

GENERAL SPECIFICATION

ELECTRICAL

GS EP ELE 021

Electrical design criteria for floating units
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1. Scope

This specification defines the design criteria used for the engineering, supply, manufacture, and installation of the electrical systems to be installed within the hull and accommodation 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).

The design criteria for Topsides process and utilities systems to be installed on steel decks/structures above the hull tank deck are covered by Company General Specification **GS EP ELE 001**.

For the purpose of the present specification, the abbreviation **“F.U” (Floating Unit)** shall be used.

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, Classification Society standards, codes and rules.

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
- Rules edited by the Classification Society¹
- Company Particular Specifications and data sheet (if any)
- Company General Specifications
- Applicable International Electrotechnical Commission (IEC) standards
- Applicable European Standards by CENELEC
- Applicable recognized standards and codes (UTE-NFC, BS, VDE, etc.) when IEC publications have not yet been issued.

In case of conflict between Classification Society rules and Company General Specifications the most stringent requirements shall apply.

Where no recognised standard exists the Contractor is to define and agree with the Company the requirements to be followed:

¹ Rules applying to Electrical systems subject to classification by one of the classification societies listed in Company General Specification **GS EP STR 651**.

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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
CAP 437	Offshore helicopter landing areas - Guidance of standards
EN 50272-2	Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries
IALA	Recommendations for the marking of offshore structures
ICAO	International Convention On Civil Aviation
IEC 60038	IEC Standard Voltages
IEC 60050 (All parts)	International Electrotechnical Vocabulary - All parts
IEC 60083	Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC
IEC 60092 (All parts)	Electrical installations in ships - All parts
IEC 60228	Conductors of insulated cables
IEC 60309 (All parts)	Plugs, socket-outlets and couplers for industrial purposes - All parts
IEC 60331-21	Tests for electric cables under fire conditions - Circuit integrity - Part 21: Procedures and requirements-Cables of rated voltage up to and including 0.6/1.0 kV
IEC 60502 (Parts 1; 2)	Power cables with extruded insulation and their accessories for rated voltages from 1 kV up to 30 kV - Parts 1; 2
IEC 60529	Classification of degrees of protection provided by enclosures
IEC 60533	Electromagnetic Compatibility of Electrical and Electronic Installations in Ships and of Mobile and Fixed Offshore Units
IEC 60617 (All parts)	Graphical symbols for diagrams - All parts
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 60909 (All parts)	Short-Circuit Current Calculation in 3 phase AC Systems - All parts
IEC 61000 (All parts)	Electromagnetic compatibility (EMC) - All parts

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Reference	Title
IEC 61558-2-6	Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1100 V - Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers
IEC 61892 (Parts 2; 4; 6; 7)	Mobile and fixed offshore units - Electrical installations - Parts 2; 4; 6; 7
IEC 62259	Secondary cells and batteries containing alkaline or other non-acid electrolytes-Nickel cadmium prismatic secondary single cells with partial gas recombination
IEC 62402	Obsolescence management - Application guide
IEEE 519	Recommended practices and requirements for harmonic control in electrical power systems
NR445	Bureau Veritas: Rules for the classification of offshore units
SOLAS	International Convention for the Safety of Life at Sea

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 ELE 001	Electrical design criteria
GS EP ELE 011	Electrical requirements for packaged units
GS EP ELE 013	Electrical requirements for generating units
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
GS EP ELE 114	HV Synchronous Motors
GS EP ELE 121	HV Variable Speed Drive Systems
GS EP ELE 131	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

Reference	Title
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 221	Electrical Control System (ECS)
GS EP ELE 311	Cables trays/ladders
GS EP ELE 321	Navigational Aids System
GS EP ELE 364	Electrical installations
GS EP ELE 451	Third party inspection. Independent verification of electrical facilities
GS EP ELE 460	Engineering Studies
GS EP EXP 105	Precommissioning execution
GS EP EXP 107	Commissioning execution
GS EP INS 107	Design and installation of instrumentation links
GS EP SAF 216	Area classification
GS EP STR 651	General principles for a F(P)SO design
GS EP TEC 007	Obsolescence and Lifetime Cycle Management

3. Vocabulary, units and symbols

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

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).

4. Design parameters

4.1 Design lifetime and environmental conditions

Electrical equipment design lifetime shall be minimum 20 years.

Environmental conditions shall be specified, according to the actual site environmental conditions, subject to Society approval.

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.

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4.2 Ambient air temperatures and Humidity

Unless otherwise specified in project particular specification, electrical equipment design temperature for continuous operation shall be:

- 45°C in enclosed spaces
- 40°C in environmentally controlled spaces, provided requirements of BV rule [NR445](#) part C + CH2 Sect. 12 - § 1.4 are fulfilled, except equipment used for Emergency services which shall be designed for 45°C.

Unless otherwise specified in project particular specification following values of relative humidity in non air conditioned areas shall be considered:

- 95% up to 45°C
- 70% above 45°C.

In air conditioned rooms, electrical equipment shall be designed for continuous operation under relative humidity of 60%.

4.3 Sea water temperature

Sea water temperature range shall be specified, according to the actual site environmental conditions, subject to Classification Society approval.

4.4 Corrosive atmosphere

In case of corrosive atmosphere (e.g.: 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.

4.5 Degrees of protection provided by enclosures

Degree of protection of enclosures as defined in [IEC 60529](#) shall comply with the requirements of the Classification Society rules.

Yet, the minimum degree of protection of enclosures shall comply with the relevant equipment specification and/or data sheet and shall be at least:

- | | |
|---|--|
| • Internal equipment: | IP 21 |
| • External equipment (general): | IP 55 |
| • External equipment (on exposed deck): | IP 56 (IP 66 for lighting apparatus, junction boxes) |

4.6 Operating design conditions

Electrical equipment design shall take into account the maximum operating conditions defined for transit to the Operating Site, as well as for conditions after Installation at the Operating Site.

Maximum operating conditions data are those required on table 1 and table 2 of [GS EP STR 651](#) - Appendix 2.

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5. Hazardous area

ATEX European directive 94/9/EC shall apply to equipment installed in hazardous areas.

For category 3 equipment, certification by Manufacturer only is not accepted. A "type examination certificate" shall be delivered by a Notified Body.

For facilities located outside the European Union (EU countries), alternative IECEx scheme may be applied (IEC Scheme for Certification relating to Equipment for use in Explosive Atmospheres).

Selection of electrical apparatus for hazardous areas shall be done according to the recommendations of the Classification Society rules, IEC 61892-7 and GS EP ELE 079. In case of discrepancy, the most stringent shall apply.

6. System basis of design

6.1 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
- 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.

For the purpose of this specification, the loads are classified into normal, essential or emergency according to the following definitions:

- Normal loads:

Loads which in case of failure of the main power generation have no effect either on the safety or on the safeguard of installation or equipment. They are mainly equipment for process treatment and offloading.

- Essential loads are:
 - Essential Marine/LQ loads
 - Equipment for maintaining normal comfort and habitability conditions for people on board
 - Equipment for maintaining marine operations
 - Essential Flow assurance loads
 - Essential start-up loads (starting of main power generation).

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- Emergency loads:
 - Loads affecting personal safety whether directly or indirectly and inducing risk of major damages on installation or equipment.

For the purpose of this specification typical lists of essential and emergency services are given in § 10 below.

6.2 Frequencies and voltages

Association of voltages and frequencies used must keep to the values recommended by the IEC standards.

For new F.U the standard [IEC 60038](#) shall apply.

For existing F.U (refurbished units) the standard [IEC 60092](#) remains acceptable.

6.3 Standard frequency

50 Hz, unless otherwise specified in the Project Particular Specification.

6.4 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-circuits levels.

Unless otherwise specified, the following voltage levels shall be used:

- **A.C High voltage** (50 Hz)

Power generation:	11 - 6.6 kV	Main & Essential generators output voltage
Power distribution:	22 - 11 - 6.6 kV	HV/HV - HV/LV transformers, HV motors, Interconnection with other fields and satellites

- **A.C Low voltage** (50 Hz)

Power generation:	400 - 690 V	Essential & Emergency generators output voltage
Power distribution:	400 - 690 V	Motor loads, and main power distribution
	230 V	Lighting, heat tracing, small power boards
	400 V - 230 V	UPS, Control and instrumentation - Telecommunications - Navigational aids

- **D.C Low voltage**

110 V - 120 V	DC lube oil pumps (e.g. turbine packages), Electrical control
48 V	Electrical control, etc.
24 V	Electrical control, Instrumentation, Telecom systems (SOLAS)

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6.5 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:

6.5.1 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

6.5.2 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: $\pm 25\%$
- Voltages variations for DC components supplied by battery shall be as per BV rule [NR445](#) part C - CH2 - Sect. 2.

6.6 Distribution System Voltage Drops

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

6.6.1 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 FLC): 3%
- During motor starting
 - The voltage at the motor terminals shall ensure a sufficient accelerating torque
 - The voltage drop at bus bar shall not cause shutdown of other consumers.

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Note: For cable sizing, the usual practice in the industry is to limit the voltage drop for Direct on line (D.O.L) starter to 15% in such conditions.

- Lighting & small power (at distribution board): 2%
- Lighting sub-circuits:
 - Average 2%
 - Maximum at farthest lighting fixture 4%
- Other (heaters, packages...): 5% unless particular requirement.

6.6.2 DC systems

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

6.7 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.

- 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 F.U.

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

6.8 Electromagnetic Compatibility (EMC)

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

7. Neutral Earthing Systems

Principles defined hereafter shall apply to both Topsides and Hull & Accommodation electrical networks.

7.1 High voltage systems

7.1.1 General

High voltage system shall be 3 phase - 3 wire, earthed by a low impedance, to limit the fault current to at least twice the capacitive current of the network. A basic value of 30A shall be usually considered, unless otherwise specified.

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When the F.U distribution network with HV generators on both topsides and Hull, one earthing transformer at least shall be provided on each side.

7.1.2 Generators operating in parallel

In the case of a network configuration with two or more generators running synchronized, provision shall be taken to keep only one earthing transformer in operation. Automatic transfer sequences shall be implemented into the Electrical Control System in case of failure of the earthing transformer.

7.1.3 Networks 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 may be provided.

7.2 Low voltage systems

System earthing shall be as follows:

- The 400 V - 690 V, three phases - three wires, system shall be isolated, (IT system)
- In case of supply by HV/LV transformer, a surge arrester shall be installed between the neutral and the earth.
 - A permanent earth fault monitoring device shall be installed on each primary L.V. switchboard bus bar.
 - Only one device shall be in operation when the tie-breaker is closed.
 - The permanent insulation monitoring device characteristics shall be such that the maximum earth fault current remains below 30 mA.
 - The permanent insulation monitoring device shall have functionality allowing fault localization.
 - When required fixed fault localization device shall be provided on each outgoing feeder of the primary switchboards/MCCs.
- The lighting and small power distribution system 400 V/230 V, 3-phase, 5-Wires shall have neutral earthed and distributed (TNS system).
- The heat tracing system 400 V/230 V, 3-phase, 5-Wires shall have neutral earthed and distributed (TNS system).
- The AC UPS distribution system derived via inverters shall be insulated from earth (IT system).
- DC systems shall be isolated from earth (IT system).
- Each unearthed system (AC UPS distribution networks, DC distribution networks) shall be provided with an earth fault monitoring device. Each earth fault monitoring device shall provide a local alarm signal with a remote alarm to the **F.U** Electrical Control System (ECS).

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- Section boards dedicated to sub distribution boards (see § 13.7) shall be equipped with permanent automatic earth fault detection and each feeder fitted with a fixed fault location device.

7.3 Hull return systems

The hull return system of distribution shall not be used ([SOLAS Reg. II-V 45.3.1](#)).

8. Power generation

The power generation shall be split into three categories:

8.1 Main power Generation

Unless otherwise specified, the main generating units shall be installed on the Topsides and shall be within Topsides EPC Contractor scope of supply.

Under normal operating conditions the generating units supply both Topsides and Hull & Accommodation consumers.

The number of main generating units shall be such that if one set becomes unavailable (because of a fault or for maintenance purpose), the power supply to the F.U is ensured by the remaining generators (i.e. 'n+1' configuration is provided, with "n" generating units running under normal operating 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 duly substantiated by a report requiring Company formal approval.

8.2 Essential power Generation

For start up, or on failure or shutdown of the main power generation system, power is provided to loads designated as essential by a minimum of two Essential Services diesel driven generators. Essential power generation configuration (n or n+1) shall be addressed by a Reliability, Availability, Maintainability study (R.A.M).

These generating units shall be located within the hull and shall supply:

- Hull & Accommodation essential loads
- Topsides essential loads
- Emergency loads.

8.3 Emergency power Generation

Emergency sources

- Emergency Diesel Generator

Upon failure of either the essential services supply or the main supply, an Emergency Diesel Generator shall supply the designated emergency loads via an Emergency Switchboard.

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- Transitional sources of power

Where required, the emergency loads shall be supplied by batteries upon voltage failure on emergency switchboard, or before emergency generator starting.

Battery autonomy shall be 30 minutes as a minimum.

9. Typical electrical network architecture

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

Electrical network on the **F.U** is to be considered as a whole and same design principles shall apply to both Topsides and Hull (e.g. neutral earthing systems). A typical one line diagram is shown in Appendix 6.

9.1 Main and essential power distribution switchboard

A Main / Essential power distribution switchboard for Hull & Accommodation shall be installed in a dedicated switch room located within the Hull. This switchboard shall have two bus sections as a minimum and shall include:

- Incoming feeders from the main power generation, used for power supply in normal operating condition
- Incoming feeders from the Essential Services generators
- Outgoing feeder(s) to earthing transformer(s)
- Outgoing feeders to the Hull & accommodation loads (Normal, Essential, and Emergency switchboards either directly connected or through HV/LV power transformers as appropriate)
- Outgoing feeders to the Topsides Essential loads:
 - HV essential loads located on topsides may be fed either directly or through an essential switchboard installed in topsides switchroom
 - LV essential loads located on topsides shall be fed from LV essential switchboard installed in topsides switchroom.

9.2 Emergency power distribution

The emergency switchboard shall have at least three bus sections fed from the Emergency generator and from the Hull Main/Essential switchboard, with the central bus section dedicated to the Emergency generator incomer.

It shall be located in an emergency switch room, in the same fire zone as the emergency generator.

The Emergency switchboard shall be directly linked to a Topsides emergency switchboard to supply the Topsides emergency loads:

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9.3 Uninterruptible Power Systems (UPS): AC and DC UPS's

AC and DC Uninterruptible Power Systems (UPS's) shall be installed to provide a no-break power supply to operation and safety related equipment in the event of main power failure or total shutdown

UPS's installed within Hull and accommodation shall not be backed up by Topsides UPS's.

9.3.1 AC UPS's

AC UPS's shall be provided for:

- Emergency Shutdown System (ESD), Fire & Gas systems (F&G), Hull Control System (HCS), etc.
- Data network
- Electrical Control System (ECS).
- Telecom systems
- Helideck lighting and beaconing.

For systems which require a dedicated source, separate UPS or converter may be provided by the system Manufacturer (e.g.: Navais).

Hull AC UPS's shall be powered from the emergency switchboard.

Topsides AC UPS's shall be powered from the topsides essential switchboard.

Redundant equipment shall be fed from different bus sections.

9.3.2 DC UPS's

DC UPS's shall be provided for:

- Instrumentation and Electrical Control
- Telecom systems
- Global Maritime Distress and Safety System (GMDSS).

For systems which require a dedicated source, separate DC UPS shall be provided (e.g.: GMDSS, Back-up lube-oil pumps of rotating machines, Navais).

Hull DC UPS's shall be powered from the emergency switchboard.

Topsides DC UPS's shall be powered from the topsides essential switchboard.

Redundant equipment shall be fed from different bus sections.

A DC UPS, installed in the emergency switchroom shall be dedicated to Emergency generator and switchboard.

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10. General network operation

General principles of the electrical network operation are the following:

10.1 Main power generation

Under normal operating condition, power supply shall be provided to the whole network by the main generating units, synchronised on the Topsides main HV switchboard and running in equal active and reactive load sharing.

Speed regulation shall be able to run in isochronous, droop and base load mode as defined in **GS EP ELE 013**.

Status of tie breakers between bus sections of the main Topsides HV switchboard shall be "Normally Closed" ("N.C").

Status of tie breakers between bus sections of the downstream HV and LV switchboards shall be "Normally Open" ("N.O").

10.2 Load shedding

A load shedding system is required. Loads to be shed shall be selected in accordance with the process operational requirements.

Load shedding shall be implemented in the Electrical Control System which shall guarantee a response time as per **GS EP ELE 221**.

10.3 Essential power generation

10.3.1 General

During essential operating conditions, status of tie breakers between bus sections of the main / essential HV switchboard shall be "Normally Closed" ("N.C").

Note: In case Essential generators are required for power supply during towing and commissioning, a specific study shall be carried out to define if provisions are to be taken for appropriate network configuration/operation in such conditions.

10.3.2 Essential loads

The essential loads shall include typically, but not be limited to, the following services:

- Hull and accommodation Essential services:
 - Essential sea water lift and circulating pumps (if any) for Essential generators cooling and HVAC
 - Fuel oil transfer pumps and fuel oil treatment equipment
 - Lubrication oil transfer pumps and lubrication oil treatment equipment
 - Bilge, ballast and heeling pump
 - Ventilation fans for essential diesel engine rooms
 - Electrical equipment for watertight closing appliances

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- Heating, Ventilation and Air Conditioning (HVAC)
- Services necessary to maintain cargo in a safe condition (e.g. inert gas plant)
- Cranes
- Lighting
- Services for maintaining habitability conditions
 - . Cooking
 - . HVAC
 - . Domestic refrigeration
 - . Sanitary and fresh water.
- Topsides Essential services
 - Main generating units' auxiliary equipment (fuel oil supply pumps, lubricating oil pumps and cooling water pumps...)
 - Process control and monitoring services
 - Process emergency shutdown system
 - Loads required for asset preservation
 - Utility systems such as air compressors, cooling water lift and circulating pumps (if required)
 - HVAC, cranes...
- Lighting (see § 13.8).

10.3.3 Essential power supply operation

Upon detection of loss of voltage at the Hull Main Switchboard, the Essential generators will be automatically started (unless start inhibition from Fire & Gas System (FGS), to supply their respective bus section.

Automatic starting operation shall fulfil the requirements of **GS EP ELE 013** § 3.4.1

Auxiliaries required for Essential generators shall be supplied from Essential switchboard.

The Essential generators shall be fitted with suitable facilities for synchronisation and parallel operation with each other, with the main generators and with the emergency generator.

Speed regulation shall allow generators to run in isochronous, droop and base load mode (refer to **GS EP ELE 013**).

In case of shutdown of one of the Essential generating units, a load shedding scheme shall be performed according to a load shedding program implemented in the Electrical Control System (refer to § 10 below).

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10.4 Emergency power generation

10.4.1 Emergency loads

Emergency services shall include typically, but not be limited to, the following loads:

- Emergency lighting
- Internal communication systems required in emergency conditions
- Nautical and aeronautical navigation lights, aids and sound signals
- Fire and gas detection and alarm systems
- Fire fighting equipment and associated auxiliaries
- Ballast system and assorted control system
- General alarm and public address system
- Emergency shutdown system
- Ventilation of hazardous areas and those areas maintained at an overpressure to exclude the ingress of dangerous gases (battery rooms, paint room, Forward...)
- Temporary refuge ventilation
- Emergency generator auxiliaries (heater, lube oil pump, Fans etc.)
- Starting air compressor
- Living quarter elevator
- Life boat control panel
- Helistarter
- ... Other systems as might be required by the Classification Society.

10.4.2 Emergency power supply operation

The Emergency generator shall be fitted with suitable facilities for synchronisation and parallel operation with the Main generators and with the Essential generators.

As per **GS EP ELE 013** Speed regulation shall enable generator to run in isochronous, droop and base load mode (for periodic full load testing).

Under normal operating conditions, the emergency generator shall be in stand-by mode (ready to start upon loss of voltage at emergency bus bar).

The emergency generator shall be able to start from blackout conditions and to supply all emergency loads within 45 seconds and for a minimum period of 18 hours (as per **SOLAS** requirements).

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In case of simultaneous loss of voltage on emergency and normal/essential switchboards:

- The Emergency generator is automatically started to supply the emergency switchboard, until essential power supply is available and stabilised
- Then, Essential and Emergency generators are synchronized, and no-break load transfer is carried out before Emergency generator shutdown sequence.

In case the emergency generator fails to start or is unavailable, the Emergency switchboard shall be automatically supplied from the Essential switchboard.

In Emergency operating condition the emergency diesel generator will run in “island” mode.

If required by Project, the emergency generator may be used, subject to Classification Society approval, for temporary service during towing or commissioning activities.

10.5 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.
- Intertripping sequences and interlocking shall not be achieved via the Electrical Control System (ECS) but hardwired only.

Inter-tripping study between Topsides and Hull equipment shall be within the scope of the main power generation Supplier.

- Interlocking shall be provided where applicable to prevent incorrect operation. This shall be achieved, depending on the particular equipment involved, either electrically or by a system of locks and key switches.

10.6 Electrical shutdown requirements

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

Exception shall be made for equipment and relevant power supplies which have to remain in operation and must be suitable for zone 1 hazardous area. (E.g.: DC post lube pumps controllers, navigational aids...).

10.7 Black start requirements

Black start facilities shall be provided to allow re-starting after a total shutdown (i.e. shutdown of all AC and DC sources) due to a gas release.

Emergency generator is to be used at first but, in case of fault or unavailability, Essential generators packages shall also be designed to allow black-start operation.

For essential generating units requiring external water cooling loop, the UCP shall also control the relevant water lift and circulation pump and control valves to allow for black-start operation.

UPS's shall be so designed as to have sufficient remaining battery Ah to allow power supply of diesel generators auxiliaries and switchboards control.

The black start shall always be manually executed.



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A simplified black start sequence with emergency generator for main power generation recovery may be described as follows, but complete black start procedures shall be issued during studies by Engineering Contractor.

Some consumers used for emergency and essential services (the list shall be defined by the BV or other classification Company), shall be able to start independently of any computer based system. These consumers shall be equipped with an hardwire local start/stop push button.

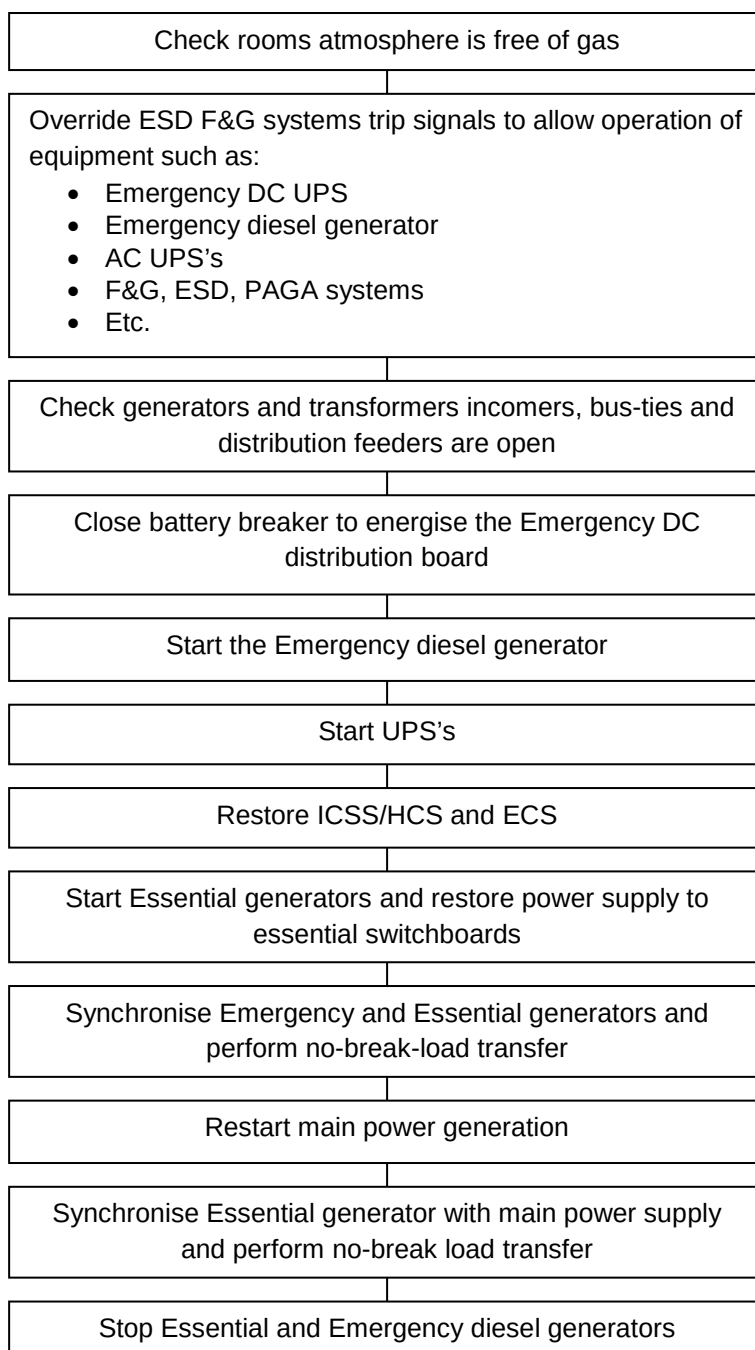
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10.8 Typical Black start sequence



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11. Electrical Control System (ECS)

11.1 General

An Electrical Control System shall be provided and shall be in accordance with the Company general specification, **GS EP ELE 221**.

The ECS shall comprise a microprocessor based system providing control, supervision and monitoring of the power generation and distribution network. It shall interface with the unit control panels of each turbine and diesel generator, the HV and LV switchboards, and the AC and DC UPS by serial link connection. Communication protocol shall be determined in detailed design in conjunction with the respective equipment Manufacturers.

The ECS shall provide a display of the complete **F.U** distribution network in single line representation and shall indicate the status and alarms of all main elements.

The Electrical Control System shall have two separate parts:

- One for the Topsides
- One for the Hull & Accommodation.

Topsides and Hull systems shall be of the same type and from the same Manufacturer and Supplier. Topsides CPU shall be redundant with the hull CPU.

Dedicated communication link shall be provided between the separate parts of the ECS.

The following functions and features shall be included as part of each ECS in accordance with the above described arrangements:

- Control of the power distribution system is required, i.e. open and close control facility of the main circuit breakers of the HV and LV networks
- VDU (Video Display Unit) based system to provide an animated display of the power generation and distribution system, data acquired and to provide operator/machine interface
- Load shedding
- Start inhibit of loads according to generators spinning reserve
- Automatic transfer sequences (see note 1)
- Automatic switchover of earthing transformers
- Event recording and parameter trending
- Disturbance recording
- Display of alarms
- Interface with ICSS.

Note 1: Automatic transfer upon loss of supply on one branch must be compatible with safe process operation, and feasibility confirmed by dynamic stability study.

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11.2 Load shedding

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

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

11.3 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.

Events to be discriminated shall be listed in the ECS particular specification.

ECS shall have capability for event history recording over a continuous period of 6 months.

12. Electrical Equipment rooms

Electrical distribution equipment shall be installed within dedicated electrical rooms with the associated power transformers located in separate location, as close as possible to the room.

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

Room pressurisation shall be provided in case of location in hazardous area.

Unless otherwise required by standard shipbuilding practice, all electrical equipment rooms (excluding generator rooms and battery rooms) shall be provided with 1000 mm free height dedicated for electrical within raised floor. Equipment shall be bolted on metal frames directly fixed to the ground.

Suspended ceilings are not required in electrical rooms.

Dimensions of rooms shall enable easy and safe operation and maintenance. Following minimum clearances for equipment shall be considered, unless otherwise specified by equipment Manufacturer:

- | | |
|--|-----------------|
| • 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 recommendation shall be adhered to.

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

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

Each Electrical room shall be equipped with 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 (HV rooms)
- Mobile earthing kit with clamps (HV rooms)
- "First aid" safety instructions and first aid posters
- Portable light.

13. Equipment general characteristics

13.1 General

As far as possible Manufacturers standard products shall be utilised.

Standardisation of equipment (Manufacturer, type, wiring diagram...), shall be provided across the complete F.U installation (Hull and Topsides).

13.2 Equipment rating and sizing

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

Unless otherwise specified in a particular project specification, all equipment (main and essential generators, transformers, switchboards, UPS, etc.) of the power distribution system shall have at least 20% spare capacity above the expected load.

In order to avoid over design of the power generation, the level of power margin may be reduced, with Company formal approval:

- The largest loads may not be considered for the calculation of the power margin on main power generation (typically loads ≥ 5 MW or sum of the successive loads in Gas compression trains)
- Likewise, largest loads required for preservation (Typically, Dead oil circulation pumps) may not be considered for the calculation of power margin on essential power generation.

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.

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

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 to be avoided, unless technically justified (e.g. for major revamping) and shall be subject to Company written approval.

13.3 Emergency generator

The emergency generator shall meet the requirement of the **GS EP ELE 113**.

The emergency generating unit and its unit control panel shall be housed in a dedicated A60 rated enclosure.

The emergency generator shall be equipped with two independent starting systems.

13.4 Essential generators

The essential generator shall meet the requirement of the **GS EP ELE 113**.

The essential generators shall be equipped with two independent starting systems.

Essential generators shall have black start capability in case of unavailability of the Emergency generator

13.5 HV switchboards

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

HV switchboards with at least two power supplies shall have two bus sections. Redundant equipment shall be judiciously split between the two bus sections.

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

The switchgear will preferably be of the withdrawable SF6 break type.

If Vacuum breaking technology is used, necessary study to check requirement for protection against switching overvoltages (Surge arrestors, RC filters...) shall be performed.

Each incomer and outgoing feeder cubicle shall be equipped with microprocessor based protection and measurement relays. These relays shall interface the ECS and or ICSS as required.

For typical lists of protection required for HV incomers / feeders refer to Appendix 1, Appendix 2, Appendix 3, Appendix 4 and Appendix 5.

Space for future extension of at least one cubicle shall be allowed at each end of the switchboard.

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13.6 LV switchboards

LV switchboards design shall meet the requirements of **GS EP ELE 135**, unless otherwise specified in a Project particular specification.

Main LV switchboards and Motor Control Centres (MCC's) shall have two incomers and one tiebreaker with the exception of MCC's dedicated to turbo generator/ turbo compressor/ auxiliaries.

Microprocessor based relays shall provide protection, control and monitoring for incoming breakers. These relays shall be interfaced as appropriate with the ECS.

Emergency stop pushbuttons of equipment shall be directly hardwired to starter feeders.

When a local control station for a motor is required, it shall be hardwired directly to the MCC.

13.7 Section boards and Distribution boards

Lighting and small power distribution, UPS's distribution shall use section boards and distribution boards.

"Section board" means a switchgear and controlgear assembly which is supplied by another assembly and arranged for the distribution of electrical energy to other section boards or distribution boards or final sub-circuits.

"Distribution board" means a switchgear and controlgear assembly arranged for the distribution of electrical energy to final sub-circuits.

Section boards and distribution boards design shall meet the requirements of **GS EP ELE 137**, unless otherwise specified in a Project particular specification.

Section boards and Distribution boards with two bus sections shall have their tie breaker "Normally open".

DC section boards with two bus sections may be their tie breaker "normally closed", if blocking diodes are installed on the DC UPS output.

All socket outlet circuits (except on UPS's network) shall be equipped with earth leakage current protection set at 30 mA.

Equipment located in hazardous areas shall be avoided as far as possible. However, where they are necessary, these boards shall be certified as Category 2.

13.8 Lighting & Small Power

13.8.1 General lighting

The Hull & Accommodation lighting and small power main distribution shall consist of two separate distribution networks:

- Normal lighting & small power distribution
- Emergency lighting & small power distribution.

The normal lighting shall be fed from essential power distribution network and shall be 100% available in both Normal and Essential operating conditions.

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General lighting illumination levels shall be based on recommendations of [IEC 61892-2](#) and [GS EP ELE 081](#).

The cable routings of Emergency lighting circuits shall be separated from the normal lighting.

Emergency lighting shall be provided to illuminate specific areas such as muster stations, escape routes, staircases, emergency exits and ladders, embarkation areas, fireman's cabinets, sick bays, electrical switch rooms and all control and radio rooms that must be manned during emergency and other places, as required by the Classification Society.

In addition to [SOLAS](#) requirements, 50% of the luminaires installed in places such as switch rooms, generator room, battery room..., shall be self contained battery back-up, suitably designed for use in zone 1, in order to ensure 90 minutes illumination of panels/switchboards and equipment used during re-starting operation.

In order to minimise the number of spare parts, luminaires of the same type shall be supplied from one Manufacturer only, with the number of types of luminaires kept to a minimum.

A lighting study shall be performed in accordance with Company specification [GS EP ELE 081](#).

The lighting transformers shall be installed indoor, in the same switch room as the main lighting panel they are supplying.

13.8.2 Escape lighting

Escape lighting shall be fed by the emergency power distribution network.

Escape lighting shall be provided to illuminate escape routes, staircases, exits and other locations manned during an emergency.

Escape lighting illumination levels shall be at least as per Table 6 of [IEC 61892-2](#).

Escape lighting luminaires shall have an integrated NiCd battery and inverter unit providing 90 minutes illumination following failure of the AC power supply. These luminaires shall be ATEX certified as category 2, or IECex with EPL Gb and connected to the emergency power distribution network.

13.8.3 Helicopter Landing Lights, wave-off lights and Aviation Obstruction Lighting

The helicopter landing lights, wave-off lights and aviation obstruction lights shall be supplied and installed in accordance with the requirements of the relevant international and local regulations (refer to [GS EP ELE 221](#)).

They shall be fed from the emergency power supply system or, when required, from an AC UPS system.

13.8.4 Socket Outlets

Socket outlets shall comply with [IEC 60092-306](#) and Classification Society requirements.

Outdoor Areas

Socket outlets rated 230V -16A, 2P+E and 400V - 63A, 3P+E shall be provided.

For each rating, 10% of the socket outlets shall be supplied with the plug.

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Unless otherwise specified, socket outlets shall be such located that all points on any one level may be reached:

- By a 15 metre extension cable for 230 V
- By a 25 metre extension cable for 400 V.

All socket outlets shall be constructed to [IEC 60309](#) standard and shall be suitably designed for use in zone 1.

Circuit breakers shall be fitted with shunt trip coil for remote isolation from the Fire and Gas system.

An appropriate number of safety isolating transformers shall be provided to allow connection of portable appliances used for works within restrictive conductive locations (e.g. use of lamp holders inside tanks). These transformers shall comply with requirements of [IEC 61558-2-6](#).

Indoor Areas

Socket outlets rated 230 V, 16 A, 2P+E, either conforming to [IEC 60309](#) (Industrial type) or [IEC 60083](#) (domestic type) standards shall be provided in technical rooms and domestic/living areas. Number and location shall be defined by Contractor, subject to Company approval.

Socket outlets for 230 V AC UPS distribution shall be identified by colour coding.

Socket outlets and lighting switches inside the domestic/living areas shall be of the flush mounting type.

When required, installation of 24 V AC sockets outlets, suitably located close to equipment shall be studied to allow Very Low Safety Voltage supply to portable apparatus (e.g. lamp holders).

13.8.5 Marine Navigation Identification Equipment

Visual and audible marine navigation identification equipment shall be provided by the shipyard in accordance with the requirements of the [IALA](#) (International Association of Lighthouse Authorities).

This navigation aids system shall meet the requirement of the [GS EP ELE 321](#).

A centralised battery and charger unit shall be provided as part of marine navigation aids system. A centralised system is required to avoid installing the battery in areas subject to seawater spray and wash. The battery shall be sized to support the required loads for a period of 96 hours.

13.8.6 Small power for shower cabins

Feeders supplying shower cabins shall be fitted with 30 mA Residual Current operated Circuit Breaker (RCBOs) with integral overcurrent protection.

13.9 Transformers

13.9.1 General

Power transformers design shall meet the requirements of [GS EP ELE 141](#) unless otherwise specified in a Project particular specification.

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Oil immersed HV/HV & HV/LV transformers may be used provided requirements of the standard [IEC 60092-303](#) are fulfilled.

All LV/LV transformers shall be dry type (lighting, heat tracing...).

Rating of HV/LV transformers shall be limited to 2500 kVA for LV = 400 V or 4000 kVA for LV = 690 V.

Any transformer shall be able to feed the total load of its downstream switchboard (including 20% provision for future).

13.9.2 Transformer installation

HV/HV & HV/LV Power transformers shall be installed outdoor, unless impractical.

Oil immersed power transformers shall be installed outdoor.

Unless otherwise specified indoor installed transformers shall be Dry type.

Transformers installation shall meet the requirements of [IEC 60092-401](#).

Outdoor transformers shall be protected against rain falls, direct sun rays and equipped with oil drip pan connected to the open drain circuit. Fencing and roof, if any, shall ensure natural ventilation.

Oil filled power transformers shall be separated by an A60 fire rated wall.

Minimum clearance for transformer connections shall be 1000 mm (cables not included), and 850 mm for the other sides. Adequate space and mechanical handling facility shall be provided for withdrawal of a complete unit to a suitable lay down area for lifting access by the **F.U** crane. Interlocking device shall be provided between the access to the transformer high voltage plug-in terminals and isolating devices.

13.10 Motors

Fix speed induction motors design shall meet the requirements of [GS EP ELE 111](#) unless otherwise specified in a Project particular specification.

Variable speed induction motors design shall meet the requirements of [GS EP ELE 121](#) unless otherwise specified in a Project particular specification.

Synchronous motors design shall meet the requirements of [GS EP ELE 114](#) unless otherwise specified in a Project particular specification.

As a general rule, motors up to 150 kW should be Low Voltage, and High Voltage above 400 kW.

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

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

13.11 AC UPS

AC UPS's design shall meet the requirements of [GS EP ELE 152](#), unless otherwise specified in a Project particular specification.

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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 systems.

Where redundancy is required, AC UPS shall comprise two 2 x 100% systems (schematic 2) and shall consist of:

- 2 x 100% rated rectifier/charger
- 2 x 100% rated battery
- 2 x 100% rated inverter
- 2 x mains bypass supply via a static switch
- 2 x maintenance bypass via interlocked circuit breakers or contactors
- 2 x Distribution board.

Where redundancy is not required, AC UPS shall comprise one 1 x 100% rated system (schematic 1) and shall consist of:

- 1 x 100% rated rectifier/charger
- 1 x 100% rated battery
- 1 x 100% rated inverter
- 1 x mains bypass supply via a static switch
- 1 x maintenance bypass via interlocked circuit breakers or contactors
- 1 x Distribution board.

13.12 DC UPS's

DC UPS's design shall meet the requirements of **GS EP ELE 151**, unless otherwise specified in a Project particular specification.

13.12.1 Type 1

Where redundancy is not required, DC UPS shall consist of:

- 1 x 100% rated rectifier/charger
- 1 x 100% rated battery
- 1 x Distribution board.

This type is suitable for applications such as package auxiliaries, and nav aids.

13.12.2 Type 2

Where redundancy is required, DC UPS's shall comprise two systems and shall consist of:

- 2 x 100% rated rectifier/charger in parallel operation through blocking diodes
- 2 x 50% rated battery (with battery chargers sized for charging the two batteries)
- 1 x Distribution board (2 bus sections).

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This type is suitable for applications such as E&I and Telecom auxiliary supplies.

13.12.3 Type 5: Secondary DC supplies

Where other DC power supplies are required, they shall be derived from the centralized UPS's.

This type comprises two rectifiers in parallel operation through blocking diodes, supplied from AC UPS sources

13.13 Batteries

13.13.1 Centralized battery type

Accepted types of battery are:

- Nickel-Cadmium - vented cell type (as per IEC 60623)
- Nickel-Cadmium - partial recombination cell type with a recombination level of 90% and above, (as per IEC 62259)
- Nickel-Cadmium - sealed cell type (as per IEC 60622).

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

Type of cells \ Installation	Dedicated battery room	Cabinet in technical room
Ni-Cd Vented type	R	F
Ni-Cd Recombination type (recombination rate $\geq 90\%$)	P If $P_{\text{charge}} \geq 4 \text{ kW}$	R If $P_{\text{charge}} < 4 \text{ kW}$
Ni-Cd sealed type	P If $P_{\text{charge}} \geq 4 \text{ kW}$	R If $P_{\text{charge}} < 4 \text{ kW}$

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

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

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13.13.2 Battery autonomy

The batteries shall be sized to support the loads according to operational and/or safety requirements.

When several loads (or groups of loads) which are fed by a same UPS require different back-up duration, a sequential load shedding is to be implemented.

13.13.3 Battery installation

Batteries installation shall comply with requirements of the Classification Society, [IEC 61892-6](#) standard and [GS EP SAF 216](#).

Batteries shall be preferably installed on stands suitable to withstand FU movements during towing into dedicated battery rooms

When required in Project particular specification, battery might be installed inside cubicles located in a standard technical room, provided dilution ventilation requirements are fulfilled.

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).

A battery circuit breaker with overcurrent protection shall be provided in an enclosure located adjacent to 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" IIA T3/ category 2.

"Reset" of this breaker shall be possible by an "externally accessible" operating handle.

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

13.13.4 Dilution ventilation

Minimum dilution ventilation shall be calculated as per [IEC 61892-7](#).

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](#).

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

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.

13.13.5 Safety kit

Safety kit shall be provided in each battery room (Glasses, gloves, eye-wash...).

13.14 Cables and cabling

13.14.1 Cable Construction

Electrical power and control cables shall be manufactured in accordance with [IEC 61892-4](#), [IEC 60092-300](#), [IEC 60092-351](#), [IEC 60092-359](#) and Company General Specification [GS EP ELE 161](#).

Utilization of the armour as earthing conductor is prohibited.

Armoured cables are required in the following conditions:

- Installation in Hazardous areas, as per § 7.10 of [IEC 61892-7](#)
- Installation on weather exposed deck in any hazardous area
- Installation in particular locations such as bilge, or exposed to permanent mechanical hazards
- fire resistant cables

Fire resistant cables are required for the following services:

- Safety systems (Fire & Gas protection)
- Emergency Shutdown System
- Process Safety Devices
- Foam injection system auxiliaries and controls
- Fire pump auxiliary circuits
- Deluge and extinguishing release circuits
- Public address and general alarm systems
- Essential telecommunications equipment
- Navigation aids field cabling
- Helideck lighting circuits
- Battery backed power supply feeders to all systems associated with the above.

Mineral insulated copper cables (MICC) are prohibited.

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Indoor cables for the living quarter areas and permanently manned technical rooms shall be Zero Halogen type.

13.14.2 Cable Identification and Marking

Cable identification and marking shall be as per [GS EP ELE 161](#) § 13.14.2.

Outer sheath colour of cables for intrinsic safety circuits shall be blue.

13.14.3 Cable Sizing

Cable sizing shall be carried out in accordance with the requirements of the following:

- The rules of the nominated marine Classification Society
- [IEC 61892-4](#).

Company general specification, [GS EP ELE 061](#) may also be used, subject to Classification Society approval.

Cable cross sections shall be chosen among the standardised list of [IEC 60228](#).

Minimum cross-sections authorized are:

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

As far as is practical, core cross section shall not exceed:

- LV = 3 x 185 mm² (three cores)
= 1 x 400 mm² Copper (single core)
= 1 x 630 mm² Alu (single core)
- HV = 3 x 120 mm² (three cores)
= 1 x 300 mm² Copper (single core)
= 1 x 630 mm² Alu (single core)

For connection to switchboards of power transformers and generators, the number of cables per phase shall be limited to six.

13.14.4 Cable Installation

13.14.4.1 General

The cable installation shall comply with the requirements of the nominated Classification Society and of the Company General Specifications [GS EP ELE 364](#) and [GS EP INS 107](#).

General Specification		GS EP ELE 021
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13.14.4.2 Cable Routing

As far as is practical, cables serving following equipment shall follow different routings so as not pass through the same areas:

- Bus section feeders of a same switchboard
- Redundant equipment
- Equipment requiring duplicated power supplies.

Emergency circuits shall not be routed on the same cable a tray than Normal/Essential circuits.

Different cable trays shall also be designed for:

- H.V cables
- L.V power cables, Lighting circuits
- Control, measuring, signalling cables
- Intrinsic Safety circuits (if practical, divider on control cable tray is acceptable).

All cable routes shall be designed such that they allow the maximum amount of cable installation and commissioning work to be completed during the shipyard construction phase.

All cables shall be of one continuous length. Cable joints shall not be used between junction boxes or equipment.

All cable routes shall be designed so as not to obstruct correct and safe access to mechanical equipment for maintenance purposes.

13.14.4.3 Cable Trays and ladders

Cable trays and ladders shall comply with Company General Specification **GS EP ELE 311**.

Heavy duty, grade 316, stainless steel, Aluminium 5754, or GRP ladder or cable tray shall be used throughout external areas.

For all internal areas heavy duty hot dip galvanised mild steel ladders or cable trays may be used.

Cable ladders or trays shall be adequately mounted according to Manufacturer instructions to ensure galvanic isolation with supports.

Cable support systems shall be designed so that there is approximately 20% spare capacity.

Cables installed within a raised floor shall be supported on ladders.

Conduit system is not allowed.

13.14.4.4 Cable glands and cable transits

Cable glands and cable transits shall be designed and installed as per **GS EP ELE 364**.

Schrouds on cable glands shall not be used.

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Cable transits design shall be:

- Block system (MCT) for Indoor to outdoor transits and for all transits of single core power cables
- Block system or Multi cable penetration system for Indoor to indoor transits.

Casting compound is prohibited.

13.14.4.5 Junction boxes

Unless otherwise specified, junction boxes shall be IP 65, 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 element.

13.15 Miscellaneous

13.15.1 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 hull structure.

Earthing of exposed conductive parts of machines and equipment shall comply with Classification Society requirements.

13.15.2 Heat tracing distribution system

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

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

13.15.3 Lightning protection

Provisions shall be taken in accordance with local national regulation, [IEC 60092](#) standard and Classification Society requirements.

13.16 Electrical Equipment Obsolescence Dossier

O&G facilities are usually design with an expected design life ranging from 20 to 25 years at least. Electrical equipment which have shorter life cycle will require one or more upgrading during the design life of the facility.

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.

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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.

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 potential known future extensions.

This dossier shall be prepared for the **F.U** as detailed in **GS EP ELE 460** § 4.48 in line with **IEC 62402** guidelines and **GS EP TEC 007**.

14. Electrical design studies

Typical description of required electrical studies is given in **GS EP ELE 460**.

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 Classification Society requirements.

14.1 Basic Engineering studies

The Contractor shall perform the complete electrical network studies, including topsides and hull.

14.2 Detailed Engineering studies

The EPC Contractor in charge of the main power generation shall be responsible for the coordination of the studies and shall provide the other EPC Contractor with the up-dated electrical studies required for proper design of the network.

The required design and Vendor data shall be provided to the EPC Contractor in charge of the whole electrical network studies. These studies shall have to be approved by Hull and Topsides EPC Contractors.

Short circuit current calculations

The short circuit calculations shall be carried out in accordance with **IEC 60909** and shall include balanced and unbalanced maximum and minimum short circuit currents at any location according to the predictable network configurations.

Short circuit calculations shall be reviewed by Classification Society for approval.

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15. Testing

The design, installation, testing and commissioning of the electrical systems and equipment for the Hull & Accommodation shall be completed at the shipyard and shall be fully operational in all respects.

The design, construction and testing of the Hull and living quarters building for the **F.U** shall be based upon the [IEC 60092](#) standard for “Electrical installation in ships” and the applicable rules from the nominated marine Classification Society.

Pre-commissioning and commissioning procedures shall be prepared by Contractor according to Company Specifications [GS EP EXP 105](#) / [GS EP EXP 107](#).

16. Third Party inspection

EPC Contractor shall include an independent third party inspection for document review and installation tests as per [GS EP ELE 451](#).

17. Other references

Following documents are applicable:

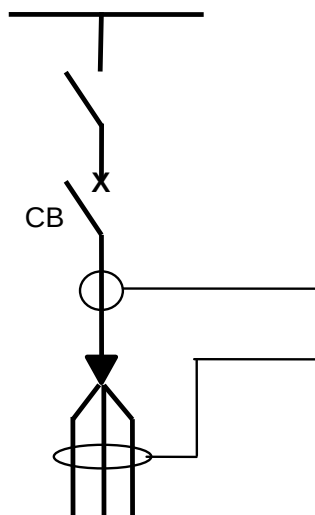
- External documents: [IEC 60331-21](#), [IEC 60502 \(Parts 1; 2\)](#), [CAP 437](#), [ICAO](#)
- Total General Specifications: [GS EP ELE 011](#).

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Appendix 1
Appendix 1 Feeder output


Protection	ANSI code	Action
Instantaneous overcurrent $I \gg (2)$	50	open CB
Time overcurrent $I > (1) (2)$	51	open CB
Earth leakage current $I_o > (3)$	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 :

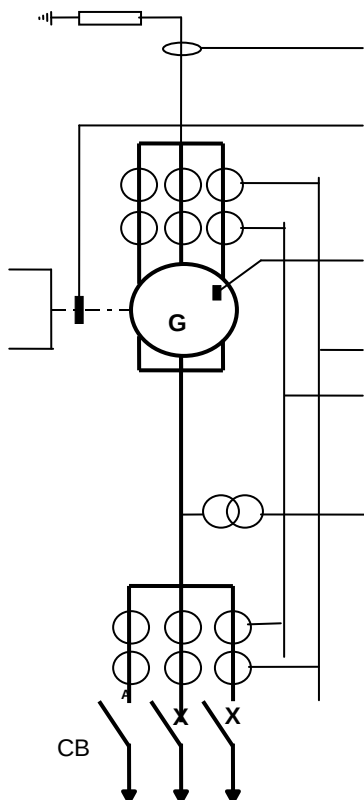
- cable shield strength
- limit fault current

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Appendix 2
Appendix 2 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 over temperature	26	Alarm (1 st) and trip CB (2 nd)
Coolant over temperature or failure	26	Alarm
Stator differential over current	87 G	stop machine
Time delayed overcurrent or 3 phases voltage restraint overcurrent	51 or 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)	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 over current protection	67 / 67N (3)	Stop Machine

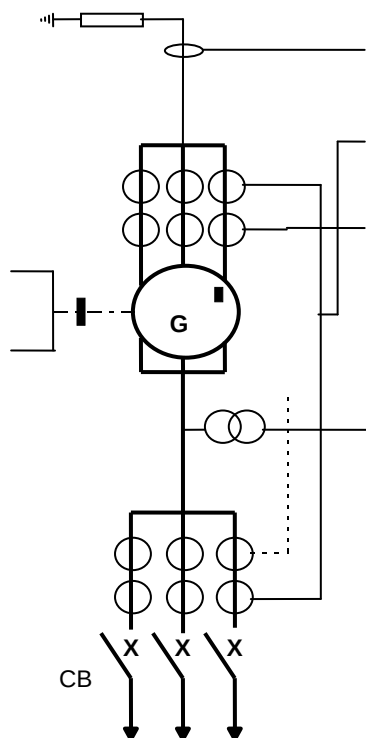
- (1) For generator connected to a network protected by earthing transformer (homopolar generator)
- (2) For generator above 5000 kVA
- (3) For generators running in parallel and connected to the earth via earthing resistors.

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Appendix 3
Appendix 3 Diesel Generator


Protection	ANSI code	Action
Earth over current	51N	Open breaker and stop engine
Stator differential over current (1)	87 G	Stop engine
Time delayed overcurrent or 3 phases voltage restraint overcurrent	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 over temperature	26	Alarm (1 st) and trip CB (2 nd)
Bearing over temperature	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

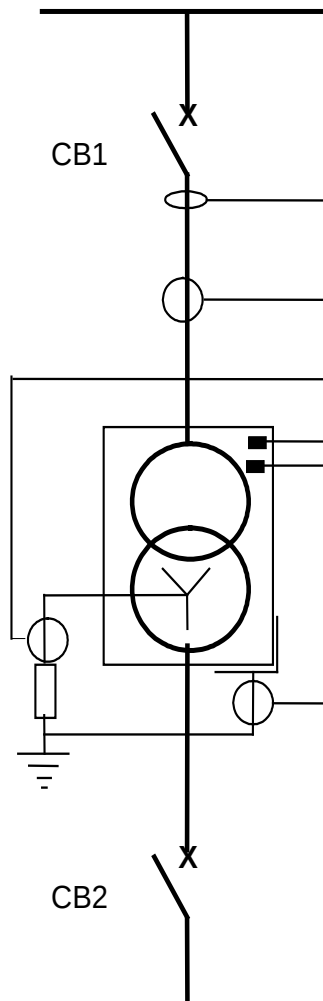
- (1) For generator above 1250 kVA
- (2) For generator connected to a network protected by earthing transformer (homopolar generator)
- (3) For generators running in parallel and connected to the earth via earthing resistors.

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Appendix 4
Appendix 4 Transformer


Protection	ANSI code	Action
Instantaneous overcurrent $I >>$ (1)	50	open CB1
Time overcurrent $I >$	51	open CB1
Primary Earth leakage current	51N	open CB1
Secondary Earth leakage current	51N	open CB1
1st threshold temperature θ_1 (5) 2nd threshold temperature θ_2 (5)		alarm open CB2
1st threshold Buchholz relay (2) 2nd threshold Buchholz relay (2)		alarm open CB1
Drop in liquid level (5) Overpressure (5)		open CB1 open CB1
Earth tank leakage (3)	50G	open CB1
Transformer differential (4)	87 T	Open CB1

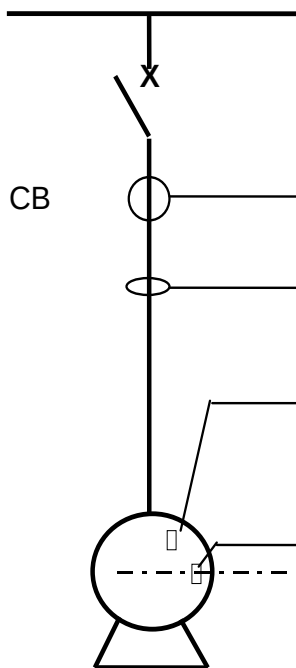
(1) $(I >>) > (I_{cc} LV)$ - (2) Only for oil immersed breathing type transformer
(3) $P \geq 10$ MVA - (4) For $P > 20$ MVA or generator unit-transformer (In this case all opening actions are on CB2, as CB1 doesn't exist).
(5) These functions may be integrated in one multifunction relay

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Appendix 5
Appendix 5 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
Stator Differential (5)	87	open CB
Winding probe (3) θ1	38/49T	alarm
θ2		open CB
Bearing probe (3)		open CB
Vibration (1)		open CB ⁽⁴⁾

(1) If $P \geq 1000$ kW

(4) Via vibration monitoring system of the package

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

(3) If $P \geq 200$ kW

(5) if $P \geq 5$ MW

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Appendix 6

Appendix 6 Typical One Line Diagram

