

## **2. DIESEL GENERATOR UNITS**

### **2.1. MAIN DIESEL GENERATORS**

#### **2.1.0. Safety requirements**

##### **2.1.0.1. Safety functions**

This system does not contribute directly to the three basic safety functions.

However, if external electrical power is lost the system must function in order to restore the power supply to the supported systems.

##### **2.1.0.2. Functional criteria**

The power of the diesel generators is based on the loading of equipment to the bus bars and the equipment role in each of the design basis accidents. The nominal power of the diesel engines is sized to the reference accident having the greatest power demand.

In order to comply with the principle of segregation of the four electrical divisions, each division must be backed-up by an independent diesel.

The diesel reaches nominal speed (frequency) and voltage within 15 s from start-up signal.

In back-up mode, the diesel generator units provide electrical power having the voltage and frequency defined by the RCC-E (Chapter B.6).

The diesel generator units can be started without any auxiliary source of electrical power.

The auxiliary diesel systems enable each diesel generator unit to function at full load for 72 hours. This period is compatible with the time taken to commission heavy equipment which could be used to provide a long term supply. In addition the 15 day MDTE [LOOP] (following an earthquake) is to take into account in the design.

##### **2.1.0.3. Requirements related to the design**

###### **2.1.0.3.1. Requirements resulting from the safety classifications**

###### **Safety classifications of system**

The diesel generator units are safety classified in accordance with the classification principles given in Chapter C.2.

###### **Single failure criterion (active and passive)**

The single failure criterion applies to the active components of the diesel generator units which provide F1 functions.

###### **Emergency electrical supply**

Not applicable since the diesel generator units are self-contained.

**Qualification under operating conditions**

The equipment in the diesel generator units is subject to a qualification ensuring that it will carry out its safety role in the ambient conditions in which it is required to function.

**Classification of mechanical, electrical and instrumentation and control equipment**

The main diesels are classified EE1 and E1A in conformity with the electrical and instrumentation and control classifications given in Chapter C.2.

**Seismic classification**

The main diesel units are safety classified in accordance with the classification given in Chapter C.2.

**Periodic tests**

The main diesel units are tested periodically in order to ensure their availability.

**2.1.0.3.2. Other regulatory requirements**

Technical Guideline B.2.4.1 "Electrical supplies" states the following:

The main diesel generator sets are diverse from the two ultimate back-up/emergency diesel generators in order to eliminate common mode failures between the two types of generators.

**2.1.0.3.3. Hazards**

See Chapter C.3 for external hazards and Chapter C.4 for internal hazards.

**2.1.0.4. Tests****2.1.0.4.1. Preliminary tests**

The system is subject to first start-up tests in conformity with its safety function.

**2.1.0.4.2. Monitoring during operation**

Since the system is always on stand-by under normal plant operating conditions, and could be called on to start up at any time, the system parameters are monitored on a regular basis during operation.

**2.1.0.4.3. Periodic tests**

The system is designed to allow periodic testing in conformity with the general operating rules.

**2.1.1. Role of the system**

When the system is available, the engine is in stand-by mode. The main diesel generators are ready to start up at any time.

All the required auxiliaries are powered in order to ensure that the diesels can start up at any time.

### 2.1.2. Design bases

As a support system, the diesel generator unit is sized according to the equipment being supplied. The continuous nominal power of the diesel engine is designed to exceed the demands of the design basis accident which requires the most power, in the external temperature and humidity conditions defined in Chapter C.6.

The design criteria depend on:

- the nature of the equipment to be supplied,
- the power for the actuators,
- the requirement for the voltage to remain within the acceptable dynamic and static voltage range for the equipment in emergency mode, specifically during restart in the course of the re-powering sequence.

### 2.1.3. Description of the system and characteristics of the equipment

Each of the 10 kV emergency diesel generator units forms a self-contained unit together with the following auxiliary systems:

- diesel fuel system,
- lubrication oil system,
- coolant system,
- start-up air system,
- system for air intake and extraction,
- alternator, excitation and protection circuit,
- local instrumentation and control, control and signalling of alarms network.

#### Diesel fuel system:

Each diesel generator is fitted with a “day” tank fed from a storage tank.

The diesel fuel is pumped from the storage tank to the “day” tank by a backed-up pump (transfer pump) which is started at the same time as the diesel generator, thus ensuring that the « day » tank remains full.

The contents of the “day” tank enable the diesel generator unit to function for two hours at full load.

#### Lubrication oil system,

The diesel engine is provided with a self-contained lubrication system using a coupling booster pump.

A pre-lubrication device fitted with a re-circulating electrical pump reduces the time taken for the engine to run-up upon priority start-up signal.

Coolant system:

The cooling system is based on air coolers. The heat produced by the diesels is transferred to the cooling loop via a water/air heat exchanger.

Start-up air system:

Each diesel generator unit has a compressed air starter comprising:

- a compressor,
- one (or more) tank(s),
- two start-up air system trains,
- start-up valves.

A single air start-up train is necessary to start the engine for a priority start-up. The diesel is therefore considered as being available for its safety function when one of the two air start-up trains is available.

The capacity of the compressed air tank is sized so that several consecutive start-ups can be carried out on a single train without refilling.

System for air intake and extraction:

A sufficient supply of air is supplied for combustion and cooling.

The air intake and extraction systems are designed to avoid any flow recirculation.

The combustion air is taken from outside via air filters and air ducts and is delivered to the air chambers of the cylinders by a turbo-compressor driven by the exhaust gases.

The expanded exhaust gases leave the turbo-compressors through silencers and exhaust pipes to the outside.

Alternator, excitation and protection circuit:

The alternator is of the synchronous three-phase type.

It is air cooled.

It is fitted with a self excitation system with electronic voltage regulation.

Ventilation system for the diesel building:

A ventilation system for each diesel building provides air renewal for the rooms. The physical value of all temperatures is given in Chapter I.4.1.

Local instrumentation and control network for control and signalling of alarms:

The equipment can be started from the local control panel in order to enable tests to be carried out. Measurements and information on the diesel are recorded on this panel.

The diesels can be started:

- either by operator action:
  - o remotely via an electric signal coming from the Main Control Room,
  - o locally.
- or automatically by via a signal from the protection system.

A start-up without any external electrical source is also possible locally.

#### **2.1.4. Operating conditions**

##### **2.1.4.1. Normal operation**

During power operation, the diesel engine is available in stand-by mode at any time. To achieve this, it is always pre-lubricated and pre-heated.

##### **2.1.4.2. Steady operating mode**

The steady state of the engine is reached after start-up and the accompanying transients due to the re-powering of the backed-up actuators following the predefined sequence of powering up.

This stable operating condition is characterised by the power supply to the safety equipment until supply via the electrical network is restored.

The engine may be stopped:

- by operator action:
  - o either remotely from the Main Control Room,
  - o or locally using the emergency stop device.
- or by a priority protection action.

N.B.: In a long-term MDTE [LOOP], certain non-priority protections will be re-activated.

#### **2.1.5. Tests, inspection and maintenance**

##### **a) Periodic tests**

The periodic tests on the diesel generator unit and its auxiliaries must be capable of being carried out with the plant at power operation.

In order to avoid interruptions in the supply and to enable tests under full load to be carried out, it is possible to synchronise the diesel generator units to the network. If there is a loss of external electrical sources during this "linked to the grid" operation, the diesel generator will switch automatically to "back-up" mode. This function is classified only if the diesel has to remain available in the terms of the "General Operating Rules" during "linked-to-the-grid" operation.

##### **b) Maintenance**

With the plant operating, it is possible to carry out maintenance operations on one diesel generator unit at a time. It is also possible to carry out preventative maintenance on the auxiliaries.

Checks on diesel fuel, lubrication oil and cooling water are carried out within the maintenance operations and inspections.

## **2.2. ULTIMATE BACK-UP/ EMERGENCY DIESEL FOR STATION BLACKOUT**

### **2.2.0. Safety requirements**

#### **2.2.0.1. Safety functions**

The system does not contribute directly to the three basic safety functions.

However, if there is a total loss of electrical power (station blackout), it functions to restore power supply to essential equipment.

#### **2.2.0.2. Functional criteria**

An ultimate emergency diesel with its auxiliaries is sufficient to provide required electrical power following a total loss of the external electrical sources and of the internal back-up power sources.

The function of the system is to supply power to all required equipment at a voltage within the dynamic and static limits allowed by the equipment.

The ultimate back-up/emergency diesels must be available for operation within 2 hours after total loss of electrical sources.

#### **2.2.0.3. Requirements related to the design**

##### **2.2.0.3.1. Requirements resulting from safety classifications**

1: Safety classification of the system:

The ultimate back-up/emergency diesel units are safety classified in accordance with the classification given in Chapter C.2.

2: Single failure criterion

No single failure criterion is associated with the ultimate back-up/emergency diesel in terms of the classifications in Chapter C.2.

3: Emergency electrical supply

Not applicable since the ultimate back-up/emergency diesels are self-contained.

4: Qualification under operating conditions

The ultimate emergency diesel units are qualified in order to ensure their ability to fulfil their safety role under the most unfavourable operating conditions to which they may be exposed in carrying out their function.

#### 5: Classification of mechanical, electrical and instrumentation and control equipment

The ultimate emergency diesel required for safety functions is EE2 and E2A classified in conformity with the electrical and instrumentation and control classifications in Chapter C.2.

#### 6: Seismic classification

The ultimate back-up/emergency diesel unit is classified in conformity with the classification given in Chapter C.2.

#### 7: Periodic tests

The ultimate emergency diesels will be tested periodically in order to ensure their availability.

#### **2.2.0.3.2. Other regulatory requirements**

Consequence of the Technical Guidelines §B.2.4.1 "Electrical supply":

The ultimate emergency diesels are diverse from the four main diesel generators in order to eliminate common mode failures between the two types of diesel generators.

#### **2.2.0.3.3. Hazards**

Chapter C.3 describes the external hazards and Chapter C.4 describes the internal hazards.

#### **2.2.0.4. Tests**

##### **2.2.0.4.1. Preliminary tests**

The system is subject to first start-up tests in conformity with its safety function.

##### **2.2.0.4.2. Monitoring during operation**

Since the system is always on stand-by under normal plant operating conditions, and could be called on to start up at any time, the major parameters of the system are monitored on a regular basis during operation.

##### **2.2.0.4.3. Periodic tests**

The system is designed to enable periodic testing in conformity with the general operating rules.

#### **2.2.1. Role of the system**

The ultimate emergency diesels are available in standby mode. If there is a total loss of external electrical sources and of internal back-up sources (station blackout), the ultimate emergency diesel generators and their auxiliaries will be capable of being started and increased in power following a predefined sequence by the operator from the Main Control Room.

#### **2.2.2. Design basis**

As a backup system, the ultimate emergency diesel is designed according to the equipment it has to supply. The nominal steady power of the ultimate emergency diesel engine is sized according to the total loss of power accident with the greatest power demand together with a safety margin.

The design criteria are:

- the nature of the equipment to be supplied,
- the power of the actuators,
- the voltage to be within the limits of the dynamic and static voltage of the equipment in backup mode.

### **2.2.3. Description of the system and characteristics of the equipment**

Each of the ultimate emergency diesel generators forms a self-contained unit with the following auxiliary systems:

- diesel fuel system,
- lubrication oil system,
- coolant system,
- start-up air system,
- system for air intake and extraction,
- alternator, excitation and protection circuit,
- local instrumentation and control, control and signalling of alarms network

#### Diesel fuel system:

Each diesel generator is fitted with a “day” tank fed from a storage tank.

The storage tank can operate independently for 24 hours at full load.

The “day” tank is sized in such a way that the fuel remaining once the lowest allowed level has been reached is enough for two hours at full load.

#### Lubrication oil system:

Continuous pre-lubrication is not necessary.

#### Coolant system:

Continuous pre-heating is not necessary.

#### Start-up air system:

Each diesel generator has a complete compressed air start-up unit comprising a compressor, one (or more) tank(s), two start-up air lines and start-up valves

The capacity of the compressed air tank is sized so that several start-ups can be carried out without refill.

#### System for air intake and extraction:

The description is given in Chapter I.5.2.1.3.

Alternator, excitation and protection circuit

The description is given in Chapter I.5.2.1.3.

Local instrumentation and control system for control and signalling of alarms:

The equipment can be started for operation in back-up mode or to enable tests to be carried out from a local control panel. Measurements and information about the diesel are recorded on this panel.

The local control panel also displays analogue or on-off measurement values as well as individual alarms.

The ultimate emergency diesel auxiliaries are supplied from a local distribution sub-switchboard.

## **2.2.4. Operating conditions**

### **2.2.4.1. Normal operation**

During normal plant operation, the engine is in stand-by mode and ready to start under full load.

The start-up commands may come from:

- the Main Control Room,
- a local control panel.

A start-up without any electrical source is also possible locally.

### **2.2.4.2. Steady operation**

Steady operation of the engine is reached after a start-up initiated following station blackout and following the transients from the re-powering of the various supported equipment .

When in steady mode, the diesel generator supplies electrical power to the terminals of its bus bar.

In station blackout conditions, it is possible to shut down the diesel generator:

- by operator action,
  - o either remotely from the Main Control Room,
  - o or locally using the emergency stop device.
- or by a protection action.

## **2.2.5. Tests, inspection and maintenance**

### **a) Periodic tests**

The periodic tests on the ultimate emergency diesel and its auxiliaries may be carried out with the plant in normal operation.

In order to avoid interruptions in the supply and to enable tests under full load to be carried out, it is possible to synchronise the ultimate emergency diesel generator units with the normal supply.

b) Maintenance of equipment

With the plant at power, maintenance operations will only be performed on one set at a time. It will be possible to carry out preventative maintenance on the auxiliaries with the plant at power.

Checks on diesel fuel, lubrication oil and cooling water will be carried out during maintenance operations and inspections.