

GENERAL SPECIFICATION

ELECTRICAL

GS EP ELE 001

Electrical design criteria

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1. Scope

This specification defines the design criteria used for the engineering, supply, manufacture, and installation of the electrical power/distribution systems to be installed within Company installations located either onshore or offshore.

This specification also covers design and engineering studies for Topsides of 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) etc.

For Hull and accommodation systems of Floating Units, refer to general specification **GS EP ELE 021**.

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.

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.

Any conflict or inconsistency between the above set of documents (standards, specification, codes and local regulation or laws) shall be raised to Company attention for resolution.

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External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the effective date of this document.

Reference	Title
ATEX directive 94/9/EC	European Directive 94/9/EC (23/03/94) on the approximation of the laws of the Member State concerning equipment and protective systems intended for use in potentially explosive atmosphere
EN 50272-2	Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries
IEC 60038	IEC Standard Voltages
IEC 60050	International Electrotechnical Vocabulary
IEC 60059	IEC Standards current ratings
IEC 60071-1	Insulation co-ordination - Part 1: Definitions, principles and rules
IEC 60079 (Parts 10-1; 14)	Explosive atmospheres - Parts 10-1; 14
IEC 60196	IEC Standard Frequencies
IEC 60228	Conductors of Insulated Cables
IEC 60331-21	Tests for electric cables under fire conditions. Circuit integrity - Part 21: Procedures and requirements-Cables of rated voltage up to 0.6/1.0 kV
IEC 60332-3-22	Tests on electric and optical fibre cables under fire conditions - Part 3-22: Tests for vertical flame spread of vertically-mounted bunched wires or cables-Category A
IEC 60364 (All parts)	Low voltage electrical installations - All parts
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 60533	Electromagnetic Compatibility of Electrical and Electronic Installations in Ships and of Mobile and Fixed Offshore Units
IEC 60617	Graphical symbols for diagrams
IEC 60622	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Sealed Nickel-Cadmium prismatic rechargeable single cells
IEC 60623	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Vented Nickel-Cadmium prismatic rechargeable single cells
IEC 61000 (All parts)	Electromagnetic compatibility (EMC) - All parts
IEC 61111	Live working - Electrical insulating matting

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Reference	Title
IEC 61892 (Parts 1; 2; 3; 4; 5; 6; 7)	Mobile and fixed offshore units - Electrical installation - Parts: 1; 2; 3; 4; 5; 6; 7
IEC 61936-1	Power installations exceeding 1kV a.c. - Part 1: Common rules
IEC 62259	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Nickel-Cadmium prismatic secondary single cells with partial gas recombination
IEC 62262	Degrees of protection provided by enclosures for electrical equipment against external mechanical impact (IK code)
IEC 62271-1	High voltage switchgear & controlgear - Part 1: Common specification
IEC 62402	Obsolescence management - Application guide
IEEE 519	Recommended practices and requirements for harmonic control in electrical power systems
NF C13-200	High voltage electrical installations - Requirements
NF C15-100	Low voltage electrical installations

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

Reference	Title
GS EP CIV 401	Minimum requirements for building design and construction
GS EP CIV 403	Temporary construction camps and associated facilities (onshore)
GS EP ELE 011	Electrical requirements for package units
GS EP ELE 013	Electrical requirements for generating units
GS EP ELE 021	Electrical design criteria for floating units
GS EP ELE 031	Design of earthing and bonding systems
GS EP ELE 051	Design and installation of lightning protection
GS EP ELE 061	Minimum requirements for HV & LV cable sizing
GS EP ELE 079	Electrical apparatus for potentially explosive gas atmospheres
GS EP ELE 081	Lighting
GS EP ELE 091	Minimum Contractor document requirements
GS EP ELE 111	Induction motors
GS EP ELE 113	AC generators

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Reference	Title
GS EP ELE 114	HV Synchronous Motors
GS EP ELE 121	HV Variable Speed Drive Systems
GS EP ELE 122	LV Variable Speed Drive Systems for ESP
GS EP ELE 131	High voltage switchgear and controlgear
GS EP ELE 133	G.I.S. High voltage switchgear and controlgear
GS EP ELE 135	Low voltage switchgear assembly
GS EP ELE 137	Distribution boards
GS EP ELE 141	Power transformers
GS EP ELE 151	DC Uninterruptible Power Systems (UPS)
GS EP ELE 152	AC Uninterruptible Power Systems (UPS)
GS EP ELE 161	Electrical cables
GS EP ELE 211	Electrical cabin. Construction and equipment
GS EP ELE 221	Electrical Control System (ECS)
GS EP ELE 251	Closed Cycle Vapour Turbogenerator (CCTV)
GS EP ELE 261	Solar Power System
GS EP ELE 311	Cables trays/ladders
GS EP ELE 321	Navigational Aids System
GS EP ELE 331	Tape trace heating
GS EP ELE 364	Electrical installations
GS EP ELE 374	Construction site electrical installations
GS EP ELE 451	Third party inspection. Independent verification of electrical facilities
GS EP ELE 460	Engineering Studies
GS EP ELE 765	Submarine cables
GS EP INS 107	Design and installation of instrumentation links
GS EP MEC 101	Driver Power Sizing
GS EP SAF 216	Area classification
GS EP TEC 007	Obsolescence and Lifetime Cycle Management

3. Environmental conditions

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

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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.

Unless otherwise specified in the project specification, in air conditioned rooms, electrical equipment shall be designed for continuous operation under relative humidity of 60% and below.

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 respectively as per [IEC 60529](#) and [IEC 62262](#)) shall comply with the relevant equipment general specification and/or data sheet.

4. Vocabulary, units and symbols

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).

5. Frequencies and voltages

5.1 General

Association of 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 is subject to written Company approval.

5.2 Standard frequencies

50 Hz is the recommended frequency.

However 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 unless otherwise specified.

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5.3 Standard voltages

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-circuit levels
- Existing systems and supplies
- Distributor's supply voltage
- Distances between consumers and supplies.

5.3.1 AC systems

- **High voltage**

The general electrical characteristics shall be in compliance with the values indicated in [IEC 62271-1](#) - paragraph 4.2 rated insulation level, Table 1a - Rated insulation levels for rated voltages of range I, series I. and as follows:

System	3 phases / 3 wires				
Rated frequency	50 Hz				
Nominal system voltage	66 kV	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**

- 690 V or 400 V for motive power, main distribution, etc.
- 230 V for lighting, heat tracing and small power
- 230 V (UPS).for control and instrumentation supplies, public address (PA/GA).

5.3.2 DC systems

- 110 V for electrical control, essential lube oil pumps (e.g. turbogenerators, turbocompressors, etc.)

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- 48 V e.g. for electrical control, telephone system (PABX)
- 24 V e.g. for instrumentation (F&G, ESD, PCS) and telecommunications (SOLAS).

5.4 Voltage and frequency variations

All A.C. electrical equipment supplied is to be so designed and manufactured that it is capable of operating satisfactorily at the variations of voltage and frequency hereunder specified:

5.4.1 A.C systems

Unless otherwise specified electrical equipment shall operate satisfactorily with the following simultaneous variations, from their nominal value, when measured at the consumer input terminals.

Voltage:

- Steady state variations: +10%, -10%
- Transient variations: +20%, -20% Recovery within 1.5 seconds

Frequency:

- Steady state variations: $\pm 5\%$
- Transient variations: $\pm 10\%$ Recovery time: within 5 seconds

5.4.2 D.C systems

Voltage variations

For D.C. equipment the following shall apply:

- Steady state voltage variations: +10%, -15%
- Voltage Cyclic variation: 5%
- Transient voltage variations: $\pm 25\%$

5.5 System voltage drops

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

5.5.1 AC systems

The distribution system cable sizing shall ensure that the following voltage drops, at the circuit full load current, are not exceeded:

- Feeders (from main to sub-main Switchboard & MCC's): 2%
- Transformer Feeders (from Transformer to Switchboard): 1%
- Motor feeders (at motor terminals, running at full current): 5%

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

Note: For cable sizing, the usual practice in the industry is to limit the voltage drop for Direct On Line starter to 15% in such conditions.

- Lighting sub-circuits and sockets: 2% average with a maximum of 4% at to the farthest fitting
- Other (heaters, packages, etc.): 5% unless particular requirement.

5.5.2 DC systems

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

5.6 Harmonic distortions

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. The following limits shall apply for the voltage distortions:

- Total Harmonic distortion $\leq 5\%$
- Single harmonic $\leq 3\%$

For shorter periods, e.g. during start-ups or unusual conditions, the limits may be exceeded by 50%.

Calculations to demonstrate that emission levels of harmonics remains within the requirements of [IEEE 519](#), including size and effect of harmonics and inter harmonics, shall be provided by Contractor, taking into account data of all drives and converters installed on the installation.

When required, action shall be taken either by equipment over-sizing or by additional filtration to meet these limits.

5.7 Electromagnetic Compatibility (EMC)

In order to comply with the EMC requirements of [IEC 60533](#) (offshore) and of [IEC 61000](#) all electrical systems and equipment shall meet the current applicable levels of "emission" and "immunity" detailed therein.

6. Earthing systems

6.1 High voltage systems

6.1.1 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.

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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.

6.1.2 Networks fed from an isolated generator

Neutral shall be earthed via a resistance.

6.1.3 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.

6.1.4 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.

6.2 Low voltage systems

6.2.1 Motive and main power distribution

The main low voltage system (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.

Onshore plant:

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

Offshore installations:

Similarly to onshore, 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

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- Impedance measurements shall be done on Site at commissioning stage to confirm the assumptions taken on the grounding network impedance for the cable calculation.

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

6.2.2 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 + Neutral + Earth (Protection conductor), 5-Wires for 3 phase distribution (or 1 phase + Neutral + earth, 3 wires for single phase distribution) may be considered for FPSO Topside (harmonisation between Hull & Topside based on Classification Societies rules applicable to the Hull lighting and small power distribution system).

6.2.3 Heat Tracing distribution system

Where required by process or other reasons, a heat tracing system shall be provided. If the trace heating system requires more than 50 kVA, this system shall be independent and comprise a transformer (400/230 V) and dedicated distribution panel.

The 400/230 V, 3-phase + neutral, tracing system shall have a neutral earthed and distributed (TT system).

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

6.2.4 400/230V UPS distribution system

Unless otherwise specified by the ICSS 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 socket outlets per circuit are allowed.

6.3 Construction site electrical installation

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

6.4 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 EP CIV 401](#).

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6.5 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.

6.6 System Voltages - Neutral Earthing system

Nominal voltages	Neutral system	Service	Maximum voltage drops at equipment terminals
Internal power generation 11 kV/6.6 kV AC	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	
Power distribution 66-33-22-11-6.6 kV	Earthed by low impedance at transformer or earthing transformer.	Main HV switchboard	
690 VAC or 400 VAC	IT (Neutral not distributed) Earthed via high impedance	MCC	
		Motors	5% at full load current
		Diesel generators	
230 VAC	TT system (Neutral earthed and distributed)	Lighting distribution board	
		Lighting fittings	8% max to the farthest fitting
		Small power board	
	TT System Neutral earthed and distributed	Heat tracing	
230 V UPS	Isolated IT system (Neutral not distributed) TN acceptable	Control and instrumentation	
DC system 110/48/24 VDC	Unearthed	Control, instrumentation, telecommunications, essential services	2% of nominal voltage

7. Electrical distribution systems

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

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7.1 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.) which may be backed up by an emergency generator.
- 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). On loss of normal supply, the equipment shall be restarted automatically or manually by the operator and re-fed from the essential generator(s).
- Normal loads: Loads, which have no effect either on the safety or the safeguard of installation or equipment in case of normal generation failure.

7.2 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. In particular, when the electrical network of a specific project encompasses significant loads (above 5 MW per single electrical load); the 20% spare might not apply on these loads.

For alternator sizing, refer to Appendix 4.

All components (e.g. bus bars, circuit breakers, contactors, switches, etc.) 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 likely to be simultaneously in operation, including future phases.

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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 or major revamping and in any case, subject to Company written approval.

7.3 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 has 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 EP ELE 079**.

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

As a reminder, motor space heater when not suitable for Zone 1 shall be switched-off automatically in case of ESD linked to gas detection.

7.4 Overall configuration

7.4.1 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, etc.)

The main incoming transformers shall be fitted with an automatic on-load tap changer unless detailed analysis of grid voltage fluctuation demonstrates that such device is not required.

7.4.2 Main power Generation (see Appendix 2)

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

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 plant shall be provided normally by the remaining generators (i.e. 'n+1' configuration is provided with 'n' generating units running under normal conditions). The selection of n=1 (i.e. 2x100%) shall be validated by a specific study at pre-project stage sanctioned by Company internal validation process.

The alternator in the generating unit shall be 4 poles machines. Use of 2 poles generator will require to be fully substantiated by a report requiring Company formal approval.

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).

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7.4.3 Offshore platform

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

- **Main power generation**

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 by the remaining generators (i.e. 'n+1' configuration is provided with 'n' generating units running under normal conditions). The selection of n=1 (i.e. 2x100%) shall be validated by a specific study at pre-project stage sanctioned by Company internal validation process.

- **Supply via submarine cable**

Unless otherwise specified, only one power supply transformer shall be installed. The main incoming transformers shall be fitted with an automatic on-load tap changer unless detailed analysis of grid voltage fluctuations demonstrates that such device is not required.

7.4.4 Special cases

For installation with low power demand, less than 10 kW, closed cycle vapour turbo generators (CCVT) shall be used, refer to **GS EP 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
- THEG (THERmo-Electric Generator based on Seebeck effect)
- Wind generators
- Hybrid systems, such as solar panels + wind generator, solar panels + CCVT or THEG
- Etc.

7.5 System configuration

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

HV switchboards design shall meet the requirements of **GS EP ELE 131**, unless otherwise specified in a Project particular specification.

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

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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 33 kV and above:

- For voltage rated 33 kV, refer to Company specification **GS EP ELE 131**
- For voltage rated 72.5 kV and above, refer to Company Specification **GS EP ELE 133**.

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

Bus bar rating and distribution of the loads along the bus sections shall allow the load flow in any network configuration (including future loads).

Other HV switchgear with at least two power supplies shall have two bus sections. Status of tie breakers between bus sections of the downstream HV and LV switchboards shall be "Normally Open" ("N.O").

In order to increase availability, redundant equipment shall be judiciously split between the different bus sections.

Each incomer, bus-section cubicle shall be equipped with microprocessor type protection and measurement relays. These relays shall be interfaced with the E.C.S. Motor feeder circuits shall be interfaced with E.C.S, and if required with I.C.S.S.

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 EP ELE 131**.

7.5.2 Diesel generator(s)

Under normal operating conditions, the diesel generator shall be in stand-by mode.

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 period of time, 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 EP 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 EP ELE 113**.

7.5.3 LV switchgear

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

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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 § 7.7).

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 busbar 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.

7.5.4 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).

7.5.5 Uninterruptible power systems

UPS shall be designed to limit the number of units.

7.5.6 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.

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7.5.7 HVAC distribution

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

- Starters integrated into normal/essential switchboards
- From a dedicated HVAC switchboards (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.

7.6 Intertripping and Interlocking

- Intertripping sequences and interlocking shall not be achieved via the Electrical Control System (E.C.S) but hardwired only.
- 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.
- Intertripping sequences shall not be implemented in the Electrical control System (E.C.S) but hardwired only.
- Interlocking shall be provided where applicable to prevent incorrect 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.

7.7 ECS

7.7.1 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.

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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 EP ELE 221**.

Typical functions to be included are:

- Control of power distribution e.g. remote open and close control facility of the main circuit breakers of the HV and LV networks from a central control point (which may be the control room or an electrical technical room)
- Provision of a VDU based system to provide animated display of power generation and distribution system, data acquired and provide operator/machine interface
- Load shedding; fast load-shedding based on event triggering, slow load-shedding based on TG exhaust temperature drift or frequency drift
- Start inhibit of loads according to generators spinning reserve
- Automatic transfer sequence
- Reacceleration for large onshore facility/plant
- Event recording and parameter trending
- Disturbance recording
- Display of alarms
- Interface with Integrated Control and Safety System (ICSS)
- PMS might be integrated into ECS on specific project, after Company prior Approval.

7.7.2 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 and the Load shedding priority sequence shall be operator configurable.

Load shedding shall be achieved either by the Electrical Control System and providing a response time suitable for successful operation.

To ensure this successful operation, the load shedding sequence shall be completed within 200 ms. This time to include:

- Detection and transmission to the E.C.S of the information used to initiate the sequence
- Elaboration by the E.C.S of the shedding orders to the loads
- Opening of the relevant feeders.

7.7.3 Event stamping and historic

Switching time of the apparatus providing information to be discriminated shall be greater than the time required for acquisition of the time and date stamped events.

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Events to be discriminated shall be listed in the E.C.S particular specification.

E.C.S shall have capability for event history recording over a continuous period of 6 months.

7.8 Disturbance and fault recording system

For industrial facilities Onshore & Offshore with an overall power demand of 20 MVA and above, and/or a connection to a public grid, a disturbance and fault recording system shall be installed on the main switchboard to record the following information:

- Voltage, current & frequency of each Turbo-generator
- Voltage, current & frequency of Public grid Incomer, if any
- Voltage, current & frequency of Switchboard Busbars
- Status (Open & Close positions) of Incomers & bustie Circuit-breakers
- Statuses of Pyrotechnic current breaking devices.

For other industrial facilities with a lower rating, the decision of installation or not of a disturbance and fault recording system shall be taken on a project by project basis at pre-project or basic design stage depending on the network complexity and criticality.

This equipment shall have a serial link interface with the ECS to display records and issue reports.

7.9 Black start requirements

A black start 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 black start 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 black start sequence.

The black start shall always be manually executed.

For Offshore platforms with power generation water cooled (direct dedicated sea water loop or through an intermediate fresh water loop), a specific blackstart sea water lift pump shall be connected to the emergency board to restart the power generation cooling loop and ultimately the installation in case of complete shutdown. This small pump and associated valves can be controlled by ICSS.

For floating units, refer to [GS EP ELE 021](#) § 10.7.

7.10 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 zone 1 (e.g.: Nav aids, DC post lube pumps see Appendix 3).

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8. Electrical substations

8.1 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.

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 EP ELE 211**).

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 15 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 free height of 1000 mm dedicated to electrical cable routing (without any reservation for HVAC ducting), and shall be compatible with the bending radius of the largest cross-section of cables) or technical void (onshore, minimum height of 1.80 m below beams) 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 deck structure. Equipment shall be fixed on metal frame by bolts.

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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, except for large water cooled VSDS unit.

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 evenness shall be in accordance with switchgear Manufacturer requirements).

When the voltage exceeds the safety voltage, insulating mats as per [IEC 61111](#) shall be provided in front of switchgear and controlgear assemblies and also at the rear if access from rear is required. The insulating mat shall be oil-resistant and non-slip.

For onshore concrete substation, necessary provision shall be taken to have metallic frames embedded in concrete to achieve the required floor evenness.

Floors shall be coated with anti dust coating.

Electrical rooms with concrete walls and ceiling shall be painted.

8.2 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 or HVAC ducting	450 mm (note 1)
Front of operating side of high voltage switchgear	1500 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

Note 1: Arc resistant equipment might require greater clearances, Manufacturer recommendations shall be adhered to.

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8.3 G.I.S substation

The following special requirements are needed:

8.3.1 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 EP 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.

8.3.2 Overhead travelling crane

An overhead 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

8.3.3 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.

9. Equipment

9.1 Transformers

9.1.1 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 EP ELE 141**.

Rating of HV/LV distribution transformers shall be limited to 2500 kVA for 400 V and 4 MVA for 690 V.

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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, etc.).

9.1.2 Transformers installation

Oil immersed transformers shall be located outdoor.

Dry type transformers shall be located indoor.

Oil immersed power transformers shall be installed as follow:

- For Onshore installation, Oil immersed power transformers shall be separated by fire rated walls (A60) and shall be protected against rain falls or direct sun rays by a removable roof. Walls, front fencing and roof shall ensure natural transformer ventilation. An oil-receiving pit shall be built under each transformer and shall be connected to an oily water drainage system via a fire break valve.
- For Offshore installation, Oil immersed power transformers shall be separated by fire rated walls (A60) 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 by safety concept, deluge system shall be considered. A receiving tank shall be provided under each transformer and shall be connected to the open drain system via a fire break valve.

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

Minimum clearance for transformer connections shall be 1000 mm (cables not included), and 850 mm for the other sides. Overall layout shall be in line with the requirements of [IEC 61936-1](#).

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.

9.2 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 should be Low Voltage (400Vac or 690Vac), and High Voltage above 400 kW

Motors between 150 and 400 kW shall be subject to technical and economical study during basic engineering. 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).

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When required by the Project, motors shall be provided with a control station (start/stop pushbutton) adjacent to the equipment. Emergency stop push buttons shall always be directly hardwired to the tripping coil of the switching device.

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 EP ELE 111**.

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

9.3 DC and AC UPS

9.3.1 General

DC and AC UPS systems shall comply with Company Specifications **GS EP ELE 151** and **GS EP ELE 152**.

Provision shall be taken for electrical isolation, ESD and blackstart in the design of UPS distribution panel and of the battery isolation circuit breaker.

9.3.1.1 DC UPS

DC UPS shall be selected depending of the service required in the following predefined types as mentioned on the data-sheet:

- Type 1: where redundancy is not required, the DC UPS shall consist of:
 - 1x100% rated rectifier/charger
 - 1x100% rated battery
 - 1 distribution board.

This type of DC UPS is suitable for applications such as package auxiliaries, and Nav aids.

- Type 2: where redundancy is required, the DC UPS shall consist of:
 - 2x100% rated rectifier/charger in parallel operation through blocking diodes
 - 2x50% rated battery (with battery chargers sized to charge both sets of batteries)
 - 1 distribution board.

This type of DC UPS is suitable for applications such as E&I and Telecom supplies.

- Type 5 (secondary DC supplies):

Where there are already AC UPS and only limited power of DC supply is required, the DC supplied shall be derived from the centralized AC UPS.

This type of DC supply is basically made of two rectifiers in parallel operation through blocking diodes supplied from the AC UPS sources.

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9.3.1.2 AC UPS

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

The inverter output shall be 230 V single phase for UPS rated less than 50 kVA and 400/230 V three phase + neutral output for larger UPS.

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.

9.3.2 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 backup	Without EDG backup		
Electrical Switchgear	30 minutes	90 minutes	48/110 V DC or 230 V AC	Unearthed
Post lube pump of machine	Vendor standard requirements	Vendor standard requirements	110V or 24 V DC	Vendor standard requirements
Navigation aids	96 hours	96 hours	12/24 V DC or 230 V AC	Unearthed
Instrument ICSS	30 minutes	90 minutes	24 V DC	Unearthed
Instrument ICSS	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 1 hour at full load	6 hours 6 hours 1 hour at full load	24 V DC 48 V DC 230 VAC	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
Office computers	10 minutes	10 minutes	230 V AC	Unearthed

9.3.3 Batteries

9.3.3.1 Battery type

Battery shall be of the following type:

- Nickel-Cadmium - vented type - [IEC 60623](#)
- Nickel-Cadmium recombination type - [IEC 62259](#) with a recombination level of 90% and above
- Nickel-Cadmium - sealed type - [IEC 60622](#).

Unless otherwise specified, the Nickel-Cadmium vented type shall be preferred.

9.3.3.2 Battery installation

Batteries shall be preferably installed into dedicated battery rooms. Installation in cubicles or outdoor battery box or stands might also be required in Project particular specification. In such a case, the battery cubicle shall be properly ventilated, either naturally or by forced ventilation to avoid gas accumulation. In case of forced ventilation, fan units shall be category 2 as per [ATEX directive 94/9/EC](#).

Battery ventilation shall be in accordance with Company specification [GS EP SAF 216](#).

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 EP SAF 216](#).

Installation Type of cells	Dedicated battery room	Cabinet in technical room	Outdoor battery box
Ni-Cd Vented type	R	F	P *
Ni-Cd Recombination type	P If $P_{\text{charge}} \geq 4$ kW as per IEC 61892-6	R If $P_{\text{charge}} < 4$ kW as per IEC 61892-6	P *
Ni-Cd sealed type	P If $P_{\text{charge}} \geq 4$ kW as per IEC 61892-6	R If $P_{\text{charge}} < 4$ kW as per IEC 61892-6	P *

R: Recommended

P: Possible

F: Forbidden

P* To be checked with Manufacturer according to environmental conditions, in particular with respect to Site temperature and sealed type batteries.

For NiCd recombination or sealed type batteries, the location of the batteries will be decided based on the charging current as recommended by [IEC 61892-6](#), paragraph 10.1.2:

- If $P_{\text{charge}} < 4$ kW, the batteries of the various systems can be installed in adequately ventilated cabinet in normal technical room (Electrical room)
- If $P_{\text{charge}} \geq 4$ kW, the batteries of the various systems shall be installed in a dedicated battery room.

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Where $P_{\text{charge}} = \sum U_{\text{rated}} \times I_{\text{charging current}}$ of each individual charging system installed in the same technical room (Electrical room)

- $I_{\text{charging current}}$ = maximum obtainable charging current in A
- U_{rated} = nominal voltage in V.

A battery circuit breaker with overcurrent protection shall be provided in an enclosure located adjacent to the battery room.

When required, an undervoltage tripping coil shall be provided for ESD purpose.

The enclosure shall be standard IP31, unless the battery has to supply loads after a gas detection shutdown (e.g.: navais, PAGA, turbine post lub pumps, etc.), in which case it shall be certified Ex"d" IIC T3 / category 2.

"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.

Particular attention shall be given to the fact that the gas emitted is lighter than air and will tend to accumulate in any pockets at the top of the space, therefore the technical room ceiling where the batteries are installed, shall be completely flat (no structural beam shall remain apparent forming retention space on the ceiling).

9.3.3.3 Installation in a dedicated battery room

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

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 EP 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.

Particular attention shall be given to the fact that the gas emitted is lighter than air and will tend to accumulate in any pockets at the top of the space, therefore the battery room ceiling shall be completely flat (no structural beam shall remain apparent forming retention space on the ceiling).

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9.3.3.4 Dilution ventilation criteria

The purpose of ventilating a battery location or enclosure is to maintain the hydrogen concentration below the 4%_{vol} hydrogen lower explosion limit (LEL) threshold and limit the oxygen content to normal level. Battery locations and enclosures are to be considered as safe from explosions, when by natural or forced (artificial) ventilation the concentration of hydrogen is kept below this limit.

The formula selected for the dilution factor calculation in [IEC 61892-7](#) is based on the criteria developed in [EN 50272-2](#).

$$Q = 0.05 \times n \times I_{\text{gas}} \times C_{\text{rt}} \times 10^{-3} \text{ [m}^3/\text{h]}$$

n Number of cells

I_{gas} Current producing gas in mA per Ah rated capacity for the float charge current I_{float} or the boost charge current I_{boost} according to Table 6 or Manufacturer data

C_{rt} Capacity C5 for NiCd (Ah), $U_f = 1.00$ V/cell at 20°C

Typical values can be taken from the [IEC 61892-7](#), paragraph 8.6.1.3, Table 6.

Note: In France, the dilution criteria to be used shall be the one from the [NF C15-100](#), paragraph 554.2.

9.3.3.4.1 Safety and Maintenance tool kits

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

9.4 Lighting/Small power and welding sockets

9.4.1 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.

For topsides of Floating units, the essential lighting shall be fed from the emergency services.

- Emergency system: Selected luminaires of the above essential system, which illuminate escape routes, emergency exits and ladders shall have an integrated Ni-Cd battery (90 minutes autonomy) 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.

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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 EP ELE 081**.

Separate lighting circuits shall be provided for floodlights and lighting fixtures with the following maximum fixtures per circuit:

- Four plus one possible additional for floodlights
- Ten plus two possible additional for other lighting fixtures.

Each outdoor lighting fixtures shall be provided with its dedicated and accessible junction box.

9.4.2 Socket outlets

Socket outlets 16A (Ph+N+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.

Socket outlets installed indoors shall be as follows:

- Essential 230 V, Phase + Neutral + earth 16A
- UPS 230 V 2 phase + earth 16A with covers. Unless otherwise specified blue colour shall be used
- Socket outlets shall be fitted with a 30 mA earth leakage protection, except those supplied by UPS's
- Office computers shall be supplied by UPS's.

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

Within buildings, indoor single-phase convenience socket outlets fed from lighting distribution boards (230 V - Ph+N+E) 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.

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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 (offices, accommodation, etc.).

9.4.3 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 - 3 W + Earth, 50 Hz.

9.5 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.

9.6 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.

The heater control will be split as follow:

- 2 fixed steps of 30% each of the rated power switched on & off by contactors
- 1 variable step of 40% of the rated power in zero-crossover or phase angle control. The 10% overlap is to avoid too frequent switching of the contactors

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:

- Three-phase heating elements
- Complete thyristor control description including control management modes

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- 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 $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and $\frac{4}{4}$ loads
- Complete arrangement drawing, schematic diagrams...

9.7 Cables and cabling

9.7.1 Cables

All cables shall be flame retardant type to [IEC 60332-3-22](#), Category A.

In addition to this requirement, cables for special (vital safety) services (i.e. public address system, foghorn, beaconing with centralised batteries, ultimate emergency distribution) shall also be fire resistant type to [IEC 60331-21](#).

Indoor cables for the living quarter areas and continuously, permanently and normally manned rooms/enclosures shall be Zero Halogen type.

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, maximum 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)

Cable minimum core cross section shall be as follow:

- Power : 2.5 mm²
- Control : 1.5 mm²
- Lighting : 2.5 mm².

For links rated 2000A and above, use of fully insulated bus ducts shall be considered, subject to a joint technical economical evaluation carried out by the Engineer/Contractor. However, in case of brownfield developments with offshore hook-up work, the use of busduct shall be discarded due to the amount of Work required compare to cable run solutions. Similarly, busduct shall not be used on offshore Wellhead platforms.

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

- Buried cables
- Cables running in hazardous areas in zone 1 & 2 (as per [GS EP ELE 079](#))
- Fire resisting cables.

Unless otherwise specified, mixing of two different voltages (level & source) in the same cable is forbidden.

Electrical cables for power and control shall be designed as indicated in Company Specification [GS EP ELE 161](#).

When subsea cables are required, they shall be designed in accordance with the Company specification [GS EP ELE 765](#).

9.7.2 Cable routings

Cable routing shall be as defined in Company general specification [GS EP ELE 364](#) and [GS EP INS 107](#).

9.7.3 Segregation

Segregation distances between various systems and voltages shall be as [GS EP ELE 364](#) and [GS EP INS 107](#).

9.7.4 Cable glands

Cable gland type and size shall be as specified on the drawings. Barrier glands shall only be used where required by [IEC 60079-10-1](#).

For certified equipment, cable glands shall be of the same mode of protection as the device being cabled (i.e. Ex"d" glands for Ex"d" equipment).

For offshore installation, cables shall be terminated into enclosures using mechanical compression type cable glands, either Nickel plate Brass or stainless steel 316 (metallic enclosures or armoured cables), or polyamide (Polyester enclosures and non armoured cables). Aluminium alloy cable glands are prohibited.

For Onshore installation, cables shall be terminated into enclosures using mechanical compression type cable glands, either Brass (metallic enclosures or armoured cables) or polyamide (Polyester enclosures and non armoured cables).

9.7.5 Junction boxes

Unless otherwise specified, junction boxes shall be IP65, IK08, made of Glass Reinforced Polyester, provided with a minimum of 1 spare entry.

Suitable accessories shall be provided with GRP boxes for earthing of armoured cables.

Outdoor Junction boxes (except small lighting JB's) shall be fitted with a pressure compensation device.

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10. Miscellaneous

10.1 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 VDC and 230/400/690 VAC) found on the site.

10.2 Electrical safety kit

Each Electrical room shall be equipped with electrical safety devices, selected according to voltage level.

Safety devices shall be grouped together on a rack fixed to the wall close to the main door access, and shall include as a minimum:

- One pair of rubber gloves (in a box) + tester
- Safety anti-flash glasses
- One isolating platform (HV rooms)
- One Rubber mat (LV rooms)
- One rescue stick
- One voltage detector
- Mobile earthing kit with clamps (HV rooms)
- "First aid" safety instructions and first aid posters
- Portable light suitable for zone 1 hazardous area (category 2).

10.3 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 EP ELE 031**.

10.4 Lightning protection

For sites, which are subject to lightning strikes, provisions shall be taken in accordance with the Company specification **GS EP ELE 051**.

10.5 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

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- Fault/Trip: YELLOW
- Voltage presence: WHITE

Push button:

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

10.6 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.

11. 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.

Network calculations shall be carried out using approved power system analysis software.

Deliverables shall be in accordance with the Company's specification **GS EP ELE 091** and **GS EP ELE 460**.

11.1 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.

11.2 Power system studies

Power system studies shall be produced.

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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:

11.2.1 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.

11.2.2 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.

11.2.3 Short circuit calculation

The load flow calculation shall be carried out for each network configuration (normal, essential, emergency, etc.).

11.2.4 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.

11.3 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.

11.4 Hazardous area Verification Dossier

This verification dossier shall be prepared for the facility (Onshore or Offshore) in line with the requirements of the [IEC 60079-14](#) as detailed in [GS EP ELE 460](#) § 4.47 in order to be available on Site for Operation personnel.

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11.5 Electrical Equipment Obsolescence Dossier

O&G facilities are usually design with an expected design life ranging from 20 to 25 years at least. On the other hand the electrical equipment have shorter life cycle, which might result in one or more upgrading during the design life of the facility.

Obsolescence management shall be in accordance with **GS EP TEC 007**.

Strategy for managing obsolescence starts at the pre-project phase and needs to be regularly updated as an integral part of the core functions

- Design and development
- Sourcing and production
- In-service sustainability
- Vendors support.

The electrical design scope shall be given specific attention to ensure that electrical network, components (in particular electronic & software based ones), individual elements and the respective running tools, test equipment, software and human skills can be maintained or replaced such that the original function and integrity of the whole production system can continue in an uninterrupted manner for the field life.

Therefore the electrical network design shall incorporate provisions to mitigate the obsolescence of electrical equipment during the foreseen lifetime of the installation. These requirements shall be developed from the basic engineering stage.

The design shall include provision to allow the upgrade of the contemplated electrical equipment with minimal disturbance to the production, the power generation and electrical distribution. Such provision shall include for instance space provision to ease equipment replacement minimising disturbance, redundancy in the power distribution allowing one branch to fed the entire system when the other one is being replaced, etc.

The obsolescence dossier shall develop equipment lifecycle management strategy focusing on product obsolescence, support options and further software migration, components or equipment replacement or upgrades.

Level of compliance to those requirements ought to be verified during the CFT stages and cost of obsolescence and resolution costs for obsolete electrical equipment or main sub components are recommended to be included in the Vendor bid evaluation and selection process.

The design provisions shall also take into account satellite facilities and potential known future extensions.

This dossier shall be prepared for the facility (Onshore & Offshore) as detailed in **GS EP ELE 460** § 4.48 in line with **IEC 62402** guidelines.

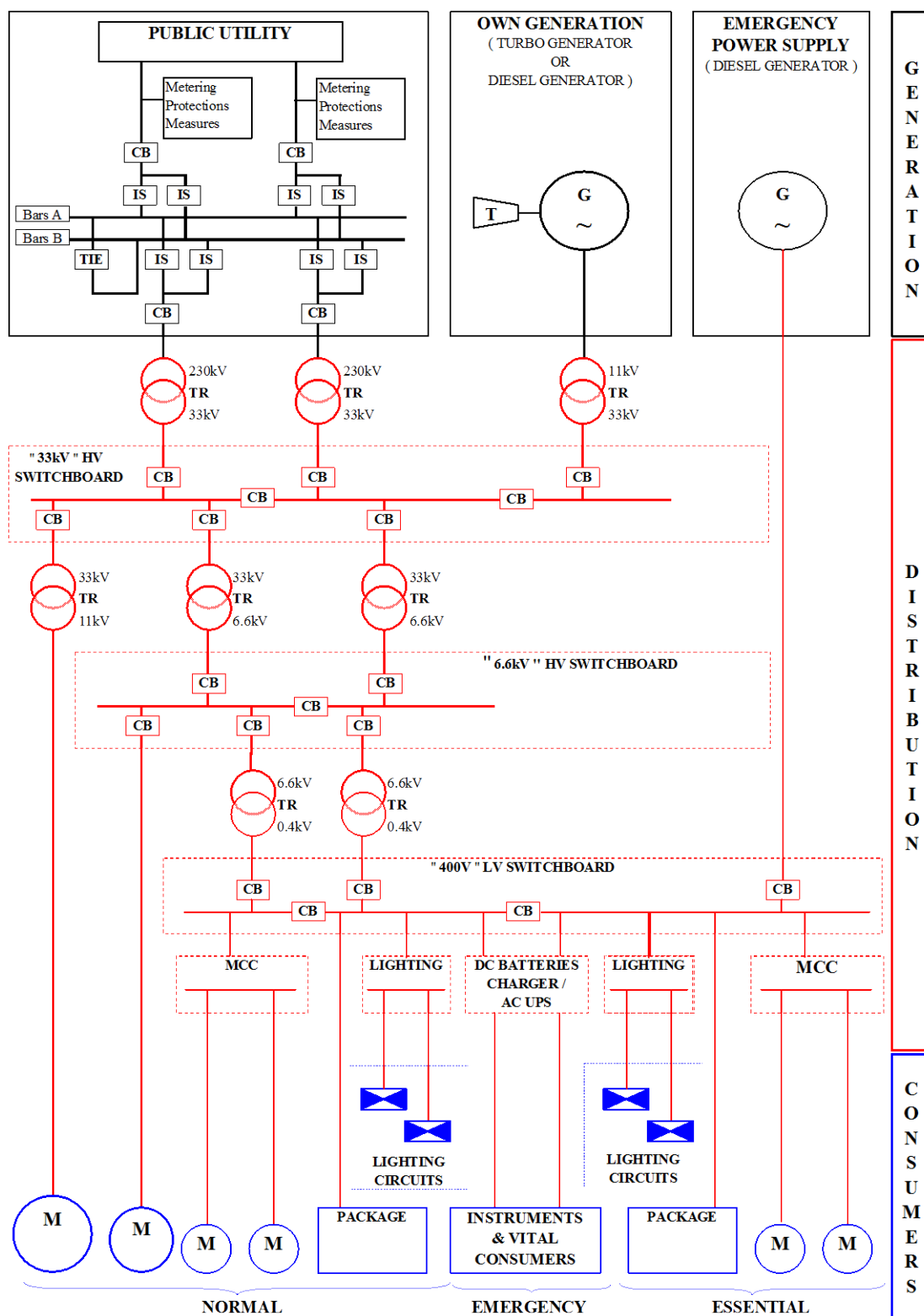
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12. Other references

Following documents are applicable:

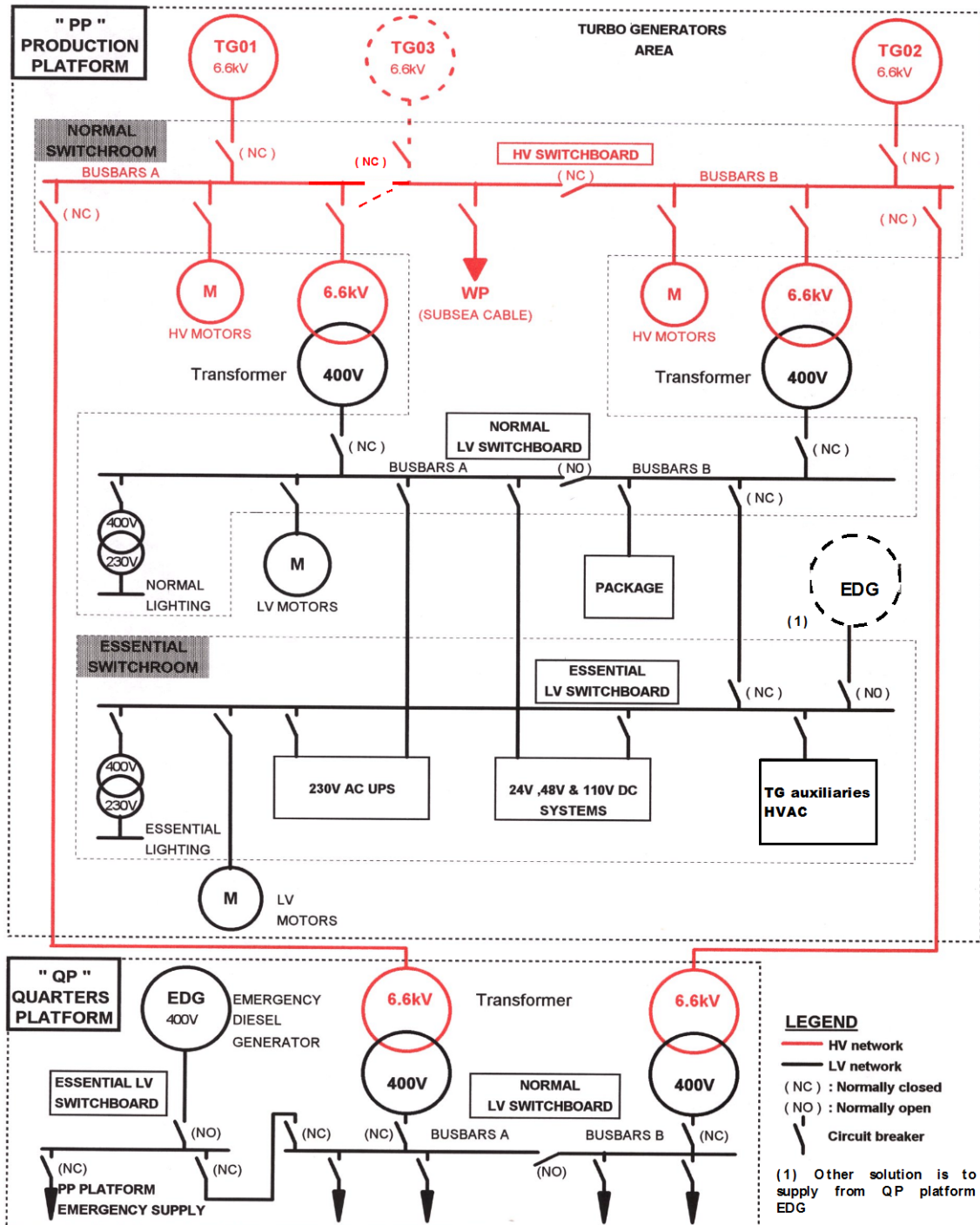
- External documents: [IEC 60059](#), [IEC 60071-1](#), [IEC 60196](#), [IEC 60364](#), [IEC 61892 \(Parts 1 to 5\)](#), [NF C13-200](#), [IEC 60038](#)
- Total General Specifications: [GS EP ELE 011](#), [GS EP ELE 061](#), [GS EP ELE 114](#), [GS EP ELE 121](#), [GS EP ELE 122](#), [GS EP ELE 135](#), [GS EP ELE 137](#), [GS EP ELE 261](#), [GS EP ELE 311](#), [GS EP ELE 321](#), [GS EP ELE 331](#), [GS EP ELE 451](#), [GS EP MEC 101](#).

Appendix 1 Typical onshore key one line diagram

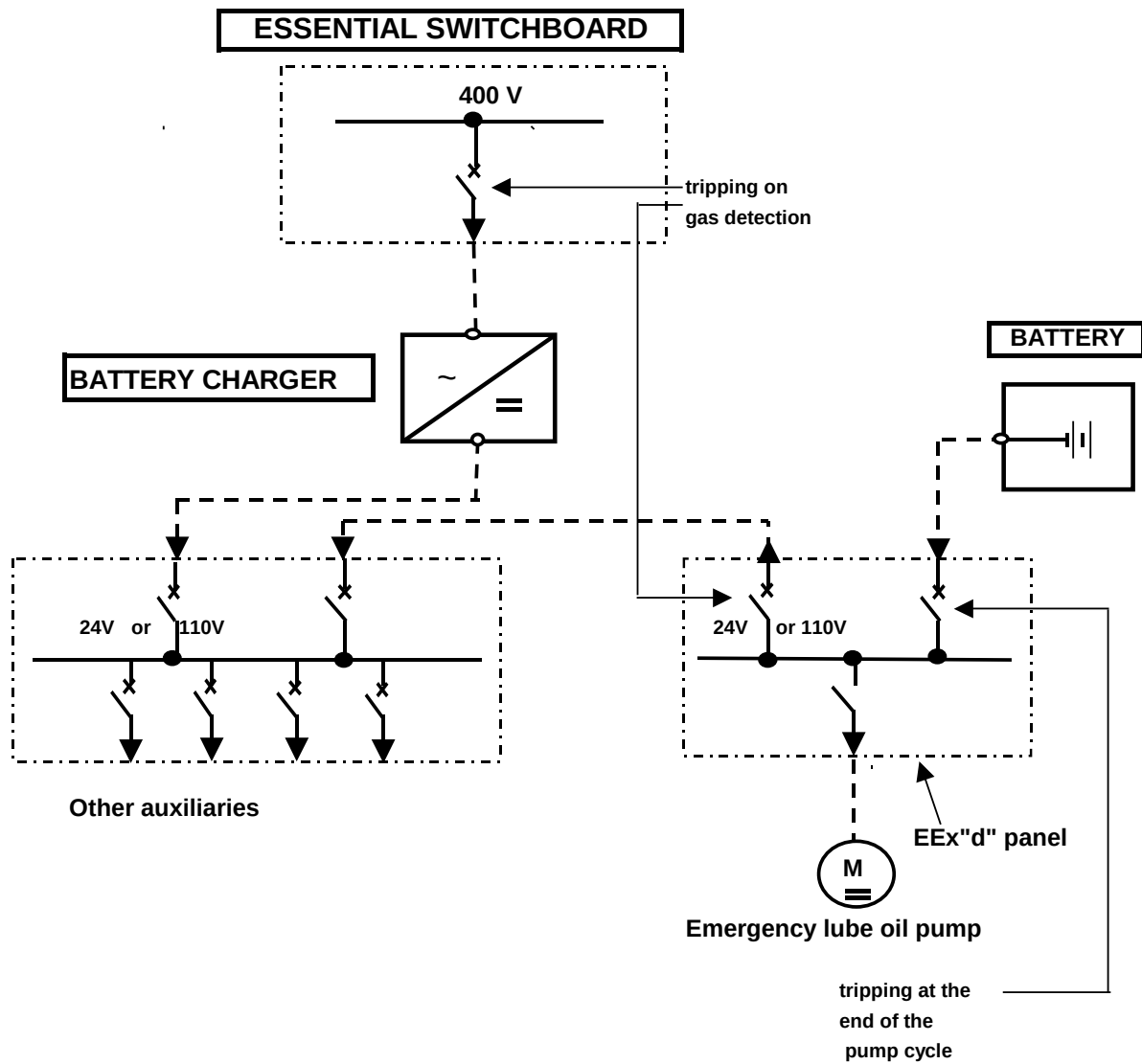


Appendix 2 Typical offshore key one line diagram

TYPICAL OFFSHORE KEY ONE LINE DIAGRAM



Appendix 3 Gas turbine generator - DC Distribution



Electrical design criteria

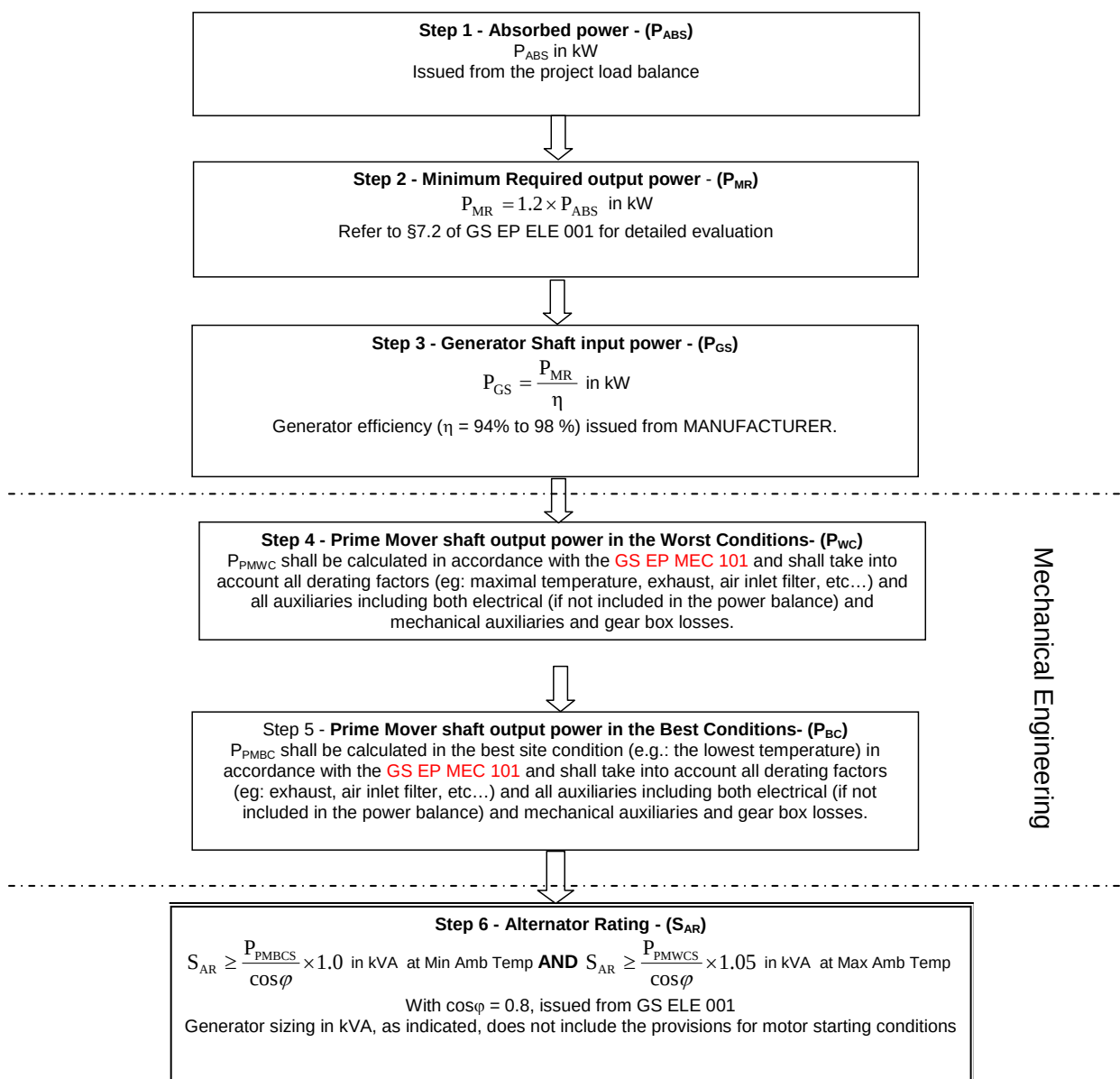
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Appendix 4

Appendix 4 Alternator sizing

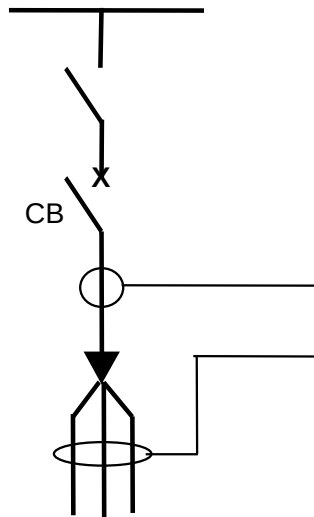


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Appendix 5

Appendix 5 Feeder output

(Radial feeder or open ring)



Protection	ANSI code	Action
Instantaneous overcurrent $I \gg (2)$	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 :

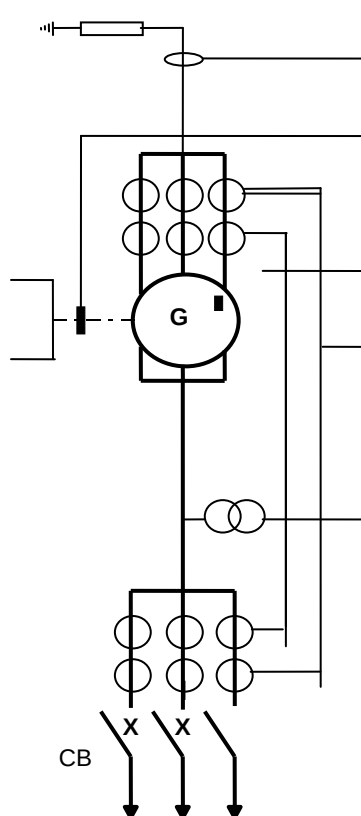
- cable shield strength
- limit fault current

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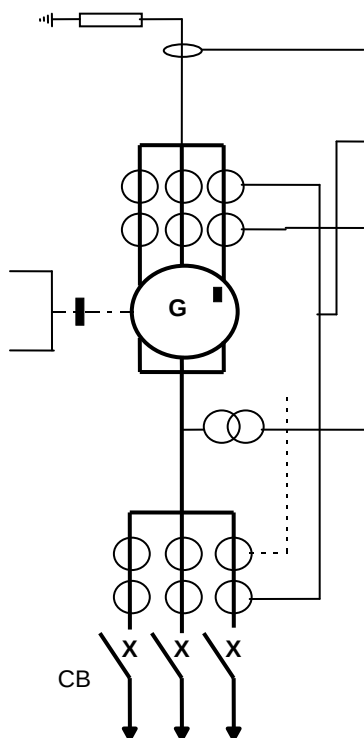
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Appendix 6
Appendix 6 Turbine Generator


Protection	ANSI code	Action
Earth over current	51N	Open breaker and stop generator
Bearing over temperature	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
Time delayed overcurrent or 3 phases overcurrent restraint voltage	51 or 51 V	Trip CB 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)	59N/64S	Stop machine
Rotor earth fault (2)	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 (3)	Trip CB

- (1) For generator connected to a network protected by earthing transformer (homopolar generator)
- (2) For generator above 5000 kVA
- (3) For generators running in parallel and connected to the earth via earthing resistors.

Appendix 7 Diesel Generator



Protection	ANSI code	Action
Earth overcurrent	51N	Open breaker and stop engine
Stator differential overcurrent (1)	87 G	Stop engine
Time delayed overcurrent or 3 phases overcurrent restraint voltage	51 or 51 V	Trip CB and stop engine 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)
Neutral voltage displacement (2)	59N/64S	Stop machine
Stator reverse power	32	Trip CB
Directional over current protection	67 / 67N (3)	Stop Machine

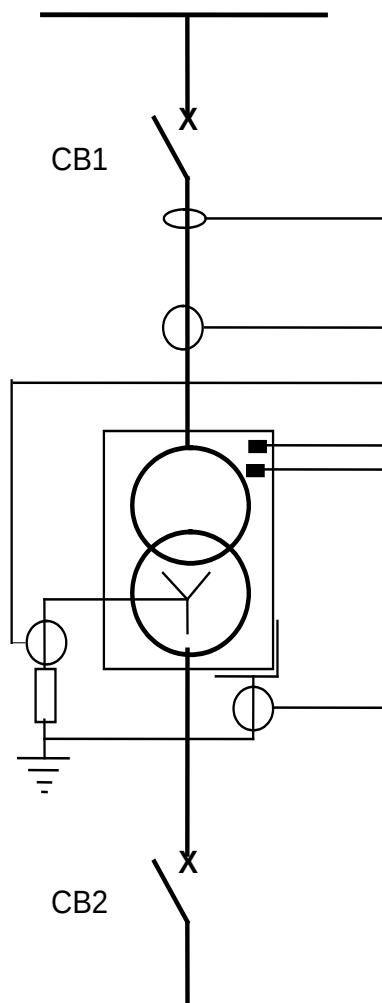
- (1) For generator above 1250 kVA
- (2) For generator connected to a network protected by earthing transformer (homopolar generator)
- (3) For generators running in parallel and connected to the earth via earthing resistors

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Appendix 8
Appendix 8 Transformer


Protection	ANSI code	Action
Instantaneous overcurrent $I \gg$ (1)	50	open CB1
Time overcurrent $I >$	51	open CB1
Primary Earth leakage current	51N	open CB1
Secondary leakage current	51N	open CB1
1st threshold temperature θ_1 (5) 2nd threshold temperature θ_2 (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)	50 G	open CB1
Transformer differential (4)	87 T	Open CB1

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

(2) Only for oil immersed breathing type transformer

(3) $P \geq 10 \text{ MVA}$

(4) For Generator transformer units and transformer with $P > 20 \text{ MVA}$.

In this case all opening action are on CB2, as CB1 doesn't exist.

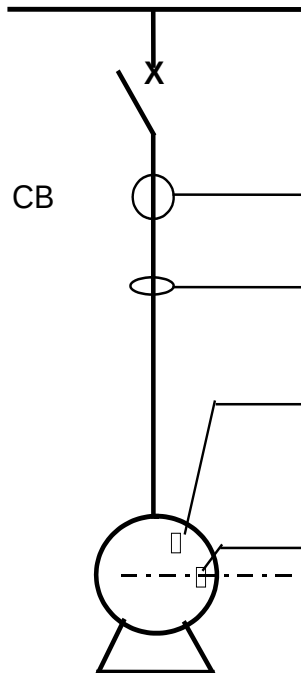
(5) These functions shall be integrated in one multifunction relay.

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Appendix 9
Appendix 9 Motor


Protection	ANSI code	Action
Locked rotor	48	open CB
Excessive starting time	51 LR	open CB
Phase unbalanced	46	open CB
Inst. overcurrent/Time overcurrent I >>	50/51	open CB
Thermal overload	49	open CB
Earth leakage Io	50N/51N	open CB
underpower P < (2)	37	open CB
Limitation of consecutive number of starts	66	Prevent startup
Winding probe (3)	38/49T	
θ1		alarm
θ2		open CB
Bearing probe (3)		open CB
Vibration (1)		open CB

(1) If $P \geq 1000$ kW

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

(3) If $P \geq 200$ kW

Note: For motor rated 5 MW & above, a motor differential protection (87M) shall be implemented.