribution network.

(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 100% of the requirement of water for the most demanding fixed suppression system and the hydrant requirements.
The primary pump on the external loop is motor driven or diesel driven and the secondary pump is diesel driven. Main 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 fire water tanks are 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. Required duration of water supply is 90 min. for both fixed extinguishing system (water spray extinguishing system) and manual suppression system, based on NFPA 15 and BS 12845.

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 stand-by condition. The fire pumps can be started either automatically by detecting low pressure in 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 pump on the external loop is motor driven or diesel driven and the secondary pump is diesel driven.

(4) Measurement
The following items are measured and monitored in the fire water system:
   (a) Water level at fire water tank
   (b) Water pressure of water supply (fire pump discharge header pressure)

(5) Alarm
In order to maintain this system's functions, following alarms are provided.
   (a) Fire water tank water level high (before overflowing)
   (b) Fire water tank water level low (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.

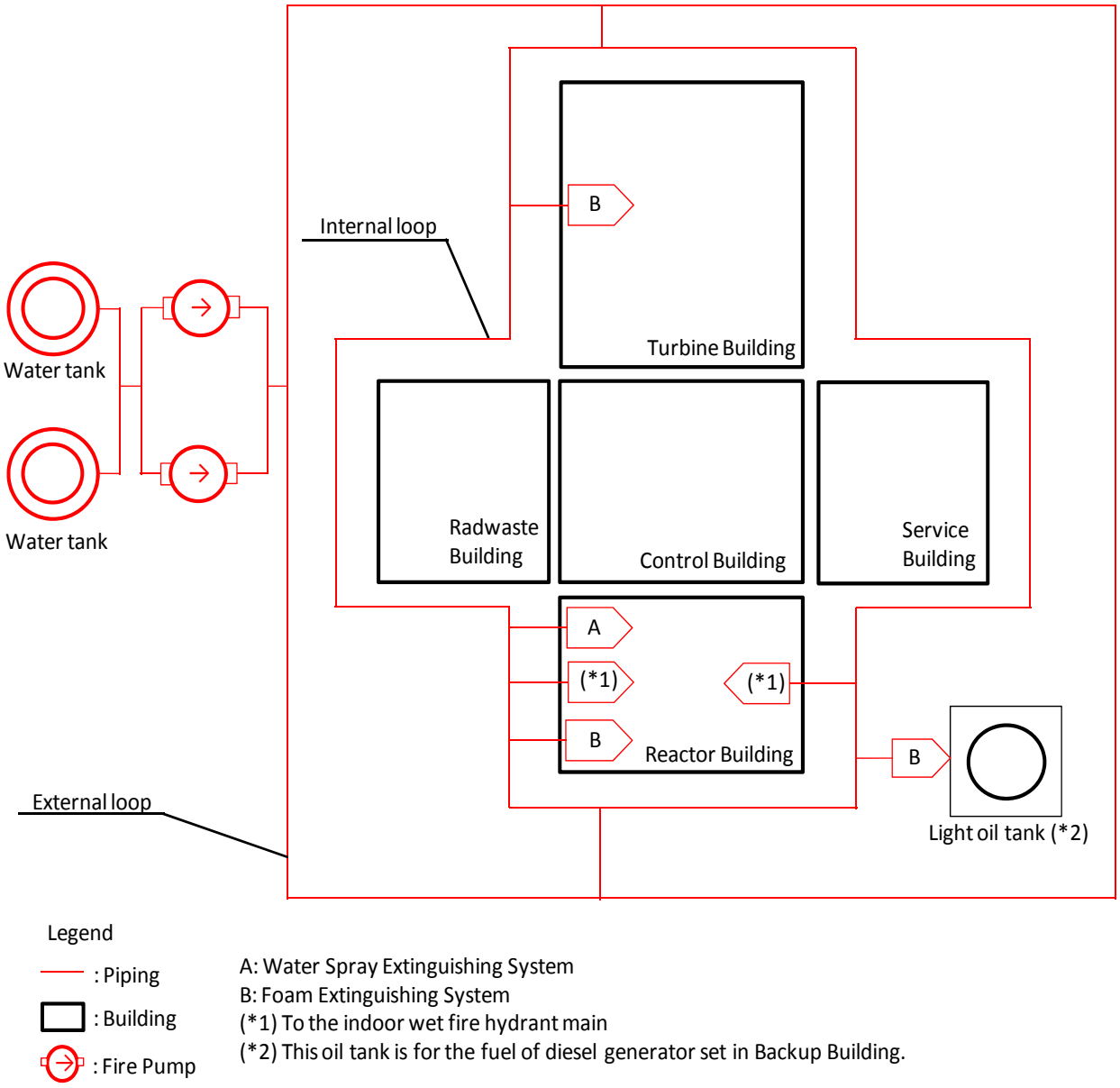

Figure 16.4-1 : Outline of the Fire Fighting Water Supply System

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, 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. 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

16.4.1.4.6 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 are designed to extinguish fires that may occur in emergency diesel generator rooms where there is the potential for oil fire.
Foam extinguishing systems are designed to extinguish fires that may occur in fuel day tank rooms, light oil tank and other areas of high fire risk where there is the potential for oil fire.

Each fixed fire suppression system has a separate direct connection to the water distribution network. 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 for the three emergency diesel generator rooms. 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 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 flow rate of at least 12.2 L $min^{-1}m^{-2}$ for duration of 90 minutes over the whole protected area, based on NFPA 15 and BS 12845.

16.4.1.4.6.2.2 Foam Extinguishing System

(1) Configuration
  (a) Foam sprinkler system
  Foam sprinkler systems are for fuel day tank rooms, and other areas of high fire risk. The systems use low expansion foam and are automatically operated and allow for manual operation.
  (b) Foam extinguishing system for light oil tank
  The foam extinguishing system for light oil tank suppresses fire by low expansion foam. This system is for the light oil tank which supplies fuel to the emergency diesel generators set in Back-up Building. It is used to suppress oil surface fires.
  The light oil tank is surrounded by a dike in order to contain spilled oil. The foam extinguishing system is also designed for the dike area to put out the fire may cause from leaked oil. Both of these systems are manually operated.

(2) Performance
  (a) Foam sprinkler system
  The system is designed to suppress oil pool fires and calculated based on a nominal application rate of 4.0 L min-1m-2 for duration of 60 minutes over the whole protected area based on BS13565-2.
  (b) Foam extinguishing system for light oil tank
  The system is designed to suppress oil pool fires and calculated based on a nominal application rate of 4.0 L $min^{-1}m^{-2}$ for duration of 60 minutes for inside of tank and for 30 minutes for dike area based on BS13565-2.

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. The power source is supplied from normal power supply system.

16.4.1.4.6.3.2 Foam Extinguishing System

(1) Foam sprinkler system
Foam sprinkler 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 foam extinguishing system in order to activate the system operation automatically. The power source is supplied from normal power supply system.
(2) Foam extinguishing system for light oil tank
The foam extinguishing system is supplied water from fire fighting water supply system, and fire detectors are provided to detect fire may that occur in light oil tank. 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 indoor fire mains, outdoor fire hydrants and building piping networks.

16.4.1.5.5 Design Basis

The fire brigade equipments limit fire growth and spread following ignition. 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.

16.4.1.5.6 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 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 from the fire fighting water supply system.
(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 supplied from fire fighting water supply system.

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 arisen 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 zones 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 zones, such as the fuel building and nuclear auxiliary building, the function of smoke extraction is restricted by radiological considerations. All smoke extracted from controlled zones is filtered through a stack before vented to atmosphere. (Provisional)

In both controlled and non-controlled areas in the safety divisions, there is a requirement for the smoke control system to create a slight overpressure in stairways, landings and emergency exits, in order to prevent any smoke entering from the affected fire sectors.

16.4.1.6.4 Basic Configuration

Every fire safety sector emergency stairway has blower fans to form an overpressure and keep smoke in a fire-affected area. (Provisional)

Extractor fan circuits with vents are provided for all non-controlled areas, whilst controlled areas in the Power Block have an independent venting system that goes through a stack with radiological filters. (Provisional)

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

16.4.1.6.5 Design Basis

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. (Provisional)

Excluding the smoke control across the controlled zones 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 classified as Class 3 safety components according to the safety categorization and classification of UK ABWR.

16.4.1.6.6 System Design

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, with the controlled areas having a requirement to filter the smoke before release through a stack. 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. (Provisional)

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. (Provisional)

16.4.1.6.6.1.1 System Operation Conditions

Fire dampers automatically close upon alarms received to the main control panel. (Provisional)

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, (Provisional)
- One extractor fan per circuit, whose capacity is regulated (by a motorized control damper) according to the under-pressure achieved in the sector from which the smokes have been extracted. (Provisional)

The fire zones involved in fume extraction in the non-controlled zone 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 to 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 zone 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. (Provisional)

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. (Provisional)
The stairways are over-pressurised, by opening a damper automatically and by starting the fan. This enables the fire sector to be approached or to be evacuated. (Provisional)

- 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. (Provisional)

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: (Provisional)

- 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

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 System Summary Description

This section is a general introduction to the Emergency Power Supply System (Emergency Diesel Generator (EDG)) where the system roles, system functions, system configuration and modes of operation are briefly described.

16.4.2.1.1 System Roles

The role of the EDG 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 should occur simultaneously.

16.4.2.1.2 Functions Delivered

The EDG is designed to perform the following operation and safety functions:
(1) The EDG supplies 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.

16.4.2.1.3 Basic Configuration

The EDG consists 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

16.4.2.1.4 Modes of Operation

Modes of operation of the EDG are summarised as follows.

16.4.2.1.4.1 Emergency operating mode

The EDG supplies 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.

16.4.2.1.4.2 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 and DG Cooling Water System.

16.4.2.2 Design Bases

This section describes the design basis for the EDG.

16.4.2.2.1 Safety Functions

The EDG has been designed to meet the following safety functions.

(1) The EDG 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. From this perspective, the EDG delivers a Category A safety function, and as principal means, the components necessary to deliver this function are classified as Class 1 safety components according to the safety function categorisation and classification of UK ABWR.

16.4.2.3 System Design

This section describes the design of the EDG.

16.4.2.3.1 Overall Design and Operation

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

16.4.2.3.2 Equipment Design and Operation

16.4.2.3.2.1 Engine

(1) Configuration and Operation
The EDG is provided with three exhaust turbocharged engines. The engine is designed to be started by compressed air automatically. The engine shall be able to be started up and shut down by remote manual operation from the main control panel or local control panel.

(2) Performance Design
The engine is designed to be able to continuously operate at rated power under the specified operating condition. Rate of engine speed variance is lower than specified value.

16.4.2.3.2.2 DG Fuel Oil System

(1) Configuration and Operation
Each engine is supplied fuel oil from independent DG Fuel Oil System (DGFO). The DGFO consists of tanks, pumps, piping and valves.

(2) Performance Design
The storage capacity of DGFO is sufficient for operation each engine for seven days at rated power.

16.4.2.3.2.3 DG Cooling Water System

(1) Configuration and Operation
Each engine is supplied cooling water from independent DG Cooling Water System (DGCW). The DGCW consists of tanks, pumps, heat exchanger, piping and valves.

(2) Performance Design
The cooling capacity of DGCW is sufficient for operation at rated power. In order to facilitate rapidly starting of the engine, the engine is pre-heated.
The water consumption of DGCW is supplied automatically from MUWP.

16.4.2.3.2.4 DG Lubricant Oil System

(1) Configuration and Operation
Each engine is supplied cooling water from independent DG Lubricant Oil System (DGLO). The DGLO consists of tanks, pumps, heat exchanger, piping and valves.

(2) Performance Design
The cooling capacity of DGCW is sufficient for operation at rated power. In order to facilitate rapidly starting of the engine, the engine is pre-heated and pre-lubricated.

16.4.2.3.2.5 DG Compressed Air System

(1) Configuration and Operation
The DG Compressed Air System (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.

(2) Performance Design
Each compressed air system has enough air storage capacity for specified number of times starts. The EDG 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.

16.4.2.3.2.6 DG Air Intake and Exhaust Gas System

(1) Configuration and Operation
Each engine is supplied combustion air and discharge exhaust gas by independent DG Air Intake and Exhaust Gas System (DGAE). The DGAE consists of expansion joint, exhaust silencer, piping and valves. The exhaust gas drives turbocharger to increase amount of intake air.

(2) Performance Design
The air intake is from the piping through the outside of R/B and exhaust gases are released atmosphere via exhaust silencer on the R/B roof.

16.4.2.3.2.7 Generator

(1) Configuration and Operation
The generator is a synchronous generator and direct coupled with engine.

(2) Performance Design
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.

16.4.2.3.3 Main Support Systems

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

16.4.2.3.3.1 Reactor Building Cooling Water System (RCW)

The RCW supplies water to the Heat Exchangers of EDG. The EDG is connected to independent and separated RCW divisions such that EDG division A components are supplied cooling water by RCW division A, EDG division B components are supplied cooling water by RCW division B and EDG division C components are supplied cooling water by RCW division C.
For further details refer to PCSR Chapter 16 “water systems”.

16.4.2.3.3.2 Makeup Water Purified System (MUWP)

The MUWP supplies cooling water to 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.

16.4.2.3.4 System Architecture

16.4.2.3.4.1 Redundancy

The EDG consists of three redundant divisions A, B and C with their respective systems such that, single failure of any dynamic mechanical component does not prevent the delivery of the safety function.

16.4.2.3.4.2 Independence

The three divisions of the EDG are independent and separately arranged in different locations to prevent failure of a component in one of the divisions from leading to a common cause failure of all divisions.

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.

16.4.3.1.1 System Roles

The purpose of 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 utilized for water-filling of the upper pools as well (Reactor Well and Steam Dryer, Steam Separator Pit (D/S Pit)).
Moreover, 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 SPCU is to provide continuous purifying water treatment for the S/P. SPCU removes miscellaneous impurities by filtration, adsorption, and ion exchange processes. Moreover, it maintains 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) Piping and Valves
(3) 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 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.

16.4.3.1.4.2 SFP Water-Filling and Drainage Mode

Water from the S/P is transferred to the SFP prior to fuel replacement on this mode. 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 F/D operation. 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 the 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

The function of SPCU is to provide continuous purifying water treatment for the S/P. SPCU removes miscellaneous impurities by filtration, adsorption, and ion exchange processes. From this perspective of safety function in normal operation, the SPCU delivers a Category C function, and the components necessary to deliver water cleanup function are classified as Class 3 safety components according to the safety categorisation and classification of UK ABWR.

Part of the SPCU forms the Primary Containment Vessel Boundary (PCV Boundary). Therefore, the components within the PCV boundary form a barrier to maintain the integrity of the boundary and thus prevent the dispersion of radioactive substances. From this perspective, the SPCU delivers a Category A safety function (confinement) and the components necessary to deliver this function are classified as Class 1 safety components according to the safety categorisation and classification of UK ABWR. This function is developed and justified in the section related to the Containment Isolation System in PCSR chapter 13.

The SPCU is capable of supplying makeup water to the SFP even if it is under the environmental conditions post LOCA. This function is developed and justified in the section related to the SFP cooling system in PCSR chapter 19.

16.4.3.3 System Design

16.4.3.3.1 Overall 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 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 refueling outage.

16.4.3.3.2 Equipment Design and Operation

16.4.3.3.2.1 SPCU Pump

(1) 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 operating modes and the pump suction line remains flooded.

(2) 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 is shown as follows:

(a)	Number	1 unit
(b)	Rated Flow	approx.250 m^3/h
(c)	Design Temperature	66 °C
(d)	Design Pressure	1.57 MPa[gauge]

16.4.3.3.2.2 FPC Filter-demineraliser

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

(2) Performance

(a)	Number	1 unit
(b)	Capacity	approx. 250m^3/h
(c)	Others	It is common to use it with the FPC

16.4.3.3.3 Main Support Systems

16.4.3.3.3.1 Instrumentation and Control

(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.

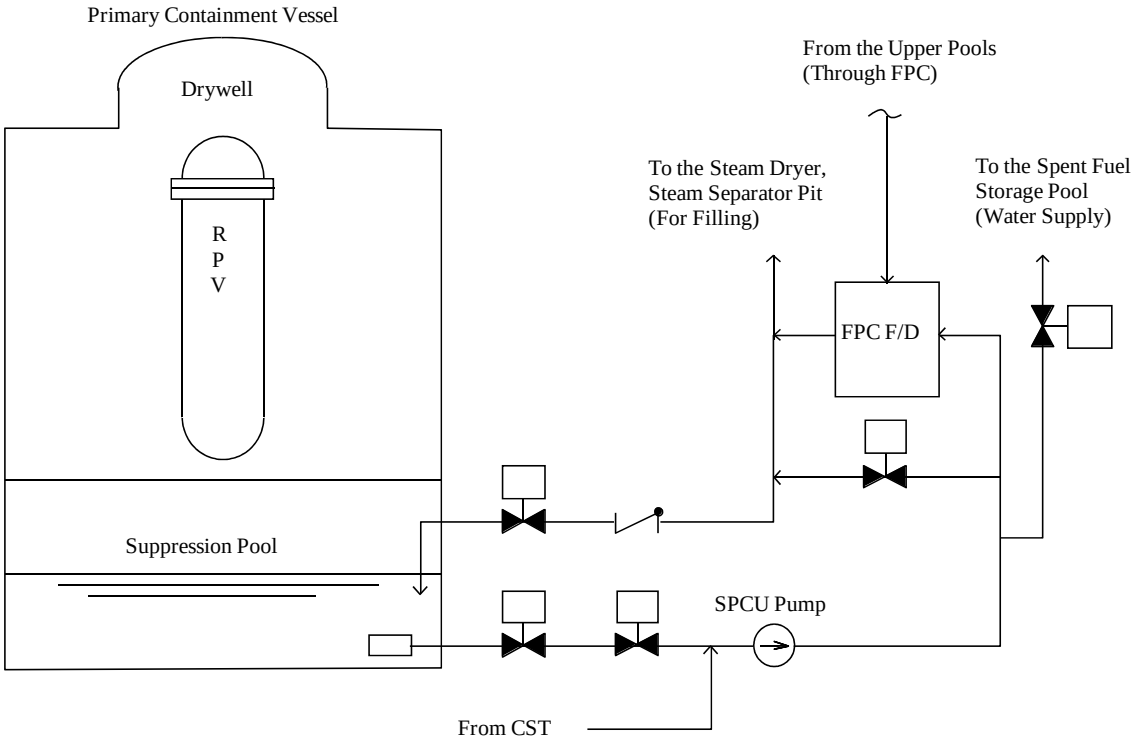

Figure 16.4-2 : Outline of SPCU configuration

16.4.4 References

[Ref-1] GA91-9201-0002-00042 Rev.0, Basis of Safety Cases on Emergency Power Supply System, Hitachi-GE