



Exploration & Production

GENERAL SPECIFICATION

ELECTRICAL

GS ELE 001

Electrical design criteria

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Contents

1. Scope	5
2. Reference documents	5
3. Environmental conditions	7
4. Particular rules for Floating Units.....	8
5. Vocabulary, units and symbols	8
5.1 Contractual matters	8
5.2 Technical matters	8
6. Frequencies and voltages	9
6.1 General.....	9
6.2 Standard frequencies.....	9
6.3 Standard voltages.....	9
6.4 System voltage drops	10
7. Earthing systems	10
7.1 High voltage systems.....	10
7.2 Low voltage systems	11
7.3 Construction site electrical installation.....	12
7.4 Buildings and permanent base camps.....	12
7.5 Direct current systems	12
7.6 System Voltages – Neutral Earthing system	12
8. Electrical distribution systems	13
8.1 General principles.....	13
8.2 Equipment rating/sizing	14
8.3 Hazardous areas and restricted areas.....	14
8.4 Overall configuration.....	15
8.5 System configuration	16
8.6 Intertripping and Interlocking	18
8.7 ECS	18
8.8 Blackstart requirements	19
9. Electrical substations	20



9.1	General.....	20
9.2	Minimum clearances in substations.....	21
9.3	Electrical shutdown requirements.....	21
9.4	G.I.S. substation	21
10.	Equipment.....	22
10.1	Transformers	22
10.2	Motors.....	23
10.3	DC and AC UPS systems	24
10.4	Lighting/Small power and welding sockets	27
10.5	Capacitor banks.....	28
10.6	Thyristor controlled electrical heater.....	28
10.7	Cables and cabling	29
11.	Miscellaneous.....	31
11.1	Electrical workshop.....	31
11.2	Electrical safety kit.....	31
11.3	Earthing	31
11.4	Lightning protection	31
11.5	Colour code	31
11.6	Early smoke/fire detection	31
12.	Electrical design studies	32
12.1	Electrical Consumer Lists and load balance.....	32
12.2	Design basis for cable sizing	32
12.3	Co-ordination of electrical system protective devices.....	32
12.4	Power system studies.....	33
12.5	Harmonic studies	35
Appendix 1	Typical onshore key one line diagram.....	36
Appendix 2	Typical offshore key one line diagram	37
Appendix 3	Gas turbine generator - DC Distribution.....	38
Appendix 4	Alternator sizing	39
Appendix 5	Feeder output	40



Appendix 6	Turbine Generator	41
Appendix 7	Diesel Generator.....	42
Appendix 8	Transformer	43
Appendix 9	Motor	44

1. Scope

This specification covers the basic design requirements for the electrical power/distribution systems for COMPANY installations located either onshore or offshore. Where particular or differing requirements exist for a particular location, these are stipulated separately. The basic technical features are outlined and general guidelines are given for the design and engineering aspects.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Design and engineering shall conform to the appropriate sections of the latest editions (with amendments) of the relevant IEC, CENELEC standards and codes.

The following order of precedence applies specifically to electrical equipment:

- Applicable laws, rules and regulations of the country in which the system will be operated. In cases where no "local" regulations exist, then French laws and regulations shall be used
- COMPANY Particular Specifications and data sheet (if any)
- COMPANY General Specifications
- Applicable International Electrotechnical Commission (IEC) standards
- Applicable European Standards by CENELEC
- Applicable recognised standards and codes (UTE-NFC, BS, VDE, etc.) when IEC publications have not yet been issued.

Standards

Reference	Title
IEC 60038	IEC Standard Voltages
IEC 60050	International Electrotechnical Vocabulary
IEC 60059	IEC Standards current ratings
IEC 60071	Insulation co-ordination
IEC 60092	Electrical installations in ships
IEC 60196	IEC Standard Frequencies
IEC 60364	Electrical installations of buildings
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 60617	Graphical symbols for diagrams
IEC 62262	Degrees of protection provided by enclosures for electrical equipment against external mechanical impact (IK code)

For items not covered by the above referenced standards, the following French standards shall be used:

Reference	Title
NF C 13-200	High voltage electrical installations - Requirements
NF C 15-100	Low voltage electrical installations

Professional Documents

Reference	Title
Not applicable	

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS ELE 011	Electrical requirements for package units
GS ELE 013	Electrical requirements for generating unit
GS ELE 021	Electrical requirements for Floating Unit
GS ELE 031	Design of earthing and bonding systems
GS ELE 051	Design and installation of lightning protection
GS ELE 061	Minimum requirements for HV & LV cables sizing
GS ELE 079	Electrical apparatus for explosive gas atmospheres
GS ELE 081	Lighting
GS ELE 091	Minimum Contractor document requirements

Reference	Title
GS ELE 111	Induction motors
GS ELE 113	AC generators driven by turbines
GS ELE 115	AC generators driven by diesel engines
GS ELE 131	High voltage switchgear
GS ELE 133	GIS High voltage switchgear and controlgear
GS ELE 135	Low voltage switchgear assembly
GS ELE 137	Distribution boards
GS ELE 141	Power transformers
GS ELE 151	DC Uninterruptible power systems
GS ELE 152	AC Uninterruptible power supply (UPS) systems
GS ELE 161	Electrical cables
GS ELE 211	Electrical cabin for hazardous area. Construction and equipment
GS ELE 213	Electrical cabin for safe area
GS ELE 221	Power distribution control system
GS ELE 251	Closed Cycle Vapour Turbogenerator (CCTV)
GS ELE 311	Cables trays/Ladders
GS ELE 321	Navigational Aids System
GS ELE 331	Electrical trace heating tape
GS ELE 364	Electrical Installations
GS ELE 374	Construction site electrical installations
GS ELE 451	Third party inspection. Independent verification of electrical facilities
GS ELE 765	Submarine cables
GS CIV 401	Minimum requirements for building design and construction
GS CIV 403	Temporary construction camps and associated facilities (onshore)
GS INS 107	Design and installation of instrumentation links
GS SAF 216	Rules for determination and classification of hazardous areas
GS SAF 253	Impacted area restricted area and fire zone

3. Environmental conditions

Electrical equipment design and installation shall be performed in accordance with the data given in the "Environmental conditions particular specification".

Outdoor electrical equipment shall be designed to operate continuously in an ambient temperature corresponding to the extreme outside temperatures as defined in the project specific environmental data.

Unless otherwise specified, Indoor electrical equipment shall be installed within air conditioned rooms with an ambient air temperature of 25°C but they shall be able to operate as long as room temperature does not exceed 40°C.

In case of corrosive atmosphere (Salt laden air, H₂S...) special provisions shall be taken by the equipment SUPPLIER to avoid equipment corrosion. The SUPPLIER shall indicate in his bid which protection / measures have been taken for all equipment.

The minimum degree of protection of enclosures (IP and IK codes) shall comply with the relevant equipment general specification and/or data sheet.

4. Particular rules for Floating Units

Design and engineering studies for Floating Units such as FPSO (Floating Production, Storage and Offloading System), FSO (Floating Storage and Offloading System), FPS (Floating Production system), FSU (Floating Storage Unit)... shall conform to the following rules:

For revamping of existing and old Floating Unit:

Applicable Rules and Regulations for the classification of Ships used for the construction.

For new Floating Unit:

- a) Hull including electrical equipment:

Nominated Classification Society rules

Company General Specification **GS ELE 021**

IEC 60092.

- b) Topsides located 3.5 m above deck:

Company General Specifications

IEC standards.

5. Vocabulary, units and symbols

5.1 Contractual matters

Within the context of the Specification, all contractual terminology utilised shall be as defined in the relevant CONTRACT used for a particular project.

5.2 Technical matters

The Electrotechnical vocabulary and graphical symbols used shall be as defined in the [IEC 60050](#) and [IEC 60617](#).

Units used shall be as defined in the International System of units (SI).

In the case of utilisation of any vocabulary, units or symbols that are not in the above IEC publications, the ENGINEER/CONTRACTOR is required to produce a glossary (for vocabulary), correspondence table to IEC units (for units) and/or clear legend (for symbols).

6. Frequencies and voltages

6.1 General

Frequencies and voltages used for COMPANY electrical installations shall be selected among the values recommended by the IEC. Use of voltage levels and/or frequencies not herein recommended are subject to written COMPANY approval.

6.2 Standard frequencies

50 Hz or 60 Hz.

At all times the frequency of the local National Electrical Board shall be adopted for the COMPANY installation, either onshore or offshore.

AC equipment shall operate satisfactorily at frequencies within $\pm 5\%$ of the stated frequency.

6.3 Standard voltages

Mainly the selection of voltages shall be based on the following parameters:

- Power to be delivered (based on the power balance established for each consumer voltage level).
- Short-circuits levels.
- Existing systems and supplies.
- Distributor's supply voltage.
- Distances between consumers and supplies.

6.3.1 AC systems

Electrical equipment shall operate satisfactorily during voltage fluctuations within $\pm 10\%$ of the stated voltage levels

- **High voltage**

The general electrical characteristics shall be in compliance with the values indicated in [IEC 60694](#) - paragraph 4 (table 1a) and as follows:

System	3 phases / 3 wires				
Rated frequency	50 Hz				
Nominal system voltage	63kV	33 kV	22 kV	11 kV	6.6 kV
Highest voltage for equipment kV (r.m.s)	72.5 kV	36 kV	24 kV	12 kV	7.2 kV
Rated one minute power-frequency withstand voltage kV (r.m.s)	140 kV	70 kV	50 kV	28 kV	20 kV
Rated lightning impulse withstand voltage kV (peak)	325 kV	170 kV	125 kV	75 kV	60 kV
Neutral system	Earthed through an impedance				
	See data sheet	200 A	150 A	20 to 50 A	20 to 50 A

- **Low voltage**

- 400 V for motive power, main distribution....
- 230 V for lighting, heat tracing and small power
- 230 V (UPS).for control and instrumentation supplies

Other voltages (as indicated in [IEC 60038](#)) may be used (e.g. 690 V) if technically and economically justified.

6.3.2 DC systems

- 110 V for electrical control, essential lube oil pumps (e.g. turbogenerators, turbocompressors, etc.)
- 48 V e.g. for electrical control, telephone system (PABX), public address (PA/GA)
- 24 V e.g. for instrumentation (F&G, ESD, DCS) and telecommunications (SOLAS).

6.4 System voltage drops

The maximum allowed voltage drops at equipment terminals are based on the system nominal voltage.

6.4.1 AC systems

- Motor feeders: 5 % at full load current.

During motor starting voltage at motor terminals shall ensure a sufficient accelerating torque and voltage drop at bus bar shall not cause shutdown of other consumers.

- Lighting sub-circuits and sockets: 2 % average with a maximum of 8 % at to the farthest fitting.
- Other (heaters, packages...): 5% unless particular requirement

6.4.2 DC systems

The voltage drops in DC distribution shall not exceed 2 % of nominal voltage taking into account inrush currents and transient loads.

7. Earthing systems

7.1 High voltage systems

7.1.1 General

If the installation is derived from a Local Electricity Grid, the neutral system and the relevant fault current value are imposed by the local Electricity Board.

For installation with their own power generation and electrically isolated from a Local Electricity Board, high voltage neutral shall be earthed by a low impedance, to limit the fault current to at least twice the capacitive current of the network.

7.1.2 Networks fed from an isolated generator

Neutral shall be earthed via a resistance.

7.1.3 Networks fed from generators operating in parallel

In the case of only two generators in parallel, the neutrals may be earthed either via an earthing transformer or directly via resistance.

These two solutions should be studied and a technical/commercial conclusion proposed.

In the case of three or more generators in parallel, an earthing transformer shall be installed on each bus bar section likely to be used separately with a minimum of two.

In the case where more than one section is used in parallel, only one earthing transformer shall be left in operation.

7.1.4 Networks or power supply branch lines fed by transformers

A neutral point resistor shall be installed on the secondary side of each transformer. Depending on the operating philosophy, a switching device might be provided.

7.2 Low voltage systems

7.2.1 Motive and main power distribution

The main low voltage system (400 V, 3-phase, 3 wires) shall be earthed by a high impedance (diagram IT) with neutral not distributed. This impedance shall be sized to limit the first earth fault to 150 mA maximum.

In case of supply by HV/LV transformer, a surge arrester shall be installed between the neutral and the earth

Permanent earth fault monitoring device shall be installed on each L.V. switchboard busbar. Only one device shall be in operation when busbar is closed.

An earth fault leakage relay (with time delay if required) will be provided for each consumer, it shall be set at 2 A in order to trip when a second fault occurs unless following conditions are fulfilled:

- Local equipotential bonding is provided on each equipment
- Short-circuit calculation is performed at each feeder termination to allow selection of the appropriate protective device .

Welding Socket outlets shall be fitted with an earth fault leakage relay set at 30 mA.

7.2.2 Lighting and small power distribution system

The lighting and small power distribution system 400 V/230 V, 3-phase, 4-Wires shall have neutral earthed and distributed (TT system).

Multipoles (phases and neutral) switching is required for all incoming/outgoing circuits.

Each individual outgoing feeder shall have differential device with 300 mA sensitivity, which will trip on first earth fault.

Socket outlets shall be fitted with an earth fault leakage relay set at 30 mA.

TNS system 400 V/230 V, 3-phase, 5-Wires may be considered

7.2.3 Heat Tracing distribution system

Where required by process or other reasons, a heat tracing system shall be provided. This system shall be independent and comprise a transformer (400/230 V) and dedicated distribution panel.

The 230 V, 3-phase, 4-Wires tracing system shall have a neutral earthed and distributed (TT system).

TNS system 400 V/230 V, 3-phase, 5-Wires may be considered

Each individual outgoing feeder shall be fitted with earth leakage circuit breaker (ELCB) with 30 mA sensitivity, which will trip on first earth fault.

7.2.4 400/230V UPS distribution system

Unless otherwise specified by the DCS Supplier or by particular project specification, isolated IT system shall be used.

Permanent earth fault monitoring device shall be installed.

Socket outlet circuits shall be fitted with an earth fault leakage relay set at 300 mA. A maximum number of three sockets per circuit are allowed.

7.3 Construction site electrical installation

Refer to COMPANY Specification [GS ELE 374 - GS CIV 403](#).

7.4 Buildings and permanent base camps

For Low-voltage, if the neutral system is not imposed by the local Electricity Board it shall be preferably TNC-S. For small installations, the neutral system might be TT.

Refer to COMPANY Specification [GS CIV 401](#).

7.5 Direct current systems

DC systems shall be insulated from earth and equipped with permanent earth fault detection except for DC supplies for PABX equipment, which shall have, positive or negative earthed according to equipment MANUFACTURER requirements.

7.6 System Voltages – Neutral Earthing system

NOMINAL VOLTAGES	OPERATIONAL VOLTAGES RANGE	NEUTRAL SYSTEM	SERVICE	MAXIMUM VOLTAGE DROPS AT EQUIPMENT TERMINALS
Internal power generation 11kV / 6.6 kV AC	$\pm 10 \%$	Earthed by low impedance One or two generators: Earthing resistance Two or more generators: Earthing transformer	Generators output voltage.	
			Motors	5% at full load current
			Interconnection with other platform , sub station	

NOMINAL VOLTAGES	OPERATIONAL VOLTAGES RANGE	NEUTRAL SYSTEM	SERVICE	MAXIMUM VOLTAGE DROPS AT EQUIPMENT TERMINALS
Power distribution 63 –33-22-11-6.6 kV	$\pm 10 \%$	Earthed by low impedance at transformer or earthing transformer.	Main HV switchboard	
400 V AC (690 V AC)	$\pm 10\%$	IT (Neutral not distributed) Earthed via high impedance	MCC	
			Motors	5% at full load current
			Diesel generators	
230V AC	$\pm 10 \%$	TT system (Neutral earthed and distributed) TNS system	Lighting distribution board	
			Lighting fittings	8% max to the farthest fitting
			Small power board	
		TT System Neutral earthed and distributed TNS system	Heat tracing	
230V UPS	$\pm 10 \%$	Isolated IT system (Neutral not distributed) TN acceptable	Control and instrumentation	
DC system 110/48/24VDC	$\pm 10 \%$	Unearthed	Control, instrumentation, telecommunications, essential services	2 % of nominal voltage

8. Electrical distribution systems

The following principles shall be applied regarding the basic requirements and configuration of the generation and distribution systems.

8.1 General principles

All distribution systems shall be designed to fulfil the following requirements:

- To ensure maximum continuity of supply to users as far as possible
- To provide reliable power sources for essential and emergency loads
- To allow operation and maintenance of the system in a safe manner without unduly affecting the production of the plant

- To allow remote operation from a centralised control room, or technical room
- To design a system for which the necessary elements e.g. switchgear, cables, etc. are currently manufactured, and tested. Industrial type equipment with a minimum of two years field proven experience is required.
- Selection of equipment shall be based on OPEX and CAPEX considerations.

The loads shall be classified into normal, essential or emergency type according to the following definitions:

- Emergency loads: Loads affecting personal safety whether directly or indirectly and inducing risk of major damages on installation or equipment. These loads are connected to switchgear with an emergency source of power (e.g. batteries, inverter fed from batteries, etc.). On loss of normal supply, equipment supply shall be maintained.
- Essential loads: Loads involved in the safeguard of equipment or installation and in the restarting of the installation after a plant shutdown (all power generation auxiliaries). These loads are connected to an essential power source (Diesel driven generators)
- Normal loads: Loads, which have no effect either on the safety or the safeguard of installation or equipment in case of normal generation failure.

8.2 Equipment rating/sizing

Equipment sizing for each installation shall be such that all extensions known at design phase shall be taken into account.

As a general rule, and unless otherwise specified in a particular project specification, all equipment (main and essential generators, transformers, switchgear, UPS, DC systems....) of the power distribution system shall have at least 20 % spare capacity above the expected load.

For alternator sizing, refer to Appendix 4

All components (e.g. bus bars, circuit breakers, contactors, switches, etc.) and cables shall be rated for at least the fault rating of the equipment in which they are installed.

In particular, the short circuit rating of the generator switchgear shall be calculated taking into account the maximum number of generators simultaneously in operation, including future phases.

When the electrical installations are connected to an external grid, the equipment short circuit rating shall be at least 10% above the prospective fault level value.

The short circuit rating of LV switchboards shall be determined with one transformer in operation (bus tie normally open) and all the LV consumers in service.

The use of short circuit limiting device (e.g.: pyrotechnic type...) is prohibited except when justified for offshore platforms, Floating Units or major revamping and in any case, subject to COMPANY written approval.

8.3 Hazardous areas and restricted areas

The hazardous area classification and restricted area drawings shall be prepared by the Safety discipline but never by the electrical discipline. These drawings are under the responsibility of the plant manager.

Where electrical equipment have to be installed in hazardous area, equipment with a type of protection suitable for the relevant zones shall be selected and specified in accordance with the specification **GS ELE 079**.

Regarding the type of equipment to be installed in restricted areas, selection shall be made in accordance with **GS SAF 216** and **GS SAF 253**.

8.4 Overall configuration

8.4.1 Power supply from a local Electricity Board (see Appendix 1)

The main intake substation shall be designed in accordance with the local Electricity Board requirements (protection, metering, and access....)

When required, the main incoming transformers shall be fitted with automatic on-load tap changer.

8.4.2 Main power Generation (see Appendix 2)

The number and size of generators selected will be a result of a joint technical and economical study.

Use of generators with unit-transformers (supplied as a single source package) may be required in certain cases (no circuit breakers are required between generator and transformer).

8.4.3 Offshore platform

The normal power supply shall be provided either by a main power generation or via a submarine cable.

- **Main power generation**

Unless otherwise specified, the number of main generating units to be installed shall be such that if one unit becomes unavailable (because of a fault or for maintenance inspection), the power supply to the platform shall be provided normally.

- **Supply via submarine cable**

Unless otherwise specified, only one power supply transformer shall be installed.

8.4.4 Special cases

For installation with low power demand, less than 5 kW, closed cycle vapour turbo generators (CCVT) shall be used, refer to **GS ELE 251**.

When required by the project particular specification a redundancy N+1 shall be provided. This redundancy doesn't take into account lighting loads, which could be load shed in case of one CCVT failure.

In some other special cases (geographically isolated sites, offshore platforms, etc) and in the absence of conventional supplies such as those described above, special solutions may be envisaged, such as:

- solar panels,
- fuel cells,

- wind generators,
- etc.

8.5 System configuration

8.5.1 HV switchboard (HV - 3 Ph - 3 W)

In case of local grid power supply, incomers' protection shall be designed in accordance with the Local Electricity Board requirements.

The main HV switchboard shall be normally connected directly to the local electricity grid. The choice of configuration (double busbar, H type, 1+ 1/2 circuit breaker etc.) shall be defined during basic engineering phase.

Gas Insulated Switchgear (G.I.S.) shall be considered for voltages rated 72.5 kV and above. Refer to COMPANY Specification **GS ELE 133**.

Main high voltage switchgears shall have as many bus sections as power sources and shall be operated with "Normally Closed" tie breakers.

Other HV switchgears with at least two power supplies shall have two bus sections. In order to increase availability, redundant equipment shall be judiciously split between the two sections.

Unless otherwise specified, circuit breaker control (closing and tripping) shall be achieved by means of a shunt trip coil (energise to trip).

Refer to COMPANY Specification **GS ELE 131**.

8.5.2 Diesel generator(s)

The diesel generator(s) shall receive a start signal upon loss of voltage and shall automatically restore power to essential/emergency loads with a minimum interruption.

For normal power recovery, synchronisation between the main power source and the diesel generator(s) shall be provided. Upon restoration of the main power source and after a short period (5 minutes), the diesel generating unit(s) shall be stopped manually.

Provisions shall also be made to test periodically starting and loading of the diesel generating unit(s). This will require synchronisation of the diesel generator with the main power source. (for further details, refer to GS ELE 013).

The main generating unit auxiliaries shall be powered from diesel generator. This shall be taken into account for its sizing.

Refer to COMPANY Specifications **GS ELE 113** and **GS ELE 115**.

8.5.3 LV switchgear

Low voltage switchgears and Motor Control Centres (MCCs) shall have two incomers and one tiebreaker with the exception of MCCs for turbogenerator/ turbocompressor/ HVAC auxiliaries LV switchgears.

The two bus sections (A and B), and associated incoming breakers (A and B) and bus tie breaker (C) can be in the following configurations:

1. Incoming circuit breakers A and B closed and the bus tie C open
2. Incoming circuit breaker A and the bus tie C closed, incoming B open
3. Incoming circuit breaker B and the bus tie C closed, incoming A open.

The configuration 1 represents the normal operating condition.

The configurations 2 and 3 may be used during maintenance on one of the incoming feeder.

Transfer from one configuration to another one shall not cause any loss of supply to consumers, ("make before break"). This sequence will result in the three circuit breakers all being closed for a very short period of time (e.g. 1 sec). The short circuit rating of the switchboard however is not calculated to cover for this condition as the risk of a fault occurring at the instant when all three circuit breakers are closed is considered extremely unlikely. In all cases, the three circuit breakers shall never be simultaneously closed for more than 1 second as described above.

This transfer shall be controlled manually at the switchboard by selecting and closing the "third" circuit breaker or at the Electrical Control System (if any; see § 8.7).

Additionally, the "third" circuit breaker selected shall be closed only if the requirements for safe coupling are met.

In normal operating configuration, loss of voltage on one half bus bar shall, after a time delay, automatically open the corresponding incoming circuit breaker and then close the bus tie circuit breaker. This sequence shall only be actuated if the following conditions are satisfied:

- The loss of voltage is not due to a tripping of the incoming circuit breaker initiated by protection trip
- Voltage is detected on the other bus section.
- There is not a simultaneous fault on both bus sections.

The system shall return to normal configuration using manual control.

8.5.4 Transformers

Each power transformer shall be able to feed the total load of its downstream switchboard. In normal configuration, the two transformers shall feed each bus section (50% of total load).

8.5.5 Uninterruptible power systems

UPS shall be designed to limit the number of units.

8.5.6 Distribution boards

Distribution boards (e.g. for lighting and small power) shall be normally fed by only one feeder coming from one upstream board.

For certain loads (e.g. DC and AC UPS), two feeders may feed the distribution board.

8.5.7 HVAC distribution

HVAC drives may be fed in the following manner, either:

- Starters integrated into normal/essential switchgears
- From a dedicated HVAC switchgears (with normal and essential sections). Each section being fed by one feeder from a normal switchboard and one feeder from an essential switchboard.
- From separate dedicated normal and essential HVAC switchboards, each being fed by one feeder from the respective electrical board.

8.6 Intertripping and Interlocking

- Intertripping shall be provided where applicable between associated equipment to correctly isolate faulty items and to leave the system in a predictable orderly state after the operation of protection devices:

E.g.:

- Normal opening or tripping by protection of an HV breaker shall cause the opening of the corresponding LV breaker.
- **Interlocking** shall be provided where applicable to prevent wrong operation of equipment. This shall be achieved, depending on the particular equipment involved, either electrically or by a system of locks and key switches:

E.g.:

- Mechanical interlock between the earth switch of the generator incomer breaker and the generator excitation control panel shall be provided.
- Downstream breakers and tie breakers shall not be capable of closure until upstream breakers are closed
- Key interlocking shall be provided in order to prevent application of earthing devices until all sources of supply are isolated (access to transformer terminals, HV live parts in switchboard, etc.)
- Mechanical interlocking shall prevent closing of an earthing switch on an energised part of an HV circuit.

8.7 ECS

8.7.1 General

Depending on the size, complexity and operating requirements of the distribution system an Electrical Control System (ECS) shall be considered to facilitate control, supervision and monitoring of the network.

The ECS functions however should only be an aid to the operation of the network with the safety requirements being ensured by the normal direct acting devices (e.g. protection relays acting on circuit breakers) which are themselves not linked to the ECS. In addition, the network shall remain in service should the ECS fail.

The ECS shall be in accordance with COMPANY Specification **GS ELE 221**.

Typical functions to be included are:

- Control of power generation and distribution e.g. remote closing of circuit breakers from a central control point (which may be the control room or an electrical technical room)
- Provision, at the central control point, of a VDU based system to provide animated display of power generation and distribution system, data acquired and provide operator/machine interface
- Load shedding
- Permissive motor starting
- Sources automatic transfer sequence
- Event recording and parameter trending

- Display of alarms
- Interface with Integrated Control and Safety System (ICSS).

8.7.2 Load Shedding

Depending on the power generation design and the load balance a load shedding system may be required.

Loads to be shed shall be selected in accordance with Process.

Load shedding shall be achieved either by the Electrical Control System (if any) or by dedicated fast acting modules as a part of the Integrated Control and Safety System (ICSS) and providing a response time suitable for successful operation (20ms maximum).

8.8 Blackstart requirements

A blackstart philosophy shall be incorporated into the electrical design to allow re-starting of the facilities after a total shutdown (i.e. shutdown of all AC and DC sources) due to a gas release.

The generating unit used for blackstart shall be able to start without external power source.

The required equipment and associated steps to be taken shall be developed during the design stage and care shall be taken regarding the location of certain equipment to facilitate the blackstart sequence.

The blackstart shall always be manually executed. A typical sequence for general guidance is shown below:

- Initial status
 - All sources of power are shut down and all batteries discharged and switched off
 - All electrical rooms filled with gas
 - Batteries and/or fuels to be provided from external sources.
- Make sure that there is no gas around or inside the diesel generator enclosure or room. Room purge can be ensured by natural ventilation (opening louvers, doors, etc) or by an independent portable fan (suitable for hazardous areas).
- Purge the electrical rooms.
- When the atmosphere is recognised as safe, start the diesel generator.
- Energise the generator switchgear
- Energise the DC and UPS systems. Note that it may be necessary to keep it running alone to supply all of the battery supported systems until the batteries have been sufficiently re-charged before re-starting the main turbogenerators.
- Purge the power generation technical room (if applicable)
- Purge the normal electrical room, other electrical rooms and control room
- Progressive starting of the turbogenerators
- Progressive restarting of the plant.

9. Electrical substations

9.1 General

Electrical distribution equipment shall be normally installed within dedicated electrical rooms. Outdoor installation shall be subject to COMPANY written approval.

The associated power transformers shall be located outside in separated bays adjacent to the room.

The number and location of sub-stations and associated transformers shall be determined according to the following criteria:

- Installation shall be as near as possible to the loads
- Installation shall be, as far as practical, outside hazardous areas
- Transformers shall be dedicated to a single or several process areas
- Number of different types shall be limited as much as possible
- Dimensions of substations shall enable easy and safe operation and maintenance
- Provisions shall be taken to mitigate PVC wiring fire consequences (emission of corrosive smokes leading to spurious trips with possible production losses).

Substations shall be built from concrete for large onshore buildings, or of pre-fabricated or modular construction for offshore and small onshore buildings (refer to **GS ELE 211** and **GS ELE 213**).

Only authorised personnel shall enter into the electrical substations.

Electrical rooms shall be air-conditioned to provide clean and dry environment.

Room pressurisation shall be provided in case of sandwind, dusty atmosphere or location in hazardous area.

The layout within the room shall be governed by the size and quantity of switchgear and a reservation shall be made for extensions (e.g. at least 25 % extra space to be provided for future phases unless otherwise specified).

For HV and LV switchgear, available space for one cubicle at each side shall be provided as a minimum.

The layout will provide safe access and adequate space for operation, maintenance and removal of each item of equipment.

Doors shall be provided such that an unobstructed exit route is available in case of emergency. The maximum distance to be crossed inside the substation to reach an exit is set at 10 metres.

One door shall be sized to allow entry of the largest single item of equipment. Rooms shall be designed with raised floor (offshore, with minimum height of 600 mm) or technical void (onshore, minimum height of 1.80 m) for cable routing. Cable penetrations in the buildings shall be by MCT (offshore) or by adequate sealing method (onshore). Spares penetrations for temporary cable entries shall be provided.

In case of technical room with raised floor, equipment shall be installed on suitable metal frame fixed directly to the ground. Equipment shall be fixed on metal frame by bolts.

Typical requirements for onshore and offshore are as follows:

- **Offshore**
 - 1 normal electrical room
 - 1 essential / emergency electrical room (containing essential/emergency switchboard, battery charger, inverter, etc.)
 - 1 battery room (if any)
- **Onshore**
 - Either electrical rooms as per Offshore in the case of large plant or one electrical room containing both normal and essential switchgear.

In all cases no flanged pipe shall be accepted within electrical rooms.

Cable trays shall be used for cable routings in raised floors and technical voids.

Floor finishing shall be designed for rolling of the heaviest load (circuit breaker on its truck, etc) and tolerance (floor flatness shall be in accordance with switchgear manufacturer requirements).

Floors shall be coated with anti dust coating.

Electrical rooms with concrete walls and ceiling shall be painted.

9.2 Minimum clearances in substations

Following figures are minimum values given as a general guidance, unless otherwise specified by equipment / switchgear manufacturer (especially for pressure relief in case of arc resistant switchgear).

	Minimum clearance
Vertical from equipment to ceiling	450 mm
Front of operating side of high voltage switchgear	1400 mm
Front of operating side of low voltage switchgear	1000 mm
Switchgear from each end and non operating side	100 mm
Front of operating side of low voltage distribution board / panels	750 mm
Neutral grounding resistors, at least on 3 sides	500 mm

9.3 Electrical shutdown requirements

In case of gas detection inside the electrical substation, all power supplies, including batteries, shall be switched-off.

Exception shall be made for equipment and relevant power supplies which have to remain in operation and shall be suitable for hazardous area. (E.g.: Nav aids, DC post lube pumps see Appendix 3).

9.4 G.I.S. substation

The following special requirements are needed:

9.4.1 Mesh Earthing to minimise the voltage step

Due to the high earth fault current, special care shall be taken to design the earth mesh network for a building receiving a GIS switchgear.

The building earthing network design shall be reviewed and approved by the GIS manufacturer before installation.

The purpose of this additional requirement to **GS ELE 031** is to minimise the voltage step.

Joints and overlaps in the concrete reinforcing mesh shall be welded to provide good electrical continuity. The minimum is one weld every two crossing points.

The mesh shall be connected to the earthing network by a minimum of two points.

The mesh shall be designed with squares smaller than 20 cm large.

9.4.2 Crane

A crane shall be installed in the GIS room (for voltage above 70 kV), to be used during equipment installation and maintenance.

The design shall be reviewed and approved by the GIS manufacturer before installation.

The control command shall be easy to use even when there are busduct across the way

9.4.3 SF6 Leak Detection

The room building containing GIS shall be equipped with a SF6 leak detection system.

Detectors shall be installed in the lowest parts of the building.

A remote alarm shall be sent to the control room.

At the door entrances, flashing lights shall be provided.

10. Equipment

10.1 Transformers

10.1.1 General

ONAN is the COMPANY preferred cooling method, however in particular condition, other cooling methods may be used subject to COMPANY written approval.

Provisions shall be made for a 30 % upgrading of HV/HV transformers by the future fitting of automatically controlled forced air cooling fans. All parts of the transformers shall be designed to carry such an increased rating continuously without modification.

Transformers shall comply with COMPANY Specification **GS ELE 141**.

Rating of HV/LV distribution transformers shall be limited to 2500 kVA for 400V and 3150kVA for 690V.

LV/LV transformers shall be dry type.

Supply of surge arrester between earth and phases shall be studied during basic engineering (use of vacuum breakers, overhead lines...).

10.1.2 Transformers installation

Oil immersed transformers shall be located outdoor.

Dry type transformers shall be located indoor.

Oil immersed distribution transformers shall be separated by walls (onshore) or fences (offshore) and shall be protected against rain falls or direct sun rays by a removable roof. Fencing and roof shall ensure natural transformer ventilation.

When required, transformers located offshore shall be separated from process area by a fireproof wall

For onshore installation an oil-receiving pit shall be built under each transformer and shall be connected to an oily water drainage system.

For offshore installation, a receiving tank shall be provided under each transformer and shall be connected to the closed drain system via a fire break valve.

Minimum clearance for transformer connections shall be 1000 mm (cables not included), and 850mm for the other sides.

Access to transformer bay shall be obtained via a lockable-screened door.

Interlocking device shall be provided between access to transformer plug-in terminals and isolating devices.

Neutral earthing resistances shall be located in safe area and as close as possible to the transformers.

10.2 Motors

Motors shall be of the squirrel cage induction type unless otherwise specified in a Project particular specification.

As a general rule, motors up to 150 kW shall be Low Voltage, above 250 kW motors shall be High Voltage.

Motors between 150 and 250 kW shall be subject to technical and economical study by ENGINEER/CONTRACTOR.

As far as possible motors shall be designed for direct-on-line starting.

An appropriate starter shall be provided for motor in particular starting conditions (e.g: on Diesel Generator).

When required by the Project, motors shall be provided with a control station (start/stop pushbutton) adjacent to the equipment.

For electrical facilities connected to a public grid and subject to very short interruptions (e.g.: $t \leq 0.3$ s) or voltage dips up to 30%, natural re-acceleration shall be considered.

Motor Manufacturer shall confirm the acceptable voltage disturbance duration.

Motors shall comply with COMPANY Specification **GS ELE 111**.

Motors and associated frequency converters shall be within the scope of a single supplier.

10.3 DC and AC UPS systems

10.3.1 General

DC UPS systems consisting of battery chargers, stationary batteries and distribution boards shall be used to supply switchgear control, instrumentation and telecommunication systems and/or emergency or essential services.

AC UPS systems comprising battery charger, stationary batteries, inverter and by-pass transformer shall be used as required to provide uninterruptible supplies.

For small UPS, less than 10 kVA, modular equipment may be used.

Redundancy for UPS shall be determined taking into account the criticality of loads, to be analysed in conjunction with instrumentation/safety disciplines.

DC and AC UPS shall comply with COMPANY Specifications **GS ELE 151** and **GS ELE 152**.

10.3.1.1 Typical autonomy

Unless otherwise specified in the Project particular specification the autonomy of the UPS are defined in the following table:

Type of load	Autonomy		Voltage	Earthing system
	With EDG	Without EDG		
Electrical Switchgear	30 minutes	90 minutes	48 /110V DC or 230 VAC	Unearthed
Post lube pump of machine	Vendor standard requirements	Vendor standard requirements	110 V or 24V DC	Vendor standard requirements
Navigation aids	96 hours	96 hours	12/24 VDC or 230 VAC	Unearthed
Instrument DCS	30 minutes	90 minutes	24 V DC	Unearthed
Instrument DCS	30 minutes	90 minutes	230 V AC	Unearthed
Electrical Control System ECS	30 minutes	90 minutes	230 V AC	Unearthed
Telecom - SOLAS - PABX - PA/GA	6 hours 6 hours 90 minutes under continuous alarm +30 min at 20% full load	6 hours 6 hours 90 minutes under continuous alarm +30 min at 20% full load	24 V DC 48 V DC 48 V DC	unearthed Vendor standard Unearthed
Telecom - MUX - Trunk/local radio	30 minutes 30 minutes	30 minutes 30 minutes	230 V AC 230 V AC	Unearthed Unearthed

10.3.2 Batteries

10.3.2.1 Battery type

Battery shall be of the following type:

- Nickel-Cadmium - vented type
- Lead-acid - vented type
- Nickel-Cadmium - Recombination type 92% minimum

10.3.2.2 Battery installation

Batteries shall be preferably installed into dedicated battery rooms. Installation in cubicles or outdoor battery box might also be required in Project particular specification.

Selection of the batteries types (vented or recombination) shall comply with following table.

Appropriate precautions for installation shall be taken in accordance with COMPANY specification **GS SAF 216**.

Installation Type of cells	Dedicated battery room	Cabinet	Outdoor battery box
Ni-Cd Vented type	R	P	P
Lead-Acid Vented type	R	F	P
Ni-Cd Recombination	P	R	P *

R: Recommended P: Possible F: Forbidden P*: To be checked with Manufacturer

When required, a circuit breaker with overcurrent protection and undervoltage tripping coil shall be provided for ESD purpose. It shall be in an EEx"d" IIC T3/ category 2 enclosure located close to each battery. "Reset" of this breaker shall be possible by an "externally accessible" operating handle.

As batteries might release hydrogen, dilution ventilation shall be provided in the enclosures containing battery cells.

Facilities shall be provided to inhibit the charge mode in case of failure of ventilation system and revert to float mode.

For recombination batteries with chargers fitted with charging current limitation, batteries may be installed in a standard electrical room with no hydrogen detection.

Batteries and charger may be located in the same cubicle only if this cubicle is provided with dilution ventilation as per the requirements of this chapter.

10.3.2.3 Installation in a dedicated battery room

Batteries shall be installed either on wooden or insulated steel stands.

If lead acid batteries are used, floors shall receive an anti acid coating.

A motor driven fan shall ventilate the battery room. This fan shall be category 2 IIC T3.

Hydrogen detectors shall be installed and in case of hydrogen detection the battery charge shall be switched off and all ignition sources in the room shall be stopped, with the exception of the electrical equipment category 2 IIC T3.

COMPANY specification **GS SAF 216** shall apply.

Ventilation failure shall initiate an alarm in the control room. Stopping and/or inhibition of the charge mode shall be provided.

10.3.2.4 Dilution ventilation criteria

10.3.2.4.1 Vented batteries

The minimum air flow Q in m3/h required is: **$Q = 0.05 I N$**

"I" is the maximum charging current in Ampere (A) and N the number of elements.

The value of the maximum charging current "I" shall be stated by the battery MANUFACTURER:

- For a charger fitted with downstream charging current limitation and voltage monitoring which stops the charge mode, the value of "I" may be assumed to be $0.2 \times C_5$ (capacity in Ah) for a rough estimation of the ventilation.
- For a charger fitted with upstream maximum current protections only, (e.g.: battery charger for starting or post lube motors) the value of "I" shall not be estimated without charger MANUFACTURER's data.

10.3.2.4.2 Recombination batteries

The minimum air flow Q in m³/h required is: **$Q = 0.0025 I N$**

"I" is the maximum charging current in Ampere (A) and N the number of elements.

This condition is acceptable if the charger is fitted with downstream charging current limitation, voltage monitoring and temperature compensation.

In case of over charging current, the charge mode shall be stopped.

The value of "I" may be assumed to be $0.2 \times C_5$ (capacity in Ah) for a rough estimation of the ventilation. This shall be checked as soon as charger data are available.

10.3.2.4.3 Safety and Maintenance tool kits

Safety and maintenance tool kits shall be provided in each battery room and for each type of battery.

10.4 Lighting/Small power and welding sockets

10.4.1 Lighting

The lighting system shall be split into three main systems:

- Normal system: fed from normal distribution boards
- Essential system: fed from essential distribution boards

The essential system shall consist of:

- 100% of lighting inside technical rooms
- 30 % minimum of total lighting in other areas,
- Emergency system: Selected luminaires of the above essential system, which illuminate escape routes, emergency exits and ladders shall have an integrated Ni-Cd battery and shall be category 2.

Inside technical rooms, appropriate number of fluorescent luminaires' category 2 with integrated Ni-Cd battery shall be installed to provide 90 minutes illumination of panels/switchboards used for re-starting operation.

High Pressure Sodium (HPS) floodlights shall be used for well head, boat landing and work over areas lighting.

No outdoor lighting switch shall be provided on offshore platform unless otherwise specified.

Lighting systems shall comply with COMPANY Specification **GS ELE 081**.

10.4.2 Socket outlets

Socket outlets 16A (2P+E) shall be provided on each deck and laid out so as they can be reached from any location with 25 m cable. These sockets shall be fed from essential 230 V distribution boards.

Welding sockets 63A (3P+E) shall be provided (one per deck minimum) and so installed as they can be reached from any location with 35 m cable. These welding sockets shall be fed from 400 V essential switchboards.

All external sockets shall be provided with plugs.

All socket outlets shall be fitted with a 30mA earth leakage protection.

Socket outlets installed indoors shall be as follows:

- Essential 230V, 2 phase + earth 16A,
- UPS 230V 2 phase + earth 16A with covers. Unless otherwise specified blue colour shall be used.

Socket outlets installed inside technical rooms shall be of Industrial type IK08 with cover

Normal internal single-phase convenience socket outlets fed from lighting distribution boards (230 V - 1 ph) shall be provided at suitable points and in suitable number to meet exploitation /maintenance requirements.

Convenience socket outlets circuits shall not be mixed with lighting circuit.

As a minimum and unless otherwise specified, the following number of UPS socket shall be installed:

- 1 UPS socket in technical room and work shop
- 2 UPS sockets in each office, control room , laboratory and instrument and telecom workshop if any
- 4 UPS sockets in Instrument & Telecom room

The standard of the convenience socket outlets inside rooms shall be in accordance with the standard use in the country where the installation is located.

10.4.3 Platform supply socket

When required in Project particular specification, an external socket from which all the platform, or only special equipment (e.g. crane) can be supplied from an external source shall be installed. This socket shall be located near the boat landing for supply from boat or on the upper deck for tendering supply.

Unless otherwise specified, socket voltage shall be 400V – 3W, 50 Hz

10.5 Capacitor banks

When required, capacitor banks shall be installed to improve the power factor to a value for which the local Electricity Board cannot apply penalties. A joint technical economic evaluation shall be carried out by the ENGINEER/CONTRACTOR.

10.6 Thyristor controlled electrical heater

Thyristor controller panel shall be equipped with a switch.

In addition, the thyristor controller panel shall be equipped with the following as a minimum:

- High speed fuse for the thyristor protection
- Incoming voltage monitoring
- Panel over-temperature protection in the converter panel.
- Electrical heating element over heating protection

If the thyristor controller is not compatible with the high impedance neutral earthing system, SUPPLIER shall provide the necessary isolating transformer. This shall be clearly identified / stated in SUPPLIER bid.

The thyristor control shall be such that a fully adjustable combination of both zero crossing switch and phase angle control can be performed from no load to full load. In order to limit the input current variation that may potentially affect the power generation (vibrations...) in case of zero crossing switch control, phase angle control will be preferably considered during operation.

To minimise the impact of the induced harmonics, active anti-harmonic filters shall be implemented directly within the heater control panel.

The SUPPLIER shall provide with his offer the following:

- Complete thyristor control description including control management modes,
- Harmonic rejection/content (THD should be less than 5% whatever the load) and active filter sizing and complete electrical and mechanical characteristics. The Active Filters accounted for shall be compatible with the high resistance earthing system (including permanent insulation monitoring) as mentioned above. (Isolation transformer may be required.
- Thyristor controller panel heat dissipation for 1/4, 1/2, 3/4 and 4/4 loads,
- Complete arrangement drawing, schematic diagrams...

10.7 Cables and cabling

10.7.1 Cables

All cables shall be flame retardant type except for special services (i.e.: Public address system, foghorn, beaconing with centralised batteries, emergency distribution,...) where a fire resistant type following to [IEC 60331](#) is required.

Cables associated with electrical power for HVAC systems shall be as per electrical Specification, all other HVAC system cables shall be as per instrument Specification.

Cable cross sections shall be chosen among the standardised list of [IEC 60228](#). As much as possible, core cross section shall be as follow:

- LV = 3 x 240 mm² (three cores) onshore
- = 3 x 185 mm² (three cores) offshore
- = 1 x 400 mm² Copper (single core)
- = 1 x 630 mm² Alu (single core)

- HV = 3 x 185 mm² (three cores) onshore
- = 3 x 120 mm² (three cores) offshore
- = 1 x 300 mm² Copper (single core)
- = 1 x 630 mm² Alu (single core)

For links rated 2000A and above, use of bus ducts shall be considered, subject to a joint technical economical evaluation carried out by the ENGINEER/CONTRACTOR.

As a general rule, cables shall be armoured in following cases:

- Buried cables
- Cables running in hazardous areas in zone 1
- Fire resisting cables

Cables installed in hazardous area shall be mechanically protected against mechanical shocks.

Unless otherwise specified, mixing of two different voltages in the same cable is forbidden.

Electrical cables for power and control shall be designed as indicated in COMPANY Specification **GS ELE 161**.

When subsea cables are required, they shall be designed in accordance with the COMPANY specification **GS ELE 765**.

10.7.2 Cable routings

Cable routing shall be as defined in COMPANY general specification GS ELE 364 and GS INS 107.

Separate routings shall be designed for:

- H.V., L.V. power cables, lighting, measuring, signalling, solenoid and/or relay output cables, telecom cables, Intrinsic Safety signals and hydraulic tubing
- Standby and duty equipment
- Emergency/Essential and normal equipment.

Lay up cables on the ground shall be forbidden even in raised floor.

Cable runs shall be routed in vertical and horizontal planes and shall be run with the minimum number of changes of direction consistent with good engineering practice and neat appearance.

Cable crossing at the same height is forbidden.

Power cables will pass across signal cables at right angle and on different levels.

LV Power cables trays shall not have more than 2 layers.

HV Power cables trays shall have 1 layer.

10.7.3 Segregation

Segregation distances between various systems and voltages shall be as follows:

- Minimum distances (for parallel routings) between power and electronic/Signal wiring:
 - LV 600 mm
 - HV up to 33 kV 1000 mm

- For cable crossings (at right angle), minimum distances shall be 200 mm.
- A 400-mm distance minimum shall be kept for parallel cable runs.

11. Miscellaneous

11.1 Electrical workshop

The electrical workshop shall be equipped with an electrical test panel for maintenance purposes to allow testing of the various types of equipment at various voltages (24/48/110 V DC and 230/400/690V AC) found on the site.

11.2 Electrical safety kit

An electrical safety kit(s) shall be provided in each electrical room including, stool, voltage detector, pole, gloves, shoes, mobile earthing kit with clamps, warning and first-aid posters, rechargeable portable lighting suitable for hazardous areas, etc.

11.3 Earthing

Steelwork associated with the structure and all equipment vessels, pumps, compressors, etc. shall be bonded together to ensure electrical continuity. All main electrical equipment shall be bonded in two points to the general earth grid.

Refer to COMPANY Specification [GS ELE 031](#)

11.4 Lightning protection

For sites, which are subject to lightning strikes, provisions shall be taken in accordance with the COMPANY specification [GS ELE 051](#).

11.5 Colour code

Unless otherwise specified, the following colour code shall be used as a general rule:

LED:

On / Closed / Running:	RED
Off / Open / Stopped:	GREEN
Fault / Trip:	YELLOW
Voltage presence:	WHITE

Push button:

On / Close / Start:	GREEN
Off / Open / Stop:	RED

11.6 Early smoke/fire detection

When required by the Project, an early detection system shall be provided and integrated into the HV or LV switchgear assemblies.

12. Electrical design studies

Electrical studies and/or calculations are required to be done by the CONTRACTOR/ENGINEER to substantiate the selection and sizing of electrical equipment such as generators, transformers, busduct, switch gear, etc.

Deliverables shall be in accordance with the Company's specification **GS ELE 091**

The following sections, which are non-exhaustive, are intended to describe the general rules to be followed.

12.1 Electrical Consumer Lists and load balance

The CONTRACTOR shall be prepared a load summary, which will list all electrical loads.

This document shall include as a minimum:

- Equipment tag numbers,
- Driver equipment service,
- Rated voltage,
- Absorbed mechanical power,
- Nameplate rating,
- Efficiency,
- Absorbed electrical power in kW and KVAR,
- Diversity or cyclic factor
- Power factor.

All the loads, including standby units, shall be listed under the switchboard/motor control centres to which they are connected so that the load and size of each switchboard/MCC can be determined.

The individual power transformer ratings and generator ratings shall also be included in the summary.

The total design load is defined below:

Total design load = Continuous (essential and non-essential) load + an agreed percentage of the intermittent load or the largest intermittent load, whichever is the larger.

12.2 Design basis for cable sizing

Cable sizing shall be performed according **GS ELE 061**.

The CONTRACTOR shall produce Sizing calculation note and Charts for COMPANY approval.

12.3 Co-ordination of electrical system protective devices

COMPANY protection philosophy is:

- Time constant protection system shall be preferred. Time dependent protection system may be considered.
- Selectivity shall be preferably time graded (time delayed).
- No logical interlock between protections shall be considered.

- Protection settings are based on minimum short circuit values.
- In case of protection failure, any electrical fault shall be tripped by the upstream protection
- A lockout relay (86) shall be installed on all equipment to inhibit automatic restart after a failure (except thermal overload 49). It can be reset only locally.
- Protection settings shall not be changed through communication links.
- Differential protection shall be considered only for large/critical equipment.

Preliminary protection and co-ordination diagrams shall be proposed when loads are tentatively sized and before major equipment is placed on order, to ensure that all the HV, LV and DC systems will be ultimately selective.

The final electrical co-ordination study shall include the following:

- Detailed Electrical protection diagrams showing the protective devices and associated current and potential transformers
- MANUFACTURER's name, type, designation and ranges as applicable, for all protective devices
- Selected relay settings, circuit breaker trip settings and fuse sizes
- Time-current diagrams showing the co-ordinated minimum and maximum clearing time curves for the selected settings and sizes of the protection devices
- Supporting data, such as motor starting and running currents, calculated fault currents, equipment protection requirements, inrush currents and references that were used in establishing the setting and sizes of the protective devices
- Copies of the MANUFACTURER's characteristic curves for all relays, circuit breaker trips and fuses used for equipment protection
- MANUFACTURER's instruction manuals for all protective devices.

Final study shall be completed when the loads and electrical system are adequately defined and the equipment types and ratings are firm.

Selectivity Study and relay set booklets for all AC and DC systems (set of curves with settings, tripping time, etc.) shall be prepared by the CONTRACTOR.

12.4 Power system studies

Power system studies shall be produced. The number/type of studies and their timing of execution (e.g. during basic engineering or detail design) will depend on the size and complexity of the installation. A basic outline of study types is given below:

12.4.1 Load flow study (steady state conditions)

This study will be used to calculate voltages at any location in the network plus currents in all branches thus giving MW/MVAR/MVA flows.

This information will allow adjustment of machine ratings, transformer and cable sizes, etc. to ensure that steady state voltages are maintained within acceptable limits and ensure that equipment will operate within desired ratings.

12.4.2 Motor starting studies

Voltage drop will be studied during motor starting operations.

The maximum system transient impedance shall be used in calculating voltage drops relating to motor starting, restarting and re-acceleration requirements.

The actual distribution of the allowable overall steady-state voltage drop across the different parts of the electrical system will depend on the circuit configurations and distances between circuit components.

The steady state voltage drop of each circuit shall be calculated on the premise that the total load on the circuit is equal to the sum of the nameplate full load amps of all connected utilisation devices that will be in operation under normal conditions.

12.4.3 Short circuit calculation

These studies shall be used to calculate fault data as follows:

- Balanced short circuit currents at any location e.g.:
 - Initial symmetrical short circuit current, I''_k and steady state short circuit current, I_k for thermal withstand of switchgear
 - Peak short circuit current used for electrodynamic stresses and making capacity of circuit breakers: i_p
 - Symmetrical short circuit breaking current (e.g. at 100 ms) used for breaking capacity of circuit breakers: I_b
 - Decaying (aperiodic) component of short-circuit current : i_{DC}
- Unbalanced short circuit currents at any location e.g.:
 - Line to line
 - Double line to earth
 - Line to earth.

12.4.4 Dynamic stability studies

Depending on the size and complexity, a particular electrical network dynamic stability study may be required. It shall be required for installations with internal electrical generation.

This study models the dynamic response of an electrical power system and monitors the ability of the network to give stable responses to transient conditions and disturbances such as short circuits, generator tripping and starting of large motors.

The results will be used to:

- Verify selection of equipment and system configuration
- Determine the need for load shedding following a fault and or loss of generation and maximum acceptable load shed times
- Confirm the protection plan
- Confirm stability of the system and maximum acceptable fault clearance times
- Verify motor starting capability
- Verify motor reacceleration and restart capability and develop restart sequences.

Motor Reacceleration and Starting/Restarting Study/Specifications will be issued by the CONTRACTOR

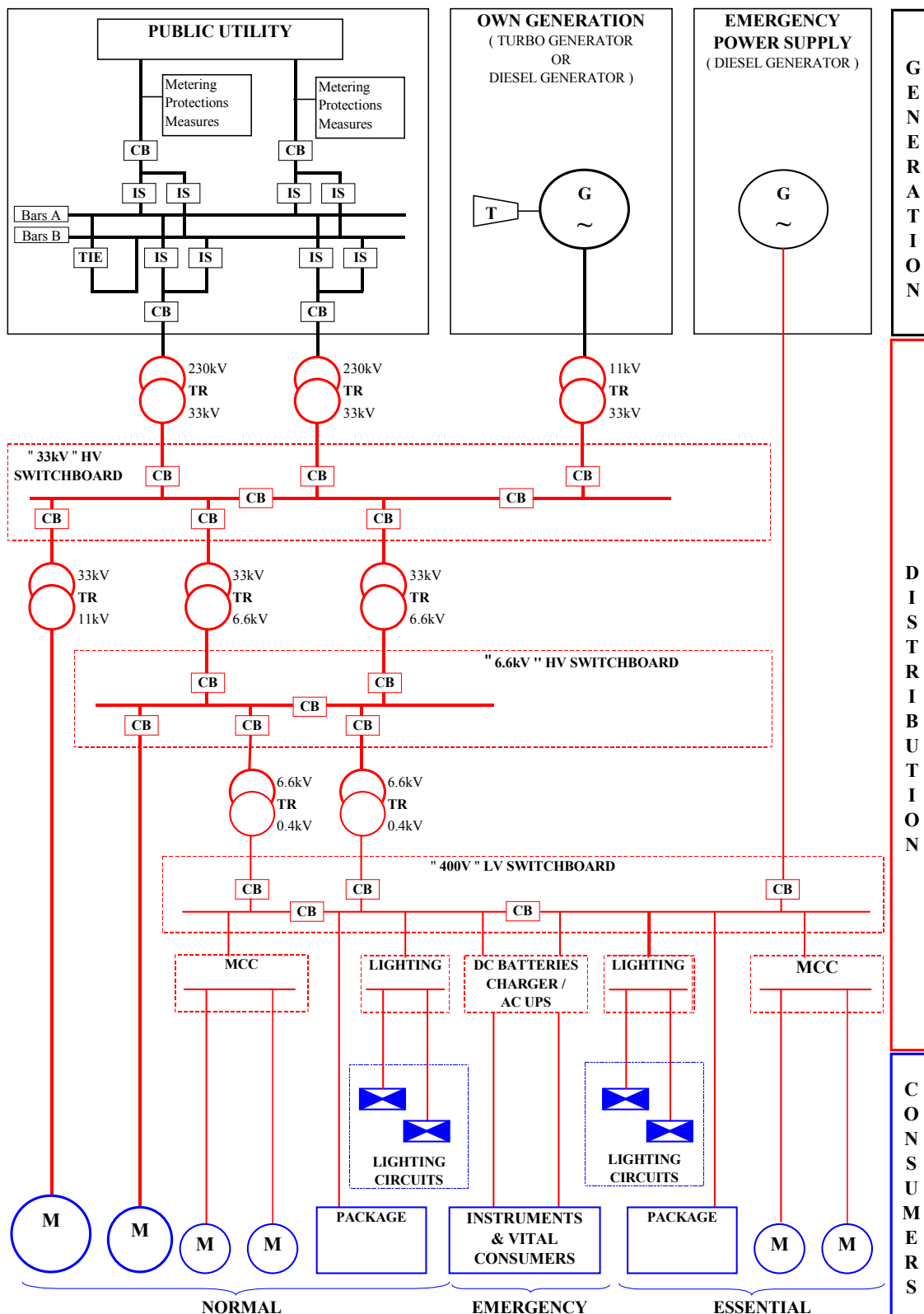


12.5 Harmonic studies

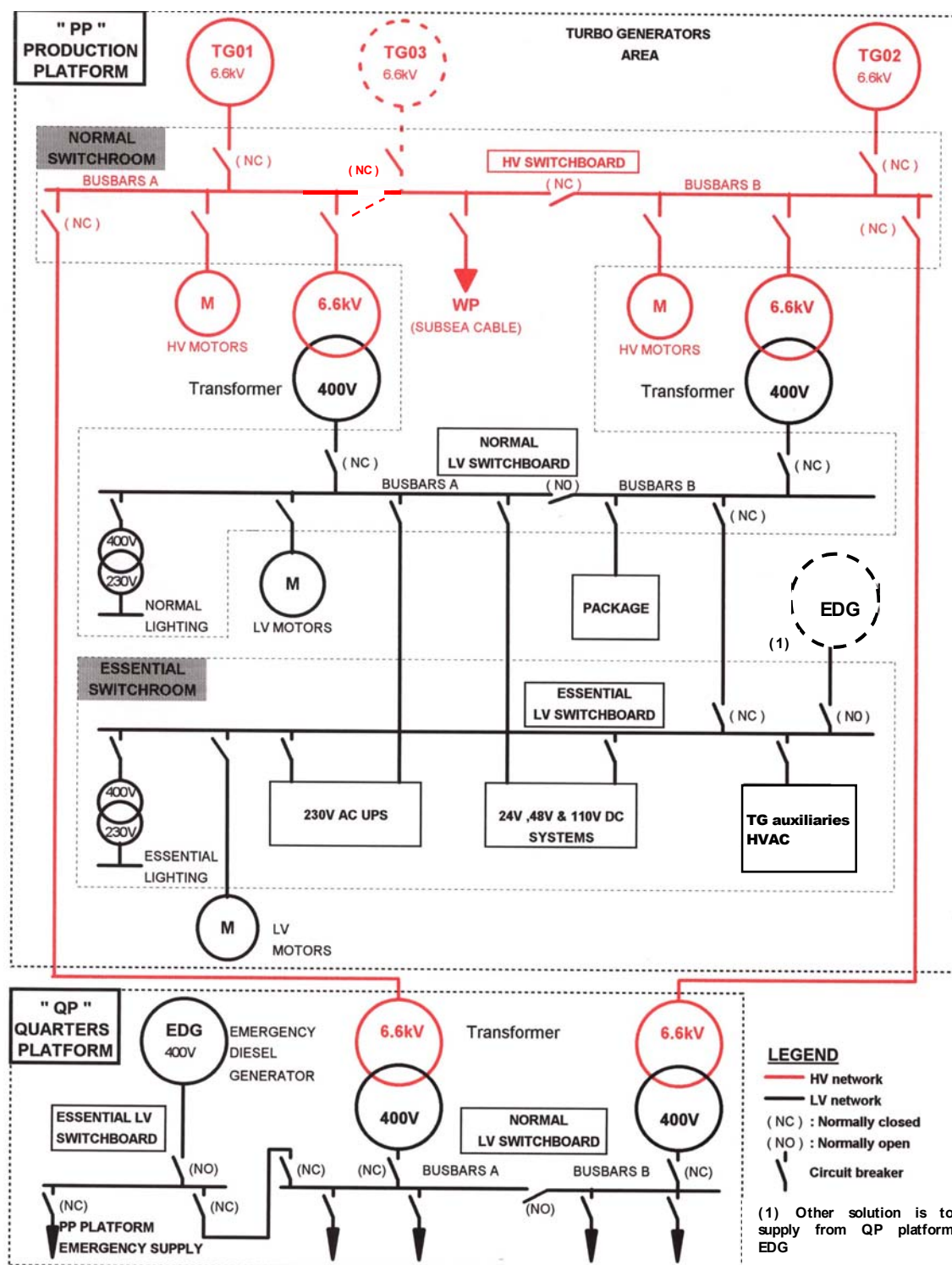
For installations which contain a significant percentage of non-linear loads (e.g. variable speed drives, large thyristor controlled heaters, etc.), harmonic studies shall be produced.

These studies shall verify that any harmonics on the system are in accordance with acceptable limits as per IEEE 519, taking full account of the various harmonic sources in the network. Where required, action shall be taken either by equipment over-sizing or by additional filtration to meet these limits.

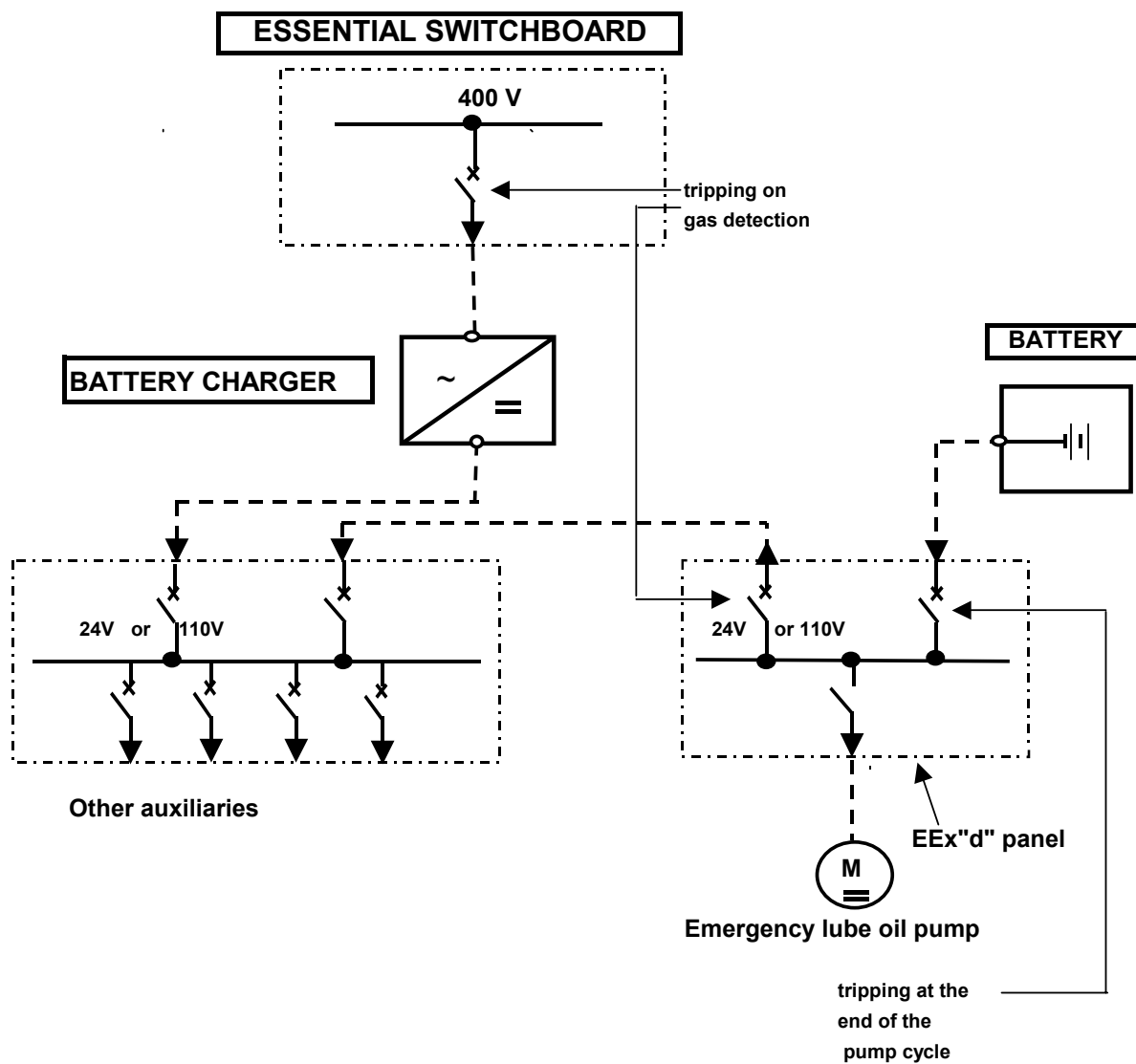
Appendix 1 Typical onshore key one line diagram



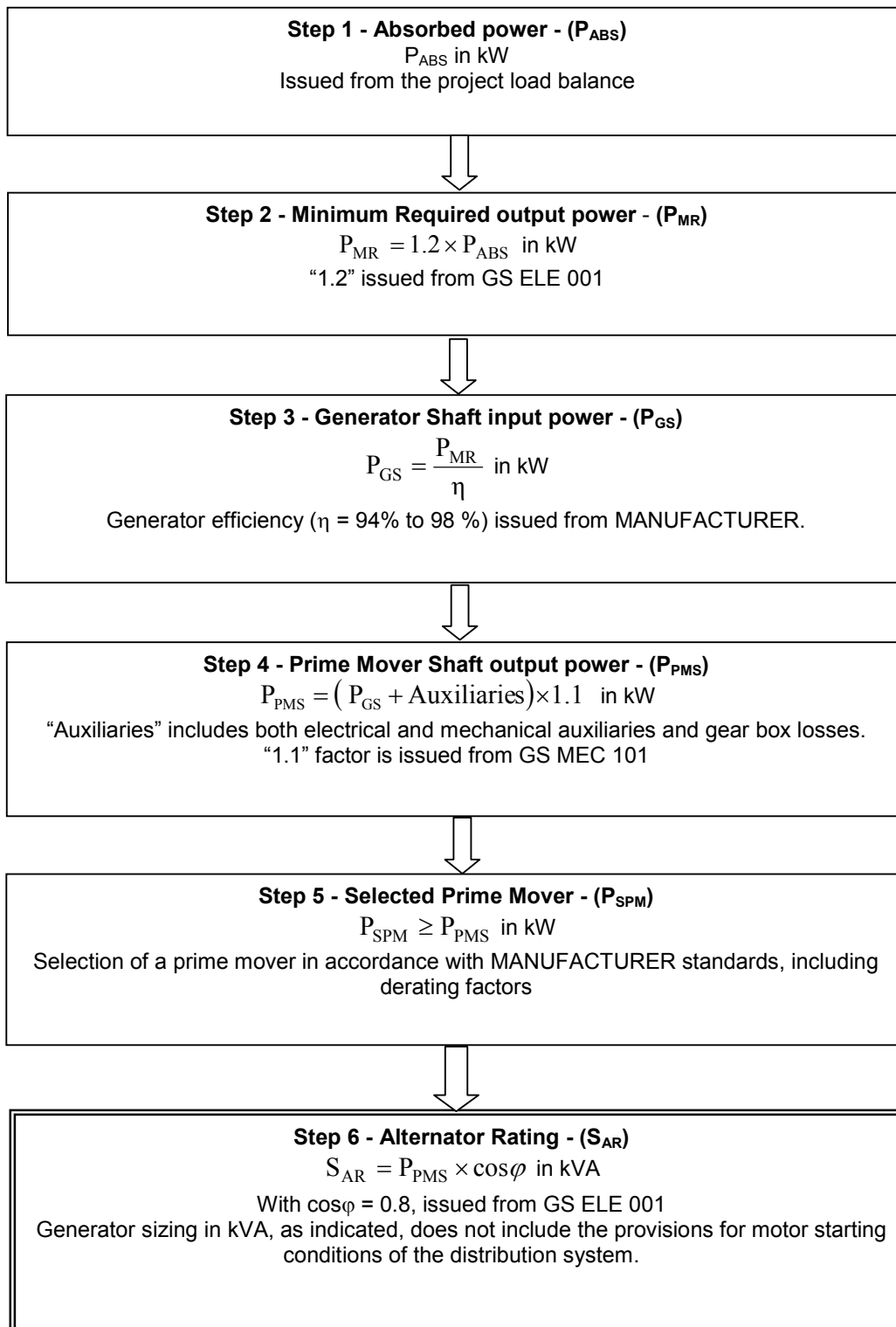
Appendix 2 Typical offshore key one line diagram



Appendix 3 Gas turbine generator - DC Distribution

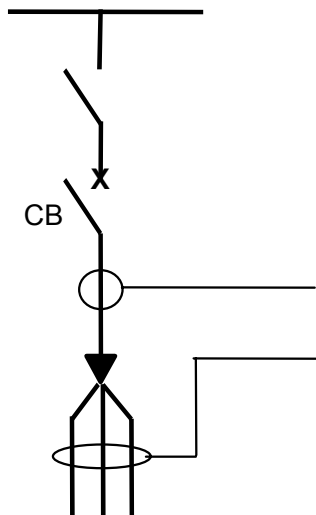


Appendix 4 Alternator sizing



Appendix 5 Feeder output

(Radial feeder or open ring)



Protection	ANSI code	Action
Instantaneous overcurrent $I >> (2)$	50	open CB
Time overcurrent $I > (1) (2)$	51	open CB
Earth leakage current $I_o > (1)$	51N	open CB

(1) Time delay depends on:

- I_{cc}
- cable cross-sectional area
- selectivity

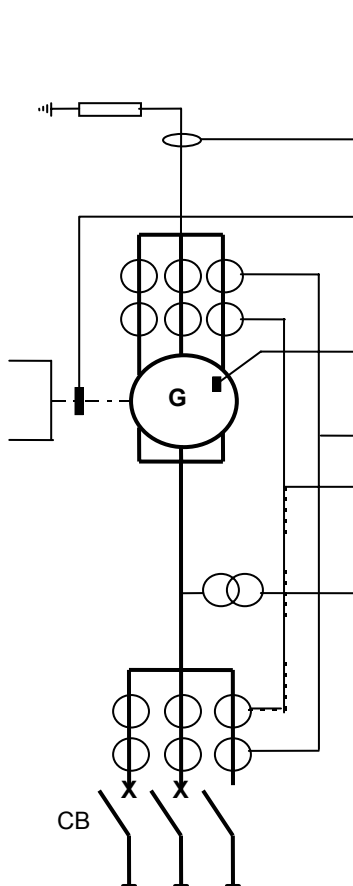
(2) Setting depends on

- minimum I_{cc}
- cable cross-section

(3) Setting depends on :

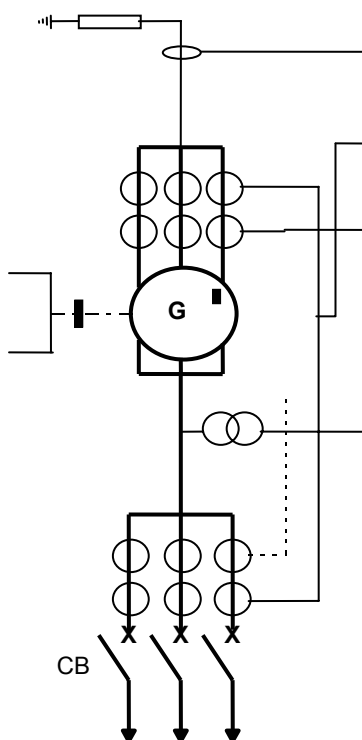
- cable shield strength
- limit fault current

Appendix 6 Turbine Generator

Protection	Protection	AINS code	Action
	Earth overcurrent	51N	Open breaker and stop generator
	Bearing overtemperature	26	Alarm (1 st) and stop generator (2 nd)
	Bearing vibration	39	Alarm (1 st) and stop generator (2 nd)
	Winding overtemperature	26	Alarm (1 st) and trip CB (2 nd)
	Coolant overtemperature or failure	26	Alarm
	Stator differential overcurrent	87 G	stop machine
	Instantaneous phase overcurrent	50	Trip CB
	3 phases stator overcurrent	51 V	Trip CB
	Stator reverse power	32	Trip CB
	Stator under/over frequency	81	Load shedding or Trip CB
	Stator under/over voltage	27 – 59	Trip CB
	Overload	49	Trip CB
	Neutral voltage displacement (1)	51N/64S	Stop machine
	Rotor earth fault (1)	64R	Stop machine
	Rotating rectifier diode failure	94 d	Stop machine
	Field failure or loss of synchronism	40	Trip CB
	Phase unbalance	46	Trip CB
	Directional overcurrent protection	67 / 67N	Trip CB

(1) For generator above 5000 kVA

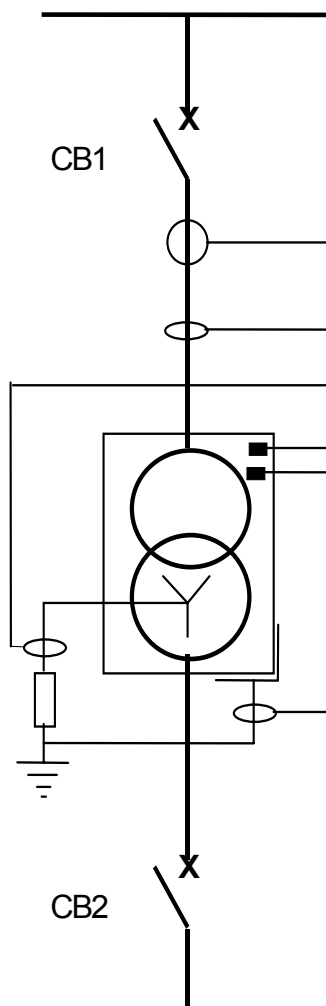
Appendix 7 Diesel Generator



Protection	ANSI code	Action
Earth overcurrent	51N	Open breaker and stop engine
Stator differential overcurrent (1)	87 G	Stop engine
Instantaneous phase overcurrent	50	Trip CB and stop engine
3 phases stator overcurrent	51 V	Trip CB and stop engine
Overload	49	Trip CB
Stator under/over frequency	81	Trip CB
Stator under/over voltage	27 – 59	Trip CB
Winding overtemperature	26	Alarm (1 st) and trip CB (2 nd)
Bearing overtemperature	26	Alarm (1 st) and trip CB (2 nd)
Stator reverse power	32	Trip CB

(1) For generator above 1250 kVA

Appendix 8 Transformer



Protection	ANSI code	Action
Instantaneous overcurrent I >> (1)	50	open CB1
Time overcurrent I >	51	open CB1
HV Earth leakage current	51N	open CB1
LV Earth leakage current	51N	open CB1
1st threshold temperature θ1 (5) 2nd threshold temperature θ2 (5) 1st threshold Buchholz relay (2) 2nd threshold Buchholz relay (2) Drop in liquid level (5) Overpressure (5)		alarm open CB2 alarm open CB1 open CB1 open CB1
Earth tank leakage (3)	51G	open CB1
Transformer differential (4)	87 T	Open CB1

(1) $(I >>) > I_{cc\ LV}$

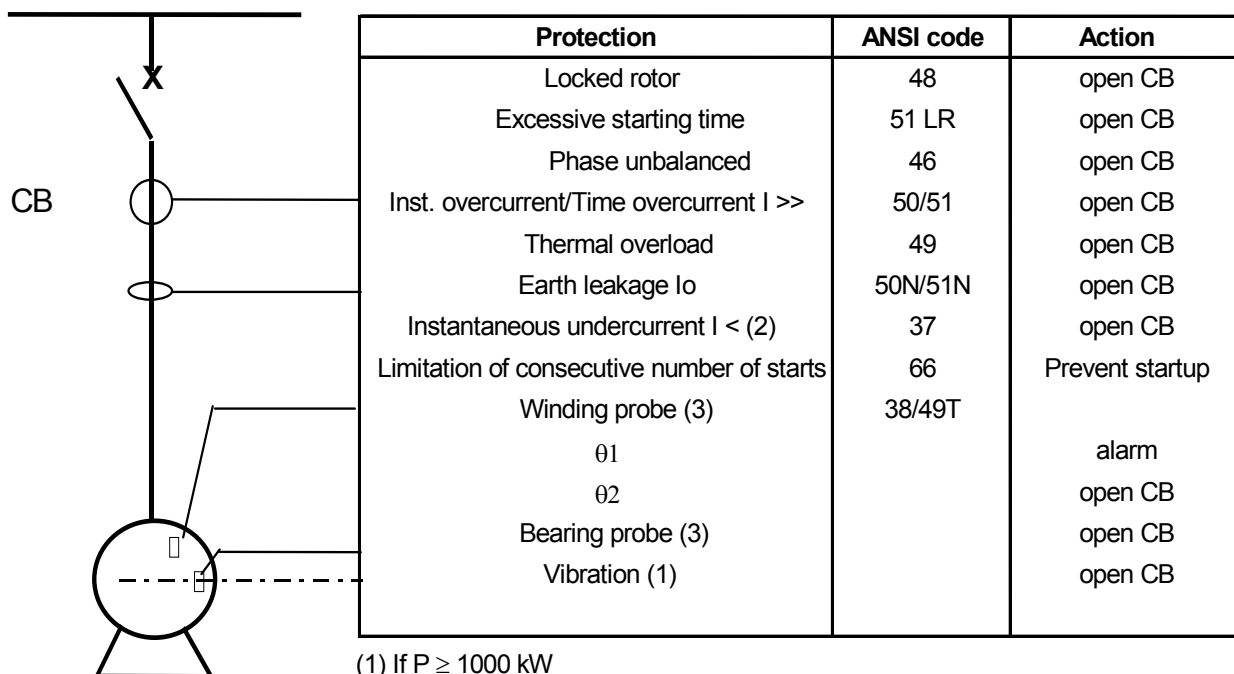
(2) Only for oil immersed breathing type transformer

(3) $P \geq 10\ MVA$

(4) For Generator transformer units and transformer with $P > 20\ MVA$. In this case all opening action are on CB2, as CB1 doesn't exist.

(5) These functions shall be integrated in one multifunction relay

Appendix 9 Motor



(1) If $P \geq 1000$ kW

(2) Pump drive (cavitation - loss of priming)

(3) If $P \geq 200$ kW