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UK ABWR

Document ID	:	GA91-9101-0101-15003
Document Number	:	EE-GDA-C283
Revision Number	:	A

UK ABWR Generic Design Assessment

Generic PCSR Sub-chapter 15.3 : Architecture

Hitachi-GE Nuclear Energy, Ltd.

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Table of Contents

15.3.1 Electrical Distribution System

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 the 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 3 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 the equipment having a principle role in delivering safety is connected to the B/B Class 2 buses. Other equipment is connected to safety Class 3 buses.

The on-site power sources comprise of:

- 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) divisions safety Class 1 power source
One (1) DC non safety class power source for plant investment protection
Two (2) divisions DC safety Class 2 power source for safety Class 2 instrumentation
Two (2) divisions DC B/B Class 2 power systems for the backup-building

Figure 15.3-1 shows the overview of the auxiliary power distribution system.

15.3.2 Electrical Systems

The purpose of the electrical system is to transmit electrical power generated at the power station to the external grid and secure safety of the power station during both normal operation and fault conditions by ensuring the supply of electrical power to equipment necessary to carry out safety functions.
The electrical system mainly consists of the systems below.

(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 the safety Class 1 buses are supplied from the E D/Gs.

(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.

(3) Auxiliary Medium Voltage Distribution Buses

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

Safety Class 3 buses - supplied from ANT or AST

Safety Class 1 buses - supplied from safety Class 3 medium voltage buses or E D/Gs

B/B Class 2 buses - supplied from safety Class 3 medium voltage buses or A/Gs

(4) Emergency Diesel Generators (Safety Class 1 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.

(5) Alternative AC generators in the Backup-Building (B/B Class 2 A/Gs)

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/Gs supply power to FLSS in Class 2 which consists of two (2×100%) systems.

(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 safety Class 1 DC power supply system supplies power to structures, systems and components (SSCs) required for the performance of Category A safety functions in the event of station blackout. This includes electrical power to safety control and instrumentation (C&I) equipment including the Class 1 C&I system regarding the emergency core cooling system (ECCS).

The safety Class 2 DC power supply system is provided as an uninterruptible standby power supply for loads of the safety Class 2 C&I equipment. The safety Class 2 C&I equipment is based on two (2) × 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.

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).

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).

(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 UPSs)
・Safety Class 3 UPS (Class 3 AC UPSs)
・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 Class 1 AC UPSs supplies power to Class 1 instrument and control systems which cannot tolerate momentary power failure, such as the reactor protection system (4 divisions), radiation monitoring and turbine control system.

The safety Class 3 AC UPS systems supply 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.

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.

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

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

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.

Figure 15.3-1 shows the overview of the auxiliary power distribution system, and figure 15.3-2 shows the overview of the instrumentation and controlling power supply system.

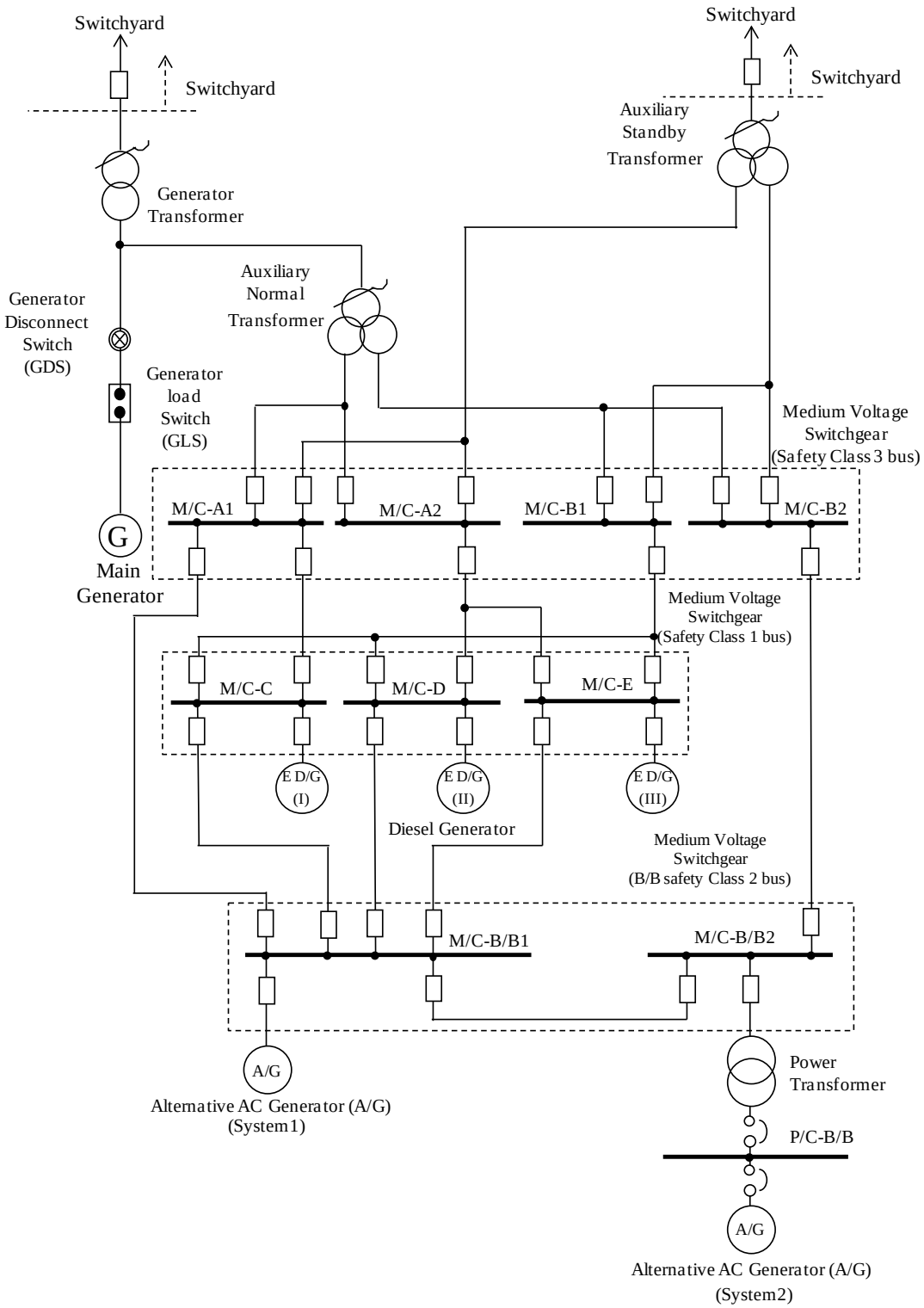

Figure 15.3-1: Single Line Diagram of Auxiliary Power Supply System

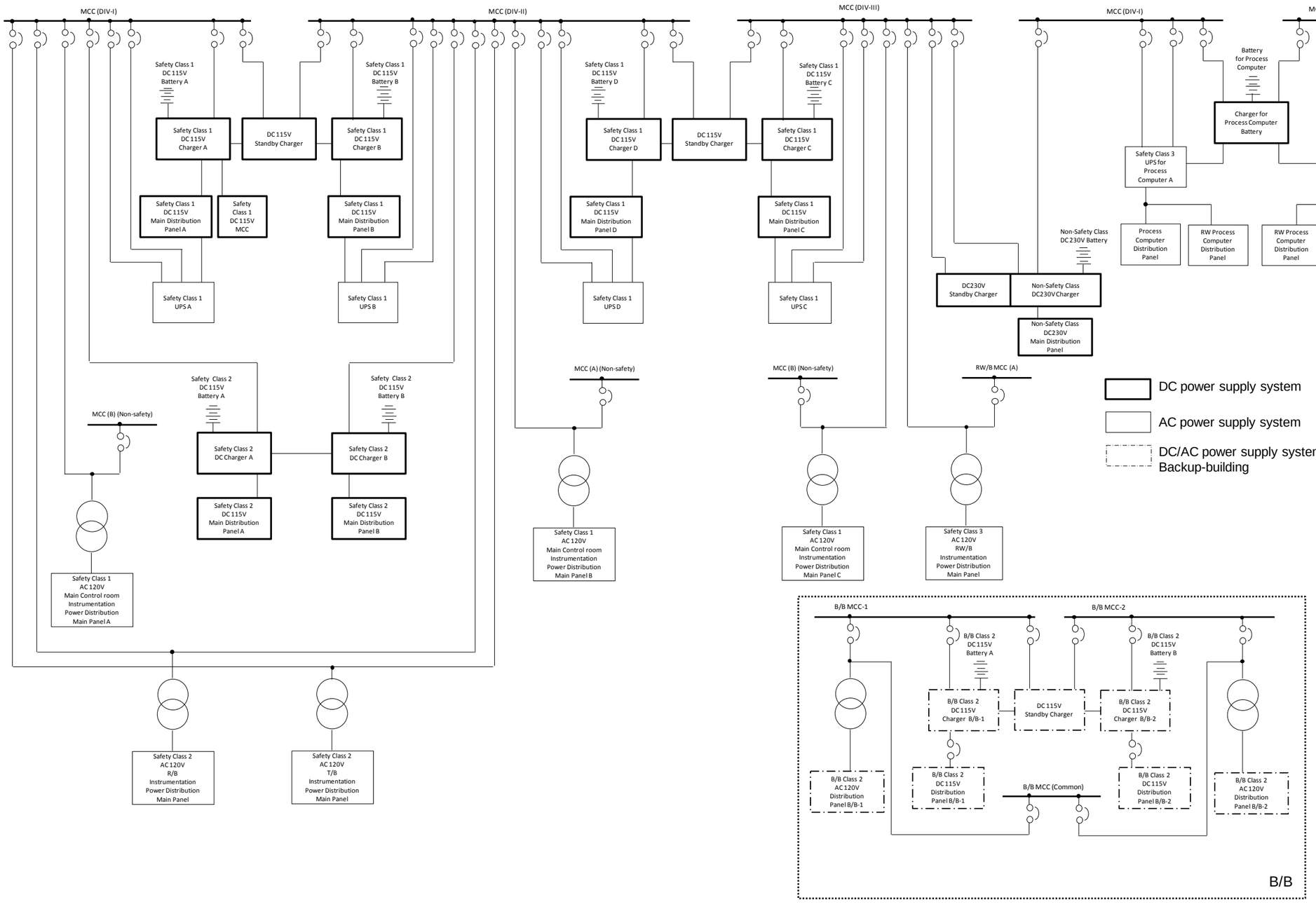

Figure 15.3-2: Single Line Diagram of Power Supply System for Instrumentation and Control System

15.3.3 Protection against Common Cause Failure

This section describes the arguments and evidence corresponding to a set of safety requirements for Common Cause Failure (CCF). They define all the considerations taken into account in terms of the prevention of CCF to meet all the safety requirements.

For details, refer to “Diversity Strategy Report”.

15.3.4 References

[Ref-1] “Basis of Safety Case on Electrical Engineering” (GA91-9201-0002-00033, Rev0)
[Ref-2] “Electrical Power Distribution System System Design Description”
(GR10-1001-0001-00001, Rev.0)
[Ref-3] “Emergency Diesel Generator System System Design Description”
(GR43-1001-0002-00001, Rev.0)
[Ref-4] “Diversity Strategy Report” (GA33-9920-0001-00001, Rev.0)
[Ref-5] “Alternative Generator System System Design Description”
(GR44-1001-0002-00001, Rev.0)
[Ref-6] “DC Power Supply System System Design Description”
(GR42-1001-0001-00001, Rev.0)
[Ref-7] “Uninterruptible AC Power Supply System System Design Description”
(GR46-1001-0001-00001, Rev.0)
[Ref-8] “Instrument and Control Power Supply System System Design Description”
(GR47-1001-0001-00001, Rev.0)
[Ref-9] “Single Line Diagram (High Voltage)”
(GA33-2201-0001-00001, Rev.0)