



Chapter 8

ELECTRIC POWER

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8. ELECTRIC POWER

8.1. INTRODUCTION

8.1.1. Utility grid description

The Korea Electric Power Corporation (KEPCO) grid system consists of interconnected hydroelectric plants, fossil fuel plants, and nuclear plants supplying electric energy over a system of 345 kV and 154 kV transmission lines and lower voltage distribution networks. Figure F-8.1-1. shows the 345 kV systems in the Korea peninsula connected to Korea Nuclear Units UCN 1 and 2.

Korea Electric Power Corporation provides all of the electric power used in Republic of Korea.

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8.1.2. Onsite power description

The onsite power system is shown in Figure F-8.3.1., main single line diagram. Two sources of offsite power are provided power to the onsite Class 1E systems.

The main features of the distribution network are as follows :

- a) The generator circuit breaker in the 22 kV busbars between the generator and the generator transformer enables the generator to be synchronized and then linked to the network.
- b) The auxiliaries for each Unit are divided into groups depending on their safety and operational function, including consideration of all the different operational situations and foreseeable abnormal situations. The auxiliaries are supplied from three groups of swithboards : the Unit boards, the service boards (including the general service board), and the safeguard boards.
- c) The two Units are electrically independent. In case of an accident, the faulty Unit must be able to respond to the accident regardless of the condition of the other Unit. For this reason, each Unit has two independent diesel generator sets.

Auxiliaries common to both Units have no safety function and can, therefore, be shed without affecting the availability or the safety of the Station. These common auxiliaries may be supplied from either Unit, and the changeover from one source of supply to another is authorized by the Unit Shift Supervisor and performed manually. The above system provides independent electrical distribution between the Unit, preventing any possible faults on one Unit being transferred to the other Unit.

In addition to the Class 1E emergency diesel generators descried above, another Non-Class 1E diesel generator is provided as an alternate AC(AAC) source for common use of UCN 1 and 2 to cope with station blackout(SBO).

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- d) The onsite electrical distribution system has the minimal amount of automation and obtains a maximum degree of reliability with the equipment provided. Only the transfer of supplies is performed automatically. The distribution system is in a radial configuration in order to avoid faults between independent trains.

8.1.3. Safety-related loads

Power supplies to the auxiliaries are designed to meet requirements of Unit availability and most important, nuclear safety.

Nuclear safety depends among other things on the electrical supply conditions of certain auxiliary systems of the NSSS. The systems under consideration are those which supply power to equipment and auxiliaries in safety Class 1E.

Table T-8.1-1. gives the corresponding safety feature loads and their functions.

8.1.4. Design bases

As described in RCC-P Paragraph 1.3.4.2., the design of the electric power system which supplies the Unit auxiliary systems required during incidents or accidents, complies with the following features.

a) Electric sources

The electric sources are independent and redundant. They include :

- two off-site sources separately routed from the main grid,
- two on-site sources consisting of 100 % redundant electric diesel generator sets,
- One on-site alternate AC(AAC) diesel generator set for station blackout(SBO).

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b) Electric power supplies

- The electric power supply system consists of two identical trains. These trains are independent and are normally supplied by one of the offsite sources (the second source ensures redundancy) and are backed up by the onsite sources in the event of main grid failure. Each diesel generator is connected to one train.
- The redundant electrical equipment connected to redundant mechanical equipment is supplied by redundant trains.

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8.1.5. Acceptance criteria for electric power

8.1.5.1. Design criteria

Power supplies are designed following criteria of RCC-P Paragraph 2.4.2.3.2. They are expressed as follows :

- a) The off-site power supplies satisfy the following conditions
- they comprise two physically independent systems (not necessarily separately routed) to ensure that simultaneous failure is minimized,
 - the quality of both sources is such that the auxiliaries supplied can be operable or be started as soon as they are transferred from one source to the other,
 - if the main power source fails, the auxiliary source is automatically put into service (after a brief time motor flux to decay) ; the main source is restored to operation manually.

- b) The on-site AC power supplies of a Unit are taken from independent sources, e.g. independent from each other and from off-site power sources :

- there is one supply for each of the two safeguard train,
- there are no interconnections between trains of separate Units, **except for an AAC power supply bus as described in paragraph 8.3.21.**
- each power train supplies the electrical auxiliaries of each independent train of the redundant mechanical systems (physical separation), so that loss of one train does not lead to a loss of functions,
- each bus supplying a single train is provided with both off-site power and a separate on-site supply,
- selective protection features limit power supply degradation,
- the diesel generator sets are started automatically upon the following ;
 - loss of voltage,
 - safety injection signal,
 - high pressure in the containment.

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Changeover of the emergency supplied auxiliaries from the off-site to the on-site sources is automatic with loss of voltage on the buses. The return to normal power and diesel shut down is manual.

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- in addition, the instrumentation and control system enables the following functions to be performed manually from the control room,
 - control of the on-site power supplies,
 - switchover of the emergency supplied auxiliaries to the on-site power supply (see Subparagraph 8.3.1.9.1.), with non-class 1E auxiliaries being disconnected if necessary,
 - monitoring of the power supply status (voltage, power, position of circuit breakers, availability of sources).
 - the disconnecting devices of non class 1E auxiliaries are installed on the safety-related switchboards.
 - if both the off-site power and the Class 1E emergency diesel generators are unavailable, one division of the Class 1E auxiliary power system shall be supplied from an AAC source facility. | 201
- c) DC power supplies are subject to the same rules of separation and protection as the associated AC supplies, but with the following special features :
- the auxiliaries and their DC equipment are supplied by the associated buses in such a way that loss of power to one train of auxiliaries does not adversely affect equipment on another train.
 - each redundant power source consists of a battery and two battery chargers (on manually switched mutual standby) connected to a same emergency AC supply.
 - another direct current power source for coping with station blackout(SBO) consists of a battery and charger. | 201

8.1.5.2. Other criteria

The following criteria essentially concern tests.

a) Qualification

A qualification program (RCC-E – Volume B Qualification) involving specific tests are applied to Class 1E equipment. Procedures are developed as follows :

- classic qualification tests on electrical equipment,
- 1EB qualification tests,
- 1EA qualification tests.

b) Preoperational tests and inspections (See RCC-P Paragraph 2.4.2.4.1.)

The power supply system equipment for the safeguard auxiliary systems is subjected to a performance test. This test is designed to demonstrate the ability of the equipment to fulfill its functions, particularly under accident conditions.

Once all components are installed, equipment tests and inspections are conducted to check that installation and circuit are correct, and that all components are in good working order.

Tests are then performed to monitor the capacity of each power supply to handle the scheduled loads and to check switchover from one supply to another.

c) Periodic tests during operation (See RCC-P Paragraph 2.4.2.4.2. and RCC-E - Volume C 3000)

The power supply tests described above are repeated periodically to ensure that no faults develop which may lead to an unacceptable situation.

- In-cycle tests to be performed during power operation are based on Reg. Guide 1.9 rev 3.(July 1993) paragraph 2.3.2.1 except monthly testing frequency.
- 18 months tests to be performed during every refueling outage are based on Reg. Guide 1.9 rev 3(July 1993) paragraph 2.3.2.3 except "Endurance and Margin test", and "Synchronizing test". Also test for the 8 hours "Load-run test" is performed instead of "Endurance and margin test".
- Target reliability set in accordance with Reg. Guide 1.155(Station Blackout), (August. 1988) C.1

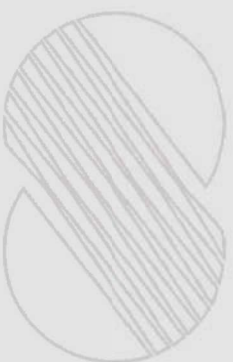
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TABLE T-8.1-1

ENGINEERED SAFETY FEATURE LOADS IDENTIFICATION AND FUNCTION

A - The following system loads are Class 1E AC powered unless otherwise noted.	
Safety load	Function
Safety injection system (high and low pressure pumps)	Emergency core cooling
Containment spray system	Spray and containment heat removal
Component cooling water system	Provides cooling water (for engineered safety features)
Essential service water system	Provides cooling of reactor plant component cooling systems
Auxiliary feedwater system	Provides water to steam generator when main feedwater is not available
Fuel pool cooling system	Provides cooling for the fuel pool
Safety-related air conditioning and ventilation system	Provides cooling for Class 1E electrical areas, control areas and engineered safety features areas
Motor operated valves (Class 1E)	Provides fail safe mode of operation for all abnormal and accident conditions
B - The following system loads are powered from Class 1E DC and/or inverted AC from Class 1E AC.	
Reactor protection system	Protects reactor core
Engineered safety features actuation system	Protects reactor core and containment
Post accident monitoring system	Provides post accident indication and recording
Essential instrumentation	Provides monitoring and essential control for safety-related systems

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POWER GENERATION AND TRANSMISSION
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Figure 8.1-1

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FIGURES

F-8.2-1 Switchyard one line

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F-8.2-3 Physical arrangement of switchyard and GB(Gas Insulated Bus)

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8.2. OFFSITE POWER SYSTEM

8.2.1. Description

145	<p>Electric power for startup, shutdown, and normal operation of safety-related equipment of Ulchin Nuclear Power Plant 1,2 is supplied from the Korea Electric Power Corporation (KEPCO) transmission system as shown in Figure F-8.1-1.</p>	<div>32</div> <div>7</div>
	<p>In the event that power supply is not available from the unit auxiliary transformer, all inplant auxiliary equipment may receive power from stand-by auxiliary transformer. There will be four 345 kV circuits connected to 345 kV switching station located at the plant site. These circuits will be carried on two sets of double circuit towers. This station uses a breaker-and-a-half arrangement as shown in Figure F-8.1-1. Two 345 kV lines (a double circuit) are connected to Ulchin 3,4 switchyard, identified as Route A, and two 345 kV lines (a double circuit) are connected from Samcheok 1,2 switchyard, identified as Route B.</p>	<div>145</div> <div>32</div> <div>352</div>
	<p>The right-of-way distance between Ulchin 1,2 switchyard and Samcheok 1,2 switchyard(Route B) is approximately 21 km and the distance to Ulchin 3.4 switchyard(Route A) located In the Ulchin division is approximately 2 km. The physical routing of offsite power sources is shown in Figure F-8.2-2. The 345 kV transmission lines and their associated structures are routed on separate and independent rights-of-ways. They are designed to withstand the loading for various environmental conditions such as wind, temperature, salt contamination, lighting, flood, etc so as to minimize the number of line failures.</p>	<div>352</div> <div>32</div>
	<h4>8.2.1.1. <u>Transmission system</u></h4>	
	<p>Four 345 kV transmission lines connect Ulchin 1,2 to the KEPCO transmission system at the 345 kV switchyard, as indicated in Figure F-8.2.1. Route A provides two of the four 345 kV transmission line connections between the Ulchin 3,4 switchyard and the Ulchin 1,2 switchyard. The remaining two 345 kV transmission line connections between the 345 kV Samcheok 1,2 switchyard and the Ulchin 1,2 switchyard are shown on the right-of-way identified as Route B. Each of the two 345 kV transmission lines, identified as Route A and Route B respectively, are run on identical double circuit, steel towers. The transmission lines enter the switchyard on separate rights-of-way and no other lines cross these circuits. The physical separation is such that no single event, such as a tower falling or a line breaking, can simultaneously affect these circuits in such a way that one 345 kV transmission line cannot be returned to service in time to perform its intended function.</p>	<div>32</div> <div>32</div> <div>32</div> <div>352</div>

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The structural design of the transmission towers and lines is based upon Korea standard design practices. Four 480 square mm ACSR conductors per phase are supported on insulator hardware assemblies on the lattice type steel towers. Maximum tension of the conductor is limited to 4202 kg per subconductor. The use of bundled conductors with spacers and dampers reduces vibration to acceptable levels.

A single groundwire is installed above the phase wires of each tower line to provide protection against outages caused by lightning.

The offsite sources are capable of operating independently of the onsite sources and are provided with electrical protective relays, breaker control circuits, and power supplies to assure that loss of one preferred system circuit will not cause or result in loss of the redundant counterpart.

Out-of-Rejection System is established to prevent the effect to all units from one or two units disconnected from grid. Out-of-Rejection System is designed and programmed to be maintained in operating mode of the UCN units so as to enable system to be maintained stable in the transmission line event.

8.2.1.2. Switchyard

The 345 kV switchyard for UCN 1 and 2 is shared by both Units. The switchyard electrical equipments including the circuit breakers and connecting buses between switchyard and high voltage side of power transformers are of the metal - enclosed type and are insulated by sulphur hexafluoride (SF 6) gas.

The gas insulated switchyard (GIS) and gas insulated bus duct (GIB) are the most suitable equipment for application in areas with heavy contamination and tight installation spaces.

The switchyard is designed such that three circuit breaker are provided for every two lines. This configuration is referred to as a breaker-and-a-half arrangement. The breaker-and-a-half scheme provides flexibility and reliability of operation and ease of maintenance in that any one line or any one breaker may be removed from service without loss of performance of the remaining lines and breakers in the switchyard. The switchyard is connected to the four 345 kV transmission lines and UCN 1 and 2 main transformers and standby auxiliary transformers.

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Figure F-8.2-1 shows the one line arrangement of the 345 kV switchyard and all its interconnections.

The switchyard operates with all circuit breakers normally closed. Each circuit is provided with primary and secondary relays for rapid isolation of components in the event of failure or abnormal conditions. Also, if one of the power circuit breakers fails to clear a faults, breaker failure protection relaying is provided to clear the faulted circuit of all sources of power. DC current for operation of the switchyard circuit breakers is obtained from redundant batteries independent of the plant batteries. A switchyard control house is provided.

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The structural arrangement of the 345 kV switchyard is obtained from designs which were derived from experience under seismic, wind-loading, and short circuit conditions. Bus and line insulation is in accordance with proven practice for seaside installations.

Two physically independent circuits provide offsite preferred source of power from the switchyard to the onsite AC distribution systems in the plant. These two 345 kV circuits are routed through gas-insulated (SF 6) buses to the physically separated main transformers and standby auxiliary transformers as shown in Figure F-8.2-3.

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During normal power operation, the station electrical auxiliary system receives its power from the main generator through the unit auxiliary transformer. During startup, shutdown or any time the main generator become unavailable, power can be supplied either from the main transformer through the unit auxiliary transformer with the generator circuit breaker open or from the standby auxiliary transformer. In addition to the above two offsite sources, each of the two class 1E distribution system is provided with an emergency diesel generator.

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8.2.1.3. Industry standards

The preferred power system is not a Class 1E system and is designed as a normal power system on the basis of good engineered judgment, experience, and the applicable standards and recommendations of the following :

- RCC-E : Rules for electrical equipment of Nuclear Power Plants.
- RCC-P : Rules for system design of 900 MWe PWR Nuclear Power Plants.

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8.2.2. Analysis

Two independent routes, each with one 345 kV double circuit line, supply ac offsite power with adequate separation to UCN 1 and 2. Failure of one transmission line will not cause failure of the other line since these two lines are connected to separate remote substations and each enters the switchyard on a separate right of way. The KEPCO transmission system is designed to withstand the outage of a double circuit transmission line of an entire power plant without uncontrolled widespread tripping of line and/or unit. This means that sequential loss of two units at UCN 1 and 2 would not adversely affect the transmission system and the power to replace the loss of generation could be partly supplied by the spinning reserve. Under these circumstances, the 345 kV line serving the plant would continue to be energized from the grid system so that the supply of offsite power to the ESF buses would not be lost. The transmission lines to the plant are designed to meet the requirements of RCC-P Paragraph 2.4.2.

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8.2.2.1. Stability considerations

Transient stability studies were conducted on the UCN 1 and 2 transmission system using a digital computer program.

Three-phase faults were simulated at the UCN 1 and 2 345 kV bus with the resulting outage of two critical transmission circuits. Normal fault clearing time was assumed to be six cycle : two-cycle relay operation time, three cycle breaker time, and one-cycle margin.

This study proves the following results : In case that the one or two transmission lines are lost simultaneously due to the three-phase short event, if the fault is removed within 8 cycles and the one or two units among 6 UCN units are forced to be disconnected, then KEPCO transmission network and UCN units maintain stable operation and the voltage and the frequency of transmission become in normal condition. The critical time for generator forced disconnection is 9 cycles from the event.

Further analysis indicates that an accident signal causing the loss of either UCN 1 and 2 main generator does not result in system instability or impairment of the Class 1E system capability to start and accelerate the emergency shutdown loads.

In addition to the Class 1E emergency diesel generator described above, another Non-Class 1E diesel generator, which is in the independent AAC building separated from the power blocks, is provided as an alternate AC(AAC) source for common use of UCN 1 and 2 to cope with station blackout(SBO).

It is extremely improbable that all 345 kV transmission lines would be out of service simultaneously. However, such an event would not jeopardize the safe shutdown of the even when taking into account of single random failure since two electrically independent and physically separated onsite diesel generators are provided to each nuclear unit. Each diesel generator along with the associated electrical distribution system is capable of supplying the necessary power required for safe shutdown.

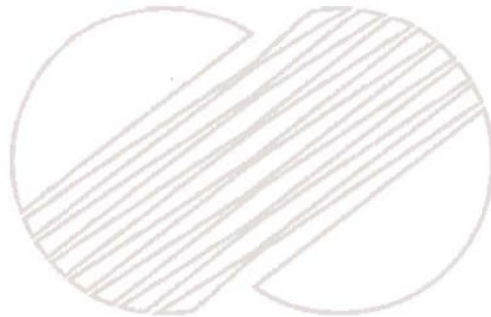
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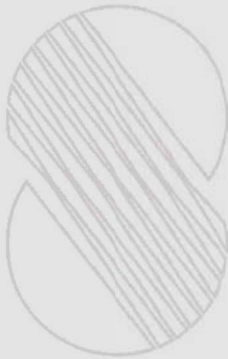
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Protective relays are designed and calibrated to initiate the automatic starting and sequential loading of the diesel generator should offsite power system voltage falls below the minimum required for safety-related equipment.

The grid stability analysis also shows that the loss, through a single event, of the largest single supply to the grid or removal of the largest load from the grid, does not result in the complete loss of the preferred offsite power. In addition, the study shows that the frequency decay rate of the grid will not result in a reactor coolant pump motor braking action, sufficient to create an unsafe condition due to reduced reactor coolant flow.





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FIGURE 8.2-2

345 kV transmission line routes



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8.3. ONSITE POWER SYSTEM

8.3.1. AC power systems

8.3.1.1. General description

A detailed description of the engineered safety featured (ESF) related to the electrical power distribution system is given in Reference 1.

8.3.1.1.1. Type of auxiliaries to be supplied

The power station auxiliaries are divided into three types : Unit auxiliaries, permanent auxiliaries, emergency power supplied auxiliaries.

- The Unit auxiliaries are those auxiliaries necessary for normal operation of the plant (ex : reactor coolant pumps, circulating water pumps, etc.).
- The "permanent" auxiliaries are used more particularly during Plant shutdown and as such are to be "permanently" supplied although with adequate redundancies. Some of them may be shutdown when maintenance is to be performed on their supply switchboard (example : air compressors, barring gear, etc.).
- The emergency power supplied auxiliaries comprise :
 - Class 1E auxiliaries which are necessary from a nuclear safety point of view in the event of an accident in the plant, to maintain the plant in a safe condition and bring it to a cold shutdown (example : safety injection pumps, residual heat removal pumps, etc.),
 - auxiliaries which - if not operation - would lead to important damage to the plant equipment(example : rod drive mechanism cooling, etc.).

8.3.1.1.2. Electrical supply of these auxiliaries

The basis for the electrical supply of these auxiliaries is shown on figure F-8.3-1. "single line diagram".

The Unit auxiliaries are supplied :

- either from the main generator when the Unit is operating via the 22/6,9/6,9 kV Unit auxiliary transformer,
- or from the main grid when the Plant is shutdown via the 362/22 kV main transformer and the Unit auxiliary transformer.

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A generator circuit Breaker located between the unit auxiliary transformer and the generator is designed for clearing electrical faults , allowing synchronization and normal unit trips.

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The permanent auxiliaries are supplied :

- from the main generator when the Unit is operating, via the 22/6.9/6.9 kV Unit auxiliary transformer,
- from stand-by auxiliary transformers which, in turn, is supplied from an auxiliary network (relatively independent from the main network), in the event that no power is available on the Unit auxiliary transformer.

The emergency switchboards are supplied :

- normally from the permanent auxiliaries switchboards when these switchboard are energized,
- from two diesel generators in the event the above switchboards are not energized. these diesel generators are then automatically connected to the emergency switchboards.

The switchboards, as well as, the diesel generators are totally separated into two "trains" A and B. They supply the redundant auxiliaries of the Plant.

However, train A also supplies a number of auxiliaries not directly related with nuclear safety and more particularly equipment which – if not supplied – would jeopardize large equipment integrity.

In addition to the above mentioned onsite ac power system, one Non-Class 1E diesel generator, which is in the independent AAC building separated from the power blocks, is provided as an alternate AC(AAC) source for common use of UCN 1 and 2 to cope with station blackout(SBO). 201

8.3.1.2. 6.6 kV switchboard configuration

The auxiliaries required for normal operation are fed from four separate switchboards ; LGA and LGD for Unit auxiliaries, LGB and LGC for permanent service auxiliaries.

The auxiliaries required for emergency situations are distributed from two independent switchboards, LHA and LHB which are fed, under normal conditions, via the LGB and LGC service boards, respectively.

The auxiliaries common to both Units are fed from the general services board 9LGI, which, in turn, is fed from either Unit via the 1 or 2 LGC service boards.

8.3.1.2.1. Supply from the Unit auxiliary transformer

The 6.6 kV switchboards are normally supplied from the 22/6.9/6.9 kV Unit auxiliary transformer.

The cable feeders and the circuit breakers are rated to ensure the simultaneous supply to the normal and emergency auxiliaries which are required for any operational or emergency situation.

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Each emergency switchboard is designed to supply the full load power consumed by emergency auxiliaries.

8.3.1.2.2. Supply from the stand-by auxiliary transformer

The changeover from the preferred supply to the auxiliary supply is automatic, sequential, and slow. A two-second time delay allows for the magnetic motor flux to decay. The changeover usually occurs automatically but can be performed manually either from the control room or the emergency shutdown panel. To revert to the normal preferred supply, authorization is required from the Unit Shift Supervisor, and the changeover is performed manually in the control room or at the emergency shutdown panel.

The interconnection between the stand-by auxiliary transformers and the 6.6 kV switchboards can supply the service and safeguard auxiliaries and one reactor coolant pump during steady-state distribution network operation on request from operations management, provided stand-by auxiliary transformer are available.

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8.3.1.2.3. Supply of the safeguard switchboards

When are the external source of supply fail, both safeguard switchboards are fed by the diesel generator sets. An undervoltage (timelagged 0.9 s) detected on the safeguard bus is one of the conditions which initiates diesel generator startup. Once the diesel generator is in the ready state (i.e., when voltage and frequency are within limits) and provided that the undervoltage is maintained for more than 7 s, the safeguard auxiliaries breaker 001JA trips, unloading selected safeguard auxiliaries, and emergency power supply breaker 002 JA closes after an 1.5 second delay corresponding to 001 JA/002 JA interlock, permitting shed auxiliaries to be reloaded.

An order to revert to the external supply is given from the control room or from the emergency shutdown panel.

If both external power and the Class 1E emergency diesel generators are unavailable, one division of the Class 1E auxiliary power shall be supplied from an alternate AC(AAC) source as described in paragraph 8.3.21.

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8.3.1.3. Description of the 6.6 kV switchboards

The normal and emergency 6.6 kV switchboards are identical.

The cells are fitted with circuit breakers rated at 3 000 A or 1 250 A. The contactor cells feed the 6.6 kV auxiliaries with a rated power of less than or equal to 750 kW (normal current less than 80 A). The fuses of the fused contactors all have the same rating of 250 A.

The outgoing breakers are fitted with a time delayed 1,2 times normal current (I_N) overload protection and with an instantaneous overcurrent protection.

The incoming circuit breakers are fitted with a time delayed overcurrent protection (0,3 to 1 s).

The 6,6 kV network operates totally isolated from ground.

Insulation from ground is continuously monitored and alarms are provided when this insulation drops below a pre-determined threshold.

There are contactor fuses for protection against overcurrent on the three phases.

As far as emergency supplied motors and transformers are concerned, it is necessary to add an overcurrent protection to fuse protection, because of the short circuit Diesel power which is lower than the network short circuit power. This overcurrent protection is temporized at 0,1 sec and the set point is :

- for transformer feeders : $8 I_N$,
(I_N = nominal current)
- for motor feeders : $1,43 \times$ starting current, i.e.
 $1,43 \times 6,6 I_N = 9,44 I_N$

All the contactors are fitted with an overload protection :

- outgoing transformers : $1,3 I_N$ 60 seconds,
- outgoing motors : $1,54 I_N$ 10 seconds.

These two protections perform the feeder tripping.

The opening and closing mechanism of the circuit breaker is activated by a spring. The electrical control is energized from the 125 V DC power supply.

Each cell is insulated from the adjoining cell by means of sheet metal partitions. The high degree of cell protection is according to IP 30 (which is in compliance with Standard IEC 529) with the cell in the withdrawn position and according to IP 20 with the cell in the plugged in position. These degrees of protection are defined precisely in the RCC-E (Volume E 3100).

The instrumentation and control associated with the 6,6 kV panels for normal and emergency operation provide remote control room indication of actuator position, feeder load current, busbar voltage, and possible faults (such as a loss of voltage, voltage transformer fault) and indication of actuator position is located at local panel.

Each 6,6 kV breaker cubicle can be tested in the withdrawn position.

The safety-related switchboards are identified by special markings as follows :

- train A safeguard switchboard : identified by an orange label, engraved in white,
- train B safeguard switchboard : identified by a green label, engraved in white.

8.3.1.4. Installation of the 6,6 kV switchboards

The 6,6 kV switchboards are installed at the + 7,00 m level in the electrical building.

The LHA and LHB switchboards are installed in separate rooms which constitute the physical separation.

The electrical rooms are designed to prevent flooding and to protect against missiles and seismic events.

Dry type cable is used for the connections between the boards and the supply transformers.

8.3.1.5. 480 V switchboard configuration

The 480 V switchboards are supplied from the 6,6 kV/480 V stepdown transformers which are incorporated into the 480 V boards and connected to the 6,6 kV board fused contactors.

The 480 V auxiliaries of the normal network are distributed between several functional panels which are supplied from the 6,6 kV switchboards.

The rating of the switchboards and 6,6 kV/480 V transformers and the distribution arrangement allows all the emergency auxiliaries to be supplied adequately whatever the operational situation might be.

For normal operation, the switchboards linked up to the 6,6 kV LGA, LGB, LGC and LGD switchboards have the same source of supply.

For emergency situations, the boards and sub-boards connected to the 6,6 kV LHA and LHB safeguard boards have the same source of supply.

Neither the boards used in normal operation nor the safeguard boards have common connections or automatic or manual synchronising devices between different trains.

8.3.1.6. Description of the 480 V switchboards

The 480 V boards used in normal operation and the emergency 480 V boards are identical except monitoring circuit.

Each board is composed of metal clad columns fitted with removable drawers carrying the switching devices. The main busbars are enclosed in a separate frame. The contactors and the breakers are driven by the 125V DC battery network and the reversing contactors are driven by the 48 V DC and the 125 V DC.

The following table shows the switching devices used, with their relevant protections :

Type of equipment	Use	Protections
Contactors	Actuators in intermittent use	Thermal + fuse (*)
Circuit breakers	Actuators in permanent operation without any automatic devices	Magnetic + thermal
Reversing contactors	Motor-operated valves	Thermal + fuse (*)
(*) As the actuator breaking capacity is insufficient, it is linked with high rupture capacity fuses.		

Each board is fed via a dry, H class insulated, 6,6 kV/480 V, 630 kVA transformer with adjustable off circuit taps at $\pm 5\%$.

The transformer is connected directly onto the busbars. This connection is fitted with overcurrent protection. The neutral of the transformer is solidly grounded through a connection fitted with a zero sequence ground fault protection.

The instrumentation and control related to 480 V switchboards provide local and remote control room indication for faults on feeders and voltage monitoring panels.

The 480 V emergency switchboards are identified by a label similar to the corresponding 6,6 kV emergency boards.

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8.3.1.7. Installation of the 480 V switchboards

All 480 V emergency boards are installed at the + 7,00 m level in the electrical building. Those of train A are grouped with the 6,6 kV switchboard of the same train. The boards of train B are grouped in separate rooms.

The train A (LLG) and train B (LLW) switchboards are installed inside the building of the train A or train B diesel generator sets, respectively.

The connections between the feeder cells and the motors are copper or aluminium cables.

8.3.1.8. Transfer of normal supplies after a fault detection

8.3.1.8.1. House loading

The detection of a network fault, as well as, the actions taken by the turbogenerator set protections, leads to the following situations :

- the network faults cause the opening of the 345 kV HV circuit breaker. When the house loading operation has been successful, The LGA,LGB,LGC and LGD Unit boards are supplied from the generator through the generator circuit breaker and the Unit transformer. 1
- should either the house loading be unsuccessful or internal electrical faults inherent to the Unit occur, then the LGA through LGD switchboards are de-energized, the LGB and LGC switchboards transfer to the stand-by auxiliary transformer from the main transformer. 1

The house loading is initiated by the detection of low primary pump speed, when the voltage drops rapidly. However, where the reactor coolant pumps maintain their speed, the other motors might be tripped, and the house loading order initiated by a voltage drop criterion. 1 | 137

The house loading operation will be successful if the generator voltage recovers rapidly. However, at the auxiliary motor feeders, voltage recovery is slower due to the generator and Unit transformer independence. Depending on the factors which have led to the house loading operation, the slowing down of the induction motors might be such that the torque, at the moment when the voltage recovers, is too low for re-accelerating the motors, and surge currents would reach abnormally high values. The voltage must recover in 1 second, or an emergency shutdown signal is given, which leads to a turbine trip and the opening of the generator circuit breaker.

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8.3.1.8.2. Transfer of supplies on LGB and LGC service boards

a) Downgraded situation (first level)

The electrical faults internal to the Unit, which lead to the opening of the 345 kV circuit breaker and, consequently, to an unsuccessful house loading operation, result in the disconnection of the Unit transformer.

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The loss of this preferred source of supply causes the automatic transfer of the LGB and LGC switchboards to the stand-by auxiliary transformers by opening the incoming circuit breakers from the main transformer. The incoming circuit breakers from the station transformers on the LGB and LGC service boards are then closed after 2 seconds. As a safety precaution, in response to a loss of voltage (0,7 Un for more than 0,9 second) on the LGB or LGC boards, the diesel generating sets are automatically started.

b) Downgraded situation (second level)

If the voltage on the safeguard switchboards does not recover, the load shedding and reloading program for the diesel generator is initiated.

The transfer can also be initiated manually from either the "turn-push-light" (TPL) control switch located on the control room panel or from the TPL control switch on the emergency shutdown panel.

c) Definitive loss of voltage on any of the following switchboards
LGA, LGB, LGC, LGD

If the voltage has not recovered within 10 seconds, a part of the switchboard actuators are tripped to avoid untimely starting of the motors when the voltage recovers.

d) Return to normal condition

The resupply to the switchboards from external sources can only be achieved manually.

The reverse transfer to the preferred source of supply must be initiated manually, but the actual transfer operation is done automatically.

8.3.1.9. Emergency supply to auxiliaries from on-site sources - diesel generating sets

8.3.1.9.1. Basic concepts

Each of the two diesel generating sets providing internal emergency electrical supply is able to fulfill the following functions :

- in case of a loss of the external power sources, to supply the safeguard auxiliaries and enable a safe shutdown of the Unit without damage to the equipment, for instance, to ensure the cooling of the reactor,
- in case of loss of the external power sources and with a simultaneous reactor coolant accident (such as loss of primary coolant), to supply without delay the necessary Class 1 E equipment for the reactor core emergency cooling and to reduce, as far as possible, the radio-active release to the environment.

The power needed by the motors during the restarting of the auxiliaries is higher than their rated power, and the generator sets are not designed to cope with this initial step load on the emergency busbars.

For this reason, a load shedding and reloading program is provided to perform the following functions :

- shed most of the auxiliaries so that only certain auxiliaries are resupplied when the diesel incoming circuit breaker 002 JA on the safeguard switchboard (LHA or LHB) is closed,
- allow for gradual reloading of the shedded auxiliaries taking into account the maximum step loads that the diesel generator is capable of accepting.

The rating of the diesel generator set is based on the power balances occurring after three types of accidents, all of them causing the switchover to the generator set and which involve automatic shutdown of the Unit. The three types of accidents are :

- loss of supply to the 6,6 kV switchboards, which is detected by the "loss of voltage" signal at the safeguard busbar level,
- loss of supply to the 6,6 kV switchboard coincident with any accident which initiates the safety injection system and the auxiliary feedwater system, which are identified by the "loss of voltage" and "safety injection" signals,
- loss of supply to the 6,6 kV switchboard coincident with any accident initiating the above systems plus the containment spray system, which is identified by the appearance of the following signals : "loss of voltage" plus "safety injection" plus "very high pressure in the containment". This corresponds to a breakage of certain primary or secondary pipelines (water and steam) within the reactor building which are classified as Category 3 and 4 situations.

For these three types of incidents or accidents, Table T-8.3-1. indicates the list of the auxiliaries to be emergency supplied and their relevant power.

These three reloading programs for each generator set comply with the following conditions (see Figure F-8.3-7.) :

a) SI and containment spray signals received prior to initiation of the reloading sequence

Safety injection

LHSI pump is not shed. It reaccelerates at step 0.

Containment spray

The containment spray pump is unloaded for 15 s after step 0 and then restarted. Non-safety related auxiliaries remain unloaded until the end of the reloading sequence.

b) SI and containment spray signals received during the reloading sequence

Safety injection

LHSI pump is unloaded for 20 s after step 0 and then restarted.

Containment spray

Containment spray pump is shed for 15 s after step 0 and then restarted. Non-safety-related auxiliaries remain unloaded until the end of the reloading sequence.

c) SI and containment spray signals received during the reloading sequence between 15-20 second reload steps

Safety injection

LHSI pump is unloaded for 20 s after step 0 and then restarted.

Containment spray

Containment spray pump is unloaded for the entire reloading sequence and restarted 5 seconds after the end of the sequence.

d) SI and containment spray signals received during the reloading sequence between 20-40 second reload steps

Safety injection

LHSI pump is not unloaded and restarts immediately.

Containment spray

See (c).

e) SI and containment spray signals received after the reloading sequence

Safety injection

See (d).

Containment spray

Containment spray pump starts 5 seconds after containment spray signal is received.

The power balances for the different cases of operation have led to the specification for a diesel generator set with a rated output power of 4 500 kW.

The voltage and frequency variations under normal and transient operation are limited to ensure the normal running of the safeguard and essential safety auxiliaries.

8.3.1.9.2. Principle of supply

As explained above, the emergency supply is from two generator sets per Unit.

Each diesel generator is installed in its own room. The auxiliaries associated with the diesel generator are supplied under normal operation in the same manner as other auxiliaries. When the generator is connected to its associated safeguard board, it supplies its own auxiliaries.

Both generator sets are independent of one other and also independent of those of the adjoining Unit.

One diesel generator supplies the 6,6 kV LHA busbars ; the other diesel supplies the 6,6 kV LHB busbars. Both, LHA and LHB supply the safeguard auxiliaries. These auxiliaries are systematically redundant.

It is sufficient to have only one of the two diesel generators operational for the safe shutdown of the Unit.

8.3.1.9.3. Switchover from the preferred electrical supply source

The switchover from the preferred electrical supply source of the 6,6 kV and 480 V safeguard switchboards to the emergency supply source can occur as follows :

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a) Automatically

The starting order is given for a loss of voltage on the safeguard switchboard for longer than 0,9 second. When the frequency and the voltage of the generator set are correct (about 10 seconds after the order for startup), the circuit breaker on the preferred supply to the 6,6 kV safeguard switchboard is opened, and the safeguard auxiliaries are shed. The incoming circuit breaker on the diesel generator set is closed. The reloading sequence is then followed over a period of 40 seconds on train A and 30 seconds on train B.

b) Manually

The switchover may be performed manually via the transfer control switch located on the control room rear panel. This causes the starting of the diesel generator set, and, when the voltage and frequency are correct, the same procedure as above is followed.

The diesel generator set can be manually started from the control room by means of a pushbutton located on the rear panel ; however, in this case, no switchover is performed.

8.3.1.9.4. Diesel generator stop

Stopping the diesel generator is only possible locally after resetting from the control room.

8.3.1.10. Instrumentation and protection relative to the diesel generator

The diesel generating set starting mode selector switch located on the local control panel is normally in the automatic mode position. The only time it is in the manual position is for routine periodic testing. If the switch is not returned to the automatic position, an alarm in the control room is activated until the switch is returned to the automatic mode.

Automatic and manual control of the diesel generating sets and safety-related loads requiring automatic sequencing are provided. Control of safety-related systems is available both locally and in the main control room. To bring the Plant to a hot shutdown, additional controls are located on the shutdown panel used in case of control room evacuation. Control circuitry maintains required redundancy with the associated power circuit.

The following instrumentation is provided to monitor the operability of each diesel generating set :

- voltmeter,
- ammeter,
- frequency meter,

- varmeter,
- wattmeter,
- running time meter.

The diesel generating set protection systems initiate automatic and immediate protective actions to prevent or limit equipment damage and allow restoration of the equipment upon correction of the trouble. In emergency operation the following protections initiate diesel generator trip (which cannot be overridden by the operator) :

- overspeed protection (automatic),
- undervoltage protection (automatic),
- manual emergency cut-out.

Excluding emergency operation, tripping of the diesel generating set occurs for any of the following :

- crankcase oil overpressure,
- under pressure in lube oil system,
- over temperature in lube oil system,
- low level oil sump,
- cooling water pressure, low,
- cooling water temperature high high,
- insulation fault 2nd threshold,
- overspeed protection,
- undervoltage protection,
- manual emergency cut-out,
- reserve power flow.

8.3.1.11. Testing of the diesel generating set

In order to insure the reliability of the emergency generator sets to supply the designed load, tests are performed following the procedures below :

a) Qualification testing

A qualification test program is applied to the diesel generator units to demonstrate the start and load carrying capability of these units with some margin in excess of design requirements.

If failures are found to be of a generic nature in a single component, it may be possible to correct the problem by use of a different kind of component or to correct the deficiency in the component. After the cause of the problem is corrected, the diesel generator unit is tested sufficiently to verify the correction.

b) Preoperational tests

During the Plant preoperational test program, consecutive tests with no failure are to be run, to demonstrate the required reliability.

C) Periodic tests

These tests ensure that no faults develop which may lead to an unacceptable situation.

- In-cycle test

Test once every month of one of the two diesels are performed at 90 % ~ 100 % power by synchronizing to the grid.

- 18 months test

At least during reactor shutdown, tests are to be performed in the following.

- Full-Load Rejection Test
- Single-Load Rejection Test
- Loss-of offsite Power Test
- Load-Run Test
- Hot Restart Test
- Test Mode Change-Over Test
- SIAS Test
- Combined Test
- Protective Trip Bypass Test
- Redundant Unit Test

Tests for load shedding and reloading are performed once every refueling outage period. Test signals required for reloading sequence test are "loss of voltage", "safety injection" and "Hi-hi pressure in the containment building". These tests are coupled if possible with the 18 months test of the safety system sets connected to the diesel.

- The level of the fuel storage tanks of each emergency diesel generator set is monitored periodically and after each operation.

8.3.1.12. Vital instrument and control power supply

In order to comply with the redundancy criterion applicable to safety-related systems and with the general design of the reactor protection system and the nuclear instrumentation, there are four fully independent 220 V AC boards LNA, LNB, LNC and LND, which supply the four protection and instrumentation groups.

Each one of these switchboards has its own 125 V DC power supply comprising :

- a lead-acid storage battery with a designed autonomy of two hours, for train A&B boards.

- a charger fed by emergency supplied 480 V AC switchboard.

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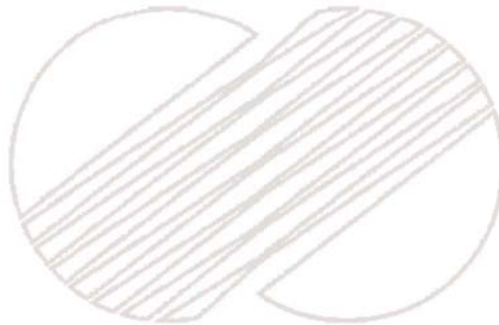
For each board, 220 V AC is produced by a 5 kVA 125 V DC/220 V AC inverter.

In addition, each of these 220 V AC distribution boards has emergency power provided by a regulating transformer supplied from the 480 V AC emergency backed switchboard.

8.3.1.13. Other important control and instrument AC power supply

The other AC power supplies are :

- one 220 V AC board LNE which supplies :
 - the computer (KIT),
 - the monitoring of full length control rod assembly,
 - the reactor core internal instrumentation,
 - the radioprotection system, etc.,



220 V AC is produced by three 25 kVA inverters in parallel ; design is such that two inverters are capable of carrying the total load,

- two 260 V AC power sources which supply the control rod drive mechanism cabinets.

8.3.1.14. Tests relative to the AC systems

a) Factory tests - seismic withstand capability

All distribution switchboards are submitted to factory testing and the rating, and the protections of each feeder are checked. Vibration tests are performed on a switchboard column, an inverter, a battery, and a rectifier in order to check that this equipment is not affected by the specified earthquake.

b) Checking and testing during commissioning

The following are checked during commissioning :

- connections are in compliance with electrical diagrams,
- electrical circuits are complete,
- electrical circuits are separated as required,
- measurement and protection devices are correctly rated.

Tests are carried out on protection devices, the emergency automatic sequencer, and electrical interlocking systems without power supply.

Tests of the emergency automatic reloading sequencer are also to be performed during normal operation.

c) Checking and testing during operation

Periodic testing and checking of the system during continuous operation are also scheduled.

Main Class 1E circuit breakers are testable during reactor operation. During periodic tests, systems such as safety injection, containment spray, and containment isolation are actuated, thereby causing appropriate circuit breaker or contactor operation.

The 6,6 kV and 480 V circuit breakers and control circuits can also be tested independently while individual equipment is shut down. The circuit breakers can be placed in the test position and exercised without operation of the associated equipment.

8.3.1.15. Design criteria for class 1E equipment

Framatome's usual practise is that class 1E equipment is not designed differently from other equipment which has to perform a function connected to the process.

All this equipment is designed according to technical specifications issued for each type of electrical equipment and are relative to :

- motors (motor size, minimum accelerating voltage, motor starting torque, motor insulation, temperature monitoring devices),
- motor valve actuators (motor size, minimum accelerating torque, coupling, motor circulation),
- 6,6 kV power cables,
- 600 V power cables,
- MV/LV distribution transformers.

More precisely the following design criteria are applied :

a) Motor size

Motor size (horsepower capability) is equal to or greater than the maximum horsepower required by the driven load under normal running, runout, or discharge valve (or damper) closed condition.

b) Minimum motor accelerating voltage

The electrical system is designed so that the total voltage drop on the Class 1E motor circuits is less than 20 % of the nominal motor voltage. The Class 1E motors are specified to have accelerating capability with 80 % nominal voltage at their terminals.

c) Motor starting torque

The motor starting torque is capable of starting and accelerating the connected load to normal speed within sufficient time to perform its safety function for all expected operating conditions, including the design minimum terminal voltage.

d) Minimum motor torque margin over pump torque through accelerating period

The minimum motor torque margin over pump torque through accelerating period is determined by using actual pump torque curve and calculated motor torque curve at 80 % terminal voltage. The minimum torque margin (accelerating torque) is such that the pump-motor assembly reaches nominal speed in less than 3 seconds. This margin is usually not less than 10 % of the pump torque.

e) Motor insulation

Insulation systems are selected on the basis of the particular ambient conditions to which the insulation is exposed. For Class 1E motors located within the containment, the insulation system is selected to withstand the postulated accident environment.

f) Temperature monitoring devices provided in large horsepower motors

Three resistance temperature detectors (RTD) are provided in the motor slots, per phase, for 6,6 kV motors.

g) Interrupting capacities

The interrupting capacities of the protective equipment are determined as follows :

- Switchgear

Switchgear interrupting capacities are greater than the maximum short circuit current available at the point of application. The magnitude of short circuit currents in medium voltage systems is determined in accordance with RCC-E Volume C 2222. The off-site power system, the main turbine generator, a single operating diesel generator, and running motor contributions are considered in determining the fault level. High voltage power circuit breaker interrupting capacity ratings are selected in accordance with RCC-E Volume C 2222.

- Load centers, motors control centers, and distribution panels.

Load center, motor control center, and distribution panel circuit breaker interrupting capacities are greater than the maximum short circuit current available at the point of application. The magnitude of short circuit currents in low-voltage systems is determined in accordance with RCC-E Volume C 2222. Low-voltage power circuit breaker interrupting capacity ratings are selected in accordance with RCC-E Volume C 2222. Molded case circuit breaker interrupting capacities are determined in accordance with RCC-E Volume C 2222.

h) Electric circuit protection

Electric circuit protection follows the criteria expressed in RCC-E Volume C 2300.

i) Grounding requirements

A ground grid is furnished over the station area to provide personnel safety and to provide facilities for systems, structures, and equipment grounding. Bare copper conductors and driven copper ground rods are of

sufficient size to carry the maximum ground fault current. Conductors are located to limit touch and step potentials to safe values under any fault conditions. The design and analysis is based on RCC-E Volume C 2330.

j) Logic and schematic diagram

Sufficient logic and schematic diagrams have been provided in Design System Reports to permit an independent evaluation of compliance with safety criteria.

8.3.1.16. Electrical supply safety analysis

8.3.1.16.1. General

The following analysis proves that the KNU 9 and 10 supply and distribution network complies with all requirements relating to off-site power supplies and on site AC power supply (RCC-P, Paragraph 2.4.2.) :

- all permanent and emergency auxiliaries (for safety and safeguard purposes) may be supplied from two external sources of supply : the preferred and auxiliary sources of supply. The rated power of each transformer is chosen in order to supply all auxiliaries regardless of the circumstances,
- the electrical power is supplied by two independent 345 kV networks via the plant switch-yard as described in Section 8.2.
- the high voltage, medium voltage, and control supply network has been designed so that it is possible to come back to the available source of supply despite the downgraded condition of the network,
- the following provisions are taken to reduce the probability of a total loss of the electrical power supply sources as a consequence of the following events (event : action taken) :
 - . loss of power generated by the Unit : opening of the generator circuit breaker,
 - . loss of power coming from the off-site 345 kV network : house loading. In case of failure of house loading the auxiliaries are supplied from the auxiliary network (source transfer),
 - . loss of power supplied from onsite sources : actions in Technical Specifications should be followed (Chapter 16, Subsection 16.4.7. electrical power systems).

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- each safeguard train is powered by the non-safety electrical distribution system which has access to the main generator and two off site networks. In addition, a dedicated D.C. is connected to each safeguard train.
- there is no interconnections between redundant safety trains of the same Unit or between any two trains of separate Units,
- each power train supplies the electrical auxiliaries of each independent train of the redundant mechanical systems (physical separation), so that loss of one train does not lead to a loss of function,
- each bus supplying a single train is provided with both off-site power and a separate on-site supply,
- diesel generator sets are started automatically upon specific events (refer to Paragraph 8.3.1.9.1.),
- change over of the emergency supplied auxiliaries from the off-site to the on-site sources is automatic with loss of voltage on the buses ; the return to normal power and diesel shutdown is manual.

8.3.1.16.2. Safety related equipment exposed to hostile environment

The detailed information on all Class 1E equipment that must operate in a hostile environment during and/or subsequent to an accident is furnished in section 3.11.

8.3.1.17 Alternate AC Power Supply (SBO)

One Non-Class 1E diesel generator, which is in the independent AAC building separated from the existing power blocks, is provided as an alternate AC(AAC) source to cope with station blackout(SBO) for the common use of UCN 1 and 2, as required by 10 CFR 50.63 and Regulatory Guide 1.155. The AAC source is designed to start manually from the main control room of each unit of UCN 1 and 2, and one division of two safety-related buses is available to power within 10 minutes of the onset of station blackout. In order to provide power to AAC D/G auxiliary systems and electrical loads in the AAC D/G building, the AAC bus can be connected only to one safety-related bus of UCN 1 and 2 during normal plant operation.

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The Class 1E circuit breaker is located in Class 1E 6.6 kV switchgear panel and allowed as an isolation device to connect between Class 1E bus and Non-Class 1E bus. The AAC source may be synchronized and operated in parallel with a preferred power source to allow test of AAC source during normal operation of power plant. Interlocks are provided to permit control of the AAC source from only one unit at a time in order to prevent the parallel operation from two units. The AAC source is designed to be inspected, maintained and tested periodically in accordance with NUMARC 8700.

The AAC source and its supporting systems can be controlled and monitored locally and remotely from each main control room of UCN 1 and 2. The following instruments are provided on each control panel of UCN 1 and 2 and on local control panel which is installed in AAC D/G building. The status lights of AAC D/G and supply breaker position in the main control room and at the circuit breaker cubicle.

Indicators in the main control room and the AAC D/G room :

- A. Voltage of AAC D/G output
- B. Amperes of AAC D/G output
- C. Watts and VARs of AAC D/G output
- D. Frequency of AAC D/G output
- E. Voltage of field
- F. Amperes of field

Handswitches and status lights in the main control room :

- A. Handswitches of AAC D/G and supply breaker to each unit
- B. Status lights of AAC D/G and supply breaker position

If the loss of offsite power(LOOP) is occurred, in the unit which supplies power of AAC facility, the AAC bus is automatically disconnected by the undervoltage relays on class 1E bus. Or if the SIS is occurred in the unit which supplies power of AAC facility, the AAC bus is also automatically disconnected from the safety related bus.

And then AAC bus is manually connected to any Class 1E bus of the other units which are available offsite power.

If the SBO is occurred in any of the units, the AAC source is manually started by the operator in main control room and connected to the AAC bus which is tied to the Class 1E bus. And then the loads required to bring and maintain the plant in safe shutdown are manually started.

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During a SBO, the trip of AAC diesel generator is provided with the only protective trip functions by differential relay, engine overspeed device and handswitch, and other devices generate alarm only. But the trip of AAC diesel generator is provided by all protective devices during testing of the AAC diesel generator.

When the offsite power is restored, the loads of the Class 1E bus will be transferred to the normal or alternate offsite power. The AAC source can then be unloaded, disconnected, and shut down. If the emergency diesel generator is restored, it can be connected to the Class 1E after tripping of the AAC feed breaker to the bus.

Rating for AAC diesel generator sets are calculated to satisfy the requirements of Regulatory Guide 1.155.

The continuous rating of the AAC source is based on the maximum total loads required at any one time. The AAC source is capable of supplying all loads necessary to shut down and maintain the plant in a safe shutdown condition to mitigate the consequences of postulated accident. The SBO load list is provided in Table 8.3-1a

The AC source system of Alternate AC source facility consist of the 6.6 kV switchgear, 480 V load center, 480 V motor control center, 120 V distribution panel in 480 V motor control center and AAC diesel generator set.

The AAC diesel generator is rated as shown below :

- a. Continuous Rating 5 500 kW
- b. 2-hour rating in any 24-hour period 6 050 kW

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8.3.1.18. 220 V AC transportable diesel generator and power connection equipment

8.3.1.18.1. Design basis

According to Fukushima nuclear power plant accident follow-up actions, the buildings are changed to be waterproof. If the integrity of power supply facilities(EDG, AAC D/G and power distribution systems) are secured by these actions, the current power system is sufficient for coping with a variety of accident scenarios. But considering unexpected loss of power, Ulchin unit 1, 2, 3, 4, 5 and 6 shall secure a common transportable diesel generator and power connection equipment to increase the availability of the safety parameter display system.

The transportable diesel generator(1 phase / 220 V AC / 60 Hz / 30 kVA / 72 hours continuous operation capacity) shall supply emergency power to safety parameter display system.

Transportable diesel generator will not perform plant safety function, but it is emergency equipment to cope with long-term station blackout, like that occurred by Fukushima nuclear power plant accident, so it is designed as Non safety-related equipment.

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By the lessons learned from Fukushima nuclear power plant accident, transportable diesel generator is kept in a safe zone from flooding. If situation occurs, it is moved in front of EDG(LHP) building where power supply is possible, after connecting temporary cables, the power is supplied.

In the event of power failure, transportable diesel generator shall supply emergency power within two(2) hours.

8.3.1.18.2. Coping analysis of power loss of safety parameter display system

8.3.1.18.2.1. Coping period

Transportable diesel generator is installed in order to cope with the situation of power loss of safety parameter display system. Transportable diesel generator supplies power to safety parameter display system to provide safety parameter to emergency response organization.

8.3-21d

Transportable diesel generator is equipped with auxiliary fuel tank, of eight(8) hours capacity, and it is designed to operate continuously more than 72 hours.

Since the same fuel, that is used for 220 V AC transportable diesel generator, is available on-site inside EDG fuel tank, if more than eight(8) hours of operation is required, continuous operation is possible by transferring fuel manually.

8.3.1.18.2.2. Coping ability

Coping ability of 220 V AC transportable diesel generator is considered as follows:

- A. In the event of power loss of safety parameter display system, 220 V AC transportable diesel generator is secured.
- B. Considering the capacity of essential loads that is required in the situation of power loss of safety parameter display system, the capacity of emergency power shall be 30 kVA.
- C. If the power loss of safety parameter display system occurs, 220 V AC transportable diesel generator is moved in front of EDG(LHP) building. Temporary power cables are connected to 220 V AC Distribution Panel (1/2-KIT-001CR,002CR,003CR,004CR,005CR,001CR(UPS)) by using terminal box. After that, generator is started manually. Power is supplied to 220 V AC Distribution panel(1/2-KIT-001CR,002CR,003CR,004CR,005CR, 001CR(UPS)).
- D. Temporary power cable length from 220 V AC transportable diesel generator to the position of connection point, considering enough margin, shall be maximum 30 m.
- E. 220 V AC transportable diesel generator is equipped with auxiliary fuel tank, with capacity of eight(8) hours, and if additional fuel is supplied, continuous operation is possible.
- F. Transportable diesel generator is kept in highlands of plant site safe from flooding and in a place considered as having convenience of mobility, rapidity and suitability of storage.
- G. 220 V AC transportable diesel generator moves along the existing road network. And the point where power is supplied should be

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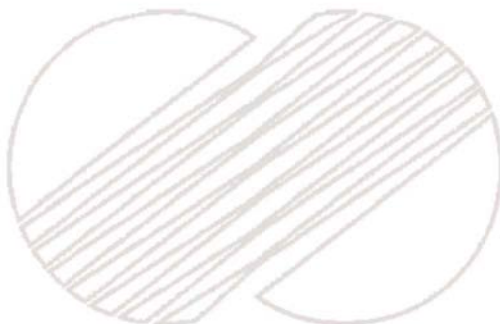
near the location of EDG(LHP) building and where distance from power connection terminal is minimum. When the transportable diesel generator arrives at the location, the flooding water level at the point is low so that power supply is possible. Site layout, building structure and convenience of installation of temporary power cable are also considered.

- H. To minimize the time required for power supply by 220 V AC transportable diesel generator, three groups, i.e., the first group for transportable diesel generator movement, the second group for installation and connection of cables and the third group for operating the breaker, shall be organized to establish the task.

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8.3.1.18.3. Periodic Testing

220 V AC transportable diesel generator shall be periodically tested according to manufacturer's instruction manual to prove availability for operation.



8.3.1.19. 4.16 kV mobile gas turbine generator and power connection equipment

8.3.1.19.1. Design basis

According to Fukushima nuclear power plant accident follow-up actions, the buildings are changed to be waterproof. If the integrity of power supply facilities, such as, EDG, AAC D/G and power distribution systems are secured by these actions, the current power system is sufficient for coping with variety of accident scenarios. But considering unexpected loss of power, Ulchin unit 1, 2, 3, 4, 5 and 6 shall secure a common mobile gas turbine generator to increase the safety of the system.

The mobile gas turbine generator shall be 3 phase/4.16 kV/60 Hz, the rating capacity for continuous operation of 72 hours is 3,200 kW.

Mobile gas turbine generator will not perform plant-specific safety function. But it is emergency equipment to cope with long-term station blackout, like that occurred by Fukushima nuclear power plant accident, so it is designed as quality class S.

By the lessons learned from Fukushima nuclear power plant accident, Mobile gas turbine generator is kept in a safe zone from flooding. If situation occurs, it is moved to access point where power supply is possible, after connecting temporary cables, the power is supplied. In the event of power failure, mobile gas turbine generator shall supply emergency power within two(2) hours.

8.3.1.19.2. Long-term SBO coping analysis

8.3.1.19.2.1. Coping period

4.16 kV mobile gas turbine generator is installed in order to cope with the situation of unavailability of AAC D/G, which is to cope with SBO.

4.16 kV mobile gas turbine generator supplies power for AC and DC loads essential to secure safety of plant. It also supplies power for facilities to prevent damage to the core of the reactor by maintaining the cooling function by natural circulation of reactor coolant.

8.3-21g

4.16 kV mobile gas turbine generator is installed with a day tank, of one hour capacity, and it is designed to operate continuously more than 72 hours.

Since the same fuel oil, that is used for 4.16 kV mobile gas turbine generator, is available on-site inside DIESEL generator fuel oil tank, if more than one hour operation is required, continuous operation is possible by transferring of fuel oil manually, etc.

8.3.1.19.2.2. Coping ability

Coping ability of 4.16 kV mobile gas turbine generator for long term SBO is considered as the follows:

- A. In the event of SBO and condition of unavailability of AAC D/G power occurs at the same time under long-term, to provide power for essential facilities, 4.16 kV mobile gas turbine generator is secured.
- B. Considering the capacity of essential loads that is required in the situation of SBO under long-term, the capacity of 4.16 kV mobile gas turbine generator shall be 3,200 kW.
- C. If the long term SBO occurs, 4.16 kV mobile gas turbine generator is moved to power supply point. Power is supplied to the bus, LHA or LHB, using temporary power cable and terminal box. After the connection, the generator is operated and load is input manually in sequence.
- D. 4.16 kV mobile gas turbine generator from the position of connection point, temporary power cable length shall be maximum 70 m considering enough margin.
- E. 4.16 kV mobile gas turbine generator is equipped with a day tank, with capacity of one hour. If additional fuel oil is supplied, continuous operation is possible.
- F. Mobile gas turbine generator is kept in highlands(+44.3m above site level) of plant site for safety from flooding. And a place is considering convenience of mobility, rapidity and suitability of storage.
The storage structure is designed according to KBC Code(2009 edition) and KCI Code(2007 edition) for protection from Ulchin 1,2 SSE and applied quality class 'S' and non-safety related class.
- G. 4.16 kV mobile gas turbine generator moves along the existing road network to the power supply point. This point locates near the location of DIESEL generator building, where distance from

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power connection terminal is minimum. That point considers the period of time for flooding water level to decline to a level that power supply is possible, when the mobile gas turbine generator arrives at the location. Site layout, building structure and convenience of installation of temporary power cable are also considered.

- H. To minimize the time required for power supply by 4.16 kV mobile gas turbine generator, three groups shall be organized to establish the task. The three groups mean the first group for mobile gas turbine generator movement, the second group for installation and connection of cables and the third group for operating the breaker.

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8.3.1.19.3. Periodic Testing

4.16 kV mobile gas turbine generator shall be periodically tested according to manufacturer's instruction manual to prove availability for operation.

8.3.2. DC power systems

8.3.2.1. Description

The DC systems supply all the control and signal systems and the vital and permanent 220 V AC production through DC/AC inverters.

Each Unit has its own direct current power supplies, except the common DC auxiliaries which are normally fed from the 9LGI switchboard.

Several independent DC systems are provided :

- the 125V DC networks feed in particular the control circuits of contactors and circuit breakers and the DC/AC inverters, which give the vital 220 V AC Voltage to the safety channels and some other circuits,
- the 48 V DC networks feed in particular the relaying automatic control and monitoring equipment, the visual annunciator alarms, computer logic information acquisition circuits, electrovalves and motor-driven valves actuators,

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- the 230 V DC networks feed the DC/AC inverters, which give the permanent. 220 V AC voltage to recorders, radiation monitoring system, process instruments, computer and some safety auxiliaries,
- the 30 V DC networks are intended to supply the regulation circuits of the Unit.

This voltage level functional organization is itself divided into three groups. In order to ensure optimum safety, some essential functions are duplicated, thus providing totally independent parallel trains, called train A and train B by means of separated sources and distribution switchboards. The third group, independent of the others, feeds the consumers which are common to the two Units.

The networks 48 V DC, 125 V DC, and 220 V AC belonging to the safety train A and the 30 V DC, 48 V DC, 125 V DC, 230 V DC and 220 V AC networks belonging to the non-safety train A are connected to the train A medium voltage (MV) emergency supplied LHA switchboard through the 480 V AC switchboards.

The 48 V DC, 125 V DC and 220 V AC networks belong to the safety train B and are connected to the train B MV emergency supplied LHB switchboard through the 480 V AC switchboards.

The control of the safety-related actuators of train A is fed by the train A, DC sources. The control of the safety-related actuators of train B is fed by the train B, DC sources.

The turbine direct current auxiliaries are fed by the 230 V DC networks. These networks are connected through rectifiers and intermediate AC switchboards to the LGB medium voltage (MV) switchboard.

The common auxiliaries fed with the 48 V DC, 125 V DC and 220 V AC networks in relation with the two Units (Units 1 and 2) are connected through the normal 480 V AC switchboards to the 9 LGI common non-emergency supplied medium voltage (MV) switchboard.

All the production equipment and distribution switchboards for the DC systems described above are located in the electrical building.

In addition to the DC power systems described above, another DC power system for coping with station blackout(SBO) of UCN 1 and 2 is supplied by an independent Non-Class 1E 125 V battery with an associated battery charger and a distribution panel.

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8.3.2.2. Design basis

8.3.2.2.1. 125 V DC production and distribution system

The 125 V DC networks feed the Unit actuators control circuits (circuit-breakers, contactors) the DC/AC inverters (Vital 220 V AC) and some decentralized control cabinets.

The 125 V DC systems constitute two networks in each Unit : one corresponding to train A, the other to train B.

The two Units have a common network feeding mainly the nuclear auxiliary building actuators.

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The redundant control actuators are fed by train A and train B. The nonredundant actuators are fed by train A.

A specific 125 V DC battery is provided to supply the various breakers whose operation is necessary to supply the LHB busbar from the auxiliary network in the event of a total loss of the train A batteries.

Each system includes :

- one lead-acid battery,
- one or two battery charger (s) ensuring the battery charging and the normal feeding of the consumers,
- one distribution switchboard with the incoming and outgoing circuitbreakers and switches.

The essential DC systems include two battery chargers fed with 460 V AC from two different LV switchboards (one of them is emergency supplied by one MV diesel generator set).

- lead-acid batteries are provided for the power supplies feeding all the train A&B switchboards and the circuits which do not ensure a redundant service.

Safety-related batteries are designed to supply the required loads for two hours. Other batteries are designed to supply the required loads for one hour.

The fully static battery chargers charge and maintain the lead-acid batteries capacity and, simultaneously, provide load circuits with a continuous power supply within close voltage limits.

Automatic charging is effected in two stages :

- charging on a virtually constant current at a value at least equal to 0.1 C10* discharge rate until a voltage of 2.28V per cell is reached.

Charging continues at this voltage until the battery has recovered 90% approximately of its capacity.

The duration of this mode is about 15 hours for lead-acid batteries.

- after this period, the battery is put on a floating voltage charge to bring it up to full charge.

One distribution switchboard is provided for each production system.

(*) C10 : lead-acid battery rated capacity

Each switchboard includes :

- one protected busbar,
- incoming and outgoing breakers and switches,
- control and signal relaying system.

The arrangement is such that live parts are not accessible during normal operation.

8.3.2.2.2. 48 V DC production and distribution systems

137 | The 48 V DC systems feed in particular the relaying automatic control and monitoring equipment, the visual annunciator alarms, computer logic information acquisition circuits, electrovalves, and the reversing contactor for motor-driven valves.

The 48 V DC systems constitute three networks in each Unit :

- one corresponding to train A,
- one corresponding to train B,
- one for corresponding train A - train B (decoupling).

One network common to the two Units feed mainly the relaying equipment of the nuclear auxiliary building.

The redundant actuators relaying is fed by trains A and B. The non-redundant actuators relaying is fed by train A.

Each system includes :

- 137 |
- one battery,
 - two battery chargers
 - one distribution switchboard with the incoming and outgoing breakers and switches.

8.3.2.2.3. 230 V DC production and distribution systems

These systems mainly supply the DC/AC inverters for the Unit control safety and data processing circuits, the standby and continuous lubricating oil pump of the turbine, as well as, the generator sealing oil pump.

Each system includes :

- one battery,
- one or two chargers,
- one distribution switchboard with the incoming and outgoing breakers and switches.

8.3.2.2.4. 30 V DC production and distribution system

These systems supply only the regulation equipment of the Unit.

Each Unit has its own 30 V DC production and distribution systems. The battery chargers are fed from the 480 V AC switchboards (one of them is emergency supplied by one MV diesel generator set).

Each system includes :

- one lead-acid battery,
- two chargers, one of them ensures the battery charging and the normal feeding of supplied equipment
- one distribution switchboard with the incoming and outgoing circuit breakers and switches.

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8.3.2.3. DC power safety analysis

As mentioned in RCC-P Paragraph 2.4.2.4.1 "Preoperational tests and Inspections" and in RCC-E Volume C 3000 "Periodic tests and availability of Class 1 E Equipment", testing of the DC power system is performed prior to and during Plant operation.

The following in service tests and inspections are performed :

- all cells are checked weekly for cracks and electrolyte leakage,
- the plates of all cells are checked quarterly for buckling, discoloring, grid cracks, and plate growth,
- float voltage is measured quarterly,
- battery charging current is measured quarterly when the battery is on float charge,
- the temperature of the electrolyte is measured and recorded quarterly,
- the specific gravity of the electrolyte and the voltage of each cell and the battery terminal voltage are measured and recorded quarterly,
- the electrolyte level of each cell is checked quarterly and any water addition is recorded,
- a battery discharge test is performed on every refueling outage

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The following inspections and tests are performed on Class 1 E battery chargers :

- each charger is visually inspected weekly,

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- performance tests are conducted on each charger during every outage. During these tests, charger input and output voltages are measured, and alarms and protective devices are checked for proper operation.

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General Design Criteria concerning separation and protection relative to DC power supplied (cf. RCC-P Paragraph 2.4.2.3.) are met :

- the auxiliaries and their DC equipment are supplied by the associated busbars in such a way that loss of power on one train of auxiliaries does not affect equipment on another train,
- sizing criteria of DC power source consists of a battery and two battery chargers connected to the same emergency AC supply,
- installation criteria for the DC power supply are the same as those for AC power and are met equally : charger, inverters and DC switchboards are installed in the electrical building (separate rooms for train A and train B).

8.3.2.4 Non-Class 1E DC Power for AAC Source

In addition to the existing batteries, a separate non-Class 1E dc power system is provided for the loads related common AAC source. The dc power system consists of one 125 V battery, one battery charger and one control center. This dc power system provides control and dc power for the common AAC source-related loads and common UPS located in the AAC diesel generator building. Non-Class 1E dc power for AAC Source is shown in figure 8.3-2.

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8.3.3. Fire protection for cable system

See Subsection 9.5.1.

8.3.4. Diesel generator sets

8.3.4.1. Design

Generator sets are of the twin diesel type i.e., generator is driven by two identical engines mounted at either end, one rotating clockwise, the other counter-clockwise.

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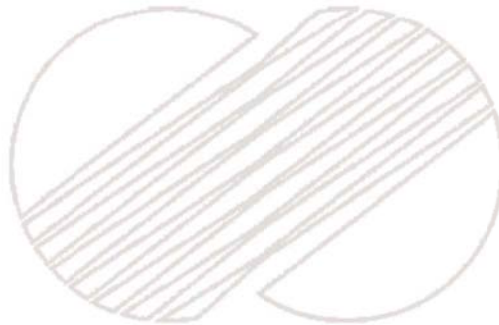
8.3-26a

Engines used are an off-the-shelf model which has been extensively field-proven. Each cylinder is supplied by a separate fuel injection pump : failure of a single injection pump will not cause shutdown of the diesel generator set.

The unit is designed to be capable of withstanding the following faults:

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- the three-phase or two-phase short-circuits at the generator terminals due to an external fault,
- overspeed operation at 1.15 times rated speed,
- overvoltages (at a frequency of approx. 60 Hz) of :
 - 1.4 × rated voltage for 4 seconds,
 - 1.2 × rated voltage for several minutes.



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- phase-to-ground steep-front grid overvoltage with 1,2/50 microsecond and 200/1500 microsecond waveforms and peak amplitude of 25 kV,
- synchronizing to the grid with phase shift from 120 to 180 ° a minimum of two times.

Temperature of the combustion air is the temperature of the room in which the diesel generator is located. With the generator set operating at full power and outside ambience at 15 °C or more, ventilation of the diesel generator room is designed so that the temperature of the room will not exceed the temperature of the outside air by more than 10 °C.

The design of the diesel generator auxiliaries is given in Section 9.5.

8.3.4.2. Description

Diesel generator sets and their auxiliaries are installed in two separate buildings :

- one close to the fuel building,
- one close to the electrical building.

General characteristics of the engines and of the generators are given in Table T-8.3-3. A detailed description of the diesel generator sets is provided in Reference 2 whereas a summary description of the main components of the engine is given below :

- Cylinder block

The cylinder block is en-block cast iron. It consists of 2 rows of 6 cylinders set at an angle of 50 ° to each other. It is compact and strongly ribbed. Six ports on each side of the engine block give access to the connecting rod assemblies for case of disassembly. A second series of 6 apertures gives access to the camshaft and push rod.

- Engine frame

The engine frame is welded structural steel. The frame supports the crankcase and selected auxiliary equipment such as heat exchangers, valves, lines, and moving part guards.

- Cylinder heads

Cylinder heads are individual cast iron type. Two inlet and two outlet valves are mounted on each head.

Valves have special-alloy seat ring inserts for long running life without relap.

Exhaust valve bearing surfaces are stellited and stems are nitrided.

Two helical springs are provided on each valve.

The fuel injection pump (injector) is mounted on the cylinder head. It is designed to be easily removed without allowing fuel to drain into the crankcase.

- Cylinder liners (sleeves)

Cylinder liners, made of centrifugally-cast iron, are of the wet type. Inner liner surface is honed. A metal-to-metal head-to-liner seal is provided. Water/oil resistant synthetic rubber ring gaskets at the top and bottom of the liner ensure liner/cylinder block leaktightness.

- Connecting rod

The connecting rod is made of drop forged alloy steel. Master-articulated rod design is used. The articulated rod is linked to the big end of the master rod. Easy access to the cap bolts is provided through special access ports. Moving parts can be readily removed through the cylinder barrel.

- Crankshaft

The crankshaft is hardened chromium-molybdenum steel, forged in one piece. Crank-pins and journals are face-hardened and honed. Hardness and surface roughness are carefully controlled. Steel counterweights are provided for crankshaft balancing.

- Vibration damper

A torsional vibration damper is fitted on the crankshaft free end.

- Bearings

Main bearings and master rod bearings are fitted with bushings. Bushings are replaceable to obviate the need for resizing.

The shells are of trimetal alloy and have excellent rubbing characteristics.

- Gear

Helical gears, located opposite the flywheel end of the crankshaft, drive the two camshafts.

The gear assembly also drives the governor and the auxiliary power take off. The assembly is enclosed in a cast iron housing.

As the camshaft rotates, the cam lobe forces the valve lifter push rod assembly upwards, causing the rocker arm and tappet to push down and open the inlet valve.

- Lubrication

Two gear pumps provide automatic lubrication of the engine block and all components, except the fuel injection pumps and the cooling water pump.

- Couplings

Couplings are mounted between each engine and the generator to transmit the driving torque between the prime mover and the driven machine. Each coupling is of the material-flexible type with two coupling halves :

- the flanged driving coupling half is fitted rigidly to the diesel engine shaft by means of dowels and screws,
- the driven coupling half, also flanged, is fitted rigidly to the shaft of the driven machine by means of keys.

Symmetrical coupling flanges are made of fabric-reinforced natural rubber.

- Auxiliaries

Refer to Section 9.5.

8.3.4.3. Safety evaluation

The diesel generator buildings, diesel generator sets and their associated equipment are designed to withstand an SSE.

Diesel generator sets and auxiliaries are laid-out in two separate building (see Paragraph 8.3.4.2.). This arrangement makes the risk of the fire spreading from one set to the other, negligible.

The diesel buildings are not designed to withstand plane crashes due to the small target area of these buildings and the shadowing effect of other buildings, and thus a low probability of occurrence.

Refer also to Section 9.5. related to diesel generator set auxiliaries.

8.3.4.4. Tests and inspections

The diesel generator sets are submitted to periodic tests according to Chapter 16, Technical Specifications requirements.

In case of inoperability of a set, the Technical Specifications lists the fallback time and the fallback mode according to the initial Unit operating mode (Refer to the Subsection 16.4.7.).

The emergency diesel generator reliability program is applied to maintain and monitor their target reliability more than 0.95. This emergency diesel generator reliability program is in compliance with Reg. Guide 1.155 C.1.2 (August, 1988).

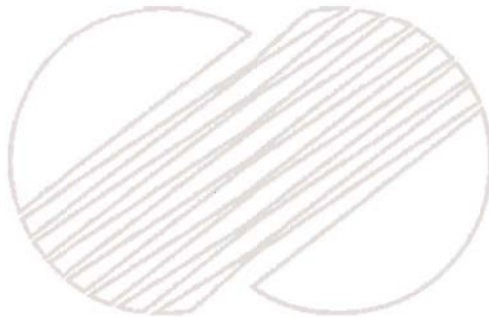
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8.3.4.5. Instrumentations requirements

A detailed description of the control principles is given in the licensing document Reference 2.

8.3.5. References

- 1 - 12 EDR 02 - Electrical design report
Electrical power distribution system
- 2 - 12 EDR 01 - Electrical design report
Diesel generator sets



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TABLE T-8.3-1 (1/2)

UCN 1 AND 2 POWER BALANCE (KW)

System	Designation	Rated power	Operat. power	Operation status			
				Start up	Normal operation	Shutdown + network loss	LOCA + network loss
RCV EAS RIS SEC SEC RRI RRI RRA ASG DEG	<u>LHA switchboard</u>						
	Charging pump n° 1	750	720	720	505	720	720
	Containment spray pump	475	490	—	—	—	490
	LH safety injection pump	265	270	—	—	130	270
	Essential serv. water pump 1	265	232	232	232	232	232
	Essential serv. water pump 3	265	232	—	—	—	—
	Component cooling pump 1	475	455	455	455	455	455
	Component cooling pump 3	475	455	—	—	—	—
	Residual heat removal pump	355	—	—	—	—	—
	Auxiliary feedwater pump	335	360	360	360	360	380
	N.I. chilled water unit 1	460	—	—	—	—	—
	L.V. switchboard (LLA)	570	509	509	509	509	353
	L.V. switchboard (LLC)	580	514	514	514	514	430
	L.V. switchboard (LLE)	440	390	390	390	395	230
	L.V. switchboard (LLI)	620	580	580	580	580	530
	L.V. switchboard (LLN)	630	585	585	585	585	395
<u>TOTAL</u>				4,345	4,130	4,480	4,485

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TABLE T-8.3-1a
UCN 1&2 STATION BLOCKOUT(SBO) LOAD LIST

System	Description	Rated Power	Operation Power
RCV SEC RRI ASG	<u>LHA Switchboard</u>		
	Charging Pump	750 kW	758 kW
	Essential Service Water Pump	265 kW	244 kW
	Component Cooling Pump	475 kW	468 kW
	Auxiliary Feedwater Pump	335 kW	360 kW
	Switchboard LLA	570 kVA	539 kW
	Switchboard LLC	580 kVA	417 kW
	Switchboard LLE	440 kVA	407 kW
	Switchboard LLI	620 kVA	539 kW
	Switchboard LLN	630 kVA	342 kW
	AAC D/G Building Loads	500/667 kVA	300 kW
	<u>TOTAL</u>		4 374 kW

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TABLE T-8.3-1 (2/2)

UCN 1 AND 2 POWER BALANCE (KW)

System	Designation	Rated power	Operat. power	Operation status			
				Start up	Normal operation	Shutdown + network loss	LOCA + network loss
RCV RCV EAS RIS SEC SEC RRI RRI RRA ASG DEG DEG	LHB switchboard Charging pump n°3 Charging pump n°2 Containment spray pump LH safety injection pump Essential serv. water pump 2 Essential serv. water pump 4 Component cooling pump 2 Component cooling pump 4 Residual heat removal pump Auxiliary feedwater pump N.I. chilled water unit 2 N.I. chilled water unit 3 L.V. switchboard (LLB) L.V. switchboard (LLD) L.V. switchboard (LLJ) L.V. switchboard (LLQ) <div>Delete</div>	750	720	—	—	—	—
		750	720	720	505	720	720
		475	490	—	—	—	490
		265	270	—	—	130	270
		265	232	232	232	232	232
		265	232	—	—	—	—
		475	455	455	455	455	455
		475	—	—	—	—	—
		355	455	—	—	—	—
		335	360	360	360	360	380
		460	—	—	—	—	—
		460	—	—	—	—	—
		590	530	530	530	530	209
		470	420	420	420	420	285
		620	573	573	573	573	569
	550	490	490	490	490	300	
TOTAL				3,780	3,565	3,910	3,910

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TABLE T-8.3-2

MAIN DC POWER SOURCES INVENTORY

Train A	Battery ampere hour rating	Rated intensity of chargers	Maximum ampere demand		
Control circuit of contactors and circuit-breakers :					
LBA(125 V)	1 200 Ah	250 A	209.9 A	108	268
LCA(48 V)	2 000 Ah	600 A	285 A		
Control circuit of switching MV boards :					
LBJ(125 V)	90 Ah	60 A	11 A	268	
Decoupling relaying :					
LCC(48 V)	250 Ah	100 A	42 A	108	
Control loops :					
LDA(30 V)	400 Ah	100 A	61 A	108	
Train B					
Control circuit of contactors and circuit-breakers :					
LBB(125 V)	440 Ah	100 A	47 A	108	
Relaying control circuits :					
LCB(48 V)	800 Ah	250 A	102 A	108	
COMMON(AAC SOURCE)					
LBK(125 V)	400 Ah	200 A	80 A	201	

TABLE T-8.3-3

DIESEL GENERATOR SETS
GENERAL CHARACTERISTICS

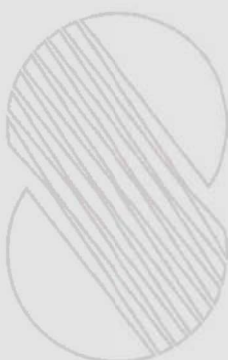
A. Engine (One diesel generator set comprises two engines)

Manufacturer	: HEMCO (in collaboration with SACM)
Type	: AGO 240 V 12 RVR
Number and arrangement of cylinders	: V 12. 50°
Engine speed rating	: 1200 rpm
Bore	: 240 mm
Cubic capacity	: 204,4 l
Stroke	: 220 mm
Displacement	: 122,5 l
Type of cycle	: 4 - stroke
Compression ratio	: 9
Avg piston speed	: 8,8 m/s
Rated power at 1200 rpm	: 2400 kW
Engine dead weight	: 18 500 kg

B. Generator

Manufacturer	: JEUMONT-SCHNEIDER
Rated output	: 5625 kVA
Rated voltage	: 6,6 kV
Rated frequency	: 60 Hz
Power factor	: 0,8
Insulation class	: F
Temperature rise	: B at 40 °C room temperature
Excitation	: Potential - source - rectifier with solid-state voltage and current control





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