

UK ABWR

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UK ABWR Generic Design Assessment

Generic PCSR Sub-chapter 15.2 : Safety Principles and Standards



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15.2.1 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, faults during operation and post shutdown.

15.2.1.1 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.

15.2.1.2 On-site Power System

- (a) The safety Class 1 on-site power sources (emergency diesel generators (E D/Gs), safety Class 1 storage batteries and power supply equipment related to these) have redundancy, are physically separated and are independent from each division.
- (b) The safety Class 1 on-site power sources (E D/Gs, safety Class 1 storage batteries and power supply equipment related to these) have sufficient capacity and function in order to be able to shut down 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.
- (c) The Class 1 medium voltage Division I, II and III buses, and associated E D/Gs, low voltage distribution systems, and AC instrumentation and control power supply systems, and Division I, II, III and IV Class 1 Uninterruptible Power Supplies (UPSs) and DC power supply systems conform to Seismic Category 1 requirements.
- (d) The Backup-Building (B/B) Class 2 power sources (B/B Class 2 storage batteries, B/B Class 2 Alternative AC Generators (A/Gs) and power supply equipment related to these) have redundancy, are physically separated and are independent from each division.

- (e) The B/B Class 2 power source (B/B Class 2 storage batteries, B/B Class 2 A/Gs and power supply equipment related to these) have sufficient capacity and function in order to be able to supply power to the B/B equipment, in particular the Flooder System of Specific Safety Facility (FLSS), which is the second line means of providing the Emergency Core Cooling System (ECCS) function when off-site power is lost.

15.2.1.3 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.

15.2.1.4 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, fault conditions during operation or post shutdown.

15.2.1.5 Safety System Logic and Control Power Supply System

In order to provide redundant, reliable power of acceptable quality and reliability to support the safety system logic and control (SSLC) functions during normal operation, transient events, fault conditions during operation or post shutdown.

- (a) SSLC for ECCS has four separate and independent safety Class 1 DC power supply systems.
- (b) SSLC for the reactor protection system (RPS) has four separate and independent safety Class 1 UPSs each backed by separate safety Class 1 batteries.

15.2.1.6 Controls and Indications

The UK ABWR electrical system design provides controls and indications, and the specific design bases are described as follows.

- (a) The UK-ABWR electrical system provides controls and indications in the main control room

Displays provided for the main generator include the main generator output voltage, amperes, watts, VARS and frequency. Displays provided for the electrical power distribution system include safety Class 1 and Class 3 medium voltage switchgear (M/C) bus voltage, incoming amperes and circuit breaker positions. Controls are provided for the generator load switch (GLS), the generator disconnecting switch (GDS), the field switch (FS), M/C feeder circuit breakers, the load circuit breakers from the M/C to their respective low voltage power center (P/C), P/C incoming circuit breakers and P/C bus coupling circuit breakers.

- (b) The design provides for control and indications outside the main control room

The electrical power distribution system displays and controls are also provided at the remote shutdown system (RSS) panels. Displays on the two panels provided include bus voltage for the safety Class 1 Division I and II M/C. Controls are provided for the incoming circuit breakers and E D/G circuit breakers of safety Class 1 Division I and II M/C, the load circuit breakers from the M/C to their respective safety Class 1 Division I and II low voltage P/C, safety Class 1 Division I and II P/C incoming circuit breakers, and safety Class 1 Division I and II P/C bus coupling circuit breakers.

15.2.1.7 Testing Availability

The safety electrical systems (E D/Gs, A/Gs, 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) E D/Gs and A/Gs

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 Class 1 and B/B Class 2 batteries

Safety Class 1 and B/B Class 2 batteries are at floating charge status at all times and the conditions (voltage etc.) of the batteries can always be checked.

15.2.2 Safety Requirements

This section describes the safety requirements applicable to the electrical power supply system. The safety requirements will be presented in the form of a Claims Arguments Evidence structure which will be developed in detail in the BSC [Ref-1].

Top level claims are set out in the following section :

15.2.2.1 Top Claims of the Electrical Power Supply System

- TC1: The electrical power supply system is designed in accordance with its safety functional requirements defined from the safety analysis.
- TC2: The electrical system architecture supports the SSC's providing Category A safety functions required for frequent faults. This requires 2 independent and diverse provisions. The first line provision is implemented by a Class 1 system, the second line provision is implemented by Class 1, 2 or 3 systems as required by the reliability and risk reduction assessment.
- TC3: Where functions are claimed to be independent in the safety analysis they will be assigned to independent systems in the electrical power supply system.
- TC4: The divisions of the safety Class 1 and B/B Class 2 power supply systems are designed to be physically and electrically separated from each other thus ensuring independence among the divisions as much as possible.
- TC5: The safety Class 1 power supply systems and B/B Class 2 power supply systems are designed to be diverse from each other as much as practically possible.
- TC6: Classification, independence, redundancy and diversity requirements placed on Structures Systems and Components (SSCs) is applied in principle to the design of the electrical power supply system and associated support systems including C&I, HVAC and cooling systems.
- TC7: Provision will be made in the design to protect against the common cause failure (CCF) of the safety Class 1 power supply system and the B/B Class 2 power supply system.
- TC8: The electrical equipment is designed to be robust to a wide range of electrical transients assumed during plant operation and to the assumed environmental conditions.
- TC9: The electrical system shall be designed to be robust to internal hazards. Electrical faults will be contained and cleared so as not to affect other equipment.
- TC10: The electrical system shall be designed to be robust to external hazards.
- TC11: The electrical power supply system has several levels of provision to supply electrical power in order to secure the safety of the power station during both normal operation and accidents without losing all of the on-site power.
- TC12: Safety measures to deliver the safety functions will be automatically initiated.

15.2.2.2 Categorisation and Classification

Table 15.2-1 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-2]” and will continue to be developed in following GDA steps.

Since the electrical systems are support to the plant systems, the 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-3]” for overall information of C&C.

Table 15.2-1: Preliminary assumption of C&C of the Electrical System

		Classification			
		1	2	3	N
Category	A	<ul style="list-style-type: none"> • 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) 	<ul style="list-style-type: none"> • 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	--	<ul style="list-style-type: none"> • Safety Class 2 DC 115V • Safety Class 2 AC (for C&I) • Communication System (telephone for safety Class 2) • Lighting System (Emergency AC, DC for safety Class 2) 	<ul style="list-style-type: none"> • Safety Class 3 AC buses • Earthing System (for safety Class 3) • Switch Yard • Generator • Excitation system • AST, GT, ANT • IPB, NPB • GLS, GDS 	--
	C	--	--	<ul style="list-style-type: none"> • 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	--	--	--	<ul style="list-style-type: none"> • 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-2] and [Ref-3].

15.2.3 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-4].

For reference, in addition to the industry standards, Japanese ABWR electrical engineering is subject to Japanese Safety Design guide # 48 (electrical system).

15.2.4 References

[Ref-1] “Basis of Safety Case on Electrical Engineering”

(GA91-9201-0002-00033, Rev.0)

[Ref-2] “Preliminary Safety Report on C&I” (GA91-9901-0001-00001, Rev.B)

[Ref-3] “Categorisation and Classification of Systems, Structures and Components”

(GA91-9901-0007-00001, Rev.B)

[Ref-4] “Codes and Standards Report” (GA91-9901-0008-00001, Rev.B)