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Replacement Research Reactor Project

SAR CHAPTER 9
ELECTRIC POWER

Prepared By

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For

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9 ELECTRIC POWER

9.1 INTRODUCTION

This chapter describes the Electric Power Supply for the Replacement Research Reactor (Reactor Facility), which is made up of the Normal Power System (NPS) and the Standby Power System (SPS). Emphasis is placed on the dependability and adequacy of the various electric power supplies, and their relationship to safety. Functionality, use of good engineering practice, compliance with standards and ease of testing is established.

Reactor operation requires the availability of off-site electric supply and the Normal Power System (NPS). Total loss of off-site supply or NPS causes a reactor shut down. The NPS includes the High Voltage distribution board in the Reactor Facility Substation Auxiliary Building, and downstream equipment (with the exception of the SPS), finishing at motor control centres and distribution boards for lighting, general purpose outlets and supplies to packaged plant such as the HVAC systems.

The Standby Power System (SPS) is an Engineered Safety Feature. This system is appropriately qualified. It is normally powered by the NPS, but contains standby diesel generators to ensure supply during loss of Normal Supply. It also includes Uninterruptible Power Supply units to ensure continuity of supply to selected loads during the short delay between loss of Normal Supply and availability of supply from the diesel generators.

The design is based on design requirements, good engineering practices, and the requirements of the appropriate standards of the Institute of Electrical and Electronics Engineers (IEEE) and Australian Standards. In addition, International Atomic Energy Agency (IAEA) guidance is considered.

An outline of the power systems, a detailed description of the three different sources of electrical power for the facility, and associated safety issues follow. Subsequent sections deal with cabling and routing of cables, the earthing systems of the facility, the safety features of important components of the system and the operating modes of the two electric power systems. The design is evaluated against the design requirements. The scenario analysis, diagrams and load summaries complete the chapter.

End of Section

9.2 DESIGN REQUIREMENTS

There are three groups of loads that are supplied with electric power:

a) Equipment that is designed to function only while the normal power supply is available,

b) Equipment that is designed to function even when the normal power supply is interrupted, but can tolerate a brief interruption of supply,

c) Equipment that is designed to function even when the normal power is interrupted and can not tolerate any interruption to its power supply.

In addition to these supply requirements, the safety category of the load is a consideration.

9.2.1 Normal Power System (NPS)

SAR Chapter 2 provides design requirements for the NPS. These are summarised as follows:

a) Reliably provide electric power of acceptable quality to the equipment in the Reactor Facility that is required to function only when normal power is available, and to the SPS during these times,

b) Have sufficient separation from instrumentation and control systems and other systems so that it does not cause interference to them,

c) Be tolerant to equipment faults so that the impact of any equipment failure is minimised,

d) Provide power in a manner that will minimise electrical hazards to personnel, or equipment

9.2.2 Standby Power System (SPS)

SAR Chapter 2 provides design requirements for the SPS. These are summarised as follows:

a) Include a design that has two separated trains capable of supplying electric power of acceptable quality to loads that are important to nuclear safety, and also to some safety-related loads, even when normal power is unavailable,

b) Be constructed as an ESF, and meet the applicable requirements identified in Section 2.4.10.

c) Provide a reliable source of power under all design basis conditions.

d) Provide power in a manner that will minimise electrical hazards to personnel.

9.2.3 Design Conditions

Offsite Power Supply Conditions and Events:

System Voltage	11 kV, 3-phase, 50 Hz
System Fault Level	250 MVA (3-phase) as required by the supply authority
Supply Variations	Voltage ± 6% Frequency -6%, +4%
Voltage Spikes	Frequent

Seismic Events: Refer to Chapter 2, Section 2.5 and 2.6.

Radiation Exposure Conditions: Refer to Sections of Chapter 2 where design criteria adopted to minimise personnel exposure to radiation are presented.

Definitions of safety categories for this system are included in Section 9.3.1.

9.2.4 Qualification of Safety Category 1 Electrical Equipment

Electrical equipment that makes an important contribution to nuclear safety is qualified to a high standard. There are no appropriate Australian Standards fit for this purpose, therefore reference is made to international standards.

The available international Nuclear Standards (such as IEEE and associated standards) are written with the aim of providing guidance for the standby power systems in power producing reactors of a much large scale and different type of reactor than the small research, pool-type reactor.

The design of the diesel generator system is based on the use of three 100% capacity diesel generator units utilising high quality, commercially available components. The rest of the standby power system uses two 100 % capacity systems using IEEE and associated standards, where relevant, as the basis for system design, equipment procurement, installation and system operation, with careful consideration of the interface points.

The appropriate parts of the IEEE Standards for Class 1E Power Systems for Nuclear Power Generating Stations were used for guidance throughout the design of the SPS.

End of Section

9.3 DESCRIPTION OF SYSTEMS

A schematic single-line diagram of the electric power systems is shown in Figure 9.3/1. The NPS has the following source of power:

Normal Power	-	11kV AC incoming supply from the ANSTO Main Substation (2 feeders) and a 415 V AC supply from NPS main distributions switchboards

The ANSTO Main Substation is fed from two separate 33/11 kV transformers, each supplied from a separate zone substation. Two 11 kV feeders from the ANSTO substation supply two separate power "trains" (A and B) within the NPS. The switch configuration on the 33 kV and 11 kV systems allows these two trains to be connected together. From the High Voltage Switchboards, the power is fed to six transformers.

The two High-Voltage and three pairs of main Low-Voltage switchboards have bus-ties that can be used for interconnection of the two trains, so that they can be supplied from a single incoming line if required. The transformer ratings are sufficient to exceed this demand.

The SPS System has the following sources of power:

Normal Power	-	a 415 V AC supply from NPS switchboards MD-A & MD-B,
Standby Power	-	a 415 V AC supply from two dedicated diesel generators that are part of the SPS,
Uninterruptible Power	-	a 240 V AC supply from several Uninterruptible Power Supply units that are part of the SPS.

In the event of failure of the NPS, the SPS is automatically energised from the diesel generators. The two independent trains of the SPS cannot be connected. During normal operation they are connected upstream in the Normal Power Supply, either at low voltage or in the high-voltage network. The Class 1E isolation between the NPS and the 2 SPS trains ensures that faults cannot propagate from one SPS train to the other via the NPS. One Low Voltage Standby Distribution switchboard, SD-C, can be fed from either train using a manual changeover switching arrangement, but not from both trains simultaneously. When Normal Power is available, each train is fed from the associated Normal Supply train. When diesel generator power is required, the associated Standby Distribution (SD) switchboard is automatically disconnected from the Normal Power supply and connected to the standby diesel generator by means of an Automatic Transfer Switch. The Automatic Transfer Switches are, supplied from the diesel generators and NPS. Return to the Normal Power is a manual operation. There is no parallel connection of the diesel generators with the Normal Power supply or with each other.

Power circuits are separated from other electrical systems, including instrumentation, by distance and/or separate enclosure of circuits to avoid electrical disturbances.

9.3.1 Equipment Categories

NPS and SPS equipment is categorised as:

- Safety Category 1 - Being essential for nuclear safety (all SPS equipment),
- Safety Category 2 - Providing an additional contribution to nuclear safety,
- Safety Category 3 - Being the remainder of the power system.

The Safety Category 2 equipment that is required after a loss of NPS and can tolerate a short interruption of power is connected to the SPS through an appropriate isolation device that will maintain the integrity of the Category 1 system.

Uninterruptible Power Supplies (UPSs) are provided for some loads to allow them to operate without interruption. There are additional small UPSs in the facility for applications such as support of desktop PCs that do not relate to safety and are not part of the SPS. Batteries for applications such as High Voltage trip supplies are standard industrial equipment and are considered an integral part of items of equipment rather than a source of power to equipment fed from the system.

The main equipment of the NPS and SPS, such as the transformers, main low-voltage switchboards for the reactor area, diesel generators, UPS units and batteries, are all housed in separate locations with fire-rated walls or appropriate separation.

Guidance is taken from IEEE nuclear power standards, IAEA Safety Series 50-SG-D7 (Emergency power systems at nuclear power plants) and IAEA 2001 Research Reactors Safety Standard Series Draft DS272 for systems and equipment where appropriate. The electrical equipment is appropriately qualified using the previously mentioned standards for guidance (see section 9.2.4). This ensures rigorous quality practices in the supply of high-quality equipment and a highly fault tolerant configuration. Rigorous quality practices are employed for equipment that provides an additional contribution to nuclear safety, and design is of a higher standard than that of Safety Category 3 equipment. The Safety Category 3 equipment is to a standard consistent with good industrial practice.

9.3.2 Normal Supply

During normal plant operation, the Reactor Facility is fed from the High Voltage off-site electric power through the transformers. This is the Normal Power Supply. This power supply is not required for nuclear safety.

9.3.3 Standby Power Supply (diesel generators)

Essential loads (Safety Category 1 and some Safety Category 2 loads) are supplied by the Standby Power System (SPS). The SPS is an ESF.

Two diesel generators in the SPS are used to provide a source of power. Each diesel generator supplies one train of the SPS. Loss of voltage or degradation of the Normal power supply is sensed and used to initiate a transfer from Normal Power to the associated diesel generator. The diesel generators are designed to start and attain the required voltage and frequency to be able to accept a load within 1 minute. This includes the time for sequenced loads to be connected.

In addition to the two in-service units, a spare diesel generator that can be used to replace either of the in-service units during an extended maintenance outage is provided. The spare unit must be manually connected after the out-of-service unit is disconnected, ensuring that separation of the two standby power trains is maintained. The spare unit is located near the two in-service units and, like the two in-service units, is supplied from its own dedicated fuel tank. Each Diesel Generator has a dedicated DC supply for control and starting. There is no interconnection of the DC supplies for different diesel generator systems, including by diode sharing or any other method.

The Standby electric power equipment, with the exception of some electrical monitoring equipment, is seismically qualified. Such equipment is designed to maintain its structural integrity during a design basis earthquake and is capable of fulfilling its safety function following the event.

The diesel generators are installed sufficiently far apart to prevent common-mode failures from fires or wind-borne missiles. The separation distance is determined with reference to Australian Standards and IEEE Nuclear standards where appropriate as well as advice from security advisers.

Testing under load as recommended by the manufacturer of the diesel generators is allowed for. Underground bulk fuel tanks are situated west of the substation and located in close proximity to their respective diesel generator. Fuel lines are double-wall pipes. The bulk fuel tanks each have a capacity for at least seven days of fuel supply. The diesel generator capacity is sufficient to ensure that even in the unlikely event that all connected loads are on the diesel generators will not be overloaded. The ratings are sufficient to supply the total maximum demand of the SPS loads, including in-rush currents of UPS systems and motors.

Step load increases or the disconnection of the largest single load will not cause unacceptable transients. The diesel generators are protected during all modes of operation and testing by appropriate protective devices. The diesel generator power will also be interrupted if the diesel generator circuit breaker trips. Protective functions of the engine or the generator circuit breaker, and other abnormal conditions, are annunciated in the control room and locally

The seismic performance of the SPS was verified by specific technical analysis (see Section 9.5.2).

9.3.4 Uninterruptible Power Supplies

The function of the main UPS units is to provide reliable 240 VAC uninterruptible power to loads required for continuity of equipment operation in case of loss of Normal Power. Each main UPS consists of a battery-charger rectifier, batteries, DC/AC converter, static by-pass switch, maintenance by-pass switch and isolation transformers. On an interruption to the Normal Power Supply, and until Standby AC Power becomes available, long-life batteries support the Uninterruptible Power Supplies. Each Battery is separately housed in a ventilated room, and is separate from its charger. All the batteries are sized so that the designed loads will not exceed warranted capacity at the end-off-installed-life with 100% design demand. The batteries have sufficient stored energy to operate connected loads continuously or intermittently, as required.

The main UPS units are:

UPS-RPS1

UPS-RPS2

UPS-RPS3

UPS-RCMS

When power is restored to the Standby Distribution Switchboards, the battery charger of the UPS units will recharge the batteries while simultaneously supplying the inverter. The capacity of each UPS is based on the largest combined demand of the various continuous loads, plus the largest combination of non-continuous loads that are likely to be connected to the power supply simultaneously during normal or accident conditions, with provision for spare capacity.

All abnormal conditions of important system parameters, such as charger failure or low voltage, are annunciated in the control room and locally. Display for battery voltage, DC amperes, breakers/disconnect switch positions and earth-fault detection are provided in the control room.

The Safety System and Logic Control for the Reactor Protection Systems and the Post Accident Monitoring System derive their power from three independent Safety Category 1 UPS systems fed from different trains. These UPSs and the downstream power distribution systems are appropriately qualified (see section 9.2.4). This arrangement provides redundant, reliable power of acceptable quality to support the safety logic and control functions during normal, abnormal and post-accident conditions.

The Reactor Control and Monitoring System (RCMS) is fed from a dedicated Safety Uninterruptible Power Supply (UPS-RCMS) supported by a separate long-life battery. In the event of loss of Normal power, the UPS is fed from Standby Power through an isolation device that will maintain the integrity of the system. This arrangement provides reliable power of acceptable quality to support both the control and monitoring functions during Reactor Facility operation.

The Uninterruptible Loads of the Physical Security Systems are fed from a Main Uninterruptible Distribution Switchboard supplied by one dedicated Uninterruptible Power Supply (UPS-PSS) supported by a long-life battery. The UPS-PSS provides reliable power of acceptable quality to support both the control and monitoring functions of the Physical Security Systems during normal conditions.

9.3.5 System Operation

The operator is provided with accurate, complete and timely information pertinent to the system status. Monitoring includes switch position (on/off), supply voltage, load current and equipment faults for major items of equipment.

On loss of Normal Power, both diesel generators start and automatic switches connect the diesel generators to the SPS switchboards (after disconnecting the normal supply), without the need for human action. Equipment layouts are arranged so that adequate access for operation, testing and maintenance is available.

Some equipment can be tested during Reactor Facility operation; other equipment is tested during shutdown (e.g. main circuit breakers). Selected routine testing with guidance from Australian Standards is provided for.

In order to prevent unauthorised access to essential equipment of the power system, locking arrangements are provided. Switchgear panels, as well as individual circuit breakers and main switches, are provided with padlocking facilities. The performance of switching operations within the power system is controlled by means of systematic procedures and instructions.

Analyses of the different operational scenarios are presented in Section 9.6.

9.3.6 Electrical Protection

Simplicity of circuit arrangement facilitates the use of conventional, protective relaying practices for isolation of faults. Emphasis is placed on preserving function and limiting the loss of equipment function in situations of power loss or equipment failure. The protection system grading and coordination is based on fault-current analysis throughout the power system and on coordination with protection equipment at the source of the incoming supply. Electrical protection of the electrical equipment within the Reactor Facility is provided by suitable protection relays of appropriate Safety Category.

The fault ratings of switchboards, transformers, motor control centres, and distribution panels are equal to or greater than the maximum available fault current to which the equipment is exposed under all modes of operation until the fault is cleared.

9.3.7 Cables and Routing

Equipment rooms within the Reactor Facility Substation are arranged so that related equipment is configured to minimise the lengths of interconnecting cables. Cabling associated with nuclear safety is segregated using guidance from IEEE by means of physical distance and/or metallic barriers from other safety categories (see section 9.2.4). In addition, cables from the two power distribution trains are segregated from each other. Allocation of cable routes is based on the appropriate criteria of physical separation, protection, seismic effects and avoidance of single points of failure. The necessary physical space allocation in compliance with these criteria has been observed in the design. All cable runs are installed on a cable support system, located for ease of access and such that cables may be removed and replaced without disturbing adjacent cables.

The low-voltage power cables are low-smoke, halogen-free and fire-rated where appropriate. Power supply and sub-main cable routes are accessible where practical.

Physical separation of power cables from other cables has been observed to ensure that the power cables do not cause unacceptable electromagnetic interference with other systems.

Cables are protected from radiation damage where necessary. Supports for cable trays are suitable for the design-basis seismic events). Cables are rated in with guidance from AS 3008, including de-rating for the effects of mutual heating and ambient conditions. Provision is made for voltage drop with guidance from AS 3000.

9.3.8 Earthing

Earthing of electrical equipment serves to place a protective barrier between personnel and equipment developing an internal fault that would otherwise cause the equipment casing to become live. At the same time, earthing facilitates the operation of circuit protection devices (fuses and circuit breakers) to disconnect supply from the faulty equipment. In addition, earthing serves to limit the voltage on the circuit and/or equipment, which might otherwise rise through exposure to lightning, switching surges or the potential rise due to earth-fault conditions, and to reduce interference fields inside the buildings.

9.3.8.1 Facility Earthing

The facility is provided with a dedicated earth grid to satisfy the following objectives:

a) To keep the earthing system impedance sufficiently low as to maintain the earth potential rise to an acceptable value when faults on the 415V, 11kV and 33kV supply networks have been considered,

b) To keep touch and step voltages within the vicinity of the facility maintained at less than the hazardous potential differences prescribed for a line-to-earth fault on the of the 415V, 11kV and 33kV supply networks.

The facility earthing is formed by a combination of earth grid, earth electrodes and reinforcing system earthing. The design includes the power substation earthing system, the reinforced concrete earthing system and the High Voltage power supply earthing systems. The high-voltage supply cables have a continuous cable sheath bonded to the earthing system at the facility and at Lucas Heights Zone substation. This interconnects the earthing systems of the two installations and provides a metallic return path for 11kV faults. The neutral points of the power transformers are solidly connected to earth.

9.3.8.2 Instrumentation Grounding

The principal objective of Instrumentation and Control Earthing is to create a reference earth plane to which electronic hardware is connected and to minimise noise interference. The earthing system design is based on considerations of the equipment earth and the instrument earth.

The objective of the equipment earth is to prevent hazardous potentials by electrical power faults. Specifically, it refers to non-current carrying enclosures, such as cabinets, frames, racks and exterior housings of instrumentation and control systems.

The rejection of noise and provision of a uniform, reliable reference for instrumentation signals is the purpose of the signal earth.

The lightning system covers all the buildings and structures of the facility. In principle, the same considerations and rules that apply to common structures govern the lightning protection for the facility. However, since a reinforced-concrete construction is used for buildings, it is highly appropriate that the inherent advantages offered by this type of construction should be fully utilised for the purposes of lightning protection. When utilising the structures of the facility by correct bonding to the lightning-protective system of all internal and external constructional elements, the installation of separate down conductors becomes unnecessary. Furthermore, such a structure now approaches the condition of a Faraday cage, so that the risk of internal side flashing is practically eliminated.

The lightning protection system is designed with guidance from AS 1768. The Lightning Protection Assessment for the plant focuses on those areas of plant housing hazardous, flammable or explosive substances.

As the lightning earthing system is an integral part of the main earthing system for the site, it is coordinated with the requirements for corrosion minimisation (i.e. all below-ground connections or connections to the reinforcing are made either above ground or in a controlled location).

9.3.9 Distribution Equipment

This section provides a brief description of the major items of distribution equipment in the electrical power systems.

9.3.9.1 High Voltage Switchgear

The incoming 11kV supply from the ANSTO main substation terminates in the main Reactor Facility Substation at the 11kV Switchboards HV-A and HV-B.

HV-A and -B portions are arranged in the form of a single assembly, separated by the bus-section circuit breaker. Earthing facilities are provided at each panel.

The overall design of the Switchgear complies with the requirements of Australian Standards AS 2067 and AS 2086. The power System protection is provided by microprocessor controlled relays. The protection, control and tripping functions are operated from a separate, dedicated Rectifier-Charger and Battery System.

9.3.9.2 Transformers

Power transformers are sized as based on the respective maximum demands identified in the load summary, and their impedance coordinated with other equipment so that low-voltage switchboards, Motor Control Centres and panels are within the manufacturer's recommended ratings for interrupting capacity, and so that coordination of over-current devices is facilitated.

All transformers are standard oil-filled (ONAN) type, complying with Australian Standard AS 2374. Each transformer is mounted in a bund of sufficient volume to contain the oil from the transformer in case of a leak.

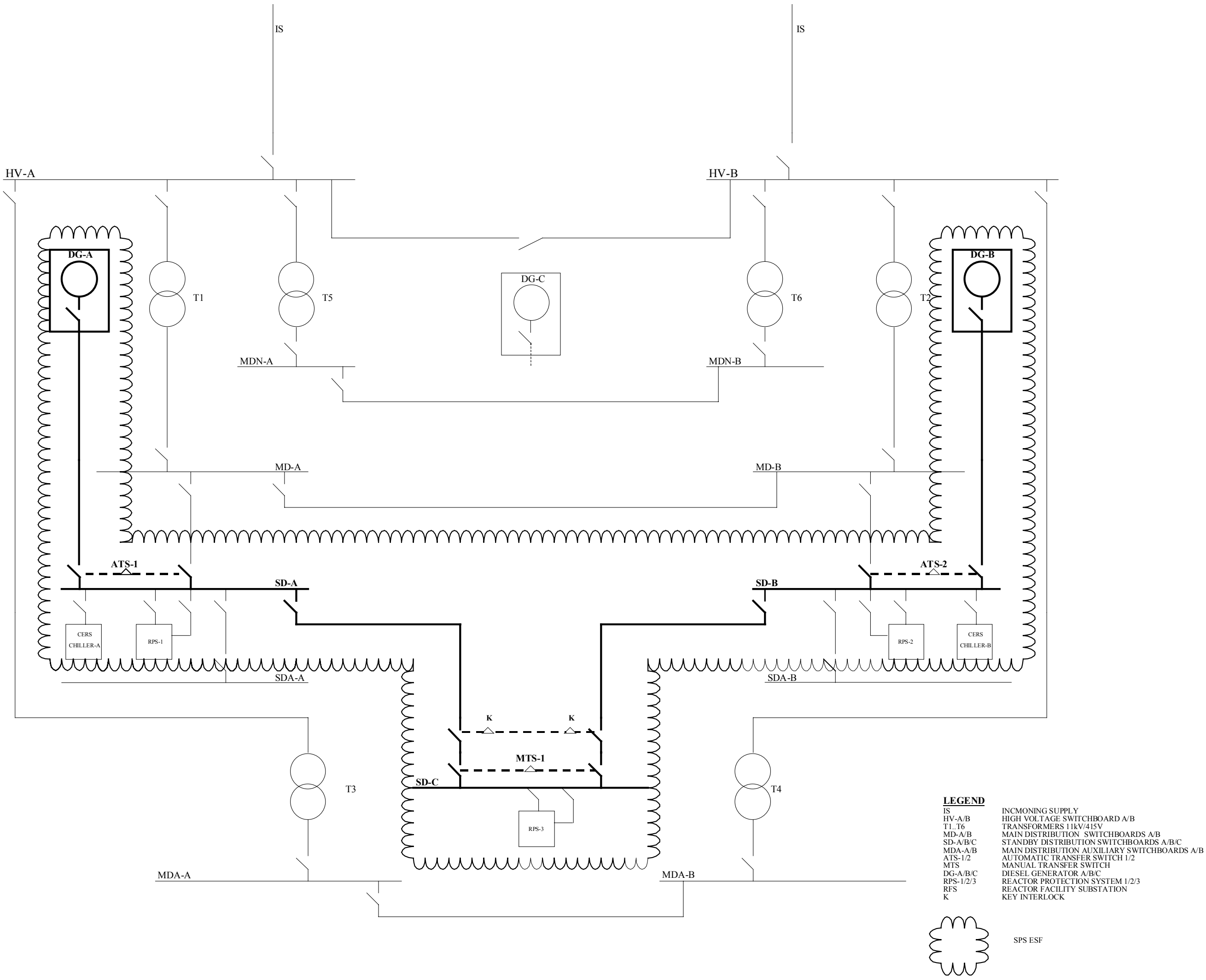
9.3.9.3 Low-voltage Switchboards and Motor Control Centres

Switchboards and motor control centres are ‘dead front’ sheet steel of the modular cubicle type, totally enclosed and conforming to AS 3439. Switchboards associated with nuclear safety, and any switchboard with rating greater than 100 Amps per phase and more than 10 kA breaking capacity, are Form 4 as specified by AS 3439. Arc-fault containment is provided for standby switchboards and large main switchboards. The minimum degree of protection is IP41. The switchboards are designed to withstand the specified fault conditions without presenting danger to personnel. Suitable venting away from operators is provided where arc-fault containment is required.

Outgoing cable connections within any one tier are segregated from other cable connections within the same tier as required by AS 3439.

End of Section

Figure 9.3/1 Power Supply Single Line Diagram



End of Figures

9.4 SIGNIFICANT LOADS

Types of loads that consume a significant amount of electric power are discussed below. The power requirements are set out in Section 9.7. The effect of motor starting on the system voltage level at various locations is within the limits identified in the relevant Australian Standard

9.4.1 Electric Motors

Motors are sized to produce the starting, pull-in and driving torque needed for the particular application, with due consideration of capabilities of the power sources. Plant design specifications for electrical equipment require such equipment be capable of continuous operation during voltage fluctuations of ±10%. Safety Category 1 motors and associated equipment must be able to withstand voltage drops to 70% of rated voltage during starting. These motors are appropriately qualified (see section 9.2.4).

Three-phase current monitoring for motors with rating greater than 5 kW is provided. In addition, temperature monitoring is provided for those motors credited with nuclear safety and with a rating greater than 15 kW. For motors with rating greater than 100 kW, motor temperature and vibration of the motor and the connected load is also monitored. Overload protection is provided for all motors, with motor protection relays for motors above 15 kW.

9.4.2 Containment Energy Removal System (CERS)

The Containment Energy Removal System is an ESF. Each SPS train feeds one train of the Containment Energy Removal System.

9.4.3 Lighting

Different types of lights are used in the different zones of the reactor, so that security and visual comfort are ensured. Three lighting systems are used: normal, emergency and evacuation.

9.4.3.1 Normal Lighting

Lighting levels in all areas are based on the requirements and recommendations of AS 1680. In general, Distribution Boards (DBs) throughout the facility supply normal lighting lights from the Normal Power System. Lighting power circuits are designed so that a single circuit does not feed an entire area, building floor or control room.

9.4.3.2 Emergency Lighting

The objective of the emergency lighting system is to enable essential tasks to be performed during failure of the Normal Power Supply. The emergency lighting system provides sufficient visibility for continuation of specific tasks until the normal lighting system is restored. Emergency lighting consists of lighting with batteries and lighting without batteries.

Emergency lighting is fed from the Standby Power System. This emergency lighting system supplies approximately 30% of the lights from Safety Category 2 switchboards. In addition, battery-powered lights provide emergency lighting until the Standby AC Power Supply begins operation. Hot re-strike features are provided for discharge lights where required.

9.4.3.3 Evacuation Lighting

In addition to the emergency lighting, permanently energised evacuation lighting is located along evacuation routes and in part of the control room.

9.4.3.4 Standby Power System Important Loads

SPS loads that are essential for nuclear safety are:

Train A	Train B	Train C
CERS-A and associated fans and chilled water pumps	CERS-B and associated fans and chilled water pumps	UPS-RPS-3
UPS-RPS-1	UPS-RPS-2	AMS
AMS & CIFAL	AMS & CIFAL	
ECC Ventilation	ECC Ventilation	
DG-A Auxiliary power	DG-B Auxiliary power	
SD-C	SD-C	

End of Section

9.5 DESIGN EVALUATION

The design requirements stated in Section 9.2 are satisfied as follows. The requirements for both Normal and Standby systems are discussed.

9.5.1 Normal Power System

9.5.1.1 Requirement a)

Reliably provide electric power of acceptable quality to the equipment in the Reactor Facility that is required to function only when normal power is available, and to the SPS during these times.

Reliability of the supply is achieved by:

a) The provision of power from two offsite zone substations to the ANSTO Main Substation.

b) The provision of two separate feeds from the ANSTO main Substation to the Reactor Facility

c) A two-train distribution system in the Reactor Facility

d) The use of high quality equipment

e) Fire Protection which includes:

   (i) Fire Protection of cable systems incorporated into the design and installation by use of fire resistant and non-propagating cables, and conservative application in regard to current ratings and cable ladder space. The cables are insulated fire resistant cables, and have low smoke and halogen free characteristics.

   (ii) Two-hour rated fire segregation is provided between Safety Category 1 trains and also between major items of NPS electrical equipment in the Reactor Facility Substation. Segregation is achieved by various means including barriers, separation by distance and fire loading.

An appropriate quality of supply is achieved by:

a) The provision of tap-changers on incoming power transformers

b) Appropriate earthing for the Facility, including lightning protection

c) The electrical system design includes controls and indicating equipment using guidance from IAEA Safety Series 50-SG-D7 (Emergency power systems at nuclear power plants) and IAEA 2001 Research Reactors Safety Standard Series Draft DS272. The Reactor Facility Substation equipment is monitored (locally and remotely), using the Reactor Control & Monitoring System (RCMS) for remote monitoring, alarms, equipment status and operational parameters

d) Electrical and control equipment assemblies, devices, and cables are identified so that the train they belong to and electrical source is apparent, and so that an observer can visually differentiate between and other equipment.

9.5.1.2 Requirement b)

Have sufficient separation from instrumentation and control systems and other systems so that it does not cause interference to them.

This is achieved by good cabling practice (see Section 9.3.7).

9.5.1.3 Requirement c)

Be tolerant to equipment faults so that the impact of any equipment failure is minimised.

Use of a two-train distribution system in conjunction with conventional protective relaying practice ensures minimisation of the impact of any fault on other equipment (see Section 9.3.6).

9.5.1.4 Requirement d)

Provide power in a manner to minimise electrical hazards to personnel.

The Reactor Facility earthing system, in conjunction with isolation practice in accordance with the ANSTO electrical Safety Rules ensures a safe working environment. Construction of switchboards is to a standard that will minimise the danger to personnel during operation and in the event of a fault. The Facility earthing system is designed to limit the step and touch potentials to acceptable levels (see Section 9.3.8).

9.5.1.5 Requirement e)

Not impact adversely on the structural integrity of the building.

The earthing using guidance from IEEE 80 ensures the rate of corrosion due to direct currents flowing in the building concrete reinforcing will not be significantly increased (see Section 9.3.8).

9.5.2 Standby Power System

The features of the design of the SPS that fulfil the requirements of section 9.2.2 are summarised below.

9.5.2.1 Requirement a)

Include a design that has two separated trains capable of supplying electric power of acceptable quality to loads that are important to nuclear safety (Safety Category 1 loads), and also to some safety related loads, even when normal power is unavailable.

The system is separated into two independent trains. An acceptable power supply, even in the event of a Normal Power failure is ensured as follows:

a) Loss of Normal Power initiates the starting and automatic connection of the diesel generators to the SPS distribution system.

b) The Safety Category 1 electrical Switchboards, diesel generators, Uninterruptible Power Supplies, Batteries, 415/240 AC Volt Distribution System (raceways, cables) and Motors, meet the appropriate Seismic requirements.

c) The Safety Category 2 Loads that can tolerate a certain interruption of power supply are connected to the SPS by means of an isolation device, which will assure the integrity of the safety category 1 power system in accordance with appropriate sections of IEEE-384.

d) Isolation of power circuits from instrumentation and control circuits, and from safety related circuits, which is provided by physical separation or separate enclosure of circuits to avoid electrical disturbances.

e) Electric power systems and equipment are periodically tested. Each diesel generator will be load tested using guidance from the manufacturers.

f) A separate direct-buried, double-skinned fuel storage tank with a seven-day capacity is provided for each diesel generator, a total of three tanks.

g) The SPS electrical trains are provided with separate switchboards, distribution cables, control relays and other electrical devices. In any design-basis event, coincident with a single failure of equipment in a train, the remaining train can still provide supply to the connected loads.

h) For loads that can not tolerate an interruption to the power supply, UPS units have been provided. In the case of the Reactor protection system, there are three UPS units, one from each standby train, and one that can be switched between the trains. These UPS units are appropriately qualified (see section 9.2.4). This approach ensures the power supply for the reactor protection system meets the requirements placed on it.

9.5.2.2 Requirement b)

Be constructed as an ESF (see Chapter 2.8 for details).

The use of IEEE standards and /or its guide where appropriate, ensures this requirement is met.

9.5.2.3 Requirement c)

Provide a reliable source of power under all design basis conditions.

The use of IEEE standards where appropriate throughout the SPS ensures this requirement is met.

9.5.2.4 Requirement d)

Provide power in a manner to minimise electrical hazards to personnel.

The Reactor Facility earthing system, in conjunction with isolation practice in accordance with the ANSTO electrical Safety Rules, where appropriate, ensures a safe working environment. Construction of switchboards is to a standard that will minimise the danger to personnel during operation and fault conditions. The facility earthing system is designed to limit the step and touch potentials to acceptable levels. (See Section 9.3.8.)

End of Section

9.6 ANALYSIS OF OPERATING SCENARIOS

This section includes basic information about different operating scenarios. Chapter 16 considers the impact of loss of Electric Power.

9.6.1 Normal Power (Both High Voltage Feeders supplying power)

The normal configuration for the NPS is supply through the two 11 kV feeders from the ANSTO Main Substation, each feeder supplying one train of the Reactor Facility High Voltage Switchboard. The High Voltage bus-tie circuit breaker is open. All six main power transformers are energised. The Low Voltage bus-tie circuit breakers on the Main Distribution Switchboards, Main Distribution Auxiliary Switchboards and the Neutron Guide Hall Switchboards are open.

The Uninterruptible Loads are fed from the UPS units. The output of the inverters is synchronised with the input AC power. Batteries are maintained with full charge.

The diesel generators are off.

Note 1: It is acceptable to start and operate 100% of the total maximum demand of the Main Distribution Switchboard with only one Transformer available and the MD bus-tie circuit breaker closed.

Note 2: It is acceptable to start and operate 100% of the total maximum demand of the Main Auxiliary Distribution Switchboards with only one transformer available and the bus-tie circuit breaker closed.

Note 3. It is acceptable to start and operate 100% of the total maximum demand of the Neutron Guide Hall Switchboards with only one transformer available and the bus-tie circuit breaker closed.

9.6.2 Normal Power (One High Voltage Feeder supplying power)

With one external supply from the ANSTO Main Substation unavailable, the configuration for the NPS is a single feed to the High Voltage distribution board to either train A or B and the High Voltage bus-tie circuit breaker closed. The rest of the configuration is the same as for the normal configuration (9.6.1).

9.6.3 Normal Power Supply Failure

Where both external supplies from the ANSTO Main Substation become unavailable (a total loss of Normal Power) the standby diesel generators feed the SPS loads (after a brief interruption while the diesel generators start). The non-essential Loads are not fed. The Uninterruptible Loads are fed from the UPS units without interruption or supply transient. The batteries support the UPS units until the Standby Power Supply becomes available. Once the Standby Power Supply becomes available, the batteries are recharged, again without any disturbance in the Uninterruptible Power.

When the Normal Power becomes available, power can be restored to the Main Distribution Switchboards, the Main Distribution Auxiliary Switchboards and the Neutron Guide Hall Switchboards. The Standby Switchboards must be manually switched from the Standby Power Supply to the Normal Power Supply. This will require a brief interruption to the power on the Standby switchboards. The uninterruptible loads will be fed from the UPS units, supported by batteries during this time.

9.6.4 Normal Power Supply Failure and One Diesel Generator Failure

When there is a failure of Normal Power, standby diesel generators feed the Standby Distribution Switchboards, which supply power to essential loads after a brief interruption while the diesel generators start. The two standby diesel generators operate independently, providing two trains of Standby Power to the essential loads.

If one of the standby diesel generators fails, supply is lost to one Standby Distribution train. In the worst case, this would include the SD-C switchboard. Standby Power would be available from one Standby Distribution switchboard only.

The three Uninterruptible Power Supplies (UPS-RPS1, UPS-RPS2, and UPS-RPS3) operate independently, providing Power Supply for the Reactor Protection System. They can be powered by battery backup. Although not required for safety, switchboard SD-C could be transferred to the operating Standby Power Supply.

End of Section

9.7 POWER SUPPLY RATING

The load value is the anticipated maximum load, generally at 0.8 power factor.

The values allow for load diversity factors and spare capacity. For conservative design, the load factors for all loads connected to the Standby Power System (SPS) are taken as unity, which means that even in the unlikely event that all connected loads are on, the SPS will not be overloaded.

To ensure correct operation of the power system, the demand load is less than the capacity of the associated power supply and distribution system. This applies throughout the distribution system. The loads are arranged so that the ratings shown in the following table are not exceeded.

End of Section