	TECHNICAL SPECIFICATION		No. I-ET-3010.00-5140-700-P4X-007
	CLIENT:		SHEET: 1 of 19
	JOB:		--
	AREA:		
TITLE:		SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS	INTERNAL
			ESUP

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INTERNAL
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1 OBJECTIVE

- 1.1 This specification establishes the necessary technical requirements for design, manufacture and supply generic electrical equipment and components for all facilities of PETROBRAS Offshore Units, including installations in modules and packages.
- 1.2 Specific requirements stated for equipment in other specific Technical Specifications issued by PETROBRAS are mandatory and shall prevail over this Technical Specification.
- 1.3 Classification Society requirements shall prevail over requirements of this document.

2 REFERENCE STANDARDS AND DOCUMENT LIST


2.1 GENERAL

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

2.2 CODES, STANDARDS AND RECOMMENDED PRACTICES

2.2.1 IEC – INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC 60068-2-14	Environmental Testing - Part 2-14: Tests - Test N: Change of Temperature
IEC 60071-2	Insulation co-ordination - Part 2: Application guide
IEC 60076-6	Power Transformers - Reactors
IEC 60092	Electrical Installations in Ships - All Parts for FPSO and FSO or when required
IEC 60099	Surge Arresters - All parts
IEC 60137	Insulated bushings for alternating voltages above 1000 V.
IEC 60255	Measuring relays and protection equipment – All Parts
IEC 60270	High-Voltage Test Techniques - Partial Discharge Measurement
IEC 60445	Basic and Safety Principles for Man-Machine Interface, Marking and Identification - Identification of Equipment Terminals, Conductor Terminations and Conductors
IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)
IEC 60831	Shunt Power Capacitors of the Self-Healing Type for A.C. Systems Having a Rated Voltage up to and Including 1000V - All Parts
IEC 60865-1	Short-circuit currents – Calculation of effects – Part 1: Definitions and calculation methods
IEC 60871	Shunt Capacitors for A.C. Power Systems Having a Rated Voltage above 1000V - All Parts
IEC 60931	Shunt Power Capacitors of the Non-Self-Healing Type for A.C. Systems Having a Rated Voltage up to and Including 1000V - All parts
IEC 61439	Low-Voltage Switchgear and Controlgear Assemblies - All Parts
IEC 61643	Low-Voltage Surge Protective Devices - All parts

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IEC 61800-4	Adjustable speed electrical power drive systems - General requirements – Rating specifications for a.c. power drive systems above 1000 V a.c. and not exceeding 35 kV		
IEC 61850	Communication Networks and Systems in Substation – All parts		
IEC 61869	Instrument transformers – All Parts		
IEC 61892	Mobile and Fixed Offshore Units - Electrical Installations - All parts		
IEC 61921	Power capacitors – Low-voltage power factor correction banks		
IEC 62041	Transformers, power supplies, reactors and similar products – EMC requirements		
IEC 62271-1	High-Voltage switchgear and controlgear Part 1: Common Specifications		
IEC 62271-200	High-Voltage switchgear and controlgear Part 200: A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV		
IEC 62305	Protection against lightning - All parts		
IEC 62439-3	Industrial communication networks – High availability automation networks – Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)		
<p>Note: When all parts are informed, all applicable parts shall be used as reference. If a specific part is mentioned in text, it will be listed following the general code reference.</p>			
2.2.2 IEEE – INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERING			
C37.23	Standard for Metal-Enclosed Bus		
C57.32	IEEE Standard for Requirements, Terminology, and Test Procedures for Neutral Grounding Devices		
C57.32a	IEEE Standard for Requirements, Terminology, and Test Procedure for Neutral Grounding Devices Amendment 1: Neutral Grounding Resistors Clause (AM)		
2.2.3 LABOUR SECRETARY - MINISTRY OF ECONOMY - REGULATORY STANDARDS FOR OCCUPATIONAL SAFETY AND HEALTH			
NR-12	Segurança no Trabalho em Máquinas e Equipamentos		
2.2.4 NATIONAL FIRE PROTECTION ASSOCIATION			
NFPA 70	National Electrical Code		
NFPA 780	Standard for the Installation of Lightning Protection Systems		



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2.3 REFERENCE 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-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS
- [3] I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS
- [4] I-ET-3010.00-5140-741-P4X-002 - MEDIUM-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS
- [5] I-ET-3010.00-5140-741-P4X-004 - SPECIFICATION FOR LOW-VOLTAGE **GENERIC ELECTRICAL** PANELS FOR OFFSHORE UNITS
- [6] I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE
- [7] I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST
- [8] I-LI-3010.00-5140-700-P4X-001 - **ELECTRICAL EQUIPMENT** DATA SHEET MODELS
- [9] I-ET-3010.00-5143-700-P4X-001 - ELECTRICAL SYSTEM PROTECTION CRITERIA

3 GENERIC ELECTRICAL EQUIPMENT

3.1 AUXILIARY RELAYS

Contactors and auxiliary relays shall be adequate to work without economy resistance.

3.2 BUSBAR TRUNKINGS (BUSWAYS)

3.2.1 GENERAL REQUIREMENTS

3.2.1.1 Manufacturer shall provide lists of tools and accessories necessary for maintenance and installation and list of recommended spare parts.

3.2.1.2 Components requiring periodic replacement shall be listed in the spare parts list with the recommended replacement frequency.

3.2.1.3 Manufacturer shall provide complete manuals and documentation.

a) MTTR shall be informed.

b) For equipment manual requirements, see item 4.

3.2.1.4 Manufacturer shall provide the necessary spare parts for the commissioning and pre operation periods.

3.2.2 CONSTRUCTIVE CHARACTERISTICS

3.2.2.1 Low-voltage busbar trunkings shall be designed manufactured and rated complying with the requirements of IEC 61439-6.

3.2.2.2 Medium-voltage busbar trunkings shall be metal enclosed type and shall be designed, manufactured, and rated complying with IEEE C37.23.

3.2.2.3 Busbar trunkings protection degree shall comply with requirements of I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

3.2.2.4 Busbar trunkings and their mounting brackets shall be designed to operate on structures subjected to vibrations and movements.

3.2.2.5 Busbar trunkings shall have enclosure made of non-magnetic material, to avoid losses by Foucault's current. Enclosures of aluminium sheets may be accepted for indoor installations. For outdoor installations, the enclosures shall be of stainless steel AISI-316L.

3.2.2.6 The ends shall be flanged to allow perfect connections with panels and transformers, which shall be interconnected.

3.2.2.7 The Manufacturer shall adapt the busbar trunking flange with switchgear and transformer raise edge, to avoid electrolytic corrosion.

3.2.2.8 All electrical connections shall be made with suitable connectors/joints, not being permitted connections by means of weld. Connectors or joints shall be expansion type and flexible connections shall be provided for both ends.

3.2.2.9 All connections shall use bolts, nuts and Belleville spring washers made of AISI-316L stainless steel or galvanized steel.

3.2.2.10 The external last coat of enclosure shall comply with I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

- 3.2.2.11 The internal last coat of enclosure shall be painted in black for better dissipation of heat.
- 3.2.2.12 The amount of heat to be dissipated under normal conditions and under the maximum operation condition, with environmental temperature of 45°C, shall be informed.
- 3.2.2.13 Seals against fire and gas propagation, equivalent to A-0 type bulkhead, shall be provided inside the busbar trunking, where they cross A-0 bulkheads.
- 3.2.2.14 Certificate Reports of seals, issued by reliable laboratory, shall be presented for PETROBRAS approval.
- 3.2.2.15 The enclosure shall be provided with barriers to prevent the propagation of flame and smoke between the connected equipment.
- 3.2.2.16 Busbar trunkings interconnecting rooms with different temperatures, like transformers room and panel's room, shall have sealing means or baffles to prevent interchange of air between rooms.
- 3.2.2.17 When a busbar trunking cross through a bulkhead to a different area, a test or a certificate shall be provided to PETROBRAS as a warranty of the maintenance of the bulkhead insulation properties against gases and fire propagation.
- 3.2.2.18 The sections of the busbar trunking shall be provided with heating resistors (one for each section or compartment), in 220VAC. The resistors shall be automatically controlled by means of a thermostat with scale up to 60°C maximum. A circuit-breaker shall be provided on each resistor circuit.
- 3.2.2.19 Space heaters shall be protected against accidental contacts. The wiring next to them (about 300 mm) shall have proper insulation to avoid damages due to overtemperature.

3.2.3 ELECTRICAL CHARACTERISTICS

- 3.2.3.1 For medium-voltage busbar trunkings, the minimum short-duration power-frequency withstand voltage (U_d) and the minimum lightning impulse withstand voltage (U_p) shall comply with the requirements of Table 1, as defined in IEC 62271-1, and shall be equal to or greater than the respective values of the panel to which the busbar trunking will be connected.

Table 1 - Busbar Trunking Electrical Requirements

System Rated Voltage [kV]	Busbar Trunking 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	4.76	19	21	60	66
6.6	8.25	36	40	95	105
13.8	15	36	40	95	105

- 3.2.3.2 For low-voltage busbar trunkings, the rated voltage (U_n), the rated operational voltage (U_e), the rated insulation voltage (U_i) and the rated impulse withstand voltage (U_{imp}) shall comply with IEC 61439-6, considering overvoltage category III and possibility of operation with isolated neutral.

3.2.3.3 Optical arc monitors shall be installed inside the busbar trunkings, to disconnect them instantaneously in case of internal fault. The number of sensors shall be defined so that the whole length is protected.

3.2.4 BUSBARS

3.2.4.1 Busbars shall be three-phase and made of electrolytic copper in A.C. systems, identified with coloured strips as follows:

- a) Phase: red, white and black (R – S – T, respectively);
- b) Ground: bi-colour combination green-and-yellow according to IEC 60445.

3.2.4.2 Busbars shall be sized to conduct the rated current related to the rated power under steady state condition, with the temperature rise limited to the values specified on standards.

3.2.4.3 Busbar shall be dimensioned to support the mechanical and thermal stresses due to short-circuit currents. The space between supports shall not exceed the insulators minimum rupture load guaranteed by the respective manufacturers.

3.2.4.4 If parallel bars are used for a same phase, shims shall be used, suitably spaced along these bars' longitudinal axis.

3.2.4.5 Bars at junction points shall be silver-coated according to ASTM B700 with minimum thickness of 2.5µm and placed in such manner to guarantee a perfect alignment and high-pressure contact.

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

3.2.4.6 Busbar shall have a fluidized bed, high dielectric epoxy insulation that is flame retardant, track resistant, non-hygroscopic and resistant to degradation due to aggressive saline, damp, and hot marine atmosphere. Celeron and Fiberglass shall not be accepted.

3.2.4.7 The joints shall be covered by insulation plates, fixed to the bar, and filled in with insulation putty to guarantee a homogeneous insulation.

3.2.4.8 Calculation reports of busbars and isolators sizing, complying with requirements of IEC 60865-1 and IEEE C37.23 shall be presented for PETROBRAS approval.

3.2.4.9 The short-circuit withstand currents of the busbar trunking shall be equal to or greater than the respective short-circuit withstand currents of the panel to which the busbar trunking will be connected.

3.2.4.10 Low-voltage busbars shall comply with requirements of IEC 61439-2.

3.2.5 GROUNDING

3.2.5.1 Busbar trunkings shall be assembled in order to maintain electrical continuity (ground) between equipment connected to their ends.

3.2.5.2 All sections of the busbar trunkings shall be grounded. For assure the electrical continuity between the enclosures, two cable jumpers shall be installed at opposite sides over each flanged coupling. The construction shall permit the return of ground fault currents through the enclosure.

3.2.5.3 Two non-welded type connectors, one at each end, suitable for connection to stranded copper cables with cross-sectional area according to I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS, shall be

supplied.

3.2.6 TESTS

3.2.6.1 At least the tests listed below shall be carried out for busbar trunkings.

Table 2 – Minimum Reference Tests for Low-Voltage Busbar Trunkings

Test	TT	RT	Method and Acceptance Criteria
Examination of technical documentation		X	
Verification of certificate of accuracy for measurement instruments to be used in tests		X	
Dimensional verification		X	
Visual inspection and verification of data on nameplates		X	
Painting (colour, thickness, and adhesion)		X	See reference 3.2.2.10
Verification of temperature rise limits	X		IEC 61439-6
Verification of dielectric properties		X	IEC 61439-1
Verification of short-circuit strength calculation report		X	IEC 60865-1 and IEEE C37.23
Verification of short-circuit withstand strength ⁽¹⁾	X		IEC 61439-6
Verification of clearance and creepage distances ⁽²⁾	X		IEC 61439-6
Verification of degree of protection of enclosure (IP)	X		IEC 60529
Check of operation of optical monitor devices		X	
Verification of heating resistors operation		X	I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS
Verification of operation of overpressure relief devices	X		

Notes: 1) The expansion connection joints shall be connected during test.
2) Unless otherwise specified, consider pollution degree 1.

Table 3 – Minimum Reference Tests for Medium-Voltage Busbar Trunkings

Test	TT	RT	Method and Acceptance Criteria
Examination of technical documentation		X	
Verification of certificate of accuracy for measurement instruments to be used in tests		X	
Dimensional verification		X	
Visual inspection and verification of data on nameplates		X	
Painting (colour, thickness, and adhesion)		X	See reference 3.2.2.10
Verification of temperature rise limits	X		IEC 62271-200
Verification of dielectric properties		X	IEC 62271-1
Verification of short-circuit strength calculation report		X	IEC 60865-1 and IEEE C37.23
Verification of short-circuit withstand strength ⁽¹⁾	X		IEC 62271-200
Verification of clearance and creepage distances ⁽²⁾	X		IEC 60071-2
Verification of degree of protection of enclosure (IP)	X		IEC 60529
Check of operation of optical monitor devices		X	
Verification of heating resistors operation		X	I-ET-3010.00-5140-741-P4X-002 - MEDIUM-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS
Partial discharge measurements		X	IEC 60270
Verification of operation of overpressure relief devices	X		

Notes: 1) The expansion connection joints shall be connected during test.
2) Unless otherwise specified, consider pollution degree 1.

3.3 EPOXY RESIN INSULATED BUS BARS

3.3.1 GENERAL REQUIREMENTS

3.3.1.1 As an alternative to conventional bus-bar trunking or to cables connecting high power generators and/or loads (above 1 MVA), it may be permitted the use of an insulated cylindrical bus-bar system, made of aluminium or electrolytic copper. The insulation body shall be protected by a corrugated tube in polyamide.

3.3.1.2 This system may be used for interconnection of medium-voltage bus sections, including:

- Current Limiter device connections when available.
- between medium-voltage panels and transformers.
- between generators and panels.

3.3.1.3 Interconnections between medium-voltage transformers secondaries and medium-voltage MCCs and interconnections between low-voltage secondaries transformers and thyristorized panels may be also evaluated by BIDDER.

Note: All proposed connections shall be approved by PETROBRAS.

3.3.1.4 Manufacturer shall provide complete manuals and documentation.

- a) MTTR shall be informed.
- b) For equipment manual requirements, see item 4.

3.3.1.5 Manufacturer shall provide the necessary spare parts for the commissioning and pre operation periods.

3.3.2 CONSTRUCTIVE CHARACTERISTICS

3.3.2.1 The single bars shall be custom designed by manufacturer, according to the final arrangement of Electrical Rooms and location of the equipment. The manufacturer shall submit a customized project, proposing the best routing for the isolated bus system, considering its optimization and easy assembly.

3.3.2.2 The technology of construction shall consider that insulation lies directly on the conductor cylindrical bar and consists of wrapped paper dried under vacuum and impregnated with EPOXY resin.

3.3.2.3 Its formation shall include conductive grading layers, embedded during the wrapping in the insulation to mitigate electric field. An earth screen made in copper, with minimum section of 50 mm² embedded in the insulation, and it shall be also considered as protection for personal and installation. Any different technology shall be previously submitted to PETROBRAS approval.

3.3.2.4 Effective means to avoid ingress of moisture and protection against mechanical harm shall be provided throughout the length of the bar.

3.3.2.5 Minimum constructive characteristics shall include:

- Comply with IEC 60137 – Insulated bushing for alternating voltage above 1000V (where applicable).
- Solid, separate, and fully isolated phase bus.
- Protection degree: Busbars cylinder IP 67 and connection boxes IP 64.

- Ambient temperature -40°C to $+45^{\circ}\text{C}$.
- Proper for marine offshore environment.
- Proper to resist the inclination and motion of the unit without damages.
- Symmetrical and peak rated short-circuit withstand.
- Partial discharge free.
- Approved by Classification Society.

3.3.2.6 Among routine tests, each single bar shall be submitted to the following tests:

- Visual and dimensional inspection,
- verification of degree of protection,
- measuring of capacitance,
- tan delta,
- partial discharges and,
- withstand voltage test at 60Hz.

3.4 GROUNDING RESISTORS

- 3.4.1 Grounding resistors shall be designed, built, and tested according to C57.32, C57.32a, IEC 61892-2 and the requirements of Datasheet.
- 3.4.2 Grounding resistors for transformers shall be installed inside floor-mounted, self-supporting panels. Grounding resistors for main generators shall be installed inside the neutral terminal box. The constructive characteristics for these panels shall comply with requirements of I-ET-3010.00-5140-741-P4X-004 - SPECIFICATION FOR LOW-VOLTAGE **GENERIC ELECTRICAL** PANELS FOR OFFSHORE UNITS.
- 3.4.3 Grounding resistors shall be provided with insulation suitable for the phase-to-phase voltage of the systems to which they are connected.
- 3.4.4 They shall be designed to carry their rated fault current for at least 10s in addition to any continuous loading, without any destructive effect to their component parts.
- 3.4.5 Suitable disconnecting links, which allow for measuring purposes, shall be provided.
- 3.4.6 Features of the neutral grounding methods shall be according to IEC 61892-2.
- 3.4.7 Unless otherwise stated in Project Documentation, grounding resistors shall comply with the requirements of Table 4. Voltages and frequency rates, number of TAPs and other defining values are stated in the informed table. Manufacturer shall carefully observe these values. Any deviation shall be informed to PETROBRAS for previous approval before proceeding to construction.
- 3.4.8 Grounding resistors in 4.16 kV or 6.6 kV shall have VTs to allow the implementation of protective functions. For more information, refer to I-ET-3010.00-5143-700-P4X-001 - ELECTRICAL SYSTEM PROTECTION CRITERIA.
- 3.4.9 Grounding resistors for transformers shall be supplied together with 59G relays. However, the relays installed in **secondary** relay can be used for this purpose.
- 3.4.10 Transformers used for grounding resistors shall be at least 50 kVA. The power in kVA, the impedance, and the X/R shall be informed in grounding transformer datasheet.

3.4.11 Grounding resistors requirements for painting shall follow requirements of I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

3.4.12 Manufacturer shall provide lists of tools and accessories necessary for maintenance and installation and list of recommended spare parts. Components requiring periodic replacement shall be listed in the spare parts list with the recommended replacement frequency.

3.4.13 Manufacturer shall provide complete manuals and documentation.

a) MTTR shall be informed.

b) For equipment manual requirements, see item 4.

3.4.14 Manufacturer shall provide the necessary spare parts for the commissioning and pre operation periods.

3.4.15 The neutral grounding device tests shall include resistance measurements, dielectric tests, and temperature rise tests according to IEEE C57.32a and loss measurements.

Note: Temperature elevation tests shall be made at the lower current and at the higher current tap in order to evaluate the complete resistor.

3.4.16 Except for resistor material, all grounding resistors definitions shown in Table 4 shall be in grounding resistor equipment identification plate.

Table 4 - Grounding Resistor Requirements

System Voltage [V]	480/690	4160/6600	13800
Rated Frequency [Hz]	60	60	60
Taps Quantity	5	5	5
Rated Voltage [V]	480/690	4160/6600	13800
Initial Current [A]	1.0 / 1.5 / 2.0 / 2.5 / 3	Defined by Detailed Design NOTE (1)	Defined by Detailed Design NOTE (1)
Maximum Load Time [s]	Continuous	10 NOTE (2)	10 NOTE (2)
Resistance at 40°C [Ω]	277.1 / 184.7 / 138.6 / 110.8 / 92.3 for 480V 398.4 / 265.6 / 199.2 / 159.3 / 132.8 for 690V	Defined by Detailed Design	Defined by Detailed Design
Environmental Temperature [°C]	According to I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.		
Maximum Admissible Temperature [°C]	120	120	120
Pedestals Insulation [kV]	0.6/1 NOTE (3)	8.25 NOTE (3)	15.0 NOTE (3)
Resistor Material	Stainless Steel AISI-316L	Stainless Steel AISI-316L	Stainless Steel AISI-316L
Protection Degree	Refer to panels' protection degree in I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.		

Note (1) – A minimum of 5 tapes shall be provided unless otherwise defined and approved by PETROBRAS.

Note (2) – Continuous current rating (% of the initial rated current) shall be informed in Datasheet.

Grounding resistor shall be able to continuously withstand a current of at least 10% of the initial rated current.

Note (3) – Rated Voltage Insulation (Ui) phase-ground, shall be informed in Datasheet.

3.5 INSTRUMENT TRANSFORMERS

- 3.5.1 Instrument transformers shall comply with IEC 61869.
- 3.5.2 Electronic instrument transformers shall comply with IEC 61869-10 and IEC 61869-11.
- 3.5.3 Current Transformers for measurement or protection shall have thermal and mechanical capacity sufficient to withstand short-circuit currents equal to the momentary specified current and shall have a rated continuous thermal current equal to 120% according to IEC 61869-2. Manufacturer shall provide means to short-circuit the secondary of current transformers.
- 3.5.4 Instrument transformers complying with IEC 61850 requirements are acceptable, for protection and measurement in panels using this network protocol. The digital interface shall follow IEC 61869-9.
- 3.5.5 Voltage Transformers shall be dry-type.
- 3.5.6 Manufacturer shall provide the necessary spare parts for the commissioning and pre operation periods.

3.6 INTELLIGENT RELAYS (IRs)

- 3.6.1 IRs are IED (Intelligent Electronic Device, as defined by IEC 61850, not necessarily using IEC 61850 protocols). IR shall be three-poles and with manual reset. They shall be provided with ambient temperature compensation and protection against overload due to phase loss. The regulation and calibration devices shall have graduated scale.
- 3.6.2 IRs shall have communication facilities through one Ethernet communication port using the protocols specified in I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE. This port shall also be capable of communicating with the configuration and parameterization software of the IR.
- 3.6.3 Except for panels inside packages, means for communicating with the relay by using the Ethernet Network communication in front of the panel, without opening panel doors, and with the drawers inserted shall be available.
- 3.6.4 IRs shall have digital inputs and shall be able to supervise input circuit-breakers.
- 3.6.5 Each IR shall have a fixed IP address to network communication. There shall be an electrical interlock to avoid operation of a functional unit if it is inserted in a wrong place, so that remote commands do not command wrong loads.

3.7 LIGHTNING AND SURGE ARRESTERS

- 3.7.1 Lightning and surge arresters shall comply with IEC 60099, IEC 61643, and IEC 62305.
- 3.7.2 Lightning and surge arresters' material requirements shall comply with NFPA 780, Class II.
 - 3.7.2.1 All copper air terminals shall be 12.7 mm.
 - 3.7.2.2 Stained copper cables shall be used for System of Electrical Protection against Atmospheric Discharges, SPDA, aluminium cables are forbidden.
 - 3.7.2.3 Stainless steel or bronze connectors are allowed for SPDA if requirements of NFPA 780 chapter 10 (Protection for Watercraft requirements) are met.
 - 3.7.2.4 Main SPDA conductors and down SPDA conductors shall have insulation according to NFPA 780, IEC 61892-6 and IEC 60092-401.



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3.7.2.5 All SPDA connections shall have corrosion protections according to NFPA 780, IEC 61892-6 and IEC 60092-401.

3.7.3 Manufacturer shall provide lists of tools and accessories necessary for maintenance and installation and list of recommended spare parts. Components requiring periodic replacement shall be listed in the spare parts list with the recommended replacement frequency.

3.7.4 Manufacturer shall provide complete manuals and documentation.

a) MTTR shall be informed.

b) For equipment manual requirements, see item 4.

3.7.5 Manufacturer shall provide the necessary spare parts for the commissioning and pre operation periods.

3.8 LOCKOUT RELAYS

3.8.1 The use of MMRs for lockout function (86) is not permitted.

3.8.2 Lockout relay shall be of the rotating type, with manual reset and maximum operating time of 12 ms.

3.8.3 Lockout relays shall be mechanical, external to multifunction relay, models HEA of GE, or C26L of Kraus & Naimer.

3.8.4 The application of lockout relays other than the models specified above shall be submitted to PETROBRAS approval.

3.8.5 Manufacturer shall provide the necessary spare parts for the commissioning and pre operation periods.

3.9 MICROPROCESSOR-BASED MULTIFUNCTION PROTECTION RELAYS (MMR)

3.9.1 MMRs shall be multi-function, digital microprocessor-based type (based on microelectronics and integrated circuits which has an analogue-to-digital converter, a digital signal processor (DSP), software and communication), and allow replacement of the software version through the communication ports. MMRs requirements shall follow IEC 60255 series.

3.9.2 Considering differential protection (function 87), it shall not be permitted the use of MMR with RMS readings.

3.9.3 MMRs shall have at least two communication port on the back side, complying with the requirements defined for the network where they are connected.

3.9.4 MMRs shall have a frontal communication port available on the front side of the panel for connection to a computer, for data configuration and reading. The data mentioned are current data, event recording data and oscillography data.

3.9.5 MMRs shall be capable to synchronize their internal clocks via communication network (SNTP), with a resolution better than or equal to 1 ms.

3.9.6 The parameterization software shall be provided.

3.9.7 MMRs shall allow remote download of oscillography and remote upload and download of configuration data, protected by password access.

- 3.9.8 The oscillography recorder shall have at least the following characteristics:
- a) capacity to store at least 8 (eight) oscillograph records, with at least 300 ms each one; The events recorded shall contain all currents and voltages of the monitored circuit and allow visualization of pre-fault time for at least 2 cycles.
 - b) filing shall be of the line type, i.e., upon the occurrence of a new event, the first position of the line (oldest record) shall be erased.
 - c) the oscillography data shall be accessible via remote network communication.
 - d) sampling rate equal to or greater than 16 per cycle.
 - e) oscillography trigger by pick-up, trip, drop out, control or alarm event, discrete input activation or manual command, selectable by the user.
 - f) the oscillography software shall be capable of making voltage and current phasors, as well as their instantaneous values, available for viewing. The software for capturing data and for viewing the oscillography shall be included in scope of supply.
- 3.9.9 The performance for trip binary output (trip contact) shall be according to IEC 60255-1.
- 3.9.10 The other output contacts shall have at least the following characteristics:
- a) rated current in continuous duty: 5A.
 - b) limit interruption capacity: 1A @ 220VDC.
- 3.9.11 Unless the discrete inputs of MMRs are checked by self-diagnosis routine, these discrete inputs shall not be used to control the load by external protective devices or external safety signals (e.g., high temperature of bearings, high pressure of vessels, etc.).
- 3.9.12 Unless otherwise defined, communications failure, watchdog and self-diagnosis routine failure indications shall be signalled as an alarm, and they shall not be used as trip signal for loads.
- 3.9.13 MMRs shall have means for implementation of logic selectivity schemes and breaker failure function without the need for external auxiliary relays.
- 3.9.14 MMRs shall have self-diagnosis routines for at least the following systems and functions:
- a) all voltages of auxiliary power supply, including voltage of the internal battery.
 - b) error in logical equation, when applicable.
 - c) detection of short-circuit or open RTD for MMRs with input for RTD.
 - d) operation of digital signal processor and memory.
 - e) communication among processor, memory, and network ports.
 - f) operation of analogue-to-digital converter.
 - g) analogical outputs.
 - h) monitoring of circuit of trip coil of circuit-breaker.
 - i) monitoring of MMR internal temperature.
 - j) monitoring of communication ports.
- 3.9.15 MMRs for protection of motors and generators shall have at least three inputs for platinum resistance temperature detectors (RTDs), three-wire, 100 Ω at 0°C.

- 3.9.16 MMRs shall operate properly without exceeding their temperature limit, in continuous duty, under the following conditions:
- temperature inside the cubicle: 55°C max..
 - ambient room temperature: 45°C max..
 - relative humidity of air: up to 90% non-condensing at 40°C.
 - altitude below 1000 m.
 - damp and salt laden atmosphere.

3.9.17 Thermal cycle test:

- it shall be performed on at least 20% of the units of each lot supplied; the test shall be in accordance with standard IEC 60068-2-14, test Nb, energized equipment, within a temperature range of -10°C to +70°C, at a rate of at least 5°C/min, 2 cycles.
- in case a single unit is rejected, the entire lot shall be tested.

3.9.18 External temporization relays shall not be used for protection purpose.

3.9.19 Manufacturer shall provide lists of tools and accessories necessary for maintenance and installation and list of recommended spare parts. Components requiring periodic replacement shall be listed in the spare parts list with the recommended replacement frequency.

3.9.20 Manufacturer shall provide complete manuals and documentation.

- MTTR shall be informed.
- For equipment manual requirements, see item 4.

3.9.21 Manufacturer shall provide the necessary spare parts for the commissioning and pre operation periods.

3.9.22 MMRs shall allow the implementation of voting for temperature protection by temperature sensors (function 49).

3.9.23 For MMRs, It shall be supplied the memory map for the communication between equipment and Electrical System Automation considering, at least, signals listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST and protocols according to I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE.

3.9.24 The MMR hardware shall be able to communicate in the IEC 61850 standard natively in PRP redundancy protocol according to IEC 62439-3, without use of external converters or gateways.

3.10 MOTOR ACTUATED VALVES

3.10.1 Contactors, relays, and all other components necessary to control and command the motor actuated valves shall be included inside the valves case.

3.10.2 Manufacturer shall provide lists of tools and accessories necessary for maintenance and installation and list of recommended spare parts. Components requiring periodic replacement shall be listed in the spare parts list with the recommended replacement frequency.

3.10.3 Manufacturer shall provide complete manuals and documentation.

- a) MTTR shall be informed.
- b) For equipment manual requirements, see item 4.

3.10.4 Manufacturer shall provide the necessary spare parts for the commissioning and pre operation periods.

3.11 POWER CAPACITORS AND CAPACITOR BANKS

3.11.1 High voltage power capacitors and capacitor banks shall comply with the requirements of IEC 60871.

3.11.2 Low-voltage power capacitors shall comply with the requirements of IEC 60831 or IEC 60931.

3.11.3 Low-voltage capacitors for power factor correction shall comply with the requirements of IEC 61921.

3.11.4 Manufacturer shall provide lists of tools and accessories necessary for maintenance and installation and list of recommended spare parts. Components requiring periodic replacement shall be listed in the spare parts list with the recommended replacement frequency.

3.11.5 Manufacturer shall provide complete manuals and documentation.

- a) MTTR shall be informed.
- b) For equipment manual requirements, see item 4.

3.11.6 Manufacturer shall provide the necessary spare parts for the commissioning and pre operation periods.

3.11.7 UPS capacitors (DC link capacitor in UPS A.C. and output capacitors in Battery Charger) shall have overpressure and overtemperature disconnecter safety system.

3.12 REACTORS

3.12.1 Low-voltage and medium-voltage reactors shall comply with the requirements of IEC 60076-6 and IEC 62041.

3.12.2 Manufacturer shall provide lists of tools and accessories necessary for maintenance and installation and list of recommended spare parts. Components requiring periodic replacement shall be listed in the spare parts list with the recommended replacement frequency.

3.12.3 Manufacturer shall provide complete manuals and documentation.

- a) MTTR shall be informed.
- b) For equipment manual requirements, see item 4.

3.12.4 Manufacturer shall provide the necessary spare parts for the commissioning and pre operation periods.

3.12.5 Reactors designed as output filters of VSD-FC shall comply with IEC 61800-4.

3.12.6 The reactor section/column shall be provided with heating resistors (one for each section or compartment) in 220VAC, installed at the lower part. The resistors shall be automatically controlled by means of a thermostat with scale up to 60°C maximum. A circuit-breaker shall be provided on each resistor circuit.

3.13 SURGE PROTECTIVE DEVICES

- 3.13.1 Surge Protective Devices (SPD) shall only be used in insulated or high impedance electrical systems as indicate in NFPA 70.
- 3.13.2 For the main distribution busbars of UPS panels, Lighting Panels, Direct Current Panels, UPS Circuits of Switchgears, MCCs, Remote I/O Panels, Control Panels, etc, Surge Protective Devices (SPD) shall have a maximum discharge current of 10 kA in 8/20 microseconds, as required by NFPA 780.
- 3.13.3 Surge Protective Devices (SPD) in all power energy incomings (generators) shall have the surge protection characteristic of 1.2/50 microseconds or 8/20 microseconds. The minimum phase current shall be 20 kA and 8/20 microseconds according to NFPA 780.
- 3.13.4 Manufacturer shall provide the necessary spare parts for the commissioning and pre operation periods.

4 EQUIPMENT MANUAL REQUIREMENTS

- 4.1 Documents provided by Equipment Manufacturer shall be delivered in an electronic format (original version and PDF version).
- 4.2 The original documents shall be editable, and the PDF documents shall be searchable.
- 4.3 Manuals shall comply with content requirements of NR-12 as defined in I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS.
- 4.4 All Documents and reference manuals shall be provided in English language and, if required by I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS, in Brazilian Portuguese language.

5 DATASHEET FORMS

- 5.1 All existing data sheet templates are available at I-LI-3010.00-5140-700-P4X-001 - **ELECTRICAL** EQUIPMENT DATA SHEET MODELS.
- 5.2 The Datasheets are models and do not refer to any equipment. The manufacturer shall fill in a Datasheet for each equipment.
- 5.3 For equipment without Datasheet model, Manufacturer shall fill in Datasheets according to its own standard and submit to PETROBRAS approval.

6 ANNEX I – ABBREVIATIONS AND ACRONYMS

ANSI	American National Standards Institute
DPC	Departamento de Portos e Costas
ET	Technical Specification
FPSO	Floating, Production, Storage and Offloading Unit
FSO	Floating, Storage and Offloading Unit
IEC	International Electrotechnical Commission
IED	Intelligent electronic device
IEEE	Institute of Electrotechnical and Electronic Engineers
INMETRO	Instituto Nacional de Metrologia Normalização e Qualidade Industrial
IP	Internet Protocol
IR	Intelligent Relay
ISO	International Standardization Organization
MCC	Motor Control Center
MTTR	Mean Time To Repair
NFPA	National Fire Protection Association
RMS	Root Mean Square
RT	Routine Test
SPD	Surge Protective Devices
SPDA	System of Electrical Protection against Atmospheric Discharges
ST	Special Test
TT	Type Test
U_d	Power-Frequency Withstand Voltage
U_e	Rated Operational Voltage
U_i	Rated Insulation Voltage
U_p	Lightning Impulse Withstand Voltage
U_{imp}	Rated Impulse Withstand Voltage
U_n	Rated Voltage
UPS	Uninterruptible Power Supply
VSD-FC	Variable Speed Drive – Frequency Converter
VT	Voltage Transformer