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EXECUTION	ESPOSTE	BD36	BD36	CSJP	CSJP	FABIO.P	FABIO.P	CSJP	BD36
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1. GENERAL

1.1. Scope

1.1.1. This specification and its references establish the guidance to be followed for the execution of Detailed Engineering Design for all electrical systems inside offshore Units, including installations inside modules and for integration among modules and between Hull and modules.

1.1.2. This specification defines rules for design, specification, construction and installation of electrical systems, but does not define scope of supply of equipment.

1.1.3. The electric design shall comprise at least the following systems:

a) Electric Main, Hull, Emergency and Auxiliary power generation;
b) Power distribution system in medium and low-voltage;
c) Lighting distribution system;
d) Grounding network;
e) Marine and aircraft obstruction signalling;
f) UPSs and DC systems;
g) Lightning protection system;
h) Area classification plans;
i) Cathodic protection systems.

1.1.4. For Area Classification requirements, refer to Safety documentation.

1.1.5. For Cathodic Protection requirements, refer to Structure documentation.

1.2. Environmental Conditions

1.2.1. For environmental requirements, refer to I-ET-3010.00-5140-700-P4X-009 - GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

1.3. Applicable Standards

1.3.1. The Electrical Design shall comply with the requirements of Classification Society, Brazilian Legislation, Ports and Coasts Department, applicable regulatory rules and the standards listed below.

1.3.2. At the design development and for equipment specification, all standards shall be used on their latest revisions.

1.3.3. IEC – International Electrotechnical Commission

IEC 60034-1 Rotating electrical machines - Part 1: Rating and performance

IEC TS 60034-25 Rotating Electrical Machines – Part 25: Guidance for the Design and Performance of A.C. Motors Specifically Designed for Converter Supply

IEC 60076-12 Power Transformers – Part 12: Loading Guide for Dry-type Power Transformers

IEC 60079 Explosive Atmospheres – All parts

IEC 61892	Mobile and Fixed Offshore Units – Electrical Installations – All parts
IEC 60092-201	Electrical Installations in Ships – Part 201: System Design - General
IEC 60092-401	Electrical Installations in Ships – Part 401 – Installation and Test of Completed Installation
IEC 60092-502	Electrical Installations in Ships – Part 502: Tankers – Special Features
IEC 60146-1-3	Semiconductor Convertors - General Requirements and Line Commutated Convertors – Part 1-3: Transformers and Reactors
IEC 60331	Tests for Electric Cables under Fire Conditions – Circuit Integrity – All parts
IEC 60364-4-41	Low-Voltage Electrical Installations – Part 4-41: Protection for Safety – Protection Against Electrical Shock
IEC 60533	Electrical and Electronic Installations in Ships – Electromagnetic Compatibility
IEC 60417-SN	Graphical Symbols for Use on Equipment - Database Snapshot
IEC 60909	Short-Circuit Currents in Three-Phase A.C. Systems
IEC 61111	Electrical insulating matting
IEC 61378-1	Converter Transformers – Part 1: Transformers for Industrial Applications
IEC 61914	Cable Cleats for Electrical Installations

1.3.4. INMETRO – Instituto Nacional de Metrologia, Normalização e Qualidade Industrial

Portaria n° 115, Mar 21st 2022

1.3.5. NFPA – National Fire Protection Association

NFPA 780	Standard for the Installation of Lightning Protection Systems

1.3.6. IEEE – Institute of Electrical and Electronics Engineers

IEEE Std 242	Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
IEEE C57.110	Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformers Capability when Supplying Nonsinusoidal Load Currents
IEEE Std 519	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE Std 1584	Guide for the Specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculation Study in Accordance with IEEE Std 1584™
IEEE Std 485	IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications

IEEE Std 1115 Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications

1.3.7. IMO – International Maritime Organization

IMO 160E SOLAS - International Convention for the Safety of Life at Sea

Resolution A.753(18) Guidelines for the Application of Plastic Pipes on Ships

Resolution MSC.61(67) International Code for Application of Fire Test Procedure

1.3.8. API – American Petroleum Institute

API-RP-14FZ Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Zone 0, Zone 1, and Zone 2 Locations.

API-RP-505 Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, zone 1, and Zone 2

1.3.9. DPC – Diretoria de Portos e Costas – Marinha do Brasil

NORMAM 01 Normas da Autoridade Marítima para Embarcações Empregadas na Navegação em Mar Aberto

NORMAM 05 Normas da Autoridade Marítima para Homologação de Material

NORMAM 27 Normas da Autoridade Marítima para Registro de Helideques Instalados em Embarcações e em Plataformas Marítimas (from the version approved by Portaria n° 394 of 10 December 2018 onwards)

RIPEAM 72 Convenção sobre o Regulamento Internacional para Evitar Abalroamentos no Mar

Note: The Detailed Design shall comply with all DPC standards and rules. Reference is made to the abovementioned regulations just for the sake of highlighting the most commonly applied ones.

1.3.10. Secretariat of Labour – Brazilian Ministry of Economy

NHO 11 Procedimento técnico - Avaliação dos níveis de iluminamento em ambientes interno de trabalho

NR-10 Segurança em Instalações e Serviços em Eletricidade

NR-12 Segurança no Trabalho em Máquinas e Equipamentos

NR-13 Caldeiras e Vasos de Pressão

NR-17 Ergonomia

NR-26 Sinalização de Segurança

NR-37 Segurança e Saúde em Plataformas de Petróleo

1.3.11. ASTM – ASTM International

D 178-01 Standard Specification for Rubber Insulating Matting

1.3.12. DNV GL – Det Norske Veritas Germanischer Lloyd

DNVGL-OS-D201 Electrical Installations

1.3.13. ISO – International Organization for Standardization

ISO 8995-1 Lighting of Indoor Work Places

ISO 5659-2 Plastics – Smoke Generation – Part 2: Determination of Optical Density by a Single-Chamber Test

1.3.14. PETROBRAS

NI-1710 Coding of Technical Engineering Documents

1.4. Reference Documents

[1] UPS AND DC SYSTEMS ONE-LINE DIAGRAM

[2] DR-ENGP-M-I-1.3 - SAFETY ENGINEERING

[3] I-DE-3010.00-5140-700-P4X-001 - LIGHTING INSTALLATION TYPICAL DETAILS

[4] I-DE-3010-00-5140-700-P4X-003 - GROUNDING INSTALLATION TYPICAL DETAILS

[5] I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM

[6] I-ET-3010.00-1200-800-P4X-010 - CRITERIA FOR ESTABLISHING CABLE CODES AND CABLE GLAND CODES

[7] I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS

[8] I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS

[9] I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS

[10] I-ET-3010.00-5140-700-P4X-007 - SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS

[11] I-ET-3010.00-5140-700-P4X-008 - SPECIFICATION FOR LIGHTING AND ELECTRICAL SIGNALLING FOR OFFSHORE UNITS

[12] I-ET-3010.00-5140-700-P4X-009 - GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS

[13] I-ET-3010.00-5140-700-P4X-006 - REQUIREMENTS FOR ELECTRICAL STUDIES FOR OFFSHORE UNITS

[14] I-ET-3010.00-5140-714-P4X-001 - SPECIFICATION FOR ELECTRICAL BATTERIES FOR OFFSHORE UNITS

[15] I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS

[16] I-ET-3010.00-5140-741-P4X-002 - MEDIUM-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS

[17] I-ET-3010.00-5140-773-P4X-001 - SPECIFICATION FOR D.C. UPS FOR OFFSHORE UNITS

[18] I-ET-3010.00-5140-773-P4X-002 - SPECIFICATION FOR GENERIC D.C. UPS FOR OFFSHORE UNITS

[19] I-ET-3010.00-5140-773-P4X-003 - SPECIFICATION FOR A.C. UPS FOR OFFSHORE UNITS

[20] I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE

[21] I-ET-3010.00-5267-750-P4X-001 - TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION

[22] I-ET-3010.00-5400-947-P4X-002 - SAFETY SIGNALLING

[23] FIELD INSTRUMENTATION DOCUMENTATION

[24] I-ET-3000.00-1200-940-P4X-001 - TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN

[25] I-LI-3010.00-5140-700-P4X-001 - ELECTRICAL EQUIPMENT DATA-SHEET MODELS

[26] I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST

[27] TOPSIDE MECHANICAL HANDLING PROCEDURE SPECIFICATION

[28] HULL MECHANICAL HANDLING PROCEDURE SPECIFICATION

[29] I-ET-3010.00-5520-888-P4X-001 - AUTOMATION PANELS

[30] I-ET-3010.00-1200-800-P4X-002 - AUTOMATION, CONTROL AND INSTRUMENTATION ON PACKAGE UNITS

[31] I-ET-3000.00-1350-940-P4X-013 - TECHNICAL REQUIREMENTS FOR DIGITAL ENGINEERING

Note: Documents without code in the list are documents with variations according to project characteristics. Verify in project documentation list the reference for codes of these documents.

1.5. Electrical Apparatus for Use in Hazardous Areas

1.5.1. Electrical apparatus shall comprise all equipment and components (including those for automation and control) connected to an electrical installation.

1.5.2. Electrical apparatus for use in hazardous areas (or Ex electrical apparatus) shall comply with the requirements of IEC 60079, IEC 61892-1, IEC 61892-7 and Classification Society. They shall be of type approved and certified by international recognized laboratory. Ex electrical apparatus shall also be in accordance with INMETRO Portaria n° 115, Mar 21st 2022.

1.5.3. The certificates issued for Ex electrical apparatus shall be gathered in dedicated design documents, as stated in item 2.23.

1.5.4. Electrical apparatus installed in non-hazardous external (open) areas, expected to operate during emergency shutdown ESD-3P or ESD-3T, shall, as a minimum, be certified for installation in hazardous areas Zone 2 Group IIA temperature T3, unless they are automatically de-energized in case of confirmed gas in equipment area, exception made to searchlights (see 3.11.3.5).

1.5.5. All electrical apparatus suitable to operation during ESD condition, shall have a label with mark “ESD”. These labels shall be installed so that they are easily identified.

1.5.6. For a perfect identification of hazardous areas in the Areas Classification drawings, DR-ENGP-M-I-1.3 - SAFETY ENGINEERING and equipment Data Sheet shall be observed.

1.6. Training in Electrical System and Electrical Equipment

1.6.1. BIDDER shall provide training for at least 10 (ten) PETROBRAS personnel, focused on electrical system and electrical equipment.

1.6.2. Packages’ Suppliers shall provide training for at least 10 (ten) PETROBRAS personnel focused on electrical system and electrical equipment.

1.6.3. All trainings shall be provided in Brazil, during commissioning period.

1.6.4. The training plan shall include at least: storage, transportation, installation, operation, corrective maintenance, preventive maintenance, predictive maintenance, disassembly, assembly, configuration and adjustment of electrical components.

1.6.5. All documents and manuals included in item 2, related to electrical system and equipment, shall be delivered at least one month before the starting of all trainings.

1.6.6. Detailed Engineering Design shall revise and complement training requirements of PETROBRAS documents.

2. DETAILED DESIGN DOCUMENTATION

2.1. Introduction

2.1.1. The Detailed Design documents shall be developed based on documentation issued by PETROBRAS.

2.1.2. The Detailed Design shall issue all documents and studies requested in this specification.

2.1.3. All Detailed Design documentation to be issued shall be developed and delivered to PETROBRAS in digital format.

2.1.4. All design documentation shall keep consistency (the same technical solutions, the same pattern and quality of documentation), no matter whether the covered area belongs to production or utility space of the Unit. Detailed Design scope includes the responsibility of keep the consistency among the several areas. Common documents like Typical Details, Cable List, Load List, Equipment List, etc. shall be unique for all areas.

2.1.5. Typical Details for Power, Lighting and Grounding issued by PETROBRAS shall be complied with and complemented by Detailed Design.

2.1.6. Functional Units Typical diagrams shall be developed by Detailed Design and shall be presented to PETROBRAS for approval.

2.1.7. All plans shall have the following items included:

a) Elevation details showing all Unit deck elevations;
b) Key plan showing the positioning of the represented area related to the referred deck;
c) Details showing the direction of prevailing winds, sea currents, and true and design north;
d) Indication of all reference documents.

2.1.8. Documents issued during Detailed Design, based on documents issued by PETROBRAS shall indicate all modifications between the last revision issued by PETROBRAS and the first revision issued by Detailed Design. For drawings, bubbles, amoebas or clouds shall indicate these modifications and for text documents the modifications shall be indicated by revision marks.

2.1.9. On drawings, all revisions shall be clearly signalled by a letter indicating the revision. The revisions indication shall be placed as close as possible to the region (or area) in the drawing where the respective revision has been performed. The region (or area) in the drawing that has been modified due to the new revision shall be indicated with bubbles, amoebas or clouds and an indication of the new revision shall be placed as close as possible to this area.

2.2. Materials List

2.2.1. This document shall be furnished by Detailed Design, by Package Suppliers and by electrical equipment Suppliers, detailing all components of electrical system.

2.2.2. Two alternative solutions are acceptable for detailing materials as complementary information to installation design:

a) Materials List can be presented in a table belonging to the same drawing they refer to. In this case a material list presented as an annexed sheet to the drawing shall not be accepted.
b) Materials List can be presented by means of an independent document (List of Materials).

2.2.3. In both solutions the document shall present the materials weight per unit and materials total weight.

2.3. Electrical Equipment List

2.3.1. This document shall encompass all electrical equipment. The following information shall be, as a minimum, provided for each piece of equipment:

a) Identification (TAG);
b) Identification (Description);
c) Classification regarding Normal, Essential and Emergency load;
d) Rated power (kW/kVA);
e) Rated voltage (V);
f) Dimensions (m);
g) Weight (kg);

h) Location (module or deck, room (when applicable) and level);
i) Hazardous area classification with IEC gas group, temperature class and EPL (Equipment Protection Level) marking;
j) Heat dissipation at maximum and normal operational conditions (W).

2.3.2. The Electrical Equipment List shall contain only those heat dissipation data provided by equipment manufacturers. These data shall be required upon the purchase order placement.

2.3.3. The final revision of the Electrical Equipment List shall be filled in with the "as purchased" equipment data.

2.4. One-Line and Three-Line Diagrams

2.4.1. One-line and three-line diagrams shall be issued for each panel, showing:

a) Supply sources, including voltage, frequency, number of phases, rated power in kW and in kVA;
b) Incoming and outgoing sections;
c) Devices and interconnections for forced ventilation equipment of transformers;
d) Normal operating condition of circuit-breakers;
e) Representation and identification (NAME and TAG) of all panels, equipment and loads;
f) Indication of voltage, number of phases and current capacity of busbars in continuous operation and in short-circuit (RMS and Peak Value);
g) Rated current of circuit-breakers and switching devices;
h) Panel grounding busbar;
i) Feeders' grounding switch;
j) Spare and future panel compartments;
k) Protective devices;
l) Metering, signalling and alarm devices;
m) Interlocks arrangements;
n) Heating resistors for panels, motors and generators, and their sources of supply;
o) Identification of circuits;
p) Cables cross-section;
q) Total quantity of conductors per circuit;
r) UPSs and DC systems;
s) Interconnections between equipment related to protection, alarm, signalling, and interlock circuits, individualizing all items by specific numbering systems.

2.4.2. When the Manufacturer issues Functional Diagrams (item 2.6) including power (three-phase) and control circuits, separate three-line diagrams are not required.

2.5. Panoramic Block Diagrams

Diagrams of Essential and Emergency Electric System for AC and DC systems shall be issued. These drawings, that shall compose the Manual of Operation of the Unit, shall allow a global visualization of the respective systems, indicating clearly where all essential loads are connected and indicating duplicated and redundant loads that should be derived from busbars and redundant systems. These diagrams shall include tags, names and functions of all equipment, in Portuguese, in compliance with Brazilian standards NR-12 and NR-37, and in English.

2.6. Functional Diagrams

2.6.1. These diagrams shall be prepared for control circuits of circuit-breakers, functional units, disconnecting switches, electrical interlock or command, normal and essential motor and non-motor loads, etc. Complete functional diagram for generation systems shall be provided and shall contain all interfaces between each generator and the respective power and control panels.

2.6.2. Functional Diagrams shall show:

a) Types and values of supply voltages for control circuits and specific grounding, if any;
b) Protective devices for circuits and/or branches;
c) All devices represented with respective contacts and components thereof;
d) Functions of contacts intended for alarm, command, signalling, operation, shutdown or interlock at remote points, and reserve contacts;
e) Indication of point of installation of remote devices acting on circuit.

2.6.3. If the sequence of commands of a particular piece of equipment displays a certain level of complexity, hampering preparation or interpretation of the functional diagrams, block diagrams shall be preferred. (Refer to item 2.8 below).

2.6.4. Functional diagrams shall be issued for electrical equipment with control circuits.

2.7. Interconnection Diagrams

Diagrams for all types of electrical cables e optical cables connecting all separate equipment showing:

a) Identification of terminal block boxes and equipment;
b) Identification of terminal blocks and correlated equipment;
c) Identification of origin and destination of conductors entering or leaving a terminal block unit;
d) Identification of circuits at output of terminal blocks, with indication of number(s) and destination of these circuits;
e) Global vision of all interconnections corresponding to each functional diagram.

2.8. Block Diagrams

2.8.1. Block diagrams with logical sequence of actions shall be provided for the functional units (incomings, outgoings, “ties”, current limiting devices, back-feeders, etc.) of all electrical panels, including control ones.

2.8.2. Block diagrams shall be made up whenever the volume of data on protection, signalling, alarm and interlocking circuits is too great for indication of this wiring on the single line diagram. They shall duly identify all equipment represented by blocks, as well as circuits interconnecting them, and all wiring inherent to the respective unit.

2.9. Layout of Electrical Equipment Rooms – Sections and Details

Plans of all electrical equipment rooms showing:

a) Location, size and identification of electrical equipment;
b) Spaces intended for future expansion depicted by means of dashed lines;
c) The necessary quotes between equipment and from equipment to bulkheads;

d) Location of equipment belonging to other systems (VAC, fire protection, etc.), when these are important under the viewpoint of interference with the electrical part;
e) Sections, views and details in the vertical plane, including complete identification and dimensions of equipment.

2.10. Electrical equipment handling report

A report shall be issued using 3D models of the unit in order to delivery recorded videos of removal, handling and installation of main electrical equipment, according to TOPSIDE MECHANICAL HANDLING PROCEDURE SPECIFICATION and HULL MECHANICAL HANDLING PROCEDURE SPECIFICATION

2.11. General Plan

This document, for purposes of orientation, shall be prepared in those cases in which the detailing covers a very extensive area, calling for the preparation of a number of plans for its detailed representation. It shall contain at least the following pieces of information:

a) Orientation of drawing;
b) Delimitation of areas corresponding to various system plans;
c) Indication of all component plans of the system in a Key Plan.

2.12. Trays, channels and ladders sizing calculation report and list

2.12.1. Calculation reports for trays and channels sizing shall be submitted to PETROBRAS approval. These documents shall have at least the following information:

a) Individual point supplementary weight supportability according to 3.10.2.13;
b) Information of cable circuits installed in each section of cable trays and channels;
c) Calculation of space occupied by cables in trays, channels and ladders in order to ensure a reserve section defined in this specification (refer to 3.10.2.16).

2.12.2. These documents shall be consistent with the 3D model of the Unit, considering at least, TAGs, routes, sizes, weight, material, type and quantity of levels.

2.12.3. Detailed Design shall issue lists showing the main properties, parameters and quantities related to the cable tray installations. The said lists shall be extracted from the 3D model data bank and structured as follows:

a) List of Cable Tray Properties and Parameters

This document aims to simplify the search and identification of the main properties and parameters associated to the cable tray installations. The following attributes shall be shown:

- Cable tray identification;
- Cable tray cross-sectional dimensions (width and height);
- Cable tray cross-sectional area;
- Cable tray material;
- Cable tray length;

- Cable tray location (module, deck, floor, room, level, etc.);
- Cable tray weight;
- Cable tray engineering discipline ('E' for Electrical, 'T' for Telecommunication, 'I' for Instrumentation);
- Identification of each circuit placed into the cable tray;
- Overall diameter of each circuit placed into the cable tray;
- Individual and total weight of the circuits placed into the cable tray;
- Individual and total cross-sectional area of the circuits placed into the cable tray;
- Cable tray fill ratio (%).

b) List of Cable Tray Quantities

This document aims at providing a quantitative summary of the cable tray system parts (straight sections, fittings, supports and accessories), according to the place of the offshore unit where they are installed and the material from which they are manufactured. The following attributes shall be shown:

- Part type (straight section, horizontal tee, vertical tee, vertical inside bend, vertical outside bend, horizontal bend, cross, reduction, splice plate, etc.);
- Cross-sectional dimensions (width 1 x height 1, width 2 x height 2, …, width n x height n);
- Material (stainless steel, aluminium, FRP, etc.);
- Location (module, deck, floor, room, level, etc.);
- Cable tray engineering discipline ('E' for Electrical, 'T' for Telecommunication, 'I' for Instrumentation);
- Total length (for straight sections) or total quantity (for fittings and accessories).

2.13. Power/Grounding Distribution Plans

2.13.1. Representation in one unique drawing per area/location of power and grounding systems components of that area/location including:

a) Simplified layout of the area;
b) Representation of all power equipment located in the referred area including power sockets, push-buttons and other small equipment in junction boxes;
c) Representation of all power cableways: cable trays main route (above 200mm) and sub-route (200mm and below), channels, solid bottom trays, and other similar structures, giving identification, quotes, elevations, accessories, rated sizes, changes in levels, orientation of design, and indication of continuity in other drawings;
d) Representation of all power cableway supports;

e) The cable tray size (with tag number), cable tray routing and cables to be placed into the cable tray (cable circuit number) shall be shown on that drawing. Elevation views shall be prepared to ensure satisfactory clearance in all orientation;
f) Representation of all grounding connections and respective details;
g) Indication of installation typical details;
h) Calculation of total weight of electrical equipment for each plant.

2.13.2. For accommodation areas, it will be acceptable presenting the above required information in two different drawings. One drawing containing the information described on subitems a), b), c), d), e), and g) and the other drawing showing the information requested on subitems a), b), c) and f).

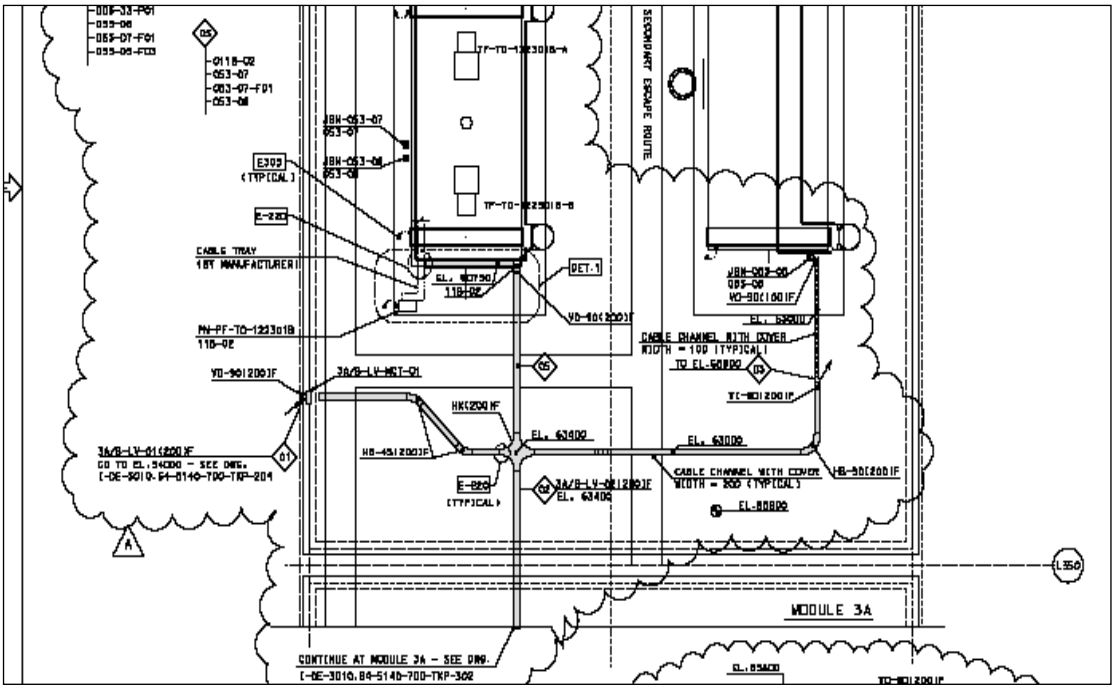


Figure 1 - Typical Power/Grounding Distribution Plan

2.14. Multi-cable Transit Detailed Drawing

2.14.1. These documents shall be issued for each module or area where multi-cable transits are installed, including at least the following information:

a) Identification of codification
b) Legends of symbols;
c) Summary of MCTs with codes and frames;
d) Detailed drawings of each MCT with detailed dimensions, types, weight, codes, circuits, and quantities.

2.15. Lighting Levels Calculation Memory

2.15.1. Calculation memories for lighting sizing shall be submitted to PETROBRAS approval. This document shall have at least the following information:

a) Area to which the calculation memory refers;
b) Average General Lighting Levels for Normal, Essential and Emergency Lighting according to purposed lighting plan;
c) Table containing calculated and required (refer to Table 5 of item 3.11) lighting levels for normal, essential and emergency lighting, including the quantity of lighting fixtures and floodlights for each kind of lighting system.

2.15.2. The Detailed Design shall issue a final revision of the Lighting Level Calculation Memory after the layout plans have been completely defined (with all equipment, piping, HVAC, cable trays, etc.) and the Lighting Level Measurement Report has been approved by PETROBRAS.

2.16. Lighting Level Measurement Report

This technical report shall gather the results of the lighting levels measured in all areas of the production unit, in accordance with NR-37. Recommendations to improve the illuminance of the places where the measured values lied outside the limits established in Table 5 shall also be provided.

2.17. Lighting Distribution Plans

2.17.1. Representation in one unique drawing per area/location of lighting systems components of that area/location including:

a) Simplified layout of the area;
b) Representation of all lighting equipment located in the referred area including lighting fixtures, lighting panels, general use sockets, switches, and other small equipment in junction boxes;
c) Representation of all lighting cableways: cable trays main route (width greater than 200mm) and sub-route (width 200mm or lower), channels, solid bottom trays, and other similar structures, giving identification, quotes, elevations, accessories, rated sizes, changes in levels, orientation of design, and indication of continuity in other drawings;
d) Representation of all lighting cableway supports;
e) The cable tray size (with tag number), cable tray routing and cables to be placed into the cable tray (cable circuit number) shall be shown on that drawing. Elevation views shall be prepared to ensure satisfactory clearance in all orientation;
f) Representation of all grounding connections and respective details;
i) Indication of installation typical details;
g) Calculation of total weight of electrical equipment for each plant.

2.17.2. For accommodation areas, it will be acceptable presenting the above required information in two different drawings. One drawing containing the information described on subitems a), b), c), d), e) and i), and the other drawing showing the information requested on subitems a), b), c) and f).

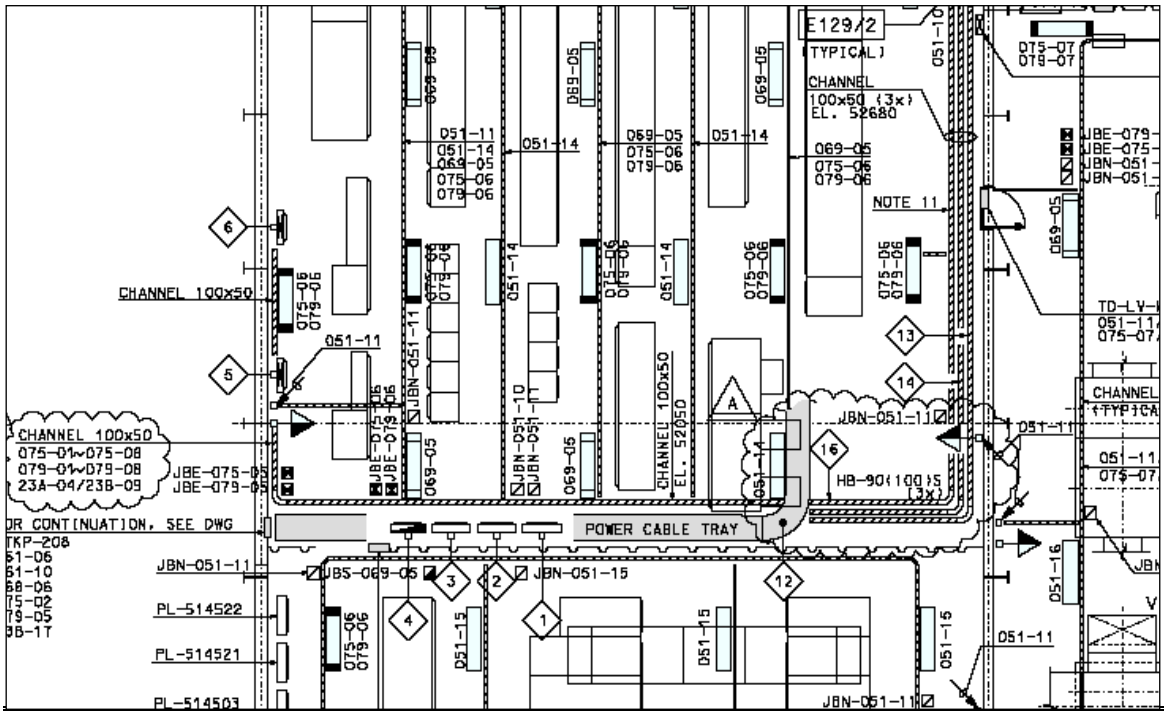


Figure 2 - Typical Lighting Distribution Plan

2.18. Electrical Cables List

The Electrical Cables List shall be issued as Microsoft Excel ® spreadsheet and shall contain information of all electrical cables for power, lighting, control, protection, heating, and network circuits. The following information shall be provided, as a minimum:

a) Circuit number, according to item 3.10.3 of this specification;
b) Function;
c) From (origin of the cable) (Equipment/Module);
d) To (destination) (Equipment/Module);
e) Power (kW);
f) Circuit Voltage (V);
g) Insulation Class of the cable (kV);
h) Formation (number of phases, number of conductors and cross-section in square millimeters);
i) Length (m): (Circuit/Cable);
j) Drum number;
k) Cable Material Code;
l) Cable Route (circuit path in each cableway section);
m) Cable weight;
n) Cable type;
o) Cable gland type;
p) System and sub-system.

2.19. Electrical Cables Sizing Calculation Report

Calculation reports for cable sizing shall be submitted to PETROBRAS approval. This document shall have at least the following information:

a) Standard considered for calculation criteria;
b) Cable rated current capacity;
c) Cable calculated current capacity;
d) Short-circuit currents considered;
e) Protective device actuation times considered;
f) Voltage drop limits considered;
g) Calculated voltage drops;
h) Calculation report for distances between cleats, according to IEC 61914.

2.20. Electrical Typical Assembly Details

For depicting typical details, reference shall be made to designers' standards after approval by PETROBRAS, or specific drawings shall be prepared. Details of equipment assembly shall contain at least the following information:

a) Representation in plans, views and sections of all equipment supported by the various structures, including cable trays;
b) Representation of all equipment grounding connections;
c) Representation of quotes on horizontal and vertical planes;
d) Orientation of details on the plan;
e) Indication of respective bill of materials, which shall contain the following information: item number, description of material, material code as used in Materials List, number of items, respective item, and identification of suppliers' drawings, where applicable. List shall be exhibited on the drawing itself, adjacent to details;
f) Cable entries in equipment;
g) Penetration in decks and bulkheads;
h) Grounding details.

2.21. Electrical Loads List

The Electrical Loads List shall be issued by Detailed Design as Microsoft Excel ® spreadsheet and shall contain information of all electrical loads. The following information shall be provided, as a minimum:

a) Load Identification (TAG);
b) Load Identification (Description);
c) Feeder panel TAG;
d) Rated voltage (V);
e) Rated power (kW for motor and kVA for other loads);
f) Rated current (A);
g) Starting time (s) and starting current (p.u.);
h) Speed (rpm);
i) Load required power (bkW);
j) Motor plus load consumptions (kVA);
k) Service factor;
l) Efficiency (%) at 25, 50, 75 and 100% of load;
m) Power factor at 25, 50, 75 and 100% of load;
n) Maximum locked-rotor time (s)
o) Load classification according to control mode (EA01, EA02, EA03, EA04);

p) Phase number;
q) Starting method (soft-starter, direct-on-line, VSD, etc.);
r) Vendor;
s) Status (Preliminary, Confirmed, Final Information);
t) Remarks.

2.22. Electrical System and Automation Interface List

The Electrical System and Automation Interface List shall be provided by Detailed Design with information about all signals exchanged between Electrical System Equipment, A&C, Electrical System Automation, Packages, PMS and generator control panels (TGCPs, HGCPs, EGCP and AGCP), among others. For more details, refer to I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST and I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE.

2.23. Certificate of Conformity for Ex Electrical Apparatus

2.23.1. The Certificate of Conformity related to a given Ex electrical apparatus shall be issued in a dedicated design document, through a searchable PDF file.

2.23.2. Each individual certificate document file shall be coded as follow:

CEEX - <Equipment TAG or Description and Model> - <Manufacturer> - <Certificate number>

Notes: 1 - It shall not be used character "/". Replace it by "-", when necessary;

2 - E.g.: CEEX – Junction Box GHG 74 – Cooper Crouse-Hinds – CEPEL-EX-067-2002.

2.23.3. A given Certificate of Conformity may be assigned to identical Ex electrical apparatus from the same subsystem/contractor. In this case, only one design document need to be issued.

2.24. List of Ex Electrical Apparatus

This document shall be provided by Detailed Design and consists to list all Ex electrical apparatus installed in hazardous and non-hazardous areas. This list shall inform:

a) Ex electrical apparatus tag (all Ex apparatus shall have an individual TAG);
b) Description of the Ex electrical apparatus;
c) Location of installation with information of module or deck, floor, room (if applicable), etc.;
d) Serial number;
e) Manufacturer;
f) The number of the corresponding Certificate of Conformity for Hazardous Area complying with INMETRO Portaria n° 115, Mar 21st 2022;
g) Authorized laboratory that issued the Certificate of Conformity;
h) Issue date of the Certificate of Conformity;
i) Document Code where the Certificate of Conformity according to f) is presented.

This document can be divided in more documents (according to the location, for example) to better organize the certificates.

2.25. List of Certificates for Ex Electrical Apparatus

This document shall be provided by Detailed Design and consists to list, for each Ex electrical apparatus:

a) Ex electrical apparatus tag;
b) Description of the Ex electrical apparatus;
c) Number of the Certificate of Conformity for Hazardous Area;
d) Document Code where the Certificate of Conformity is presented.

Identical Ex electrical apparatus shall be listed in different rows, even if assigned to the same Certificate of Conformity.

2.26. Databook of Certificates for Ex Apparatus

This document shall have all certificates for Ex Apparatus of the platform, listed in item 2.24.

2.27. Emergency Electrical and Electronic Equipment List

This document shall comprise the list of all electrical and electronic equipment expected to operate in emergency condition (ESD-3) and shall be provided by Detailed Design and Package Suppliers.

The location (internal/external) of all equipment shall be indicated, to check if they are being supplied with certificate for classified area.

This list shall inform, for each equipment and instrument:

a) Equipment or instrument tag;
b) Description of the equipment or instrument;
c) Location of installation with information of module or deck, floor, room (if applicable), etc.;
d) Serial number;
e) Manufacturer;
f) The number of the corresponding Certificate of Conformity for Hazardous Area complying with INMETRO Portaria n° 115, Mar 21st 2022 (for all electrical and electronic equipment specified for installation in hazardous areas);
g) Authorized laboratory that issued the Certificate of Conformity;
h) Issue date of the Certificate of Conformity;
i) Document Code where the Certificate of Conformity according to f) is presented;

This document can be divided in more documents (according to the location, for example) to better organize the certificates.

2.28. Electrical Functional Units Classification List According to Control Mode

This document shall be provided by Detailed Design and consists to define the classification to be applied for functional units for electrical loads, regarding remote operation or supervision from Automation and Control System, in accordance with the requirements of I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE. This document shall also include the location where it is possible to start the electrical load (field, electrical panel, SOS HMI, control panel, Electrical Automation System Operational Workstation, etc.)

2.29. Electrical Functional Units List with individual earth fault detector (EFI)

This document shall be provided by Detailed Design and consists of a list of functional units whose cables cross hazardous area Zone 1, in order to define which functional units shall have individual earth fault detectors.

2.30. Technical Specifications

Technical Specifications issued by PETROBRAS shall be followed in Detailed Design phase. Detailed Design shall provide, in addition, the Technical Specifications for electrical equipment which are not covered by PETROBRAS documentation.

2.31. Data Sheets

Data Sheets issued by PETROBRAS shall be followed and updated in Detailed Design phase. Detailed Design shall provide, in addition, the Data Sheets for electrical equipment which are not covered by PETROBRAS documentation.

For PETROBRAS datasheet templates, refer to I-LI-3010.00-5140-700-P4X-001 - ELECTRICAL EQUIPMENT DATA-SHEET MODELS.

2.32. Material Requisitions/Purchase Orders

Material Requisitions issued by PETROBRAS shall be followed in Detailed Design phase. Detailed Design shall provide, in addition, the Material Requisitions for all electrical equipment and materials, which are not covered by PETROBRAS documentation.

2.33. List of Documents of Equipment

2.33.1. Manufacturers/Suppliers/Detailed Design shall prepare this list.

2.33.2. The list shall identify all documents to be prepared by manufacturers. Document number shall follow PETROBRAS NI-1710 standard rules. For each document listed, scheduled dates of issuance and status shall be indicated (for PETROBRAS approval or for information).

2.34. Test Reports and Certificates

2.34.1. These documents shall be issued by Detailed Design and by equipment Suppliers.

2.34.2. Purchase documents issued shall define which intermediate inspections, routine tests, type tests, string tests at factory and functional tests on board are required. These documents shall always be in accordance with PETROBRAS specifications, Classification Society and applicable standards.

2.34.3. Test programs and acceptance criteria shall follow the respective Technical Specification and the Classification Society rules. Test programs shall be submitted by Detailed Design/Supplier for PETROBRAS approval.

2.34.4. Reports of type and routine tests carried out after manufacture shall be forwarded for information, with the respective Classification Society approval/Certificate, as soon as they are carried out, whether or not they have been attended by an inspector appointed by PETROBRAS.

2.34.5. The same requirements of item 2.34.4 shall also apply to the functional tests carried out on the protective devices (circuit-breakers, relays, etc) installed inside all medium and low-voltage switchgears and MCCs.

2.35. List of Bonded Flanges and Piping

2.35.1. This document shall indicate flanges and piping that need bonding and those that do not need, and the reason they do not need them.

2.35.2. The criterion used for the need for bonding shall be indicated.

2.36. Grounding Resistance Measurement Reports

These documents shall be provided by the Detailed Design in Portuguese and English languages, in accordance with the requirements of items 3.13.1.16 and 3.13.2.6.

2.37. Electrical System Studies

Except as otherwise defined herein, the Electrical System Studies shall be carried out in accordance with the requirements of I-ET-3010.00-5140-700-P4X-006 - REQUIREMENTS FOR ELECTRICAL STUDIES FOR OFFSHORE UNITS.

2.37.1. General

2.37.1.1. The manufacturers of the electrical panels and generators (together called “manufacturers” for the purposes of item 2.37) shall, under the contractual scopes that concern each of them, carry out the Protection Preliminary Analysis (see item 2.37.2) and, in addition, validate the Final Protection Coordination Study (see item 2.37.3) issued by the specialist company (Consultant) to fulfil the requirements of I-ET-3010.00-5140-700-P4X-006 - REQUIREMENTS FOR ELECTRICAL STUDIES FOR OFFSHORE UNITS.

Notes: 1 - For the purposes of Protection Preliminary Analysis of item 2.37, “electrical panels” shall mean all switchgears and MCCs of the production unit, while “generators” shall mean main, hull, auxiliary and emergency generators.

2 - Intermediate and Final Protection Coordination Studies shall include, besides the equipment defined in Protection Preliminary Analysis, the UPSs (AC and DC) systems (including their distribution panels) and all other low-voltage systems.

3 - For the purpose of Intermediate and Final Protection Coordination Studies, “electrical panels” mean all electrical panels.

2.37.1.2. Main Contractor shall be solely responsible for collecting and providing all the information and data manufacturers need to accomplish the tasks under the scope of item 2.37.1.1.

2.37.1.3. Main Contractor shall gather all the information provided by the manufacturers and issue a single design document for each, the Protection Preliminary Analysis and the Validation of the Final Protection Coordination Study.

2.37.1.4. The direct communication and exchange of information between all parties involved (Petrobras, Consultant, Main Contractor, and manufacturers) shall at any time be allowed.

2.37.2. Protection Preliminary Analysis

2.37.2.1. This study shall be carried out in accordance with the requirements of IEEE Std C37.110, IEEE Std C57.13, IEC 61869-1 and IEC 61869-2.

2.37.2.2. The Protection Preliminary Analysis shall comprise a comprehensive technical memorandum of the calculations performed with the aim of sizing the current transformers (CTs) that will be installed inside the electrical panels.

2.37.2.3. The Protection Preliminary Analysis shall be issued prior to the beginning of the assembly stage of the electrical panels and shall provide at least the following information for each of the CTs to be sized:

a) Manufacturer’s name or trademark;

b) Manufacturer’s serial number;

c) Input data (full-load current and maximum short-circuit current at the point of installation);

d) Current ratio;

e) Accuracy class;

f) Continuous thermal current rating factor;

g) Short-time current ratings (mechanical and thermal);

h) Excitation curves on log-log coordinate paper, with square decades, plotted between excitation current and induced secondary voltage for each published ratio, extending from 1% of the relay accuracy rating secondary terminal voltage to a voltage that will cause an excitation current of five times rated secondary current;

Note: Curves shall also show the knee-point of the CT.

i) Outcomes of the saturation investigation (see item 2.37.2.4) and of the withstand capacity assessment (see item 2.37.2.5).

Note: Even though the ratings requested in paragraphs e) to g) are based on the provisions of IEEE Std C37.110 and IEEE Std C57.13, similar ratings of IEC 61869-1 and IEC 61869-2 may also be informed instead.

2.37.2.4. Also included in the scope of the Protection Preliminary Analysis is the investigation of the current transformers as to the possibility of saturation. This investigation shall be carried out in accordance with the specific requirements established in I-ET-3010.00-5140-700-P4X-006 - REQUIREMENTS FOR ELECTRICAL STUDIES FOR OFFSHORE UNITS.

2.37.2.5. CTs and relays shall also withstand the thermal and mechanical stresses imposed by the short-circuit currents to which they may be subjected over the entire lifetime of the production unit. An assessment of this withstand capacity shall also be carried out as part of the Protection Preliminary Analysis scope.

2.37.2.6. The manufacturers of the main generators shall in addition check the adequacy of the set of CTs belonging to the differential protection as to possible difference between the transient responses to a fault outside the zone of protection at the primary side (false differential current).

2.37.3. Validation of the Final Protection Coordination Study

2.37.3.1. A technical memorandum shall be issued with the aim of validating and fully detailing the Final Protection Coordination Study carried out by the specialist company (Consultant) under the scope of I-ET-3010.00-5140-700-P4X-006 - REQUIREMENTS FOR ELECTRICAL STUDIES FOR OFFSHORE UNITS.

2.37.3.2. The technical memorandum to which item 2.37.3.1 refers shall encompass at least:

a) Validation of all protective device settings.

The settings provided by Consultant in the Final Protection Coordination Study shall be either confirmed or revised. They shall also be updated to match the actual settings of the protective devices supplied.

b) Update of the time-current curves (TCCs) related to those protective devices whose settings have been revised.

The TCCs shall be updated by means of a computer program.

c) Provision of tables with the actual settings of the protective devices supplied.

The tables shall present only those settings available for configuration through either the human-machine interface or the specific setup software of the purchased protective devices.

d) Provision of logic selectivity diagrams.

The logic selectivity diagrams shall be provided for the low-voltage switchgears and for the medium-voltage switchgears and MCCs. Each diagram shall indicate all tripping and logic signals sent by and exchanged between the relays that participate in the logic selectivity scheme, as well as the wait times associated to the delay in the transmission of the logic signals from the devices affected by a given fault to the upstream stages.

For each busbar section of the said electrical panels, faults shall be simulated at the following points: downstream of an outgoing circuit-breaker, busbar compartment, and upstream of an outgoing circuit-breaker.

2.37.3.3. Manufacturers shall prepare the functional logic and protection setting files, which shall be later on submitted to Petrobras for approval.

2.38. Risk Analysis and Reliability Study

2.38.1. The basic purpose of this study is to analyse the interactions existing between the Electrical System, Automation and Control System, Safety Systems and Unit movements, proposing safer and more reliable alternatives. This study is not required for projects related only for topsides installations when Hull installations are out of scope.

2.38.2. This study shall include at least:

a) Analysis of interfaces between Electrical and Automation systems for each sub-system analysed;

b) Analysis of signal flow between Electrical and Automation systems for each sub-system analysed;

c) Analysis of controllers programming for control of electrical equipment;

d) Analysis of control logics of valves actuation for load and unload of crude oil tanks of vessel, regarding electrical aspects;

e) Analysis of control logics of ballast and bilge systems, regarding electrical aspects;

f) Analysis of proper and safe operation of electrical equipment according to Unit inclinations;

g) Analysis of proper and safe operation of electrical equipment according to emergency conditions (ESD, flood, green-water, fire and gas detection, failure of A&C, failure in compressed air, etc.), including possibility of manual local operation;

h) Analysis of configuration of UPS and Battery Charger systems;

i) Analysis of impact of electrical failure in one system, regarding propagation for other systems;

j) Analysis of operability independence of Emergency Generation, Essential Panels, UPSs, and Battery Chargers systems.

2.39. Instruction Manuals

2.39.1. Instruction manuals shall comply with the corresponding requirements of NR-12.

2.39.2. These documents shall be issued in both Portuguese and English language. The translation for Portuguese language shall be issued by Brazilian sworn public translator.

2.39.3. The manuals shall contain at least the following information:

a) Technical specifications of equipment and of all components and accessories required in accordance with all requirements of the original tender as approved, and such revisions as have been made thereon at time of technical clarification and/or formal technical opinions;
b) Data sheet duly filled out "as purchased" and/or "as built";
c) Reference standards related to the equipment;
d) Definitions and terms;
e) Information about components sub-suppliers;
f) Warnings and cautions;
g) Symbols for warnings, dangerous and safety;
h) Integrity;
i) Risks;
j) General view of equipment;
k) Procedures for storage;
l) Procedures for assembly;

m) Procedures for transport;
n) Procedures for installation;
o) Procedures for commissioning;
p) Procedures for operation;
q) Original adjustment settings;
r) List of components, including item, description, draw, unit, quantity, and part number;
s) List of spare parts;
t) List of necessary tools and equipment for maintenance, assembly, and disassembly;
u) Procedures for predictive, preventive, and corrective maintenance of equipment and for all requested accessories;
v) Procedures for cleaning;
w) Procedures for deactivation and disposal;
x) Technical catalogues with all characteristics data of accessories requested "as built";
y) Records of all tests and trials to which equipment was subjected after manufacture;
z) Detailed drawings of equipment, including electronic circuit diagrams, functional diagrams, etc;
aa) Troubleshooting and solutions;
bb) Conformity Certificates complying with INMETRO Portaria n° 115, Mar 21st 2022, for all electrical equipment specified for installation in hazardous areas;
cc) Ladder Diagram.

2.39.4. Instruction manuals shall be issued for all electrical equipment and components, mainly:

a) Main, Hull, Auxiliary and Emergency generators, including their drivers, control panels and accessories;
b) Medium and Low-Voltage Motors;
c) Firefighting pumps power and control panels;
d) Ballast and bilge pumps power and control panels;
e) UPSs, battery chargers, rectifiers, inverters, and batteries;
f) Variable speed drivers and soft-starters;
g) Capacitors, Zorcs, lightning arresters;
h) Power transformers, medium-voltage reactors;
i) Medium and Low-Voltage switchgears and motor control centers;
j) Power Management System (PMS);
k) Short-circuit Current Limiter Devices;
l) Protection relays, insulation monitoring devices, measurement devices and power quality measurement systems (PQMS);
m) Protection relays configuration software;
n) Circuit-breakers, power fuses, contactors, etc.;
o) Electrical system automation devices (switches, computers, controllers, etc.);
p) Software for the configuration of the electrical system automation.

2.40. Configuration Tables

2.40.1. It shall be issued configuration tables with "as built" adjustment settings of all parameters for all equipment or device with configuration capability, such as soft-starters, VSDs, MMRs, IRs, battery-chargers, rectifiers, AVRs, PMS, UPSs, etc.

2.40.2. The configuration tables shall indicate the respective configuration softwares to be used.

2.40.3. The configuration tables shall be issued in printable media and in digital media (to upload service), compatible with the respective configuration software.

2.40.4. All configuration softwares shall be supplied.

2.41. Electrical System Descriptive Memorandum

2.41.1. This document shall have a complete description of the electrical system, including at least:

a) Premises;

b) Description of generation systems;

c) Description of distribution systems and voltage levels;

d) Description of uninterruptible power supply systems;

e) List of rated values of parameters and tolerances related to electrical system;

f) List of guaranteed values of parameters related to electrical system;

g) Description of lighting systems;

h) Description of grounding systems;

i) Description of operational instructions (including starting sequences, stopping sequences, load transference procedures, manual operation, automatic operation, remote operation, emergency procedures, etc.);

j) Description of interlocks (including hardwired and electronic interlocks);

k) Description of protection criteria;

l) Description of synchronism criteria;

m) Description of load sharing criteria;

n) Description of load shedding criteria;

o) Description of automation of electrical system (including architecture, hardware, software, table of I/O variables, etc.);

p) Description of interfaces with A&C;

q) Description of alarms;

r) Description of the procedures needed to bring the main electrical system into operation from a "dead ship" condition ("dead-start" procedures – "dead ship" as defined in IEC61892-1);

s) Description of the procedures needed to bring the main electrical system into operation from a "blackout" condition ("black-start" procedures – "blackout" as defined in IEC61892-1);

t) Information defined in 2.42.2q).

2.41.2. This document shall be issued in both Portuguese, in compliance with Brazilian standards NR-12 and NR-37, and English language.

2.42. Legal Documentation

2.42.1. The Detailed Design shall provide complete documentation according to Brazilian laws, including NR-10 requirements. This documentation shall be issued in Brazilian Portuguese language, in compliance with the requirements of NR-12 and NR-37 and signed by legitimately qualified personnel.

2.42.2. This documentation shall be kept organized in both a folder and electronic media comprising the NR-10 Databook, in order to facilitate future audits, and shall include the items listed below and all items foreseen in NR-10:

a) ART (Anotação de Responsabilidade Técnica) (Technical Responsibility Record) according to Brazilian laws;

Notes: 1 - The ART shall inform the data required by Brazilian laws about the person how is technical responsible for the electrical design, detailing, construction and installation of the platform.

2 - The field "*Observações"* (Notes) of the ART shall inform detailed data about the platform (name, or code), the construction yard, the country of the construction yard and any other relevant data to tie the ART with the project.

b) One-line diagrams (in Portuguese and English languages) of electrical installations and equipment;

c) Specification of both the safety grounding and bonding system and the electrical system grounding;

d) Specification, tests, inspections, and safety requirements of all electrical equipment;

e) Protection Coordination Studies, in accordance with item 2.37 of this specification and the corresponding requirements of I-ET-3010.00-5140-700-P4X-006 - REQUIREMENTS FOR ELECTRICAL STUDIES FOR OFFSHORE UNITS;

f) Manuals with implemented technical and administrative procedures and instructions for safety and health regarding electrical equipment and installations, and a description of the existing control measures.

g) Studies, inspections, and measurements documentation regarding lightning protection system (SPDA), to be issued in both Portuguese and English languages;

h) Studies, inspections, and measurements documentation regarding electrical safety grounding, to be issued in Portuguese and English languages;

i) Specifications for personal and group protection equipment and tooling, applicable according to NR-10;

j) Supporting documentation regarding workers qualification, clearance, training and authorization of the workers and their performed trainings;

k) Electrical insulation performed test reports regarding personal and group protection equipment;

l) Certificate of Conformity for all Ex electrical apparatus installed in hazardous and non-hazardous areas (refer to item 2.24), according to INMETRO Portaria n° 115, Mar 21st 2022;

m) List of all Ex electrical apparatus, including the identification of the components, type of Ex protection, characteristics, nameplate, marking label, certification body, Ex conformity certificate number and validity, name of entity that issued the certificate;

n) Technical reports of the initial inspection and inspections thereafter, including recommendations and a schedule of adequacy comprising items f) to m);

Note: The inspections related to Ex apparatus shall comply with requirements of IEC 60079-17. All inspected items shall be included in the report with the respective inspection schedule tables.

o) Area Classification Plan (in Portuguese and English languages) approved by Classification Society, including Area Classification Data List;

p) Arc-flash (Incident Energy) study, according to IEEE Std 1584 (see I-ET-3010.00-5140-700-P4X-006 - REQUIREMENTS FOR ELECTRICAL STUDIES FOR OFFSHORE UNITS);

q) Electrical system descriptive memorandum including items defined in item 2.41 and the following safety items:

- Specification of the features regarding protection against electrical shock, burns and other additional risks;
- Position status indication of the electrical circuits switching devices;
- Description of equipment and electrical circuits identification system, including switching, control, protection and interlocking devices, cables and own equipment and structures, with the definition of how the physical application of the identification shall be applied;
- Recommendations of restrictions and warnings regarding access of people to installation components;
- Precautions and warnings that are applicable due to external factors;
- Functional principle of the protection devices, included in the project, that designated for personal protection;
- Description of the compatibility of the protection devices with the electrical installation.

3. GUIDANCE FOR DETAILED DESIGN

3.1. Minimum Requirements for Electrical System

3.1.1. BIDDER shall submit to PETROBRAS approval alternative measures or specifications needed to comply with the minimum requirements stated below.

3.1.2. General

3.1.2.1. Voltage and frequency shall vary within the corresponding steady-state and transient limits established in IEC 61892-1 and IEC 61892-3. These standards shall also apply to both the maximum permissible voltage unbalance and the allowable cyclic voltage variation.

3.1.2.2. The voltage distortions and the notch depth shall remain within the following limits, as stated in IEEE 519:

a) Total Harmonic Distortion (THD):

- For voltages up to 1 kV – 8%;
- For voltages above 1 kV and up to 69 kV – 5%;

b) Individual Harmonic Distortion:

- For voltages up to 1 kV – 5%;
- For voltages above 1 kV and up to 69 kV – 3%;

c) Notch depth – 20%.

3.1.2.3. The electrical system shall be so designed that the expected motor starting events are successfully completed without exceeding, at any time during the acceleration process, the following allowable voltage drop limits: 15% (of the system rated voltage) at the busbar where the starting motor is connected and 20% (of the equipment nameplate voltage) at the terminals of all motors.

3.1.2.4. The electrical system shall be capable of withstanding, without exceeding the limits to which item 3.1.2.3 refers and under predicted operational conditions, the starting of at least the following motors (one at a time):

a) Gas Compressor Motors or Main Injection Water Pump Motors

Operational condition – Two Main Turbogenerators are connected to the main switchgear prior to the beginning of the starting process and all other generators turned off.

Note: The use of the AVR field forcing signal of the generators is allowed.

b) Main Turbogenerator Start-up Motors

Operational conditions:

b.1) The Auxiliary Generator is connected to the auxiliary switchgear and delivers 65% of its rated power prior to the beginning of the starting process;

b.2) The Emergency Generator is connected to the auxiliary switchgear and delivers 65% of its rated power prior to the beginning of the starting process.

3.1.2.5. Unless otherwise stated in PETROBRAS documentation, motors other than those mentioned in paragraph a) of item 3.1.2.4 shall successfully start even when only one Main Turbogenerator is connected to the electrical system prior to the beginning of the starting process.

3.1.2.6. The calculated short-circuit levels (thermal and peak) shall lie below the rated withstand short-circuit currents of the panels for all allowed operational conditions.

3.1.2.7. The incident energy due to arc-flash internal to all electrical panels, calculated according to IEEE Std 1584 at working distance, shall lie below 8cal/cm².

Notes: 1 - Except voltage variation (item 3.1.2.1), all performance requirements defined in item 3.1.2 are applicable for:

- all normal operational conditions;
- all single failure contingency conditions (failure in one main generator, failure in one distribution transformer in each distribution level, failure in one main distribution cable in each distribution level, failure in CDC in each distribution level, etc.);
- all specific contingency condition defined in items related to electrical studies.

2 - The voltage tolerance (item 3.1.2.1) operational requirements defined by IEC 61892-1 shall be complied with in all normal operational conditions;

3 – The voltage tolerance (item 3.1.2.1) withstand requirements defined by IEC 61892-1 shall be complied with in all single failure contingency and all specific contingency conditions.

3.1.3. Specific Requirements for Essential and Emergency Systems

3.1.3.1. In case of failure of the main generation, the emergency generator shall automatically start and, within 45s, provide a stable supply of energy to all the essential loads.

3.1.3.2. The emergency generator shall be sized to simultaneously supply:

a) Two sets of redundant emergency UPSs or battery-chargers turned on, each one delivering the power demanded (not the rated power of) by 50% of the loads connected to the downstream panels and the batteries in float operation. For this calculation, spare demand for future UPS loads shall not be considered;

b) Non-redundant emergency UPSs or battery-chargers delivering the power demanded by (not the rated power of) both 100% of the loads connected to the downstream panels and the batteries in float operation;

c) The power demanded by one electrical firefighting system (water mist or similar) for machinery hoods of gas turbines (fire only in one hood);

d) The power demanded by all power and control panels for diesel-hydraulic fire-fighting pumps;

e) The power demanded by the number of electrical fire-fighting pumps needed to comply with the operational configuration defined by the design, in accordance with the Safety requirements;

f) The power demanded by the number of foam concentrate pumps (for fire-fighting) needed to comply with the operational configuration defined by the design, in accordance with the Safety requirements;

g) The power demanded by one purge exhaust fan for machinery hoods of gas turbines (gas leakage only in one hood);

h) The power demanded by the number of bilge pumps for engine room needed to comply with the operational configuration defined by the design, in accordance with the requirements of Safety and Marine Systems;

i) The power demanded by one diving system (services being carried out at one diving station only);

j) The power demanded by one of the sets of electrical air compressors and electrical air dryers;

k) 42% of the rated power of each redundant essential lighting transformer (each transformer is rated for 120% of the total load);

l) The power demanded by the number of emergency electrical sea water lift pumps needed to comply with the operational configuration defined by the design, in accordance with the requirements of Safety, Process and Marine Systems;

m) The power demanded by the number of emergency electrical cooling water pumps needed to comply with the operational configuration defined by the design, in accordance with the requirements of Safety, Process, HVAC and Marine Systems.

Notes:

1) All electrical jockey pumps have been deemed to consume no power, since they do not operate after main fire-fighting pump start;

2) All rescue boat davits, lifeboat davits and liferaft davits have been deemed to consume no power, due to their intermittent and sparse operation;

3) All emergency power packs for cranes have been deemed to consume no power, because the operation in emergency condition, if needed, is carried out just to drive the crane to a safe position.

3.1.3.3. Emergency loads shall have redundant separated power supplies, from different sources, with voltages according to I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS, with no common mode failure.

3.1.3.4. It shall be possible to energize simultaneously all emergency consumers of each emergency system under one of its respective UPSs (AC or DC), with no failure or trip. To guarantee this requirement, all protective devices of these emergency systems, including devices internal to UPSs, battery-chargers, distribution panels and consumers, of the emergency loads distribution systems shall be selected considering, at least:

- The rated current and the demanded current of each consumer;
- The demanded current of each circuit;

- The short-circuit current of each circuit;
- The in-rush current of each consumer, to avoid trip due to individual energization of each load;
- The simultaneous in-rush current of all consumers in each circuit, to avoid trip due to collective energization of each circuit;
- The simultaneous in-rush current of all consumers in each UPS (AC, or DC) system, to avoid collective trip due to collective energization of all loads.

Notes: 1 - Internal power supplies of emergency consumers use to have high in-rush current. Selection of low in-rush power supplies make it easy the selection and coordination of the distribution system;

2 - The requirement of no failure or trip when energizing all emergency consumers of each emergency system includes proper operation of all internal devices (rectifiers, inverters, static-switches, etc.) of UPSs (AC or DC);

3 - The circuit-breakers' trip curves shall be selected in order to coordinate the proper operation (without trip) due to in-rush currents, with the suitable protection for short-circuit.

3.2. Electrical System Rated Voltages and Grounding

3.2.1. The Electrical System of the UNIT shall use the rated voltages and grounding system defined in Table 1:

Table 1 – System Rated Voltages and Grounding Systems

System Rated Voltage	Grounding System	Remark
13800Vac	High Resistance	Grounded at Generators neutral point, using grounding resistors with grounding transformers.
4160Vac/6600Vac (1)	High Resistance	Grounded at Generators (if any) neutral point, using grounding resistors with grounding transformers. Grounded at distribution transformers neutral point.
480Vac/690Vac (1)	Ungrounded (2)	
220Vac	Ungrounded	
220/127Vac	Solidly Grounded	Grounded at lighting transformers neutral point. Only for distribution inside accommodation module.
220Vdc	Ungrounded	
125Vdc	Ungrounded	
120Vac	Solidly grounded	Only for control inside LV MCCs (except for the Turbogenerators' ones)
48Vdc	According to telecommunication documentation	Only for telecommunication loads
24Vdc	Ungrounded	

Notes: 1) The choices for a rated voltage of 6600Vac or 4160Vac and for a rated voltage of 480Vac or 690Vac is indicated in the specific design documentation;

2) For SS and Fixed Units, this grounding system shall be with high resistance.

3.2.2. The grounding resistors shall comply with the requirements of I-ET-3010.00-5140-700-P4X-007 - SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS. The value of the resistance and the tap selection shall be defined by Detailed Design.

3.3. Electrical Equipment Rated Voltages

3.3.1. The selection of rated voltage of electrical equipment shall follow the criteria defined in Table 2:

Table 2 - Rated Voltage for Electrical Equipment

Equipment	Rated Voltage N º Phases or Poles	Remarks
Main Generators	13800Vac 3ph	
Motors with rated power above 1200kW	13800Vac 3ph	
Motors with rated power above 150kW up to 1200kW (1) (2)	4000Vac/6300 Vac 3ph	(3)
Motors with rated power above 400kW up to 1500kW using VSD (5)	4000Vac/6300 Vac 3ph	(3)
Resistive loads of Heaters	690Vac 3ph	(4)
Resistive loads with rated power above 4kW	480Vac/690Vac 3ph	(3)
Power socket-outlets	480Vac 3ph	10)
Motors with rated power up to 150kW using direct-on-line start	440Vac/660Vac 3ph	(3)
Motors with rated power up to 400kW using soft-starter or VSD	440Vac/660Vac 3ph	(3)
Motors and loads for refrigerant chambers, galleys and laundries	220Vac 3ph	
Resistive loads with rated power up to 4kW	220Vac 2ph	
Anti-condensation heaters	220Vac 2ph	Fed from normal panels
General use socket-outlets for external areas	220Vac 3ph	
General use socket-outlets for internal and external areas	220Vac 2ph	(6)
Fan coil motors with rated power up to 0.5kW	220Vac 2ph	Fed from lighting panels
Normal lighting	220Vac 2ph	
Essential lighting	220Vac 2ph	
External power source for control of switchgears, medium-voltage MCCs and auxiliary MCCs for main generation	220Vdc 2p	Fed from battery-chargers

Equipment	Rated Voltage N º Phases or Poles	Remarks
External power source for A&C control panels, remote I/O panels and workstations	220Vdc 2p	Fed from battery-chargers (7)
Subsea Master Control Stations	220Vac 2ph	Fed from UPS
Emergency Lighting	220Vdc 2p	Fed from battery chargers
Socket-outlets for accommodations, galleys and maintenance rooms	127Vac 1ph	(8)
Navigation aid warning lights	125Vdc 2p	
Motors of post lubrication pumps for gas compressors and main generators	125Vdc 2p	If necessary
Internal control circuits of switchgears, medium voltage MCCs and auxiliary MCCs for main generation	220Vdc 2p	Fed from battery-charger
Internal control circuits of low-voltage MCCs	120Vac 1ph	Fed from internal VT
Telecommunication equipment	220Vac 2ph 48Vdc 2p or 24Vdc 2p	(9)
Gas and fire detection sensors	24Vdc 2p	
A&C instruments	24Vdc 2p	

Notes:
1) There may be some loads (typically Package loads) above 150kW rated 440Vac/660Vac (motors) or 480Vac/690Vac (non-motors) due to PACKAGER standard;
2) The limit of 1200kW shall be replaced by 1800kW in systems with rated voltage 6600V. For sea-water lift pumps with submersible motors, this limit may be surpassed, as defined in each Project specific documentation;
3) The choices for a rated voltage of 6300Vac or 4000Vac, for a rated voltage of 440Vac or 660Vac, and for a rated voltage of 480Vac or 690Vac is indicated in the specific design documentation;
4) Usually high power heaters, with limits according to Project specific documentation;
5) There may be some motors (typically Package ones) above 355kW rated 440Vac/660Vac due to PACKAGER standard;
6) Socket-outlets for general service shall be fed from normal lighting panels or essential lighting panels, depending on their location. See I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS for details;
7) Some A&C panels are not fed from battery-chargers. Refer to I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS for more details;
8) This voltage shall not be allowed outside accommodation module. Maintenance rooms shall also have socket-outlets in 220Vac;

9) Telecommunication equipment in 220Vac are fed by normal, essential and emergency panels. Refer to I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS for further details;

10) See item 3.15.21 for Electrical Workshop additional socket-outlet.

3.4. Loads Distribution

3.4.1. Unless otherwise stated in Data-Sheet or in electrical load balance documentation, the following loads shall be fed from low-voltage MCCs:

a) motor loads up to 55kW with direct-on-line start. In case of package units, depending on PETROBRAS approval, it may be accepted motor loads with power higher than 55kW, since the voltage at panel busbar does not fall below 85% of rated voltage during direct-on-line motor start;
b) motor loads up to 90kW with soft-starter or VSD;
c) non-motor loads up to 150kVA.

3.4.2. Unless otherwise stated in Data-Sheet or in electrical load balance documentation, the following loads shall be fed from low-voltage CDCs:

a) motor loads from 56kW up to 150kW with direct-on-line start. In case of package units (e.g.: motors for inert gas generators, air compressors, cranes, hydraulic power units for pull-in, hydraulic power units for subsea system, hydraulic power units for offload tandem system, hydraulic power unit for chain jacks, etc.), depending on PETROBRAS approval, it may be accepted motor loads with power higher than 150kW, since the voltage at panel busbar does not fall below 85% of rated voltage during direct-on-line motor start;
b) motor loads up to 355kW with soft-starter or VSD [(1)];
c) non-motor loads up to 670kVA.

Notes: 1 - This is a recommended practice. Other values could be accepted since the voltage total harmonic distortion THD at the Panel busbar does not exceed 5% and the individual harmonic voltage components does not exceed 3%;

2 - Exceptions shall be submitted to PETROBRAS for approval.

3.4.3. Unless otherwise stated in Data-Sheet or in electrical load balance documentation, loads with power above 150kW up to 1200kW (or 1800kW, in case of 6600V) shall be fed from medium-voltage MCCs.

3.4.4. Unless otherwise stated in Data-Sheet or in electrical load balance documentation, loads above 1200kW (or 1800kW, in case of 6600V) shall be fed from medium-voltage CDCs.

3.4.5. Redundant electrical loads shall be fed by different panels or busbars in order to avoid load unavailability caused by a common fault.

3.4.6. When the electrical loads are not redundant, it shall be fed by the panel or busbar with highest availability.

3.4.7. Detailed Design shall perform properly the electrical installed load balance between panels or busbars.

3.4.8. Main equipment and their auxiliary loads shall be fed by the same electrical source. For example: the auxiliary load of a certain main equipment shall be fed:

- by the same panel that feed that main equipment;
- by a panel fed directly by the panel that feeds the main equipment or;
- by a panel fed by a transformer which primary winding is fed by the panel that feeds the main equipment.

3.4.9. Detailed Design shall balance properly the quantity of functional units among redundant panels and busbars.

3.4.10. Installed power and demanded power shall be balanced between busbars of switchgears with the same function (complementary switchgears of one part of Electrical System).

3.4.11. Installed power and demanded power shall be balanced between MCCs with the same function (complementary MCCs of one part of Electrical System).

3.4.12. Main and stand-by (or redundant) loads shall be installed in separate busbars or MCCs.

3.4.13. Ballast and deballast pump electrical motors shall be fed by different busbars or panels in order to ensure that a single failure in one busbar or panel does not impact the ballast and deballast process.

3.4.14. Detailed Design shall perform properly the electrical installed load balance between redundant transformers windings.

3.5. Electrical Motors Drive

3.5.1. Unless otherwise stated in Project documentation, electric motors shall use direct-on-line starting system.

3.5.2. Electronic soft-starters or variable speed drives (VSD) shall be used as auxiliary starting devices when the voltage-drop (with direct-on-line start) at the busbar of the panel that feeds the motor surpasses the limit of 15% of the rated voltage of the panel.

3.5.3. Electronic soft-starters or variable speed drives (VSD) shall be sized taking account losses in motors driven by them (considering motor rated power) and their interconnecting power cables.

3.6. Transformers Sizing

3.6.1. The rated power indicated for power and lighting transformers in PETROBRAS documentation are preliminary and estimated. Detailed Design shall verify through more detailed information about the loads, the transformers final loads and shall modify the rated power and impedances whenever necessary, based on Detailed Design Electrical Studies recommendations.

3.6.2. Power Transformers are transformers with secondary voltage (and tertiary voltage, if applicable) greater than 220VAC, and Lighting Transformers are transformers with secondary voltage in 220VAC.

3.6.3. Rated power sizing rules for power transformers:

a) Case 1 - Two two-winding power transformers feeding one switchgear with two busbars:

Each transformer shall be sized to supply 110% of the maximum switchgear load demand. Unless otherwise stated in specific Project Documentation, this shall be accomplished without the aid of the transformer forced air cooling system.

b) Case 2 - Two three-winding power transformers feeding two switchgears with two busbars each:

The secondary and tertiary sides of each transformer shall be sized to supply 110% of the maximum load demand of the corresponding downstream switchgears. Unless otherwise stated in specific Project Documentation, this shall be accomplished without the aid of the transformer forced air cooling system;

For both cases, the maximum switchgear load demand shall be taken as the power consumption of the switchgear with the tie circuit-breaker closed, being one of the supplying transformers out of service.

3.6.4. Lighting transformers rated power sizing rules:

a) Case 1 - Two lighting transformers feeding one switchboard with two busbars:

Each lighting transformer shall be sized to feed 120% of the switchboard load demand on a contingency condition (“L” configuration with the redundant transformer out of service.

b) Case 2 - One lighting transformer feeding one switchboard:

The lighting transformer shall be sized to feed 120% of the switchboard load demand.

3.6.5. Unless otherwise stated in project documentation, transformers rated power shall be sized considering none electrical demand due to future loads.

3.6.6. Transformers that feed only non-linear loads (rectifiers, VSD-FCs, UPSs, thyristors, etc.) shall comply with the requirements of IEC 61378-1.

3.6.7. Transformers dedicated to feed line commutated converters (LCI) shall comply with the requirements of IEC 60146-1-3.

3.6.8. In case of systems where harmonic contents are expected (current distortion greater than 5%), non-dedicated transformers that feed linear and non-linear loads shall be sized with consideration to the recommended de-rating of the following standards, prevailing the worst case:

a) IEC 60076-12 – Power Transformers – Part 12: Loading Guide for Dry-Type Power Transformer;

b) C57.110 - IEEE Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability when Supplying Nonsinusoidal Load Currents.

3.7. Medium and Low-Voltage Switchgears and MCCs Rated Current Sizing

3.7.1. Rated Current of the main switchgear shall be sized considering at least the current of two main generators in a scenario where these main generators in one busbar feed all loads of the other busbar. This criteria shall only be applied for offshore units with 3 (three), or 4 (four) main generators.

3.7.2. Rated Current of the Switchgears fed by power transformers shall be sized in order to be capable to feed 125% of upstream power transformer secondary or tertiary rated power without forced ventilation.

3.7.3. Rated current of redundant MCCs shall be sized so that each MCC is capable of feeding the power demanded by two (2) MCCs plus a contingency of 25%.

3.7.4. Rated current for groups of 4 (four) redundant MCCs shall be sized so that each MCC is capable of feeding half of the power demanded by four (4) MCCs plus a contingency of 25%.

3.7.5. Rated current for groups of 6 (six) redundant MCCs shall be sized so that each MCC is capable of feeding 1/3 of the power demanded by six (6) MCCs plus a contingency of 25%.

3.7.6. Unless otherwise stated in project documentation, rated current of switchgears and MCCs shall be sized considering none electrical demand due to future loads.

3.8. UPSs, Battery Chargers and Batteries Sizing

3.8.1. For UPSs, battery-chargers and batteries sizing criteria, see I-ET-3010.00-5140-714-P4X-001 - SPECIFICATION FOR ELECTRICAL BATTERIES FOR OFFSHORE UNITS, I-ET-3010.00-5140-773-P4X-001 - SPECIFICATION FOR D.C. UPS FOR OFFSHORE UNITS, I-ET-3010.00-5140-773-P4X-002 - SPECIFICATION FOR GENERIC D.C. UPS FOR OFFSHORE UNITS and I-ET-3010.00-5140-773-P4X-003 - SPECIFICATION FOR A.C. UPS FOR OFFSHORE UNITS.

3.9. Cable Sizing

3.9.1. Cables shall be sized by the criteria of current carrying capacity, voltage drop and short-circuit, prevailing the one that leads to the biggest rated cross-section.

3.9.2. Current Carrying Capacity Criteria

3.9.2.1. Cables shall be sized in function of the rated current of equipment (motors, generators, etc.) and related to thermal solicitations under normal operational conditions, in order to not exceed the maximum permitted temperature. For panels incoming cables sizing see 3.9.2.2.

3.9.2.2. Incoming cables of panels directly fed from transformers (cables at secondary/tertiary side of transformers) and outgoing cables of panels that feed the transformers (cables at primary side of transformers) shall be sized in function of the rated current of the transformer winding (added 25%, unless otherwise stated in project documentation) and related to thermal solicitations under normal operational conditions, in order to not exceed the maximum permitted temperature. Incoming cables of panels not directly fed from transformers shall be sized in function of the panel busbar rated current and related to thermal solicitations under normal operational conditions, in order to not exceed the maximum permitted temperature.

3.9.2.3. The cable rated capacity shall be referred at the following installation conditions:

a) Cables installed outdoors, on trays;
b) Environmental temperature of 45°C or higher if required by Classification Society;
c) Correction factors for different ambient air temperature according to IEC 61892-4;
d) Cables grouping correction factors according to IEC 61892-4;
e) Current carrying capacity in continuous service at maximum rated conductor temperature of 90ºC, according to IEC 61892-4 and Classification Society requirements.

3.9.3. Voltage Drop Criteria

3.9.3.1. The reference parameter for this sizing is the percent voltage drop expressed on the following formulas:

a) $\Delta V[\%] = \dfrac{\sqrt{3}.I.l.(R.\cos\varphi + X.sen\varphi).100}{V}$, for three phase circuits;

b) $\Delta V[\%] = \dfrac{2.I.l.(R.\cos\varphi + X.sen\varphi).100}{V}$, for single phase circuits;

c) $\Delta V[\%] = \dfrac{2.I.l.R_{dc}.100}{V}$, for direct current circuits.

Where: V = system rated voltage (V);
I = current to be carried (A);
l = circuit length, from feeding point up to the load (km);
R = resistance in A.C. system at a conductor temperature of 90°C (Ohm/km);
X = line inductive reactance (Ohm/km);
$cos\ \varphi$ = load power factor;
R_{dc} = resistance in D.C. system at a conductor temperature of 90°C (Ohm/km);

3.9.3.2. Cables shall be conveniently sized in order to comply with the maximum permitted voltage drop values, being necessary to verify if equipment terminal voltages are within suitable values.

3.9.3.3. The admissible voltage drop in circuits, to calculate the cables' cross-sections, when conductors are carrying the maximum current under normal conditions of service, shall be based on Figure 3.

3.9.3.4. Alternative values could be used since the total voltage drop for each subsystem does not exceed the values of Table 3.

3.9.3.5. The voltage drop limits of Table 3 and Figure 3 are intended for cable sizing and shall not be considered during load-flow calculation.

Table 3 – Voltage Drop Limits for Cable Sizing

VOLTAGE DROP LIMITS FOR CABLE SIZING [%]			
SUBSYSTEM	Load Type		
	Normal	Essential	Emergency
24VDC or 48VDC (1)	-	-	10
125VDC or higher (1)	-	-	6
220VAC (from UPS) (2)	-	-	5
120 to 240VAC (3)	6	5	-
380V to 690V Systems (4)	6	4	-
4160V to 6600V Systems (5)	4	-	-
13800V Systems (6)	3	-	-

NOTES:
1) Limits considering the whole circuit from battery terminals to loads' terminals and considering the current correspondent to the condition of batteries in their final discharge voltage supplying the circuit (load modelled as constant power);
2) Limits considering circuits from UPS terminals to loads terminals;
3) Limits considering circuits from lighting transformer secondary terminals to terminals of the last lighting fixture of the circuit;
4) Limits considering circuits from transformers secondary terminals to loads terminals in LV MCCs, not including incoming reactors of MCCs;
5) Limits considering circuits from transformers secondary terminals to loads terminals;
6) Limits considering circuits from generators terminals to loads terminals in 13.8kV CDCs.

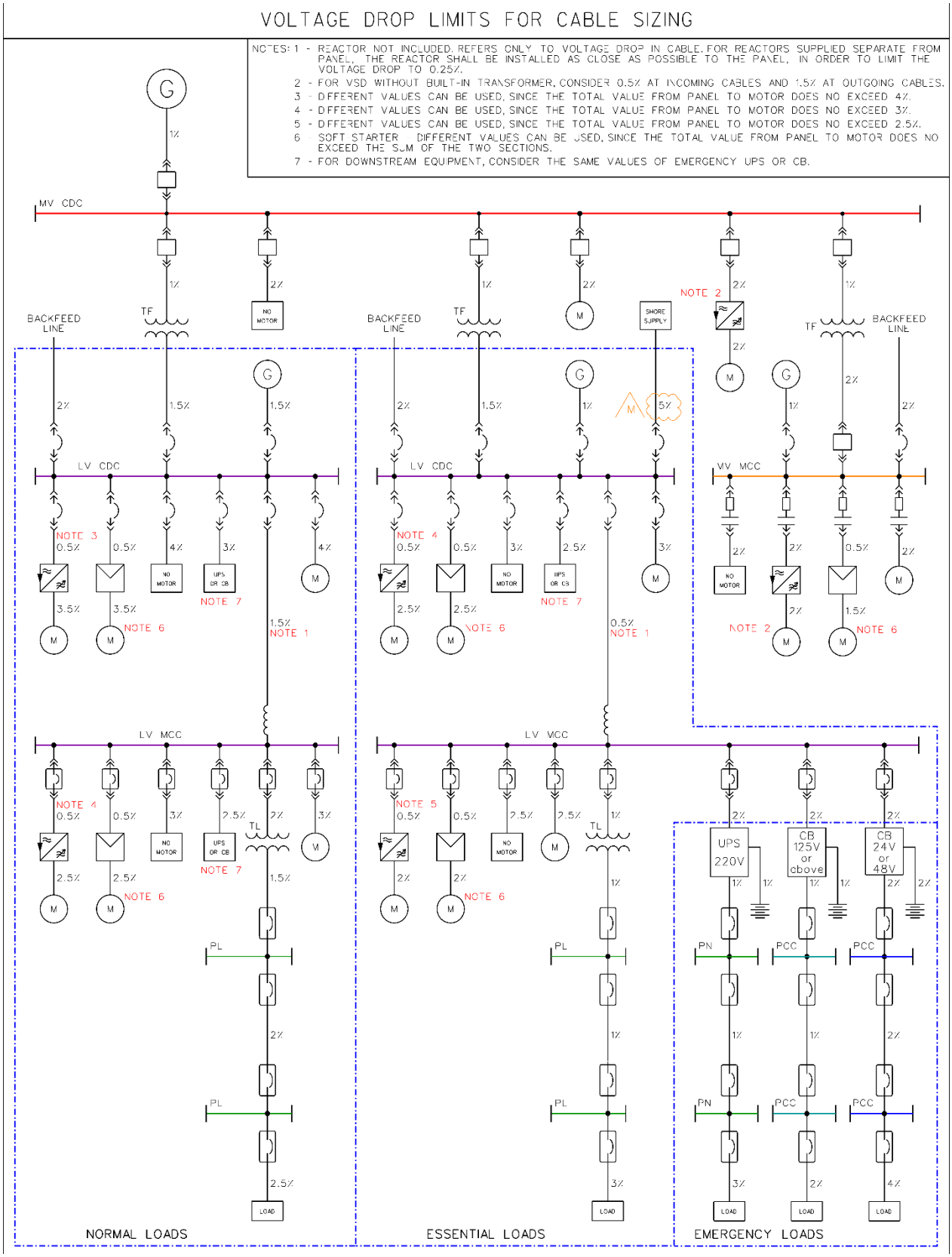


Figure 3 - Voltage Drop Limits for Cable sizing

3.9.4. Short-Circuit Criteria

3.9.4.1. This sizing allows determining:

a) The maximum short-circuit current permitted on a cable;
b) The necessary conductor section to withstand a particular short-circuit condition and;
c) The maximum time that a cable can operate, with short-circuit current, without insulation damage.

3.9.4.2. The minimum conductor cross-section (mm²) shall be calculated with the expression:

$$S > \frac{\sqrt{I^2.t}}{K}$$

Where: K = 143, for EPR or XLPE insulated cable;
I = Calculated thermal equivalent short-circuit current (A) (I_{th} according to IEC 60909) at the end of the cable, corresponding to the protection device actuation time (t);
t = protection device actuation time, for current I (s). According to estimated clearing times of protective devices of IEEE Std 242.

3.9.4.3. The current limitation effect caused by the circuit impedance and the I²t limiting capacity of the protection device shall be considered.

3.9.4.4. The cable external temperature under short-circuit conditions shall be limited to 250ºC.

3.9.4.5. The conductor temperature under normal operational rate is limited to 90°C.

3.9.5. General Considerations for Cable Sizing

3.9.5.1. When single core cables are used, the situation in which the cables are grouped running together on the same cable tray shall be considered to selection of the impedance to be used in calculation of voltage drop.

3.9.5.2. The low-voltage cables shall have the following minimum cross-sections:

a) control cables: 1.5 mm²
b) voltage (VT) circuits: 2.5 mm²
c) current (CT) circuits: 4.0 mm²
d) power cables: 2.5 mm²
e) lighting cables: 2.5 mm²

3.9.5.3. The minimum conductor cross section for control circuits inside panels shall be 1mm² for discrete signals cables and 0.5mm² for analogue signals cables.

3.9.5.4. The use of three-core cables is mandatory for low-voltage three-phase circuits with cross-section 150mm² and below. For circuits demanding cross-sections above 150mm², three-core cables in parallel shall be used, considering the same limit for maximum cross-section of 150mm². For circuits demanding five or more circuits in parallel, single-core cables limited to cross section of 300mm² may be used, since approved by PETROBRAS. The fourth core or the fourth cable shall be applied when required in PETROBRAS documentation.

3.9.5.5. The use of three-core cables is mandatory for medium-voltage three-phase circuits with cross-section 120mm^2 and below. For circuits demanding cross-sections above 120mm^2, three-core cables in parallel shall be used, considering the same limit for maximum cross-section of 120mm². For circuits demanding five or more circuits in parallel, single-core cables limited to cross section of 300mm² may be used, since approved by PETROBRAS. The fourth core or the fourth cable shall be applied when required in PETROBRAS documentation.

3.9.6. Cables for Intrinsically Safe (I.S.) Circuits

3.9.6.1. Cables for I.S. circuits shall be designed for this specific application.

3.9.6.2. Characteristics of cables for I.S. circuits shall be selected in order to guarantee that their stored energies do not violate the safety limits of the installation.

3.9.6.3. Cross-sections of I.S. circuits shall be 1.5mm² or the nearest lower compatible with the L/R limits for the installations lengths.

3.9.6.4. The sizing of all I.S. cables demonstrating their compatibility with the upstream barriers/devices parameters shall be presented to PETROBRAS for approval, including those furnished in packages.

3.9.7. Data Link Cables

Data link cables shall be specifically designed to optimize the transmission characteristics of each type of travelling data.

3.10. Power Installation

3.10.1. General

3.10.1.1. All electrical installations shall comply with requirements of IEC 61892-6, IEC 60533, Classification Society Rules, NR-10, NR-12 and NR-37.

3.10.1.2. Electrical installations in hazardous areas shall additionally comply with requirements of IEC 61892-7.

3.10.1.3. The installation of electrical equipment and cables in hazardous areas shall be limited to those items essential to the operation.

3.10.1.4. Busbar trunking systems may be adopted on interconnections between transformers and panels with current higher than 2500A.

3.10.1.5. The installation of cables shall comply with the following guidelines:

a) Cables for circuits from 120V to 240V in living quarters shall be installed in steel conduits or cable trays;
b) Cables for circuits from 380V to 690V in living quarters shall be installed in cable trays;
c) When passing through Zone 1 hazardous areas, load-handling areas, places subject to the impact of dropped objects and places subjected to mechanical impacts, cables shall be installed in cable trays provided with covers for mechanical protection. Covers shall have the same thickness and material of the cable trays;
d) Non-armoured cables in process areas and panels' rooms shall be installed in cable trays. Derivation from cable tray to equipment shall be carried through perforated channels;

e) It is not permitted to install cables in flat bars;
f) Armoured cables shall be installed in cable trays or perforated channels;
g) The use of conduits in process areas shall not be permitted, except inside Packages;
h) Conductors for the electric fire pump shall be according to DR-ENGP-M-I-1.3 - SAFETY ENGINEERING;
i) It is not permitted to run medium-voltage cables in the void space between the ceiling and the steel deck and between the computer floor and the steel deck in the Central Control Room;
j) Only the cables/cable trays addressed for batteries and batteries rooms lighting are permitted to run inside batteries room. No other cable/cable tray shall cross batteries room area;
k) Cables from the flare tower shall be installed in high temperature resistant cable trays, channels, or conduits.
l) Cable tray covers shall be provided for vertical trays, in areas where it can be accessed by non-qualified (electrical) personnel. These covers shall have at least 2m height (measured from floor).

Note: Vertical cable trays in flare tower shall not have covers, due to low probability of mechanical impact and since these covers would be difficult to be installed, inspected, and maintained, generating risk of accidents by covers falling.

3.10.1.6. Conductors' penetrations on bulkheads A-60 and A-0 shall use seals for cables passage, according to I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS.

3.10.1.7. Conductors' penetrations on bulkheads B-15 can use seals for cables passage, according to I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS or steel sleeves with watertight cable glands.

Note: The installation details shall follow SOLAS, IEC 61892 series and applicable Classification Society rules.

3.10.1.8. Installation of MCTs in watertight decks, below the worst damage water line and columns void space shall be according to I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS.

3.10.1.9. Penetrations in ceilings of electrical equipment rooms shall be done avoiding any risk of liquid leakage to the electrical equipment room. In case of coamings in the space above the electrical equipment room (e.g.: HVAC room above the electrical equipment room), the penetrations shall be outside the coamings, or shall be elevated above the coaming border height.

3.10.1.10. In conduits, where they are accepted, cables occupation rate shall not exceed 40% of the area.

3.10.1.11. Conduits installation, when they are accepted on hazardous areas Zone 1 shall follow API-RP-14FZ.

3.10.1.12. Cables for intrinsically safe circuits can run with same energy level circuits, in the same cable tray, since segregated from each other in accordance with IEC 60079-11.

3.10.1.13. Connection of cables to equipment installed in hazardous areas shall comply with requirements of IEC 60079-14. For equipment inside packages following requirements of NFPA 70 (NEC), the connection of cables shall follow the requirements of API-RP-14FZ.

3.10.1.14. All cables shall be fixed by cleats, straps, saddles or bands, except when carried in conduits. The minimum spacing of cleats, straps, saddles or bands for fixing points shall comply with Classification Society requirements.

3.10.1.15. The distance between trefoil cleats for single core cables shall be as specified by the cable Manufacturer, based on the forces caused by short-circuit currents. The calculation of those forces shall be carried out in accordance with IEC 61914. BIDDER shall submit this Calculation to PETROBRAS approval.

3.10.1.16. Grounding and cables installation for motors fed from VSDs shall comply with requirements of IEC TS 60034-25.

3.10.1.17. Splices (joints) shall be submitted to PETROBRAS approval, and when approved, they shall comply with requirements of IEC 61892-7.

3.10.1.18. If, as a result of the voltage drop calculations, a given cable is assigned such a large cross-sectional area that does not fit into the connection terminal at the load side, Detailed Design shall provide a junction box of adequate size to allow the connection of the said cable to the load feeder. This junction box shall be located next to the load.

3.10.1.19. Supports for trays, control boxes, socket-outlets, instruments, lighting fixtures and floodlights and lighting poles shall be identified in all documents, software, data-banks, software and circumstances when the item appear according to following criteria:

SPX-YYYY-ZZZ, where:

SP = Fixed identification for supports;

X = Applicability identification letter, with the following options:

- I - Instruments;
- L - Lighting fixtures and Floodlights;
- C - Control Boxes;
- S - Socket-outlets;
- T - Trays and channels;
- M - Multiple applicability (for supports installed for more than one applicability, e.g., socket-outlets and push-buttons installed in a same support.

YYYY = Area identification, following options of Table 4;

ZZZ = Sequential, 000 to 499 for Topsides and 501 to 999 for Hull installations.

E.g.: **SPT-ACMA-009** for support for trays or channels located in Accommodation, deck A and sequential 009.

Table 4 - Mnemonic for Area Identification

Mnemonic	Area
ACM{X}	Accommodation. "X" is a letter that varies according to accommodation deck. Eg.: ACMA, ACMB, etc.
AFTX	Aft extension.
COFF	Cofferdam.
COLU	Columns.
CRN{X}	Cranes. "X" is a letter that varies according to crane tag.
DVS{9}	Diving stations. "9" is a number that varies according to station number.
EMB{9}	Embarkation stations. "9" is a number that varies according to station number.
ENG{9}	Engine room. "9" is a number that varies according to engine room level.
FLRT	Flare tower.
FRCT	Forecastle.
HELK	Helideck.
HULL	Generic for full area, to be used only in specific cases where detailed mnemonics are not available.
LABO	Laboratory.
LWRB	Lower riser balcony.
M{99X}	Modules. "99" varies according to module number. "X" is a letter that varies according to module number. Eg.: M10, M15B, etc.
MDCK	Main deck.
MPPR	Marine pipe-rack.
MORB	Mooring balcony.
OFFB	Backward offloading area.
OFFF	Forward offloading area.
PLLI	Pull-in area.
PPDK	Poop deck area.
PPRK	Topsides pipe-rack.
PMPR	Pump room.
RSPR	Riser pipe rack.
STEG	Steering gear room.
TWST	Towing station.
UPRB	Upper riser balcony.
UTLR	Utility Room
VBTP	Vent post.

Notes:

1 – Table 4 is based on Annex B of I-ET-3000.00-1350-940-P4X-013 - TECHNICAL REQUIREMENTS FOR DIGITAL ENGINEERING, with adaptations, in order to use mnemonics related to area identification of 3D model.

2 – Lighting Poles shall be identified as supports for lighting fixtures and floodlights.

3.10.1.20. Socket-outlets shall be identified in all documents, software, data-banks, software and circumstances when the item appear according to following criteria:

SKV–YYYY–ZZZ, where:

SK = Fixed identification for socket-outlets;
V = Safety identification letter, with the following options:
N - Normal;
E - Essential.
YYYY = Area identification, following options of Table 4;
ZZZ = Sequential, 001 to 499 for Topsides and 501 to 999 for Hull installations.

E.g.: **SKN–M02–003** for socket-outlet located in Module M-02, sequential 03.

3.10.1.21. Junction Boxes for Electrical discipline shall be identified in all documents, software, data-banks, software and circumstances when the item appear according to following criteria:

CXV-W-YYYY-ZZZ, where:

CX = Fixed identification for junction boxes;
V = Safety identification letter, with the following options:
N - Normal;
E - Essential and/or Emergency.
W = Applicability identification letter, with the following options:
L - Low-voltage and heating cables;
M - Medium-voltage cables;
S - Control, network and protection cables.
YYYY = Area identification, following options of Table 4;
ZZZ = Sequential, 001 to 499 for Topsides and 501 to 999 for Hull installations.

e.g.: **CXN–L–M06-001** for junction box for normal low-voltage cable(s) located in Module M-06, sequential 001.

3.10.1.22. Junction boxes, socket-outlets and supports shall have body identification.

3.10.2. Cable Trays Installation

3.10.2.1. Cable trays installation shall comply with the requirements of IEC 61892-6, IEC 60092-401 and Classification Society.

3.10.2.2. Cable trays and channels shall be identified in all documents, software, data-banks, software and circumstances when the item appear according to following criteria:

XY–YYYY–U–V-TRAY–ZZZ, where:

X = Discipline identification, with the following options:
- E - Electrical;
- I - Instrumentation and Automation;
- G - Multiple disciplines;
- T - Telecommunication.

Y = Type with the following options:
- C - Channel;
- T - Cable tray.

YYYY = Area identification, following options of Table 4;

U = Voltage level identification, with the following options:
- H - 13.8kV;
- M - 4.16kV or 6.6kV;
- L - Low-voltage;
- C - Direct current;
- S - Signal (instrumentation, telecommunication, network, control, etc.);
- T - Tubbing.

V = Safety identification letter, with the following options:
- N - Normal;
- E - Essential and/or Emergency.

TRAY = Fixed identification for trays and channels;

ZZZ = Sequential, 001 to 499 for Topsides and 501 to 999 for Hull installations;

E.g.: **ET-M05-M-TRAY-007** for electrical cable tray, Module M-05, 4.16kV, sequential 007.

3.10.2.3. Cable trays and channels shall have body identification.

3.10.2.4. The shortest routes shall be chosen, with the following restrictions:

a) It shall be avoided to run cables on classified areas Zone 1;

b) Cables feeding redundant and duplicated essential and emergency equipment shall follow different routes. The same rule shall be applied for essential and emergency lighting circuits. The use of fire-resistant cables according to IEC 60331 shall be acceptable as alternative to installation in different routes;

c) Cables routing for redundant and duplicated essential and emergency equipment shall take into account the Fire and Explosion Propagation Study, so that one event does no reach both routes;

d) Cables for essential and emergency power circuits may share the same cable tray. Cables for normal power circuits shall be installed in separated cable trays. Cables for normal, essential and emergency lighting circuits may share the same cable tray;

e) Cables for normal, essential and emergency circuits may share the same shaft in stabilization column of semi-submersible Units, since the cables for essential and emergency circuits receive PFP (Passive Fire Protection) or are fire resistant according to IEC 60331;

f) For equipment with double feeding, each feeder cable shall run on different route, to increase the reliability;

g) Cables feeding essential and emergency circuits shall be installed away from areas with risk of fire and from areas with risk of falling objects (maintenance areas, lay down areas, etc.). Exceptions for cables feeding loads installed inside these areas are acceptable;

h) In order not to trip the Turbogenerator LV MCCs due to an EFI actuation, the Detailed Design shall avoid routing the feeders of the said MCCs through Zone 1 hazardous areas along all their way from Hull panels;

i) Sensitive circuits between two equipment shall avoid separate routes from other circuits between the same two equipment to optimize protection against high frequency surges (reducing the looping area between these circuits). Parallel routes for these circuits are preferred, but considering the minimum distances defined in item 3.10.2.11;

j) Sensitive circuits installed in external areas subjected to high frequency surges shall be installed in metallic cable trays (see I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS for acceptable materials).

3.10.2.5. All single-core cables shall have phases installed and grouped on the same cable tray and penetration pieces to minimize the electromagnetic induction effects. Cables entries at panels shall be of non-magnetic material and gathering all phases.

3.10.2.6. Cable tray installation shall be executed considering an easy access for maintenance.

3.10.2.7. Cable trays and ladders in decks shall be installed close to the deck to minimize the cross-sectional area of the loop existing between the cable and the deck, according to IEC 61892-6.

3.10.2.8. There shall be independent cable trays for the cable systems listed in item 3.10.2.9. It shall not be acceptable the installation of different cable systems in the same cable tray.

3.10.2.9. In internal areas, for cable trays disposed on levels, it shall be adopted the following sequence, from top to bottom:

a) Cable tray for communication network cables (any kind);

b) Cable tray for safety system (FGS) cables (analog and discrete signals);

c) Cable tray for instrumentation, automation, and control (when connected to A&C) cables (analog and discrete signals);

d) Cable tray for electrical low-voltage power, protection, control (when connected to electrical panels) and measuring cables (when connected to electrical panels);

e) Cable tray for medium-voltage cables.

Note: For further details about cable trays for A&C systems, refer to FIELD INSTRUMENTATION DOCUMENTATION.

3.10.2.10. In open areas, to optimize the protection of sensitive circuits against impacts from high frequency surges, the following sequence, from top to bottom is recommended (variations are acceptable considering all other relevant requirements related to cable routing):

a) Cables trays for medium-voltage cables;

b) Cable tray for electrical low-voltage power, protection, control (when connected to electrical panels) and measuring cables (when connected to electrical panels);

c) Cable tray for communication network cables (any kind);

d) Cable tray for instrumentation, automation, and control (when connected to A&C) cables (analog and discrete signals);

e) Cable tray for safety system (FGS) cables (analog and discrete signals).

Note: For further details about cable trays for A&C systems, refer to FIELD INSTRUMENTATION DOCUMENTATION and I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

3.10.2.11. The minimum distances between electric power cable trays and control, instrumentation and telecommunications cable trays shall be:

- 300mm horizontally and vertically for power cables up to 1kV;
- 600mm horizontally and vertically for power cables above 1kV up to 4.16kV;
- 750mm horizontally and vertically for power cables above 4.16kV.

This distance shall be taken between supports vertically and from the limits of each cable tray horizontally.

3.10.2.12. Cable tray accessories must be such as to permit the execution of the minimum radius of curvature of the biggest cable installed thereon.

3.10.2.13. Spacing and characteristics of the tray supports shall be determined so that they shall not be subjected to permanent distortion (allowing for 120% of installed cables), and also taking into account an 80kg individual point supplementary load applied at any point. Supports holding up the cable trays and conduits shall have a maximum spacing of 3 meters between them.

3.10.2.14. A minimum clearance of 300mm shall be kept between cable trays and heated piping or engine exhaust lines in case of parallel runs and 150mm in case of a cross-over.

3.10.2.15. The cables installation shall be planned to minimize the difference of the inductance between the circuits, in order to maintain balanced the current in the circuits.

3.10.2.16. Cable trays, channels and ladders shall be designed with a reserve section of at least 20% of the total cross-section. The cables shall be installed beginning from the edges of the cable trays, keeping the central area as the reserve section to optimize protection against high frequency surge (the central area is the most affected region).

3.10.2.17. When the use of single-core cables is approved, the preferential arrangement of the circuit shall be in trefoil (Arrangement 1 in Figure 4).

3.10.2.18. If the Preferential Arrangement can not be used, the single-core cables shall be installed in accordance with Arrangement 2 of Figure 4.

3.10.2.19. In any case, the fixation of the single core cables shall be made only with devices tested for the short-circuit levels present in the installations and the test reports and fixation schemes shall be submitted to PETROBRAS for approval.

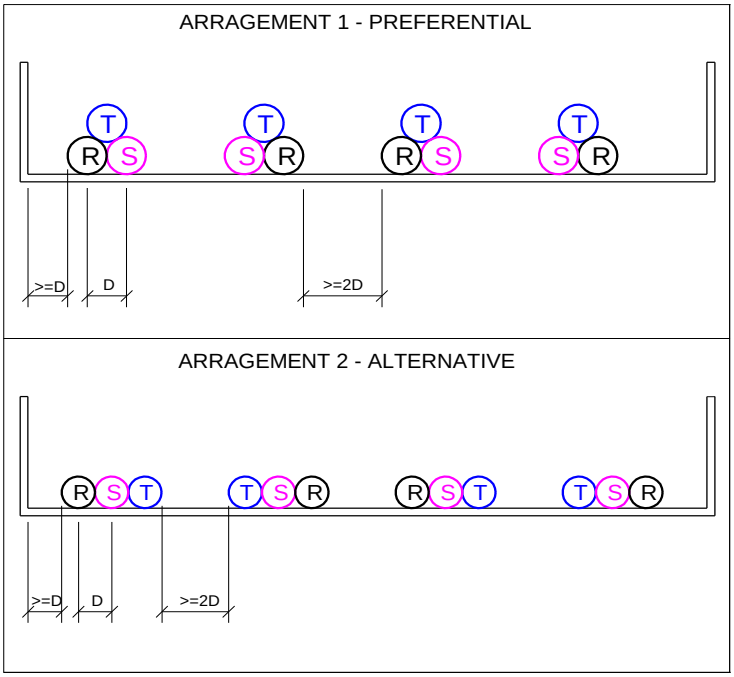


Figure 4 - Single-Core Cables Arrangement

3.10.3. Cables Identification

3.10.3.1. All cables shall be clearly identified by means of stainless stell AISI 316L labels in outdoor installations, and stainless stell AISI 316L labels or plastic rings in indoor installations, with the design number, at least at the following points:

a) at panels, boxes and equipment entrance;
b) at both sides of MCTs and any bulkhead crossing point incomings and outgoings;
c) at the ends of conduits feeding single equipment.

Note: For outdoor installations the labels shall be fixed using stainless steel AISI 316L straps. For indoor installations and for labels inside protected enclosures (junction boxes, terminal boxes, etc.) of outdoor equipment the label shall be fixed using stainless steel AISI 316L or plastic straps.

3.10.3.2. Cables shall be identified in all documents, software, data-banks, software and circumstances when the item appear according to following criteria, with numbering pattern starting from top to bottom and from left to right:

a) Power and Lighting Cables:
XXX-YYY-ZZ, where:
XXX = Busbar number identification;
YYY = Kind of circuit according to electrical supply [3];
ZZ = Circuit number.

b) Control, Heating, Protection Cables:
XXX-YYY-WW-UZZ, where:
XXX = Busbar number identification;
YYY = Kind of circuit according to electrical supply [3];

WW = Circuit number;
U = Identification Letter [(2)];
ZZ = Sequential.

Notes:

1 – Cable numbering is based on busbar and semi busbars numbering for electrical panels which shall identify from where the electric cable is coming from;

2 – Identification letters:
P - protection and measurement;
C - control, signalling and alarm;
A - heating.

3 – Kind of circuit according to electrical supply:
CNO – Normal cable;
CES – Essential cable;
CEM – Emergency cables;
CGE – General Cables (control, heating, protection, etc.).

E.g.1: **503-CNO-05** for normal power or lighting cable connected to a busbar with number identification 503 and circuit number 05.

E.g.2: **503-CGE-05-A01** for general heating cable with sequential 01 connected to a busbar with number identification 503 and circuit number 05.

3.10.3.3. For identification of telecommunication cables, refer to Telecommunication documentation.

3.10.3.4. For identification of automation and instrumentation cables, refer to I-ET-3010.00-1200-800-P4X-010 - CRITERIA FOR ESTABLISHING CABLE CODES AND CABLE GLAND CODES and I-ET-3000.00-1200-940-P4X-001 - TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN.

3.10.4. Multicable Transit (MCT) Identification

MCTs shall be identified in all documents, software, data-banks, software and circumstances when the item appear according to the following criteria:

X–YYYY–U–MCT–VVV, where:

X = Discipline identification, with the following options:
E - Electrical;
I - Instrumentation and Automation;
T - Telecommunication.

YYYY = Area identification, following options of Table 4;

U = Voltage level identification, with the following options:
H - 13.8kV;
M - 4.16kV/6.6kV;
L - Low-voltage;
C - Direct current;
S - Signal (instrumentation, telecommunication, network, control, etc.).

MCT = Fixed identification for MCTs;

VVV = Sequential, 001 to 499 for Topsides and 501 to 999 for Hull installations.

E.g.: **E-ENG1-H-MCT-001** for electrical MCT, Engine Room, level 1, 13.8kV, sequential 001.

3.11. Lighting Installation

3.11.1. General

3.11.1.1. The lighting system of the Unit shall comply with requirements of IEC 61892, ISO 8995-1, NR-37 and NHO 11, and with regulations from Secretariat of Labour – Brazilian Ministry of Economy (Secretaria do Trabalho do Ministério da Economia), Brazilian Navy (Marinha Brasileira) and Diretoria de Portos e Costas (DPC). Any other mandatory international regulations shall also be complied with.

3.11.1.2. Design of external lighting and illumination system shall avoid the disturbance on seawater, meaning that BIDDER shall avoid directing the lighting to the sea. Outdoors lighting fixtures shall be directed to internal areas of the Unit, in order to not affect/impact marine life. BIDDER shall consider that only specific lighting systems required by Brazilian and international regulations, Class and Flag requirements and Unit safe operation shall be directed to overboard in direction to seawater area.

3.11.1.3. Floodlights and pendant lights shall be provided with an extra safeguard, in order to protect operational personnel and installation against an accidental fall of the said lighting fixtures. See I-DE-3010.00-5140-700-P4X-001 - LIGHTING INSTALLATION TYPICAL DETAILS for further information.

3.11.1.4. In normal operation condition, the normal lighting, together with the essential and emergency lighting, shall guarantee for the different Unit places, lighting levels according to normal column in Table 5.

3.11.1.5. When the Unit operates fed from the emergency generation system and with the main generation system out of service (ESD condition), the essential lighting, together with emergency lighting, shall guarantee lighting levels suitable for the Unit places, according to Essential column in Table 5. Special attention shall be given to the definition of IEC 61892-2 about this kind of lighting, which defines it as emergency lighting and shall not be confused with the definition of emergency lighting (refer to 3.11.1.7) given by that specification.

3.11.1.6. The essential lighting level shall, as a minimum, be 30% of the normal lighting level requirement and shall not be below the escape lighting level, according to IEC 61892-2. This requirement does not refer to quantity of lighting fixtures.

3.11.1.7. The emergency lighting system shall be designed in such way that when the normal and essential lighting fail, it shall comply with lighting levels indicated in the Emergency column of Table 5. Special attention shall be given to the definition of IEC 61892-2 about this kind of lighting, which defines it as escape lighting.

Table 5 - Average Lighting Levels (14)

LIGHTING LEVEL TABLE				
POS	AMBIENT	AVERAGE LIGHTING LEVEL [lux]		
		NORMAL	ESSENTIAL	EMERGENCY
01	Offices	500 (2)	167	5
02	Galley (general areas)	300	167	15

LIGHTING LEVEL TABLE

POS	AMBIENT	AVERAGE LIGHTING LEVEL [lux]		
		NORMAL	ESSENTIAL	EMERGENCY
03	Galley (specific areas)	500 (4)		
04	Telecommunication and Radio Room	500	250	250
05	Laundry	300	100	5 (5)
06	Internal Corridor	100	33	5 (5)
07	External Corridors, Passageways, and all Stairs	150	50	5 (5)
08	Transit Room (Reception)	300	100	5 (5)
09	Auditoriums and Movies Room	0 to 500 16)	167	5 (3)
10	Panels and Transformers Rooms	200	67	5 (5)
11	Front of Normal LV Switchgears and LV MCC	300	100	5
12	Process Control Rooms (front of panels and workstations)	0 to 500 16)	350	250 (5)
	Desk for Reading with Local Luminaries	500		
13	Electric Control Rooms (front of panels and workstations)	500	167	15 (5)
14	Medical Station (attendance)	500	500	300
15	Medical Station (rest)	0 to 300 16)	100	5 (5) (3)
16	Workshops (general)	500 (13)	167	10 (5)
	Workbenches	500		
17	Warehouse	200 to 300 17)	100	5 (5)
18	Utilities Room for Compressors and Centrifugal Units	200	67	5 (5)
19	General Cabins	0 to 150 16)	90	5 (3)
	Headboard	200		
	Writing Desk	500		
20	General Laboratory	500	167	5 (5)
	Benches	750 (9)		
21	General Bathrooms	200	67	5
	Mirror	300		
22	Collective Bathrooms and Cloakrooms	200	67	5 (5)
23	Mess Room	300	100	5 (5)
24	Process and Utilities Internal and External Areas	300	100	10 (5)
25	Panels Front, External Control and Measuring Stations	300	100	10 (5)
26	Well Head Areas	200	67	5 (5)
27	Mooring Areas	200 (12)	67	5 (5)
28	Rig Areas (open decks)	200	67	5 (5)
29	Load Handling Areas	200 (1)	67	20
30	Gymnasium	300	100	5
	Recreation Areas	200		
31	TV Room	0 to 300 16)	100	5 (5) (3)
32	Muster Station, Embarkation Station	200	67	20
33	Lifeboat Landing Area (sea level)	50	50	20 (6)
34	Emergency and Auxiliary Generator Area (general), Control Panels. Emergency Start-up Air Compressor and Diesel Air Compressor. Fire Pumps and Control Panels (front of panel)	300	100	15
35	Front of Emergency and Auxiliary Generators Control Panels	300	100	50
36	Front of Essential Panels, Fire and Gas Alarms Panels and others Control Stations.	300	100	15
37	Front of Ballast Mnemonics Panels, Valves Control on the Top of the Columns.	300	100	50
38	Engine Rooms, Pump Rooms, Pontoons, Ballast Manifolds	200 (11)	67	15 (5)
39	Batteries Room	200	67	15 (5)
40	Garbage Area	200 to 300 17)	10	5
41	Pull-in Area and Riser Balcony	50 to 200 (8)	67	5

LIGHTING LEVEL TABLE

POS	AMBIENT	AVERAGE LIGHTING LEVEL [lux]		
		NORMAL	ESSENTIAL	EMERGENCY
	Pull-in Area (Sea level)	50	-	-
42	Inside of Hoods and Turbines Filters Room	200	15	5 (5)
43	Main Deck Area	100	33	5 (5)

Notes:
1) Besides the general lighting indicated on item "29" a directed lighting through floodlights shall be provided at crane boom, able to supply 200 lux on the point where the work is going to be done. The floodlight shall remain off if load handling operations are not in progress.
2) The work area height, when not defined, shall be 750mm above the floor.
3) Cabins, auditorium, movies room, medical station and TV room shall have safety exit lighting signalling (places where lighting could be turned off, being not sufficient to activate photoluminescent or phosphorescent signalling plates in case of ESD), according to pattern of I-ET-3010.00-5400-947-P4X-002 - SAFETY SIGNALLING. These lighting signalling shall be considered for any other closed space where lighting could be kept off. Lighting with battery incorporated shall not be used for these indication lights.
4) Over stoves and benches proper for cutting and selection works.
5) Escape routes (exits and stairs) and all way long.
6) The landing area shall be lighted by floodlights.
7) The lighting levels defined by this table shall be applied if no higher lighting levels are defined by Classification Society rules.
8) Consider 200 lux during pull-in operation and 50 lux when pull-in operation is stopped.
9) It shall be provided a minimum colour rendering index (CRI) of 80.
10) The most restrictive value shall prevail in case of conflict among this table, IEC 61892-2, NHO 11, ISO 8995-1, Classification Society, any other mandatory international regulations, and regulations from Secretariat of Labour – Brazilian Ministry of Economy (Secretaria do Trabalho do Ministério da Economia), Brazilian Navy (Marinha Brasileira), and Diretoria de Portos e Costas (DPC).
11) The average lighting level herein defined shall also be achieved at the lower platform of Engine Rooms.
12) The required lighting levels shall allow hook-up services to be carried out at night. Additionally, it shall be possible to manually switch off the lighting systems if the light is directed to overboard (thrown onto the seawater), in order not to disturb the marine life (see item 3.11.1.2).
13) A direct-lighting arrangement shall be provided for the mechanical lathe.
14) The lighting level of each ambient is defined as average measurement at several points at the time where maintenance is planned to be carried out, as defined in IEC 61892-2. Single point measurements are not acceptable to define lighting level of an ambient.
15) The minimum acceptable average lighting level during emergency condition on fire-fighting hydrant areas is 15 lux.
16) Controlled by dimmer.
17) Minimum 200 lux for large areas and minimum 300 lux for small areas.
18) Detailed Design shall calculate the essential and emergency lighting systems, aiming lighting levels slightly above the minimum values defined in Table 5, to avoid unnecessary oversizing in electrical demand from essential lighting transformers and from the emergency lighting UPS system (to keep the total essential demand within Emergency Generator capacity).

3.11.1.8. The point by point and the lumen method shall be considered for lighting calculation development. The zonal cavity method, replacing the method of lumens, is also accepted.

3.11.1.9. In order to avoid insufficient lighting level after the assembly of the installations during Detailing Design (due to interference of HVAC ducts or structures, for example), the evolution of the lighting calculation and plans shall be verified according to 3D models of the unit. The final documentation defined “as built” shall be also complied with the lighting levels foreseen in this technical specification. See 2.15.2.

3.11.1.10. The lighting level required for any area of the production unit shall be achieved by means of lighting fixtures installed, preferentially, on surrounding bulkheads. In their absence, metallic floor railings nearby the area shall be used for the same purpose. The installation of lighting fixtures on poles shall be avoided or, at least, kept to a minimum.

3.11.1.11. See I-ET-3010.00-5140-700-P4X-008 - SPECIFICATION FOR LIGHTING AND ELECTRICAL SIGNALLING FOR OFFSHORE UNITS for details about approved lamp types and about lighting fixtures requirements.

3.11.1.12. All lighting fixtures for external areas, process plant areas and pump room shall be from the same manufacturer and type (standardization).

3.11.1.13. Cancelled.

3.11.1.14. Lighting fixtures for workbenches shall not cause inconvenient obfuscation, reflex and excessive shadows and shall be provide with diffuser.

3.11.1.15. All lighting fixtures shall be installed using a junction box for derivation from the supply cable, in order to permit the lighting fixture replacement without impair the operation continuity of other lighting fixtures in the same circuit.

3.11.1.16. When installing the lighting fixtures, enough space for maintenance shall be considered around them when the lamps replacement is made by the ends.

3.11.1.17. Floodlights shall be used to illuminate the load-handling and open areas, such as those of towboats, pull-in facilities (pull-in area, riser balcony and sea-level), mooring winches, and top of modules.

3.11.1.18. The identification plates of the Unit shall be lighted by sodium vapour floodlights.

3.11.1.19. Local lighting panels distributed at the Units shall be provided in enough quantity, in order to centralize the lighting circuits’ distribution for a certain area. The same lighting circuit shall not supply at the same time indoor and outdoor areas.

3.11.1.20. There shall be independent lighting panels for normal, essential and emergency lighting systems.

3.11.1.21. For FPSO and FSO Units, it shall not be allowed distribution of neutral point for 220V or 240V systems, to use phase-neutral circuits, outside accommodation areas. Inside accommodation areas, it is permitted the distribution of neutral for 220V or 240V systems, to use phase-neutral circuits, only for normal and essential systems.

3.11.1.22. Unless otherwise stated in PETROBRAS documents, in case of expansion of existing Units, the rated voltage of lighting system shall be the rated voltage of the existing system.

3.11.1.23. The lighting circuits shall have their switches at lighting panels, except in accommodation areas, where it shall be provided local switches.

3.11.1.24. The luminosity control shall be done by means of dimmers, which shall be appropriate for working with approved types of lamps in the following places:

a) Cinemas and auditoriums;
b) TVs' rooms;
c) General cabins;
d) Medical Station;
e) Front of panels and workstations in Process Control Rooms.

3.11.1.25. In locations where there is false lining, inserted lighting fixtures fitted with diffusers shall be provided.

3.11.1.26. The lighting circuits shall be distributed in order not to exceed 16A or to feed no more than 24 lighting points (each lamp is deemed to be a point, while each convenience outlet comprises 2 points).

3.11.1.27. Socket-outlets and lamps shall be fed by different circuits.

3.11.1.28. A minimum of 2 (two) lighting circuits shall be provided on each area or compartment, being one normal and one essential.

3.11.1.29. The quantity of essential and emergency lighting fixtures per area shall be defined according to items 3.11.1.5 and 3.11.1.6, considering additionally a minimum (essential + emergency) of:

- 20% of total quantity of lighting fixtures - Utilities areas
- 10% of total quantity of lighting fixtures - Process areas
- 50% of total quantity of lighting fixtures - Control rooms
- 50% of total quantity of lighting fixtures - Muster stations
- 30% of total quantity of lighting fixtures - Electrical panels rooms
- 30% of total quantity of lighting fixtures - Emergency generator room
- 30% of total quantity of lighting fixtures - Auxiliary generator room
- 5% of total quantity of lighting fixtures - Offices

3.11.1.30. The lighting circuits shall also be distributed in accordance with the zones determined at the safety plans.

3.11.1.31. Lighting Panels rated current sizing rules:

a) For sizing the rated currents of lighting panels, it shall be used a composition of demand factors applied to lighting circuits and socket-outlet circuits;

b) For lighting circuits, the demand factor to be applied in consumed power is equal to 1;

c) For socket-outlet circuits, the demand factor to be applied in consumed power is equal to 0.3.

3.11.2. Normal Lighting System

3.11.2.1. Normal lighting shall only be fed through the main, hull or auxiliary power generation.

3.11.2.2. For non-electronic ballasts, in order to reduce stroboscopic effect in areas where exposed rotary equipment exists, the adjacent lamps shall be fed by different phases.

3.11.2.3. In FPSO and FSO units, two floodlights shall be installed for aid of the offloading operations on bow and stern areas.

3.11.3. Essential Lighting System

3.11.3.1. Essential lighting shall be fed through the main, auxiliary and/or emergency power generation.

3.11.3.2. Essential lighting fixtures shall be identified by a round yellow label with the inscription “GE” in black letters.

3.11.3.3. In Fixed and SS Units, at least four (04) rescue and searchlights (for aid rescue of men at sea) shall be provided at a maximum height of 20 meters over sea level. One rescue and searchlight shall be installed on each corner of the Unit.

3.11.3.4. In FPSO and FSO Units, searchlights (for aid of rescue of men in the sea) shall be installed, in way to assist the whole perimeter of the embarkation, taking into account that there is no certified searchlight for hazardous areas. If approved by the Classification Society, the certified floodlights designed for aid of the offloading operations can be integrated into the searchlight system.

3.11.3.5. Searchlights, if not suitable for hazardous areas, shall be individually monitored and turned off by a gas sensor located within 1 meter or less from the corresponding searchlight.

3.11.4. Emergency Lighting System

3.11.4.1. The emergency lighting system shall consist of LED lighting fixtures supplied by 220VDC system. For 220VDC – Emergency Lighting System Architecture, refer to UPS AND DC SYSTEMS ONE-LINE DIAGRAM.

3.11.4.2. Two (02) sets of batteries and battery-chargers shall be provided to feed the emergency lighting system.

3.11.4.3. Each ambient with emergency lighting shall have at least two emergency lighting fixtures (the quantity of lighting fixtures shall be enough to comply with lighting levels defined in item 3.11.1.6, with minimum quantity of two lighting fixtures per ambient).

3.11.4.4. Each ambient with emergency lighting shall be fed by at least two emergency lighting circuits. One lighting circuit shall be supplied by one battery-charger (through its lighting distribution panel) and the other circuit shall be supplied by the other battery-charger (through its lighting distribution panel). Each ambient shall have at least one lighting fixture fed by each one of these lighting circuits.

3.11.4.5. The autonomy for emergency lighting system is defined in DR-ENGP-M-I-1.3 - SAFETY ENGINEERING.

3.11.4.6. Emergency lighting fixtures with extended autonomy shall be installed at specific locations. The locations and the autonomy for these lighting fixtures are defined in DR-ENGP-M-I-1.3 - SAFETY ENGINEERING.

3.11.4.7. The emergency lighting system shall not be grounded.

3.11.4.8. Emergency lighting fixtures shall be identified by a round red label with the inscription “BAT” in white letters.

3.11.4.9. Emergency Lighting installation complying with the requirements of NR-13 shall be provided for pressure vessels.

3.11.4.10. The emergency lighting of the escape routes shall include, at least:

a) All exits;
b) Stairs;
c) The route direction change points and respective safety signalling.

3.11.4.11. It shall be provided emergency lighting fixtures at places where operation or manoeuvring is required during emergency condition, for example, at least on the following areas:

a) Engine and control panels of the Emergency and Auxiliary Generators;
b) Start-up air compressors and vessels for emergency equipment;
c) Fire water pumps stations;
d) Remote I/O panels;
e) Central Control Room (CCR);
f) Automation and Electrical Panels Room (AEPR);
g) Frontal area of essential MCCs and CDCs;
h) Frontal area of emergency UPSs and battery chargers.

Note: Detailed Design shall evaluate necessity in other areas, including lighting fixtures when necessary.

3.11.5. Lighting Fixture and Floodlight identification

3.11.5.1. Lighting fixtures and floodlights shall be identified in all documents, software, data-banks, software and circumstances when the item appear according to following criteria:

LXX–WWW–UU-YYYY-ZZZ, where:

L = Fixed identification for lighting fixtures and floodlights;
XX = Safety identification, with the following options:
NO - Normal;
ES - Essential;
EM - Emergency.
WWW = Busbar number identification;
UU = Sequential for circuit number;
YYYY = Area identification, following options of Table 4;
ZZZ = Sequential, 001 to 499 for Topsides and 501 to 999 for Hull installations.

E.g.: **LNO-531-08-M06-007** for normal lighting fixture or floodlight 007 located in module M-06 and fed by busbar with identification number 531, circuit number 08.

Note: The identification mentioned in items 3.11.3.2 and 3.11.4.8 shall also be complied with.

3.11.5.2. Lighting fixtures and floodlights shall have body identification.

3.12. Safety Signalling

3.12.1. The electrical design shall detail the following signalling systems:

a) Navigation aid signalling;
b) Aircraft obstruction warning signalling;
c) Emergency alarm signalling;
d) Helideck signalling.

3.12.2. The location of lanterns, horns and signalling boxes shall be according to safety arrangement plans.

3.12.3. Requirements of I-ET-3010.00-5140-700-P4X-008 - SPECIFICATION FOR LIGHTING AND ELECTRICAL SIGNALLING FOR OFFSHORE UNITS shall be complied with.

3.12.4. Navigation Aid Signalling System

3.12.4.1. The control panel of this system shall automatically control the Navigation Aid System signalling lighting fixtures and foghorns.

3.12.4.2. These signalling systems shall be supplied with 125VDC from Navigation Aid System battery charger.

The navigation aid signalling shall comply with the requirements of NORMAM 05, NORMAM 27 and RIPEAM 72 standards. Refer to I-ET-3010.00-5140-700-P4X-008 - SPECIFICATION FOR LIGHTING AND ELECTRICAL SIGNALLING FOR OFFSHORE UNITS.

3.12.5. Aircraft Obstruction Warning Signalling System

3.12.5.1. The control panel of this system shall automatically control the Obstruction Warning System signalling lighting fixtures.

3.12.5.2. These signalling systems shall be supplied with 220VAC from essential lighting system.

3.12.5.3. The aircraft obstruction warning signalling shall comply with the requirements of NORMAM 05, NORMAM 27 and RIPEAM 72 standards. It shall be composed by warning lighting fixtures in towers, cranes, rigs and helideck. Where it is not possible to install aircraft obstruction lights on obstacles (e.g., flare tower), floodlights shall be used as an alternative solution. Floodlights shall be positioned in order to not dazzle the vision of the pilots during landings and takeoffs. Refer to I-ET-3010.00-5140-700-P4X-008 - SPECIFICATION FOR LIGHTING AND ELECTRICAL SIGNALLING FOR OFFSHORE UNITS.

3.12.6. Emergency Alarm Signalling

3.12.6.1. The control panel of this system shall process the fire, gas and abandonment signals sent by instrumentation and control systems and shall control the flicker lamps distributed on the Unit.

3.12.6.2. This system shall be supplied with 220VDC from Emergency Loads UPS. There shall be independent circuits for each specific area.

3.12.6.3. The system operation shall be automatic through grouped signals from fire and gas instrumentation. It shall signal the abnormal (fire or gas) situations, or the Unit abandonment.

3.12.6.4. In noise areas, white flicker lamps shall be used as warning to indicate abnormal situations at the Unit.

3.12.7. Helideck Signalling

3.12.7.1. The control panel of this system shall automatically control the signalling and lighting of helideck (helideck perimeter lighting fixtures, touch area lighting, windsock lighting and runway searchlights, status light, etc.).

3.12.7.2. When the helideck is unguarded, or the parameters provided by the Helideck Monitoring System (HMS) are out of safety limits, or the offshore unit is under gas leakage, the status light shall remain on, according to NORMAM 27.

3.12.7.3. This system shall be supplied with 220VAC from essential lighting transformers.

3.12.7.4. For further information, refer to I-ET-3010.00-5140-700-P4X-008 - SPECIFICATION FOR LIGHTING AND ELECTRICAL SIGNALLING FOR OFFSHORE UNITS.

3.13. Safety Grounding and Bonding

3.13.1. General Requirements

3.13.1.1. For the design of safety grounding and bonding, the following definitions shall be considered:

- Ground: metallic mass of the main structure, hull of the offshore unit, or continuous structure of modules that are assembled and welded, having a permanent connection to the main structure (hull or jacket);
- Grounding cable: copper conductor used to directly connect the equipment frame to grounding bar or Earth Boss or to connect the grounding bar to Earth Boss;
- Grounding Bar: bar, with material according to I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS, to be connected to the Earth Boss terminal, to allow multiple connections of grounding cables. They shall be readily accessible for use, inspection and maintenance. All grounding terminals and bars shall be visible, allowing their inspection after cable fixation;
- Bonding: conductor used for connection of elements made of conductive material that have any kind of isolation between them, ensuring equipotential condition between isolated conductive parts;
- Earth Boss: component that shall be welded to the structure (ground) and made of the AISI 316L, with threaded terminal that allows the direct connection of the grounding cable or grounding bar for multiple grounding cable connections;

- Safety grounding: intentional electrical connection between any metal part of equipment or structure which are not intended for conducting electric current (frames, skid, metal piping, trays, etc.) to ground. The bars used for safety grounding shall be identified by the code PE (Protective Earth);
- Signal Grounding: Exclusive grounding for connection of cable shields for control, instrumentation, and automation to ground, ensuring low interference from other safety grounding systems. The bars used for grounding of signals shall be identified by the codes IE (Instrument Earth) and IS (Intrinsically Safe).

3.13.1.2. Metallic structures, equipment, cables and accessories shall be grounded in accordance with the requirements of IEC 61892-6 and Classification Society. For FPSO and FSO units, the requirements of IEC 60092-201 and IEC 60092-502 shall also be complied with for grounding of equipment, cables and accessories.

3.13.1.3. In hazardous areas, the requirements of IEC 61892-7 shall be additionally complied with.

3.13.1.4. IS circuits shall be grounded in accordance with the requirements of IEC 61892-2, IEC 61892-3, IEC 61892-6, IEC 60079-14 and IEC 60079-25.

3.13.1.5. The requirements of IEC 61892-2, IEC 61892-3, IEC 61892-6 and IEC 60079-14 shall apply to the grounding of instruments and instrument circuits/cables.

3.13.1.6. The grounding installation shall equalize all extraneous conductive metallic parts (conductive part not forming a part of the electrical installation and liable to propagate a potential, including ground potential) at the same potential to ensure that danger to operator is minimized.

3.13.1.7. All grounding connections shall be made with self-locking screws (connectors). Welded terminals or exothermic connections are permitted only between earth bosses and structure/skid.

3.13.1.8. Cleats, clamps and other metal fixture elements of electrical cables and piping systems shall not be used as grounding conductors, either temporarily or permanently. The application of those elements shall be restricted to temporary bonding connections.

3.13.1.9. Earth Bosses shall be installed in metallic structures taking account the cleaning of the surface and ensuring that surface is free of painting, corrosion etc., allowing proper electrical continuity between the parts.

3.13.1.10. The quantity of earth bosses that shall be installed in offshore unit ambient shall be enough to connect properly the grounding cables in grounding bar and perform properly electrical continuity measurements.

3.13.1.11. A weld bead with at least 10 cm length is acceptable in order to ensure electrical continuity between skids and structures (e.g. supports) welded to the main structure.

3.13.1.12. The length of bondings and grounding cables shall be as short as possible and installed in a way that mechanical impacts are avoided. In cases where high frequency signals are involved, a conductor with a length-to-width ("l-w") ratio of less than 5:1 shall apply, as shown in Figure 5.

Figure 5

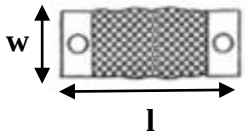


Figure 5 - Length-to-width ratio of conductors for grounding and bonding of high frequency signals

3.13.1.13. The bonding terminals shall be made of the same material as the equipment or structure that will be equipotentialized. If materials with different chemical compositions are used, the galvanic potential difference between them shall not exceed 600 mV, in order to avoid the galvanic corrosion of the components. Equalization material shall be used in these connections between dissimilar materials, or when there is no equalization material available, both sides shall be directly grounded. Table 6 presents typical potential values for some materials:

Table 6 – Typical potential values for different materials

Metal Potential	mV
Nickel99.6	46
Brass SoMs 70	28
Monel	12
Copper	10
CrNi steel 1.4301	45
LeadPb 99.9	-259
Steel	-335
Cadmium	-519
Aluminium Al99.5	-667
AlMgSi	-785
Electrolytic zinc covering	-806
TinSn 98	-809
ElectronAM 50	-1355

3.13.1.14. Unless otherwise stated in this specification, metal structures used in electrical installations (cable trays, ladders, channels, etc.) and for any other purpose, when directly welded or bolted to the main platform structure, need no additional connections to earth, provided the ground resistance of any point on them, as measured with a DC multimeter, does not exceed 10 Ω. Measurements shall be carried out at the final stage of the commissioning phase, aiming at keeping the ground resistance of the said metallic structures below 10^6 Ω over the lifetime of the offshore unit, in accordance with IEC/TS 60079-32-1.

3.13.1.15. Unless otherwise stated in this specification, metallic structures in compliance with the requirements of item 3.13.1.14 need no additional bonding jumpers across splice plates.

3.13.1.16. Detailed design shall issue a dedicated report aiming at gathering the grounding resistance values as measured in accordance with the requirements of item 3.13.1.14. In order to be included as part of the NR-10 dossier and used as reference in future audits, the said report shall indicate the positions of the bonding jumpers (if any) on the structures and, in addition, the reasons to conclude on the need or not for the bonding jumpers in each situation.

3.13.1.17. Safety grounding is mandatory for modules mounted on supports isolated from the hull structure. Grounding cables shall be connected at least in two points.

3.13.1.18. When isolated from the main structure of the offshore unit or hull to prevent galvanic corrosion, metal structures of electrical installations (cable trays, ladders, channels, etc.) shall be grounded at both ends. Bonding jumpers, as short as possible to optimize protection against high frequency surges, shall be additionally installed across splice plates if a ground resistance value of less than 10 Ω, as measured in accordance with the requirements of item 3.13.1.14, is not attained.

3.13.1.19. Metallic removable grating shall be interconnected between each other and to the metallic structure through grounding bondings. Metallic fixed clamps may be alternatively used for this purpose, provided the removable grating ground resistance, as measured in accordance with the requirements of item 3.13.1.14, does not exceed 10 Ω. However, if this is not attained with the metallic fixed clamps alone, grounding bondings shall be additionally installed until the measured ground resistance falls below the said threshold (10 Ω).

3.13.1.20. The removable grating ground resistance measurements shall also be included in the report to which item 3.13.1.16 refers.

3.13.1.21. Grounding and bonding of the following non-metallic elements are not required: removable floor gratings, cable trays, ladders and channels.

3.13.1.22. When welded to the structure, metallic supports do not need to be grounded.

3.13.1.23. The metal to metal junctions of metallic structures shall be directly welded.

3.13.1.24. Accommodation module metallic parts shall have their electrical continuity assured.

3.13.1.25. Battery racks shall be bonded to the structure through a grounding cable.

3.13.1.26. Different sections of busbar trunking structures shall be interconnected between them and to the metallic structure through grounding bonding.

3.13.1.27. Aluminium superstructures shall be grounded according to requirements and materials defined in DNVGL-OS-D201.

3.13.1.28. For safety grounding installation typical details, see I-DE-3010-00-5140-700-P4X-003 - GROUNDING INSTALLATION TYPICAL DETAILS.

3.13.2. Static Electricity Discharge Protection

3.13.2.1. Protection against static electricity shall be provided in compliance with grounding requirements of IEC 61892-6 and Classification Society.

3.13.2.2. Additionally, for FPSOs and FSOs units, the requirements of IEC 60092-502 shall also be complied with.

3.13.2.3. Metallic piping, equipment, valves, instruments and accessories shall have means to assure both galvanic contact through screwed flanges and an electrically continuous connection to vessels or tanks directly grounded, in order to allow the discharge of static electricity, in accordance with the requirements of IEC 61892-7, IEC/TS 60079-32-1 and IEC 60092-502.

3.13.2.4. Unless otherwise stated in this specification, metallic structures (equipment, vessels, tanks, piping, etc.) for use in fluid handling applications, when directly welded or bolted to the main platform structure, need no additional connections to earth, provided the resistance to ground, as measured with a DC multimeter at any point of the said metallic structures, does not exceed 10 Ω. Measurements shall be carried out at the final stage of the commissioning phase, aiming at keeping the resistance to ground below 10^6 Ω over the lifetime of the offshore unit, according to IEC/TS 60079-32-1.

3.13.2.5. Unless otherwise stated in this specification, structures in compliance with the requirements of item 3.13.2.4 need no additional bonding jumpers between flange connections.

3.13.2.6. Detailed design shall issue a dedicated report aiming at gathering the grounding resistance values as measured in accordance with the requirements of item 3.13.2.4. In order to be included as part of the NR-10 dossier and used as reference in future audits, the said report shall indicate the positions of the bonding jumpers (if any) on the structures and, in addition, the reasons to conclude on the need or not for the bonding jumpers in each situation.

3.13.2.7. Metallic structures, HVAC ducts, vessels, tanks, parts of metallic piping and non-electrical equipment skid, if not connected to vessel's metallic structure or hull, shall be wired (through grounding cables) from two different points to PE Earth Bosses welded to the main structure.

3.13.2.8. Bonding jumpers shall be installed across metal piping flange connections provided with non-conductive gaskets between them, regardless of the kind of fluid that flows inside the piping. However, if RTJ (Ring Type Joint) metal gaskets or equivalent are used, the interconnection of flanges with bonding becomes unnecessary. In either case (need of bonding jumpers or use of RTJ metal gaskets), the whole structure shall be in compliance with the requirements of item 3.13.2.4.

3.13.2.9. When connected to non-metallic structures (such as piping systems), metallic equipment (instruments, valves, etc.) and fittings for use in fluid handling applications shall be earthed through a grounding cable. If two or more pieces of metallic equipment are next to each other, they may be alternatively bonded together and thereafter connected to ground in one common point, instead of being individually earthed.

3.13.2.10. Regardless of the need for fixed bonding, flanges shall be provided with grounding terminals for temporary bonding during piping maintenance.

3.13.2.11. Non-metallic piping, tanks and vessels grounding and bonding shall comply with the requirements of IMO Resolution A.753 (18).

3.13.2.12. The helideck shall have provisions for temporary grounding, in order to allow the aircraft refuelling system (fuel supply facilities, fuel hoses, etc.) and the aircrafts themselves to be earthed during refuelling operations. All other places where transference and/or filling of recipients, vessels or tanks are foreseen shall have provisions for temporary grounding.

3.13.3. Grounding of Electrical Cables

3.13.3.1. Shields and armours of three-core cables shall be earthed at both, sending (source side) and receiving (load side) ends.

3.13.3.2. Shields and armours of single-core cables shall be earthed at only one end. At the floating end, they shall be properly insulated from each other and from the earth. If the load to be supplied is located in a hazardous area, both shields and armours shall be earthed only at the receiving end.

3.13.3.3. Shields of electrical cables shall be earthed by connecting them to the grounding facilities (terminals, bars, etc.) through a grounding cable.

3.13.3.4. In order to be earthed, armours of electrical cables shall be initially attached to the metallic cable glands installed into entries of enclosures or removable plates. The subsequent connection to the grounding facilities (terminals, bars, etc.) shall be in accordance with the following rules:

a) For cable glands installed into entries of non-metallic removable plates

The cable glands shall be connected to the grounding facilities (PE grounding bar) through a grounding cable.

b) For cable glands installed into non-threaded entries of metallic enclosures and removable plates

The cable glands shall be connected to the grounding facilities (PE grounding bar) through a grounding cable.

c) For cable glands screwed into threaded entries of metallic enclosures and removable plates

The sheets of enclosures and the removable plates shall be connected to the grounding facilities (PE grounding bar) through a grounding cable.

3.13.3.5. Inside panels, shields of both three-core and single-core cables shall be connected to the grounding bar of the corresponding feeder compartment according to the arrangement of Figure 6.

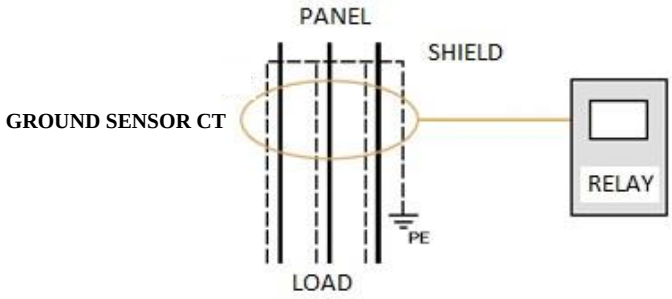


Figure 6 - Connection of shields of electrical cables to the grounding bars of panels

3.13.3.6. Inside panels, armours of both three-core and single-core cables shall be earthed as required in item 3.13.3.4. The final connection to the grounding bar of the corresponding feeder compartment, from either metallic cable glands, sheets of enclosures or removable plates, shall be according to the arrangement of Figure 7.

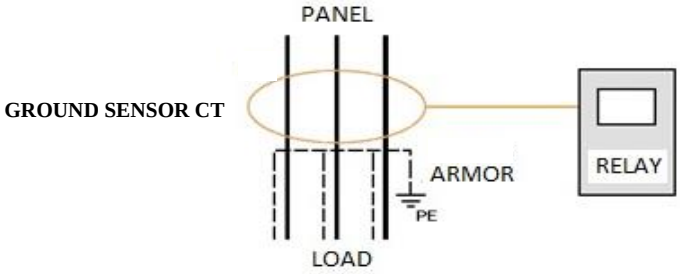


Figure 7 - Arrangement for the connection of armoured electrical cables to the grounding bars of panels

3.13.3.7. Electrical cables for the supply of motors driven by high-frequency switched-mode converters shall be earthed according to the corresponding requirements of IEC 60034-25.

3.13.3.8. For cables provided with a grounding conductor, the latter shall be earthed at both sending and receiving ends.

3.13.3.9. Single point grounding of shield and armouring is permitted for DC cables with high ripple content. The floating side shall be properly insulated.

3.13.3.10. For grounding of cables proper for signals or IS circuits, refer to 3.13.6.

3.13.4. Electrical Panels Grounding

3.13.4.1. All electrical panels shall have PE bars, where all metallic components not intended to current carrying (panels structures, doors, mounting sheets, secondary of measurement, protection and auxiliary transformers, electrical power cable shields and armours, grounding wire, components enclosures, etc.) shall be connected.

3.13.4.2. PE bars of medium and low-voltage MCCs, CDCs, and thyristorized panels shall be connected to two (2) PE Earth Bosses. PE bars of all other panels shall be connected to only one PE Earth Boss. In both cases, the PE bars and PE Earth Bosses shall be interconnected by dedicated grounding cables.

3.13.5. Grounding of Instrumentation and Telecom Panels

3.13.5.1. The PE bars of Instrumentation and Telecommunication panels shall be connected to an PE Earth Boss through a dedicated grounding cable. If two or more of such panels are sufficiently close together, their PE bars may be interconnected through grounding cables. In this case, only one among the common PE bars need to be wired, through a grounding cable, to an PE Earth Boss.

3.13.6. Grounding of Panels with Signal Circuits

3.13.6.1. The enclosures of panels with signal circuits shall be grounded at both top and bottom parts if the panel is higher than 2000 mm. Otherwise, the enclosures shall be grounded at either top or bottom part. The grounding cables shall be as short as possible, with a length-to-width ratio of less than 5:1 (see Figure 5).

3.13.6.2. Panels with signal circuits shall have dedicated PE, IE and IS grounding bars, which shall be individually connected (through dedicated grounding cables) to the corresponding Earth Bosses. Additionally, IE and IS grounding bars shall be isolated from the panel enclosure.

3.13.6.3. There shall be dedicated Earth Bosses for IE and IS grounding. The connections between the IE/IS grounding bars and Earth Bosses shall be as short as possible. PE Earth Bosses of the safety grounding shall be located at least 1 meter away from the IE or IS Earth Bosses.

3.13.6.4. If, due to the size of a panel with signal circuits, two or more IE grounding bars are needed to be installed, they shall be internally interconnected, and, from one of the bars, a grounding cable shall be wired to an IE Earth Boss welded to the structure. The same applies to IS grounding bars.

3.13.6.5. In panels with signal circuits, cable armours shall be connected to safety grounding bars (PE bar) at both ends, while the cable shields shall be connected in only one end to IE or IS grounding bars, depending on the type of circuit.

3.13.7. Grounding of Lighting Fixtures and Floodlights

3.13.7.1. Lighting panels shall provide the ground reference to the lighting fixtures and floodlights supplied by them. This shall be accomplished as follows:

a) For lighting fixtures and floodlights with metallic frame

A grounding cable shall be wired from the lighting panel to a grounding terminal inside the lighting fixture or floodlight. This internal grounding terminal shall then be connected to the frame of the lighting fixture or floodlight.

b) For lighting fixtures and floodlights with non-metallic frame

A grounding cable shall be wired from the lighting panel to a grounding terminal inside the lighting fixture or floodlight. This internal grounding terminal need not be connected to the frame of the lighting fixture or floodlight.

3.13.8. Power Transformers Grounding

3.13.8.1. The structures, grids, boxes and all transformer non-conducting metallic parts shall be connected in one point to PE Earth Boss using dedicated grounding cables.

3.13.9. Grounding of Motors and Generators

3.13.9.1. Motors and generators rated 11 kV or less shall be grounded as follows:

a) When sharing a common support structure ("skid-mounted" system) with the driven machine (motors) or the prime mover (generators).

The grounding terminal attached to the frame of the machine shall be wired, via a dedicated grounding cable, to the grounding bar of the skid. This bar shall then be connected to an PE Earth Boss welded to the structure.

b) When not sharing a common support structure with the driven machine (motors) or the prime mover (generators)

The grounding terminal attached to the frame of the machine shall be wired, via a dedicated grounding cable, to an PE Earth Boss welded to the structure.

3.13.9.2. Motors and generators rated above 11 kV shall be grounded as follows:

a) When sharing a common support structure ("skid-mounted" system) with the driven machine (motors) or the prime mover (generators)

The two grounding terminals attached to the frame of the machine shall be individually wired, via dedicated grounding cables, to the grounding bar of the skid. This bar shall then be connected to an PE Earth Boss welded to the structure.

b) When not sharing a common support structure with the driven machine (motors) or the prime mover (generators)

The two grounding terminals attached to the frame of the machine shall be individually wired, via dedicated grounding cables, to two PE Earth Bosses welded to the structure.

3.13.10. Cross-Sectional Areas of Safety Grounding Cables

3.13.10.1. Unless otherwise stated by Classification Society, the cross-sectional areas of cables for safety grounding and bonding shall follow this table:

Table 7 – Cross-sectional areas of cables for safety grounding and bonding

Application	Cross-sectional area of associated current carrying conductor	Minimum cross-sectional area of copper grounding cable
Grounding cable between modules supports and hull structure	-	2 x 70mm²
Safety grounding cable from equipment (motors, generators, transformers, etc.)[1] to skid grounding bar or PE Earth Boss	A ≤ 16mm²	A
	A > 16mm²	A/2 (not less than 16mm²)
Safety grounding cables from non-welded (to structure) skids of electrical equipment to PE Earth Bosses	-	70mm²
Bondings	-	25mm²
Safety grounding for switchgears, MCCs and thyristorized panels	-	2 x 70mm²
Safety grounding for other panels (other than switchgears or MCCs or thyristorized panels)	A ≤ 16mm²	A
	A > 16mm²	A/2 (not less than 16mm²)
Lighting Fixtures	A = 2.5mm²	A
	A > 2.5mm²	A/2 (not less than 4mm²)

Notes: 1- For motors and generators rated above 11 kV, two dedicated grounding connectors individually wired to either the grounding bar or the two (2) PE Earth Bosses.

3.14. System Grounding

3.14.1. System grounding shall be carried out with a dedicated conductor, independent of the grounding cable used for the safety grounding.

3.14.2. The system grounding connection shall be carried out through two independent grounding cables, interconnecting the neutral of the equipment after the grounding resistor or transformer to two PE Earth Bosses in the structure, increasing the reliability of the interconnection.

3.14.3. Unless otherwise stated by Classification Society, the system grounding cables cross sections, when separate fixed grounding cables are used, shall follow this table:

Table 8 – System Grounding cables cross-sections

Application	Cross-sectional area of associated current carrying conductor	Minimum cross-sectional area of copper grounding cable
System grounding cables from Main Generators grounding transformers to PE Earth Bosses, in case of high-resistance grounded systems	-	2 x 35mm²

Application	Cross-sectional area of associated current carrying conductor	Minimum cross-sectional area of copper grounding cable
System grounding cables from medium-voltage transformers grounding resistors to PE Earth Bosses, in case of high-resistance grounded systems	-	2 x 35mm²
System grounding cables from neutral of low-voltage transformers to PE Earth Bosses, in case of solidly grounded systems	A ≤ 120mm²	A/2 (minimum 10mm²)
	A > 120mm²	70mm²

3.15. Socket-Outlets

3.15.1. It shall be provided circuit-breakers with RCD (Residual Current Protective Device) of 30 mA, according to requirements of IEC 60364-4-41, for circuits up to 32A feeding:

- Socket-outlets for external areas;

  Note: For external circuits, the RCD shall be installed in the last distribution panel (closest to the socket-outlets) to avoid wrong operation due to capacitive current in long cables.
- Laundry circuits, including socket-outlets;
- Kitchen circuits, including socket-outlets;
- Infirmary circuits, including socket-outlets;
- Laboratory circuits;
- Accommodation circuits
- Lighting and socket-outlets located inside panels.

3.15.2. All socket-outlets fed from normal panels shall be powered off in case of ESD-3 signal.

3.15.3. Socket-outlets intended to supply diving equipment shall be fed from essential panels. There shall be redundant socket-outlets, each one fed from different essential panel in each diving station. There shall be at least two (2) dedicated functional units (for 480V circuits), each one in separated essential MCCs, to feed the diving station socket-outlets, providing redundancy. The cable distribution shall interconnect the socket-outlets among diving stations, so that each functional unit powers one socket-outlet in each diving station. Alternative distribution arrangements with more functional units are acceptable, since the redundancy is kept.

3.15.4. Socket-outlets for diving equipment (essential equipment) shall not be powered off in case of ESD signal.

3.15.5. Each socket-outlet shall have a plate informing the service voltage and rated current.

3.15.6. Socket-outlets supplied by Emergency Loads UPS AC shall be clearly identified with ineffaceable labels showing:

220Vac ALIMENTADO POR UPS
SOMENTE UTILIZE PARA
EQUIPAMENTOS DE EMERGÊNCIA

3.15.7. Socket-outlets supplied by Emergency Loads UPS DC shall be clearly identified with ineffaceable labels showing:

TENSÃO – 220Vdc
ALIMENTADO POR CB
USE APENAS PARA
EQUIPAMENTOS DE EMERGÊNCIA

3.15.8. Socket-outlets supplied from Emergency Loads UPS shall be installed only inside Central Control Room, Automation and Electrical Panels Room, and Essential Panels Room. Any other socket-outlet supplied from the same system and installed outside the said rooms shall be approved by PETROBRAS.

3.15.9. Socket-outlets with voltages 120V and 220V shall be provided and distributed in living quarters. At least four socket-outlets shall be provided for each living quarter, with at least one of them rated for 20A. There shall be at least one socket-outlet in living quarter rest rooms, close to mirror, rated to 20A.

3.15.10. Socket-outlets with voltage 220V shall be provided and distributed in electrical equipment rooms. The number of socket-outlets shall be defined during Detailed Engineering Design.

3.15.11. The control's rooms, essential panels' rooms, UPS rooms, workshops, generators rooms, radio rooms and telecommunication equipment rooms, shall have at least 10%, with a minimum of one, of the total of normal and essential 220V socket-outlets installed in each room, fed from the essential lighting panel. These sockets-outlets shall be clearly identified as essential circuits.

3.15.12. It shall be provided groups of assembled socket-outlets with plugs to be used during temporary service on board, fed from normal panels. These socket-outlets shall be used to feed portable tools and others. The main characteristics for these groups are:

a) 01 (one) with the rated voltage of the LV distribution system (380V to 480V, according to LV system rated voltage of the Unit) 3ph 60Hz socket-outlets with plugs;
b) 01 (one) 220VAC 3ph 60Hz socket-outlets with plugs;
c) 01 (one) 220VAC 2ph 60Hz socket-outlets with plugs.

3.15.13. All Ex socket-outlets for each kind (same voltage and current) shall be from the same manufacturer and same type, for the whole Unit (standardization).

3.15.14. At least one group of assembled socket-outlets, as defined in item 3.15.12, shall be installed in the following places:

a) Cargo areas intended for temporary installation of containers (one group per container);
b) Areas intended for temporary maintenance of equipment (turbines, generators, compressors, pumps, etc.);
c) Areas intended for temporary installation of toolshop containers;
d) Areas intended for temporary installation of warehouse;
e) Areas intended for installation of equipment for submarine inspection;
f) Areas next to lifeboats, rescue boats.

3.15.15. At least two groups of assembled socket-outlets, as defined in item 3.15.12, shall be installed close to general use cargo areas.

3.15.16. Besides these groups, 220V 3ph and 220V 2ph socket-outlets shall be provided aiming to reach any point of deck, module, columns and pontoons using cables with maximum 25m length, without crossing watertight doors or stairs between decks in closed spaces.

3.15.17. Besides these groups, socket-outlets with plugs for welding machines (380V to 480V, according to LV system rated voltage of the Unit) 3ph 60Hz shall be installed preferably in safe places, along the central pipe-rack, far from hazardous areas, distributed strategically in order to cover the places not covered by the groups listed in items 3.15.13 and 3.15.15, using welding cables with maximum 40m length. The circuits that feed these socket-outlets shall be turned off in case of emergency shutdown.

3.15.18. The groups of assembled socket-outlets shall be mechanically protected against impact and shall be installed out of hazardous areas.

3.15.19. All three-phase socket-outlets shall have the same phase sequence rotation, considering R>S>T clockwise.

3.15.20. The number of socket-outlets defined during the Detailed Engineering Design for each internal environment shall be submitted to Petrobras approval, regardless of the requirements stated above.

3.15.21. In platforms with low-voltage system in 690Vac, the power socket-outlets shall be kept in 480V and there shall be specific sub-system in 480V for these loads. In these platforms the Electrical Workshop shall have additionally one power socket outlet in 690Vac for tests. This 690Vac socket-outlet shall have constructional type different from the 480Vac socket-outlets, to avoid connection of wrong plugs among them.

3.16. Electrical Equipment Layout

3.16.1. Electrical equipment layout shall comply with the requirements of IEC 61892-6, NR-12, NR-17 and Classification Society.

3.16.2. All electrical equipment shall be located considering maintenance spaces, handling spaces, people circulation spaces and scape routes.

3.16.3. Power panels, control panels, lighting panels, junction boxes, VSDs, soft-starters, transformers, ground resistors, UPSs, rectifiers, battery chargers, batteries and other similar electrical equipment shall be located with easy access to operation, inspection and maintenance, at floor level or local footbridge level and without necessity of use of any resource like stairs, scaffold or stands to operation or maintenance.

3.16.4. Electrical equipment positions (mainly inside electrical equipment rooms) shall be defined optimizing (minimizing) length of power cables.

3.16.5. Electrical equipment positions inside electrical equipment rooms shall be defined optimizing (maximizing) internal corridors (to allow easy handling of equipment). Electrical equipment requiring only front access shall be positioned, as much as possible with back side close to bulkheads.

3.16.6. Electrical equipment, power panels, distribution panels, lighting panels, control panels, socket outlets and junction boxes installed outdoor shall be located as much as possible at non-classified areas and far from gas piping, hot piping, and hot equipment.

3.16.7. Electrical equipment, power panels, distribution panels, lighting panels, control panels, socket outlets and junction boxes shall be located as much as possible outside coamings to avoid risk of damage due to fire in the contained fluid. Not applicable to electrical equipment that are part of a skid, when the skid is inside a coaming.

3.16.8. Redundant emergency and essential equipment shall be installed as far as possible one from the other to minimize risk of damage in both equipment due to a common failure in their vicinities.

3.16.9. The suppliers of the package units shall define the layout of the equipment, accessories and piping around the skid, taking into account the free space required for passage, escape, operation, inspection and maintenance.

3.16.10. All electrical equipment shall have, on the Detailed Design stage, their external dimensions strictly controlled together with suppliers, in order to not exceed the dimensions assumed at the layout executed by PETROBRAS.

3.16.11. All layouts shall be updated with their actual dimensions, as soon as the equipment suppliers are defined.

3.16.12. All panels and other electric equipment shall be located aiming to minimize the works of hook-up at sea, within discerning consideration regarding economical and reliability points of view.

3.16.13. It shall not be permitted any liquid piping running through electrical equipment (panels, transformers, batteries, UPSs, battery-chargers, VSDs, rectifiers, etc.) rooms. It shall not be permitted any liquid piping above electrical equipment (panels) in workshop area.

3.16.14. All switchgears, motor control centers, UPSs, battery chargers and control panels shall be installed inside rooms where the temperature is controlled.

3.16.15. Electrical rooms shall be provided with air-lock at entrance doors in the following conditions:

- If the room is in a safe area and the door opens to a classified area;
- If it is a main access door to the room and leads directly to an open area.

Note: For air-lock systems required by Safety, Arrangement and Architecture engineering disciplines, refer to the corresponding documentation.

3.16.16. All power transformers shall be installed in closed rooms with artificial ventilation.

3.16.17. Enough space for panels' expansion shall be provided. At least one column in each side of the panel, for panels with possibility of expansion in both ends, and two columns in the expandable side, for panel with possibility of expansion only in one end, shall be foreseen, with no impact on escape routes. There shall be enough area to make possible the extraction of any equipment from the room.

3.16.18. Installation of cable-trays and busbar trunkings shall keep the spaces for movement of equipment (panels, transformers, grounding resistors, etc.) and the removable panels on bulkheads free, inside electrical equipment rooms.

3.16.19. Equipment that doesn't need lateral maintenance working space can stay together with other equipment or bulkheads on this side.

3.16.20. The minimum spacing around equipment and also the criteria below mentioned shall be considered on the execution of electric rooms arrangements:

Table 9 – Minimum Space for Maintenance / Expansion

Equipment	Front Side (mm)	Rear Side (mm)	Lateral Sides (mm)	Top Side (mm)
Batteries	800	800 (1)	600	700 (10)
Rectifiers, Battery chargers, LV Inverters, LV Soft-starters, Control Panels, and LV AC and DC Switchboards	800	600 (3)	600 (2)	(9)
UPSs	800	600	600 (2)	(9)
LV Switchgears and MCCs	1400 (7)	800	600 (4)	1000 (8)
Switchgears and MCCs above 1kV	1600 (7)	1000	600 (5)	1000 (8)
Power Transformers up to 2MVA (6)	1500	800	1000	(9)
Power Transformers above 2MVA (6)	2000	800	1000	(9)
Lighting Transformers (6)	800	500 (3)	500 (2)	(9)
MV Inverters	1400	1000 (3)	600 (2)	(9)
Grounding Resistors (6)	800	-	500 (2)	(9)

Notes:
1) Batteries with up to 2 steps rack arrangement may be installed with rear distance 0;
2) Free lateral area may be 0, provided the arrangement of the room complies with safety requirements for movement of people;
3) Unless otherwise stated in design documentation, wall-mounted equipment and self-supported equipment with rear side facing the bulkhead (when no rear access is required for any kind of service) is allowed. In this specific case, no free rear area is required;
4) Consider also, enough space for 2 future columns at one lateral side for MCCs and space for 1 future column at each lateral side for switchgears;
5) Consider also, enough space for 1 future column at each lateral side;
6) Considering terminal boxes at front side;
7) Consider also, a minimum of 400mm free space with the circuit-breaker or drawer in extracted position;
8) Free space for exhaust of expansion gases from internal short-circuit;

9) According to Manufacturer requirements;

10) Limit for battery elements installed vertically, to allow access to terminal poles.

3.16.21. Removable (portable) electrical safety mats shall be provided for maintenance activities in panels in order to comply with NORMAM 01 and NR-10. They shall comply with:

- IEC 61111 or ASTM D 178-01 requirements with minimum electrical class 0 (rated voltage 1kV r.m.s. and tested for 5kV) for panels with rated voltage up to 690V and minimum electrical class 2 (rated voltage 17kV r.m.s. and tested for 20kV) for panels with rated voltage above 690V;
- Type II – ABC (ozone, fire and oil resistant – ASTM D 178-01);
- Halogen free;
- Smoke density test and toxicity according to ISO 5659-2 and IMO Res. MSC 61(67);
- Non-slip (IEC 61892-6);
- Heavy traffic.

Note: These removable (portable) insulated safety mats are additional to non-conductive rubber flooring, installed where required by Architecture documentation.

3.16.22. It shall be provided the following quantity of removable (portable) electrical safety mats per electrical panels room:

- Two (2) with minimum electrical class 0, with size 1x2m;
- Two (2) with minimum electrical class 0, with size 0.6x0.6m;
- Two (2) with minimum electrical class 2, with size 1x2m.

3.16.23. Floodlight and searchlight installed at hazardous areas or open areas shall have plug-socket set for removal and maintenance at floor level. These plug-socket sets shall be Ex-e type according to hazardous area classification.

3.17. Battery Installations

3.17.1. The batteries location and installation shall comply with requirements of IEC 61892-6, IEC 61892-7 and Classification Society.

3.17.2. Storage batteries shall be located on non-hazardous areas, on well ventilated room, fitted with air intakes, exhauster and pressurization, exclusive for batteries. VRLA type batteries shall be installed in rooms with controlled temperature. In case of lack of an exclusive compartment for battery installation, they can be installed on deck, in suitable boxes or lockers.

3.17.3. The standby ventilation system of battery rooms shall start automatically in case of detection of hydrogen inside the room.

3.17.4. Redundant battery banks shall be installed in separated rooms or lockers.

3.17.5. Battery rooms shall not have openings to accommodation or indoor areas.

3.17.6. When assembled without rear access, battery racks shall be so arranged that the visualization of the electrolyte level is assured for each cell. This arrangement shall also complies with the requirement of Note 1) in Table 9.

3.17.7. It shall be avoided the installation of electrical equipment, other than lighting fixtures and batteries, inside battery rooms. Socket-outlets and switches shall not be accepted inside these rooms.

3.17.8. A box with fuses or circuit-breakers, located at the closest safe point outside the battery room shall be added to protection against short-circuit in cables between the batteries and the respective UPSs or battery chargers. A warning label shall be placed at the box front door requesting to open the battery circuit-breaker of the associated UPS or Rectifier before service. This box will not be necessary for short cable runs, if approved by PETROBRAS.

3.17.9. A suitable insulating material shall be installed on the connection terminals of the batteries, with the aim of providing protection against an accidental contact or a short-circuit.

3.17.10. Electric batteries rooms shall have acid resistant floor.

3.18. Cathodic Protection Installation

3.18.1. It shall be scope of Detailed Design the design of the cathodic protection system and equipment, including the interconnection between the monitoring panel and the anodes junction boxes.

3.18.2. The Cathodic protection system shall be sized and installed according to I-ET-3010.00-5267-750-P4X-001 - TECHNICAL SPECIFICATION FOR CATHODIC PROTECTION.

3.19. Lightning Protection System (SPDA)

3.19.1. The lightning protection system shall be sized based upon the outcomes of the Lightning Protection study, which shall be carried out in accordance with the requirements of I-ET-3010.00-5140-700-P4X-006 - REQUIREMENTS FOR ELECTRICAL STUDIES FOR OFFSHORE UNITS.

3.19.2. The Detailed Design documentation shall be updated to encompass the solutions and recommendations provided by the Lightning Protection study. At least, the following documents shall be either issued or revised:

a) Loop-diagrams and interconnection diagrams (to include the surge protective devices needed for those instruments most likely to be exposed to the undesirable effects of the lightning discharges);

b) Typical details for grounding;

c) Technical specifications and purchase orders related to the Lightning Protection System as a whole (air terminals, strike termination devices, isolation transformers, surge protective devices, cables, connectors and so on);

d) All Drawings (plans, sections, views and so on) needed to detail the Lightning Protection System design.

3.19.3. As stated in I-ET-3010.00-5140-700-P4X-006 - REQUIREMENTS FOR ELECTRICAL STUDIES FOR OFFSHORE UNITS, the resistance to earth of the Lightning Protection System, as measured from the strike termination devices or from the highest discharge attachment points on the structures, shall not exceed 10 Ω. Whenever all measured values remain below this limit, a technical appraisal report shall be issued to provide an evidence of the Lightning Protection System electrical continuity, as required in NR-37.

3.20. Short-Circuit Limits

The electrical system shall be designed so as to limit the short-circuit levels to the values defined in Table 10, considering all possible operational conditions. Surpassing of the defined limits shall be acceptable during momentary parallel operation between transformers for load transference.

Table 10 – Short-Circuit Limits

Voltage Level	Calculated Thermal Equivalent Short-Circuit Current (I_{th}) for 1s (4)	Calculated Peak Short-Circuit Current (ip) (4)
13.8kV	< 50kA	< 130kA
4.16kV or 6.6kV	< 40kA	< 104kA
440V, 480V or 690V (CDC)	< 65kA	< 143kA
440V, 480V or 690V (MCC)	< 18kA (5)	< 52,5kA
220V or 240V Switchboard (1)	< 15kA	< 30kA
220V or 240V Distribution Board (2)	< 9kA	< 20kA

Notes: 1) 220V or 240V Switchboards are the panels directly connected to either the secondary winding of 480-220V (or 690-220V) transformers or the inverter side of the UPSs.

2) 220V or 240V Distribution Boards are the panels connected to the 220V or 240V Switchboards.

3) Limits for other rated voltages shall be agreed with PETROBRAS.

4) As defined in IEC 60909.

5) Unless otherwise stated in Project Documents, this short-circuit calculation shall be taken without considering the momentary parallelism of Auxiliary or Emergency Generators with Main Generation and with switchgears in normal operation with tie circuit-breakers open.

3.21. Emergency Shutdown (ESD) Criteria for Electrical Loads

3.21.1. Electrical loads shall receive Emergency Shutdown (ESD) signal from CSS shutdown controllers, following general criteria defined in DR-ENGP-M-I-1.3 - SAFETY ENGINEERING.

3.21.2. These general criteria are detailed in specific criteria listed below:

- Loads classified as Normal loads:

- Total failure in CSS shutdown controllers shall activate all ESD signals for these loads (fail-safe condition for Normal Loads is turned off).
- All these electrical loads shall be turned off when the platform is in emergency condition;
- Each electrical load with rated voltage 440V or above, shall receive individual ESD signal;
- Electrical load with rated voltage below 440V shall not have individual ESD signal if a collective ESD signal is applied upstream (e.g. 220V loads fed from secondary 480-220V (or 690-220V) transformers need not individual ESD signal if an individual ESD signal turns off the primary winding of the transformer);
- Incoming circuit-breakers of electrical panels (including Main Generation circuit-breakers and Hull Generator circuit-breakers) shall receive ESD signals (see exceptions below);
- Incoming circuit-breakers of electrical panels connected to secondary (or tertiary) windings of transformers shall not receive ESD signal, since the outgoing circuit-breakers of the upstream panels receive ESD signal (turning off the primary of the transformer);
- Incoming circuit-breakers of low-voltage MCCs shall not receive ESD signal, since the outgoing circuit-breaker of the upstream CDC receive ESD signal;
- Tie circuit-breakers shall not receive ESD signals, since the incoming circuit-breakers of the panel receive ESD signals;
- Back-feeder circuit-breakers shall receive ESD-3T signals;
- Auxiliary Generator(s) circuit-breaker(s) shall receive ESD signal. Auxiliary Generator Power and Control Panel (AGCP) shall receive ESD signal only in case of confirmed gas detection or confirmed fire detection in its room, as required in safety data sheets;
- All ESD signals triggered by fire or gas detection shall trip, at Topside and Hull 220V normal switchboards, the outgoing circuit-breakers that supply the 220V space heater panels, in order to avoid sending individual ESD signals to each heating resistor.

- Loads Classified as Essential Loads:
  - Total failure in CSS shutdown controllers shall allow operation of all Essential Loads (no ESD signals for these loads – fail-safe condition for Essential Loads is available for operation);
  - As general rule, Essential Loads shall not receive ESD signals, except the following cases;
  - HVAC loads shall receive ESD signals to allow turning off the HVAC systems in cases of confirmed gas detection or confirmed fire detection, as required in safety data sheets;

- Emergency Generator shall not receive ESD-1, ESD-2, ESD-3P, or ESD-3T signals if it is running. If the Emergency Generator is stopped, it shall receive a signal to inhibit start-up in case of confirmed gas detection or confirmed fire detection in its room, as required in safety data sheets. When required by Classification Society, Emergency Generator diesel engine shall receive a shutdown signal from manual push-button (close to ESD4 button) at A&C Emergency Control Stations;
- Total failure in CSS shutdown controllers shall allow operation of Emergency Generator (fail-safe condition for Emergency Generator is available for operation);
- Fire Fighting Pump (including its Power and Control Panels) shall not receive ESD signal if it is running. If the Fire Fighting Pump is stopped, it shall receive a signal to inhibit start-up in case of confirmed gas detection or confirmed fire detection in its room, as required in safety data sheets;
- Total failure in CSS shutdown controllers shall allow operation of Fire Fighting Pumps (fail-safe condition for Fire-Fighting Pumps is available for operation).

- Loads Classified as Emergency Loads:
  - Total failure in CSS shutdown controllers shall allow operation of all Emergency Loads, which shall not receive ESD signals (fail-safe condition for Emergency Loads is “available for operation”).

3.21.3. Electrical panels shall be provided with interposing relays in each functional unit intended to receive ESD signals. These signals shall by no means be sent from a protection relay.

Note: Unless otherwise stated in A&C Documentation, ESD signals from A&C shall be wet contacts in 24Vdc (24Vdc from the source of the signal – A&C control panel). These signals shall comply with I-ET-3010.00-5520-888-P4X-001 - AUTOMATION PANELS and I-ET-3010.00-1200-800-P4X-002 - AUTOMATION, CONTROL AND INSTRUMENTATION ON PACKAGE UNITS.

3.21.4. Emergency Shutdown Signal (ESD) Simultaneous with Control Voltage Failure

3.21.4.1. As detailed in I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS and I-ET-3010.00-5140-741-P4X-002 - MEDIUM-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS, failure in control voltage of switchgears and medium-voltage MCCs shall generate only alarm signals and shall not generate automatic trip of functional units. However, in case ESD signal for one normal functional unit simultaneous with control voltage failure in the respective control busbar, the safety situation requires turning off the load, to avoid possible accidents. For normal loads fed from switchgears, medium-voltage MCCs and low-voltage MCCs with control voltage from UPS, ESD signal simultaneous with control voltage failure shall generate trip signals to all upstream power sources of the respective panel.

3.21.4.2. Since it is not possible to guarantee trip signal for tie circuit-breakers (due to control voltage failure) and since it is not possible to guarantee tie circuit-breaker condition (open or closed), the trip signal shall be sent to all upstream power source(s) in all busbars of the panel.

3.21.4.3. When the upstream power source(s) is(are) electrical generator(s), the trip signal shall be sent to the respective unit control panel(s) (UCP), turning off the driver, since it is not possible to open the respective circuit-breakers.

3.21.4.4. When the upstream power source(s) is(are) transformer(s), the trip signal shall be sent to primary circuit-breaker(s).

3.21.4.5. When the upstream power source(s) is(are) another panel(s), the trip signal shall be sent to the respective outgoing circuit-breaker(s) in this (these) upstream panel(s).

3.21.4.6. These trip commands are not applicable to essential switchgear, essential MCCs and Emergency Generator.

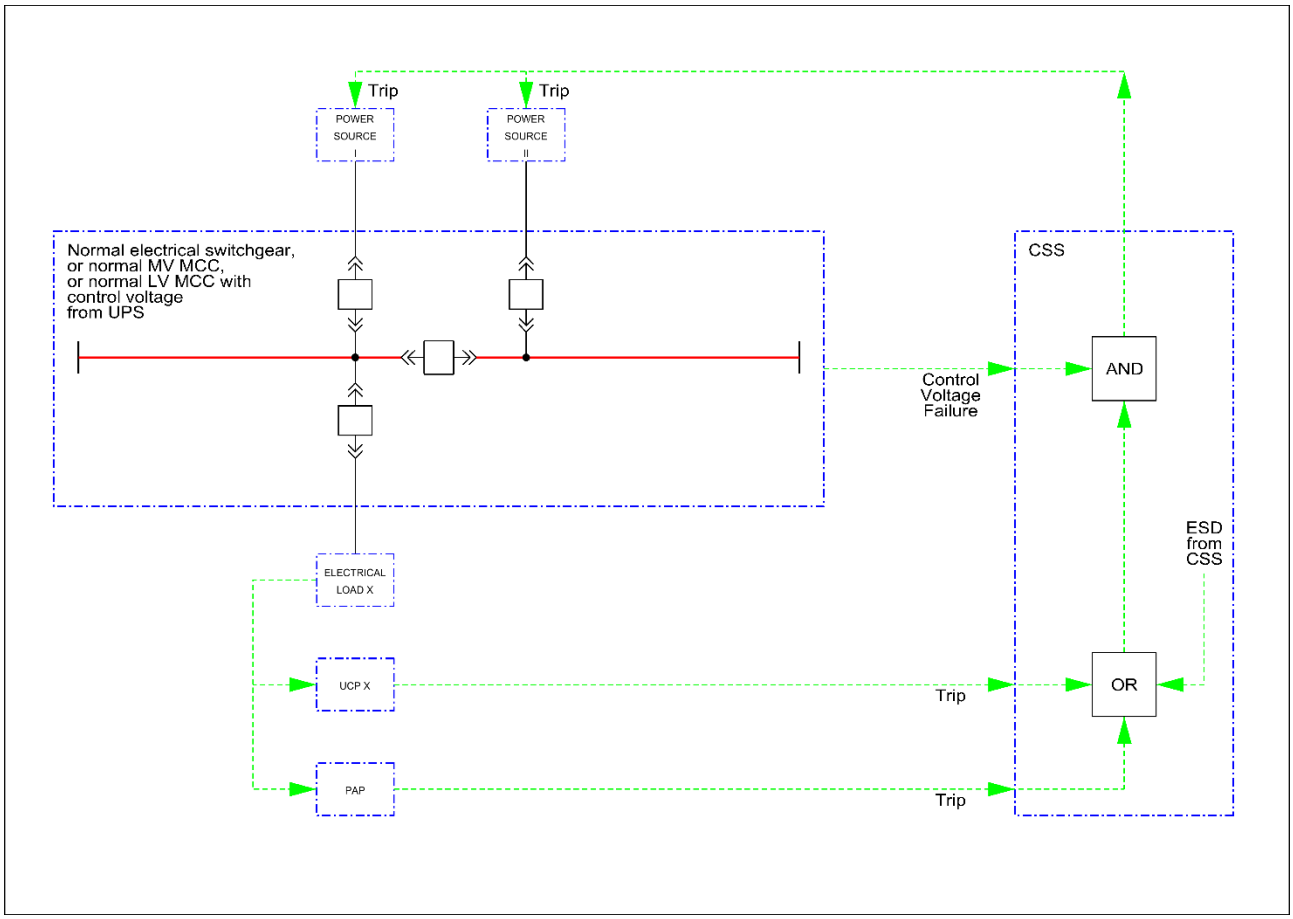
3.21.4.7. The trip signals for the upstream power source(s) shall be sent by CSS controllers.

3.21.4.8. Electrical System shall send control voltage failure signal from switchgears, medium-voltage MCCs and low-voltage MCCs with control voltage from UPS to CSS. CSS will monitor the ESD signals for each load and shall carry out the logic to verify simultaneous trip signals with control voltage failure in the respective electrical panel, to generate the trip signal(s) to the upstream power source(s).

Note: Package equipment may have ESD signals generated by Unit Control Panel (UCP), by Protection Acquisition Panel (PAP) in case of Packages P0 and by CSS controllers.

3.21.4.9. Figure 8 shows a simplified schematic of this requirement. This figure does not detail signal format and complete signal path. For details see I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST, I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS, I-ET-3010.00-5140-741-P4X-002 - MEDIUM-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS and A&C documentation.

Figure 8 - Simplified schematic for ESD simultaneous with Control Voltage Failure



4. ABBREVIATIONS AND ACRONYMS

Abbreviation	Meaning
A&C	Automation and Control System
ABNT	Associação Brasileira de Normas Técnicas
AC	Alternate Current
AGCP	Auxiliary Generator Control Panel
API	American Petroleum Institute
ART	Anotação de Responsabilidade Técnica (Technical Responsibility Annotation)
CDC	Switchgear
CSS	Control and Safety System
CT	Current Transformer
DC	Direct Current
DHC	Diretoria de Hidrografia e Navegação
DNV GL	Det Norske Veritas Germanischer Lloyd
EFI	Earth Fault Detector
EGCP	Emergency Generator Control Panel
ESD	Emergency Shutdown
FEED	Front-End Engineering Design
FGS	Fire and Gas System
FPSO	Floating Production Storage and Offloading
FSO	Floating Storage and Offloading
HGCP	Hull Generator Control Panel
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMO	International Maritime Organization
INMETRO	Instituto Nacional de Metrologia, Normalização e Qualidade Industrial
LEL	Low Explosion Limit
LV	Low-voltage
MCC	Motor Control Center
MCT	Multicable Transit
NFPA	National Fire Protection Association
NHO	Norma de Higiene Ocupacional
NORMAM	Normas da Autoridade Marítima
NR	Norma Regulamentadora
PQMS	Power Quality Measurement System
RCD	Residual Current Detector
RIPEAM	Regulamento Internacional para Evitar Abalroamentos no Mar
RMS	Root Mean Square
RTJ	Ring Type Joint
SPDA	Sistema de Proteção contra Descargas Atmosféricas (Lightning Strokes Protection System)
TGCP	Turbogenerator Control Panel
UPS	Uninterruptible Power Supply
VSD	Variable Speed Drive
VSD-FC	Variable Speed Drive – Frequency Converter
VT	Voltage Transformer