	TECHNICAL SPECIFICATION	Nº I-ET-3010.00-5140-741-P4X-002	
	CLIENT:	SHEET: 1 of 44	
	JOB:		
	AREA:		
SRGE	TITLE: MEDIUM-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS	INTERNAL	
		ESUP	

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0	ORIGINAL ISSUE
A	REVISED WHERE INDICATED
B	GENERAL REVIEW ACCORDING TO IOGP JIP 33-SUPPLEMENTARY SPECIFICATION TO IEC 62271-200 HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR (VERSION 1.0, OCTOBER 2018)
C	REVISED WHERE INDICATED
D	REVISED WHERE INDICATED DUE TO CONSISTENCY ANALYSIS
E	REVISED ITEMS 2.1 AND 5.3 , ACCORDING TO CLARIFICATION NOTICE DUE TO BIDDER QUESTIONS
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G	REVISED ITEMS 4.5.6, 4.5.12, 4.14.6.2, 4.14.6.3, 4.14.6.4 AND Table 1 ACCORDING TO CLARIFICATION NOTICE DUE TO BIDDER QUESTIONS
H	REVISED ITEM 4.6.10, ACCORDING TO CLARIFICATION NOTICE DUE TO BIDDER QUESTIONS
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APPROVAL	MATTOSO	UQBK	UQBK	UQBE	UQBE	REGGIANI	REGGIANI	REGGIANI	REGGIANI

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1. OBJECTIVE

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


2. REFERENCE DOCUMENTS, STANDARDS AND CODES


Panel design shall comply with requirements of Classification Society, Brazilian Legislation, applicable regulatory rules, Supplementary Specification to IEC 62271-200 High-voltage switchgear and controlgear (version 1.0, October 2018) attached to this Specification 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 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 FOR OFFSHORE UNITS
- [3] I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS
- [4] I-ET-3010.00-5140-700-P4X-004 - PN-5140001 - POWER MANAGEMENT SYSTEM (PMS) FOR OFFSHORE UNITS
- [5] I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEM OF OFFSHORE UNITS
- [6] I-ET-3010.00-5143-700-P4X-001 - ELECTRICAL SYSTEM PROTECTION CRITERIA
- [7] I-LI-3010.00-5140-700-P4X-001 - ELECTRICAL EQUIPMENT DATA-SHEET MODELS
- [8] I-ET-3010.00-5140-772-P4X-001 - MEDIUM-VOLTAGE FREQUENCY CONVERTER FOR OFFSHORE UNITS
- [9] I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST
- [10] I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE
- [11] I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM
- [12] I-ET-3010.00-1200-800-P4X-002 - AUTOMATION, CONTROL AND INSTRUMENTATION ON PACKAGE UNITS
- [13] I-ET-3010.00-5520-888-P4X-001 - AUTOMATION PANELS
- [14] I-ET-3010.00-1200-940-P4X-002 - GENERAL TECHNICAL TERMS
- [15] I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING

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[16]	I-DE-3010.00-5143-946-P4X-001	- MEDIUM-VOLTAGE SYSTEMS PROTECTION DIAGRAM	
[17]	I-ET-3010.00-5140-700-P4X-009	- GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS	
[18]	I-ET-3010.00-5140-700-P4X-007	- SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS	
2.2	IEC - International Electrotechnical Commission		
	60092-201	Electrical Installation in Ships - System Design - General;	
	60282-1	High-Voltage Fuses - Part 1: Current-Limiting Fuses;	
	60332-1	Tests on Electric and Optical Fibre Cables under Fire Conditions - Part 1 - all sub-parts;	
	60332-3-22	Tests on Electric and Optical Fibre Cables under Fire Conditions - Part 3 - 22: Test for Vertical Flame Spread of Vertically-Mounted Bunched Wires or Cables - Category A	
	60417-SN	Graphical Symbols for Use on Equipment - Database Snapshot	
	60445	Basic and Safety Principles for Man-Machine Interface, Marking and Identification - Identification of Equipment Terminals, Conductors Terminations and Connectors;	
	60529	Degrees of Protection Provided by Enclosures (IP Code);	
	60533	Electrical and Electronic Installations in Ships - Electromagnetic Compatibility;	
	60617-SN	Graphical Symbols for Diagrams - Database Snapshot;	
	60909	Short-circuit currents in three-phase a.c. systems – All parts;	
	61850	Communication Networks and Systems in Substation - All parts;	
	TR-61000-5-2	Electromagnetic Compatibility (EMC) - Part 5: Installation and Mitigation Guidelines - Section 2: Earthing and Cabling;	
	61086	Coating for Loaded Printed Wire Boards (Conformal Coatings) - All parts	
	61892-1	Mobile and Fixed Offshore Units - Electrical Installations - Part 1 - General Requirements and Conditions;	
	61892-3	Mobile and Fixed Offshore Units - Electrical Installations - Part 3 - Equipment;	
	TR 62063	High-Voltage Switchgear and Controlgear - The Use of Electronic and Associated Technologies in Auxiliary Equipment of Switchgear and Controlgear;	
	62271	High-Voltage Switchgear and Controlgear - All Parts.	
2.3	IEEE - The Institute of Electrical and Electronics Engineers (only where specified)		
	C37.2	Standard for Electrical Power System Device Function Numbers, Acronyms, and Contact Designations	

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<p>2.4 Brazilian Labour and Employment Ministry</p> <p>NR-10 Segurança em Instalações e Serviços em Eletricidade</p> <p>NR-12 Segurança no Trabalho em Máquinas e Equipamentos</p> <p>2.5 ASTM – American Society for Testing and Material</p> <p>F1166 Standard Practice for Human Engineering Design for Marine System, Equipment and Facilities;</p> <p>B700 Standard Specification for Electrodeposited Coatings of Silver for Engineering Use</p> <p>2.6 IMO - International Maritime Organization</p> <p>IMO IA811E Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU CODE)</p> <p>2.7 IOGP - International Association of Oil & Gas Producers</p> <p>S-620 Supplementary Specification to IEC 62271-200 High-voltage switchgear and controlgear (version 1.0, October 2018).</p> <p>3. GENERAL CONDITIONS</p> <p>3.1 For the purpose of this document, requirements concerning both MCCs and CDCs are cited using the word “Panel” or no word. Requirements concerning only MCCs are cited using the word “MCC” and requirements concerning only CDCs are cited using the word “CDC”. Refer to abbreviations on item 11.</p> <p>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 SYSTEM OF OFFSHORE UNITS and NR-10.</p> <p>3.3 The specific characteristics of the Panel shall be indicated in the Data-Sheet.</p> <p>3.4 The Manufacturer shall supply all the electric materials, accessories (connection cables, connectors, software, software licenses, calibration boxes, etc.), equipment and specific tools, which are necessary for the assembly, start-up, commissioning, operation, disassembly and maintenance of the Panel.</p> <p>3.5 The final assembly of the Panels in the Unit shall be done by Manufacturer.</p> <p>3.6 It shall not be acceptable out of date or obsolete equipment or components. Technical support and supply of replacement parts shall be guaranteed for ten (10) years.</p> <p>3.7 The use of switchgear and controlgear assemblies and sub-components with less than 3 years proven operational service shall be approved by PETROBRAS.</p> <p>3.8 For terms and definitions, refer to I-ET-3010.00-1200-940-P4X-002 - GENERAL TECHNICAL TERMS.</p>			

3.9 The following items of the Supplementary Specification to IEC 62271-200 High-voltage switchgear and controlgear (version 1.0, October 2018) shall not be applicable to this specification:

Items 2.1.2, 4.1, 4.2, 4.4.1, 4.4.2, 4.8, 4.101.2, 5.0.101, 5.0.102, 5.3.101, 5.3.101.2, 5.4.1.2, 5.4.3.4.1, 5.9, 5.15.1, 5.15.2, 5.15.3, 5.17, 5.20, 5.102.1, 5.103.1, 5.104, 5.106, 5.106.2, 5.107, 5.108.3, 5.109, 5.111, 5.112.1, 5.112.2, 5.112.4, 5.114.3, 5.115.2, 5.115.3 and 7.

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 FPSOs and FSOs platforms, the standard IEC 60092-201 shall have priority over others.
- 4.1.3 Panels shall be designed to withstand the thermal stresses due to thermal equivalent short-circuit current (I_{th} , according to IEC 60909) informed in Data-Sheet for 1s. The rated short-time withstand current (I_k according to IEC 62271-1) of the Panel considering rated duration of short-circuit (t_k according IEC 62271-1) of 1s shall be bigger than the informed I_{th} .
- 4.1.4 Panels shall be designed to withstand the dynamic stresses due to peak short-circuit current (i_p according to IEC 60909) informed in Data-Sheet. The rated peak withstand current (I_p according to IEC 62271-1) of the Panel shall be bigger than the informed i_p .
- 4.1.5 Panels using flammable liquids in its components shall not be accepted.

4.2 Spare Functional Units (Feeders and Starters)

- 4.2.1 Besides the definition from Supplementary Specification to IEC 62271-200 High-voltage switchgear and controlgear, the spare Functional Units shall include all hardwired and network interface signals regarding interlock, protection, control and supervision according to I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST considering the Spare Functional Unit Classification according control mode.
- 4.2.2 Spare functional units quantities shall be defined in Data-Sheets, but at least 1 (one) spare functional unit per busbar, suitable for motor load, shall be supplied, with rated current equal to the rated current of the biggest load of the Panel.
- 4.2.3 Spare Functional Units classification according to control mode shall comply with I-ET-3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.

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-009 – GENERAL REQUIREMENTS 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 by 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-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS and Classification Society rules.

4.4 Insulation Level

- 4.4.1 The insulation levels shall be as follow:

Table 1 - Insulation Levels for Panels

System Rated Voltage [kV]	Panel Minimum Rated Voltage - U_r [kV] (r.m.s value)	Minimum Short-Duration Power-Frequency Withstand Voltage - U_d [kV] (r.m.s value)		Minimum Lightning Impulse Withstand Voltage - U_p [kV] (r.m.s value)	
		Common Value	Across the Isolating Distance	Common Value	Across the Isolating Distance
4.16	7.2	20	23	60	70
6.6	7.2	20	23	60	70
13.8	17.5	38	45	95	110

4.5 Classification of Assemblies

- 4.5.1 The Panels shall be classified according to IEC 62271-1, IEC 62271-200, and IEC 61892-3.
- 4.5.2 Unless otherwise stated in Project Documentation, Panels shall be proper for indoor installation.
- 4.5.3 Panels shall be stationary assemblies.
- 4.5.4 The external protection degree shall be defined according to IEC 62271-200 and IEC 60529 with a minimum:
- IP42, for Panels installed in panel rooms;
 - IP44W, for Panels installed in machinery rooms;
 - 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.

4.5.5 Panel shall be designed to keep the external protection degree with the functional units in test and isolated positions and during transfer from one position to another.

4.5.6 Panels shall be composed by withdrawable parts with the following positions:

- a) Connected or inserted;
- b) Test;
- c) Disconnected or Extracted;
- d) Removed.

Note: Earth position shall also be foreseen in accordance with item 4.14.21 requirements, this position can act simultaneously with other positions as long as the foreseen interlocks are maintained.

4.5.7 Each functional unit shall be one separate withdrawable part. The withdrawable parts shall slide over rails.

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

4.5.9 Protection against electrical shock by indirect contact shall be ensured by means of protective circuits (earth bar), according to IEC standards.

4.5.10 There shall be partitions class PM between compartments, protecting people against contact with live parts when accessing opened compartments.

4.5.11 The compartments with circuit-breakers shall have classification of loss of service continuity category LSC2B-PM. The compartments with contactors shall have classification LSC2A-PM, being acceptable LSC2B-PM.

4.5.12 Compartments for switching devices shall be interlock-controlled accessible according to IEC 62271-200. Busbar compartments and cables compartments shall be tool-based accessible compartments according to IEC 62271-200.

Note: Interlock-controlled accessible type for cables compartment shall be submitted to PETROBRAS approval since in compliance with item 4.6.22.

4.5.13 Unless otherwise stated in the Project Documentation, Panels shall have classification for internal arc IAC AFLR (all faces with category of restricted accessibility to authorized personal).

4.6 Structure

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

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

4.6.3 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 fixed to the floor. The skid and all accessories necessary to fix the skid to the floor shall be supplied by Panel manufacturer.

- 4.6.4 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
- 4.6.5 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 SYSTEM OF OFFSHORE UNITS.
- 4.6.6 Panels shall be self-supported with extension possibility at both ends. Lifting devices at the upper side shall be provided.
- 4.6.7 The panels shall be designed in such a way that a maximum of 2 columns are connected for mechanical handling.
- 4.6.8 Panels shall have access for installation and maintenance through the front and rear side. Back doors shall be provided with hinges and locks to keep them in open position.
- 4.6.9 Panels shall be comprised of independent vertical sections, formed by metallic compartments, aiming the flame retardation of a possible fire from one functional unit to another.
- 4.6.10 Each vertical section shall contain doors with hinges in its front part. The extraction of the circuit-breaker or contactor to the test position or its insertion shall be possible only with the door closed, through crank.
- 4.6.11 All vertical sections of incoming, tie and outgoing circuit-breakers of CDCs and MCCs shall be subdivided in no less than the following compartments:
- a) compartment of busbar (busbar section for tie vertical sections);
 - b) compartment of switching devices;
 - c) cable compartment (busbar section for tie vertical sections);
 - d) compartment of low-voltage components for control, protection, signalling, measurement and other auxiliaries.
- 4.6.12 All vertical sections of measurement/protection voltage transformers (VTs) and busbar transitioning shall be subdivided in no less than the following compartments:
- a) compartment of busbar;
 - b) compartment of the device (VT or transitioning connection bars);
 - c) compartment of low-voltage components for control, protection, signalling, measurement and other auxiliaries.
- 4.6.13 All removable parts and components of the same type, rating and construction shall be mechanically and electrically interchangeable.
- 4.6.14 The arrangement shall enable easy access for external wiring installation and maintenance, including space to manipulate necessary tools.
- 4.6.15 The structure of the withdrawable parts shall be dimensioned to support its weight in all positions.

- 4.6.16 All the switching devices, being circuit-breakers or contactors, shall allow placement of padlocks to lock them in the OFF (open) position.
- 4.6.17 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 switching device compartment door to operate them. Exceptions shall be agreed with PETROBRAS.
- 4.6.18 The grips and switching devices 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 currents.
- 4.6.19 When installed in FPSO, FSO or SS, the Panels shall have isolated handrails along the front and rear sides.
- 4.6.20 Panels shall be provided with a durable mimic one-line (synoptic) diagram on the front of the assembly, displaying the single line arrangement of busbars and the main circuit switching devices of incomers, bus couplers, limiter (when applicable), feeders and starters.
- 4.6.21 The arrangement of the panels shall be conceived aiming the lowest heat dissipation in the main busbars at the worst operation condition.
- 4.6.22 The panels shall be constructed so that thermal inspection by optical infrared thermographic devices could be safely performed with the circuits energized. This facility shall not compromise arc withstand capability to comply with IEC 62271-200.

4.7 Busbars

4.7.1 Main and Auxiliary Busbars

- 4.7.1.1 Panels shall be provided with the number of horizontal main busbars (semi-busbars) as indicated in Panel Data-Sheet. The busbars shall be connected by tie circuit-breakers.
- 4.7.1.2 The busbars shall have capacity to conduct continuously the rated current specified in Panel Data-Sheet with the temperature rise limited to the standard values.
- 4.7.1.3 Busbars and supporting systems shall be dimensioned to withstand the mechanical and thermal stresses resulting from short-circuit currents indicated in Panel Data-Sheet.
- 4.7.1.4 Each vertical column shall be provided with a vertical busbar branched from the main busbar.
- 4.7.1.5 Busbars shall be three-phase, of electrolytic copper.
- 4.7.1.6 Each busbar phase shall have a permanent identification, using one colour per phase, according to:
- a) phase (R-S-T): red, white and black, respectively;
 - b) ground: bicolour combination green-yellow according to IEC 60445.

4.7.1.7 Busbars insulation 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.

4.7.1.8 The busbars insulation, supports and junction pieces materials shall be flame retardant, non-hygroscopic and resistant to the degradation due to pollutant agents. Celeron and Fiberglass shall not be accepted.

4.7.1.9 All busbars connections and outgoing bars or cables for switching devices and circuit-breakers shall be silver coated according to ASTM B700 with minimum thickness of 2.5µm. The junctions shall be placed in such a manner to guarantee a perfect alignment and high-pressure contact.

Note: Both sides of contact bus bar shall be silver coated.

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

4.7.1.11 Panels shall not have neutral bar.

4.7.2 Grounding Bars.

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

4.7.2.2 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 61892-3 described in Table 2.

Table 2 – Sizes of earth conductors when installed inside enclosures

Cross-section Q of associated current-carrying conductor (one phase or pole) (mm ²)	Minimum cross-section of earth conductor
$Q \leq 16$	Q
$Q \geq 16$	50 % of the current-carrying conductor, but not less than 16 mm ²
Earth conductors for hinged doors	Not less than 4mm ²

Note: All doors shall be provided with supplemental equipotential bonding.

4.7.2.3 The cross section of the grounding bar shall be according to IEC 62271-200. 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.

4.7.3 Electronic Reference Bar.

4.7.3.1 The low-voltage compartments shall contain a terminal block or a bar of electronic reference, isolated of the structure.

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

4.8 Internal Wiring and Conductors

4.8.1 All cables shall comply with the requirements of the I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS.

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

4.8.3 Power conductors shall be provided with EPR or XLPE insulation.

4.8.4 Cancelled.

4.8.5 Discrete signals cables shall be collectively shielded. Analog signals cables shall have twisted pairs with a shield for each pair and a collective shield under the external cover.

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

4.8.7 The insulation of cables used for D.C. circuits shall be red for wiring with positive voltage and black for wiring with negative voltage.

4.8.8 The outer sheath (protective cover) colour of cables used in ground circuits shall be striped with green and yellow, according to IEC 60445.

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

4.8.10 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.

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


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

4.8.13 The electric cables of the low-voltage compartment shall have segregated internal path and terminal blocks, according to requirements of IEC 61000-5-2. Additionally, these cables shall have path and terminal blocks segregated in the following groups:

- a) control in 220 VDC;
- b) heating, lighting and socket-outlet circuits in 220VAC,
- c) 4-20mA analogical signals, RTD signals, data transmission signals;
- d) instrument transformers incoming signals.

4.8.14 Cancelled.

4.9 External Wiring and Conductors Entrance

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4.9.1	Unless otherwise stated in Project Documentation, all incoming and outgoing cables of medium-voltage CDCs shall enter through the bottom of the Panel.		
4.9.2	All incoming and outgoing cables entrance in medium-voltage MCCs shall be according to project documentation.		
4.9.3	Unless otherwise stated in Project Documentation, if bus trunking connections are used, the Panels shall have appropriate edges and flexible connectors for entrance through the top.		
4.9.4	For single core cables, Manufacturer shall provide removable plates, with a minimum thickness of 2.8mm, made of AISI-316 stainless steel or non-magnetic material. For all other cases, the removable plates shall be of painted galvanized steel, with galvanization thickness for 30 years lifetime. The removable plates shall be provided with neoprene rubber gaskets. MCTs can be used as an alternative.		
4.9.5	Metallic cable-glands made of material galvanically compatible with the removable plates material shall be supplied with the Panel.		
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	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 during the Detailed Design execution.		
4.10.5	All cable lugs for power 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 permit enough space to perform the cable termination, their fitting, easy access to terminals and easy reading of identification.		
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.		
4.12.3	Cable channels filling shall not exceed 75% of their capacity in order to prevent damage in internal cables during construction, commissioning and maintenance.		
4.13 Heating Resistors			



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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 60°C.

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 At least 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 All medium-voltage motors 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 functional unit when the motors are turned off.

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

4.13.2.3 For motors installed in hazardous areas Zone 1 and circuits for loads which cables cross 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.

4.13.2.4 Auxiliary circuits for motor space heaters shall be energized whenever the motor starter functional unit main circuit switching device is open, when either in the inserted or the test position;

4.13.2.5 Auxiliary circuits for motor space heaters shall be deenergized when drawer is in isolated position.

4.13.3 For Generators

4.13.3.1 All generators 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 functional unit when the generators are turned off. The generator status signal shall be obtained from the generator control panel, according to I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

4.13.3.2 One miniature circuit-breaker shall be provided in each vertical section, to protect the generators' heating resistors circuits.

4.13.3.3 For generators 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



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4.14.1.1 Unless otherwise stated in Project Documentation, the starters up to 1.2MW in 4.16kV and 6.6kV systems for MCCs shall be formed by current-limiting fuses, SF6 or Vacuum contactors and microprocessor-based multifunction relays (MMRs). For other cases, the starters in MCCs shall be formed by SF6 or Vacuum circuit-breakers and MMRs. The starters shall be configured in full compliance with the NR-10 Standard.

4.14.1.2 Unless otherwise stated in Project Documentation, the starters in CDCs shall be formed by SF6 or Vacuum circuit-breakers and MMRs.

4.14.1.3 Manufacturer shall dimension all functional units according to the loads rated power defined by Detailed Design.

4.14.1.4 The CDCs and MCCs shall be fitted with motorized racking devices to permit the local and remote extraction and insertion of the circuit-breakers and contactors with the door closed. If not provided by the same Manufacturer of the circuit-breakers and contactors, the compatibility of the interlocks and the safeness of the operation shall be attested by a certificate issued by the Manufacturers of the panel and circuit-breakers and contactors.

4.14.2 Protective Devices

4.14.2.1 Circuit-breakers and MMRs shall be used as protective devices for the power conductors and power equipment in CDCs and also in incoming, tie and back-feed circuits of MCCs.

4.14.2.2 Fuses, MMRs and contactors shall be used as protective devices for the power conductors and power equipment in outgoing circuits of MCCs.

4.14.2.3 Each panel functional unit shall have dedicated miniature circuit-breaker to protect circuits of spring charging motor (when applicable), and other miniature circuit-breakers to MMRs control and signalling.

4.14.3 Power Fuses

4.14.3.1 Functional units of MCCs shall be supplied with current-limiting fuses with appropriated capacity to give the maximum protection and to allow the motors starting, complying with IEC 60282-1.

4.14.3.2 The manufacturer shall supply test certificate, issued by official laboratory, testifying that the fuses are of "current-limiting" type.

4.14.3.3 Fuses shall be installed in such a way that they can be removed and inserted with no voltage in their terminals.

4.14.3.4 Blown fuses shall trip main contactors and shall block their closing. Blown fuses signalling in the front side of the panel shall be provided according to 4.14.15.1 and 4.14.15.2 and shall be available to the MMR in order to send an alarm through network.

4.14.3.5 Contactor-fuse combinations shall be furnished by the same manufacturer and comply with IEC 62271-106.

4.14.4 Main Contactors

4.14.4.1 Power circuits of functional units of MCCs shall use withdrawable vacuum or SF6 contactors complying with IEC 62271-106 and MMRs.

4.14.4.2 Main contactors shall be with three-poles, **non-latched**, dry and suitable for direct-on-line start of three-phase induction motors.

4.14.4.3 Nominal operating voltage for contactors coils shall be 220VDC. 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 62271-1, shall be 70% of rated voltage.

4.14.4.4 Cancelled.

4.14.4.5 In the cases where is not possible to comply with the previous item, the Manufacturer of the Panel shall present a declaration of the contactor manufacturer guaranteeing that the contactor is appropriately protected by the specified fuse.

4.14.4.6 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, energizing or de-energizing coils. STOP action (turn off) shall be available through frontal push-buttons for all main contactors. START action (turn on) shall be delayed to close and available through frontal push-button for 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 functional unit in test position. For loads classification according control mode, refer also to I-ET-3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFHORE UNITS.

4.14.5 MCCs Functional Units Interlocks

4.14.5.1 There shall be a mechanical lock to prevent the opening of the enclosure door when the contactor is racked in.

4.14.5.2 There shall be a mechanical lock to prevent the racking-in of the contactor when the enclosure door is open.

4.14.5.3 There shall be a mechanical lock to prevent the racking in and out of the contactor when closed.

4.14.5.4 There shall be provided means to assure that the contactor shall never be left in an intermediary position when racked in or out.

4.14.5.5 There shall be an electrical lock to prevent the contactor from closing or remain closed between the test and operation positions.

4.14.5.6 There shall be provided means to avoid the contactor to be inadvertently extracted beyond the "Test" position.

4.14.5.7 The "Test" position shall allow local and remote test of the starter without energize the load.

4.14.5.8 There shall be provided means to prevent misoperation of the power and interlocking devices due to the application of too much force by the operator.

4.14.5.9 Refer also to interlocks with the grounding switch on item 4.14.21.



- 4.14.5.10 Temporary parallel operation of transformers shall allow the operator changing the configuration of MV MCCs, from “II” (the incoming circuit-breakers from transformers closed and the tie circuit-breaker opened) to “L” (one incoming circuit-breaker from transformer plus the tie circuit-breaker closed and the other incoming circuit-breaker from transformer opened) and return it to “II”.
- 4.14.5.11 Temporary parallel operation of transformers (secondaries or tertiaries), with the panel in “U” configuration (two incoming circuit-breaker plus the tie circuit-breaker closed) shall be possible momentarily, since synchronization conditions are guaranteed (relay function 25). For more information, refer to I-ET-3010.00-5143-700-P4X-001 – ELECTRICAL SYSTEM PROTECTION CRITERIA.
- 4.14.5.12 The “U” operation shall only be allowed for the time required to change the configuration from one to the other.
- 4.14.5.13 MV MCCs shall have two selector switches for Temporary parallel operation of transformers. The first one will allow Temporary parallel operation. The second one will allow operator to select the circuit-breaker that will open (one of the incomings from transformers or the tie circuit-breaker), after the load transference (closing of the third circuit-breaker).
- 4.14.5.14 For other interlocks see project documentation.

4.14.6 Circuit-Breakers

4.14.6.1 Power circuits of CDCs and incoming and tie functional units of MCCs shall be with three-poles and shall use withdrawable Vacuum or SF6 circuit-breakers with MMRs.

4.14.6.2 Circuit-breakers for 13.8kV systems shall be with three-poles and shall have at least the following characteristics as defined on IEC 62271-100 but with some different values, as follows:

- a) Frame minimum rated voltage (U_r) 17.5kV;
- b) Circuit-breaker interrupters minimum rated voltage (U_r) 17.5kV;
- c) DC time constant of the rated short-circuit breaking current (τ): 100ms ($X/R=37.7$);

Note: 1 - Circuit-breakers interrupters rated voltage shall be confirmed during Transient Recovery Studies during Detailed Design

2 - Test reports certified by recognized laboratory for these circuit-breakers interrupters shall confirm that circuit-breakers interrupters can withstand TRV and RRRV found in the worst scenario of Transient Recovery Studies simulated by Detailed Design

4.14.6.3 Circuit-breakers for 6.6kV systems shall be with three-poles and shall have at least the following characteristics as defined on IEC 62271-100 but with some different values, as follows:

- a) Frame minimum rated voltage (U_r) 12kV;



b) Circuit-breakers interrupters rated voltage (Ur) 12kV;

Note: 1 - Circuit-breakers interrupters rated voltage shall be confirmed during Transient Recovery Studies during Detailed Design.

2 - Test reports certified by recognized laboratory for these circuit-breakers interrupters shall confirm that circuit-breakers interrupters can withstand TRV and RRRV found in the worst scenario of Transient Recovery Studies simulated by Detailed Design.

4.14.6.4 Circuit-breakers for 4.16kV systems shall be with three-poles and shall have at least the following characteristics as defined on IEC 62271-100 but with some different values, as follows:

a) Frame minimum rated voltage (Ur) 7.2kV;

b) Circuit-breakers interrupters rated voltage (Ur) 12kV;

Note: 1 - In order to achieve these values, it shall be acceptable the use of circuit-breakers with 7.2kV frames and using interrupters with voltage class above 12kV.

2 - Circuit-breakers interrupters rated voltage shall be confirmed during Transient Recovery Studies during Detailed Design.

3 - It shall be acceptable circuit-breakers interrupters with rated voltage lesser than 12kV by means of presentation of test reports certified by recognized laboratory for these circuit-breakers interrupters. These reports shall confirm that circuit-breakers interrupters can withstand TRV and RRRV found in the worst scenario of Transient Recovery Studies simulated by Detailed Design.

4.14.6.5 The incoming and tie circuit-breakers shall be identical and interchangeable.

4.14.6.6 The opening mechanism shall be "trip free" type and the closing mechanism shall have "anti-pumping" device.

4.14.6.7 Circuit-breakers shall not have undervoltage trip (UVT) coil as opening mechanism by ANSI 27 function.

4.14.6.8 Circuit-breakers shall have mechanical and electric control. 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 I-ET-3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFHORE UNITS.

- 4.14.6.9 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, energizing the closing and opening coils. STOP action (turn off) shall be available through frontal push-buttons for all circuit-breakers. 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 functional unit in test position. For loads classification according control mode, refer also to I-ET-3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFHORE UNITS.
- 4.14.6.10 Springs shall be charged by electric motor or by a manual lever installed in the circuit-breaker. The motor shall be controlled by limiting-switches to charge the spring whenever it is discharged.
- 4.14.6.11 Cancelled
- 4.14.6.12 Indicators for the contacts position and for the spring position shall be provided at the front cover of the circuit-breaker.
- 4.14.6.13 The rated control voltage for motors and coils shall be 220VDC.
- 4.14.6.14 Trip coil circuit monitoring shall be supplied in order to provide signalling in the front side of the panel according to 4.14.15.1 and 4.14.15.2 and shall be available to the MMR in order to send an alarm through network.
- 4.14.7 CDC Functional Unit Interlocks
- 4.14.7.1 There shall be a mechanical lock to prevent the opening of the enclosure door when the circuit-breaker is racked in.
- 4.14.7.2 There shall be a mechanical lock to prevent the racking-in of the circuit-breaker when the enclosure door is open.
- 4.14.7.3 There shall be a mechanical lock to prevent the racking in and out of the circuit-breaker when closed.
- 4.14.7.4 There shall be provided means to assure that the circuit-breaker shall never be left in an intermediary position when racked in or out.
- 4.14.7.5 There shall be an electrical lock to prevent the circuit-breaker from closing or remain closed between the test and operation positions.
- 4.14.7.6 There shall be provided means to avoid the circuit-breaker to be inadvertently extracted beyond the "Test" position.
- 4.14.7.7 The "Test" position shall allow local and remote test of the circuit-breaker without energize the load.
- 4.14.7.8 There shall be provided means to prevent misoperation of the interlocking devices due to the application of excessive force by the operator.
- 4.14.7.9 Refer also to interlocks with the grounding switch on item 4.14.21.
- 4.14.7.10 For other interlocks see project documentation.

4.14.8 Microprocessor-Based Multifunction Relays (MMR)

4.14.8.1 MMRs used in Panels shall comply with the requirements of I-ET-3010.00-5140-700-P4X-007 – SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS.

4.14.8.2 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.).

4.14.8.3 The MMRs shall have the function of circuit-breakers coils monitoring activated.

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

4.14.8.5 Besides the oscillography triggering events listed in I-ET-3010.00-5140-700-P4X-007 – SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS, closing of incoming, tie and outgoing circuit-breakers and main contactors of medium-voltage panels shall also trigger the oscillography.

4.14.8.6 The watchdog signal, in case of actuation, shall be sent as an alarm signal to Electrical System Automation and it shall not generate any action regarding opening, closing or blocking circuit-breakers or contactors.

4.14.9 Lockout Relays

4.14.9.1 Lockout relays shall comply with requirements of I-ET-3010.00-5140-700-P4X-007 – SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS.

4.14.9.2 To reduce failure probability, in circuits to activate the trip coils of circuit-breakers, the trip contacts of lockout relays shall be connected in parallel with trip contacts of the respective MMRs and Arc Monitoring Relays.

4.14.10 Auxiliary Contactors, Auxiliary Relays and Interposing Relays

4.14.10.1 The use of auxiliary contactors, auxiliary relays and interposing relays for contacts multiplication shall be avoided, being mainly limited to cases where the original output contact has no capacity to switch the load and for hardwired interfaces with A&C and Package Control Panels according to I-ET-3010.00-1200-800-P4X-002 - AUTOMATION, CONTROL AND INSTRUMENTATION ON PACKAGE UNITS and I-ET-3010.00-5520-888-P4X-001 - AUTOMATION PANELS.

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

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

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

4.14.11 Arc Protection



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- 4.14.11.1 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.
- 4.14.11.2 Arc Monitoring Relay shall consider optical and current signals to prevent nuisance tripping.
- 4.14.11.3 The “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 for trip the related upstream panels circuit-breakers or generators.
- 4.14.11.4 One lockout relay shall be provided to block all circuit-breakers in each busbar and tie circuit-breaker in case of arc detection in any functional unit of the respective busbar. Lockout relays related to Arc Monitoring Relays shall send a status signal to the relay associated to the circuit-breaker where current sensor is connected. For lockout relays, refer to 4.14.8.6.
- 4.14.11.5 Arc detection in MV MCCs incoming functional units shall trip and block outgoing circuit-breakers of upstream panel. For more details, refer to project documentation.
- 4.14.12 Temperature Monitoring System of Power connections
- 4.14.12.1 For MV CDCs and MCCs, manufacturer shall provide an on-line Temperature Monitoring System for predictive temperature monitoring of all busbars connections, all circuit-breaker incoming terminals and all outgoing bars for cables connection. This monitoring shall be performed in incoming, tie, busbar connection and outgoing functional units.
- 4.14.12.2 Detailed design shall supply to Panel Manufacturer a list of all points to be monitored.
- 4.14.12.3 The Temperature Monitoring System shall consist of one or more intelligent relays with integrated HMI and a set of temperature sensors (associated to each intelligent relay) properly installed and appointed to internal targets mentioned in 4.14.12.1.
- 4.14.12.4 The power supply of intelligent relays and respective associated temperature sensors shall be 220VDC. Refer to 4.22 for more details.
- 4.14.12.5 The system shall perform continuous monitoring for all monitored points.
- 4.14.12.6 Panel manufacturer shall provide and install all accessories needed for mounting the sensors inside the panels, including (but not limited to) supports, cables and terminal blocks.



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4.14.12.7 The relay shall perform accurate temperature measurement of all sensors/targets and of the environment surrounding the sensor. It shall be possible to store and display the last alarms, with date and time of occurrence (time stamp) for at least 30 days. This information may not be lost even if the relay is turned off. The relay shall have a graphical display with the functionality of "trending", indicating predictively any faults and abnormal behavior of any monitored target.

4.14.12.8 Monitoring signals shall be available in Electrical System Automation through Ethernet network connection from temperature monitoring system. For details, refer to I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE and I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.

4.14.12.9 Panel manufacturer shall provide special tools, softwares, list of spare parts and documentation of the Temperature Monitoring System.

4.14.13 Instruments' Transformers

4.14.13.1 All transformers shall be dry-type.

4.14.13.2 VTs', CTs' and auxiliary transformers' characteristics shall be defined by the Panel Manufacturer, regarding the perfect operation of devices connected to them and complying with requirements of I-ET-3010.00-5140-700-P4X-007 - SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS.

4.14.13.3 VTs and auxiliary transformers shall be protected by fuses in their primaries. Secondary circuits shall be protected by miniature circuit-breakers.

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

4.14.13.5 CTs for differential protection for all Main Generators and Hull Generators, installed in incoming cubicles, shall be bus-type, supplied by Generators' Manufacturer. Detailed Design will update information about these CTs to Panel Manufacturer.

4.14.13.6 Ground sensors CTs data of Main Generators shall comply with Main Generators protection relays installed in MGCPs (Main Generator Control Panels).

4.14.13.7 When transformer differential protection is required, a dedicated CTs for transformers differential protection shall be installed inside the panels cubicles (dedicated CTs windings can be acceptable). Detailed Design will update information about these CTs to Panel Manufacturer. See I-DE-3010.00-5143-946-P4X-001 - MEDIUM-VOLTAGE SYSTEMS PROTECTION DIAGRAM.

4.14.14 Measurement Instruments

4.14.14.1 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.

- 4.14.14.2 Ammeters and voltmeters for the other loads, when required, shall be moving-coil type.
- 4.14.14.3 Analogue instruments scales shall be such that, at full load, the indicator needle remains between 50% and 75% of the upper limit of the scale.
- 4.14.14.4 Instruments sizes, deflections, types (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 SYSTEM OF OFFSHORE UNITS.
- 4.14.14.5 Active energy meters shall have maximum demand indicator for 15 (fifteen) minutes integration time.
- 4.14.14.6 All analogue measurement instruments shall have the gauge marked in red on the rated or maximum operational position.
- 4.14.14.7 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.
- 4.14.14.8 One Power Quality Monitoring System (PQMS) shall be furnished for CDCs.
- 4.14.14.9 The PQMS shall be capable to indicate the busbar THD_v, and individual harmonics components up to 50th harmonic. The PQMS relay shall have at least one (1) Ethernet network rear output capable to communicate through network with the Electrical System Automation according to I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE and I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM for supervision and historical data recording.
- 4.14.15 CDC/MCC Signalling
- 4.14.15.1 Incoming and outgoing functional units of CDCs and outgoing functional units of MCCs shall be provided with signalling leds for indication of:
- Red (R) - circuit-breaker or main contactor closed;
 - Yellow (Y) - circuit-breaker or contactor opened by protection;
 - Yellow (Y) - Blown fuse;
 - Green (G) - circuit-breaker or contactor opened;
 - White (W) - functional unit extracted;
 - Blue (B) - functional unit tripped by emergency shut-down.
 - White (W) – circuit-breaker trip coil circuit fault (when applicable).
- 4.14.15.2 Tie functional unit of CDCs and incoming and tie functional units of MCCs shall be provided with signalling leds for indication of:
- Red (R) - circuit-breaker or main contactor closed;
 - Yellow (Y) - circuit-breaker or contactor opened by protection;
 - Green (G) - circuit-breaker or contactor opened;
 - White (W) - functional unit extracted;



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- White (W) – circuit-breaker trip coil circuit fault (when applicable).
- 4.14.15.3 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.
- 4.14.15.4 Two signalling LEDs shall be installed upstream the control voltage decoupling module to signalize control voltage available downstream the protection of each control voltage source.
- 4.14.15.5 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 switching device.
- 4.14.16 Remote Commands, Signalling and Measuring
- 4.14.16.1 The list of remote interface signals that shall be implemented for each kind of functional unit is described in the I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.
- 4.14.16.2 Remote ESD signals shall be through wet contacts (24VDC) and through auxiliary interposing relays installed in the functional unit. The interposing relay that shall convert the discrete 24Vdc input signals into voltage-free output signals.
- These (ESD) signal shall be physical and shall not pass through relays and IEDs.
- 4.14.16.3 Regarding emergency shutdown signals (ESD) for normal loads, normally open (NO) contacts shall be applied for contactors and normally closed (NC) contacts for circuit-breakers. The auxiliary contacts of the interposing relays shall actuate directly opening contactors or circuit-breakers.
- 4.14.16.4 The interposition relays shall have a status indication.
- 4.14.16.5 Additional auxiliary contacts shall be used to replicate the trip signal to the MMR.
- 4.14.16.6 Auxiliary interposing relays for Remote ESD signals shall have enough auxiliary contacts in order to, at least, actuate directly opening the circuit-breaker or main contactor, send the ESD signal to the MMR, provide signalling and to avoid closing the circuit-breaker or main contactor.
- 4.14.16.7 Remote ESD signals shall follow the Emergency Shutdown (ESD) Criteria for Electrical Loads from I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS.
- 4.14.16.8 Hardwired interface signals with A&C and Package Control Panels shall follow the interface requirements from 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.
- 4.14.17 CDC/MCC Push Buttons

- 4.14.17.1 START (turn on) push-buttons shall be with automatic return (return after push). STOP (turn off) push buttons shall be mushroom type with release (retain after push) and with possibility to lock by padlock when activated.
- 4.14.17.2 They shall be externally operated, with no necessity to open the cubicle door.
- 4.14.18 Switches and Test Block
- 4.14.18.1 The ammeter and voltmeter selector switches shall be externally installed.
- 4.14.18.2 All control switches used at the Panel shall be rotary switches.
- 4.14.18.3 Test blocks for protection relay (MMR) secondary injection testing shall be provided to allow relay testing and calibration from the front of the panel without disconnecting wiring.
- 4.14.19 Variable Speed Drives (VSDs)
- 4.14.19.1 When required in Project documentation, medium-voltage VSDs shall be used as drive device, installed in separated panels, according to I-ET-3010.00-5140-772-P4X-001 - MEDIUM-VOLTAGE FREQUENCY CONVERTER FOR OFFSHORE UNITS.
- 4.14.19.2 Detailed Design shall define in Panel Data-Sheet the requirements of communication interfaces between Panel and VSDs, complying with requirements of I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.
- 4.14.20 Soft-Starters
- 4.14.20.1 Cancelled.
- 4.14.20.2 Detailed Design shall define in Panel Data-Sheet the requirements of communication and interfaces between Panel and soft-starters, complying with requirements of I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.
- 4.14.21 Grounding Switch
- 4.14.21.1 Incoming sections of CDCs and all outgoing sections of the CDCs and MCCs shall have grounding switches.
- 4.14.21.2 MCCs incomers shall not have grounding switches. Means for temporary grounding of these cubicles shall be supplied.
- 4.14.21.3 Grounding switches shall comply with requirements of IEC 62271-102.

- 4.14.21.4 The grounding switch shall be mechanically interlocked with the position of the disconnection device, being possible to close and open it manually only when the disconnection device is extracted. Furthermore, the insertion of disconnection device shall not be allowed when the grounding switch is closed. The automatic close/open operations of grounding switch with the racking out/in of incoming circuit-breakers of CDC are not acceptable. This automatic close/open operation of grounding switches with the racking out/in of circuit-breakers for other feeders may be acceptable but only in panels supplied by the same manufacturer of the disconnection device.
- 4.14.21.5 There shall be an electrical interlock to avoid closing of grounding switch of incoming feeder of CDCs (Main Generators) in case of presence of voltage in respective generator terminals (even residual voltage, in case of turbine running and generator exciter turned off). Presence of voltage in generator terminals shall be verified through signal from MMR.
- 4.14.21.6 There shall be an electrical interlock to avoid starting Main Generator when the grounding switch of the Main Generator incoming feeder is closed. When grounding switch is closed, an interlock signal shall be sent to MGCP (Main Generator Control Panel) to avoid starting the Main Generator.
- 4.14.21.7 The grounding switch 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 the grounding switch never can be left in an intermediary position.
- 4.14.21.8 An electrical interlock shall avoid the closing of the disconnection device if the grounding switch is not totally open.
- 4.14.21.9 The short-time withstand current shall be compatible with the system characteristics.
- 4.14.21.10 Locking facilities (for example, padlocks) shall be provided to ensure the grounding switch in closed position while functional unit is extracted, securing isolating distances during maintenance work, according to IEC 62271-201 and in compliance with the NR-10.
- 4.14.21.11 There shall be warning labels near the mechanical actuator of grounding switch of incomer sections of CDC with the following warning texts:



ATENÇÃO

EXISTE A POSSIBILIDADE DE HAVER TENSÃO NOS TERMINAIS DO GERADOR COM O MESMO DESLIGADO E COM A EXCITAÇÃO DESLIGADA, BASTANDO HAVER ROTAÇÃO NO EIXO DA TURBINA.



ATENÇÃO

O ATERRAMENTO DOS TERMINAIS DO GERADOR SÓ DEVERA SER REALIZADO APÓS A VERIFICAÇÃO DA AUSÊNCIA DE TENSÃO NOS TERMINAIS DO GERADOR, DO BLOQUEIO DA EXCITAÇÃO DO GERADOR E DO BLOQUEIO DA ROTAÇÃO DO EIXO DA TURBINA.

4.14.22 Capacitors

Capacitors installed inside the Panels may be accepted only if considered as integrated to the Panel in the type tests certificates presented in the proposal.

4.14.23 Surge Protection Devices

Unless otherwise stated, protection devices against switching surges shall not be integral part of the Panel's functional units, but installed at the loads.

4.14.24 Power Transducers

4.14.24.1 Power transducers shall comply with I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS.

4.14.24.2 It shall be provided transducers for all outgoing feeders of CDCs for gas motor compressors. These transducers shall be hardwired to Package Control Panels, sending current measurements to be used for overload control.

4.14.24.3 Galvanic isolators shall be provided for all analog signals from transducers output.

4.14.24.4 Power transducers shall be fed by UPS.

4.14.25 Voltage detecting and indicating systems

- 4.14.25.1 A capacitive three-phase voltage detecting system to confirm both the presence and absence of main circuit voltage in accordance with IEC 61243-5 shall be provided. The voltage detectors on each functional unit shall be installed adjacent to the connection (cable) compartment on all incoming circuits and outgoing feeders, and on the front of the bus coupler panels for each bus section.
- 4.14.25.2 Voltage indicating/detection systems shall be installed in panel front doors and shall be fitted with measuring test points which permit connection of an external phase comparator (phasing-out) instrument.

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-007 – SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS.

4.16 Extraction Truck


- 4.16.1 Suitable devices mounted on truck shall be supplied to remove circuit-breakers and contactors for maintenance facility. A minimum of 2 extraction trucks for each circuit-breaker and contactor frame size shall be supplied.
- 4.16.2 Circuit-breakers and contactors extraction shall be executed on a safe way, being the functional unit structure dimensioned to support the circuit-breaker or contactor weight even when totally extracted.
- 4.16.3 Circuit-breakers for CDCs shall have capability for local and remote motorized extraction and insertion, complying with interlocks of item 4.14.7.
- 4.16.4 Circuit-breakers and contactors for MCCs shall have capability for local and remote motorized extraction and insertion, complying with interlocks of item 4.14.5.

4.17 Short-Circuit Peak Current Limiting Devices (Limiter)

- 4.17.1 Limiter shall be used as short-circuit current limiting device when required in PETROBRAS documentation.
- 4.17.2 Limiter shall be capable to provide fast protection against short-circuit peak currents higher than the short-circuit withstand of the Panel, limiting the fault current in the first rise (first quarter-cycle).
- 4.17.3 Limiter shall consist of a replaceable bursting element in parallel with a high rupture capacity fuse plus sensors, control and ignition devices.
- 4.17.4 The bursting element, the fuse and the current sensors shall be part of Limiter power part, which shall be installed in the Panel to be protected.
- 4.17.5 Limiter shall be installed in series with tie circuit-breaker of the Panel and with a no-load switch, in order to isolate the Limiter for maintenance. Withdrawable Limiter is acceptable as an alternative to the no load switch, since it is not possible to insert or remove the Limiter with the tie circuit-breaker closed. No-load Switch in open position shall ground the Limiter power part (grounded position).



- 4.17.6 It shall be provided signalling for Limiter Position (Extracted or Inserted, in case of withdrawable Limiter), Limiter Blocking (Limiter Enabled or Limiter Disabled) and Limiter Actuation (Actuated or Not Actuated).
- 4.17.7 When the Limiter is withdrawn, shutters shall cover all live parts of the Limiter cubicle.
- 4.17.8 The no-load switch rated capacity shall be equal to the rated capacity of the tie circuit-breaker.
- 4.17.9 There shall be interlocks in order to permit opening Limiter power part cubicle door only when the tie circuit-breaker is open and the no-load switch is at grounded position.
- 4.17.10 There shall be interlocks between the no-load switch and the tie circuit-breaker, so that:
 - It shall be possible to move no-load switch from busbar position to the grounded position only if tie circuit-breaker is open;
 - It shall not be possible to close the tie circuit-breaker with the switch at the grounded position.
- 4.17.11 The control, measuring and tripping devices shall be preferably mounted in the low-voltage compartment of the cubicle of the Limiter. If not feasible, the devices can be mounted in a low-voltage separate steel-sheet floor-mounted cabinet, to be installed as close as possible to the Limiter cubicle.
- 4.17.12 The control, measuring and tripping systems shall be electronic and shall have protection against interference signals. The control boards shall be replaceable. Arrangement of wiring without open loop and with twisted pair wires immunized against disturbance like high frequencies. Special designed electronic (filter) against EMI (embedded inside the impulse transformer).
- 4.17.13 The control cabinet shall have local indication of tripped phases, UAM (unit alarm malfunction) and failure of control voltage.
- 4.17.14 The control cabinet shall have dry type contacts for remote indication of UAM and summary of trip.
- 4.17.15 The electronic circuitry of the Limiter shall be capable to analyze the instantaneous current magnitude (i) and the rate of current rise (di/dt) at the first rise, in order to decide when to send a triggering signal.
- 4.17.16 After the confirmation of actuation of the Limiter, its control shall send a trip signal to the tie circuit-breaker, in order to avoid unbalanced connection between the busbars.
- 4.17.17 After the confirmation of actuation of the Limiter, its control shall send a triggering signal to the MMR of tie functional unit in order to initiate an oscillography of currents and voltages in this event.
- 4.17.18 Along with the Limiter it shall also be supplied three (3) spare inserts, one (1) test equipment and three (3) test inserts.
- 4.17.19 It shall be possible to test the control, measuring and tripping systems.

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INTERNAL			
ESUP			
<p>4.17.20 Limiter control system shall be capable to receive two auxiliary supplies. The main auxiliary supply for Limiter operation shall be provided by voltage transformers (included in Limiter devices) connected to the main circuit to be protected. An external stand-by auxiliary supply shall be provided in 220VDC, provided from Unit's battery-chargers.</p> <p>4.17.21 Tests in Limiter shall be performed by Limiter Manufacturer. The manufacturer shall perform a Limiter block test during commissioning. If there is improper performance of the inserts during commissioning, the manufacturer shall replace the damaged inserts at no cost to PETROBRAS.</p> <p>4.17.22 All certificates and tests reports required for the panel shall include the column where the Limiter is installed.</p> <p>4.17.23 Limiter control system shall include one discrete input for external inhibition of its actuation.</p> <p>4.17.24 Limiter control system shall be capable of communicating in Ethernet Network according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM.</p> <p>4.17.25 Interface signals to be exchanged shall follow at least the signals listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.</p> <p>4.17.26 The manufacturer shall provide procedures and devices for the mechanical blocking of the Limiter during the commissioning phase.</p> <p>4.18 Nameplates and Markings</p> <p>4.18.1 The Panels' nameplates shall be in accordance with IEC 62271-1 and made with AISI-316L stainless steel.</p> <p>4.18.2 The Panel shall be outfitted with plate of supplemental identification containing, at least, the following data:</p> <ol style="list-style-type: none"> a) PETRÓLEO BRASILEIRO S.A. - PETROBRAS; b) name of the department of 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 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.). <p>4.18.3 MCCs nameplates shall include the TAG of the transformer and the number of the column (vertical section) of the CDC that feeds the MCC.</p> <p>4.18.4 Back doors shall have identification plates identical to the plates identifying the front sections.</p> <p>4.18.5 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-SN.</p>			

4.18.6 Functional Units Markings

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

4.18.6.2 For functional unit 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 load nominal current and circuit number;
- d) at fourth line, the electrical functional unit classification according control mode, according to I-ET-3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFHORE UNITS;
- e) at fifth line, the IP address of the functional unit.

4.18.6.3 At spare cubicles, the plates shall be supplied with the word “Reserva” engraved for sub-items a) and b), maximum continuous current allowed of the functional unit to sub-item c), the functional unit classification of the spare functional unit for sub-item d) and the IP address of the spare functional unit for sub-item e) of the previous item.

4.18.6.4 No adhesives shall be used to fix the plates.

4.18.7 Components Markings - Labels

4.18.7.1 Internally to Panels all equipment and components shall be identified with black acrylic labels, with white letters, containing the codification compatible with design documents (list of materials, diagram, etc.). Alternative methods of equipment and component identifications shall be sent to PETROBRAS approval.

4.18.7.2 The circuit-breakers labels shall include rated current and trip current set.

4.18.7.3 No adhesives shall be used to fix the labels.

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



PERIGO



RISCO DE ARCO ELÉTRICO
E CHOQUE
UTILIZE O EPI RECOMENDADO

NÍVEL DE PROTEÇÃO DO EPI: _____
 TENSÃO NOMINAL DO PAINEL: _____V
 DISTÂNCIA SEGURA DE APROXIMAÇÃO PARA ATIVIDADES
 SUJEITAS A ARCO ELÉTRICO: _____cm
 ENERGIA INCIDENTE: _____cal/cm²

- 4.18.9 It shall be provided a specific plate with warnings and instructions for access the Limiters' compartment.
- 4.18.10 Cancelled.
- 4.18.11 Panels shall have warning labels indicating that any technical intervention in the panels shall be executed only for authorized people.
- 4.18.12 Panels shall have labels with brief description of the interlocks and allowed/forbidden momentary parallelisms in Portuguese language. For the allowed momentary parallelism, there shall be an additional label with details of the synchronization and load transfer operation. The label shall also include the document number which details the interlocks and momentary parallelisms.
- 4.18.13 Panels shall have labels with information about the control voltage supply characteristics in Portuguese language, including information about control voltage earthing and expected autonomy of the Unit's Battery Chargers.
- 4.18.14 Each functional unit shall have a label indicating the maximum continuous current capacity of the functional unit, protection functions parameterized and the related relay parameterization report.
- 4.18.15 Limiter cubicle shall have a label indicating clearly the blocking criteria implemented for the Limiter operation.
- 4.18.16 Functional Units with Grounding Switch shall have a label indicating clearly the interlock and inhibition of circuit-breaker closing.
- 4.18.17 Incomers Functional Units shall have a label indicating the TAG of the feeder panel.

4.19 Painting

- 4.19.1 All electrical materials, equipment and supports shall be painted. Painting process shall be proper for offshore installations and shall comply with the requirements of I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING.
- 4.19.2 The last coat colour shall be Light Green Munsell notation 5G8/4. Inner components mounting plates, internal faces of doors and safety barriers shall be Safety Orange Munsell 2.5YR6/14.

4.20 Protection

- 4.20.1 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.
- 4.20.2 Panels shall have one key activated selector switch in their front side with the positions “Operação / Manutenção” (Operation / Maintenance). When this selector switch is in “Manutenção” position, the instantaneous overcurrent function (50) of incoming and tie MMRs shall be activated, overriding protection coordination and minimizing damage in case of internal fault.
- 4.20.3 There shall be a local signalling lamp, turned on with the switch in “Manutenção” position, indicating “Coordenação Desativada”.
- 4.20.4 There shall be a remote signalling of the position of the switch in Electrical System Automation Operational Workstation.
- 4.20.5 It shall be possible to close the functional units circuit-breakers or contactors listed in this item bypassing all necessary interlocks and protections (such as ESD and protection function 27) in a dead-ship scenario. The interlocks shall be overridden by a "OVERRIDE PROTECTIONS" switch installed in the front external part of each CDC or MCC Functional Unit. There shall be a label in this control switch with the following text “Atenção! Na posição "OVERRIDE" o sinal externo de ESD e várias proteções são desativadas. Usar apenas em cenário de dead-ship”. The following Functional Units shall have this switch:
- MCC outgoings to transformers that feeds Auxiliary and Essential low voltage CDCs;
- 4.20.6 For the cases described in 4.20.2, there shall be a label beside the switch with following warning text:



ATENÇÃO

SELECIONE "MANUTENÇÃO" APENAS QUANDO HOVER INTERVENÇÃO NO PAINEL. NESSA POSIÇÃO, A COORDENAÇÃO SERÁ DESATIVADA, REDUZINDO RISCO AO INTERVENTOR, MAS AUMENTANDO O RISCO DE DESLIGAMENTO INDEVIDO.

4.20.7 For the cases described in 4.20.5, there shall be a label beside the switch with following warning text:



ATENÇÃO

NA POSIÇÃO "OVERRIDE" O SINAL DE ESD E VÁRIAS PROTEÇÕES SÃO DESATIVADAS. USAR APENAS EM CENÁRIO DE DEAD-SHIP COM AVALIAÇÃO DOS RISCOS.

4.21 Electromagnetic Compatibility (EMC)

- 4.21.1 The Panels and all their components shall comply with the emission and immunity requirements for electromagnetic compatibility stated in IEC 60533, presenting performance criterion A.
- 4.21.2 Regarding induced disturbances, all electronic equipment shall comply with IEC 61000-4-6 class 3.
- 4.21.3 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.
- 4.21.4 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.
- 4.21.5 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.
- 4.21.6 Regarding electromagnetic disturbances, all electronic equipment shall comply with IEC 61000-4-3 class 3.

- 4.21.7 Regarding damped oscillatory magnetic, all electronic equipment shall comply with IEC 61000-4-10 level 5.
- 4.21.8 Regarding power frequency magnetic field, all electronic equipment shall comply with IEC 61000-4-8 level 5 for continuous and short duration fields.
- 4.21.9 All electronic equipment shall operate correctly in the presence of a power frequency voltage in accordance with table 1 of IEC 61850-3

4.22 Control Voltages

- 4.22.1 The control voltage for each Panel shall be in 220VDC achieved from Unit's redundant battery-chargers.
- 4.22.2 The Panels shall have two control sources for each busbar.
- 4.22.3 Each control busbar shall be fed by both control voltage sources (redundant battery chargers) continuously in parallel.
- 4.22.4 Decoupling modules, including blocking diodes, shall be foreseen to each control voltage source in order to avoid back feeding control voltage sources. These decoupling modules shall monitor continuously the decoupling path. Failure in any component of the decoupling module shall generate a network signal to Electrical System Automation by Incomers MMRs.
- 4.22.5 Control incoming circuits from the external power supply shall have surge protective devices (SPD) with a maximum discharge current of 10 kA in 8/20 microseconds, as required by NFPA 780.
- 4.22.6 Each control busbar incoming shall be protected by miniature circuit-breakers. The control busbars shall be connected by miniature circuit-breakers.
- 4.22.7 Switchgear manufacturer shall carry out the sizing of distribution panel output circuit breakers considering the load rated power, the maximum in-rush of the load and that the circuit breakers be maximized.
- 4.22.8 Undervoltage at any 220VDC control voltage sources at the panel shall generate a remote network alarm signal (control voltage source failure) to Electrical System Automation by Incomers MMRs. Each Incomer MMR shall detect control voltage source failure from both control voltage sources redundantly.
- 4.22.9 Additional undervoltage relays, one for each control voltage busbar of CDCs or MCCs, shall be included to provide hardwired control busbar undervoltage signals directly to CSS.
- 4.22.10 Functional Units shall not be tripped for lack of control voltage in MMRs
- 4.22.11 Outgoing Functional Units for motors and for transformers with protective devices supplied together with the equipment as, for example, transformer over temperature protection, shall supply 220VDC to the protective device by using a dedicated circuit breaker installed in the functional unit.

4.22.12 MCCs connected to Hull Generators shall have a third option for control voltage supply, by means of transformer, an auxiliary rectifier with incoming rated voltage in 220VAC and outgoing rated voltage in 220VDC, connected to the terminals of incoming feeders of the Hull Generators. The auxiliary rectifiers shall be installed in the MCC (one per generator, included in MCC Manufacturer scope of supply) and shall have the proper capacity to supply control loads of the MCC. In these cases, there shall be a switch in order to select the control voltage source from each Hull Generator (3 positions switch) or from the main control voltage sources (Unit's redundant battery chargers).

4.23 Auxiliary Voltages

4.23.1 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.

4.23.2 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**

4.23.3 The power supply for internal lighting and socket outlets shall be achieved from 220VAC three phase external source. The circuits for internal lighting and socket outlets shall be two phases and shall be balanced among three phases internally.

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

4.23.5 Internal lighting shall be turned on by the door opening detection devices. Internal lighting shall be installed at least in the following compartments:

- Control cubicle;
- Cable compartments;
- Other compartments where PETROBRAS understands that lighting is poor.

4.23.6 Manufacturer shall install at least 2 (two) socket-outlets inside the panel that shall comply with standardization defined by ABNT NBR 14136, and, where applicable IEC 60309.

4.24 Interface with Automation

4.24.1 Panel shall have internal communication networks among IEDs connecting these devices to the Electrical System Automation and to A&C (through Electrical System Automation) for remote control, supervision and monitoring.


4.24.2 Cancelled.

- 4.24.3 Panel Manufacturer shall propose the internal network architecture in order to comply with requirements of I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE and I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM. This internal network architecture and configuration shall be submitted to PETROBRAS approval.
- 4.24.4 Minimum Interface Signals to be exchanged are listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.
- 4.24.5 Switches internal to the panel shall be manageable.
- 4.24.6 The panel shall have its internal clock synchronized with Electrical System Automation Time Server through the time protocol according to I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE.
- 4.24.7 All devices with logging or communication capabilities internal to the panel shall have its internal clock synchronized with Electrical System Automation. Bidder is responsible to provide means of synchronization among internal components which are not connected to Electrical System Automation networks. All other internal devices connected to Electrical System Automation networks shall be synchronized with the Electrical System Automation Time Server through the time protocol according to I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE.
- 4.24.8 All events and alarms shall be logged in the equipment with the time stamp synchronized with the internal clock, which shall be synchronized with the Electrical System Automation Time Server.

5. MANUFACTURER DOCUMENTATION

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

- a) Documents list;
- b) Dimensional drawings including frontal view, upper view, 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 price 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 10, 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 and certificate for testing under conditions of arcing due to internal fault;

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<p> k) Dimensional drawing for connections to bus trunking, when applicable; l) Time-current curves, current peak limiting curves and i^2t minimum and total values of the limiting fuses; m) One-line electrical drawings; n) Other documents required in project documentation. </p> <p> 5.2 The following documents shall be provided by Panel Manufacturer, for approval: </p> <ol style="list-style-type: none"> Documents list; Dimensional drawings including frontal and upper views, details, location of lifting eyelets and area for incoming cables, fixing base details; Weight and volume of each unit for transportation; Total weight; 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; Dimensional drawing for connections to bus trunking, when applicable; Electrical drawings, including one line, three lines, functional and logical diagrams; Connection diagrams, including all terminal blocks; Electrical Functional Units Classification List according to control mode; Saturation curves of current transformers; Components and material list per functional unit; Time-current curves, current peak limiting curves and i^2t minimum and total values of the limiting fuses; Package and transportation instructions; Warranty certificate and declaration of availability of spare parts for 10 (ten) years; Certificate of compatibility between racking devices and circuit-breakers, if applicable; Extraction and insertion instructions; Network architecture internal to the Panel; Network configuration, parameterization, screens, and monitoring documentation for all equipment that will be connected by network; Memory map; Communication List, including IP list and I/O for each Functional Unit; Expected MTTR for each type of functional unit and for each component, Relays parameterization report. <p> 5.3 The following documents shall be provided by Panel Manufacturer, with the Panel: </p> <ol style="list-style-type: none"> Data-sheet full-filled “as built”; Storage, lifting and unpacking instructions in Portuguese language; Installation and assembly instructions in Portuguese language; Operation instructions in Portuguese language, including the description and reason of all interlocks; Maintenance instructions, including list of necessary equipment, accessories and tools in Portuguese language; 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, parameterization and monitoring software for switches, concentrators, IEDs, MMRs, 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 software in Portuguese language;
- k) Components list, including at least, item, description, draw, unit, quantity and part number;
- l) Certificate of compatibility between racking devices and circuit-breakers, if applicable.
- m) Constructive details about baseplate fixation screws such as quantity, size, type and position in baseplate.

5.4 Documents provided by Panel Manufacturer shall be delivered in an electronic format (original version and PDF version), the original documents shall be editable and the PDF documents shall be searchable.

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 Type Tests

- 7.2.1 Type tests shall follow the requirements of IEC 62271-200, IEC 60533. They are summarized in Table 3, where they are identified as T.
- 7.2.2 Certified test reports for type tests performed for identical Panels and approved and witnessed by Classification Society are accepted.

7.3 Routine Tests


- 7.3.1 **Routine** tests shall follow the requirements of IEC 62271-200. They are summarized in Table 3, 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 for all Panels, according to Table 3, where they are identified as S.

Table 3 – Routine and Type Tests

Test	T	R	S	Method and Acceptance Criteria
Verification of technical documentation ⁽¹⁾	x	x	x	
Verification of certificate of accuracy for measurement instruments to be used in tests ⁽¹⁾	x	x	x	
Verification of dimensions		x		Panel Data-Sheet
Verification of data on nameplates and labels and visual inspection		x		IEC 62271-200 and this ET
Verification of painting (colour, thickness and adhesion)		x		I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING and this ET
Verification of measuring instruments		x		Project documents
Verification of signalling devices		x		Project documents
Verification of operation of heating resistors		x		This ET and Data Sheet
Test of interchangeability of withdrawable parts		x		This ET
Dielectric tests (Power-frequency voltage test)	x			IEC 62271-200
Dielectric tests (Lightning impulse voltage test)	x			IEC 62271-200
Dielectric tests (Artificial pollution test) ⁽²⁾	x			IEC 62271-200
Dielectric tests (Dielectric tests on auxiliary and control circuits)	x			IEC 62271-200
Dielectric tests (Voltage test as condition check)	x			IEC 62271-200
Dielectric tests (Dielectric tests on cable testing circuits)	x			IEC 62271-200
Measurement of the resistance of circuits (Main circuits)	x			IEC 62271-200
Measurement of the resistance of circuits (Auxiliary circuits)	x			IEC 62271-200
Temperature rise tests	x			IEC 62271-200
Short-time withstand current and peak withstand current tests	x			IEC 62271-200
Verification of the protection degree (verification of IP coding)	x			IEC 62271-200
Tightness tests ⁽³⁾	x			IEC 62271-200
Electromagnetic compatibility tests (EMC)	x			IEC 62271-200
Additional tests on auxiliary and control circuits (functional tests)	x			IEC 62271-200
Additional tests on auxiliary and control circuits (electric continuity of earthed metallic parts)	x			IEC 62271-200

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Test	T	R	S	Method and Acceptance Criteria
Additional tests on auxiliary and control circuits (verification of the operational characteristics of auxiliary contacts)	x			IEC 62271-200
Additional tests on auxiliary and control circuits (environmental tests)	x			IEC 62271-200
Additional tests on auxiliary and control circuits (dielectric tests)	x			IEC 62271-200
Verification of making and breaking capacities	x			IEC 62271-200
Mechanical operation tests (switching devices and removable parts)	x			IEC 62271-200
Mechanical operation tests (interlocks)		x		IEC 62271-200
Pressure withstand test for gas-filled compartments (pressure withstand test for gas-filled compartments with pressure relief devices) ⁽³⁾	x			IEC 62271-200
Pressure withstand test for gas-filled compartments (pressure withstand test for gas-filled compartments without pressure relief devices) ⁽³⁾	x			IEC 62271-200
Tests on non-metallic partitions and shutters (dielectric tests)	x			IEC 62271-200
Tests on non-metallic partitions and shutters (measurement of leakage currents)	x			IEC 62271-200
Weatherproofing test ⁽²⁾	x			IEC 62271-200
Internal arcing test	x			IEC 62271-200
Dielectric test on the main circuit		x		IEC 62271-200
Tests on auxiliary and control circuits (inspection of auxiliary and control circuits, and verification of conformity to the circuit diagrams and wiring diagrams)		x		IEC 62271-200
Tests on auxiliary and control circuits (functional tests) ⁽⁷⁾		x		IEC 62271-200 and IEC 61850
Tests on auxiliary and control circuits (verification of protection against electrical shock)		x		IEC 62271-200
Measurement of the resistance of the main circuit		x		IEC 62271-200
Tightness tests ⁽³⁾		x		IEC 62271-200
Design and visual checks		x		IEC 62271-200
Partial discharge measurement		x		IEC 62271-200
Mechanical operation tests		x		IEC 62271-200
Pressure tests of gas-filled compartments ⁽³⁾		x		IEC 62271-200
Tests of auxiliary electrical, pneumatic and hydraulic devices		x		IEC 62271-200
Tests after erection on site		x		IEC 62271-200
Measurement of fluid condition after filling on site ⁽³⁾		x		IEC 62271-200
EMC – Conducted emission test ⁽⁴⁾	x			IEC 60533
EMC – Radiated emission test ⁽⁴⁾	x			IEC 60533
EMC – Conducted low frequency interference ⁽⁴⁾	x			IEC 60533
EMC – Power supply variation ⁽⁴⁾	x			IEC 60533
EMC – Power supply failure ⁽⁴⁾	x			IEC 60533
EMC – Surge voltage test ⁽⁴⁾	x			IEC 60533
EMC – Electrical fast transient test ⁽⁴⁾	x			IEC 60533
EMC – Electromagnetic field test ⁽⁴⁾	x			IEC 60533
EMC – Electrostatic discharges (ESD) ⁽⁴⁾	x			IEC 60533
EMC – Conducted radio frequency interference test ⁽⁴⁾	x			IEC 60533
Verification of relays calibration and operation ⁽⁸⁾			x	Selectivity study and IEC 61850
Notes: 1 For all witnessed tests; 2 Only for panel installed in external areas or in rooms without HVAC filtering; 3 Only for pressurized panels;				



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- 4 EMC tests shall be carried out when required in IEC 60533 for the equipment installed in the Panel;
- 5 Manufacturer presence can be requested by PETROBRAS, if considered necessary, for the tests to be carried out at site;
- 6 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 the factory delivered it or to verify if the Panel is ready to start operation;
- 7 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;
- 8 These tests shall include check of A/D converters of relays. These tests shall use calibration boxes certified for IEC 61850.

8. TRAINING

- 8.1 Manufacturer shall provide training for at least 10 (ten) PETROBRAS personnel, about Panel 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 switching devices, use of tools and accessories, interface with automation, use of softwares, configuration, parameterization and adjustment of MMR and 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.
- 9.4 Manufacturer shall guarantee the supply of the same or compatible network components (MMRs, concentrators, switches, etc.), from the point of view of functionality, mounting and wiring, during platform lifetime.

10. DATA SHEETS FORMS

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

11. ABBREVIATIONS AND ACRONYMS

A&C	Automation and Control System
AFD	Arc Flash Detector
AISI	American Iron and Steel Institute
ASTM	American Society for Test and Material
CDC	Switchgear

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CT	Current Transformer		
DPC	Diretoria de Portos e Costas		
EMC	Electromagnetic Compatibility		
EPR	Ethylene Propylene Rubber		
ESD	Emergency Shut-Down		
ET	Technical Specification		
FPSO	Floating, Production, Storage and Offloading Unit		
FSO	Floating, Storage and Offloading Unit		
HMI	Human Machine Interface		
I/O	Input/Output		
IEC	International Electrotechnical Commission		
IED	Intelligent Electronic Device (as defined in IEC 61850)		
IEEE	Institute of Electrical and Electronics Engineers		
INMETRO	Instituto Nacional de Metrologia Normalização e Qualidade Industrial		
I_k	Rated Short-Time Withstand Current of a Panel, according to IEC 62271-1		
i_p	Peak Short-Circuit Current of a System, according to IEC 60909		
I_p	Rated Peak Withstand Current of a Panel, according to IEC 62271-1		
I_{th}	Thermal Equivalent Short-Circuit Current of a System, according to IEC 60909		
L.V.	Low-Voltage		
M.V.	Medium-Voltage		
MCC	Motor Control Center		
MMR	Microprocessor Based Multifunction Relay		
MTBF	Mean Time Between Failure		
MTTR	Mean Time to Repair		
NEMA	National Electrical Manufacturers Association		
PLC	Programmable Logic Controller		
PQMS	Power Quality Monitoring System		
PVC	Polyvinyl Chloride		
r.m.s	Root Mean Square		
RM	Material Requisition		
R	Routine Test		
RRRV	Rate of Rise of Recovery Voltage		
SS	Semi-Submersible Floating Platform		
S	Special Test		
THD	Total Harmonic Distortion		
t_k	Rated Duration of Short-Circuit of a Panel, according to IEC 62271-1		
T	Type Test		
TRV	Transient Recovery Voltage		
UFD	Utility Flow Diagram		
UPS	Uninterruptible Power Supply		
UVT	Undervoltage Trip Coil		
VSD	Variable Speed Drive		
VT	Voltage Transformer		
XLPE	Crosslinked Polyethylene		



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