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UK ABWR Generic Design Assessment

Preliminary Safety Report on Electrical Engineering

Hitachi-GE Nuclear Energy, Ltd.

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Abbreviations and Acronyms

Abbreviations and Acronyms	Description
ABWR	Advanced Boiling Water Reactor
AC	Alternating Current
A/G	Alternative AC Generator
AST	Auxiliary Standby Transformer
ANT	Auxiliary Normal Transformer
B/B	Backup Building
BSC	Basis of Safety Case
CAMS	Containment Atmospheric Monitoring System
CB	Circuit Breaker
C&C	Categorisation & Classification
CCF	Common Cause Failure
CCI	Commercially Confidential Information
C&I	Control and Instrumentation
DC	Direct Current
ECCS	Emergency Core Cooling System
E D/G	Emergency Diesel Generator
FLSS	Flooder System of Specific Safety Facility
FS	Field Switch
GDA	Generic Design Assessment
GDS	Generator Disconnecting Switch
GLS	Generator Load Switch
GT	Generator Transformer
HVAC	Heating Ventilating and Air Conditioning System
IEC	International Electrotechnical Commission
LOOP	Loss Of Off-site Power
LOCA	Loss Of Coolant Accident
M/C	Metal Clad Switchgear
MCC	Motor Control Center
ONR	Office for Nuclear Regulation
P/C	Power Center
PI	Personal Information
R/B	Reactor Building
Rw/B	Radwaste Building
SAP	Safety Assessment Principles
SSC	systems, structures and components
T/B	Turbine Building
UPS	Uninterruptible Power Supply

Table of Contents

This document has been prepared as a PSR document on the electrical engineering of the UK ABWR, including an outline of the auxiliary electrical system.

More detailed information on the safety of the electrical design will be described in the following documents:

Basis of Safety Case (BSC) Electrical Engineering
SAP Compliance report
Diversity Strategy report
Other supporting documents
Fault Analysis Studies will also be carried out which will inform the engineering design.

1. Introduction

The ABWR is connected to the external grid via a main connection and a standby connection. The main connection is the connection between the generator transformer (GT) and the external grid. The standby connection is the connection between the auxiliary standby transformer (AST) and the external grid.

During normal plant operation, on-site electrical power is supplied from the generator via the auxiliary normal transformer (ANT). At plant startup or shutdown, the main generator is disconnected by the generator load switch (GLS) and on-site electrical power is supplied from the main connection via the generator transformer and the auxiliary normal transformer. The standby connection backs up the main connection.

The generator disconnecting switch (GDS) is installed on the grid side of the GLS. The GDS is closed during normal plant operation, and opens for maintenance of the GLS or the generator to disconnect the circuit after GLS opens.

The medium-voltage buses (metal clad switchgear: M/C) consist of four safety Class 2 buses, three safety Class 1 buses and two Backup Building (B/B) Class 2 buses. The two B/B Class 2 buses are located in the Backup Building.

On-site service equipment is mainly divided into equipment having a role in ensuring nuclear safety, and other equipment. First line provision for electrical power to equipment having a principle role in delivering safety is connected to the safety Class 1 buses. A second line diverse and independent provision for electrical power to equipment having a principle role in delivering safety is connected to the B/B Class 2 buses. Other equipment is connected to safety Class 2 buses.

The on-site power sources comprise:

- Three (3) Class 1 Emergency Diesel Generators (E D/Gs) each connected to a safety Class 1 medium voltage bus in the reactor building.

- Two (2) B/B Class 2 alternative AC generators (A/Gs) each connected to a B/B Class 2 bus installed in the backup-building.

For the safety of reactor facilities, storage batteries are provided for components requiring reliable power at all times. An Uninterruptible Power Supply (UPS) system is provided for components requiring reliable and stable AC instrumentation and control power.

The DC power equipment consists of the following:

Four (4) systems for safety Class 1 power sources
One (1) DC non safety class power system as power source for plant investment protection
Two (2) DC safety Class 2 power systems as an on-site safety Class 2 instrumentation power source
Two (2) DC B/B Class 2 power systems for the backup-building

Figure 1 shows the overview of the auxiliary power distribution system.

2. Design Policies

The electrical systems are designed, in accordance with the following policies so that the safety of the reactor facilities can be assured by ensuring continuity of electrical power supplies, regardless of transient disturbances and faults during operation.

2.1 Power Assurance

(a) To assure power supply to the components needed for normal operation and to components needed to shut down the reactor safely.

(b) Electrical power is normally provided by the off-site power system. An emergency on-site power system is provided for use as the power source needed to assure the safe functioning of the structures, systems and components which have a role in ensuring nuclear safety.

2.2 On-site Power System

(a) The safety Class 1 on-site power sources (emergency diesel generators, safety Class1 storage batteries and power supply equipment related to these) have redundancy, are physically separated and are independent from each other.

(b) The safety Class 1 on-site power sources (emergency diesel generator, safety Class 1 storage battery and power supply equipment related to these) have sufficient capacity and function in order to be able to stop and cool the reactor without exceeding the nuclear fuel design limits and the design conditions of reactor coolant pressure boundaries when transients occur during operation, even when a single failure is assumed, or to cool the core when accidents such as Loss Of Coolant Accident (LOCA) occur, furthermore, to assure the reactor containment vessel's integrity and the safety function of the other support systems and equipment.

2.3 Station Black-out

The electrical systems are designed so that, in the event of total loss of all AC power, the reactor can be shut down safely and can maintain its integrity.

2.4 Instrumentation and Control Power

AC and DC instrumentation and control power source equipment is provided and connected to safety Class 1 low voltage buses, providing monitoring and control during normal operation, transient events or fault conditions during operation.
Figure 2 shows the overview of this system.

2.5 Testing Availability

The safety electrical systems (E D/G, A/G, Batteries) are designed so that the important parts of the systems can be given appropriate tests and inspections periodically. In particular, special consideration is given to the equipment below, which is in a standby condition during plant normal operation.

(a) Emergency diesel generator (E D/G) Alternative AC generator (A/G)
Synchronizing equipment is provided so that parallel operation with on-site power supply system is possible. Therefore, testing activities such as starting, synchronizing, or load operation of E D/G and A/G are possible during plant normal operation.

(b) Safety class1 battery
Safety class1 batteries are at floating charge status at all times, and the conditions (voltage etc.) of the batteries can always be checked.

2.6 Preliminary description of electrical system safety classification

Table 1 shows the preliminary assumption of Categorisation & Classification (C&C) of the electrical system. C&C of the electrical system is based on the C&C described in the document “C&I Design and Preliminary Safety Case [Ref-1]” and will continue to be developed in following GDA steps.

Since the electrical systems are support to the plant systems, C&C of the electrical systems is designed to be consistent with the requirements and configuration of the plant systems, structures and components (SSCs) to which the electrical power is supplied.

Please refer to the document “Categorization and Classification of Systems, Structures and Components [Ref-2]” for overall information of C&C.

Table 1 Preliminary assumption of C&C of the Electrical System

		Classification			
		1	2	3	N
Category	A	・Safety Class 1 AC buses ・Safety Class 1 DG ・Safety Class 1 DC ・Safety Class 1 UPS ・Safety Class 1 AC (for C&I) ・Earthing System (for safety Class1)	・B/B Class 2 AC buses ・B/B Class 2 ACG ・B/B Class 2 DC ・B/B Class 2 AC (for C&I)	--	--
	B	--	・Safety Class 2 AC buses ・Safety Class 2 DC 115V ・Safety Class 2 AC (for C&I) ・Earthing System (for safety Class 2) ・Communication System (telephone for safety Class 2) ・Lighting System (Emergency AC, DC for safety Class 2)	--	--
	C	--	--	・Switch Yard ・Generator ・Excitation system ・AST, GT, ANT ・IPB, NPB ・GLS, GDS ・Safety Class 3 UPS (for plant process PC) ・Safety Class 3 AC (for radwaste building C&I) ・Communication system (paging for safety Class 3) ・Lighting system (Emergency AC for safety Class 3) ・Earthing System (for safety Class 3)	--
	N	--	--	--	・DC 230V (for power) ・Communication system (paging) ・Lighting system (normal for non-safety) ・Earthing System (for non-safety)

Note: This table is only a preliminary assumption and will be revised in accordance with the revision of the documents [Ref-1] and [Ref-2].

3. Guidelines and Standards

The UK ABWR electrical engineering will be based primarily on IEC standards. Please refer to the document "Codes and Standards Report" for more information [Ref-3].
For reference, in addition to the industry standards, Japanese ABWR electrical engineering is subject to Japanese Safety Design guide # 48 (electrical system).

4. Main Equipment

4.1 Grid Connection

The role of the grid connection is to transmit the electrical power generated in the ABWR plant to the external grid and to supply reliable power to the unit auxiliaries including the engineered safety systems during both normal operation and design basis faults. Normally, this function is performed by the main connection. When the main connection is not available due to maintenance or fault condition, the standby connection backs the main connection and supplies power to the unit auxiliaries via the auxiliary standby transformer.
If both connections are unavailable simultaneously, the unit auxiliary loads connected to safety Class 1 buses are supplied from E D/Gs.

4.2 Transformers

Transformers used in this plant and the roles of these transformers are as follows;

Generator Transformer …	Raises the generator voltage to the external grid voltage during normal plant operation. Also, at plant startup or shutdown, the generator transformer steps down the external grid voltage to the generator voltage.
Auxiliary Normal Transformer…	Steps down the generator voltage to the medium-voltage bus voltage.
Auxiliary Standby Transformer…	Steps down the external grid voltage to the medium-voltage bus voltage.

The electrical power generated by the generator is transmitted to the external grid via the generator transformer. During normal plant operation, on-site power is supplied from the generator via the auxiliary normal transformer. At plant startup or shutdown, the main generator is disconnected by the GLS and on-site electrical power is supplied from the main connection via the generator transformer and auxiliary normal transformer. When the main connection is not available or when a fault occurs on the generator voltage system, the generator transformer or auxiliary normal transformer, on-site power is supplied by standby connection via the auxiliary standby transformer.

When a fault occurs on the GT or ANT, the turbine generator will be tripped. This will result in a reactor scram. These transformers are classified into Class3. Also, the AST is used as external power receiving equipment when the GT or ANT is not available. Thus, the AST is also classified into Class 3.

If the GT, ANT, and AST are not available simultaneously, the power supplies to SSCs providing the Category A safety functions will be supplied from the E D/Gs.

The capacity of the ANT is designed to be able to supply power to all the auxiliary loads needed during plant normal operation, during plant startup or shutdown, or during a reactor accident including Loss of Coolant Accident (LOCA).
The detail of capacity evaluation of ANT and AST will be described in supporting documents (such as "Auxiliary Normal Transformer Design Specification (calculation report)" and "Auxiliary Standby Transformer Design Specification (calculation report)") in the following GDA steps.

4.3 Auxiliary Medium Voltage Distribution Buses

Auxiliary medium-voltage distribution buses are divided into three groups according to role carried out;

Safety Class 2 buses - supplied from ANT or AST

Safety Class 1 buses - supplied from safety Class 2 medium voltage buses or E D/Gs

B/B Class 2 buses - supplied from safety Class 2 medium voltage buses or A/Gs

The Safety Class 2 medium-voltage buses supply power to the loads necessary during normal operation. Since normal loads are under safety Class2 equipment, the safety Class 2 medium-voltage buses are classified into class2 (the detailed list of the loads which are connected to safety Class 2 buses is to be shown in supporting documents such as "Auxiliary Normal Transformer Design Specification (calculation report)", "Auxiliary Standby Transformer Design Specification (calculation report)", "Single Line Diagram (High Voltage)" in the following GDA steps). The normal loads are generally arranged into 2 redundant groups so the safety Class 2 medium-voltage buses are divided into two groups (A and B). Also, in consideration of the total capacity of loads which are connected to safety Class 2 medium-voltage buses and the capacity of buses and circuit breakers applicable, safety Class 2 medium-voltage buses of standard ABWR plant consist of four (4) buses (1A-1, 1A-2 and 1B-1, 1B-2).

During plant startup or shutdown, these buses receive power from the external grid via the GT and ANT. After the generator is synchronized and connected to external grid, these buses receive power from the generator via the auxiliary normal transformer.

If an electrical fault occurs in the generator main circuit which includes the main generator, excitation system, GT and ANT, the electrical protection relays installed to protect the generator main circuit detect the fault and send a trip signal to the GT circuit breaker (CB), the incoming CBs of the safety Class 2 medium-voltage buses from ANT and the generator field switch (FS) to isolate the affected zone.

After tripping the incoming CBs of safety Class 2 medium-voltage buses from ANT, the incoming CBs of the safety Class 2 medium-voltage buses from AST are closed automatically.
Detailed information about the automatic changeover will be provided in supporting documents (such as "Electrical Power Distribution System System Design Description" and "Interlock Block Diagram for electrical power distribution system") in the following GDA steps.

As described above, safety Class 2 buses have two possible sources of power (ANT side and AST side). During plant normal operation, only the ANT side incoming CB is closed.

The design includes the capability to manually switch the safety Class 2 buses to the AST side with power interruption or using check synchronizing. Further information about the interlocking, operation and control of manual switching will be provided in supporting documents (such as "Interlock Block Diagram for electrical power distribution system").

The safety Class 1 medium-voltage buses supply power to the safety Class 1 SSCs supporting the delivery of Category A safety functions (the preliminary load list is shown in section 4.4). Each of these buses is normally supplied from a specific safety Class 2 medium-voltage bus.

In consideration of the maintenance of the safety Class 2 medium-voltage buses there is facility to supply the safety buses from an alternative (back up) safety Class2 medium voltage bus as follows:

M/C 1C	main from M/C-1A1	back-up supply from M/C-1B1
M/C 1D	main from M/C-1B1	back-up supply from M/C-1A2
M/C 1E	main from M/C-1A2	back-up supply from M/C-1B1

In plant normal operation, only the main incoming CB from the designated safety Class 2 bus is closed. An interlocking scheme prevents simultaneous closure of the main and back up CBs. The back-up supply is only used during reactor maintenance and maintenance of the safety Class 2 bus.

If a fault occurs in the back up circuit, electrical protection relays will operate to isolate the safety Class 1 bus which will then be supplied from the E D/G.

Since the Emergency Core Cooling System (ECCS) consists of three divisions, the safety Class 1 medium-voltage buses are divided into three divisions.

When off-site power is lost, the safety Class 1 medium-voltage buses are supplied from the emergency diesel generators, capable of supporting the SSCs providing Category A safety functions. If off-site power is restored during operation with the emergency diesel generators, auxiliary loads are uninterruptedly and manually switched back to off-site power by synchronizing and connecting the emergency diesel generator to external grid.
The electrical systems supporting the delivery of Safety Functions are separated and connected to the safety Class1 bus according to the division of the system so as to prevent the loss of redundancy due to the extension of a single failure of power supply to equipment of other divisions.

The B/B Class2 medium-voltage buses supply power to the second line provision of the ECCS safety function and related equipment eg the Flooder System of Specific Safety Facility (FLSS) which is the alternative Class 2 low-pressure flooder system. Since the Class 2 FLSS is a 2×100% system, the backup-building medium-voltage buses consist of two systems (M/C-B/B1 and M/C-B/B2). In normal operation the B/B needs power supply to maintain battery chargers, HVAC, Alternative AC generator (A/G) starting system, etc. Therefore the B/B Class2 medium-voltage buses are each normally connected to a specific safety Class 2 medium-voltage bus. A bus tie line is installed between each of the back-up buses in consideration of maintenance of safety Class 2 medium-voltage buses during reactor maintenance. The CBs of this tie line are interlocked and are open during plant normal operation.

As stated earlier the power system of backup-building supplies power to the Class 2 equipment such as the FLSS which is the second line means of providing the ECCS function. Therefore the power system of the B/B is designed to be diverse in relation to the safety Class 1 system in the reactor-building

If off-site power is lost, A/Gs are automatically started and supply power to the backup-building Class 2 buses .

The medium voltage A/G connected to back up building bus 1 is capable of supplying the Class 1 safety loads connected to any one of the safety Class 1 buses.

4.4 Emergency Diesel Generators (Safety Class1 diesel generators)

The role of the emergency diesel generators (E D/Gs) is to supply power needed to shut down the reactor safely when off-site power is lost, and to supply power to the electrical systems supporting the delivery of Safety Functions if a loss of coolant accident occurs simultaneously.

Since the E D/Gs supply power to the safety Class 1 buses delivering supplies to Class 1 SSCs, they are classified as Class 1. Three E D/Gs are installed in consideration of the redundancy requirement, and each of the generators and associated control panels is installed in an independent room.
The E D/Gs start when a loss of voltage occurs on the safety Class 1 medium-voltage bus, or when a loss of coolant accident occurs. Low voltage detection relays detect the loss of voltage and simultaneously send commands to open the load circuit breakers and the incoming CB (from the normal bus) and send a starting signal to the E D/Gs. All the loads connected to the safety Class 1 buses are disconnected with the exception of the power transformers and the low-voltage motor control centers (MCCs) connected to the low-voltage bus.

When the frequency and voltage of the E D/G reaches the specified value, the E D/G is connected to the safety Class 1 bus automatically and the required loads are connected automatically and sequentially in accordance with a priority of safety importance.

The automatic switching is generated by a Class 1 safety timer and logic controller which starts when the safety bus voltage is recovered. This equipment will be described in a supporting document (“Interlock Block Diagram for electrical power distribution system”).

On the other hand, when the LOCA signal (reactor water level low signal or Drywell pressure high signal) is sent, E D/G starts up automatically regardless of the on-site power availability. On this occasion, if the power supply of safety Class 1 bus is not lost, the E D/Gs remain in standby operation and continue this way until they are shut down manually.

Should a Loss of Coolant Accident and a loss of the safety Class 1 medium-voltage bus occur simultaneously, loads related to the SSCs supporting the delivery of Safety Functions will be connected automatically to the emergency diesel generators.

Fuel storage facilities enabling the emergency diesel generator to operate continuously for seven (7) days are provided inside the power station site.

The main loads connected to each of the emergency diesel generators are those belonging to the following systems;

○Emergency diesel generator (Division I)
Residual Heat Removal System
Reactor Auxiliary Cooling System
Ventilation and Air-conditioning Systems (such as Main Control Room, Emergency Diesel Generator Room)
Storage Battery chargers
Standby Liquid Control System
Emergency Gas Treatment System
Flammability Control System
Instrumentation and Control Equipment

○Emergency diesel generator (Division II)
High-Pressure Core Flooder System
Residual Heat Removal system
Reactor Auxiliary Cooling System
Ventilation and Air-conditioning Systems (such as Main Control Room, Emergency Diesel Generator Room)
Standby Liquid Control System
Emergency Gas Treatment System
Flammability Control System
Storage Battery Chargers
Reactor Containment Vessel Isolation Valve
Instrumentation and Control Equipment

○Emergency diesel generator (Division III)
High-Pressure Core Flooder System
Residual Heat Removal system
Reactor Auxiliary Cooling System
Ventilation and Air-conditioning Systems (such as Emergency Diesel Generator Room)
Storage Battery Chargers
Reactor Containment Vessel Isolation Valve
Instrumentation and Control Equipment

Table 2 shows the loads allocated to each division.

Table 2 Class 1 safety bus loads allocated to each division

Division-I	Division-II	Division-III
RHR RCW RSW E D/G supporting system HECW SPCU HVAC (MCR, electrical equipment room, pump room, E D/G room) SLC CAMS FPC CUW SPCU HPIN SAM SGTS FCS Power supply to C&I (AC, DC, UPS)	RHR HPCF RCW RSW E D/G supporting system HECW HVAC (MCR, electrical equipment room, pump room, E D/G room SLC CAMS FPC CUW SPCU HPIN SAM SGTS FCS Power supply to C&I (AC, DC, UPS)	RHR HPCF RSW RCW E D/G supporting system HVAC(electrical equipment room, pump room, E D/G room) Power supply to C&I (AC, DC, UPS)

The detailed information about the load will be described in supporting documents (such as “Emergency Diesel Generator System System Design Description” and “Emergency Diesel Generator System Capacity Calculation Report”) in the following GDA steps.

4.5 Alternative AC generators in the Backup-Building (B/B Class2 A/G)

Two (2) B/B Class 2 A/Gs, and associated equipment are installed in the backup-building (medium-voltage A/G in system 1 and low-voltage A/G in system 2). The A/Gs are rated to supply power to backup-building equipment when off-site power is lost. For example A/G supplies power to FLSS in Class 2 which consists of two (2×100%) systems.

If the power of the B/B Class 2 medium-voltage bus in system 1 is lost, circuits connected to the bus are interrupted except the power transformer and the motor control center connected to the B/B Class 2 low-voltage buses. After the voltage and frequency of the alternative AC generator in system 1 has reached its rated value, the alternative AC generator is automatically connected to the B/B Class 2 medium-voltage bus, and power supply to the backup-building equipment in system 1 becomes possible.
Similarly, if the power of the B/B Class 2 low-voltage bus (Power Center: P/C) in system 2 is lost, the receiving C/B of the P/C is opened. After the voltage and frequency of the A/G in system 2 has reached its rated value, the A/G is automatically connected to the B/B Class 2 P/C, and power supply to the backup-building equipment in system 2 becomes possible.

Fuel storage facilities enabling the alternative AC generators to operate continuously for about (7) seven days are provided.

As explained above, A/Gs are installed in the back-up building so as to supply power to FLSSs and associated supporting systems, but the A/G of back-up building system 1 can also serve as power supply to any one safety Class 1 medium-voltage bus to support the ECCS function by using the bus coupling line between back-up building and the safety Class 1 medium-voltage bus. The connections between the Class 1 medium-voltage bus and M/C-B/B1 are achieved by remote manual operation. Further explanation of the safety interlocking systems applied to this design will be provided in “Interlock Block Diagram for electrical power distribution system”.

The power supply system of B/B is designed to be diverse from safety Class 1 power supply system, and the way that diversity is achieved will be described in supporting document (“Diversity Strategy Report”).
A/G in system 1 has the enough capacity to support one division of ECCS and its own load on the B/B Class 2 bus.

The detail of the system design and capacity evaluation for the A/G system will be described in supporting document (“Alternative Generator System System Design Description”)

4.6 DC Power Supply System

There are four groups of DC power supply system as below.

- Safety Class 1 115V DC power supply system
- Safety Class 2 115V DC power supply system
- Non safety class 230V DC power supply system
- B/B Class 2 115V DC power supply system

The detail of architecture and load list will be described in supporting documents (such as “DC Power Supply System System Design Description” and “DC Power Supply System Capacity Calculation Report”) in the following GDA steps.

The safety Class 1 DC power supply system supplies power to SSCs required to perform Category A safety functions in the event of station blackout. This includes electrical power to safety C&I equipment including the Class 1 ECCS system.

Since the safety logic of the UK ABWR consists of four channels (2 out of 4 logic), there are four divisions of safety Class 1 DC power supply system.

Each division consists of one (1) charger that receives power from one of the safety Class 1 MCCs, a battery that is kept at float charging status by this charger, a main DC distribution panel and a sub DC distribution panel for supplying 115V DC power to DC loads of that division.

Two (2) common standby chargers are installed, each common to two divisions for use as backup during maintenance power outage of the upstream 420V AC P/C / MCC. The standby chargers are not connected during plant normal operation. An interlock scheme is installed for each standby charger to ensure that it is only fed from 1 AC bus and does not simultaneously supply power to two divisions.

The batteries are designed to have enough capacity to drive all the loads required for the bounding design basis fault sequence for eight hours. Also, as measures to beyond design basis faults, the battery of Division I can supply power to the equipment needed for depressurization, feeding water and monitoring of the reactor for 24 hours.

The safety Class 2 DC power supply system is provided as an uninterruptible standby power supply for loads of the normal Class 2 C&I equipment. The normal Class 2 C&I equipment is based on two (2) x 100% systems, so the normal 115V DC power supply system is divided into two groups (A and B). This power supply has a charger and storage battery for each system.

Each system is composed of one charger that receives power from a MCC which can be supplied from an E D/G, a battery that is kept at float charging status by this charger, a main distribution panel and a sub-distribution panel for supplying power to 115V DC instrument and control device loads of the normal system.

A tie line is installed so that the other charger can supply power during maintenance of one charger. A standby charger is not installed. This tie line is only used during maintenance and is not used during plant normal operation.

The non-safety class 230V DC power supply system is provided to supply power to unclassified DC loads such as motors for plant investment protection (e.g. emergency oil pump).
The normal non Class 230V DC power system consists of one charger that can receive power from one of two MCCs which can be supplied from E D/Gs, a battery that is kept at float charging status by this charger, main distribution panel and a sub-distribution panel for supplying power to loads (e.g. 230V DC power to DC motors).

A standby charger is installed to prevent discharge of the battery in the event of maintenance or failure of the main charger.

An interlock scheme is installed to ensure that the main charger receives AC power from only one of the upstream MCCs which can be supplied from E D/Gs. AC power is manually switched over during maintenance of one of the upstream MCCs.

The B/B Class2 115V DC power supply system supplies power to safety C&I equipment in the backup-building which is needed to realize the function of Class 2 FLSS. Since the FLSS is consists of two (2)×100% systems, this power supply system is divided into two groups (DC bus 1 and DC bus 2).

The B/B Class2 115V DC power supply system is designed to be diverse from the safety Class1 115V DC power supply system. The way that diversity is achieved will be described in supporting document ("Diversity Strategy Report").

Each system is composed of one charger that receives AC power from one of the B/B Class 2 MCCs (B/B MCC 1 / 2), a battery that is kept at float charging status by this charger, a main distribution panel and a sub-distribution panel for supplying power to the B/B Class 2 loads.

One (1) common use standby charger is installed as backup for the two systems to be used during maintenance of the upstream AC P/C and MCC. This standby charger is not connected during plant normal operation. An interlock scheme is installed to ensure that the standby charger is only fed from 1 AC bus and does not simultaneously supply power to two divisions.

4.7 AC Instrumentation Power Supply System

The AC instrumentation power supply system consists of six (6) groups as follows:

- Safety Class 1 uninterruptible AC power supply system (Class 1 AC UPS)
- Safety Class 3 UPS (Class 3 AC UPS)
- Safety Class 1 AC instrumentation and control power supply system (Class 1 AC I&C PS)
- Safety Class 2 AC instrumentation and control power supply system (Class 2 AC I&C PS)
- Safety Class 3 AC instrumentation and control power supply system (Class 3 AC I&C PS)
- B/B Class 2 AC instrumentation and control power supply system (B/B Class 2 AC I&C PS)

The detail of architecture and load list will be described in supporting documents (such as "Uninterruptible AC Power Supply System System Design Description" and "Instrument and Control Power Supply System System Design Description") in the following GDA steps.

(1) Class 1 AC UPS

The Class 1 AC UPS supplies power to Class 1 instrument and control systems which cannot tolerate momentary power failure, such as the reactor protection system (4 divisions), radiation instrumentation and turbine control system.
It is normally supplied from safety Class 1 Motor Control Centers (MCC).

It is also supplied from the safety Class 1 115V DC power supply system so that it can supply power to essential loads in the event of and during loss of on-site AC power.

Since the safety logic of the UK ABWR consists of four channels, four divisions of safety class1 AC UPSs are provided. There are three divisions of safety Class 1 AC power supply systems (three emergency diesel generators), so the Class 1 AC UPS DIV-I, DIV-II and DIV-III are supplied from the Class 1 AC power supply system of each division, and the Class 1 AC UPS in DIV-IV is supplied from a Class 1 MCC AC power supply system DIV-II.

Each division of the Class 1 AC UPS therefore consists of:

- Class 1 AC static type UPS device powered from a Class 1 MCC located in the control room building.
- Standby AC supplied via a standby transformer fed from MCC which can be supplied from E D/G located in the reactor building.
- Class 1 115V DC supply
- A load distribution panel

(2) Class 3 AC UPS

The safety Class 3 AC UPS system supplies power to the Class 3 plant process computer system. It receives AC power from MCCs (which can be supplied from E D/Gs) located in the control room building or DC power supply from the plant process computer dedicated battery.
Two (2)×100% Class 3 AC UPS systems are installed (main and back-up) to enable continuous operation of the computer monitoring system during system failure or maintenance.

Each system consists of:

- Class 3 static type UPS device
- Standby AC supply to plant process computer from a reactor building MCC which can be supplied from an E D/G
- Load distribution panel
- Process computer dedicated battery
- Common battery charger

(3) Class 1 AC I&C Power Supply

The Class 1 AC I&C PS systems supply power to the main control room AC 120V power distribution panels. In the event of loss of off-site power, this power supply is interrupted until the power supply from the emergency diesel generator(s) is available.

There are three (3), safety Class 1 AC I&C PS systems corresponding to the number of safety Class 1 AC power supply systems. Each system receives power from a safety Class 1 MCC of each division, and supplies power at 120V AC single-phase to instrument and control devices of each division during normal plant operation, at startup and shutdown, and during plant outage period.

These safety, Class 1 AC I&C PS systems supply AC power to Class 1equipment such as the Containment Atmospheric Monitoring System (CAMS).
Each system is structured to be able to receive power from a normal MCC in the case of maintenance outage of the Class 1 P/C or MCC.

(4) Class 2 AC I&C Power Supply

The safety Class 2 AC I&C PS systems supply power to the Class 2 R/B, T/B I&C loads.

Safety Class 2 AC instrumentation power supply systems are installed for the reactor building and turbine building. Each system receives 420V AC power from either of 2 MCCs in different divisions, which can be supplied from E D/G.

Power is transformed to 120V single-phase and supplied to instrument and control devices during normal plant operation, at startup and shutdown, and during plant outage period.
In the event of loss of off-site power, this power supply to the R/B and T/B is interrupted until the power supply from relevant E D/G starts.

(5) Class 3 AC I&C Power Supply

The safety Class 3 AC I&C PS system supplies power to the Class 3 Radwaste building (Rw/B) I&C loads.

The system can receive 420V AC power from either, an MCC which can be supplied from E D/G or the Class 3 Rw/B MCC. Power is transformed to 120V single-phase and supplied to instrument and control devices during normal plant operation, at startup and shutdown, and during plant outage period.

(6) B/B Class 2 AC I&C Power Supply

The B/B Class 2 AC I&C PS systems supply power to the Class 2 B/B I&C loads. Two (2)×100% Class 2 systems are provided in backup-building supplied from the backup-building low-voltage buses.

The systems supply power to the equipment necessary to fulfill the functions of backup-building such as the Class 2 FLSS groups.

In consideration of CCF, the safety Class 1 AC I&C PS and the B/B Class 2 AC I&C PS are designed to be diverse. The way that diversity is achieved will be described in supporting document ("Diversity Strategy Report").

The Class 2 B/B I&C loads in system 1 and system 2 normally receive power from B/B MCCs 1 and 2. These systems are able to receive power from the common Class 2 B/B MCC in case of maintenance of B/B Class 2 P/C or MCC.

4.8 Communication System

Communication systems are composed of a paging system and a telephone system.

The paging system is designed to instruct and to alarm from the main control room to each place in the plant during normal operations and emergency conditions.

The telephone system is designed to communicate within the plant and external organizations.

The paging system is used during plant normal operation and emergency condition, so it is classified into none class and Class 3.

The telephone system is also used during emergency conditions within the plant and to external organizations, so it is classified into Class 3 and Class 2.

The detailed functions of the paging system and telephone system are described in the supporting document (" Communication System Specification").

4.9 Lighting System

Normal AC lighting system is powered from normal AC low-voltage buses. Emergency AC (Class 3) lighting system in the main control room and evacuation passages is powered from emergency AC low-voltage buses. Emergency (Class 2) DC lighting is also provided and is powered by storage batteries in case of loss of normal AC power and emergency AC power.

Lighting in rooms used under plant normal operation is classified into non class and is considered as part of the normal AC lighting system. Furthermore, lighting in main rooms of C/B, R/B, T/B used during LOOP is classified into Class 3 and includes normal AC lighting system and emergency AC lighting, system. Lighting, in rooms such as the main control room, diesel rooms and emergency electrical panel rooms is classified into Class 2 and includes normal AC lighting system, emergency AC lighting system and emergency DC lighting system.

Detail functions of normal lighting system and emergency lighting system are described in the supporting document ("Lighting and Service Power System Specification").

4.10 Earthing System

The Earthing System is designed to prevent earth fault currents, which occur during faults, from causing physical injuries and equipment damages, minimize noise and interference and protect equipment from lightning strikes.

Earthing systems are established as multiplex earthing conductors in building and in the ground.

Earthing systems are classified as Class 1, 2 and 3 and non-class according to classification of equipment and panels.

Equipment is earthed by earthing conductors installed in each building. The detail specifications of earthing system are described in the supporting document (“Earthing System Specification”).

5. Reference

[Ref-1] “C&I Design and Preliminary Safety Case” (GA91-9901-0001-00001, Rev.B)
[Ref-2] “Categorization and Classification of Systems, Structures and Components” (GA91-9901-0007-00001, Rev.B)
[Ref-3] “Codes and Standards Report” (GA91-9901-0008-00001, Rev.B)

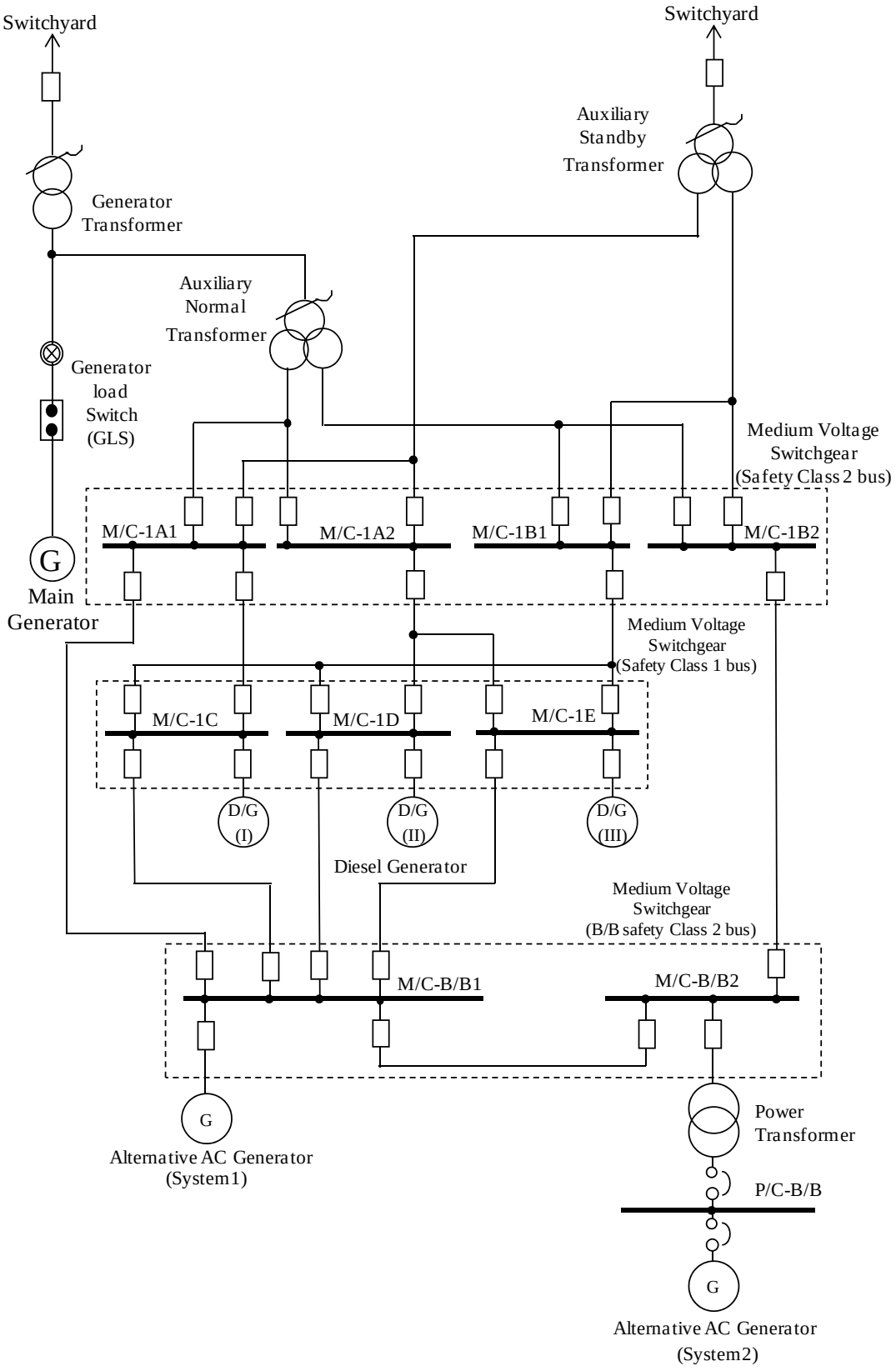

Figure 1 Single line diagram of auxiliary power supply system

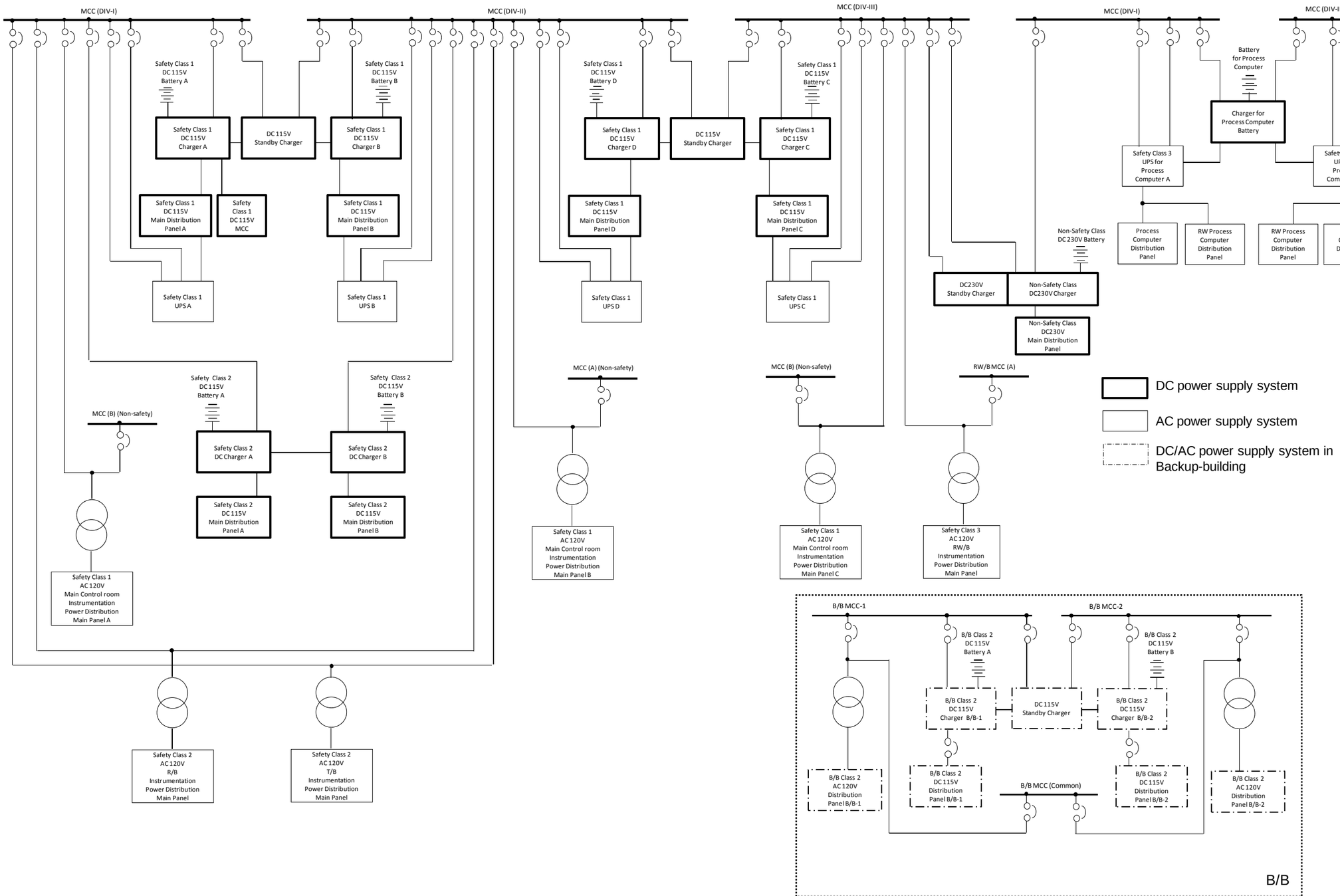

Figure 2 Single line diagram of power supply system for Instrumentation and Control System