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FORM OWNED TO PETROBRAS N-381 REV. L
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1. OBJECTIVE

This specification establishes the technical requirements for the design, construction, and tests of Low-Voltage Motor Control Centers (MCCs) and Low-Voltage Switchgears (CDCs) for Offshore Units.

2. REFERENCE DOCUMENTS, STANDARDS AND CODES

Panel design shall comply with requirements of Classification Society, Brazilian Legislation, applicable regulatory rules and standards listed below.

At the design development and for equipment specification, IEC standards shall be used, all on their latest revisions. Exceptionally, where it is clearly justifiable, the ANSI, NEMA, IEEE, VDE and other internationally recognized standards may be used. Their use shall be restricted to specific cases and approved by PETROBRAS.

2.1 PETROBRAS Documents

[1] I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS
[2] I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS
[3] I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS
[4] I-ET-3010.00-5143-700-P4X-001 – ELECTRICAL SYSTEM PROTECTION CRITERIA
[5] I-ET-3010.00-1200-956-P4X-001 - QUALIFICATION TESTS FOR PAINT SYSTEMS
[6] I-LI-3010.00-5140-700-P4X-001 - ELECTRICAL EQUIPMENT DATA-SHEET MODELS
[7] ELECTRICAL SYSTEM AUTOMATION DOCUMENTATION
[8] ELECTRICAL FUNCTIONAL UNITS CLASSIFICATION ACCORDING TO CONTROL MODE DOCUMENTATION
[9] DOCUMENTATION GUIDELINES

2.2 IEC - International Electrotechnical Commission

TS60034-25 Rotating Electrical Machines - Part 25: AC electrical machines used in power drive systems – Application guide;
60092-201 Electrical Installation in Ships - Part 201: System Design – General;
60092-302 Electrical Installation in Ships - Part 302: Low Voltage Switchgear and Controlgear Assemblies;
60076-6 Power Transformers - Part 6 - Reactors;
60079-7 Explosive Atmospheres - Part 7: Equipment Protection by Increased Safety "e"
TECHNICAL SPECIFICATION

AREA:

TITLE: LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS

1. Explosive Atmospheres - Part 14: Electrical Installations Design, Selection and Erection
2. Tests on Electric Cables under Fire Conditions - Part 3-22: Test for Vertical Flame Spread of Vertically-Mounted Bunched Wires or Cables – Category A
3. Graphical Symbols for Use on Equipment - Database Snapshot
5. Degrees of Protection Provided by Enclosures (IP Code);
6. Electrical and electronic installations in ships — Electromagnetic compatibility (EMC) – Ships with a metallic hull;
7. Graphical Symbols for Diagrams - Data Snapshot;
8. Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content;
9. Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity;
10. Short-Circuit Currents in Three-Phase A.C. Systems;
11. Low-Voltage Switchgear and Controlgear – Part 2 - Circuit-Breakers;
12. Low-Voltage Switchgear and Controlgear - Part 4-1 - Contactors and Motor-Starters - Electromechanical Contactors and Motor-Starters;
14. Electromagnetic Compatibility (EMC) - Part 5: Installation and Mitigation Guidelines - Section 2: Earthing and Cabling;
15. Low-Voltage Switchgear and Controlgear Assemblies – Part 1: General Rules
16. Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies
17. Enclosed Low-Voltage Switchgear and Controlgear Assemblies - Guide for Testing under Conditions of Arcing due to Internal Fault;
18. Measurement of smoke density of cables burning under defined conditions – Part 2: Test procedure and requirements
19. High-voltage test techniques for low-voltage equipment – All parts
20. Communication Networks and Systems in Substation - All parts;
22. Mobile and Fixed Offshore Units - Electrical Installations - Part 3 - Equipment;
62262 Degrees of protection provided by enclosures electrical equipment against external impacts (IK code)

2.3 **IEEE - Institute of Electrical and Electronics Engineers (only where specified)**

- **C37.2** Standard for Electrical Power System Device Function Numbers, Acronyms, and Contact Designations;

2.4 **Brazilian Labour and Employment Ministry**

- **NR-10** Segurança em Instalações e Serviços em Eletricidade

2.5 **ASTM – American Society for Testing and Material**

- **F1166** Standard Practice for Human Engineering Design for Marine System, Equipment and Facilities

2.6 **IMO – International Maritime Organization**

- **IMO IA811E** Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU CODE)

2.7 **IOGP – International Association of Oil & Gas Producers**

- **S-560** Supplementary Requirements to IEC 61439-1 & 2 - LV Switchgear & Controlgear

3. **GENERAL CONDITIONS**

3.1 For the purpose of this document, requirements concerning both motor control centers and switchgears are cited using the word “Panel” or no word. Requirements concerning only motor control centers are cited using the word “MCC” and requirements concerning only switchgears are cited using the word “CDC”. See abbreviations on item 11.

3.2 Panels shall be designed and manufactured complying with the requirements of Classification Society rules, I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS and NR-10.

3.3 The specific characteristics of the Panel shall be indicated in the Data-sheet.

3.4 The Manufacturer shall supply all the electrical materials, accessories (connection cables, connectors, softwares, software licenses, calibration boxes etc.), equipment and specific tools (including a truck to extract circuit-breakers from CDCs), which are necessary for the assembly, start-up, commissioning, operation, disassembly and maintenance of the Panel.

3.5 The final assembly of Panels on the Unit shall be done by Manufacturer personnel.

4. **CONSTRUCTIVE CHARACTERISTICS**

4.1 **General Requirements**

4.1.1 Panels shall be manufactured, tested and installed according to all standards listed on item 2.
4.1.2 For installation in FPSO and FSO the standards IEC 60092-201 and IEC 60092-302 shall have priority over others.

4.1.3 Unless otherwise stated in Project Documentation, MCCs shall be designed to withstand the thermal stresses due to a thermal equivalent short-circuit current \( (I_{th} \text{ according to IEC 60909}) \) of 25kA for 1s and the dynamic stresses due to a peak current \( (i_p \text{ according to IEC 60909}) \) of 52.5kA. The rated short-time withstand current \( (I_{cw} \text{ according to IEC 61439-1}) \) for 1s of the MCC shall be equal to or bigger than the informed \( I_{th} \) and the rated withstand peak current \( (I_{pk} \text{ according to IEC 61439-1}) \) of the MCC shall be equal to or bigger than the informed \( i_p \).

4.1.4 CDCs shall be designed to withstand the thermal stresses due to the thermal equivalent short-circuit current \( (I_{th} \text{ according to IEC 60909}) \) informed in Data-Sheet for 1s and the dynamic stresses due to the peak current \( (i_p \text{ according to IEC 60909}) \) informed in Data-Sheet. The rated short-time withstand current \( (I_{cw} \text{ according to IEC 61439-1}) \) for 1s of the CDC shall be bigger than the informed \( I_{th} \) and the rated withstand peak current \( (I_{pk} \text{ according to IEC 61439-1}) \) of the CDC shall be bigger than the informed \( i_p \).

4.1.5 Unless otherwise stated in Project documentation, the MCCs rated current \( (I_n \text{ according to IEC 61439-1}) \) shall be limited to 800A.

4.1.6 Panels using flammable liquids in their components shall not be accepted.

4.2 Spare Drawers and Functional Units

4.2.1 Spare drawers shall not have immediate use. However, they shall be supplied completely mounted and wired, installed with all components in the Panels and ready for operation.

4.2.2 Unless otherwise stated in Project Documentation, each MCC shall have the following minimum spare drawers:
   
a) 3 (three) spare drawers for motor with rated power 11kW, and;
   b) 2 (two) spare drawers for motor with rated power 30kW, and;
   c) 1 (one) spare drawer for motor with rated power 55kW, and;
   
d) the necessary quantity of spare drawers for motor with rated power 11kW, to complete 15% of spare drawers (relating to total number of drawers, including spare drawers listed on items a to c).

4.2.3 Unless otherwise stated in Project Documentation, each CDC shall be furnished with 2 (two) spare drawers for motor loads for each semi-bar, with the rated current equal to or bigger than the rated current of the biggest motor load outgoing feeder (not considering back-feeders).

4.3 Environmental Conditions, Inclination Requirements and Vibration Requirements

4.3.1 The ambient temperature design for the Panels shall be 45°C, as stated in IEC 61892-1.

4.3.2 The design humidity, as a function of temperature, shall be 95% up to 45°C and 70% above 45°C, as stated in IEC 61892-1.
4.3.3 Panels and internal equipment and materials shall be suitable for storage, service and installation on marine and petrochemical environment, complying with requirements related to these conditions defined in I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.3.4 When installed in mobile units and ships (FPSO and FSO), the Panels shall be suitable to operate under inclination variations (static and dynamic) and acceleration conditions specified IMO MODU CODE, IEC 61892 and Classification Society.

4.3.5 Panels shall comply with vibrations requirements defined in I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS and Classification Society rules.

4.4 Classification of Assemblies

4.4.1 Panels shall be metallic Multi-Cubicle Type Assemblies;

4.4.2 Unless otherwise stated in Project Documentation, Panels shall be proper for indoor installation;

4.4.3 Unless otherwise stated in Project Documentation, Panels shall be stationary assemblies;

4.4.4 The external protection degree shall be defined according to IEC 60529 with a minimum:
   a) IP42W, for Panels installed in panel rooms;
   b) IP44W, for Panels installed in machinery rooms;
   c) IP56SW, for Panels installed outdoors.

Notes:  
1 - W means Panel suitable for saline, hot and damp atmosphere;
2 - S means that the test for ingress of water is carried-out with the movable parts at stationary conditions;
3 - Outdoors installations shall be submitted to PETROBRAS for approval and installation in hazardous areas shall not be permitted.

4.4.5 Panel shall be designed to keep the external protection degree with the drawers in test and isolated positions and during transfer from one position to another, in compliance with IEC 61439-2. If, after the removal of a withdrawable part, it is not possible to keep the original degree of protection manufacturer shall provide measures to be taken to ensure adequate protection (e.g. removable cover). Such measures shall be presented to PETROBRAS for approval.

4.4.6 Information provided by the ASSEMBLY manufacturer may take the place of such an agreement.

4.4.7 Panels shall be composed by withdrawable parts with the following positions as defined in IEC 61439, parts 1 and 2:
   a) Connected or operation;
   b) Test;
   c) Isolated;
d) Removed or extracted.

4.4.8 Each functional unit of MCC and each air circuit-breaker of CDC shall be one separate withdrawable part. The withdrawable parts shall slide over rails.

4.4.9 Protection against electrical shock by direct contact shall be ensured by means of protective barriers or enclosures.

4.4.10 Protection against electrical shock by indirect contact shall be ensured by means of protective circuits (earth bar), according to IEC 61439-1.

4.4.11 Adjacent functional units shall be separated from each other by means of barriers, providing protection degree at least IP2X, as stated in IEC 60529, and according to Form 4b, stated in IEC 61439-2.

4.4.12 The electrical connections of functional units within assembly shall be WWW (W means withdrawable) according to IEC 61439-2.

4.4.13 Panels shall have external mechanical impact strength (IK) of minimum IK 08 as defined in IEC 62262, according to IOGP S-560.

4.4.14 According to their characteristics under arcing conditions define in IEC TR 61641, CDCs shall be classified as Arcing Class A. The permissible current under arcing condition (Ip arc) shall be equal to or greater than the rated short-time withstand current (Icw) and the permissible arc duration (tarc) shall be at least 0.3s, during tests.

4.4.15 According to IEC TR 61641, for determining the position of arc ignition in arc fault tests, the following points along the main circuit shall be considered:

a) load side of the outgoing functional unit;

b) supply side of the outgoing functional unit and any associated arc ignition protected zone;

c) along the distribution busbar (when applicable);

d) along the main busbar;

e) load side of the incoming functional unit;

f) supply side of the incoming functional unit.

4.5 Structure

4.5.1 The maximum height, including the skid, shall not exceed 2400mm (excluding the exhaust ducts for expansion of gases from short-circuits).

4.5.2 The base of the Panel shall be drilled and the panel shall be fixed to one metallic base (skid) by screws passing through the holes.

4.5.3 The skid shall be dimensioned just like a bi-supported beam along the longitudinal direction, to support the whole Panel weight. The skid shall have sides covered with plates to avoid access of humidity to the Panel’s lower portion. The skid shall be drilled and welded to the floor. Panel Manufacturer shall supply the skid and all accessories necessary to fix the skid to the floor.
4.5.4 To avoid a dangerous the inclination of equipment when manoeuvring equipment during construction and installation, the two points supported beam on the longitudinal direction fixing base shall also have transversal directional beams. These transversal beams shall not interfere with cable access and any other installation requirements. Other solution may be accepted if it is previously submitted and approved by PETROBRAS.

4.5.5 Maximum height for installation of push-buttons and instruments shall be in accordance with I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS.

4.5.6 Panels shall be self-supported and shall have lifting devices.

4.5.7 MCCs shall have extension possibility on the opposite end to the incoming reactor. CDCs shall have extension possibility on both ends.

4.5.8 CDCs shall have access for installation and maintenance through the front side. It’s acceptable CDCs with access possibilities for installation and maintenance through the rear side.

4.5.9 CDCs shall have frontal and back doors with hinges and locks to keep them in open position.

4.5.10 For MCCs, all kind of access for installation, maintenance and operation shall be preferable through the front side.

4.5.11 Panels shall be comprised of vertical sections, formed by metallic compartments, aiming the flame retardation of a possible fire from one functional unit to another.

4.5.12 The thickness of structural profiles shall be at least 1.5mm.

4.5.13 For MCCs, the thickness of steel sheets shall be at least 1.98mm (nº 14 USG) for Panels without certification for internal arc flash.

4.5.14 For MCCs, the hardware assembly, busbar, fittings, etc. shall allow interchangeability among drawers with the same characteristics. Refer also to item 4.14.7.11.

4.5.15 For CDCs, the hardware assembly, busbars, fittings, etc. shall allow interchangeability among all circuit-breakers and contactors with the same characteristics.

4.5.16 All removable parts and components of same type, rating and construction shall be mechanically and electrically interchangeable.

4.5.17 For MCCs, terminal blocks shall be located at the upper or lateral portion (cable column) of each vertical section.

4.5.18 The arrangement shall enable easy access for external wiring installation and maintenance, including space to manipulate necessary tools.

4.5.19 Each withdrawable part shall be provided with mechanical blocking to avoid its extraction or insertion when its circuit-breaker is closed.

4.5.20 It shall be provided mechanical interlocks to avoid the drawer to be inadvertently extracted beyond "Test" position.
4.5.21 Drawer in “Test” position shall allow local and remote test of main switching device without energize the load (motor, feeder, etc.).

4.5.22 The structures of the withdrawable parts shall be dimensioned to support their weights in all positions.

4.5.23 Equipment that allows either set or calibration shall be installed in such a way that it shall not be necessary to withdraw or to open the drawer to operate them. Exceptions shall be agreed with PETROBRAS.

4.5.24 The grips and drawers connection systems to busbars shall be protected against rusting and they shall be able to support, without deformations, the electrical, mechanical and thermal stresses due to short-circuit current.

4.5.25 Connections between grips and connection systems to fuses or circuit-breakers terminals shall be preferably made through isolated bars.

4.5.26 When installed in mobile units and ships (FPSO and FSO), the Panels shall have insulated handrails along the front and rear sides (rear side only when accessible).

4.6 Busbars

4.6.1 Main and Auxiliary Busbars

4.6.1.1 Busbars shall be three phase, of electrolytic copper.

4.6.1.2 MCCs shall be provided with one horizontal main busbar.

4.6.1.3 CDCs shall be provided with two horizontal main busbars, connected by a tie circuit-breaker.

4.6.1.4 The busbars shall have capacity to continuously conduct the rated current $I_n$ of the Panel (as defined in IEC 61439-1) defined by Project documentation, with the temperature rise limited to the standard values.

4.6.1.5 Busbars and supporting systems shall be dimensioned to withstand the mechanical and thermal stresses resulting from short-circuit currents indicated in Data-Sheet.

4.6.1.6 Each vertical column shall be provided with a vertical busbar branched from the main busbar. The rated current of each vertical busbar shall be indicated in Data-Sheet.

4.6.1.7 Flame retarding and non-hygroscope insulators shall support the busbars. Celeron and fiberglass shall not be accepted. Insulators shall be resistant to degradation due to pollutant agents.

4.6.1.8 The strength applied on supports shall not exceed the rupture loads guaranteed by Manufacturers of insulators.

4.6.1.9 In case where parallel bars are used for a same phase, shims shall be used, suitably spaced, along the longitudinal axis of these bars.

4.6.1.10 Junction plates, at bars joints, shall be coated with silver and placed in such manner to guarantee a perfect alignment and high-pressure contact.

4.6.1.11 Each busbar phase shall have a permanent identification, using one colour per phase, according to:
For A.C. systems:
   a) phase (R-S-T): red, white and black, respectively;
   b) neutral: light blue according to IEC 60445;
   c) ground: bicolour combination green-yellow according to IEC 60445.

For D.C. systems:
   a) positive: red;
   b) negative: black.

4.6.1.12 Busbars insulation for CDCs and busways shall completely cover each bar, except at the connection points with adjacent units, or at the connection points with disconnecting devices. These joints shall be covered by insulation plates, fixed to the bar and filled in with insulation mass to guarantee a homogeneous insulation.

4.6.1.13 MCCs busbars shall have insulation cover.

4.6.1.14 All busbars connections and all outgoing bars for connection of cables shall be silver coated. The junctions shall be placed in such a manner to guarantee a perfect alignment and high-pressure contact.

4.6.1.15 Panels shall not have neutral bar.

4.6.1.16 All busbars connections shall use bolts, nuts and Belleville spring washers made with AISI 316 stainless steel.

4.6.2 Grounding Bars.

4.6.2.1 A grounding bar shall be installed in the whole Panel length, through the internal lower or upper part.

4.6.2.2 All Panel metallic parts not intended for current conduction (such as movable parts, panel structure, doors, secondary of instrument transformers, cables armours, cables shields and others) shall be interconnected to the grounding bar, using bonding jumpers with cross section according to requirements of IEC 61892-6 described in Table 1.

<table>
<thead>
<tr>
<th>Cross-section Q of associated current-carrying conductor (one phase or pole) (mm²)</th>
<th>Minimum cross-section of earth conductor</th>
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<tr>
<td>Q ≤ 16</td>
<td>Q</td>
</tr>
<tr>
<td>Q ≥ 16</td>
<td>50 % of the current-carrying conductor, but not less than 16 mm²</td>
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4.6.2.3 Grounded Systems

The cross section of the grounding bar shall be according to Table 3 of IEC 61439-1. Each end shall be provided with non-welded type connectors, suitable for bare copper cables with cross-sectional area according to I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS.
4.6.2.4 Ungrounded Systems

The minimum cross section of the grounding bar shall be according to I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS. Each end shall be provided with non-welded type connectors, suitable for bare copper cables.

4.6.3 Electronic Reference Bar.

4.6.3.1 The electronic reference terminals grounding of the instruments and intelligent devices shall comply with the requirements of the IEC 61000-5-2.

4.7 Current Limiting Reactors

4.7.1 A current-limiting reactor shall be provided connected in series with the MCC incoming feeder, with reactances calculated to limit the calculated thermal equivalent short-circuit current at 1s ($I_{th}$ according to IEC 60909) at MCC busbar to 18kA (18kA is not the rated thermal short-circuit current of the reactor, this value is defined in item 4.7.5) and to limit the calculated peak short-circuit current ($I_{p}$ according to IEC 60909) to 52kA (52kA is not the rated withstand peak current of the panel - $I_{pk}$, according to IEC 61439-1, defined in item 4.1.3, neither the rated mechanical short-circuit current of the reactor, defined in item 4.7.5).

4.7.2 The reactors shall comply with the requirements of Standards IEC 60076-6.

4.7.3 Reactors’ reactances shall be defined and optimized combining the best solution after iterative calculations in short-circuit and load-flow analysis.

4.7.4 Mechanical Characteristics:

4.7.4.1 The reactor shall be installed in the MCC incoming column. The maximum width shall be 1000mm.

4.7.4.2 Reactor shall be provided with mobile base for easy disconnection from enclosure.

4.7.4.3 Reactors shall have dry-type insulated coils, constructed with bars or wires, with air-core magnetic circuit. They shall be cooled by natural convection of air and shall be proper for indoor use.

4.7.5 Electrical characteristics:

- Conductor material: copper or aluminium;
- Insulation Class: F;
- Temperature rise limit: according to standard IEC 61892-3 for insulation Class B;
- Quality Factor (X/R): $15 \leq X/R \leq 20$;
- Rated continuous current: equal to MCC rated current;
- Rated thermal short-circuit current: 25kA;
- Rated thermal short-circuit duration: 1s;
- Rated mechanical short-circuit current: 52.5kA
4.7.6 Tolerances:
- System rated voltage: ±10%;
- Impedance: -0% +20%;
- Losses: +10% for reactor inside the enclosure;
- Impedance (each phase): ±5% from measured medium value.

4.7.7 Manufacturer shall inform in Panel Datasheet the impedance (Z) and quality factor (X/R) of the reactor.

4.7.8 Reactors shall operate satisfactorily with the voltage and frequency variation limits in continuous and transitory conditions as stated in I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.7.9 The finishing and painting of the reactor shall be suitable for the saline environment.

4.8 Internal Wiring and Conductors

4.8.1 Unless otherwise stated, all internal cables shall comply with the requirements of the I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.8.2 All cables shall be flame retardant according to IEC 60332-3-22, Category A.

4.8.3 Internal wiring shall have low emission of smoke and halogen gases in the case of fire, according to IEC 61892-3. The following minimum requirements should be met:
   a) a minimum light transmission value of 60 %, according to IEC 61034-2;
   b) a maximum halogen gas emission of 0.5 %, according to IEC 60754-1 and IEC 60754-2.

4.8.4 Power conductors shall be provided with EPR or XLPE insulation, with minimum rated voltage (U₀/U) 0.6/1.0kV.

4.8.5 Power cables for motors fed from VSD shall be shielded and they shall comply with the recommendations of IEC TS 60034-25.

4.8.6 Control and signal conductors shall be provided with EPR, XLPE or PVC insulation. Control and signal circuits with rated voltage up to 220V with neutral bolted grounded shall use cables with minimum rated voltage (U₀/U) 150/250(300)V. Control and signal circuits with rated voltage up to 220V with isolated neutral shall use cables with minimum rated voltage (U₀/U) 450/750V.

4.8.7 Digital data cables shall be collectively shielded. Analogical data cables shall have twisted pairs/triads with a shield for each pair/triad and a collective shield under the external cover.

4.8.8 All internal wiring shall be duly identified through plastic rings, at the ends, with codification shown on the wiring drawings.

4.8.9 The insulation colour of cables used for D.C. circuits shall be red for wiring with positive voltage and black for wiring with negative voltage.
4.8.10 The outer sheath (protective cover) colour of cables used in grounding circuits shall be the combination green-and-yellow according to IEC 60445.

4.8.11 Panels shall be delivered with all connections between installed components done.

4.8.12 The wiring between sections separated for transport shall finish on terminal blocks, so that the final interconnection could be easily completed with jumpers, by the time the sections are assembled.

4.8.13 Power cables shall be suitable for the drawer rated power and withstand the thermal effect resulting from short-circuit currents.

4.8.14 Components assembled on doors shall be connected through extra-flexible conductors.

4.8.15 The minimum cross-section area for internal cables shall be of 0.5 mm² for control circuits (120VAC discrete signals), 1.0 mm² for instrumentation circuits (4-20mA), 2.5 mm² for power, lighting and VTs circuits and 4 mm² for CTs circuits.

4.9 External Wiring and Conductors Entrance

4.9.1 All incoming and outgoing cables entrance in low-voltage CDCs and MCCs shall be according to project documentation.

4.9.2 For single core cables, the Manufacturer shall provide removable sheets, with a minimum thickness of 2.8 mm, made of copper free aluminium or non-magnetic material. For all other cases, the removable sheets shall be of painted galvanized steel, with galvanization thickness for 30 years lifetime. The removable sheets shall be provided with neoprene rubber gaskets.

4.9.3 Cable-glands made with material compatible with the removable sheets’ material shall be supplied with the Panel.

4.9.4 Unless otherwise stated in Project Documentation, if bus trunking connections are used, the Panel shall have appropriate edges and flexible connectors for entrance through the top.

4.10 Cable Lugs and Terminals

4.10.1 Control circuits shall use ring (preferred) or pin cable lugs. CTs and power circuits shall use ring cable lugs.

4.10.2 Terminals for control circuits shall be indirect pressure screw type and shall be covered with melamine or other similar equivalent material, which shall not have organic and toxic substances.

4.10.3 Terminals for power circuits shall be screw type. Lugs for power circuits shall be compression type.

4.10.4 Sizes of terminals for power circuits shall be defined according to feeders’ cross-sectional area that shall be determined by BIDDER, during the Detailed Design execution.

4.10.5 All cable lugs for control circuits shall be supplied within the Panel.

4.11 Terminal Blocks
4.11.1 Only one cable shall be connected to each cable lug and only one cable lug shall be connected to each terminal. Jumpers between terminals by external conductors shall not be accepted. For this purpose metallic bridges shall be used.

4.11.2 Each control terminal block shall have at least 10% of reserve, for future application.

4.11.3 Terminal blocks installation shall consider enough space to perform the cable termination, their fitting, easy access to terminals and easy reading of identification.

4.11.4 Terminal blocks shall be logically grouped by function and operating voltage, separated from other groups using barrier plates or earthed terminals and shall be indelibly marked and voltage levels shall be clearly identified by labels, according to IOGP S560.

4.12 Channels

4.12.1 The internal conductors shall be installed in channel type cable trays with covers.

4.12.2 The power cables shall be segregated from control and data cables, by installation, in separated cable trays, placed as far as possible.

4.13 Heating Resistors

4.13.1 For Panels

4.13.1.1 Each vertical section shall be provided with heating resistors proper to 220VAC, installed at the lower part and protected by circuit-breakers. These heating resistors shall be automatically controlled, through a thermostat, with maximum limit of the graduation range of 60ºC.

4.13.1.2 The heating resistors shall be protected against accidental contacts. The wiring next to them (closer than 30cm), shall have proper insulation, in order to avoid damage due to high temperature.

4.13.1.3 One miniature circuit-breaker shall be provided per bar for interruption of all related cubicle heaters circuits of the panel.

4.13.2 For Motors

4.13.2.1 For motors with heating resistors, as required in the PETROBRAS documentation, functional units shall be suitable to feed these heating resistors, being automatically turned on when the motors are turned off.

4.13.2.2 One circuit-breaker shall be provided for each vertical section or drawer, to protect the motors’ heating resistors circuits.

4.13.2.3 For motors installed in hazardous areas Zone 1, the circuit-breaker for protection of the heating resistors shall have thermomagnetic unit with integrated or additional differential residual current protection.

4.13.3 For Generators

4.13.3.1 All motogenerators shall have circuits to feed heating resistors fed from external source (same source of item 4.13.1), being automatically turned on by the respective drawer when the motogenerators are turned off.
4.13.3.2 One circuit-breaker shall be provided in each vertical section, to protect the motogenerators’ heating resistors circuits.

4.13.3.3 For motogenerators installed in hazardous areas Zone 1, the circuit-breaker for protection of the heating resistor shall have thermomagnetic unit with integrated or additional differential residual current protection.

4.14 Functional Units

4.14.1 General

4.14.1.1 The starters for motors in MCCs shall be formed by moulded-case circuit-breakers, contactors and Intelligent Relays (IR), performing direct-on-line start.

4.14.1.2 Starters for motors in MCCs, when soft-starter is required, shall be formed by moulded-case circuit-breaker, fuses (proper to soft-starter protection), bypass contactor, soft-starter and IR. It shall be possible to carry out direct-on-line start (using bypass contactor) in case of failure in soft-starter. Refer to item 4.14.16. The bypass contactor is not necessary for normal motor loads that operate eventually and for a short time, like for start the turbines, provided that there is a soft-starter for each motor.

4.14.1.3 Starters for motors in MCCs, when VSD is required, shall be formed by moulded-case circuit-breaker, incoming contactor, fuses (proper for VSD protection), VSD and IR. Refer to item 4.14.17.

4.14.1.4 Unless otherwise stated in Project Documentation, starters for motors in CDCs shall be formed by air circuit-breakers (“power” circuit-breakers) built-in electronic trip unit (BETU) and microprocessor-based multifunction relays (MMR), performing direct-on-line start.

4.14.1.5 One power contactor shall be included in motors’ starters in CDCs, when more than two starts per day are foreseen.

4.14.1.6 Starter for motors in CDCs, when soft-starter is required, shall be formed by "power" air circuit-breaker, BETU, fuses (proper for soft-starter protection), bypass contactor, soft-starter and MMR. It shall be possible to carry out direct-on-line start (using bypass contactor) in case of failure in soft-starter. Refer to item 4.14.16.

4.14.1.7 Starter for motors in CDCs, when VSD is required, shall be formed by "power" air circuit-breaker, BETU, fuses (proper for VSD protection), VSD, MMR and outgoing contactor. Refer to item 4.14.17.

4.14.1.8 Unless otherwise stated in Project Documentation, the utilisation category for motor starters shall be AC-3 according to IEC 60947-4-1.

4.14.1.9 The utilisation category for non-motor loads shall be selected according to the load, as defined in Table 1 of IEC 60947-4-1;

4.14.1.10 Functional units for non-motor loads shall be formed by moulded-case circuit-breakers, contactors and IRs.
4.14.1.11 Functional units for non-motor loads in CDCs shall be formed by air circuit-breakers, BETU and MMR, when BETU does not provide all protective functions or the communication capability required.

4.14.1.12 Outgoing feeders for fire-fighting pumps, if any, shall have only instantaneous trip elements and protection against locked-rotor overcurrent.

4.14.1.13 All essential non-motor loads, i.e. distribution transformers, feeders for UPSs and panels, etc., shall be energized immediately after the Emergency Generator starting. In this way, the circuit-breakers of these loads shall be kept closed and shall not have undervoltage trip coils. Contactors shall not be used for these loads.

4.14.1.14 Manufacturer shall dimension all functional units according to the loads’ powers defined by Detailed Design.

4.14.1.15 The co-ordination with short-circuit protective devices for direct on-line starters shall be type “2”, as defined in IEC 60947-4-1. The Manufacturer shall attach to the technical proposal a test certificate, issued by a recognised Laboratory, proving co-ordination type.

4.14.1.16 Terminals remaining live when a functional unit is in isolated position (according to IEC61439-2) and terminals associated with external sources of supply (according to 4.21) shall be provided with a warning label, according to IOGP S560.

4.14.2 Protective Devices

4.14.2.1 Circuit-breakers shall be used as protective devices, for the power conductors and power equipment.

4.14.2.2 Miniature circuit-breakers shall be used to protect the control circuits of each functional unit.

4.14.3 Main Contactors

4.14.3.1 Main contactors shall be three-poles, dry and suitable for direct-on-line start of three-phase induction motors.

4.14.3.2 Nominal operating voltage for contactor coils and other power-operated starters shall be 115VAC or 120VAC. These devices shall close satisfactorily their contacts at voltage variation between 85% and 110% of rated voltage. The maximum voltage limit for drop out, as defined in IEC 60947-4-1, shall be 70% of rated voltage, without tolerance.

4.14.3.3 Only for non-motor normal with control mode EA02 and EA03 and all outgoing feeders for essential loads, electric closing control for contactors shall be possible through buttons or switches installed in the front door of the cubicle.

4.14.4 Circuit-Breakers

4.14.4.1 Circuit-breakers for power circuits shall be A.C., three-poles, 60Hz, 600V minimum, with trip-free switching mechanism.

4.14.4.2 Circuit-breakers shall be manufactured and tested according to IEC 60947-2.
4.14.4.3 Circuit-breakers shall be lockable in open position with a padlock. It shall not be possible to change the drawer position if its circuit-breaker is closed.

4.14.4.4 Circuit-breakers shall be provided with compensation of effects of variation of ambient temperature over tripping devices.

4.14.4.5 Circuit-breakers shall be suitable for short-circuit prospective current. It shall not be acceptable the use of circuit-breaker accessories (e.g. shot-circuit limiters devices) to achieve this limit.

4.14.4.6 Circuit-breakers for outgoing feeders and for generator incoming feeders shall not have under-voltage trip (UVT) coil.

4.14.4.7 Circuit-breakers for generator incoming feeders shall not have primary trip element.

4.14.4.8 Circuit-breakers’ electrical characteristics shall be suitable for the parameters defined in Data-Sheet for the electrical system.

4.14.4.9 Circuit-breakers for motors and for loads that not require selectivity with downstream circuits shall have selectivity category A. Circuit-breakers for loads that require selectivity with downstream circuits (feeders for panels) shall have selectivity category B.

4.14.4.10 Circuit-Breakers for MCCs
   4.14.4.10.1 MCCs’ incoming feeder shall have moulded-case circuit-breaker or switch when the MCC and its upstream panel are not in the same room.
   4.14.4.10.2 For non-motor loads each phase shall be outfitted with direct-action thermomagnetic device. For motor loads, they shall be outfitted only with direct-action magnetic device and it shall be possible to adjust the trip value at 13 times the motor full load current.
   4.14.4.10.3 Circuit-breakers shall have hand lever command and shall be mounted in a way that the levers can be directly handled from outside of the drawers. Hand lever shall be provided with indication of its position.

4.14.4.11 Circuit-Breakers for CDCs
   4.14.4.11.1 Circuit-breakers shall have mechanical and electric control with anti-pumping devices.
4.14.4.11.2 Mechanical opening (turn off) shall be executed through mechanical actuator in the front plate of all circuit-breakers. Mechanical closing (turn on) shall be executed through mechanical actuators, only for incoming and tie circuit-breakers of MCCs, outgoing feeders for transformers, for non-motor loads classified as EA03 and for non-motor loads classified as EA02. These actuators shall be accessible with the front door of the compartment closed. For loads classification according control mode, refer also to ELECTRICAL FUNCTIONAL UNITS CLASSIFICATION ACCORDING TO CONTROL MODE DOCUMENTATION.

4.14.4.11.3 Electric control shall be executed by closing and opening contacts of buttons or switches installed in the front door of the cubicle or by remote signals, operating the closing and opening coils. STOP action (turn off) shall be available through frontal push-buttons for all circuit-breakers, actuating in their trip coils. START action (turn on) shall be delayed to close and available through frontal push-button for incoming and tie circuit-breakers of MCCs, outgoing feeders for transformers, non-motor loads classified as EA03 and non-motor loads classified as EA02. For the other kind of loads the closing action from front door buttons or switches shall be active only with drawer in test position. For loads classification according control mode, refer also to ELECTRICAL FUNCTIONAL UNITS CLASSIFICATION ACCORDING TO CONTROL MODE DOCUMENTATION.

4.14.4.11.4 Springs shall be charged by electric motor and by a manual lever installed in the circuit-breaker. The motor shall be controlled by limit switches to charge the spring whenever it is discharged.

4.14.4.11.5 Indicators for the contacts position and for the spring position shall be provided at the front cover of the circuit-breaker.

4.14.4.11.6 Circuit-breakers with the same electrical characteristics shall be identical and interchangeable.

4.14.4.11.7 Circuit-breakers shall have Built-in Electronic Trip Unit (BETU) with capability to receive and send data via network connection. Protocols shall be according to ELECTRICAL SYSTEM AUTOMATION DOCUMENTATION. BETU shall have at least one (1) network output.

4.14.4.11.8 Circuit-breakers for non-motoric loads shall have long-time delay, short-time delay and instantaneous over-current trip elements. It shall be possible to override the instantaneous trip element. Circuit-breakers for motoric loads shall have only instantaneous trip element.
4.14.4.11.9 Manufacturer shall provide an interlock in order to prevent the operation of circuit-breakers after a short-circuit event in order to ensure the proper cooling of their interrupters.

4.14.5 Microprocessor-Based Multifunction Relays (MMR)

4.14.5.1 MMRs used in CDCs are kind of IED (Intelligent Electronic Device, as defined by IEC 61850) and shall comply with the requirements of I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.14.5.2 Unless the digital inputs of MMRs are checked by self-diagnosis routine, these digital inputs shall not be used to control the load by signals from external protective or safety devices (e.g. high temperature of bearings, high pressure of vessels, etc.).

4.14.5.3 The MMRs shall have the function of circuit-breakers coils monitoring activated and sending alarm signal to Electrical System Automation Operational Workstation.

4.14.5.4 Starting button of MMRs (if existent) for functional units shall be enabled only for incoming feeders, tie and outgoing feeders for non-motor normal loads with control mode EA02 and EA03 and all outgoing feeders for essential loads.

4.14.6 Lockout Relays

4.14.6.1 Lockout relays used in CDCs shall comply with requirements of I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.14.7 Intelligent Relays (IRs) for MCCs

4.14.7.1 IRs are kind of IED (Intelligent Electronic Device, as defined by IEC 61850, not necessarily using this protocol), shall be three-poles and with manual reset. They shall be provided with ambient temperature compensation and protection against overload due to phase loss. The regulation and calibration devices shall have graduated scale.

4.14.7.2 IRs shall have communication facilities through one EIA-232 serial port and through one communication port using the protocols specified in ELECTRICAL SYSTEM AUTOMATION DOCUMENTATION. The EIA-232 communication port shall be available outside each drawer, with the drawers inserted.

4.14.7.3 IRs shall have digital inputs and shall be programmable in order to protect the motor and to control the start and stop commands.

4.14.7.4 For motors with protection function 49 (by temperature sensors) required, IRs shall have inputs for PTC.

4.14.7.5 When protection function 50GS is required (for non-isolated systems), IRs shall have input for ground sensor CT.

4.14.7.6 IRs shall provide full registry of faults through the communication ports.
4.14.7.7 For loads with duty types S1, S2 and S3, the relays shall be adjustable up to a maximum of 115% of the motor rated current. For other duty types, the relays range shall be suitable for the duty characteristic.

4.14.7.8 It shall be provided an external reset button for the IR at the drawers’ front door.

4.14.7.9 The actuation time of IRs on restarts shall be dependent on previous thermal image of the motor.

4.14.7.10 The IR as described above shall be compatible, including its tolerances, with load accelerating and permissible locked rotor times. Detailed Design shall supply this information for MCC Manufacturer.

4.14.7.11 Each IR shall have a fixed code address to network communication. There shall be an electrical interlock to avoid operation of a functional unit if it is inserted in a wrong place, so that remote commands do not command wrong loads.

4.14.7.12 Starting button of IRs (if existent) for functional units shall be enabled only for non-motor normal loads with control mode EA02 and EA03 and all outgoing feeders for essential loads.

4.14.8 Auxiliary Contactors, Auxiliary Relays and Interposing Relays

4.14.8.1 The use of auxiliary contactors, auxiliary relays and interposing relays for contacts multiplication shall be avoided, being mainly limited to the following cases:
   a) when the original output contact has no capacity to switch the load;
   b) contacts multiplication in CDCs for circuit-breaker closing coil blocking;
   c) CDC/MCC signalling (refer to 4.14.12);
   d) IED input signals

4.14.8.2 All output contacts shall be sized for the making and breaking capacity required by the respective load.

4.14.8.3 Auxiliary contactors and auxiliary relays shall be able to work continuously energized, without economy resistance.

4.14.8.4 Multiplication of trip signals for safety functions and interlocks shall be done only through approved lockout (86 relays) relays.

4.14.9 Arc Protection

4.14.9.1 For CDCs, all busbar compartments (horizontal and vertical), all outgoing cables compartments and all compartments with coupling parts of switching devices shall be provided with arc flash optical sensors connected to “Arc Monitoring Relay” for protection against short-circuit with electrical arcs.

4.14.9.2 Arc Monitoring Relay shall consider optical and current signals to prevent nuisance tripping.
4.14.9.3 “Arc Monitoring Relay” shall be fitted with solid state output relays and shall be capable to send trip signal to circuit-breakers in no more than 4ms to isolate the faulty busbar. They shall also have outputs to trip the related upstream circuit-breakers.

4.14.10 Instruments’ Transformers

4.14.10.1 All transformers shall be dry-type.

4.14.10.2 VTs, CTs and auxiliary transformers characteristics shall be defined by Panel Manufacturer, regarding the perfect operation of devices connected to them and complying with requirements of I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.14.10.3 VTs and auxiliary transformers with primary voltages higher than 220V shall be protected by fuses in their primaries when installed in CDCs; otherwise they shall be protected by circuit-breakers in their primaries. Secondary circuits shall be protected by miniature circuit-breakers.

4.14.10.4 CTs for protection purposes shall not saturate for the foreseen short-circuit currents.

4.14.11 Measurement Instruments

4.14.11.1 Ammeters and voltmeters for motors, when required, shall be moving-iron type, with accuracy of 1.5%, provided with magnetic dampening, external zero adjustment, white background scale and black marking.

4.14.11.2 Ammeters and voltmeters for the other loads, when required, shall be moving-coil type.

4.14.11.3 Instrument scales shall be such that, at full load, the indicator needle remains between 50% and 75% of the upper limit of the scale.

4.14.11.4 Instruments sizes, deflection, type (analogue or digital), position orientation and quantity shall be according to I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS.

4.14.11.5 Active energy meters, when required, shall have maximum demand indicator for 15 (fifteen) minutes.

4.14.11.6 For MCCs with entrance reactors, the voltage measurements shall be taken from the busbar, downstream the reactor.

4.14.11.7 All analogue measurement instruments shall have the gauge marked in red on the rated or maximum operational position.

4.14.11.8 Digital measuring devices having capacity for data gathering and data availability through digital communication port shall be able to indicate a reverse power up to 15% of the rated power.

4.14.12 CDC/MCC Signalling

4.14.12.1 Each functional unit of MCC shall be provided with signalling LEDs for indication of energized equipment (red led) and non-energized equipment (green led).
4.14.12.2 Each functional unit of CDC shall be provided with signalling LEDs for indication of:

- Red (R) - circuit-breaker closed (and main contactor closed in case of outgoing feeders for VSDs);
- Yellow (Y) - circuit-breaker open by protection;
- Green (G) - circuit-breaker open (or main contactor closed in case of outgoing feeders for VSDs) - ready to close;
- White (W) - circuits grounded - functional unit extracted;
- Blue (B) - circuit-breaker tripped by emergency shut-down.

4.14.12.3 On each heating resistor circuit, for motors and for vertical sections, a red signalling led shall be provided, which shall be activated when the heating resistor is turned-on.

4.14.12.4 Two signalling LEDs shall be installed to indicate control voltage available after protection in each VT secondary.

4.14.12.5 Signalling LEDs shall be provided with bayonet type base. The replacement of LEDs shall be performed without necessity to open the compartment door and without necessity to extract the drawer.

4.14.13 Remote Commands, Signalling and Measurements

4.14.13.1 The list of remote interface signals that shall be implemented for each kind of functional unit is described in the ELECTRICAL SYSTEM AUTOMATION DOCUMENTATION.

4.14.13.2 Remote ESD signals shall be through wet contacts (24 Vdc) and through auxiliary interposing relays.

4.14.13.3 Functional units for loads with control mode EA04 shall be commanded from Package Panels by means of hardwired signals. “Turn on” signals shall be through normally open pulsed contacts. “Turn off” signals shall be through normally open pulsed (fail safe) contacts. “Status” signal shall be through normally open contact. The functional diagrams of these functional units shall be submitted to PETROBRAS approval. Refer to ELECTRICAL SYSTEM AUTOMATION DOCUMENTATION for more details.

4.14.13.4 Functional units that feed battery rooms fans or exhausts shall send signals to the battery chargers and UPSs related to batteries of that rooms to inhibit recharge in case of stoppage of these fans or exhausts.

4.14.14 CDC/MCC Push Buttons

4.14.14.1 Functional units for essential loads shall have a “Habilita/Desabilita Liga Local” (Enable/Disable Local Start) selector switch enabling local electrical starting function. These functional units shall have a start button actuating in closing coil.

4.14.14.2 Functional units for MCCs for normal loads shall not have starting buttons. Stop button shall be provided for all functional units.
4.14.14.3 Functional units for normal loads in CDCs shall have start buttons only if required in rules established in items 4.14.3 and 4.14.4. Stop button shall be provided for all functional units.

4.14.14.4 Functional units for loads that are spare of essential loads (e.g. air compressors) but installed in normal panels (e.g. auxiliary panels) shall also have the “Habilita/Desabilita Liga Local” selector switches and start buttons.

4.14.14.5 START push-button (TURN ON function) shall be with automatic return (return after push). STOP push-button (TURN OFF function) shall be with release (retain after push).

4.14.14.6 Push buttons shall be externally operated, with no necessity to open the cubicle door or to extract the drawer.

4.14.15 Switches

4.14.15.1 The ammeter and voltmeter selector switches shall be externally installed.

4.14.15.2 All control switches used at the Panel shall be rotary type.

4.14.16 Soft-starters

4.14.16.1 For technical specification about soft-starters, refer to I-ET-3010.00-5140-741-P4X-001 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS

4.14.16.2 When required in Project documentation, electronic soft-starters shall be used as auxiliary starting devices.

4.14.16.3 For MCCs, the selection between the installation of soft-starters within or outside the drawers shall be done trying to minimise the area occupied by panels.

4.14.16.4 Starters for motors, when soft-starter is inside MCCs shall be according to IEC 60947-4-2.

4.14.16.5 For MCCs, when the soft-starters are installed outside MCC in a separate panel, the moulded-case circuit breaker and the IR shall be installed within the drawer in the MCC. All other components shall be installed in the fixed (not withdrawable) panel. Refer to I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.14.16.6 Soft-starters to drive turbogenerator and turbocompression auxiliary loads, if any, shall be supplied by respective Packager and shall be installed outside MCCs. For technical specification about VSDs and soft-starters, refer to I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.14.16.7 For soft-starters driving turbogenerator and turbocompression auxiliary loads, all incoming and outgoing cables shall enter through the top of panel.
4.14.16.8 For CDCs, soft-starters shall be installed in a separate panel. Refer to I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS for further details.

4.14.16.9 For CDCs, when the functional unit uses soft-starter, the air circuit-breaker, BETU and the MMR shall be installed within the drawer in the CDC. All other components shall be installed in the fixed panel.

4.14.16.10 Compartments with soft-starters shall have adequate ventilation, according to soft-starter manufacturer requirements.

4.14.16.11 For soft-starters feeding essential loads not installed in hazardous areas Zone 1, protection functions “ground fault” (50GS) and “lack of phase” (46) shall be disabled or inhibited in built-in soft-starters protection or panels (CDC or MCC) protection, for isolated or high impedance systems.

4.14.16.12 For soft-starters that feed essential loads, it shall be possible start them through bypass contactor in case of soft-starter malfunction.

4.14.16.13 Soft-starters installed in MCCs shall be operated, set and monitored through the same communication network used by the IRs of the MCCs. Refer to ELECTRICAL SYSTEM AUTOMATION DOCUMENTATION.

4.14.17 Variable Speed Drives (VSDs)

4.14.17.1 For technical specification about VSDs, refer to I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.14.17.2 When required in Project documentation, VSDs shall be used as drive devices.

4.14.17.3 For MCCs, the selection between the installation of VSDs within the drawers or in a separated panel shall be done trying to minimise the area occupied by panels.

4.14.17.4 For MCCs, when the VSDs are installed in a separated panel, the moulded-case circuit-breaker, the rectifier incoming fuses, the incoming reactors and the IR shall be installed within the drawer in the MCC. All other components shall be installed in the fixed (not withdrawable) panel.

4.14.17.5 VSDs to drive turbogenerator and turbocompression auxiliary loads, if any, shall be supplied by respective Packager and shall be installed outside MCCs. For technical specification about VSDs and soft-starters, refer to I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.14.17.6 For VSDs driving turbogenerator and turbocompression auxiliary loads, all incoming and outgoing cables shall enter through the top of panel.

4.14.17.7 For CDCs, VSDs shall be installed in a separate panel.
4.14.17.8 For CDCs, when the functional unit feeds VSDs, the air circuit-breaker and BETU shall be installed within the drawer in the CDC. Outgoing contactor can be installed in CDC or in fixed (non withdrawable panels). All the other components shall be installed in the fixed (non withdrawable) panel.

4.14.17.9 Compartments with VSD shall have adequate ventilation, according to VSD manufacturer requirements.

4.14.17.10 For VSDs feeding essential loads not installed in hazardous areas Zone 1, protection functions “ground fault” (50GS) and “lack of phase” (46) shall be disabled or inhibited in built-in VSD protection or panels (CDC or MCC) protection, for isolated or high impedance systems.

4.14.17.11 VSDs installed in MCCs shall be operated, set and monitored through the same communication network used by the IRs of the MCCs. Refer to ELECTRICAL SYSTEM AUTOMATION DOCUMENTATION.

4.14.18 Temporary grounding

4.14.18.1 For MCCs, drawers shall be supplied for temporary grounding. Unless otherwise stated in Data-Sheet, Manufacturer shall supply, for each MCC, the following minimum drawers for temporary grounding:
   a) 3 (three) drawers for temporary grounding for motor with rated power 11kW, and;
   b) 2 (two) drawers for temporary grounding for motor with rated power 30kW, and;
   c) 1 (one) drawer for temporary grounding for motor with rated power 55kW.

4.14.18.2 For MCCs’ incoming feeder that have moulded-case circuit-breaker or switch, manufacturer shall supply 1 (one) drawer for temporary grounding.

4.14.18.3 The short-time withstand current shall be compatible with the system characteristics.

4.14.18.4 CDCs shall be provided with circuit-breakers for temporary grounding. Manufacturer shall supply, for each CDC:
   a) 2 (two) circuit-breakers for outgoing sections for temporary grounding downstream of circuit-breaker, and;
   b) 1 (one) circuit-breaker for incoming sections for temporary grounding upstream of circuit-breaker.

Note: Alternative solutions for temporary grounding in CDCs shall be submitted to PETROBRAS approval.

4.14.18.5 Mechanical interlocks shall be provided to avoid the insertion of circuit-breakers for outgoing sections for temporary grounding in incoming sections as well as the insertion of circuit-breakers for incoming sections for temporary grounding in outgoing sections. Other interlock solutions shall be presented to PETROBRAS for approval.
4.14.18.6 Related to item 4.14.18.5, circuit-breakers for temporary grounding shall be have warning labels indicating where they shall be used and shall not be used.

4.14.18.7 Drawers and circuit-breakers for temporary grounding shall be designed for operation with the doors closed and to provide a clear indication of its position to the operator. Means shall be provided to assure that drawers and circuit-breakers for temporary grounding never can be left in an intermediary position.

4.14.18.8 Drawers and circuit-breakers for temporary grounding shall be lockable inserted with a padlock.

4.14.19 Synchronization Interfaces

4.14.19.1 All signals from VTs required by EGCP and AGCP for the synchronization operation, according to project documentation, shall be available in terminal blocks of Essential and Auxiliary CDCs, to be connected to EGCP and AGCP.

4.14.19.2 Essential and Auxiliary CDCs shall have terminal blocks to receive the signals sent by EGCP and AGCP to close the circuit-breakers in the synchronization operation.

4.14.19.3 The switches to select the circuit breakers of the Essential or Auxiliary CDCs to be closed in the synchronization operation will be located at the EGCP and AGCP respectively.

4.14.20 Interlocks

4.14.20.1 Refer also to items 4.5.18, 4.5.19, 4.5.20, 4.14.4.3 and 4.16.3.

4.14.20.2 All interlocks related to Essential and Auxiliary CDCs, like check of undervoltage, send starting signal to EGCP and AGCP, open transformers circuit-breakers etc. shall be done using devices installed inside these panels. The interlocks and devices shall be scope of panel supplier.

4.14.20.3 Temporary parallel operation of transformers (secondaries or secondaries) in low-voltage CDCs shall be possible only when the tie circuit-breaker of main distribution CDC (primary of transformers) is closed. It does not mean inhibition of closing the tie circuit-breaker in low-voltage CDCs. It shall be possible to operate the secondary CDCs in “L” configuration when tie circuit-breaker of main distribution CDC is opened.

4.15 Busbar Trunking (Busways)

4.15.1 Busbar trunkings, when applied, shall comply with the requirements of I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.16 Extraction Truck
4.16.1 A suitable device mounted on truck shall be supplied to remove circuit-breakers for maintenance facility.

4.16.2 Circuit-breakers extraction shall be executed on a safe way, being the drawer structure dimensioned to support the circuit-breaker weight even when totally extracted.

4.16.3 The extraction system shall be provided with a blocking structure or function that shall allow the drawer introduction only with the circuit-breaker opened.

4.17 **Nameplates and Markings**

4.17.1 The Panels’ characteristics nameplates shall be made with AISI-316 stainless steel and shall include all items listed in IEC 61439-1.

4.17.2 The Panel shall be outfitted with plate of supplemental identification containing, at least, the following data:

- a) PETRÓLEO BRASILEIRO S.A. - PETROBRAS;
- b) name of the department of the PETROBRAS;
- c) name of the enterprise (platform);
- d) TAG number of the panel;
- e) number of the RM;
- f) number of the Order of Purchase of Material (PC);
- g) in alternative to paragraph e) and f) the number of the contract, in the cases of acquisition built-in in contract of the type lump sum ("Turn Key ", "Lump Sum", etc.).

4.17.3 MCC’s nameplate shall include the number of the drawer of the CDC that feeds the MCC.

4.17.4 CDC’s nameplate shall include the TAGs of the transformers that feed the CDC.

4.17.5 When accessible, back doors shall have identification plates identical to the plates identifying the front sections.

4.17.6 The panels shall have their compartments signalled with literal and graphical labels of instructions, cares, warnings and alert of dangers according to the requirements for identification plates listed in ASTM F1166 and IEC 60417.

4.17.7 **Functional Units Markings**

4.17.7.1 Black acrylic plates with white letters shall identify all functional units and vertical sections.

4.17.7.2 For functional units identification the following information shall be included:

- a) at the first line, the equipment tag number;
- b) at the second line, the equipment name in Portuguese;
- c) at third line, the rated current of the load and circuit number.
d) at fourth line, the electrical functional unit classification according control mode, according to Erro! Fonte de referência não encontrada.

4.17.7.3 At spare cubicles, the plates shall be supplied with the word “Reserva” engraved.

4.17.7.4 No adhesives shall be used to fix the plates.

4.17.8 Components Markings - Labels

4.17.8.1 Internally to Panels, all equipment and components shall be identified with black acrylic plates, with white letters, containing the codification compatible with design documents (list of materials, diagram, etc.).

4.17.8.2 The circuit-breakers labels shall include rated current and trip current settings;

4.17.8.3 The IRs labels shall include the trip current settings.

4.17.8.4 No adhesives shall be used to fix the labels.

4.17.9 The Panels shall have warning labels following the model below, with the values of rated voltage (in field “Nível de Tensão”), arc fault incident energy (in field “Energia Incidente”) and arc-flash hazard distance (in field “Distância Segura de Aproximação para Atividades Sujeitas a Arco Elétrico”). The values to be filled in will be informed to Panel Manufacturer during Detailed Design.

4.17.10 Panels shall have warning labels indicating the protective clothing risk category that shall be used for technical intervention.

4.17.11 Panels shall have warning labels indicating that any technical intervention in the panels shall be executed only for authorized people.
4.17.12 Rear side of generator incoming functional units of panels shall have warning labels regarding live terminals due to residual magnetizing even with exciter turned-off.

4.18 Painting

4.18.1 The painting process shall be proper for offshore installations and pre-qualified according to

4.18.2 I-ET-3010.00-1200-956-P4X-001 - QUALIFICATION TESTS FOR PAINT SYSTEMS.

4.18.3 The last coat colour shall be Light Green Munsell 5G8/4. Inner components mounting plates, internal faces of doors and safety barriers shall be Safety Orange Munsell 2.5YR6/14.

4.19 Protection

4.19.1 General Protection

4.19.1.1 For general protection, minimum protection functions for each functional unit and adjustments criteria, refer to I-ET-3010.00-5143-700-P4X-001 – ELECTRICAL SYSTEM PROTECTION CRITERIA.

4.19.1.2 Each semi-bar of CDCs shall have one key activated selector switch in its front side, with the positions “Operação / Manutenção” (Operation / Maintenance). When this selector switch is in “Manutenção” position, the instantaneous overcurrent protection (function 50) of the relays of incoming and tie functional units shall be activated or their set points changed, overriding the protection coordination and minimizing damage in case of internal fault.

4.19.1.3 MCCs shall have one key activated selector switch in its front side, with the positions “Operação / Manutenção” (Operation / Maintenance). When this selector switch is in “Manutenção” position, the instantaneous overcurrent protection (function 50) of the relay of upstream CDC outgoing feeder shall be activated or their set points changed, overriding the protection coordination and minimizing damage in case of internal fault.

4.19.1.4 There shall be a local signalling lamp, turned on with the switch in “Manutenção” position, indicating “Coordenação Desativada”.

4.19.1.5 A network remote signalling of the position of the switch shall be sent to Electrical System Workstation, through Electrical System Gateway, from the incoming and tie circuit-breakers MMRs.

4.19.1.6 There shall be a label beside the switch with following warning text:
4.19.2 Ground Fault Protection for High Impedance Grounded Systems

4.19.2.1 Ground fault protection shall be provided by 50GS function devices, installed in all outgoing circuits. Local alarm signalling shall be provided for each circuit.

4.19.2.2 Circuits for loads installed in hazardous areas Zone 1 and circuits for loads which cables cross hazardous areas Zone 1 shall be tripped by 50GS relay and one individual network alarm signal (UAS - Unit Alarm Shutdown signal) shall be sent by IR to A&C (Automation and Control System), through Electrical System Gateway.

4.19.2.3 One network resume alarm signal (Low Insulation - Ground Fault) shall be sent to A&C, through Electrical System Gateway, for each Panel, in case of failure in circuits that are not tripped. For CDCs, this signal shall be sent by incoming feeder BETU or MMR. For MCCs, this signal shall be sent by outgoing feeder BETU or MMR, in upstream CDC.

4.19.3 Ground Fault Protection for Ungrounded Systems

4.19.3.1 Ground fault protection shall be provided by isolation monitoring devices (IMDs). Protective devices based in residual current shall not be accepted.

4.19.3.2 One isolation monitoring device shall be installed in each busbar of CDC. These isolation monitoring devices shall be capable to operate with tie circuit-breaker of CDC in close or open position.

4.19.3.3 The isolation monitoring devices shall indicate the measured isolation resistance value between each phase and ground or between the three phases grouped and ground. The trip value shall be adjustable and the device shall be capable to detect simultaneous faults even in three different circuits.

4.19.3.4 The isolation monitoring device shall be capable to measure the isolation and to detect the ground fault in systems with cable total length (three phases) of one hundred kilometers (100km), without any failure or nuisance actuation.
4.19.3.5 All outgoing circuits of CDC shall have individual ground fault detector devices - EFI (Earth Fault Indicator). For loads installed in hazardous areas Zone 1 or which cables cross hazardous areas Zone 1, these devices shall instantaneously trip the circuit-breakers. A network alarm signal (UAS) shall be sent by BETU or MMR to A&C, through Electrical System Gateway.

4.19.3.6 In MCCs, only outgoing circuits of loads installed in hazardous areas Zone 1 or which cables cross hazardous areas Zone 1 shall have individual ground fault detector devices (EFI) that shall instantaneously trip the circuit-breakers. For functional units with IED, a network alarm signal (UAS) shall be sent by IED to A&C, through Electrical System Gateway.

4.19.3.7 Other loads fed from MCCs shall be grouped per column in a same EFI. The fault finding in outgoing cables for these circuits in MCCs shall be through portable ground fault detector. These cables shall be installed in a way to enable easy access to clamp them with a portable ground fault detector, with the circuit energized. The shields shall be installed according to the detector requirements.

4.19.3.8 In Turbogenerators MCCs, ground fault detector devices (EFI) shall be compatible with the insulation monitoring devices installed in upstream switchgear.

4.19.3.9 Detailed design shall supply to Panel Manufacturer a list of all loads installed in hazardous areas.

4.19.3.10 One hardwired resume alarm signal (Low Insulation - Ground Fault) shall be sent by isolation monitoring device to A&C, through Electrical Automation System, for each Panel, in case of failure in circuits that are not tripped. It shall also be acceptable connection to A&C through Electrical Automation System with network communication: Profibus DP, Devicenet, Ethernet Modbus or IEC 61850.

4.19.3.11 MCCs shall be supplied with devices to indicate defective phase by means of three lamps connected between phases and ground through a NO (normally open) push-button. This system shall be compatible with insulation monitoring device installed in the CDC, in order to eliminate spurious alarms or trips.

4.19.3.12 One portable ground fault detector shall be supplied with each purchased panel.

4.20 Electromagnetic Compatibility (EMC)

4.20.1 All equipment having electronic components or circuits shall comply with emission and immunity EMC (Electromagnetic Compatibility) and RFI (Radio Frequency Interference) requirements according to IEC 61000 and IEC 60533, presenting Performance Criterion A.

4.20.2 Regarding induced disturbances, all electronic equipment shall comply with IEC 61000-4-6 class 3.
4.20.3 Regarding surges, all electronic equipment shall comply with IEC 61000-4-5 class 4 with wave forms 1.2/50µs and 10/700µs and peaks up to 4kV.

4.20.4 Regarding oscillatory waves, all electronic equipment shall comply with IEC 61000-4-12 class 3 and common mode disturbances up to 150 kHz as per IEC 61000-4-16 level 4. Data communications and signal circuits shall be tested only in common mode, but at the same surge magnitude as specified for transverse mode tests, according to IEC 61850-3.

4.20.5 Regarding fast transients, all electronic equipment shall comply with IEC 61000-4-4 class 4, or above. In addition, power supply circuits shall be tested with transverse mode applied voltages, according to IEC 61850-3.

4.20.6 Regarding electromagnetic disturbances, all electronic equipment shall comply with IEC 61000-4-3 class 3.

4.20.7 Regarding damped oscillatory magnetic, all electronic equipment shall comply with IEC 61000-4-10 level 5.

4.20.8 Regarding power frequency magnetic field, all electronic equipment shall comply with IEC 61000-4-8 level 5 for continuous and short duration fields.

4.20.9 All electronic equipment shall operate correctly in the presence of a power frequency voltage in accordance with table 1 of IEC 61850-3

4.21 Control Voltages

4.21.1 MCCs

4.21.1.1 Control voltages for Turbogenerators low-voltage MCCs shall the same as for CDCs. Refer to item 4.21.2 for details.

4.21.1.2 Except for Turbogenerators low-voltage MCCs, the control voltage for each MCC shall be supplied by two withdrawable auxiliary transformers 480-120VAC, each one connected to one busbar end. Each auxiliary transformer shall be dimensioned to 125% of the MCC control circuits total power.

4.21.1.3 The primary winding of the auxiliary transformers in MCCs shall be protected by circuit-breakers. The secondary winding and each control circuit branch shall be suitably protected with miniature circuit-breakers.

4.21.1.4 The control busbar shall be split in two semi-bars, each one provided with a rotary selector switch of at least 20A for selection of the auxiliary transformer.

4.21.1.5 If it is necessary the addition of 24VDC sources to feed the IRs, the same criteria shall be adopted and two switched power supply, each one with capacity for supply the entire control system shall be installed. Blocking diodes shall be added to the output of each DC source.

4.21.1.6 The secondary winding of the auxiliary transformers shall have one terminal bolted grounded.

4.21.1.7 Undervoltage at any 120Vac control semi-bars shall generate a remote hardwired alarm signal (Control Voltage Failure) to A&C, through Electrical Automation System.
4.21.2 CDCs

4.21.2.1 The control voltage for each Panel shall be in 220VDC achieved from Unit’s redundant UPSs.

4.21.2.2 The Panels shall have two control busbars, one for loads connected to main busbar A and other for loads connected to main busbar B. Each control busbar shall be provided with a rotary selector switch to select which UPS will feed the control busbar.

4.21.2.3 For the main distribution busbars of UPS panels, Lighting Panels, and Direct Current Panels, Surge Protective Devices (SPD) shall have a maximum discharge current of 10 kA in 8/20 microseconds, as required by NFPA 780 section 4.20.3.2.2.

4.21.2.4 Each control busbar incoming shall be protected by miniature circuit-breakers. The busbars shall be connected by a normally open tie circuit-breaker.

4.21.2.5 Undervoltage at any 220VDC control busbars shall generate a remote hardwired alarm signal (control voltage failure) to A&C, through Electrical System Automation Controllers.

4.21.2.6 CDCs connected to Emergency and Auxiliary Generators shall have a third option for control voltage supply, by means of an auxiliary rectifier with incoming rated voltage in 480VCA and outgoing rated voltage in 220VDC; connected to the terminals of incoming feeders of Emergency or Auxiliary Generator. The auxiliary rectifier shall be installed in the CDC (included in CDC Manufacturer scope of supply) and shall have the proper capacity to supply control loads of the CDC. In these cases the rotary selector switches of the control busbars shall have a third position.

4.21.2.7 Undervoltage at any 220VDC control semi-bar shall generate a remote hardwired alarm signal (Control Voltage Failure) to A&C, through Electrical System Controller.

4.22 Auxiliary Voltages

4.22.1 The power supply for heating resistors shall be achieved from 220VAC three phase external source. The circuits for heating resistors shall be two phases and shall be balanced among three phases internally.

4.22.2 Each panel division for transport shall be provided with externally accessible terminals to energize the heating circuits during storage periods. These terminals shall have a label with:

TERMINAIS PARA ENERGIZAÇÃO DAS RESISTÊNCIAS DE AQUECIMENTO
4.22.3 The power supply for internal lighting and sockets outlets shall be achieved from the same 220VAC three phase external source that feeds the heating resistors. The circuits for internal lighting and sockets outlets shall be two phases and shall be balanced among three phases internally.

4.22.4 The auxiliary circuit branches for internal lighting and internal sockets shall have miniature thermomagnetic circuit-breakers with integrated or additional differential residual current protection.

4.23 Interface with Automation

4.23.1 Panel Manufacturer shall propose the internal network architecture among IEDs, complying with requirements of ELECTRICAL SYSTEM AUTOMATION DOCUMENTATION. This internal network architecture and configuration shall be submitted to PETROBRAS approval.

4.23.2 Devices connected to the networks shall have the time synchronized with A&C actual time. Refer to ELECTRICAL SYSTEM AUTOMATION DOCUMENTATION.

5. MANUFACTURER DOCUMENTATION

5.1 The following documents shall be provided by Panel Manufacturer, at proposal:

a) Documents list;

b) Dimensional drawings including frontal and upper views, estimated weight and thermal dissipation;

c) Technical catalogues with information about all components;

d) Spare parts list for two years of operation, including item, part number, quantity, description, MTBF and prices for each part;

e) Technical assistance prices and representative address;

f) Panel Data-sheet issued by PETROBRAS completely filled in with Manufacturer data with identification of the person responsible for the filling. This Data-sheet shall be submitted to PETROBRAS approval.

g) Data Sheet following template of item Erro! Fonte de referência não encontrada., when not issued by PETROBRAS, completely filled in, with identification of the person responsible for the filling. This Data-Sheet shall be submitted to PETROBRAS approval;

h) List of applicable standards;

i) Inspection and test schedule, including acceptance criteria for each test;

j) Type tests certificates;

k) Certificate for testing under conditions of arcing due to internal fault for CDCs;

l) Dimensional drawing for connections to bus trunking, when applicable;

m) Time-current curves, current peak limiting curves and i²t minimum and total values of the limiting fuses;
5.2 The following documents shall be provided by Panel Manufacturer, for approval:

a) Documents list;
b) Dimensional drawings including frontal and upper views, details, location of lifting eyelets, area for incoming cables and fixing base details;
c) Weight and volume for each unit for transportation;
d) Total weight;
e) Thermal dissipation at half load and full load, of portion of panel thermal dissipation that is independent of electrical system loading and the components responsible for this dissipation;
f) Dimensional drawing for connections to bus trunking, when applicable;
g) Electrical drawings, including one-line, three-lines and functional diagrams;
h) Connection diagrams, including all terminal blocks;
i) Electrical Functional Units Classification List according to control mode;
j) Saturation curves of current transformers;
k) Components and material list per functional unit;
l) Time-current curves, current peak limiting curves and i²t minimum and total values of the limiting fuses;
m) Package and transportation instructions;
n) Warranty certificate and declaration of availability of spare parts for 10 (ten) years;
o) Extraction and insertion instructions;
p) Network architecture internal to the Panel;
q) Network configuration, parameterization, screens, and monitoring documentation for all equipment that will be connected by network;
r) Memory map
s) Expected MTTR for each type of functional unit and for each component;
t) Type tests certifications.

5.3 The following documents shall be provided by Panel Manufacturer, with the Panel:

a) Data-sheet full-filed "as built";
b) Storage, lifting and unpacking instructions in Portuguese language;
c) Installation and assembly instructions in Portuguese language;
d) Operation instructions in Portuguese language, according to DOCUMENTATION GUIDELINES;
e) Maintenance instructions, including list of necessary equipment, accessories and tools in Portuguese language, according to DOCUMENTATION GUIDELINES;
f) Spare parts lists;
g) "As built" technical catalogue for all components;  

h) Complete test report, including type, routine and special tests;  

i) Complete version of configuration, parameterisation and monitoring softwares for switches, concentrators, gateway devices, IRs, MMR, VSDs and any other equipment that could be configured or monitored by software. These softwares shall provide facilities for full diagnosis of respective devices;  

j) Complete manuals for installation and configuration of all softwares in Portuguese language;  

k) Components list, including at least, item, description, draw, unit, quantity and part number.

6. PACKAGE AND TRANSPORT

6.1 Panels shall be packed properly for the foreseen transportation, so that no damage occurs during transport, storage and lifting operations;

6.2 Each volume shall be properly identified with:  
   a) Storage position;  
   b) PETROBRAS unit, achievement, and business unit;  
   c) Delivery address  
   d) Material Requisition number;  
   e) Panel TAG;  
   f) Manufacturer name and address;  
   g) Weight;  
   h) Contract number.

7. INSPECTION AND TESTS

7.1 General

7.1.1 The Manufacturer or an independent inspection authority accepted by PETROBRAS shall perform all inspections and tests, in conformity with the specification documents and applicable rules.

7.1.2 Manufacturer shall be responsible for obtaining all necessary certification related to the equipment.

7.1.3 Manufacturer shall be responsible for contact the Classification Society, in order to define the procedures to be followed, related to the submission of documents, and to carry out the necessary inspections and tests to certificate the Panels.

7.2 Design Verification
7.2.1 Design verification shall follow the requirements of IEC 61439-1, IEC61439-2, IEC 60092-302 and IEC 61892-3. According to IEC61439-1, the methods that check design verification are testing, comparison with a tested reference design or assessment (confirmation of the correct application of calculations and design rules, including use of appropriate safety margins). Design verification and methods are summarised in Table 2, where they are identified as “D”.

7.2.2 Certified test reports for design verification tests performed for identical panels or a panel tested reference design (when applicable, according to IEC 61439-1) and approved and witnessed by Classification Society are accepted. These reports shall be included al proposal by manufacturer.

7.3 Routine Verification

7.3.1 Routine tests shall follow the requirements of IEC 61439-1, IEC 61439-2, IEC 60092-302 and IEC 61892-3. They are summarised in Table 2, where they are identified as “R”.

7.3.2 Routine tests shall be carried out for all Panels.

7.4 Special Tests

7.4.1 Special tests shall be carried out according to Table 2, where they are identified as “S”.

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<tr>
<td>Tripping limits and characteristics for circuit-breakers</td>
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<tr>
<td>Dielectric for circuit-breakers</td>
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<tr>
<td>Operation performance capability for circuit-breakers</td>
</tr>
<tr>
<td>Overload performance for circuit-breakers, where applicable</td>
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<tr>
<td>Short-circuit breaking capability for circuit-breakers</td>
</tr>
<tr>
<td>Short-time withstand current for circuit-breakers, where applicable</td>
</tr>
</tbody>
</table>

Notes: 1. For all witnessed tests;
2. For MCCs, this test includes the current limiting reactors, installed in the enclosure;
3. EMC tests shall be carried out when required in IEC 60533 for the equipment installed in the Panel;
4. Manufacturer shall be present at site, after the panel assembly and transport, to verify, together with PETROBRAS, if the Panel is at the same conditions as it was when factory delivered it and to verify if the Panel is ready to start operation;
5. These tests shall include all tests related to network communication among devices (alarms, interlocks, GOOSE, etc.). For IEC 61850 networks, these tests shall use calibration boxes certified for IEC 61850;
6. These tests shall include check of A/D converters of relays. For relays specified for IEC 61850 protocol, these tests shall use calibration boxes certified for IEC 61850.
7. Design verification by comparison with a reference design for short-circuit withstand strength of the protective circuit can be submitted for PETROBRAS analysis and approval.

8. TRAINING

8.1 Manufacturer shall provide training for at least 10 (ten) PETROBRAS personnel, about Panels system and components.
8.2 Training shall be provided in Brazil, during commissioning period, in Portuguese language.
8.3 Training plan shall include at least control diagram analysis, storage, transportation, installation, operation, corrective maintenance, preventive maintenance, disassembly, assembly, extraction and insertion of drawers, use of tools and accessories, interface with automation, use of softwares, configuration, parameterization and adjustment of IEDs, equipment and devices.
9. SPARE PARTS AND TOOLS

9.1 Manufacturer shall provide the necessary spare parts for the commissioning and pre-operation periods;

9.2 Manufacturer shall provide a list of spare parts for all electrical equipment, for at least 2 (two) years of continuous operation, including prices and part number codes.

9.3 Manufacturer shall provide all unusual tools necessary for maintenance, assembly or disassembly of the Panel.

10. DATA SHEETS FORMS

For data-Sheet models for low-voltage MCCs and switchgears, refer to I-LI-3010.00-5140-700-P4X-001 - ELECTRICAL EQUIPMENT DATA-SHEET MODELS.

11. ABBREVIATIONS AND ACRONYMS

<table>
<thead>
<tr>
<th>ABBREVIATIONS AND ACRONYMYS</th>
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<tbody>
<tr>
<td>A&amp;C</td>
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<tr>
<td>AISI</td>
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<td>BETU</td>
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<tr>
<td>CDC</td>
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<td>CT</td>
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<td>EA01 to EA04</td>
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<td>EFI</td>
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<td>EMC</td>
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<td>Ip</td>
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<td>Ip arc</td>
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<td>Ip pk</td>
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<td>IR</td>
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<td>Ih</td>
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<td>MCC</td>
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<td>MTBF</td>
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### ABBREVIATIONS AND ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>MTTR</td>
<td>Mean Time to Repair</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl Chloride</td>
</tr>
<tr>
<td>r.m.s</td>
<td>Root Mean Square</td>
</tr>
<tr>
<td>RM</td>
<td>Material Requisition</td>
</tr>
<tr>
<td>R</td>
<td>Routine Test</td>
</tr>
<tr>
<td>S</td>
<td>Special Test</td>
</tr>
<tr>
<td>$t_{\text{arc}}$</td>
<td>Permissible Arc Duration (as defined in IEC TR 61641)</td>
</tr>
<tr>
<td>THD</td>
<td>Total Harmonic Distortion</td>
</tr>
<tr>
<td>T</td>
<td>Type Test</td>
</tr>
<tr>
<td>TTA</td>
<td>Type-Tested Low-Voltage Switchgear and Controlgear Assembly</td>
</tr>
<tr>
<td>U</td>
<td>Rated Power Frequency Voltage Between Conductors for which the Cable is Designed</td>
</tr>
<tr>
<td>$U_0$</td>
<td>Rated Voltage Between Conductor and Earth or Metallic Screen for which Cable is Designed</td>
</tr>
<tr>
<td>UAM</td>
<td>Unit Alarm Malfunction</td>
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<tr>
<td>UAS</td>
<td>Unit Alarm Shutdown</td>
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<tr>
<td>UPS</td>
<td>Uninterruptible Power Supply</td>
</tr>
<tr>
<td>UVT</td>
<td>Undervoltage Trip Coil</td>
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<tr>
<td>VSD</td>
<td>Variable Speed Drive</td>
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<tr>
<td>VT</td>
<td>Voltage Transformer</td>
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<tr>
<td>XLPE</td>
<td>Crosslinked Polyethylene</td>
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