INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL ISSUE
A	Reviewed, corrected items and references, included and excluded items indicated in text.
B	REVIEWED WHERE INDICATED.
C	REVIEWED ITEMS: 2.2.7, 3.5.5, 3.5.6, 3.5.9, 3.5.10, 3.5.11, 3.6.5.3 (Table 3), 3.6.3.3, 3.6.3.8, 3.7.3, 3.7.4, 4.7.5.8, 4.8.5.1.1, 4.8.5.7.2, 4.8.1.8, 4.8.4.8.2, 4.11.24, 4.18.12.3.2, 4.18.12.3.14, 4.20.3, 4.22.26; 4.22.29 4.22.38, 4.23.32, 5.2.3, 5.5.2.1, 5.6.3 (Table 18), 5.7.2, 5.7.8, 5.7.9, 5.7.10, 5.7.11, 5.7.14, 5.8.1, 5.8.2, 5.8.6, 5.13.2.2, 5.13.3.1 a) (iii), 5.13.3.1 b), 5.14.2.4, 5.14.2.8, 5.14.2.9, 5.14.2.10.5, 5.14.2.11.2, 5.14.2.11.3, 5.14.3.1, 5.14.3.3, 5.14.3.7.1, 5.14.4.
D	REVISED WHERE INDICATED DUE TO CONSISTENCY ANALYSIS
E	REVISED ITEM 4.18.5.1, ACCORDING TO CLARIFICATION NOTICE DUE TO BIDDER QUESTIONS
F	REVIEWED WHERE INDICATED.
G	REVISED WHERE INDICATED DUE TO CONSISTENCY ANALYSIS

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1 OBJECTIVE

1.1 This specification establishes the necessary technical requirements for design, manufacture and supply electrical equipment and material for all facilities of PETROBRAS Offshore Units, including installations in modules and packages.

1.2 Requirements stated for equipment in other specific Technical Specifications issued by PETROBRAS (e.g., induction motors, generators, switchgears, MCCs (Motor Control Centre), UPSs (Uninterruptible Power System), VSDs (Variable Speed Drive), thyristorized panels, etc.), 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 TS 60034-25	Rotating Electrical Machines - Part 25: Guidance for the Design and Performance of a.c. Motors Specifically Designed for Converter Supply
IEC 60068-2-2	Environmental Testing - Part 2-2: Tests - Test B: Dry Heat
IEC 60068-2-10	Environmental Testing - Part 2-10: Tests - Test J and Guidance: Mould Growth
IEC 60068-2-11	Basic Environmental Testing Procedures
IEC 60068-2-14	Environmental Testing - Part 2-14: Tests - Test N: Change of Temperature
IEC 60068-2-30	Environmental Testing - Part 2-30: Tests - Test Db: Damp Heat, Cyclic (12h + 12h cycle)
IEC 60071-2	Insulation co-ordination - Part 2: Application guide
IEC 60076	Power Transformers - All parts
IEC TS 60076-20	Power transformers – Part 20: Energy efficiency
IEC 60079	Explosive Atmospheres - All parts
IEC 60079-11	Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"
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 60146-1-1	Semiconductor Convertors - General Requirements and Line Commutated Convertors - Part 1-1: Specification of Basic Requirements

IEC TR 60146-1-2	Semiconductor Convertors - General Requirements and Line Commutated Convertors - Part 1-2: Application Guide
IEC 60146-2	Semiconductor Converters - Part 2 - Self-Commutated Semiconductor Converters Including Direct D.C. Converters
IEC 60214-1	Tap-changers – Part 1: Performance requirements and test methods
IEC 60214-2	Tap-changers – Part 2: Application guide
IEC 60216-1	Electrical Insulating Materials - Properties of Thermal Endurance - Part 1: Ageing Procedure and Evaluation of Test Results
IEC 60216-2	Electrical Insulating Materials - Properties of Thermal Endurance - Part 2: Determination of Thermal Endurance Properties of Electrical Insulation Materials - Choice of Test Criteria
IEC 60228	Conductors of Insulated Cables
IEC 60269-1	Low-voltage fuses – Part 1: General requirements
IEC 60269-2	Low-voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Examples of standardized systems of fuses A to K
IEC 60269-4	Low-voltage fuses – Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices
IEC 60270	High-Voltage Test Techniques - Partial Discharge Measurements
IEC 60309	Plugs, socket-outlets and couplers for industrial proposes - All parts
IEC 60331-11	Tests for electric cables under fire conditions – Circuit integrity – Part 11: Apparatus – Fire alone at a flame temperature of at least 750 degree C.
IEC 60331-21	Tests for Electric Cables under Fire Conditions - Circuit Integrity - Part 21: Procedures and Requirements - Cables of Rated Voltage up to and Including 0,6/1,0 kV
IEC 60332-1-2	Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame
IEC 60332-1-3	Tests on electric and optical fibre cables under fire conditions – Part 1-3: Test for vertical flame propagation for a single insulated wire or cable – Procedure for determination of flaming droplets/particles
IEC 60332-3-10	Tests on Electric and Optical Fibre Cables Under Fire Conditions - Part 3-10: Test for Vertical Flame Spread of Vertically-Mounted Bunched Wires or Cables - Apparatus
IEC 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
IEC 60445	Basic and Safety Principles for Man-Machine Interface, Marking and Identification - Identification of Equipment Terminals, Conductor Terminations and Conductors
IEC 60364-4-41	Low-Voltage Electrical Installations - Part 4-41: Protection for Safety - Protection Against Electric Shock
IEC 60519	Safety in Electroheat Installations - All parts
IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)

IEC 60533	Electrical and Electronic Installations in Ships - Electromagnetic Compatibility
IEC TR 60616	Terminal and tapping markings for power transformers
IEC 60622	Secondary Cells and Batteries Containing Alkaline or Other Non-acid Electrolytes - Sealed Nickel-Cadmium Prismatic Rechargeable Single Cells
IEC 60623	Secondary Cells and Batteries Containing Alkaline or Other Non-acid Electrolytes - Vented Nickel-Cadmium Prismatic Rechargeable Single Cells
IEC 60664-3	Insulation Co-ordination within Low-Voltage Systems - Part 3: Use of Coating, Potting or Moulding for Protection against Pollution
IEC 60754-1	Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content
IEC 60754-2	Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity
IEC 60793-1-52	Optical fibres – Part 1 - 52: Measurement methods and test procedures – Change of temperature tests
IEC 60794	Optical fibre cables - All parts
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 60896-11	Stationary Lead-Acid Batteries - Part 11: Vented Types - General Requirements and Methods of Tests
IEC 60896-21	Stationary Lead-Acid Batteries - Part 21: Valve-Regulated Types - Methods of Test
IEC 60896-22	Stationary Lead-Acid Batteries - Part 22: Valve-Regulated Types - Requirements
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 60947-2	Low-Voltage Switchgear and Controlgear - Part 2: Circuit-Breakers
IEC 60947-3	Low-voltage switchgear and Controlgear - Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units
IEC 61000	Electromagnetic Compatibility (EMC) - All parts
IEC 61034-2	Measurement of smoke density of cables burning under defined conditions – Part 2: Test procedure and requirements
IEC 61086	Coating for Loaded Printed Wire Boards (conformal Coatings) - All parts
IEC 61188-5-1	Printed Boards and Printed Boards Assemblies – Design and Use – Part 5-1: Attachment (land/joint) Considerations – Generic Requirements
IEC 61378-1	Converter Transformers - Part 1: Transformers for Industrial Applications
IEC 61439	Low-Voltage Switchgear and Controlgear Assemblies - All Parts
IEC 61643	Low-Voltage Surge Protective Devices - All parts
IEC 61800	Adjustable speed electrical power drive systems - All parts

IEC 61810	Electromechanical elementary relays – All Parts
IEC 61850	Communication Networks and Systems in Substation – All parts
IEC 61892	Mobile and Fixed Offshore Units - Electrical Installations - All parts
IEC 61869	Instrument transformers – All Parts
IEC 61914	Cable cleats for electrical installations
IEC 61921	Power Capacitors - Low-Voltage Power Factor Correction Banks
IEC 62040-2	Uninterruptible Power Systems (UPS) - Part 2: Electromagnetic compatibility (EMC) requirements
IEC 62040-3	Uninterruptible Power Systems (UPS) - Part 3: Method of Specifying the Performance and Test Requirements
IEC 62041	Safety of transformers, reactors, power supply units and combinations thereof – EMC requirements
IEC 61558	Safety of power transformers, power supplies, reactors and similar products – All parts
IEC 62259	Secondary Cells and Batteries Containing Alkaline or other Non-Acid Electrolytes Nickel-Cadmium Prismatic Secondary Cells with Partial Gas Recombination
IEC 62262	Degrees of Protection Provided by Enclosures for Electrical Equipment Against External Mechanical Impacts (IK Code).
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 62395	Electrical Resistance Trace Heating Systems for Industrial and Commercial Applications - All parts
IEC 62444	Cable glands for electrical installations
IEC 62485-2	Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries
IEC 62631-3-2	Dielectric and resistive properties of solid insulating materials – Part 3-2: Determination of resistive properties (D.C. methods) – Surface resistance and surface resistivity
IEC 62722-2-1	Luminaire performance – Part 2-1: Particular requirements for LED luminaires
IEC 62717	LED modules for general lighting – Performance requirements

Note: When all parts are informed, all applicable parts shall be used as reference. If a specific part in mentioned in text, it will be listed following the general code reference.

2.2.2 IEEE – INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERING

C37.23	Standard for Metal-Enclosed Bus
C57.110	Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability when Supplying Nonsinusoidal Load Currents

C57.32-2015	IEEE Standard for Requirements, Terminology, and Test Procedures for Neutral Grounding Devices
C57.32a-2020	IEEE Standard for Requirements, Terminology, and Test Procedure for Neutral Grounding Devices Amendment 1: Neutral Grounding Resistors Clause (AM)
Std 485	Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications
Std 519	IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
Std 1115	Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications
Std 1580	Recommended Practice for Marine Cable for Use on Shipboard and Fixed or Floating Facilities

2.2.3 IMO - INTERNATIONAL MARITIME ORGANIZATION

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

IMO Res. A.754 (18) RECOMMENDATION ON FIRE RESISTANCE TESTS FOR “A”, “B” AND “F” CLASS DIVISIONS

IMO Res. MSC.81(70) REVISED RECOMMENDATION ON TESTING OF LIFE-SAVING APPLIANCES

IMO SOLAS (International Convention for the Safety of Life at Sea)

2.2.4 LABOUR SECRETARY - MINISTRY OF ECONOMY - REGULATORY STANDARDS FOR OCCUPATIONAL SAFETY AND HEALTH

NR-10	Segurança em Instalações e Serviços em Eletricidade
NR-12	Segurança no Trabalho em Máquinas e Equipamentos
NR-37	Segurança e Saúde em Plataformas de Petróleo

2.2.5 INMETRO – INSTITUTO NACIONAL DE METROLOGIA NORMALIZAÇÃO E QUALIDADE INDUSTRIAL

Portaria 179	May 18th 2010
Portaria 89	Feb 23rd 2012

2.2.6 AMERICAN SOCIETY FOR TESTING AND MATERIALS (WHERE SPECIFIED)

ASTM B1	Standard Specification for Hard-Drawn Copper Wire
ASTM B2	Standard Specification for Medium-Hard-Drawn Copper Wire
ASTM B3	Standard Specification for Soft or Annealed Copper Wire
ASTM B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM B26/B26M Standard Specification for Aluminium-Alloy Sand Casting

ASTM B33	Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purpose
ASTM B108/B108M	Standard Specification for Aluminium-Alloy Permanent Mould Casting
ASTM B221	Standard Specification for Aluminium and Aluminium-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B846	Standard Terminology for Copper and Copper Alloys
ASTM D256	Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
ASTM D257	Standard Test Methods for DC Resistance or Conductance of Insulating Materials
ASTM D543	Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
ASTM D635	Standard Test Methods for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
ASTM D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E662	Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials
ASTM F3059	Standard Specification for Fiber-Reinforced Polymer (FRP) Gratings Used in Marine Construction and Shipbuilding

2.2.7 ABNT – ASSOCIAÇÃO BRASILEIRA DE NORMALIZAÇÃO TÉCNICA

ABNT NBR 5410	Instalações elétricas de baixa tensão
ABNT NBR 16820	Sistemas de sinalização de emergência — Projeto, requisitos e métodos de ensaio
ABNT NBR 14136	Plugues e Tomadas para uso Doméstico e Análogo até 20A/250V em Corrente Alternada - Padronização
ABNT NBR 14197	Acumulador Chumbo-Ácido Estacionário Ventilado - Especificação
ABNT NBR 14198	Acumulador Chumbo-Ácido Estacionário Ventilado - Terminologia
ABNT NBR 14199	Acumulador Chumbo-Ácido Estacionário Ventilado - Ensaios
ABNT NBR 14200	Acumulador Chumbo-Ácido Estacionário Ventilado para Sistemas Fotovoltaicos - Ensaios
ABNT NBR 14201	Acumulador Alcalino de Níquel-Cádmio Estacionário - Especificação
ABNT NBR 14202	Acumulador Alcalino de Níquel-Cádmio Estacionário - Ensaios
ABNT NBR 14203	Acumulador Alcalino de Níquel-Cádmio Estacionário - Terminologia
ABNT NRB 14204	Acumulador Chumbo-Ácido Estacionário Regulado por Válvula - Especificação

ABNT NBR 14205 Acumulador Chumbo-Ácido Estacionário Regulado por Válvula - Ensaios

ABNT NBR 14206 Acumulador Chumbo-Ácido Estacionário Regulado por Válvula – Terminologia

ABNT NBR 15708-1 Indústrias do petróleo e gás natural — Perfis pultrudados Parte 1: Materiais, métodos de ensaio e tolerâncias dimensionais

ABNT NBR 15708-3 Indústrias do petróleo e gás natural — Perfis pultrudados Parte 3: Grade de piso

ABNT NBR 15708-4 Indústrias do petróleo e gás natural – Perfis pultrudados Parte 4: Sistema de Bandejamento

ABNT NBR 16716 Baterias estacionárias - Diretrizes para projetos e requisitos para instalação em plataformas marítimas de petróleo e gás

ABNT NBR 6493 Emprego de cores para identificação de tubulações

2.2.8 DPC – MARINHA DO BRASIL – DIRETORIA DE PORTOS E COSTAS

NORMAM-01/DPC Normas da Autoridade Marítima para Embarcações Empregadas na Navegação de Mar Aberto;

NORMAM-05/DPC Normas da Autoridade Marítima para Homologação de Material.

NORMAM-27/DPC Normas da Autoridade Marítima para Homologação de Helideques Instalados em Embarcações e em Plataformas Marítimas.

RIPEAM 72 Regulamento Internacional para Evitar Abalroamentos no Mar.

Portaria nº 21/DPC de 29/01/2020 Altera as Normas da Autoridade Marítima para Homologação de Material -NORMAM-05/DPC.

2.2.9 ISO - INTERNATIONAL STANDARDIZATION ORGANIZATION

62 Plastics - Determination of Water Absorption

178 Plastics - Determination of Flexural Properties

179-1 Plastics - Determination of Charpy Impact Properties

527 Plastics - Determination of Tensile Properties - All Parts

4892 Plastics - Methods of Exposure to Laboratory Light Sources - All Parts

17884 Ships and marine technology — Searchlights for high-speed craft

2.2.10 UL - UNDERWRITERS LABORATORIES INC.

UL 94 UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 1581 UL Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords.

2.2.11 ANSI - AMERICAN NATIONAL STANDARDS INSTITUTE

ASME B1.20.1 Pipe Threads, General Purposes (Inch)

2.2.12 NATIONAL FIRE PROTECTION ASSOCIATION

NFPA 70 National Electrical Code

NFPA 110 Standard for Emergency and Standby Power Systems

NFPA 780 Standard for the Installation of Lightning Protection Systems

2.2.13 DEF - UK MINISTRY OF DEFENCE

DEF STAN 07-247 Determination of the Toxicity Index of the Products of Combustion from Small Specimens of Materials

2.2.14 CAA - CIVIL AVIATION AUTHORITY

CAP 437 Standards for Offshore Helicopter Landing Areas

2.2.15 IACS - International Association of Classification Societies

No. 73 (June 2002) (Rev.1 Dec 2020) Type approval procedure for cable trays/protective casings made of plastics materials.

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-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS

[3] I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS

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

[5] I-ET-3010.00-5265-773-P4X-001 - UNINTERRUPTIBLE POWER SUPPLY FOR OFFSHORE UNITS

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

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

[8] ELECTRICAL SYSTEM DESCRIPTIVE MEMORANDUM

[9] I-DE-3010.00-5140-700-P4X-002 - POWER INSTALLATION TYPICAL DETAILS

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

[11] HULL UPS AND DC SYSTEMS ONE-LINE DIAGRAM

[12] EMERGENCY LOAD LIST

[13] I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING

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

[15] I-ET-3010.00-1200-300-P4X-001 – NOISE AND VIBRATION CONTROL REQUIREMENTS

[16] I-ET-3010.00-1200-955-P4X-001 - WELDING

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

[18] METOCEAN DATA SPECIFICATION

[19] I-LI-3010.00-5140-700-P4X-001 - ELETRICAL EQUIPMENT DATA SHEET MODELS

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

[21] STRUCTURAL REQUIREMENTS SPECIFICATON

[22] I-ET-3010.00-5143-700-P4X-001 - ELECTRICAL SYSTEM PROTECTION CRITERIA

[23] I-DE-3010.00-5140-741-P4X-001 - FUNCTIONAL UNITS BLOCK DIAGRAMS

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

3 GENERAL EQUIPMENT CONDITIONS

3.1 ENVIRONMENTAL CONDITIONS

3.1.1 All equipment, materials and accessories used in electrical installations shall be suitable for storage, service, and installation on severe petrochemical, marine, tropical, damp, and saline environment described on the METOCEAN DATA.

3.1.2 To fulfil this requirement, all electrical and electronic devices, beyond mechanical parts of the equipment, shall be designed and constructed in a tropicalized version. Tropicalization process comprises use of anti-rust materials and accessories and other implementations according to manufacturers' experiences and related rules, aiming to provide a robust and reliable construction.

3.1.3 Printed circuit-boards shall additionally comply with the following requirements:

- conformal coating treatment, according to IEC 60664-3.
- application of reinforced protective resin Class 2 (high reliability), according to IEC 61086.
- test for dry heat, according to IEC 60068-2-2.
- test for mould growth, according to IEC 60068-2-10.
- test for salt mist, according to IEC 60068-2-11.
- test for change of temperature, according to IEC 60068-2-14.
- test for damp heat, according to IEC 60068-2-30.

Note: manufacturer shall provide certification reports of the tests requested above.

3.1.4 Electrical equipment and its components shall be designed based on reference temperatures established in Datasheets and Technical Specifications.

3.1.5 Either IEC 61892-1 or Classification Society rules shall be applied. Temperature conditions different from the established requirements shall be submitted to PETROBRAS approval.

3.1.6 Unless otherwise defined by Specific Datasheet or Equipment Technical Specification, relative humidity operation definitions shall be defined by either IEC 61892-1 or Classification Society.

3.1.7 Electrical equipment shall be sized for continuous operation at monthly/yearly average temperatures listed in Table 1.

3.1.8 Electrical equipment shall operate properly at any temperature from minimum to maximum temperatures listed in Table 1.

Table 1 - Reference Temperatures

Ambient Temperature for Electrical Equipment Sizing (°C)						
Equipment \ Local	Indoor Area			Outdoor Area		
	Minimum	Monthly/ Yearly Average	Maximum	Minimum	Monthly/ Yearly Average	Maximum
Generators and motors	10	45(6)	45(6)	10	45	45
Panels (1)	10	45	45	10	45	45
Electrical Cables	10	45	45	10	45	45
Transformers, Reactors and Grounding Resistors	10	45	45	10	45	45
Battery	10	45	45	10	45	45
Battery Chargers and Rectifiers	10	45	45	10	45	45
Electronic Devices Outside Panels	10 (2)	70 (2)	70 (2)	10	55	55
	-5 (3)	55 (3)	55 (3)			
Electronic Devices Inside Panels	10 (2)	70 (2)	70 (2)	10	70	70
	-5 (3)	55 (3)	55 (3)(5)			

Notes: 1) Related only to electrical panels included in item 4.8. Electrical panels with specific documentation shall comply with requirements of their respective documentation (e.g.: MCCs and switchgears);
2) For equipment in ventilated room;
3) For equipment in air-conditioned room;
4) Equipment inside refrigerant chambers shall comply with Classification Society requirements.
5) For switches, consider temperature 85ºC according to IEC 60068-2-2.
6) For machine rooms with steam boilers temperature shall be 50°C

3.2 HEAT DISSIPATION CHARACTERISTICS

3.2.1 For equipment installed in sheltered rooms, the equipment Manufacturer shall inform the quantity of dissipated heat, under normal and maximum operational conditions.

3.2.2 This information shall be included in vendor documentation.

3.3 MOTION AND INCLINATION LIMITS REQUIREMENTS

When installed in floating units and ships (FPSO and FSO), all electrical equipment shall be suitable to operate under inclination variations (static and dynamic) and acceleration conditions specified by IMO MODU CODE, IEC 61892-5, and Classification Society.

3.4 VIBRATION LIMITS REQUIREMENTS

All electrical equipment shall operate normally within vibration limits specified in IEC 61892 series and Classification Society rules.

3.5 HAZARDOUS AREAS REQUIREMENTS

3.5.1 The application of electrical equipment, instruments and accessories on hazardous areas shall follow the requirements of IEC series 60079-14 and 61892-7.

3.5.2 All materials and equipment proper to be used in hazardous areas, shall have conformity certificates complying with INMETRO Portaria n° 179, May 18th, 2010 and its annexes and Portaria nº 89, Feb 23rd, 2012 and shall be approved by Classification Society.

3.5.3 Packager shall furnish a table with the data presented in Table 2 in a document, for each individual equipment.

Table 2 - Data Requirements for Equipment Installed in Hazardous Areas

Equipment Tag. No. / Component identification	Temperature Class
Equipment Description / Characteristics	Approval Body
Unit Location / Module	Certificate Type
Equipment Manufacturer	Certificate Number
Catalogue / Type Number	Zone of Use
IP Code	Accessories
Type of Ex Protection	Certificate of Conformity
Gas Group	
EPL (Equipment Protection Level)	

3.5.4 Electrical equipment installed in hazardous areas shall have the safety execution specified in accordance with standards IEC 60079, IEC 61892 series and, for FPSO/FSO units, IEC 60092. This equipment shall be submitted to PETROBRAS approval.

3.5.5 Electrical equipment installed in external safe areas, that shall be kept operating during emergency shutdown ESD-3P and ESD-3T shall be certified for installation in hazardous areas Zone 2 (EPL Gc) Group IIA temperature T3, unless they are automatically disconnected if there is gas in the equipment area, according to IEC 61892-1.

3.5.6 Certificate for Zone 2 (EPL Gc) shall be sent for PETROBRAS knowledge and approval for equipment that shall be kept operating even when gas presence is confirmed in external area, according to Class Society Requirements and IEC 61892 parts 1 and 7.

3.5.7 All hazardous areas equipment type certificates must be valid by document approval phase in order of correct evaluation.

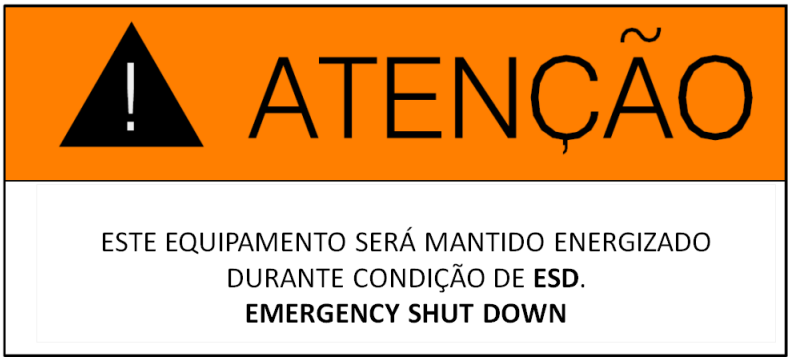
3.5.8 All hazardous areas equipment type certificates shall be delivered together with respective equipment at delivery inspection.

3.5.9 For standardization reason, all junction boxes, lighting fixtures, floodlights installed in external safe areas, that shall be kept operating during emergency shutdown ESD-3P and ESD-3T shall be certified for installation in hazardous areas Zone 1 Group IIA temperature T3.

Note: Battery room equipment shall be for Zone 1, Group IIC, T1.

3.5.10 Ex-d distribution panels, junction boxes and lighting panels shall not be permitted.

3.5.11 All Ex equipment which needs to be operated during ESD condition shall be marked for easy identification with “ESD” label, including Ex equipment installed in safe area (outside hazardous area).



3.5.12 All Ex equipment of the unit shall have an identification system for control and inventory management, i.e.: bar code, QR code, RFID. This system shall have, at least, the related equipment collection of certificates of conformity and their attachments and data document requested in Table 2.

3.5.13 See I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS for documentation and certificates requirements.

3.6 CONSTRUCTION REQUIREMENTS

3.6.1 GENERAL

3.6.1.1 Manufacturers shall keep uniformity of equipment and components for the same supply. The same model for lighting fixtures, sockets, junction box and all bulk material shall be used in all Unit modules.

3.6.1.2 All equipment shall be supplied with terminal connectors for power, control, heating, and grounding.

3.6.1.3 Unless otherwise stated in specific equipment technical specification, for 3.6.1.2 the connectors for power, control and grounding cables shall be made of non-welded type on copper alloy with high mechanical resistance, as ASTM B846, with tin coat.

3.6.1.4 Unless otherwise stated in specific equipment technical specification, for control cables, these connectors shall be eye type.

3.6.1.5 Suitable sheet or removable covers shall be provided to avoid accidental contact with energized parts in the interior of the equipment live parts, as required in NR-10.

3.6.1.6 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.

3.6.2 FIXING BASE

3.6.2.1 All floor-mounted equipment besides their normal base shall have an extra base, to which the normal base shall be fixed by means of screws. The extra base shall be fixed (welded) to the Unit floor.

3.6.2.2 This base shall be dimensioned like a two point supported beam on the longitudinal direction to support the whole equipment weight, considering a maximum deflection of 1/500 of the equipment length. This base shall have its sides covered by plates to avoid the access of humidity to the equipment lower section.

3.6.2.3 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.

3.6.3 PAINTING

3.6.3.1 Paint system for external coating of all electrical equipment, material and supports shall be proper for offshore installation and pre-qualified according to I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING.

3.6.3.2 Painting system for internal coating of all electrical equipment and material shall be proper for offshore installation according to manufacturer requirements, when not specified by PETROBRAS.

3.6.3.3 Unless otherwise stated in equipment documentation, the last coat colour for electrical equipment shall be Light Green Munsell 5G8/4. Inner components mounting plate, internal doors face shall be Safety Orange Munsell 2.5YR6/14.

Note: Colours shall comply with NR-37.

3.6.3.4 For carbon steel parts of lighting fixtures and junction boxes, the last coat colour shall be White Munsell N9.5.

3.6.3.5 For stainless steel lighting fixtures, no coat colour is required.

3.6.3.6 For FRP materials, no coat colour is required, unless otherwise required by a standard, regulation or PETROBRAS.

3.6.3.7 For firefighting associated equipment, the last coat colour shall be Safety Red Munsell 5R4/14.

3.6.3.8 Stainless steel surfaces shall be painted if exposed do saline atmosphere and temperatures above the limits indicated, as defined in I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING:

- 316L - with service temperature over 50°C shall be coated.
- Duplex SS - service temperature over 80°C shall be coated.
- Superduplex SS - service temperature over 90°C shall be coated.

3.6.4 IDENTIFICATION NAMEPLATE

3.6.4.1 Identification nameplates for equipment with specific Technical Specification (e.g., induction motors, generators, MCCs and switchgears) shall follow the requirements of that specification.

3.6.4.2 All other equipment shall have 02 (two) identification nameplates.

3.6.4.3 The first plate shall have the equipment tag number, in black acrylic engraved with white letter for equipment installed indoors and in stainless steel AISI-316 for equipment installed outdoors.

3.6.4.4 The other plate shall be in stainless steel AISI-316 with the following information, when applicable, in Portuguese language:

- Petróleo Brasileiro S.A. – PETROBRAS.

- Fornecedor (vendor name).
- Número de Série (equipment serial number).
- Ano de fabricação (year of manufacture).
- Número do pedido de compra (purchase order number).
- Other equipment specific data.
- Fabricante (manufacturer name).
- Tipo (type).
- Padrão de desempenho (performance standard).
- Valores nominais para: potência aparente de saída, tensões, frequência, correntes (rated values for: output apparent power, voltage(s), frequency, currents).
- Classificação térmica da isolação (thermal classification of insulation).
- Grau de proteção IP do invólucro e caixa de terminais (IP code of enclosure and termination box).
- Grupo de ligação de bobinas (vector group of windings).
- Máxima temperatura admissível para o meio refrigerante (maximum permissible cooling medium temperature).
- Valores das impedâncias de curto-circuito (short-circuit impedances values).
- Tipo do meio refrigerante (type of cooling medium).
- Massa total (total mass).

3.6.5 MECHANICAL PROTECTION DEGREE AND TYPE REQUIREMENTS

3.6.5.1 All equipment shall have an IP protection according with the Table 3, unless Classification Society requires a higher level of IP protection.

3.6.5.2 All equipment with mechanical protection degree IP44 or higher shall have test certificates issued by an authorized and properly identified laboratory.

3.6.5.3 All equipment shall have an external mechanical impact strength (IK) of minimum IK 08 as defined in IEC 62262.

Table 3 - Hazardous and Minimum IP Protection Code Related to Equipment Type and Location.

Location ⇓ / Equipment ⇒	Transformer	Panels (4)	Busbar Trunking	Rectifiers, Battery Chargers and UPSs	Lighting Fixtures	General Materials and Junction Boxes	Power Switches and Socket-outlets
Process Areas	Ex (7)	Ex (7)	(2)	(2)	IP55W Ex (8)	IP55W Ex e	IP55W Ex de
Machinery Room / Engine Room / Utility Room (1)	IP54W	IP44	IP44	IP44	IP55W	IP55W	IP44
Electrical Equipment Room (Normal or Essential)	IP22	IP42	IP42	IP42	IP34	IP44	IP44
Exposed Deck – Non Hazardous Area (1)	IP55W	IP56W	(2)	(2)	IP56W Ex (8)	IP56W	IP56W Ex de
Pontoons, Pump Room (below sea water line)	(2)	(2)	(2)	(2)	IP55W	IP68	IP44
Pump Room (above sea water line)	(2)	(2)	(2)	(2)	IP55W	IP55W	IP55W
Battery Room, Paint Store, acetylene gas Storage Room.	(2)	(2)	(2)	(2)	IP55W Ex (8)	IP55W Ex e	(2)
Accommodations dry areas	IP22	IP21	IP42	IP21	IP21	IP22	IP20
Accommodations wet spaces, toilets, and dressing rooms.	(2)	(2)	(2)	(2)	IP44	IP55W	IP22
Galley, Laundry and Laboratory (6)	IP44	IP44	IP44	(2)	IP44	IP44	IP44
Control Room	(2) (5)	IP42	(2)	IP42	IP22	IP22	IP22
Freezer Room and surrounding areas	(2)	(2)	(2)	(2)	IP55W	IP55W	IP55W
Spaces protected by water deluge system (1)	IP55W	IP55	(2)	(2)	IP55W	IP55W	IP55W
Spaces which may have water hose washing	IP55W	IP54	(2)	(2)	IP54	IP55	IP56W
Spider deck of SS	(2)	(2)	(2)	(2)	IP55W Ex (8)	IP56W	IP56W
Main deck of ship, FPSO, FSO, overload tank	(2)	IP56W Ex (7)	(2)	(2)	IP55W Ex (8)	IP56W Ex e	(2)
Production deck of FPSO, FSO when subjected to sea waves (green water)	(2)	IP56W	(2)	(2)	IP55W Ex (8)	IP56W Ex e	IP56W Ex de
Hazardous Areas	Ex (7)	Ex (7)	(2)	(2)	Ex (8)	Ex e	IP56W Ex de

Notes:
1) Electrical equipment shall be installed below floor grid cellar, subject to flooding, water jet, and damage caused by maintenance or heavy load handling, only if strictly necessary.
2) Equipment shall not be installed in these locations.
3) The suffix W means equipment resistant to hydrocarbon vapours, water, salt atmosphere and oil.
4) For switchgears and motor control centres, see specific technical specifications.
5) Essential and emergency transformers may be acceptable in this area under PETROBRAS approval.
6) Other minimum IP may be accepted for Laboratory, subject to PETROBRAS analysis and approval.
7) When "Ex" only is indicated, it means that Hazardous Protection Code shall be applied considering area specific requirements.
8) See Table 19 for Ex classification.

3.7 WARNING LABELS FOR ELECTRICAL EQUIPMENT

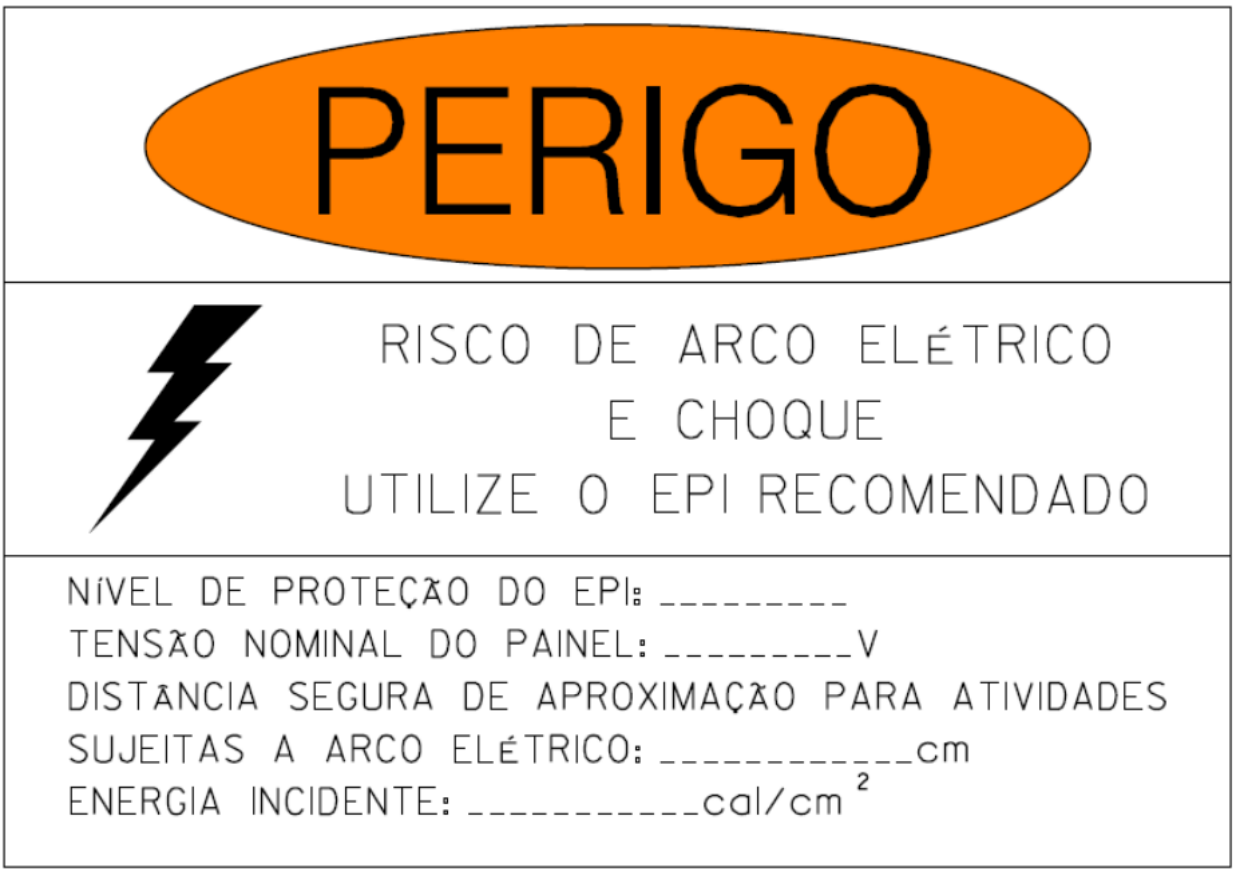
3.7.1 All electrical equipment, flour mounted, panels, or similar in construction to a panel, regardless of the area where it is installed, shall have the warnings as required by NR-10 and NR-12.

3.7.2 Warnings shall follow the standard labels as required in ABNT NBR 16820 for electrical panels risk of shock as informed in I-ET-3010.00-5400-947-P4X-002 - SAFETY SIGNALLING.

3.7.3 For all 690 V panels, 480 V panels, and for all 220 V panels fed by a transformer with rated power higher than 125 kVA, the following label applies. The Panels shall have warning labels following the model below with:

- protective clothing risk category (in field “Nível de Proteção do EPI).
- the values of rated voltage (in field “Tensão Nominal do Painel”).
- arc fault incident energy (in field “Energia Incidente”), in Cal/cm^2.
- arc-flash hazard distance (in field “Distância Segura de Aproximação para Atividades Sujeitas a Arco Elétrico”).

The values to be filled in will be informed to Panel Manufacturer during Detailed Design.



Notes: (1) Power Panels shall have warning labels indicating the protective clothing risk category that shall be used for technical intervention.

(2) Power Panels shall have warning labels indicating that any technical intervention in the panels shall be executed only by authorized people.

3.7.4 ESD label warnings shall follow requirements of section 3.5.11.

3.8 VOLTAGE REQUIREMENTS

3.8.1 Unless otherwise stated, all A.C. (Alternate Current) equipment shall operate satisfactorily with voltage variations described in Table 4, based on IEC 61892-1. This table shows the maximum acceptable divergence of values referred to the rated voltage.

Table 4 - Reference Values for A.C. Voltage Variation

System withstand requirements				
Voltage characteristics		**Value**		**Comments**
Voltage Tolerance	Overvoltage	+6% -10%		Steady state voltage tolerance on switchboards and distribution panels which electrical system and consumers in general shall withstand.
	Undervoltage			
Voltage transient variation		+15% -15%		Transient voltage tolerance on switchboards and distribution panels which consumers in general shall withstand.
Max. Voltage variation		+20% -20%		Voltage excursions (sum of transient and steady state deviation) on switchboards and distribution panels, which electrical system and consumers in general shall withstand.
System operational requirements				
Voltage characteristics		**Value**		**Comments**
		Normal	**Emergency**	
Voltage tolerance in primary distribution system	Cyclic voltage variation	+2.5% -2.5%	+3.5% -3.5%	Steady state voltage tolerance on generator switchboards.
Voltage tolerance in secondary distribution system	Cyclic voltage variation	+5% -5%		Steady state voltage tolerance on switchboards and distribution panels in secondary distribution system.
Voltage transients: slow transients e.g. due to load variation tolerance (deviation from nominal voltage)	Overvoltage	+20%	+20%	
	Undervoltage	-15%	-15%	
Transients Recovery Voltage		±3 %	±4%	After a transient condition has been initiated, the voltage in a main distribution system shall not differ from the voltage before the transient was initiated by more than ±3 % within 1.5 s. In an emergency system the limit is ±4% within 5 s.
Voltage transients recovery time		1.5 s	5	
Voltage Unbalance		7%		Including phase voltage unbalance because of unbalance of load.
Notes: Voltages are root mean square (RMS) unless otherwise stated.				

3.8.2 All A.C. equipment shall operate satisfactorily with harmonic distortion (voltage waveform) in power supply up to (based on IEEE 519):

- Maximum total harmonic distortion - 5%.
- Maximum single harmonic content - 3%.

3.8.3 All D.C. (Direct Current) equipment shall operate satisfactorily with voltage variations described in Table 5. This table shows the maximum acceptable divergence of values referred to the rated voltage.

Table 5 - Reference Limits for D.C. Voltage Variation

Parameter		Variation [%]
Continuous Operation	Overvoltage(1)	+15
	Undervoltage(1)	-15
	Voltage ripple	2(2)
		1(3)
	Cyclic voltage variation	5
Transitory Events	Overvoltage	+12
	Undervoltage	-15
The transient recovery time shall not exceed 2 s.		

Note (1): Voltage tolerance (continuous), measured at the distribution board.
Note (2): According to IEC 61892-1, for A.C. r.m.s. over steady D.C. voltage, battery in fully loaded condition.
Note (3): According to IEC 61892-1, for different battery types, for VRLA batteries.

3.8.4 All electrical equipment, materials and components operating in low-voltage isolated neutral systems or in low-voltage high-resistance grounding systems shall withstand continuously, without sacrifice of its useful life, the phase to phase voltage between any phase to ground.

3.9 FREQUENCY REQUIREMENTS

3.9.1 Equipment shall be able to withstand frequency variations as show in Table 6, based on IEC 61892-1. This table shows the maximum acceptable divergence of values referred to 60Hz.

3.9.2 All equipment shall operate satisfactorily with maximum combined voltage and frequency variation of 10%, considering the maximum individual variations described in Table 4 and Table 6.

Table 6 - Reference Limits for Frequency Variation

Parameter	Variations	
Continuous Operation	Overfrequency [%]	+ 5
	Underfrequency [%]	- 5
	Cyclic variation [%]	0.5
Transitory Events	Overfrequency [%]	+ 10
	Underfrequency [%]	- 10
	Minimum Transient Withstand Time [s]	5

3.10 EMC AND RFI REQUIREMENTS

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

3.10.2 Regarding induced disturbances, all electrical automation equipment shall comply with IEC 61000-4-6 class 3.

3.10.3 Regarding surges, electrical automation equipment shall comply with IEC 61000-4-5 class 4 with wave forms 1.2/50µs and 10/700µs and peaks up to 4kV.

3.10.4 Regarding oscillatory waves, all electrical automation 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.

3.10.5 Regarding fast transients, all electrical automation 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.

3.10.6 Regarding electromagnetic disturbances, all electrical automation equipment shall comply with IEC 61000-4-3 class 3.

3.10.7 Regarding damped oscillatory magnetic, electrical automation equipment shall comply with IEC 61000-4-10 level 5.

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

3.10.9 All electrical automation equipment shall operate correctly in the presence of a power frequency voltage in accordance with table 1 of IEC 61850-3.

4 EQUIPMENT

4.1 EMERGENCY GENERATOR

Emergency generator shall comply with specific Technical Specification and respective Datasheet.

4.2 AUXILIARY GENERATOR

Auxiliary generator shall comply with specific Technical Specification and respective Datasheet.

4.3 MAIN AND HULL GENERATORS

Main and Hull generator shall comply with specific Technical Specifications and respective Datasheet.

4.4 ELECTRIC INDUCTION MOTORS

Electric induction motors shall comply with specific Technical Specifications and respective Datasheets.

4.5 UPSs

Alternate Current UPSs shall comply with specific Technical Specification and respective Datasheets.

4.6 MEDIUM-VOLTAGE FREQUENCY CONVERTERs

Medium-voltage frequency converters shall comply with specific Technical Specifications and respective Datasheets.

4.7 TRANSFORMERS

4.7.1 GENERAL REQUIREMENTS

4.7.1.1 Transformers shall be sized for continuous duty and shall comply with the requirements of IEC 60076, IEC 62041, and IEC 61558.

4.7.1.2 Unless otherwise stated in Datasheet, all guaranteed values shall be established with measurement methods and shall comply with the tolerances foreseen on reference standards.

4.7.1.3 Transformers shall be installed as separate units with individual enclosures.

4.7.2 SCOPE OF SUPPLY

4.7.2.1 The transformers shall be furnished with at least the following items:

a) Protection enclosure.

b) Finishing, terminals, and cable glands.

c) Accessories, tools, and spare parts recommended by manufacturer own experience.

d) Drawings and Technical Documentation.

4.7.2.2 Manufacturer shall present complete Technical Documentation (drawings, test reports, manuals, catalogues, maintenance tools list, maintenance accessories list, MTTR (mean time to repair), coils disassembly and assembly detailed procedures, with drawings and weights of each part, lifting drawings, support drawings to receive each disassembled part, drawings of activity sequences, lifting heights, etc.) of transformers, indicating weights, dimensions, thermal dissipation and position of the accessories.

Note: At least, two copies in English language and two copies in Brazilian Portuguese language shall be provided for all reference manuals. 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.

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

4.7.3 CONSTRUCTION AND MECHANICAL REQUIREMENTS

4.7.3.1 CONSTRUCTION MATERIAL (TYPE)

4.7.3.1.1 Power transformers (primary, secondary, and tertiary coils) shall be dry type moulded in epoxy resin under vacuum or encapsulated in epoxy resin under vacuum.

4.7.3.1.2 Lighting transformers shall be dry type moulded in epoxy resin, encapsulated with glass fibre epoxy resin under vacuum or resin impregnated windings.

4.7.3.1.3 Only for oil dehydrator equipment, liquid cooled power transformers are accepted as part of complete package.

4.7.3.1.4 Transformers shall comply with Fire Behaviour Class F1, according to IEC 60076-11.

4.7.3.2 TEMPERATURE RISE, CLIMATIC AND ENVIRONMENTAL CLASSES

4.7.3.2.1 The permissible temperature rise referred to environmental conditions shall be as a maximum average, equal to 80ºC for the outer winding(s) and 100ºC for the inner winding(s), according to IEC 60076-11.

4.7.3.2.2 Transformers shall comply with Climatic Class C2, according to IEC 60076-11.

4.7.3.2.3 Transformers shall comply with Environmental Class E2, according to IEC 60076-11.

4.7.3.3 SHORT-CIRCUIT CURRENTS

4.7.3.3.1 Transformers shall withstand the dynamic and thermal effects of short-circuit current at the secondary and all other terminals according to IEC 60076-11 and IEC 60076-5.

4.7.3.3.2 They shall be suitable for a short-circuit level, next to the primary terminals, equal to that of the supply panel busbar.

4.7.3.4 WINDINGS CHARACTERISTICS

4.7.3.4.1 The primary and secondary windings shall have F Class (155ºC) insulation.

4.7.3.4.2 The MV (Medium-Voltage) and LV (Low-Voltage) windings shall be separated from each other.

4.7.3.4.3 The insulation resin shall be non-fire propagating and self-extinguishing and, in case of fire, shall not release toxic gases.

4.7.3.4.4 Their construction shall permit the removal of each winding separately, for maintenance in site. The core assembly shall enable the removal of the coils in the field, if this should become necessary.

4.7.3.4.5 Both windings shall have uniform insulation to permit their operation, indifferently, with grounded or insulated neutral systems.

4.7.3.4.6 Lifetime shall be at least 25 years.

4.7.3.4.7 Maximum temperature after short-circuit shall be under limits of IEC 60076-5.

4.7.3.4.8 Medium-voltage transformers with secondary neutral isolated shall have an earthed shield between the primary and the secondary winding.

4.7.3.5 ENCLOSURE

4.7.3.5.1 Manufacturer shall supply a latticed protection enclosure, with suitable ventilation, for each transformer to protect against accidental contacts, with protection degree specified in Table 3.

4.7.3.5.2 The enclosure grating shall enable thermographic inspection of transformer windings and connections with no necessity to open the enclosure.

4.7.3.5.3 Facilities for lifting of the complete transformers and for their horizontal displacements shall be supplied.

4.7.3.6 FEEDING CABLES AND BUS TRUNKING

4.7.3.6.1 All conducting parts at the high voltage side shall be insulated with resin.

4.7.3.6.2 No stress shall be applied to bushings or terminations. These fixing devices shall be built of non-magnetic material.

4.7.3.6.3 When copper/aluminium connections exist, these shall be encapsulated.

4.7.3.6.4 For transformers with bus trunking connections, flanged terminations shall be provided. Galvanic insulation shall be provided to avoid electrolytic corrosion in case of dissimilar metallic material.

4.7.3.6.5 For cables specification characteristics see section 5.13.

4.7.3.6.6 For bus trunking specification characteristics see section 4.9.

4.7.3.6.7 For optional EPOXY resin insulated bus bars specification characteristics see section 0.

4.7.3.7 NEUTRAL CONNECTIONS

Transformer secondary neutral point shall be connected to a terminal accessible and clearly marked according to IEC TR 60616.

4.7.3.8 NOISE LEVEL

Transformers shall be designed and constructed in way that, at full load, the noise level shall not exceed the values indicated in I-ET-3010.00-1200-300-P4X-001 – NOISE AND VIBRATION CONTROL REQUIREMENTS and calculated by IEC 60076-10. The most restrictive criteria shall be considered.

4.7.3.9 CONDUCTORS

4.7.3.9.1 Conductors of auxiliary circuits shall be of stranded copper, complying with requirements of item 5.13.

4.7.3.9.2 The minimum conductor gauge shall be of:

- 1.5 mm^2 for control circuits.
- 2.5 mm^2 for power and VT circuits.
- 4 mm^2 for CT circuits.

4.7.3.9.3 The minimum conductor cross section inside panels for signal circuits shall be:

- 1 mm^2 for discrete signals cables.
- 0.5 mm^2 for analogue signals cables.

4.7.3.9.4 Cables shall be grouped on a properly identified terminal block. Each block shall have at least 20% of reserve terminals. Terminals shall be eye type.

4.7.3.10 FACILITIES FOR GROUNDING

4.7.3.10.1 Facilities shall be provided to allow grounding, through screwed connectors, separately, to the transformer frame to the terminal block box and to the enclosure.

4.7.3.10.2 The manufacturer shall make the interconnection of these components with copper cables with minimum gauge according to I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS and complying with requirements of item 5.13.

4.7.3.10.3 Facilities shall be provided to allow temporary grounding by means of ground cables, through screwed connectors, separately, to the transformer frame to the terminal block box and to the enclosure.

4.7.3.11 TOOLS LIST

Manufacturer shall present a list of necessary tools for maintenance.

4.7.3.12 TERMINALS

4.7.3.12.1 Terminals shall be moulded in epoxy resin.

4.7.3.12.2 Terminals shall be silver-coated (minimum thickness of 0.008mm).

4.7.4 ELECTRICAL REQUIREMENTS

4.7.4.1 LOSSES AND EFFICIENCY

4.7.4.1.1 No-load losses and on-load losses, measured at rated voltage and frequency, at 115ºC central tap position, shall be clearly indicated on Datasheet.

4.7.4.1.2 Efficiency values shall be informed as defined in IEC TS 60076-20.

4.7.4.2 SHORT-CIRCUIT IMPEDANCE

4.7.4.2.1 This value at rated frequency and at 115ºC shall be indicated/confirmed on Datasheet.

4.7.4.2.2 For three winding transformers, all impedances are indicated as percentage (%) or per unit values referred to the base power correspondent to the lowest rated power between the involved windings.

4.7.4.2.3 All Short-circuit impedance values shall be calculated referenced to rated power by natural cooling, without forced ventilation increased power margins.

4.7.4.3 INRUSH CURRENT

4.7.4.3.1 The initial magnetizing inrush current peak value resulting from transformer primary winding to secondary winding energization shall be informed in transformer datasheet.

Note: For specific purposes, initial magnetizing inrush current peak value resulting from transformer secondary winding to primary winding energization shall be informed in datasheet indicating if the values are measured, calculated or estimated.

4.7.4.4 TYPE OF CONNECTION

Unless otherwise stated, the type of connection shall follow the indication presented on Table 7.

Table 7 - Reference Type of Connections for Transformers

Transformer Type	Type of Connection Required
Medium-Voltage Power Transformers	Dyn1 (1)
Low-Voltage Power Transformers	Dyn1 (1)
Transformers for Non-Linear Loads	See Datasheet
Distribution Transformers with Secondary Voltage up to 240V	Dyn1 (1)

Notes: (1) Dyn1 vector group, according to IEC 60076, with the low-voltage phases lagging the corresponding high voltage phases.

4.7.4.5 VOLTAGE TAPS

4.7.4.5.1 Unless otherwise stated in Datasheet, all transformers shall be provided with no-load tap changer at the higher voltage side with the taps presented in Table 8.

4.7.4.5.2 Tap changers shall comply with IEC 60214 parts 1 and 2.

Table 8 - Reference Voltage Taps for Transformers

Transformer Type \ Taps Required	- 5%	- 2.5%	V_r	+ 2.5%	+ 5%
Power Transformers	X	X	X	X	X
Distribution Transformers with Secondary Voltage up to 240V	X	X	X	X	X

4.7.4.6 TRANSFORMERS TESTS

4.7.4.6.1 Where indicated, according to Table 9, Type Tests (TT), Routine Tests (RT), and Special Tests (ST) shall be carried out for transformers following the reference standards and acceptance criteria.

Table 9 - Reference Tests Applied for Transformers

Transformer	Test	TT	RT	ST	Method and Acceptance Criteria
All Types	Measurements of winding resistance		X		IEC 60076-1
All Types	Measurement on voltage ratio		X		IEC 60076-1
All Types	Check of phase displacement		X		IEC 60076-1
All Types	Measurement of short-circuit impedance		X		IEC 60076-1 and IEC 60076-11
All Types	Measurement of load loss		X		IEC 60076-1 and IEC 60076-11
All Types	Measurement of no-load loss		X		IEC 60076-1
All Types	Measurement of no-load current		X		IEC 60076-1
All Dry Type	Separate-source A.C. withstand voltage test		X		IEC 60076-3 and IEC 60076-11
All Dry Type	Induced A.C. withstand voltage test		X		IEC 60076-3 and IEC 60076-11
All Dry Type	Lightning impulse test	X			IEC 60076-3 and IEC 60076-11
All MV Dry Type	Partial discharge measurement		X	X	IEC 60270, IEC 60076-3, and IEC 60076-11
All Types	Temperature rise tests (4)	X			IEC 60076-2 and IEC 60076-11
All Types	Determination of sound levels			X	IEC 60076-10 and IEC 60076-11
All Types	Short-circuit withstand test	X			IEC 60076-11 and IEC 60076-5
All Dry Type	Environmental tests	X			IEC 60076-11
All Types	Climatic tests	X			IEC 60076-11
(6)	Fire behaviour test	X			IEC 60076-11
All Types	Degree of protection of enclosure	X			IEC 60529
(7)	On-load tap changers tests			X	IEC 60076-1 and IEC 60214-1
All MV	Determination of capacitance windings-to-earth, and between windings			X	IEC 60076-1
All MV	Measurement of zero-sequence impedance(s) on three phase transformers			X	IEC 60076-1
All Types	Measurement of harmonics of the load current (5)		X		IEC 60076-1 and IEC 61378
(7)	Measurement of power taken by fan or oil pump motors	X			IEC 60076-1
All MV	Measurement of insulation resistance to earth of the windings, and/or measurement of the dissipation factor (tan δ) of the insulation system capacitances. (1)			X	IEC 60076-1
All MV	Measurement of frequency response			X	IEC 60076-18

Notes:
1) According to IEC, these are reference values for comparison with later measurement in the field. No limitations for the values are given.
2) In case of test methods that are not prescribed in the reference standards or listed in Table 9, they shall be presented to prior evaluation and approval by PETROBRAS.
3) IEC 60076-11 only for dry type transformers.
4) Thermograph measurements report shall be issued for temperature rise test certifying the inexistence of hot spots.
5) Only for transformers dedicated to non-linear loads.
6) Only when fire behaviour F1 is selected.
7) For all transformers with this equipment

4.7.4.6.2 The reports and measurement of frequency response tests shall be done in the following moments: at factory acceptance tests; at delivery at site, and commissioning. All results shall be recorded in digital media for comparison at each moment indicated and for warranty verification. The test shall be performed in all transformer windings.

4.7.5 POWER TRANSFORMERS

4.7.5.1 Power transformers shall be furnished according to IEC 60076.

4.7.5.2 Unless otherwise stated, all power transformers shall have the same connection type and phase displacement to permit parallel continuous operation.

4.7.5.3 For power transformers, a project report shall be issued during the design phase showing the calculations of magnetic flux and temperature distribution profiles. This report shall be presented to PETROBRAS approval before the manufacturing of the transformers.

4.7.5.4 Unless otherwise stated, power transformers shall be furnished with at least the following items, additionally to items related on item 4.7.2.1:

a) Thermal protection relays (49 Function) for each secondary voltage side winding with as required in 4.7.5.6, 4.7.5.7, 4.7.5.8 and 4.7.5.9;

b) Provisions to receive future fans for forced ventilation.

c) Complete forced ventilation equipment, when required in Datasheet.

d) Surge arresters, if required by the System Studies.

4.7.5.5 Provisions for future forced ventilation shall include temperature sensors, instruments and their circuits, design of transformer core spaces for fan mounting and all supports, so that, only the fans are not included.

4.7.5.6 Unless otherwise stated in Datasheet, power transformers shall have at least two RTD, platinum resistance temperature detectors type (PT100Ω @ 0°C), per phase of secondary windings. The first RTD is for the forced ventilation activation system, located in the transformer and to over temperature protection relay, located in the transformer. The second one is reserve. Both shall be connected to temperature protection relay and operational.

4.7.5.7 Power transformers with two windings shall have thermal protection relays (function 49) monitoring the secondary windings. The following hardwired signals shall be available for external use:

- high temperature in windings - trip signal and
- high temperature in windings - alarm signal.

The other signals shall be available through network communication. For more information,

refer to I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE and I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

Trip action only if high temperature value is detected in two or three phases of the transformer. If the high temperature value is detected in only one phase, only alarm signal shall be generated.

4.7.5.8 For Power transformers with more than two windings:

a) They shall have thermal protection relays (function 49) monitoring each low-voltage winding.

b) Trip signals for each winding shall be independent from each other, so that, in case of overheating in one secondary winding, this winding could be turned off and the other secondary is kept operating.

c) There shall be available individual trip signal for each winding (secondary/tertiary circuit breaker) and additionally, one trip signal related to simultaneous trip in all windings (primary circuit breaker).

d) Trip action only if high temperature value is detected in two or three phases of the transformer.

e) If the high temperature value is detected in only one phase, only alarm signal shall be generated.

f) Other signals shall be available through network communication. For more information, refer to I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE and I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

4.7.5.9 For transformers with more than two windings, the following hardwired signals shall be available for external use:

- individual trip signal for each winding.
- collective trip signal (simultaneous trip in all windings).
- individual high temperature alarm for each winding and forced ventilation status (turned on/off).

4.7.5.10 For transformers with medium-voltage secondaries, in-rush currents shall be limited to 10 times the nominal current.

4.7.5.11 Unless otherwise stated in Datasheet, power transformer thermal protection relays shall be fed by available voltage (220VDC), as required in I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.

4.7.5.12 Power transformers in 13.8 kV shall be provided with their primary winding “V/f x time” curves. It shall be used for correcting set up of V/f protection in generators and to be coordinated with transformer supportability curves.

4.7.6 TRANSFORMERS FOR NON-LINEAR LOADS

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

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

4.7.6.3 Transformers to feed both, linear and non-linear loads shall comply with the requirements of IEC 60076-12 and IEEE C57.110.

4.7.6.4 Unless otherwise stated in Datasheet, RTD location shall be the same as in section 4.7.4.6.2.

4.7.7 DISTRIBUTION TRANSFORMERS WITH SECONDARY UP TO 240V

4.7.7.1 Unless otherwise stated in project documentation, the rated voltages shall be 480-220V.

4.7.7.2 They shall be assembled on metallic boxes.

4.7.7.3 The transformers impedance shall be Z = 4 to 5%, unless otherwise informed in datasheet or project documentation.

Note: Minimum short circuit impedance values are defined in IEC 60076-5.

4.7.8 OIL DEHYDRATOR TRANSFORMERS

4.7.8.1 Independent of technology of oil dehydrator, this equipment shall have transformers with built-in series reactors for limiting short-circuit current at secondary to the value of rated secondary current.

4.7.8.2 For each Oil Dehydrator using A.C. technology, the following configurations are permitted:

a) 3 (three) single-phase transformers mounted on top of the vessel, each one sized for 33% of demand (3x33%). In this configuration, 4 (four) transformers must be provided, being one as stand-by, to be stored in the unit's warehouse. Each transformer must have its own set of electrodes.

b) 2 (two) three-phase transformers mounted on the top of the vessel, each one sized for 100% of demand (2x100%). In this configuration, one of the transformers remains off as stand-by, and each one must have its own set of electrodes, in order to be ready to start the Oil Dehydrator into operation after a failure.

4.7.8.3 For each Oil Dehydrator using A.C./D.C. Technology or Variable Frequency Technology, 2 (two) transformers shall be supplied. Both transformers shall be assembled on the vessel and each one shall be sized for 100% of the demand.

4.7.8.4 These transformers shall have conformity certificates for operation in hazardous areas according to item 3.5 and shall be fitted with pressure safety valves.

4.7.8.5 In order to prevent corona effect, the connection boxes of transformer output and dehydrator electrical input shall be filled in with insulation oil (according to item 4.7.8.11).

4.7.8.6 In order to prevent transformer insulation oil from contamination by oil from dehydrator, it shall be foreseen effective sealing methods between the output connection box of the transformer and the inner part of the transformer and between the electrical input connection box of the dehydrator and the inner part of the dehydrator.

4.7.8.7 Each transformer shall have an indicator panel with:

- Local indication of output voltage of transformer.

- Local indication of output current of transformer.
- Local indication of operation frequency of transformer in case of use of variable frequency technology.
- Output hardwired signal for remote indication of UAM (Unit Alarm Malfunction);
- Output hardwired signal for remote indication of status (on, off).

4.7.8.8 Each oil dehydrator shall have a local junction box with a circuit-breaker to allow disconnection of transformer primary winding from external power source. It shall be possible to block the circuit-breaker in open position with padlock. This local junction box shall permit to operate the circuit-breaker without open it.

4.7.8.9 Leakage detection in each bushing duct between each transformer and the vessel and remote leakage alarm shall be foreseen, turning off the oil dehydrator in case of leakage.

4.7.8.10 Two additional pressure safety valves (PSV) shall be provided and installed in the bushing duct between each transformer and the vessel (two in order to allow oil dehydrator operation during maintenance or calibration of one of the PSVs).

4.7.8.11 Lubrax AV60 IN PETROBRAS oil or other with the same properties shall be used as cooling medium.

4.7.8.12 All transformers shall be fitted with no-load oil immersed tap changers at secondary windings. The number of taps and its voltage levels shall be defined by manufacturer, to ensure the performance of the Oil Dehydrator for the different operational scenarios of the unit. At least 5 (five) taps shall be provided, being the highest voltage level set in 25 kV.

4.7.8.13 The tap-changer operation shall be possible externally, with the tank closed.

4.7.8.14 The secondary winding neutral terminal shall not be available.

4.7.8.15 Transformer tank, tap changer, and secondary terminal boxes shall have oil level indicators.

4.7.8.16 Entrance Bushing and Insulators requirements:

a) Entrance Bushings and Insulators shall be made of NXT-75 resin or TFM-1705 resin.

b) The resin shall be entirely pure and shall not be reprocessed.

c) The Manufacturer for the entrance bushings and for the insulators shall present the resin certification.

d) The material of entrance bushings and insulators shall be made using compression process.

e) X-ray tests, specific mass tests and penetrating tests shall be carried out to guarantee the quality of the material.

4.7.8.17 The connection between the entrance bushings and the electrodes shall be done through a pin and a plate system with a spring to guarantee the good connection even during vibration conditions.

4.7.9 PRE-MAGNETIZATION FOR POWER TRANSFORMERS

4.7.9.1 Pre-magnetization system, when required by Project Documentation, shall be scope of the transformer manufacturer.

4.7.9.2 Pre-magnetization system shall be composed, mainly, of pre-magnetization transformer, control panel, auxiliary transformer (instrument transformer) and switching devices.

4.7.9.3 Unless otherwise defined in Project Documentation, the pre-magnetization device shall be designed by means of an auxiliary transformer, installed, preferably, internally to the main power transformer enclosure.

4.7.9.4 The pre-magnetization device, if external to the transformer, shall have its construction design in agreement to section 4.8 where applicable, if internal to the transformer, it shall follow section 4.7.3, where applicable.

4.7.9.5 The pre-magnetization control panel and the low-voltage contactors (switching devices) shall be externally installed as part of power transformer enclosure if pre-magnetization device is internal to the transformer.

4.7.9.6 The pre-magnetization device shall be able to:

a) Reduce the transformer magnetization current to a value around the rated current of the main power transformer.

b) Cause no additional damping or voltage drop on the input voltage caused by switching on the power transformer.

c) Guarantee no inrush behaviour when the power transformer circuit breaker is closed after the pre-magnetizing process.

4.7.9.7 The pre-magnetization device shall be PLC controlled.

4.7.9.8 PLC signals shall be hardwired interlocked with primary transformer circuit breaker according to I-DE-3010.00-5140-741-P4X-001 - FUNCTIONAL UNITS BLOCK DIAGRAMS.

4.7.9.9 A bypass switch shall be supplied to allow the main transformer energization without the pre-magnetization system.

4.7.9.10 The pre-magnetization device shall have suitable switching and protection devices according to manufacturer standards.

4.7.9.11 Unless otherwise defined in Project Documentation, the pre-magnetization device shall be a complete solution and dedicated for the assigned transformer.

4.7.9.12 Pre-magnetization system operation shall be included in power transformer factory acceptance tests.

4.7.9.13 Unless otherwise defined in Project Documentation, the control panel power supply shall be derived inside the power transformer by an auxiliary transformer (instrument transformer).

4.7.9.14 Pre-magnetization system shall be approved by PETROBRAS.

4.7.10 TRANSFORMER PROTECTION

4.7.10.1 Transformer protection functions shall be according to I-ET-3010.00-5143-700-P4X-001 - ELECTRICAL SYSTEM PROTECTION CRITERIA.

4.8 PANELS

4.8.1 GENERAL

4.8.1.1 The following requirements refer to:

- Main distribution A.C. and D.C. panels up to 240V.
- Low-voltage panels (not MCC or Switchgear) and power transformers forced ventilation control panels up to 480VAC.
- Small heating systems panels in 480 VAC, and all other 480 VAC small panels that are not covered by I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS.
- Secondary distribution and lighting A.C. and D.C. panels up to 240V.
- Distribution Panels fed by Battery Chargers.
- Distribution Panels fed by UPS.
- Control panels, accommodation panels, distribution boards, signalling panels and other similar controlgears.
- Heat tracing panels.

4.8.1.2 Medium-voltage switchgears and medium-voltage MCCs requirements are defined in specific Technical Specification and respective Datasheet.

4.8.1.3 Low-voltage switchgears and low-voltage MCCs requirements are defined in specific Technical Specification and respective Datasheet.

4.8.1.4 A&C (Automation and Control System) Panels' requirements are defined in specific Technical Specification – see I-ET-3010.00-5520-888-P4X-001 - AUTOMATION PANELS.

4.8.1.5 Manufacturer shall inform on Datasheet the panel heat normal and maximum dissipation. Arrangement of equipment and components shall be defined in order that the components generating heat shall not damage or reduce the service capacity of the adjacent elements.

4.8.1.6 Manufacturer shall consider cable sizes for necessary internal space considering panel cable incoming, cable outgoing and future cable provisions for spare outgoings, assuring that internal cable channels will not be damaged. If cable channels are not sufficient for all cable incoming and cable outgoing, specific arrangement shall be informed to PETROBRAS for approval.

4.8.1.7 All panels shall comply with the requirements of the I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS.

4.8.1.8 All panels shall be designed to conditions defined in section 3 and voltage and frequency variations defined respectively in sections 3.8 and 3.9.

4.8.2 SCOPE OF SUPPLY

4.8.2.1 Manufacturer shall supply the panels and all accessories and tools to operate, change spare parts and adjustments, recommended by its own experience, including drawings and technical documentation.

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

4.8.3 CONSTRUCTIVE CHARACTERISTICS

4.8.3.1 GENERAL

All panels shall be designed, manufactured, and tested according to reference Standards presented in item 2.

4.8.3.2 INSULATION LEVELS

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 the requirements of IEC 61439-1.

4.8.3.3 STRUCTURE

4.8.3.3.1 All panels shall be provided with lifting eyelets.

4.8.3.3.2 The manufacturer shall supply the instructions for shipping, transportation, and installation of the panel, as well as the definition of holding points for this purpose.

4.8.3.3.3 Panels shall be able to operate on structures subject to vibrations up to the limits stated in IEC 61892-5.

4.8.3.3.4 It shall be provided at least 20% of spare complete outgoing circuits, including the terminal blocks.

4.8.3.3.5 Panels shall be floor-mounted or wall-mounted, self-supported, fitted with means of access for maintenance from front sections, unless otherwise stated in design documentation.

4.8.3.3.6 Suitable sheet or removable covers shall be provided to avoid contact with energized parts in the interior of the panels, during operation of circuit-breakers.

4.8.3.3.7 On panels with circuit-breakers, the assembly, hardware, busbars, fittings, etc., shall be built in order to allow the interchange, respectively, with all circuit-breakers of the same characteristics.

4.8.3.3.8 The whole structure, including doors, shall withstand the thermal (for a minimum period of one second) and dynamic effects due to short-circuit currents calculated.

4.8.3.3.9 Vertical sections shall have hinged front door. Doors shall be bonded to the panel structure through flexible copper cable. Hinged doors shall have an open position lock device.

4.8.3.3.10 When rear access is required, screwed rear doors shall be fitted with handles to ease their remove and installation.

4.8.3.3.11 Sensible equipment panels and control panels shall be installed in structures free of vibration above the limits of IEC 61892-5. It shall be avoided installation of these types of panels in the structure base, or skid of the controlled equipment.

4.8.3.3.12 For floating units, the floor-mounted panels shall be provided with an insulating handrail in the fixed frontal side.

4.8.3.3.13 The following criteria shall be applied:

a) Panels shall be built with steel sheets AISI 316L.

b) Panels for external non-hazardous areas: as above, but wall-mounted type.

c) Panels for hazardous areas: Ex type (see Table 3).

d) Panels built with steel sheets, shall have hinged door with latch.

4.8.3.4 THERMAL INSPECTION FACILITIES

The panels shall be constructed so that thermal inspection by optical infrared thermographic devices could be safely performed with the circuits energized.

4.8.3.5 BUSBAR

4.8.3.5.1 Panel shall have busbars of electrolytic copper in A.C. systems, identified with coloured strips as follows:

a) Phase: red, white, and black (R – S – T, respectively).

b) Neutral: light blue according to IEC 60445.

c) Ground: bi-colour combination green-and-yellow according to IEC 60445.

4.8.3.5.2 Panel shall have busbars of electrolytic copper in D.C. systems, identified with coloured strips as follows:

a) Positive pole: red.

b) Negative pole: black.

4.8.3.5.3 The panels' 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.

4.8.3.5.4 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.

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

4.8.3.5.6 Bars at junction points shall be silver-coated (minimum thickness of 0.008mm) and placed in such manner to guarantee a perfect alignment and high-pressure contact.

Note: PETROBRAS preferred option is to have both sides of contact bus bar silver coated; however, if manufacturing procedures can achieve the same results (one side only or other procedure) it should be sent to PETROBRAS for acknowledge and approval.

4.8.3.5.7 The insulation of bars, supports and junction pieces, shall be of non-hygroscopic and non-fire propagating material. Fiberglass or Celeron shall not be accepted.

4.8.3.5.8 The strength applied on supports shall not exceed the minimum rupture load of insulators, guaranteed by respective manufacturers.

4.8.3.6 GROUNDING BUSBARS

4.8.3.6.1 All panels shall be supplied with internal grounding busbars.

4.8.3.6.2 Floor-mounted panels shall have the PE grounding bar installed in the lower part and supplied with non-welded type connectors, suitable for bare stranded copper cable with cross-sectional area according to I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS.

4.8.3.6.3 Wall-mounted panels shall have an external terminal with non-welded type connector, suitable for connection to bare stranded copper cable, with cross-sectional area according to I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS, installed in one of the lateral sides of the panels. The PE grounding busbar shall be internally connected to this terminal.

4.8.3.6.4 In systems with solidly grounded neutral, the neutral busbar, when required, shall be internally connected to the grounding busbar.

4.8.3.6.5 All panel metallic parts, which are not intended for current conduction, shall be interconnected to the grounding bar, including movable parts.

4.8.3.6.6 Panels with electronic components shall have an “Electronic Reference Bar”, duly identified, complying with requirements of IEC 61000-5-2, for connection of electronic reference grounding terminals of instruments, sensors, and intelligent devices.

4.8.3.6.7 Panels shall have an IS grounding bar if it is required by circuit loads.

4.8.3.7 WIRING AND CONDUCTORS

4.8.3.7.1 All internal conductors shall comply with requirements of item 5.13.

4.8.3.7.2 The minimum conductor cross section shall be:

- 1.5 mm^2 for control circuits.
- 2.5 mm^2 for power and VT (Voltage Transformer) circuits.
- 4 mm^2 for CT (Current Transformer) circuits.

4.8.3.7.3 The minimum conductor cross section inside panels for signal circuits shall be:

- 1 mm2 for discrete signals cables.
- 0.5 mm2 for analogue signal cables.

4.8.3.7.4 Equipment assembled on the doors shall be connected with extra flexible conductors.

4.8.3.7.5 For panels installed outdoors, all cables entrances shall be through panels’ bottom side.

4.8.3.7.6 For cable entrance, the manufacturer shall provide removable aluminium or non-magnetizing material plates for installation of cable glands. The use of any type of sealing mass for cable entrance is forbidden.

4.8.3.7.7 Panel shall be delivered with all connections for instruments, transformers, controls and wiring between the units and sections installed. The interconnection wiring between sections needing to be separated for transportation shall end on terminal blocks, in order that jumpers shall complete the interconnection, when the sections are assembled.

4.8.3.7.8 The cables shall be grouped in lugs strips, properly identified at the ends. The panel shall be provided with all connections between installed components done.

4.8.3.8 PAINTING

4.8.3.8.1 The painting of electrical panels shall be according to item 3.6.3.

4.8.3.8.2 The painting of control panels shall be according to I-ET-3010.00-5520-888-P4X-001 - AUTOMATION PANELS.

4.8.3.9 IDENTIFICATION NAMEPLATE AND INFORMATION LABELS

4.8.3.9.1 All drawers, compartments, columns, and internal components shall be identified by means of black acrylic labels engraved with white letter.

Note: for small internal components (i.e.: small circuit-breakers, contactors, auxiliary relays) where acrylic labels are not feasible due to constrict sizes and small spaces, adhesive labels are allowed.

4.8.3.9.2 All panels shall have a label identifying the grounding system for the power and control systems.

4.8.3.9.3 All panels' incoming functional units shall have a label identifying the panel TAG of the feeding circuit.

4.8.3.9.4 All panels fed by uninterrupted power systems shall have a label informing expected autonomy in hours and minutes.

4.8.3.9.5 All functional units in panels that are in isolated ground system shall have a label informing if they will or not be shut down in case of fault to ground.

4.8.3.10 CIRCUIT-BREAKERS

4.8.3.10.1 Circuit-breakers shall be manufactured and tested according to recommendations of IEC 60947-2 and IEC 61439-2.

4.8.3.10.2 Power circuit-breakers shall have test certificate, furnished by a recognized laboratory in accordance with standards IEC 61439-2 and IEC 60947-2.

4.8.3.10.3 The control circuits auxiliary contacts and changeover switches shall be connected to the fixed part by plugs.

4.8.3.10.4 Circuit-breakers of same characteristics shall be interchangeable.

4.8.3.10.5 The rated ultimate short-circuit breaking capacity (Icu), the rated service short-circuit breaking capacity (Ics), the rated short time withstand current (Icw) and the rated short-circuit making capacity (Icm) shall be higher than the maximum short-circuit current indicated in the short-circuit calculation reports.

4.8.3.10.6 Circuit-breakers shall be provided with the interlocking and parallel operation mentioned in one-line diagram and in this specification.

Note: All interlocking and parallel operation allowed and not allowed shall be informed in a specific document issued during detailed design. A label with reference to interlocking and parallel operation allowed and not allowed document and a resume of main circuit breaker interlocking and parallel operation, allowed and not allowed, shall be provided.

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

- Socket-outlets for external areas when fed from high resistance grounded or bolted grounded systems (not required for isolated systems).
- Laundry circuits, including socket-outlets.
- Kitchen circuits, including socket-outlets.
- Hospital circuits, including socket-outlets.
- Accommodation circuits.
- Lighting and sockets located inside panels.

4.8.3.10.8 It shall be possible to block the circuit-breaker in open position with padlock for panel incoming and primary outgoing circuit-breakers.

4.8.3.10.9 Circuit-breakers for D.C. panels shall protect both circuit poles.

4.8.3.10.10 Incoming panel circuit-breakers shall be located near panel cable entrances.

4.8.3.11 INSTRUMENT TRANSFORMERS

For instrument transformers see item 4.28.

4.8.3.12 MICROPROCESSOR-BASED MULTIFUNCTION PROTECTION RELAYS (MMR)

For MMR requirements, see item 4.11.

4.8.3.13 LOCKOUT RELAYS

For lockout relays requirements, see 4.12.

4.8.3.14 INTELLIGENT RELAYS

For intelligent relays requirements, see 4.13.

4.8.3.15 AUXILIARY RELAYS

For auxiliary relays requirements, see 4.14.

4.8.3.16 INSTRUMENTS

4.8.3.16.1 All instruments shall comply with requirements of I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS.

4.8.3.16.2 All discrete input/output signals for instrumentation shall be voltage free (dry-contacts).

4.8.3.16.3 All indicating instruments shall have external zero adjustment, accuracy of 1.5%, white scale, black markings.

4.8.3.16.4 They shall be immune to electromagnetic interference and radio interference according to IEC 61000.

4.8.3.16.5 The active energy meters shall have a maximum demand indicator ranging for the last 15 (fifteen) minutes.

4.8.3.16.6 Preference shall be given to discrete measuring devices, having the capacity of data gathering and data availability through digital communication port.

4.8.3.16.7 These meters shall be able to indicate a reverse power up to 15% of the rated power.

4.8.3.17 HEATING RESISTORS

4.8.3.17.1 Panels shall be provided with heating resistors, (one for each vertical section or compartment), in 220VAC. The resistors shall be automatically controlled by means of a thermostat with scale up to 60ºC maximum. A circuit-breaker shall be provided on each resistor circuit.

4.8.3.17.2 Panels shall be provided with external (220Volts, two phases) outlet to energize the heating circuits during the storage period.

4.8.3.17.3 Space heaters shall be protected against accidental contacts. The wiring next to them (about 300mm) shall have proper insulation in order to avoid damages due to overtemperature.

4.8.3.18 LIGHTING

Unless otherwise defined in project documentation or panel datasheet, panels shall be provided with internal (220Volts, two phases) outlet to energize the internal lighting circuits.

4.8.3.19 SIGNALLING

According to the respective One-Line Diagram, each compartment shall have high luminosity signalling LEDs, with colours according to I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS.

4.8.3.20 TERMINALS FOR POWER CIRCUITS

All necessary terminals for connection with external power cables shall be supplied with the Panel.

4.8.3.21 FACILITIES FOR TEMPORARY GROUNDING

Facilities shall be provided to allow temporary grounding by means of ground cables, through screwed connectors, separately, to the panel frame to the terminal block box and to the enclosure.

4.8.3.22 CHANNELS

Channels shall be made of non-fire propagating material.

4.8.3.23 TESTS

Manufacturer shall carry out all tests indicated in Table 10 and all tests foreseen in standards listed in item 2.

Table 10 - Reference Test Requirements for Panels

Test Description
Visual inspection, with verification of construction in general, surfaces, structures and supports finishing and dimensions.
Mechanical tests, with verification of suitable operation of mechanical parts, such as circuit-breakers connection devices, interlock mechanisms, doors, etc.
Withstand voltage test, at 60 Hz, dry, on the main insulation components.
Verification of wiring continuity according to the last approved wiring diagrams.
Wiring insulation test.
Complete operational test, with verification of measuring instruments and relays regarding calibration and operation. After assembled, all components of control circuits and auxiliaries shall be energized with the respective rated voltages to verify the perfect operation of all concerned components (relays, measuring instruments, signalling lamps, heating resistors, etc). Instrument transformer polarities shall be verified.
Verification of painting procedures for internal and external surfaces.
Verification of nameplates arrangement, internally and externally.
Verification of the instruments and components assembled on panel.
Test of electric insulation for 1 (one) minute, between conductors and grounding, which shall have a value above of 100 Megaohms.
Note: Short Circuit test supportability test certificate shall be issued for 220VAC low voltage panels with short circuit current rating ≥ 10 kA, as required by IEC 61439-1.

4.8.4 A.C. MAIN DISTRIBUTION PANELS UP TO 240V

4.8.4.1 GENERAL

This item refers to main distribution panels up to 240V, connected to secondary winding of 480-220/127V or 480-220V transformers.

4.8.4.2 STRUCTURE

Panels shall be built with steel sheets, according to items 3.6.5 and 4.8.3.

4.8.4.3 INCOMING AND OUTGOING CIRCUITS CHARACTERISTICS

4.8.4.3.1 Two incoming circuit-breakers and one tie circuit-breaker shall be provided, mechanically interlocked through “KIRK” blocking, to avoid transformers parallel operation.

4.8.4.3.2 All outgoing feeders shall be protected with moulded-case circuit-breakers. All outgoing circuit-breakers of normal 220VAC Main Distribution Panels and outgoing circuit-breakers for HVAC essential loads panels shall have shunt-trip coils, in order to allow selective safety shutdown from A&C. The shutdown of the panels shall be selective, according to the supplied location (e.g.: modules). Other circuit-breakers for essential and emergency distribution panels shall not have shunt trip coils.

4.8.4.3.3 All ESD signals triggered by fire or gas detection shall trip outgoing circuit-breakers of normal distribution panels in order to avoid necessity of individual control of theses circuit in each load.

4.8.4.3.4 All panels expected to receive ESD or other wet signals from A&C or Package Control Panels shall have interposing relays with enough quantity to convert discrete 24 VDC signal in discrete voltage-free signal.

4.8.4.3.5 There shall be an identification label, next to each circuit-breaker, with identification of the circuit and of the load fed by the circuit-breaker.

4.8.4.3.6 Unless otherwise stated in Data Sheet, there shall be at least 3 (three) spare circuit-breakers installed in each busbar.

4.8.4.4 CIRCUIT-BREAKERS

4.8.4.4.1 Circuit-breakers shall be manufactured according to recommendations of standards mentioned on item 2 of this specification and suitable to interrupt the circuits to which they are connected.

4.8.4.4.2 They shall be moulded-case type, not being permitted the use of single-pole circuit-breakers mechanically coupled.

4.8.4.4.3 Each circuit-breaker shall have on each phase, direct action short-time, long-time and instantaneous tripping devices (STD/LTD and INST).

4.8.4.4.4 Circuit-breakers shall be provided with devices to neutralize the environmental temperature variation effect over their tripping devices.

4.8.4.4.5 The opening mechanism shall be “trip-free” type.

4.8.4.5 BUSBAR

4.8.4.5.1 Panels shall have five electrolytic copper busbars (three phases plus neutral plus grounding) dimensioned for rated current and to withstand the thermal and mechanical stresses due to short-circuit current.

4.8.4.5.2 Panels for isolated neutral systems shall not have neutral busbar.

4.8.4.6 INTELLIGENT RELAYS (IRs)

4.8.4.6.1 Panels shall have intelligent relays (IRs) according to 4.13.

4.8.4.7 GROUND FAULT DETECTION

4.8.4.7.1 One insulation monitoring device shall be installed in each busbar of A.C. Main Distribution Panels up to 240V with isolated neutral.

4.8.4.7.2 The insulation monitoring devices shall indicate the measured insulation ohmic value between phases and between phases and ground.

4.8.4.7.3 For panels with possibility to operate in "l" configuration with interconnection circuit-breakers closed, it shall be provided a logic to disable one of insulation monitoring devices in this condition. It shall also be provided a logic to enable both of insulation monitoring devices during the return to "ii" configuration.

4.8.4.7.4 In distribution panels, individual earth fault indicators shall be installed for loads located in Zone 1 or loads where the feeding cable crosses Zone 1.

4.8.4.7.5 For the other cases, not in above conditions of 4.8.4.7.4, loads shall be grouped in one individual earth fault indicator.

4.8.4.7.6 One portable ground fault detector shall be supplied by BIDDER in order to detect faults through specific portable current-clamp meter, proper for D.C. and A.C. systems. This device shall be capable to detect all faults when until three different sensors are simultaneously activated by faulted circuits.

4.8.4.7.7 The outgoing cables for all circuits shall be installed in a way to enable easy access to clamp them with a portable ground fault detector, with the circuit energized. The shields shall be installed according to the detector requirements.

4.8.4.7.8 The insulation monitoring devices shall send a discrete alarm signal to an IED (IR) inside the panel, through a voltage free contact (1A @ 220VAC PF 0.4).

4.8.4.7.9 Each bar or semi-bar of the panel shall be supplied with devices to indicate defective phase by means of three lamps connected between phases and ground through a NO (normally open) push-button.

Note: In case of use of ground fault location devices, it is forbidden the use of voltage transformers connected YNyn (two neutral grounded).

4.8.4.7.10 To indicate that the ground fault detection device is turn off, an alarm shall be sent to IED (IR) installed inside the panel through a voltage free contact (1A @ 220VAC PF 0.4).

4.8.4.8 INTERFACE SIGNALS

4.8.4.8.1 Panels shall include an IED (IR) in order to obtain all signals from internal components as required by I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

4.8.4.8.2 The IED (IR) shall communicate with protocols according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM and I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE.

4.8.5 A.C. SECONDARY DISTRIBUTION, D.C., AND LIGHTING PANELS UP TO 240V

4.8.5.1 GENERAL

4.8.5.1.1 Requirements contained on this item apply to following panels:

a) Lighting panels for accommodation.

b) Lighting panels for external non-hazardous areas.

c) Lighting panels for hazardous areas.

d) Main distribution 220VDC panels for emergency lighting system.

e) Main distribution 125VDC panels for navigation aid lighting system.

f) Main distribution 125VDC panels for emergency auxiliary loads of big compressors.

g) Main distribution 125VDC panels for emergency auxiliary loads of turbogenerators.

h) UPS A.C. and D.C. secondary distribution panels.

4.8.5.1.2 In 4.8.5.1.1, f) and g) panels shall have two incoming feeder and one bus tie circuit-breaker.

4.8.5.1.3 For the all the other panels in 4.8.5.1.1, they shall have one single incoming feeder, without bus tie circuit-breaker.

4.8.5.2 STRUCTURE

4.8.5.2.1 Panels shall be built with steel sheets, according to items 3.6.5 and 4.8.3.

4.8.5.2.2 Lighting Panels may follow 4.8.5.2.1 or, for external areas, be made of non-metallic material, complying with requirements of section 5.2.

4.8.5.3 BUSBAR

4.8.5.3.1 A.C. panels shall have five electrolytic copper busbars (three phases plus neutral plus grounding) dimensioned for rated current and to withstand the thermal and mechanical strength of the short-circuit current.

4.8.5.3.2 Panels for isolated neutral systems shall not have neutral busbar.

4.8.5.3.3 D.C. panels shall have three electrolytic copper busbars (two poles and grounding) dimensioned for rated current and to withstand the thermal and mechanical strength of the short-circuit current.

4.8.5.3.4 220VDC Main Emergency Lighting Panels shall have, besides the main busbar, a second busbar, connected to the main busbar by circuit-breaker, in order to split the loads according to the lighting autonomy time requirements (see ELECTRICAL SYSTEM DESCRIPTIVE MEMORANDUM).

4.8.5.4 INTELLIGENT RELAYS (IRs)

4.8.5.4.1 Main distribution 220VDC panels for emergency lighting system, main distribution 125VDC panels for navigation aid lighting system, main distribution 125VDC panels for emergency auxiliary loads of big compressors, main distribution 125VDC panels for emergency auxiliary loads of turbogenerators and distribution panels for heating resistors of panels and motors shall have intelligent relays (IRs) according to 4.13.

4.8.5.5 GROUND FAULT DETECTION

4.8.5.5.1 One insulation monitoring device shall be installed in each busbar of the following panels:

- 220VDC Main Distribution Panels for emergency lighting system.
- 125VDC Main Distribution Panel for navigation aid system.

  Note: for D.C. UPS panels see 4.18.7.
- Turbogenerator emergency auxiliary panels.
- Compressor emergency auxiliary panels.

4.8.5.5.2 The insulation monitoring devices shall indicate the measured ohmic value between poles and between poles and ground.

4.8.5.5.3 In distribution panels, individual earth fault indicators shall be installed for loads located in Zone 1 or loads where the feeding cable crosses Zone 1.

4.8.5.5.4 For the other cases, not in above conditions of 4.8.5.5.3, loads shall be grouped in one individual earth fault indicators.

4.8.5.5.5 For space-heaters, heat tracing and lighting panels it shall be used a specific portable current-clamp meter.

4.8.5.5.6 One portable ground fault detector shall be supplied by BIDDER in order to detect faults through specific portable current-clamp meter, proper for D.C. and A.C. systems. This device shall be capable to detect all faults, even if three different circuits are faulted simultaneously.

4.8.5.5.7 The outgoing cables for all circuits shall be installed in a way to enable easy access to clamp them with a portable ground fault detector, with the circuit energized. The shields shall be installed according to the detector requirements.

4.8.5.5.8 The insulation monitoring devices shall send a discrete alarm signal to an IED (IR) inside the panel, through a voltage free contact (1A @ 220VDC). to Electrical System Automation Panel, indicating low insulation resistance.

4.8.5.5.9 To indicate that the ground fault detection device is turn off, an alarm shall be installed.

4.8.5.6 INCOMING FEEDERS

4.8.5.6.1 A load switch, minimum AC-22B, as defined in IEC 60947-3, shall be used in case of incoming feeder is already protected by a circuit breaker in the upstream panel.

4.8.5.6.2 Circuit-breakers shall be used at the incoming feeders only if there is protection coordination study with upstream panels.

4.8.5.7 OUTGOING FEEDERS

4.8.5.7.1 Outgoing circuits shall be protected by thermomagnetic moulded-case circuit-breakers, suitable to interrupt short-circuit and overload currents. For lighting panels, miniature type circuit-breakers shall be used.

4.8.5.7.2 The outgoings shall be connected through non-welded type connectors appropriated to the cross-section of the specified cables.

4.8.5.7.3 In case of bipolar circuits, it shall not be allowed the use of single pole circuit-breakers, mechanically coupled.

4.8.5.7.4 Unless otherwise stated in Data Sheet, there shall be at least 4 (four) spare circuit-breakers installed in these panels.

4.8.5.7.5 Panel shall be supplied with enough space for future inclusion of new circuits.

4.8.5.7.6 There shall be an identification label, next to each circuit-breaker, with identification of the circuit and of the load fed by the circuit-breaker.

4.8.5.7.7 The bipolar circuit-breakers shall be identified, using the respective numbers of each bar.

4.8.5.7.8 Circuit-breakers for D.C. panels shall protect both circuit poles.

4.8.5.7.9 Navigation aid lighting panel systems, feeding navigation aid lights located in high positions and subject to lighting discharges effects:

- In 125 VDC, shall have surge arresters at outgoing circuits for lightning discharges secondary effect protection. These surge arresters shall comply with section 4.26. In this case, it shall be adopted a hybrid protection composed by spark-gap and varistor or transient-voltage-suppression diode.
- In 120 or other VAC voltage, shall have surge arresters at outgoing circuits for lightning discharges secondary effect protection. These surge arresters shall comply with section 4.26. In this case, it shall be adopted a hybrid protection composed by spark-gap and

varistor or transient-voltage-suppression diode; Additionally, this outgoing circuit shall have insulation 1:1 transformer grounded at secondary side at outgoing circuits for lighting discharges secondary effect protection.

4.8.5.7.10 For emergency lightning panels incoming circuits, it shall be provided a remote alarming of tripped circuit to a supervisory monitoring system, as required in IEC 61892-2.

4.8.5.8 INTERFACE SIGNALS

4.8.5.8.1 All signals between panels and other equipment shall comply with I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

4.8.6 UPS MAIN DISTRIBUTION PANELS

For A.C. UPS Main Distribution Panels follow the requirements of I-ET-3010.00-5265-773-P4X-001 - UNINTERRUPTIBLE POWER SUPPLY FOR OFFSHORE UNITS.

For D.C. UPS Main Distribution Panels follow the requirements of section 4.18.7.

4.8.7 ELECTRICAL CONTROL PANELS

4.8.7.1 Unless otherwise stated, electrical control panels installed in safe areas shall be wall-mounted and built with stainless steel AISI-316L sheets or carbon steel painted according to item 3.6.3.

4.8.7.2 Unless otherwise stated, electrical control panels installed in exposed areas shall be wall-mounted and built with stainless steel AISI-316L sheets.

4.8.7.3 Electrical control panels installed in hazardous areas shall have type of protection Ex according with Table 3.

4.8.7.4 The use of panels with type of protection Ex p shall be submitted to PETROBRAS approval. These panels, when approved, shall be made with stainless steel AISI-316L sheets, provided with regulation valve, pressure indicator, low-pressure local alarm, and low-pressure contact for remote alarm.

4.8.7.5 Automation panels shall comply with I-ET-3010.00-5520-888-P4X-001 - AUTOMATION PANELS.

4.8.8 BOXES OF INTERCONNECTION WITH RIG AND DIVING EQUIPMENT

4.8.8.1 These boxes shall be “Ex de” type, fabricated in non-metallic material (FRP).

4.8.8.2 They shall have insulation switch and socket-outlet mechanically interlocked with the switch.

4.9 BUSBAR TRUNKINGS (BUSWAYS)

4.9.1 GENERAL REQUIREMENTS

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

4.9.1.2 Manufacturer shall provide complete manuals and documentation. MTTR shall be informed.

Note: At least, two copies in English language and two copies in Brazilian Portuguese language shall be provided for all reference manuals. 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.

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

4.9.2 CONSTRUCTIVE CHARACTERISTICS

4.9.2.1 Busbar trunkings shall comply with the requirements of items 4.8.3.5 and 4.8.3.8.

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

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

4.9.2.4 Busbar trunkings protection degree shall comply with Table 3.

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

4.9.2.6 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.

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

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

4.9.2.9 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.

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

4.9.2.11 The internal last coat of enclosure shall be painted in black for better dissipation of heat.

4.9.2.12 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.

4.9.2.13 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.

4.9.2.14 Certificate Reports of seals, issued by reliable laboratory, shall be presented for PETROBRAS approval.

4.9.2.15 The enclosure shall be provided with barriers to prevent the propagation of flame and smoke between the connected equipment.

4.9.2.16 Busbar trunkings interconnecting places with different temperatures, like transformers room and panel's room, shall have sealing means or baffles to prevent interchange of air between the places.

4.9.2.17 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.

4.9.2.18 The sections of the busbar trunking shall be provided with heating resistors, complying with item 4.8.3.17.

4.9.3 ELECTRICAL CHARACTERISTICS

4.9.3.1 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 11, 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 11 - 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

4.9.3.2 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.

4.9.3.3 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.

4.9.4 BUSBARS

4.9.4.1 Busbars shall be three-phase and shall comply with the requirements of item 4.8.3.5.

4.9.4.2 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.

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

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

4.9.4.5 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 and shall comply with requirements of IEC 61439-2.

4.9.5 GROUNDING

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

4.9.5.2 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.

4.9.5.3 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.

4.9.6 TESTS

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

Table 12 – 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	This ET
Verification of temperature rise limits	X		IEC 61892-3
Verification of dielectric properties		X	IEC 61439-2
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	This ET
Verification of heating resistors operation		X	This ET
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 13 – 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	This ET
Verification of temperature rise limits	X		IEC 61892-3
Verification of dielectric properties		X	IEC 62271-200
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	This ET
Verification of heating resistors operation		X	This ET
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.

4.10 EPOXY RESIN INSULATED BUS BARS

4.10.1 GENERAL REQUIREMENTS

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

4.10.1.2 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.

4.10.1.3 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.

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

4.10.2 CONSTRUCTIVE CHARACTERISTICS

4.10.2.1 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.

4.10.2.2 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.

4.10.2.3 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 mm^2 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.

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

4.10.2.5 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°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.

4.10.2.6 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.

4.11 MICROPROCESSOR-BASED MULTIFUNCTION PROTECTION RELAYS (MMR)

4.11.1 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.

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

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

4.11.4 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.

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

4.11.6 The parameterization software shall be provided.

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

4.11.8 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.

4.11.9 Trip contacts shall have at least the following characteristics:

a) application Category 2 as per standard IEC 61810-1.

b) duty factor of 50% according to standard IEC 61810-1.

c) limit setting capacity for 0.5s: 30A (resistive load).

d) rated current in continuous duty: 5A.

e) limit interruption capacity: 1A @ 220VDC.

f) maximum operation time of trip relays shall be 5 ms.

g) maximum contact resistance of 100mΩ, as per standard IEC 61810-7.

h) 1.000.000 no-load operations as per standard IEC 61810-1.

i) 500.000 operations under load as per standard IEC 61810-1.

j) operating frequency under load of 720 cycles per hour as per standard IEC 61810-1.

k) maximum failure rate obtained by accessing results as per standard IEC 61810-2.

4.11.10 The other output contacts shall have at least the following characteristics:

a) rated current in continuous duty: 5A.

b) limit interruption capacity: 1A @ 220VDC.

4.11.11 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.).

4.11.12 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.

4.11.13 MMRs shall have means for implementation of logic selectivity schemes and breaker failure function without the need for external auxiliary relays.

4.11.14 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.

4.11.15 MMRs for protection of motors and generators shall have at least three inputs for platinum resistance temperature detectors (RTDs), three-wire, 100 Ω at 0ºC.

4.11.16 MMRs shall operate properly without exceeding their temperature limit, in continuous duty, under the following conditions:

a) temperature inside the cubicle: 55°C max..

b) ambient room temperature: 45°C max..

c) relative humidity of air: up to 90% non-condensing at 40°C.

d) altitude below 1000 m.

e) damp and salt laden atmosphere.

4.11.17 Thermal cycle test:

a) 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.

b) in case a single unit is rejected, the entire lot shall be tested.

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

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

4.11.20 Manufacturer shall provide complete manuals and documentation. MTTR shall be informed.

Note: At least, two copies in English language and two copies in Brazilian Portuguese language shall be provided for all reference manuals. 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.

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

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

4.11.23 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.

4.11.24 The MMR hardware shall be able to communicate in the IEC 61850 standard natively, without use of external converters or gateways.

4.12 LOCKOUT RELAYS

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

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

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

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

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

4.13 INTELLIGENT RELAYS (IRS)

4.13.1 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.

4.13.2 IRs are installed only in the panels where required in this specification. For IRs in low-voltage MCCs, refer to I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS.

4.13.3 IRs shall be fed by panel busbar where it is installed.

4.13.4 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.

4.13.5 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.

4.13.6 IRs shall have digital inputs and shall be able to supervise input circuit-breakers.

4.13.7 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.

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

4.14 AUXILIARY RELAYS

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

4.15 GROUNDING RESISTORS

4.15.1 Grounding resistors shall be designed, built, and tested according to C57.32, C57.32a, IEC 61892-2 and the requirements of Datasheet.

4.15.2 Grounding resistors for transformers and for main generators shall be installed inside floor-mounted, self-supporting panels. Grounding resistors for main generators can be installed inside the neutral terminal box. The constructive characteristics for these panels shall comply with item 4.8.3.

4.15.3 Grounding resistors shall be provided with insulation suitable for the phase-to-phase voltage of the systems to which they are connected.

4.15.4 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.

4.15.5 Grounding resistors shall be connected to the unit's structure or hull. In addition, grounding resistors shall be connected together on the structure/hull side of the resistor, whereto also the protective grounding (PE) conductor of the distribution system shall be connected. Suitable disconnecting links, which allow for measuring purposes, shall be provided.

4.15.6 The means of connection shall be separate from that provided at the unit's structure or hull for radio, radar, and communications circuits in or to avoid interference.

4.15.7 Features of the neutral grounding methods shall be according to IEC 61892-2.

4.15.8 Unless otherwise stated in Project Documentation, grounding resistors shall comply with the requirements of Table 14. 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.

4.15.9 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.

4.15.10 Grounding resistors for transformers shall be supplied together with 59G relays.

4.15.11 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.

4.15.12 Grounding resistors requirements for painting shall follow 3.6.3.

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

4.15.14 Manufacturer shall provide complete manuals and documentation. MTTR shall be informed.

Note: At least, two copies in English language and two copies in Brazilian Portuguese language shall be provided for all reference manuals. 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.

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

4.15.16 The neutral grounding device tests shall include resistance measurements, dielectric tests, impedance and loss measurements and temperature tests. Equipment type tests are acceptable.

4.15.17 Except for resistor material, all grounding resistors definitions shown in Table 14 shall be in grounding resistor equipment identification plate.

Table 14 - Grounding Resistor Requirements

System Voltage [V]	480	4160/6600	13800
Rated Frequency [Hz]	60	60	60
Taps Quantity	5	5	5
Rated Voltage [V]	480	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	Defined by Detailed Design	Defined by Detailed Design
Environmental Temperature [°C]	According to Table 1		
Maximum Admissible Temperature [°C]	120	120	120
Pedestals Insulation [kV]	0.6 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	According to Table 3 for Panels		

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.

4.16 BATTERIES

4.16.1 GENERAL

4.16.1.1 Batteries shall be stationary-use type and constituted of vented lead-acid elements. Alkaline and lead-acid valve regulated batteries are accepted.

4.16.1.2 All batteries shall comply with the requirements of IEC 61892-3, ABNT NBR 16716 and Classification Society Rules.

4.16.1.3 Lead-acid vented batteries shall be designed and tested according to IEC 60896-11.

4.16.1.4 Lead-acid vented batteries manufactured in Brazil shall comply with the requirements of ABNT NBR 14197, ABNT NBR 14198 and ABNT NBR 14199.

4.16.1.5 Lead-acid vented batteries manufactured in Brazil and used for photovoltaic application shall be tested according to ABNT NBR 14200.

4.16.1.6 Lead-acid valve regulated batteries shall be designed according to IEC 60896-22 and tested according to IEC 60896-21.

4.16.1.7 Lead-acid valve regulated batteries manufactured in Brazil shall comply with the requirements of ABNT NBR 14204, ABNT NBR 14205 and ABNT NBR 14206.

4.16.1.8 Alkaline sealed batteries shall be designed and tested according to IEC 60622.

4.16.1.9 Alkaline vented batteries shall be designed and tested according to IEC 60623.

4.16.1.10 Alkaline vented batteries with gas recombination shall be designed and tested according to IEC 62259.

4.16.1.11 Alkaline NiCad batteries manufactured in Brazil shall comply with the requirements of ABNT NBR 14201, ABNT NBR 14202 and ABNT NBR 14203.

4.16.1.12 Manufacturer shall provide a detailed calculation report, justifying the selected battery type in function of the discharge profile, showed on Datasheet.

4.16.1.13 All tools, accessories necessary and recommendations for maintenance, for cell handle (substitution), for electrolyte substitution and for level completion shall be provided. Manufacturer shall provide a list of recommended spare parts.

4.16.2 MECHANICAL CHARACTERISTICS

4.16.2.1 All plates shall be of rigid fabrication and designed in order to reduce to a minimum the active materials loosening and assure long life, with a minimum of maintenance, allowing a high quantity of charge and discharge cycles, without damaging the element.

4.16.2.2 Containers material of cells shall be flame retardant and mechanically resistant to shock.

4.16.2.3 Containers material of Vented lead-acid batteries shall be translucent, giving a visual indication of electrolyte level.

4.16.2.4 Vented lead-acid batteries shall be constituted of tubular plates, with low antimony contents.

4.16.2.5 For vented batteries, the electrolyte density, being the elements at full charge, shall be 1.21 kg/dm^3, referred to a temperature of 25ºC.

4.16.2.6 Inter-cell connections shall be provided.

4.16.2.7 Inter-cell connections and connections from end poles of the bank to the first short-circuit protection device shall be insulated or otherwise provided with protective covering to prevent inadvertent short-circuiting. These connections shall be short-circuit-proof, according to Classification Society requirements.

4.16.2.8 Connections between side by side elements shall be made of tinned copper bars with oblong holes and furnished with stainless steel sets of screws, washers, spring washers and nuts and they shall have a "U" shape middle section to reduce the transmission of efforts between terminals.

4.16.2.9 Connections between side-by-side elements shall be made considering necessary gap spaces for future maintenance procedures where individual damaged elements are extracted and replaced.

4.16.2.10 Connections between distant cells shall be made with 1 kV rated, Class 5, fire resistant, low smoke, and halogen free flexible cables.

In cases in which it is not possible to connect all external cables directly to the battery terminals without the use of adapters, interface Ex terminal blocks properly bridged and installed in a terminal box at the rack or nearest bulkhead with internal cable connections to the battery shall be provided for this purpose.

The terminals of both poles shall be located in the same head of the rack, when applicable, and an insulation barrier shall be installed between them.

4.16.3 RATED CAPACITY

4.16.3.1 For lead-acid batteries, the rated capacity shall be based on a discharge time of 10 (ten) hours. For alkaline batteries, the rated capacity shall be based on a discharge time of 5 (five) hours. The calculated rated capacity of the batteries shall be available considering new batteries and electrolyte temperature of 25ºC.

4.16.3.2 For lead-acid batteries, the minimum discharge voltage measured at elements terminals shall be 1.75V. For alkaline batteries, the minimum discharge voltage measured at elements terminals shall be 1.0V. The above informed voltages shall be assured at the end of the autonomy as well as during the transient phenomena due to insertion of solenoids or to motors starts.

4.16.3.3 Short-circuit current is understood related to the group of elements, i.e., to the battery terminals under conditions of charged battery and battery at the end of its autonomy. Therefore, it shall also be evaluated based on connection resistance.

4.16.3.4 The batteries shall be sized so that their endurance or service life characteristics comply with the minimum requirements stated in IEC 60896-11, IEC 60896-21, or IEC 60896-22.

4.16.4 SUPPORT STRUCTURE

4.16.4.1 Racks shall be supplied together with batteries, for elements installation. The racks shall be provided with cover to protect against flow of electrical current to ground and liquid spills.

4.16.4.2 Racks shall have provisions for route and fasten the interconnection cables and the incoming external cables.

4.16.4.3 Racks structures shall be calculated to not deform with the batteries weight accelerated by the platform/vessel motions and shall allow a precision alignment and a safe fixation of the cells.

4.16.4.4 Racks for vented batteries shall be step-type. For valve-regulated batteries, shelf-type racks could be used.

4.16.4.5 Racks shall be on phosphate steel and painted according to I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING.

4.16.4.6 Racks can be either grounded/bonded to structure or isolated from the structure as defined IEC 61892-6. If the isolated from the structure option is used, battery racks shall follow requirements indicated in IEC 62485-2.

4.16.4.7 Batteries which elements have a weight higher than 100kg shall be supplied with devices to lift them for maintenance.

4.16.4.8 Batteries shall be installed according with IEC 61892-6 in locations defined by IEC 61892-7.

4.16.5 LIFETIME EXPECTANCE

4.16.5.1 The lifetime for Lead Acid batteries shall be at least 10 years of operation, under service conditions, beginning at commissioning date. The lifetime expectance shall not be degraded due to storage time before commissioning.

4.16.5.2 Considering alkaline batteries, the minimum lifetime shall be 20 years. During this lifetime period, alkaline battery design shall not foresee any water replenishment.

4.16.5.3 Integral warranty for 3 years shall be given to Lead Acid type batteries.

4.16.5.4 Integral warranty for 5 years shall be given to Alkaline type batteries.

4.16.5.5 In order to not injury the batteries lifetime, batteries shall be delivered during pre-commissioning phase.

4.16.6 DELIVERY CONDITIONS AND ACTIVATION REQUIREMENTS

4.16.6.1 Unless otherwise defined, alkaline and lead-acid valve regulated batteries shall be humid charged. Batteries charge delivery condition shall be submitted to PETROBRAS approval.

4.16.6.2 All activation and batteries charging requirements shall be submitted to PETROBRAS approval.

4.16.6.3 Unless otherwise defined in specific contract requirements by PETROBRAS, all battery systems, inclusive those to be installed in modules and packages, shall be delivered at appointed construction site no more than 3 months before unit date to sail to final location. This date shall be previously agreed with PETROBRAS.

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

4.16.7 BATTERY AND BATTERY BANK TESTS

4.16.7.1 Capacity, conductance/resistance tests and other tests applicable to batteries (see 4.16.7.2) shall be done at the time of delivery/acceptance.

4.16.7.2 Applicable batteries tests regulations informed in section 4.16.1 and repeated bellow, where applicable, shall be executed at acceptance procedures during delivery.

- Lead-acid vented batteries shall be according to IEC 60896-11 and ABNT NBR 14199.
- Lead-acid valve regulated batteries shall tested according to IEC 60896-21 and ABNT NBR 14205.
- Alkaline sealed batteries shall be tested according to IEC 60622.
- Alkaline vented batteries shall be tested according to IEC 60623.
- Alkaline vented batteries with gas recombination shall be tested according to IEC 62259.
- Alkaline NiCad batteries shall be tested according to IEC 60623 and ABNT NBR 14202.

4.16.7.3 Battery bank capacity and autonomy tests and commissioning shall be executed on board unit. Bank capacity and autonomy shall be confirmed at on-board tests.

4.16.7.4 Battery bank capacity and autonomy tests shall follow the reference values in ELECTRICAL SYSTEM DESCRIPTIVE MEMORANDUM according to application.

Note: Emergency and essential generators, compressor, firefighting pumps and other packages auxiliary batteries shall have autonomy time values defined by their vendors.

4.16.8 VRLA BATTERIES SPECIFIC USE REQUIREMENTS

4.16.8.1 Battery chargers (see section 4.17) for VRLA batteries shall be specified with temperature compensation for voltage floating condition, maximum ripple (as defined in 4.17.3.4) and without deep charge mode.

4.16.8.2 VRLA batteries shall be installed in temperature controlled rooms at of 25°C.

4.16.8.3 VRLA batteries shall not be used for motor starting, i.e.: emergency generators, firefighting motor pumps, etc., as defined in NFPA 110.

4.16.9 IDENTIFICATION NAMEPLATE AND INFORMATION LABELS

4.16.9.1 All battery banks shall have an information label indication:

- Battery bank TAG.
- Battery bank voltage in V.
- Battery bank capacity in AH.
- Feeding equipment TAG number (Battery charger or UPS).
- Minimum expected autonomy in hours and minutes.

4.17 BATTERY CHARGERS

4.17.1 GENERAL

4.17.1.1 Battery chargers shall be three-phase type and specified according to the requirements of IEC 60146-1-1, IEC TR 60146-1-2, IEC 60146-2, IEC 62040-3, and IEEE 519.

4.17.1.2 Battery charger's enclosure shall comply with the requirements of item 4.8.3.

4.17.1.3 Manufacturer shall supply the accessories, tools recommended by its own experience or by the component manufacturer and recommendations for operation and maintenance and list of recommended spare parts.

4.17.1.4 Manufacturer shall inform the MTTR of equipment.

4.17.1.5 For battery chargers for telecommunication systems requirements, see Telecommunication documents.

4.17.2 MECHANICAL CHARACTERISTICS

4.17.2.1 STRUCTURE

4.17.2.1.1 Battery chargers shall be assembled on cabinets built with steel sheets of the self-supported type, with only front access, through a latched door.

4.17.2.1.2 At the cabinet door shall be installed all instruments, signalling and control devices necessary for the perfect operation of chargers.

4.17.2.2 ASSEMBLY CHARACTERISTICS

4.17.2.2.1 The electronic components of the automatic regulation device shall be assembled on a single chassis, with an easily removable protecting casing. The electrical connections shall be "plug-in" type.

4.17.2.2.2 Diodes or thyristors shall be fitted with heat sinks, cooled by natural convection or by forced ventilation.

4.17.2.3 IDENTIFICATION NAMEPLATE

4.17.2.3.1 The following information, besides those already required on this specification, shall be supplied, in Portuguese language:

a) Tensão e frequência nominais (rated voltage and frequency).

b) Número de fases da alimentação de entrada (phases number of the feeding circuit).

c) Tipo, número de elementos e capacidade das baterias para as quais o carregador foi projetado (type, elements number and battery capacity to which the charger is intended for).

d) Faixa de ajuste da tensão de flutuação (floating voltage adjustment range).

e) Faixa de ajuste da tensão de equalização (equalization voltage adjustment range).

f) Corrente de saída nominal do retificador (rectifier outgoing rated current).

g) Faixa de ajuste da corrente de saída em percentual da corrente nominal (outgoing current adjustment range in percentage of rated current).

h) Ripple máximo nos terminais do consumidor com baterias conectadas (maximum ripple on load terminals with the charger connected to battery terminals).

i) Número do manual de instruções (instructions book number).

4.17.3 ELECTRICAL CHARACTERISTICS

4.17.3.1 Battery chargers shall have the characteristics listed below:

a) enough capacity in amperes to safely comply with the battery charger system.

b) capacity to charge the battery bank up to 80% of its full load, within a period of 10 hours.

c) ability to turn off the system when the charge is finished, or when there is a current reduction to a value only to keep the battery in floating duty.

d) ability for continuous parallel operation of output, for redundant chargers.

e) simple construction and easy maintenance.

f) high efficiency.

g) high reliability.

h) network communication for monitoring, Modbus Ethernet, RJ 45 - 100 Mbps.

4.17.3.2 Means shall be provided to maintain the consumer voltage in the range of 100% to 115%. Drop diode units shall not be accepted.

4.17.3.3 Battery charger shall be able to simultaneously, keep the batteries on floating duty, as well as recharge the bank on deep charge, while it feeds all consumers associated to it, with stabilized voltage and current limitation. It shall also be provided with automatic reset to the charging duty when the A.C. supply is re-established after a failure.

4.17.3.4 Battery chargers output voltage shall have a ripple limited to below values:

a) Battery charger with battery connected: ±1% of output voltage, RMS.

b) Battery charger with battery disconnected: ±2% of output voltage, RMS.

4.17.3.5 Battery charger shall be provided with stabilizing filter at D.C. outgoing, allowing the disconnection of the battery bank, with the D.C. system not suffering any alteration.

4.17.3.6 Switched battery chargers shall have output voltage regulation within ± 1% from no-load up to full load.

4.17.3.7 Voltage transient suppressors shall be provided at the chargers A.C. input and D.C. output.

4.17.3.8 Battery charger shall be constant voltage type with current limitation.

4.17.3.9 The battery charger rectifier shall be galvanically isolated from the A.C. supply.

4.17.3.10 Battery charger shall have battery disconnecting device, which operates after the battery has reached the discharge final voltage (1.75V/element for lead-acid and 1.0V/element for alkaline). It shall not be acceptable undervoltage trip coils (UVT) for this function.

4.17.3.11 At least the following local alarm signalling shall be provided on battery chargers, in Portuguese language:

a) Sobretensão na saída (output overvoltage).

b) Subtensão na saída (output undervoltage).

c) Falha na alimentação de entrada (failure in incoming supply).

d) Polo positivo aterrado (positive pole grounded).

e) Polo negativo aterrado (negative pole grounded).

f) Temperatura alta (high temperature).

g) Disjuntor das baterias aberto (battery circuit-breaker open).

h) Bateria em descarga (battery in discharge).

i) Falha no carregador (failure at charger).

4.17.3.12 The signals listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST shall be provided by battery chargers (except for battery chargers dedicated to main, emergency, and auxiliary generation packages, ballast control package sand fire-fighting pumps packages) through Ethernet network communication with Electrical System Automation. The communication protocol shall follow 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. Signals shall be sent to A&C through Electrical System Automation.

4.17.3.13 For the battery chargers, 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.

4.17.3.14 Battery chargers dedicated to main, emergency, and auxiliary generation packages, ballast control packages and fire-fighting pumps packages shall provide one UAM alarm signal through voltage free contact (1A @ 24VDC) to be sent to Package Control Panel. This alarm signal shall include at least battery in discharge and low resistance insulation.

4.17.3.15 In order to avoid alarm during load transference, alarms related to failure in main supply shall be time delayed for 30s.

4.17.3.16 One input shall be provided to inhibit load charge according to external command (wet signal) from Fire and Gas Controllers of A&C.

4.17.3.17 All battery chargers expected to receive wet signals from A&C or Package Control Panels shall have interposing relays with enough quantity to convert discrete 24 VDC signal in discrete voltage-free signal.

4.17.3.18 Battery chargers shall be provided with a 3 (three) positions selector switch:

a) Floating.

b) Equalization.

c) Manual.

4.17.3.19 Protection against inadequate application of battery polarity shall also be provided.

4.17.3.20 Battery chargers shall have a minimum input power factor equal to 0.85, in all their operation range.

4.17.3.21 All assembly accessories and components shall be immune against electromagnetic and radio frequency interference, (EMI/RFI).

4.17.3.22 Battery charger electronic components shall be perfectly insulated from any contact with ground, in order to minimize the radio-interference effects.

4.17.3.23 Busbars shall be of electrolytic copper, dimensioned to rated current in steady state condition. Insulators duly dimensioned, for the specified voltage class shall support bars.

4.17.3.24 Ammeters and voltmeters shall be movable-coil type, voltage class of 600 V (for input voltage), accuracy class of 1.5%, built-in installation, engraved scale in black over white bottom and external zero adjustment and complying with I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS.

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

4.17.4 TESTS

Manufacturer shall carry out the tests listed in Datasheet and the tests foreseen in relevant standards.

4.18 BATTERY CHARGERS FOR D.C. UPS SYSTEMS

4.18.1 GENERAL

4.18.1.1 For battery charger dedicated to D.C. UPS SYSTEMS, unless otherwise defined, all requirements in section 4.17 apply added of the following complementary requirements.

4.18.1.2 The D.C. UPS SYSTEM shall conform in design, material, and performance, except where otherwise specified, with the current issues and amendments listed on HULL UPS AND DC SYSTEMS ONE-LINE DIAGRAM.

4.18.1.3 The D.C. UPS SYSTEM configuration shall be of simple arrangement and comprising of at least:

a) D.C. system formed by two Rectifiers (2 x 100%), operating isolated (stand-alone), with possibility of parallel operation continually for load transference without black-out.

b) Batteries (one battery bank for each Rectifier).

c) Distribution D.C. Panels with interconnection to each other.

4.18.1.4 All the equipment of this system shall have only one vendor.

4.18.1.5 All components of the D.C. UPS SYSTEM shall be new and shall be suitable for continuous operation under the environmental conditions in section 3.

4.18.1.6 The D.C. UPS SYSTEM and their auxiliaries shall be constructed in compliance with the requirements of the Classification Society.

4.18.1.7 The D.C. UPS SYSTEM and their equipment shall be designed to provide a minimum Mean Time Between Failure (MTBF) of 200,000 hours and to permit a maximum Mean Time To Repair (MTTR), with service personnel on-site, not exceeding 3 hours.

4.18.1.8 The D.C. UPS SYSTEM and auxiliary systems shall be immune to voltage transients, voltage dips and power supply distortion, as defined in section 3.8, according to IEC 62040-2 and IEC 61892-2.

4.18.1.9 The D.C. UPS SYSTEM and their equipment shall be able to withstand transient high frequency voltages of 2 kV peak superimposed on the input system voltage as a result of system short-circuit.

4.18.2 CONSTRUCTIONAL REQUIREMENTS FOR D.C. UPS

4.18.2.1 Each individual rectifier shall be housed in its own enclosure and shall comprise the following major components arranged in a modular construction. The Rectifier shall have a front door quick access to all internal components including both incoming and outgoing busbars. The rear access shall be provided too.

4.18.2.2 The components/equipment for D.C. UPS SYSTEM shall be housed in free-standing, floor-mounting, compartmented enclosures with frontal and rear access for any kind of service. They shall be furnished complete with all necessary instruments, controls, indicators, connectors, circuit-breakers, isolators, fuses, and ventilation. For redundant systems, each set of rectifiers shall be assembled in separate enclosures.

Note: Unless otherwise defined in project documentation, D.C. UPS enclosure shall have forced ventilation.

4.18.2.3 The equipment shall be designed to minimize risk of an internal short-circuit. It shall also provide safety to personnel and operation by protective barriers during inspection and maintenance. Under extreme conditions of major short-circuits or equipment failure, there shall be no danger to people near the equipment. Interlocks, barriers and covers shall be provided to prevent incorrect or unsafe operation and to prevent access to energized parts.

4.18.2.4 It shall be provided an isolated handrail in fixed parts of the frontal side of the D.C. UPS SYSTEM enclosures.

4.18.2.5 For all equipment of D.C. UPS SYSTEM, the cable entry shall be via 3 mm thickness removable gland plate(s). Gland plate(s) size shall be adequate to accommodate the cables required. They shall be made of non-magnetic material.

4.18.2.6 Frontal access doors shall be fitted with neoprene sealing gaskets and documents folders. Hinged doors shall not exceed a width of 900 mm and shall be provided with lockable handles.

4.18.2.7 The control circuits and power circuits shall be segregated in different compartments.

4.18.2.8 Internal lighting shall be provided for proper inspection and maintenance for each equipment.

4.18.2.9 All terminals and door-mounted components for each equipment shall be shrouded or otherwise protected by barriers providing a minimum protection degree IP21 with the enclosure door(s) open. This shall apply to all doors or frames giving access to internal components.

4.18.2.10 For each equipment with forced ventilation, the start of standby fans shall be automatic. Particular attention shall be paid to the location of ventilation louvers and their arrangement. Dust filters shall be provided on all louvers and shall be easily replaceable during operation. The fans shall have speed monitoring device.

4.18.2.11 Forced ventilation shall be accessible to allow replacement of the fans with the equipment in operation, without jeopardizing the safety or people and equipment.

4.18.2.12 Each equipment of D.C. UPS SYSTEM shall comply with I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS.

4.18.2.13 It shall not be necessary to open any equipment of D.C. UPS SYSTEM or distribution panel doors to operate the circuit-breakers or any other devices during operation of the system.

4.18.2.14 Each equipment of D.C. UPS SYSTEM shall have access for installation and maintenance through the front side.

4.18.2.15 The metal parts comprising the D.C. UPS SYSTEM, which are not intended to carry current, shall have electrical continuity and be connected to the grounding busbar of the D.C. UPS. The doors shall have electrical continuity with the metallic structure of the D.C. UPS through flexible copper braid.

4.18.3 ELECTRONIC EQUIPMENT FOR D.C. UPS

4.18.3.1 The electronic components for all equipment part of the D.C. UPS SYSTEM shall be the solid-state type and air cooled.

4.18.3.2 All connections to subassemblies, (e.g., transformers, semiconductor heat-sink assemblies, control modules etc.), shall be made via centralized termination or connection blocks.

4.18.3.3 All external connections of the printed circuit boards shall be made through polarized non interchangeable terminal blocks. Gold plated terminal blocks shall be selected for the signal paths. Printed circuit boards shall be replaceable without the use of a soldering iron.

4.18.3.4 The printed circuit boards shall be tropicalized according to requirements section 3.1.2. They shall also have a clear identification of the mounted components and external interfaces.

4.18.3.5 Printed circuit control boards shall be independent for rectifier, and its interface designed shall make impossible a fault at one stage to cause damages in the others.

4.18.3.6 All exposed live parts shall be shrouded and provided with warning labels.

4.18.4 PERFORMANCE

4.18.4.1 The D.C. UPS SYSTEM shall provide rated output power, under steady state variations and transient variations of the input voltage and frequency, as define in Table 4.

4.18.4.2 The radio frequency interference from D.C. UPS SYSTEM's equipment shall not exceed the limits specified in IEC 62040-2.

4.18.4.3 Calculation's power and rated output of D.C. UPS SYSTEM and battery sizing shall be submitted to PETROBRAS for approval. The batteries shall have autonomy and capacity to supply the total loads specified in EMERGENCY LOAD LIST.

4.18.4.4 Under main failure conditions, the D.C. UPS SYSTEM shall continue to supply the total loads specified with no break in output or loss of performance due to deriving the power supply from the batteries. Being reached the minimum operational voltage at the battery terminals, the unit shall send a signal to trip the MCCB (moulded-case circuit breaker) of the battery bank.

4.18.4.5 The D.C. UPS SYSTEM shall be suitable for supplying non-linear loads such as rectifiers up to its continuous nameplate rating.

4.18.4.6 Each rectifier/charger shall be able to supply the maximum rated loads and capable of charging its respective batteries bank from a fully discharged condition simultaneously.

4.18.4.7 The time to automatically fully charge the batteries from a fully discharged condition shall not exceed 10 hours in accordance with IEC 61892.

4.18.4.8 The D.C. UPS SYSTEM shall be capable of supply its rated load, within the specified output D.C. voltage. The voltage variation, shall not interrupt the power supply output, under all operating conditions, including:

a) Failure of one or both rectifiers/chargers.

b) Switching rectifier/charger control between float and boost modes.

c) Failure of the main supply to the system.

4.18.4.9 The D.C. UPS SYSTEM efficiency, under any operational condition, and including all components (rectifier, input transformer, etc.) shall not be lower than 86% for D.C. UPS with a D.C. panel voltage up to 220V.

4.18.5 RECTIFIER/CHARGER FOR D.C. UPS

4.18.5.1 In order to supply the D.C. distribution Panel, the rectifier/charger shall be formed by a thyristorized semiconductor rectifier bridge with power factor correction.

4.18.5.2 The rectifier/charger shall be of 6, 12 or more pulses industrial type.

4.18.5.3 The rectifier/charger shall operate with batteries types indicated in section 4.16 with constant voltage and current limiting control circuits.

4.18.5.4 The components within the rectifier shall be capable to operate independently from the remaining system.

4.18.5.5 The incoming circuit-breaker shall be a MCCB and shall have a load breaking, fault-making capacity in accordance with IEC 60947, utilization category AC-23. Fast action fuses compatible with the A^2s characteristic of the power semiconductors shall be added to the system if the circuit-breaker cannot provide this protection.

4.18.5.6 The rectifier unit shall be rated to recharge the battery to a nominal 90 % within 10 hours and 100 % within 24 hours following a discharge at rated load for the specified autonomy time, simultaneously meeting the inverter input requirements while the inverter is delivering its rated output.

4.18.5.7 The rectifier/charger shall be capable of supply the rated output load with an input deviation of –15% in the power supply voltage, without discharging the batteries.

4.18.5.8 The rectifier/charger shall be capable of supplying the inverters connected to distribution D.C. panel with the batteries disconnected within the specified regulation.

4.18.5.9 The rectifier/charger shall be protected against overvoltages.

4.18.5.10 The D.C. circuit shall not be grounded.

4.18.5.11 The rectifier/charger shall be provided with local instrumentation according with I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS.

4.18.5.12 Manual float/boost charge selection shall be provided in addition to the automatic charging facility. The boost charge selection shall be automatically cancelled after a timed period if it is likely to cause harm to the batteries. Boost-charging shall only be used when the battery characteristic permits.

4.18.5.13 During the process of charging, it shall be foreseen the battery charging inhibition (wet signal) when hydrogen is detected in the batteries' room. For interface details, refer to I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

4.18.5.14 All Battery Chargers for D.C. UPS expected to receive wet signals from A&C or Package Control Panels shall have interposing relays with enough quantity to convert discrete 24 VDC signal in discrete voltage-free signal.

4.18.5.15 The rectifier/charger shall be provided with a manual voltage control and automatic means for bypass the undervoltage trip signal to the battery MCCB, when the battery charge is low, but the rectifier/charger is healthy, for the initial charging process. The battery MCCB shall be fitted with a shunt trip coil.

4.18.5.16 The rectifier/charger shall be isolated from the input power supply by a dry-type transformer with electrostatic shield. The transformer shall be sized for the harmonic content according to IEC 61378-1 and shall have insulation class F with temperature rise class B. Unless otherwise stated in equipment project documentation, the insulation input transformer shall have rated primary voltage 480VAC.

4.18.5.17 The output voltage shall comply with requirements in section 3.8.3, and 4.17.3.4 to 4.17.3.6.

4.18.5.18 The total harmonic distortion of the input voltage shall comply with requirements in section 3.8.2.

4.18.5.19 The rectifier/charger shall be provided with battery capacity monitoring and testing facilities.

4.18.5.20 In order to avoid an undervoltage alarm at the input of rectifier/charger during temporary power failures a delay of at least 1 minute shall be foresee for trigger of this alarm.

4.18.5.21 The circuits shall have means to avoid accidental contact to energized parts.

4.18.5.22 The rectifier/charger input, the consumer outputs and the battery outputs shall be provided with suitable overcurrent protection with short-circuit capacity suitable to the short-circuit conditions indicated on the datasheet. These devices shall be selective with the internal protection devices of the rectifier/charger.

4.18.5.23 There shall be a heating resistor with power supply at 220VAC. External power supply to the heating resistor shall be possible during the transportation and storage period without having to open the packaging. The temperature shall be controlled by an adjustable thermostat with a maximum adjustment value of 60°C, supplied with the rectifier/charger. The power supply voltage of heating resistor shall be clearly indicated in the external side of package.

4.18.6 BATTERY FOR D.C. UPS

4.18.6.1 The batteries shall be capable to feed, at any site ambient temperature, the D.C. distribution panel for the period specified in the EMERGENCY LOAD LIST, including the 25% spare capacity with no mains input to the rectifiers/chargers and without the inverter output voltage moving outside the specified tolerances.

4.18.6.2 Batteries types shall be according to section 4.16.

4.18.6.3 Redundant battery banks shall be located in separate battery rooms.

4.18.6.4 Batteries shall be protected against the effects of overvoltage, undervoltage and overcharging, in accordance with the approved battery manufacturer's recommendations.

4.18.6.5 Manufacturer shall provide the detailed calculation report, justifying the selected battery model in function of the discharge profile and according to specific Standard.

4.18.7 DISTRIBUTION PANELS FOR D.C. UPS

4.18.7.1 It shall be provided one D.C. Distribution Panel for each rectifier/charger according to topology shown in HULL UPS AND DC SYSTEMS ONE-LINE DIAGRAM.

4.18.7.2 The D.C. Distribution panels shall be furnished by the rectifiers/chargers set Manufacturers respectively and shall comply with section 4.8 unless otherwise defined in this section, or in document HULL UPS AND DC SYSTEMS ONE-LINE DIAGRAM.

4.18.7.3 The rectifiers/chargers' manufacturers shall be responsible for executing a coordination protection study for D.C. systems and to specify the protection devices for each D.C. outgoing.

4.18.7.4 D.C. Distribution panels shall have the configuration informed in section 4.18.1.3 and shown in HULL UPS AND DC SYSTEMS ONE-LINE DIAGRAM.

4.18.7.5 All outgoing shall be assembled with Double Pole Circuit-breakers.

4.18.7.6 Minimum signals foreseen individually in each D.C. distribution panel that shall be sent to the Electrical System Automation through Ethernet. These signals shall comply with I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

4.18.7.7 D.C. Distribution panels shall have intelligent relays (IRs) according to 4.13

4.18.7.8 One insulation monitoring device shall be installed in each busbar of D.C. Distribution Panels for UPS. The insulation monitoring devices shall indicate the measured insulation ohmic value between poles and between poles and ground.

4.18.7.9 For panels with possibility to operate in "l" configuration with interconnection circuit-breakers closed, it shall be provided a logic to disable one of insulation monitoring devices in this condition. It shall also be provided a logic to enable both of insulation monitoring devices during the return to "ii" configuration.

4.18.7.10 In distribution panels, individual earth fault indication shall be installed for loads located in Zone 1 or loads where the feeding cable crosses Zone 1.

4.18.7.11 For the other cases, not in above conditions of 4.18.7.10, loads shall be grouped in one individual insulation monitoring equipment.

4.18.7.12 One portable ground fault detector shall be supplied by BIDDER in order to detect faults through specific portable current-clamp meter, proper for D.C. systems. This device shall be capable to detect all faults when until three different sensors are simultaneously activated by faulted circuits.

4.18.7.13 The outgoing cables for all circuits shall be installed in a way to enable easy access to clamp them with a portable ground fault detector, with the circuit energized. The shields shall be installed according to the detector requirements.

4.18.7.14 The insulation monitoring devices shall send a discrete alarm signal to an IED (IR) installed inside the panel, through a voltage free contact (1A @ 220VDC PF 0.4).

Note: In case of use of ground fault location devices, it is forbidden the use of voltage transformers connected YNyn (two neutral grounded).

4.18.7.15 To indicate that the ground fault detection device is turn off, an alarm shall be sent to IED (IR) installed inside the panel through a voltage free contact (1A @ 220VDC PF 0.4).

4.18.8 GROUNDING FOR D.C. UPS

4.18.8.1 A grounding bar shall be provided along the full length of each enclosure. All metallic non-current-carrying parts shall be bonded together and connected to the grounding bar. External M10 grounding terminals shall be provided to facilitate connection of the enclosures to grounding system.

4.18.8.2 For other panel grounding requirements see 4.8.3.6.

4.18.9 WIRING AND TERMINALS FOR D.C. UPS

4.18.9.1 All the internal wiring and conductor shall follow section 4.8.3.7. Cable definitions shall follow section 5.13.

4.18.9.2 The D.C. UPS SYSTEM and distribution panels shall be delivered with all devices completely connected. Wiring shall be arranged so that the insulation shall not be subject to injurious temperature.

4.18.9.3 Internal wiring shall be adequately supported by clamping of loomed runs or installed in plastic cable channels. Self-adhesive fixing is not acceptable.

4.18.9.4 The supporting arrangements for wiring shall be such that they are not liable to cause permanent physical damage or deformation to the conductor insulation.

4.18.9.5 Cable channels fill shall not exceed 75% of their capacity.

4.18.9.6 At least 300 mm clearance shall be allowed between the gland plate and any internal equipment to permit easy cable installation and connection.

4.18.9.7 Spare Terminals equal to at least 10% of the total used and shall be provided to enable any spare multicore cable conductors to be terminated.

4.18.10 CABLE TERMINATION FOR D.C. UPS

4.18.10.1 Cable terminations shall follow section 5.11.

4.18.10.2 Undrilled removable non-magnetic gland plates shall be provided on cable termination compartments.

4.18.10.3 All cable entries shall be from bottom side, and all connections shall be made from the front of the panel.

4.18.11 PROTECTION EQUIPMENT SYSTEM FOR D.C. UPS

4.18.11.1 The rectifiers/chargers shall be fully protected to prevent damage to any internal component. All circuits shall be adequately protected by means of circuit-breakers or fuses. The protective device shall be readily accessible.

4.18.11.2 MCCB shall have asymmetrical making and breaking capacity according to IEC 60947, with externally adjustable thermal and magnetic elements. The thermal element shall be compensated up to a maximum ambient temperature of 50°C. Magnetic trip indication shall be provided.

4.18.11.3 MCCB protection shall be provided in the battery charging circuit.

4.18.11.4 Fuses shall comply with IEC 60269 parts 1, 2 and 4, and shall be fitted in fully insulated carriers and bases.

4.18.11.5 Current transformer shall comply with the requirements of IEC 61869 parts 1 and 2. The secondary winding of current transformer shall be grounded and short circuited through a removable link, with provision for attaching test links. Current transformer shall be rated to withstand the thermal and magnetic stresses resulting from fault current.

4.18.11.6 During the process of charging, it shall be foreseen the battery charging inhibition when hydrogen is detected in the batteries' room. For interface details refer to I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

4.18.11.7 Two redundant independent power supplies for the control shall be provided. One fed by the main power supply and other one by the batteries (D.C. branch).

4.18.11.8 Alarm and trip functions shall be provided in accordance with Table 15 as minimum.

Table 15 - Alarm and trip functions

Trouble Description	Alarm	Rectifier Trip
A.C. input power supply - undervoltage	X	Off [1, 2]
Rectifier failure	X	X
D.C. Overvoltage	X	X
D.C. Undervoltage	X	-
Battery discharging	X	-
Battery breaker off / battery disconnected	X	-
Battery temperature high (VRLA batteries only)	X	-
Cooling fan failure	X	-
Power module overtemperature	X	-

NOTES: 1 In case of the A.C. input power supply falls below allowable limits; the rectifier shall shut down.
2 When the A.C. input power supply resumes and remains within allowable limits; the rectifier shall start automatically, and no reset is required.
3 It shall be included overtemperature alarm and trip to rectifier.
4 Battery chargers of D.C. UPS SYSTEM shall have capacitance measurement devices with alarm and trip.

4.18.12 MONITORING, SUPERVISION AND COMMUNICATION REQUIREMENTS FOR D.C. UPS

4.18.12.1 HUMAN MACHINE INTERFACE

4.18.12.1.1 The battery chargers of D.C. UPS SYSTEM monitoring, control, annunciation and diagnostics shall be microprocessor based with a HMI including display and keypad entry. The display shall give comprehensive information on the equipment status and full diagnostic information.

4.18.12.1.2 In general, the following actuation devices with its respective visual indication shall be available.

a) "ON' key.

b) "OFF" key.

c) "PARAMETERS SELECTION" key (s).

d) "ADJUSTING AND PARAMETRS PROGRAM" key (s).

e) "INCREASING OF FUNCTIONS OR CONTROL VALUES" key.

f) "DECREASING OF FUNCTIONS OR CONTROL VALUES" key.

g) "RESET" key.

h) PRE-SETS AND ADJUSTING PARAMETERS VALUE

4.18.12.1.3 In general, devices for status monitoring, in the form of synoptic or graphical representation, to present a real-time operation of the system with at least the following indications shall be available:

a) Presence of voltage at the main source and within normal parameters.

b) Rectifier in operation.

c) D.C. bus energized and within normal limits.

d) Floating battery.

e) Discharging battery.

f) Disconnected battery.

g) Discharged battery.

4.18.12.1.3.1 The synoptic or graphical representation shall show the power flow pattern through the units, the controls, annunciations, and indications described in this specification. In redundant configurations each mimic diagram shall show the full status of the A and B systems.

4.18.12.1.3.2 For Conventional synoptic LED brightness shall be such that they are clearly visible in normal artificial lighting levels.

4.18.12.1.4 In general, HMI shall have at least the following alarms available:

a) Main source undervoltage.

b) Main source overvoltage.

c) Abnormal rectifier.

d) D.C. undervoltage.

e) D.C. overvoltage.

f) Overload of the rectifier.

g) Detection of self-supervision failure.

h) Battery disconnected.

i) Battery in discharge.

j) Indication of low isolation at the battery chargers of D.C. UPS SYSTEM.

k) Failure of ventilation of the battery chargers of D.C. UPS SYSTEM.

l) Inhibition of charging by detecting gas in the battery room.

m) Discharged battery.

n) Abnormal UPS-D.C..

o) Lack of phase.

p) D.C. leakage to ground at UPS-D.C. output.

q) Activation of fuses or other overcurrent protection devices at the UP-D.C. input and in the circuits of the consumer and battery.

4.18.12.1.4.1 At least the alarms in item 4.18.12.1.4 must be contained in the alarm summary.

4.18.12.1.4.2 Failure of the HMI display or indicating equipment on the battery chargers of D.C. UPS SYSTEM shall not compromise the operation of battery chargers of D.C. UPS SYSTEM.

4.18.12.1.5 The HMI shall have password protected multiple levels of access:

a) for viewing (No password).

b) settings (by trained operating personnel). and

c) service (by the manufacturer's personnel

4.18.12.1.6 The HMI shall have storage for retaining:

a) historical data.

b) event/alarm logging with time, date stamping. and

c) historical trending for assisting troubleshooting and failure analysis.

4.18.12.2 MONITORING AND SUPERVISION

4.18.12.2.1 Devices for monitoring analogue variables:

a) Main source input – voltage, frequency.

b) Voltage and current of the rectifier output, battery current, open circuit voltage of the battery.

4.18.12.2.2 In the event of a failure of the HMI and/or of the equipment's internal supervision plates, the battery chargers of D.C. UPS SYSTEM must remain in normal operation supplying the loads.

4.18.12.2.3 Where applicable, a lamp test push-button shall be incorporated on the front of the cubicles.

4.18.12.2.4 The battery current metering shall clearly indicate the direction of the current flow.

4.18.12.2.5 All the alarms indications shall be latched until reset by means of a reset command.

4.18.12.2.6 Analogue-indicating instruments shall comply with I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEM and with IEC 60051.

4.18.12.2.7 All alarms shall be visual and audible. Test and reset push buttons shall be provided.

4.18.12.2.8 Alarms shall be arranged so that their operation may be checked by simulation, which shall be as close as possible to the alarm condition.

4.18.12.3 COMMUNICATION REQUIREMENTS

4.18.12.3.1 Minimum signals that shall be sent from each battery chargers of D.C. UPS SYSTEM to Electrical System Automation shall comply with I-LI-3010.00-5140-797-P4X-001 – ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

4.18.12.3.2 The battery chargers of D.C. UPS SYSTEM shall communicate with Electrical System Automation by Ethernet based protocol according with I-DE-3010.00-5140-797-P4X-001 – ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE and I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE.

4.18.12.3.3 The battery chargers of D.C. UPS SYSTEM shall be able to be remotely accessed for maintenance, configuration and diagnose using interface according with item 4.18.12.3.2.

4.18.12.3.4 All software for maintenance, configuration and diagnose and their respective licenses for all equipment which will be part of battery chargers of D.C. UPS SYSTEM shall be included in the scope of supply and shall be compatible with the Windows platform.

4.18.12.3.5 It shall be provided an additional licence of maintenance software to be installed at ESA Maintenance workstation.

4.18.12.3.6 It shall be provided auxiliary interposing relays for each battery chargers of D.C. UPS SYSTEM to receive the remote signals from A&C. The signals are through wet contacts (24 Vdc) to inhibit the recharging of batteries when the battery room ventilation/ exhaustion is turned off or the detection of H_2 occurs.

4.18.12.3.7 A list of mapping addresses of the data communication and signalling circuits intended to be exchanged with the information technology equipment (e.g., SCADA system, local area networks (LAN) or telecommunication networks) shall be provided.

4.18.12.3.8 All signals of controllers and peripherals shall be available in the memory map.

4.18.12.3.9 It shall be provided a switch to carry out the network interface between ESA and battery chargers of D.C. UPS SYSTEM.

4.18.12.3.10 At a minimum, the historical record of the last 5000 events, faults and alarms must be stored in non-volatile memory.

4.18.12.3.11 All configuration adjustments must be implemented in the battery chargers of D.C. UPS SYSTEM in non-volatile memory.

4.18.12.3.12 The data from the HMI shall be stored in non-volatile memory, in order to allow recovery of the parameterizations, alarms and the event records even after the battery chargers of D.C. UPS SYSTEM is completely de-energized.

4.18.12.3.13 The battery chargers of D.C. UPS SYSTEM shall be able to be configured for operation without interrupting the supply of the A.C. secure bus.

4.18.12.3.14 D.C. UPS SYSTEM shall communicate with Electrical System Automation by Ethernet based protocol according with I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM and I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE.

4.18.12.3.15 General alarms initiators of UAM and UAS shall be available and clearly identified in the event record even if several alarms being generated simultaneously.

4.18.12.3.16 The D.C. UPS SYSTEM shall have its internal clock synchronized with Electrical System Automation Time Server through the time protocol according I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE.

4.18.12.3.17 All devices with logging or communication capabilities internal to the D.C. UPS SYSTEM 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.

4.18.12.3.18 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.

4.18.13 GROUND FAULT PROTECTION FOR D.C. UPS

Grounding fault protection shall for D.C. UPS shall follow section 4.8.5.5

4.18.14 NAMEPLATES AND LABELS FOR D.C. UPS

4.18.14.1 Nameplates shall for D.C. UPS shall follow section 3.6.4 and 4.17.2.3.

4.18.14.2 Warning labels shall be provided in all necessary locations to warn workers of potentially dangerous situations. See section 0.

4.18.15 PAINTING FOR D.C. UPS

Painting for shall for D.C. UPS shall follow section 3.6.3.

4.18.16 DOCUMENTATION AND TRAINING FOR D.C. UPS

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

4.18.16.2 Manufacturer shall provide complete manuals and documentation. MTTR shall be informed.

4.18.16.3 The D.C. UPS SYSTEM assembling, operation and maintenance manual shall contain, at least, the following information:

a) Technical specifications for rectifier, as well as all the required components and fittings in conformity to all the requirements of original approved proposal, as well

as revisions made at the occasion of the technical clarification and/or technical acceptance report.

b) Data Sheet properly filled out “as purchased” and/or "as built".

c) All approved drawings.

d) The D.C. UPS. system storage procedures, as well as any other spare part elements.

e) Procedures for transportation and assembling.

f) Procedures for operation, including warning conditions.

g) Procedures for preventive and corrective maintenance of the rectifier and all fittings.

h) All test reports approved.

i) Operation sequence logical diagrams and electronic circuit boards style numbers, schematic diagrams, components list and test points waveforms.

j) Complete software’s documentation.

k) D.C. UPS. memory map.

l) Schedule to replace all equipment/component of D.C. UPS.

m) Troubleshooting guide for each electrical and electronic device and subsystem.

4.18.16.4 Manufacturer is obliged to deliver the documentation together with, or before delivery of the equipment in order to allow proper checking before final acceptance of the equipment.

4.18.16.5 The manufacturer shall furnish electronic copies of all documentation.

4.18.16.6 Training courses in operation and maintenance shall be offered for 10 (ten) PETROBRAS Engineers and Technicians. This course shall be done in Brazil. The language of the course in Brazil shall be Portuguese.

Note: At least, two copies in English language and two copies in Brazilian Portuguese language shall be provided for all reference manuals. 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.

4.18.17 SPARE PARTS AND UNUSUAL TOOLS FOR D.C. UPS

4.18.17.1 Manufacturer shall include in the scope of supply all spares required for start-up and commissioning.

4.18.17.2 Manufacturer shall further include in his quotation a proposed list of spares for two (2) years operation with separate prices for each item.

4.18.17.3 Manufacturer shall recommend the Classification Society required spares, if any.

4.18.17.4 Manufacturer shall supply all unusual tools required for installation, commissioning, operation, and maintenance of the equipment.

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

4.18.18 TESTING FOR D.C. UPS

4.18.18.1 All tests foreseen in the relevant standards shall be carried-out.

4.18.18.2 Type tests shall be carried-out for the first batch of identical rectifiers/chargers. Certified test reports for type tests performed for identical equipment and approved and witnessed by Classification Society are accepted.

4.18.18.3 Routine tests shall be carried out for all equipment/components.

4.18.18.4 Electronic modules, including spares, shall be submitted to a “burn-in” test to prevent failures occurring at early stage. The equipment shall be subject to an equivalent of 72h at 70°C with power connected to the device, according to IEC 61188-5-1.

4.18.18.5 Batteries tests see shall be according to section 4.16.

4.18.18.6 In order to verify that capacity of the bank is kept as specified, manufacturer shall perform a test at rated power on board during the commission phase.

4.18.18.7 Battery bank shall perform with 100% of capacity. If the test is not approved, the manufacturer shall replace the battery bank by a new one.

4.18.18.8 The minimum test list that shall be carried out at manufacturer factory is informed in reference datasheet, in I-LI-3010.00-5140-700-P4X-001 - ELETRICAL EQUIPMENT DATA SHEET MODELS.

4.19 SIGNALLING FOR NAVIGATION AID

4.19.1 GENERAL

4.19.1.1 The navigation aid warning lights systems shall comply with NORMAM and RIPEAM standards.

4.19.1.2 Each light circuit shall be provided with automatic monitoring device, giving indication of extinction of the lamp.

4.19.1.3 All lamps used for signalling and navigation aids shall be certified to operate in hazardous areas Zone 1 Group IIA T3 following definitions in IEC 61892-1 and IEC 61892-7.

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

4.19.2 NAVIGATION AID SIGNALLING

4.19.2.1 The navigation aid system shall be formed by intermittent white lamps installed at all four corners of the Unit. These lights shall flash in synchronism, transmitting the letter “u” in the Morse Code in accordance with the following cycle:

a) “flash” 0.4 s.

b) “eclipse” 0.5 s.

c) “flash” 0.4 s.

d) “eclipse” 0.5 s.

e) “flash” 1.2 s.

f) “eclipse” 12 s.

4.19.2.2 These flashlights shall have a minimum range of ten (10) nautical miles on any direction. The lamps shall operate automatically, by photocell, between sunset and sunrise and shall be fitted with manual actuation devices installed in the Control Room or in the Radio Room. Photocell enclosures shall be made of copper free aluminium according to item 5.1.13.

4.19.2.3 Two foghorns shall be located at Unit in diametrically opposite corners position (next to white intermittent lamps), with a range of at least 2 (two) nautical miles in any direction.

4.19.2.4 The foghorns shall emit in synchronism the character "u" in the Morse Code, in accordance with the following cycle:

a) whistle 0.75 second.

b) silence 1.00 second.

c) whistle 0.75 second.

d) silence 1.00 second.

e) whistle 2.50 seconds.

f) silence 24.0 seconds.

4.19.2.5 All lighting fixtures shall be weather, vapour and gas proof and shall be provided with protective gratings.

4.19.2.6 Equipment for control of the lamps and foghorns shall be housed in weatherproof boxes built of non-metallic material.

4.20 AVIATION OBSTRUCTION WARNING SIGNALS FOR AIRCRAFT

4.20.1 The aircraft warning lights systems shall comply with NORMAM and RIPEAM standards.

4.20.2 Each light circuit shall be provided with automatic monitoring device, giving indication of extinction of the lamp.

4.20.3 Continuous red lamps installed on elevated points of the Unit, such as derrick, booms of cranes and other vertical obstructions to approach by helicopter shall form the warning signals for aircraft. Provision shall be made for installation of a lamp at the top of each obstacle previously related and others of such fittings along the respective structure, with spacing from top downwards at intervals not exceeding ten meters. These lamps shall have a minimum range of ten (10) nautical miles on any direction.

4.20.4 Flare towers for systems that operate with flame and pilot unlit (i.e., closed flare system) shall have permanent obstruction warning lights clearly visible from any direction of approach indicating the presence of the structure from a height ten meters above the level of the landing area until the top. The warning lights system shall be composed of sets of low intensity omnidirectional steady red lights located at ten meters intervals and/or sets of non-glare metal halide floodlights. The number of warning lights or floodlights per set shall be at least the same number of legs of the flare tower. The luminous flux shall be approved by PETROBRAS and Classification Society.

4.20.5 These lights shall be installed with heat shields when necessary and shall have a minimum intensity of 10 candelas. For floodlights the minimum produced luminosity shall be of 10 candelas/sqm. Except for cranes' signalling, the lamps shall operate automatically by photocell, between sunset and sunrise and shall be fitted with manual actuation devices installed in the Central Control Room and in the Radio Room.

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

4.21 HELIDECK LIGHTING SYSTEM

4.21.1 Helideck lighting system shall be designed in accordance with the Marine/Aeronautic directive NORMAM-27/DPC, which complementary aspects are mentioned below:

a) The helideck lighting system shall not cause dazzling sight on the pilot during landing and take-off operations.

b) LED technology or Floodlights can be applied.

4.21.2 LEDs inside landing area floor or LED strips, these technologies shall not result in floor elevations and shall not have its sealing be compromised.

4.21.3 Floodlights:

a) Four floodlights shall be installed to light the touch area. These floodlights shall be proper for LED and shall be located in each of the helideck's corners.

b) It shall not be is accepted sodium vapour lamps or Xenon floodlights.

4.21.4 The lighting fixtures shall be weatherproof and suitable for marine use, being provided with protective gratings.

4.21.5 Provision shall be made for illumination of the wind direction indicator (windsock) for night-time use or when conditions of visibility so require. This lighting shall be made with LED floodlights or with internal LEDs.

4.21.6 Helideck Status Light shall be designed in accordance with the Marine/Aeronautic directive NORMAM, shall be weatherproof and suitable for marine use, being provided with protective gratings.

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

4.22 LOW-VOLTAGE VSD-FC (VARIABLE SPEED DRIVER – FREQUENCY CONVERTER)

4.22.1 The components and systems of VSD-FCs shall be designed for continuous operation under rated output power conditions, considering the allowable overload cycles, and under continuous speed control conditions in the full output frequency range of the VSD-FC, without reduction of system capability, complying with IEC 61800.

4.22.2 VSD-FCs shall have internal protection against voltage surges and accumulation of electrostatic charges.

4.22.3 In case of VSD-FCs installed in panels, these panels shall be provided with 1 (one) heating resistor for each vertical section, fed by external 220VAC. These resistors shall be protected by thermomagnetic circuit-breakers and be automatically controlled by means of adjustable thermostats with a maximum scale range of 60 ºC.

4.22.4 The auxiliary or control voltage needed for internal circuits of the VSD-FC, excluding heating resistor circuits, shall be obtained from external main power source.

4.22.5 VSD-FCs shall comply with environmental requirements of item 3.

4.22.6 Self-supported VSD-FCs shall comply with requirements of item 4.8.

4.22.7 Printed circuit boards shall be manufactured in accordance with standard IEC 61188-5-1. Semiconductor components shall be suitable for operation at temperatures up to 70ºC and shall have undergone burn-in tests.

4.22.8 All points of wiring for external connection (input and output circuits) shall be functionally identified within the converter on each terminal block or power connection, including power cables, grounding, controls, signals, and alarms.

4.22.9 Control conductors shall be grouped in terminal blocks exclusively used for this purpose. Cables and terminal blocks shall be properly identified according to the wiring diagrams. If spare control circuits are foreseen, terminal blocks shall also have spare terminal blocks.

4.22.10 VSD-FCs shall have a local digital HMI (human machine interface) on its front side to allow man/machine interface and user-friendly dialog. This panel shall contain at least the following devices for operation and monitoring:

a) selector switch or parameter definable option for selection of mode of operation (LOCAL/REMOTE).

b) START switch.

c) STOP switch.

d) parameter selection switches.

e) parameter and adjustment programming switches.

f) key for increment of functions or control values.

g) key for decrement of functions or control values.

h) signalling LED indicating energized equipment.

i) digital alphanumeric display to indicate:

- frequency.
- speed.
- current.
- fault diagnosis.
- alarms.
- self-supervision system messages and
- adjustment parameter values.

4.22.11 VSD-FCs shall have at least input, and output signals listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

4.22.12 All VSD-FCs shall include network interfaces and shall follow 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 regarding architecture and Ethernet communication protocols. The VSD-FC network interface shall be used for control and monitoring signals, parameterization, and programming.

4.22.13 For all VSD-FC, 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.

4.22.14 The VSD-FC 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.

4.22.15 All devices with logging or communication capabilities internal to the VSD-FC 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.

4.22.16 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.

4.22.17 All VSD-FC shall have galvanic isolators for analogic interfaces with A&C or Package Control Panels.

4.22.18 All VSD-FC expected to receive ESD or other wet signals from A&C or Package Control Panels shall have interposing relays with enough quantity to convert discrete 24 VDC signal in discrete voltage-free signal.

4.22.19 Remote START and STOP controls shall initiate pre-programmed acceleration and deceleration ramps, respectively. Remote TRIP command shall immediately de-energize the motor.

4.22.20 VSD-FCs control shall be microprocessor-based and contain at least the following functions:

a) selectors.

b) alarm functions.

c) network communication with automation system.

d) monitoring and diagnostics.

e) input and output functions.

4.22.21 VSD-FCs shall permit in its programming and configuration at least the following basic adjustments:

a) acceleration and braking ramps, separately programmable, capable of being started from the external reference command.

b) minimum and maximum operation frequencies.

c) output frequency during operation.

d) inhibition of critical resonance frequency ranges of the mechanical system.

e) programming of automatic re-start function, after a trip or undervoltage event.

f) torque limit.

4.22.22 VSD-FCs shall have at least the following protections:

a) disconnection of VSD-FC due to internal defect.

b) VSD-FC overload.

c) lack of phase.

d) monitoring of temperature of power semiconductor stages, with alarm and trip signalling.

e) overvoltage.

f) undervoltage.

g) motor overload thermal protection by electronic thermal relay.

h) ground fault in motor.

NOTE: in IT grounding systems this function shall be disabled.

i) short-circuit at output.

4.22.23 VSD-FCs shall provide electronic protection to the motor, which shall be capable of estimating the temperature of its windings based on programmed parameters referring to the motor. This protection shall cause the motor to be turned off when its thermal capacity is exceeded.

4.22.24 VSD-FCs shall comply with requirements of item 3.10.

4.22.25 VSD-FCs shall be built in such a manner that total harmonic distortions (THD) for voltage and current do not exceed the values recommended in standard IEEE 519, under the worst normal operating conditions.

4.22.26 VSD-FCs shall be built with output dV/dt filter. This filter shall be sized for motor protection considering VSD harmonics, cable sizes and characteristics and feeding motor. Only if transient studies approved by PETROBRAS prove that filter is not necessary it may be not considered.

4.22.27 VSD-FCs shall be tested according to IEC 60146-2, IEC 60533, and IEC 61000.

4.22.28 For VSD-FCs feeding motors installed in hazardous areas Zone 1 or Zone 2 and outdoors motors that are turned on during ESD-3P or ESD-3T condition, the entire set (motor and drive) shall be certified to this location taking into consideration the VSD type and the frequency variation range, according to requirements of IEC 60079.

4.22.29 As requested in I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS, when VSD-FC is required as a starter for motors:

a) in MCCs, its functional unit shall be formed by moulded-case circuit-breaker, fuses (proper for VSD-FC protection), bypass contactor (only for essential loads), VSD-FC and IR (Intelligent Relays).

b) in CDCs, its functional shall be formed by "power" air circuit-breaker, fuses (proper for VSD-FC protection), VSD-FC, and MMR.

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

4.22.31 For MCCs, when the VSD-FCs are installed in a separate panel, this panel shall be fixed mounting type, protection degree IP-42, with circuits separated in compartments according to forms 3b or 4b according to IEC 61439-1 and with access for installation and maintenance from the front side. It shall be acceptable use of wall mounted VSD-FCs separate from this panel since the minimum protection degree of the VSD-FCs is IP-41.

4.22.32 For CDCs, when the functional unit uses VSD-FC, the air circuit-breaker shall be installed within the drawer in the CDC. All the other components shall be installed in the fixed (non-withdrawable) panel.

4.22.33 For CDCs, when VSD-FCs is installed in a separate panel, fixed mounting type, protection degree IP-42, with circuits separated in compartments according to forms 3b or 4b according to IEC 61439-1 and with access for installation and maintenance from the front side. It shall be acceptable use of wall mounted VSD-FCs separate from this panel since the minimum protection degree of the VSD-FCs is IP-41.

4.22.34 As required in I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS:

a) The fixed panels shall have electrical and mechanical properties complying with the calculated short-circuit level.

b) VSD-FCs shall be operated, set, and monitored through the same communication network used by the IRs of the VSD-FC feeder panel. See I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM and I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE.

4.22.35 For VSD-FCs feeding essential loads not installed in hazardous areas Zone 1, protection function “ground fault” (50GS) shall be disabled or inhibited in built-in VSD-FCs’ protection or panels (CDC or MCC) protection, for isolated or high impedance systems.

4.22.36 Grounding and cables installation for motors fed from VSD-FCs shall comply with requirements of IEC TS 60034-25.

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

4.22.38 Manufacturer shall provide complete manuals and documentation. MTTR shall be informed.

Note: At least, two copies in English language and two copies in Brazilian Portuguese language shall be provided for all reference manuals. 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.

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

4.22.40 When the VSD-FCs are installed in a separate panel, facilities shall be provided to allow temporary grounding by means of ground cables, through screwed connectors, separately, to the panel frame to the terminal block box and to the enclosure.

4.22.41 When VSD-FC is used with an input transformer, VSD-FC manufacturer shall define grounding type (high-value resistance, neutral isolated, etc.) of secondary windings of the input transformer in order to avoid unwanted: ground system interactions, harmonic flows, and common mode voltages. This grounding type shall be suitable to low-voltage system grounding type and shall allow protective functions defined in I-ET-3010.00-5143-700-P4X-001 - ELECTRICAL SYSTEM PROTECTION CRITERIA.

4.23 LOW-VOLTAGE SOFT-STARTERS

4.23.1 The components and systems of LV soft-starters shall be designed for operation (continuous or not continuous) under rated output power conditions without reduction of system capability.

4.23.2 Soft-starters shall have internal protection against voltage surges and accumulation of electrostatic charges.

4.23.3 In case of soft-starters installed in separated panels, these panels shall be provided with 1 (one) heating resistor for each vertical section, fed by external 220VAC. These resistors shall be protected by thermomagnetic circuit-breakers and be automatically controlled by means of adjustable thermostats with a maximum scale range of 60ºC.

4.23.4 The auxiliary or control voltage needed for internal circuits of the soft-starters, excluding heating resistor circuits, shall be obtained from external main power source.

4.23.5 Soft-starters shall comply with environmental requirements of item 3.

4.23.6 Self-supported soft-starters shall comply with requirements of item 4.8.

4.23.7 Printed circuit boards shall be manufactured in accordance with standard IEC 61188-5-1. Semiconductor components shall be suitable for operation at temperatures up to 70ºC and shall have undergone burn-in tests.

4.23.8 All points of wiring for external connection (input and output circuits) shall be functionally identified within the soft-starter on each terminal block or power connection, including power cables, grounding, controls, signals, and alarms.

4.23.9 Control conductors shall be grouped in terminal blocks exclusively used for this purpose. Cables and terminal blocks shall be properly identified according to the wiring diagrams. If spare control circuits are foreseen, terminal blocks shall also have spare terminal blocks.

4.23.10 Soft-starters shall have a local digital HMI (human machine interface) on its front side to allow man/machine interface and user friendly dialog. This panel shall contain at least the following devices for operation and monitoring:

a) selector switch or parameter definable option for selection of mode of operation (LOCAL/REMOTE).

b) START switch.

c) STOP switch.

d) parameter selection switches.

e) parameter and adjustment programming switches.

f) key for increment of functions or control values.

g) key for decrement of functions or control values.

h) signalling LED indicating energized equipment.

i) digital alphanumeric display to indicate:

- current.
- fault diagnosis.
- alarms.
- self-supervision system messages. and
- adjustment parameter values.

4.23.11 Soft-starters shall have at least Input, and Output signals listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

4.23.12 All soft-starters shall include network interfaces and shall follow 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 regarding architecture and Ethernet communication protocols. The Soft-starter network interface shall be used for control and monitoring signals, parameterization, and programming.

4.23.13 For soft-starters, 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.

4.23.14 The soft-starters 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

4.23.15 All devices with logging or communication capabilities internal to the soft-starters 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.

4.23.16 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.

4.23.17 All soft-starters expected to receive ESD or other wet signals from A&C or Package Control Panels shall have interposing relays with enough quantity to convert discrete 24 VDC signal in discrete voltage-free signal.

4.23.18 Soft-starters shall have either a programmed temporary delay or a programmed start sequence to allow contactor or circuit breaker to be closed first than soft-starters controls functions.

4.23.19 Soft-starters controls shall be microprocessor-based and contain at least the following functions:

a) selectors.

b) alarm functions.

c) network communication with automation system.

d) monitoring and diagnostics.

e) input and output functions.

4.23.20 For soft-starters connected via network communication with Electrical System and A&C, the discrete and analogical signals above may be changed to network signals.

4.23.21 Soft-starters shall permit in its programming and configuration at least the following basic adjustments:

a) up and down voltage x time ramps, programmable, capable of being started from the external reference command.

b) programming of automatic re-start function, after a trip or undervoltage event.

4.23.22 Soft-starters shall have at least the following protections:

a) disconnection of soft-starters due to internal defect.

b) Soft-starters overload.

c) lack of phase.

d) monitoring of temperature of power semiconductor stages, with alarm and trip signalling.

e) overvoltage.

f) undervoltage.

g) motor overload thermal protection by electronic thermal relay.

h) ground fault in motor.

Note: in IT grounding systems this function shall be disabled.

i) short-circuit at output.

4.23.23 If in continuous operation, soft-starters shall provide electronic protection to the motor, which shall be capable of estimating the temperature of its windings based on programmed parameters referring to the motor. This protection shall cause the motor to be turned off when its thermal capacity is exceeded.

4.23.24 Soft-starters shall comply with requirements of item 3.10.

4.23.25 If in continuous operation, soft-starters shall be built in such a manner that total harmonic distortions (THD) for voltage and current do not exceed the values recommended in standard IEEE 519, under the worst normal operating conditions.

4.23.26 Soft-starters shall be tested according to IEC 60146-2, IEC 60533, and IEC 61000.

4.23.27 For Soft-starters feeding motors installed in hazardous areas Zone 1 or Zone 2 and outdoors motors that are turned on during ESD-3P or ESD-3T condition, the entire set (motor and drive) shall be certified to this location taking into consideration the Soft-starters type and the frequency variation range, according to requirements of IEC 60079.

4.23.28 For Soft-starters feeding essential loads not installed in hazardous areas Zone 1, protection function “ground fault” (50GS) shall be disabled or inhibited in built in soft-starters protection or panels (CDC or MCC) protection, for isolated or high impedance systems.

4.23.29 Soft-starters with control only in two phases shall not be accepted.

4.23.30 Soft-starters shall have an incorporated bypass contactor.

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

4.23.32 For soft-starters that feed normal motor loads, the bypass contactor is not necessary when the motor operates eventually and for a short time, like for start the turbines, provided that there is a soft-starter for each motor. As required by I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS.

4.23.33 For MCCs, when the soft-starters are installed in a separate panel, the moulded-case circuit-breaker and the IR (Intelligent Relays) shall be installed within the drawer in the MCC. All other components shall be installed in the fixed (not withdrawable) panel.

4.23.34 For MCCs, when the soft-starters are installed outside MCC, a separate panel shall be supplied for this purpose. This panel shall be fixed mounting type, protection degree IP-42, with circuits separated in compartments according to forms 3b or 4b according to IEC 61439-1 and with access for installation and maintenance from the front side. It shall be acceptable use of wall mounted soft-starters separate from this panel, since the minimum protection degree of the soft-starter is IP-41.

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

4.23.36 For CDCs, soft-starters shall be installed in a separate panel, fixed mounting type, protection degree IP-42, with circuits separated in compartments according to forms 3b or 4b of IEC 61439-1 and with access for installation and maintenance from the front side. It shall be acceptable use of wall-mounted soft-starters separate from this panel, since the minimum protection degree of the soft-starters is IP-41.

4.23.37 The fixed panels shall have electrical and mechanical properties complying with the calculated short-circuit level.

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

4.23.39 Manufacturer shall provide complete manuals and documentation. MTTR shall be informed.

Note: At least, two copies in English language and two copies in Brazilian Portuguese language shall be provided for all reference manuals. 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.

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

4.24 INVERTERS (D.C.-A.C. CONVERTERS)

4.24.1 The components and systems of inverters shall be designed for operation (continuous or not continuous) under rated output power conditions without reduction of system capability.

4.24.2 Inverters shall have internal protection against voltage surges and accumulation of electrostatic charges.

4.24.3 In case of inverters installed in separated panels, these panels shall be provided with 1 (one) heating resistor for each vertical section, fed by external 220 VAC. These resistors shall be protected by thermomagnetic circuit-breakers and be automatically controlled by means of adjustable thermostats with a maximum scale range of 60ºC.

4.24.4 The auxiliary or control voltage needed for internal circuits of the inverters, excluding heating resistor circuits, shall be obtained from external main power source. The external main power source shall be downstream panels.

4.24.5 Inverters shall comply with environmental requirements of item 3.

4.24.6 Self-supported inverters shall comply with requirements of item 4.8.

4.24.7 Printed circuit boards shall be manufactured in accordance with standard IEC 61188-5-1. Semiconductor components shall be suitable for operation at temperatures up to 70ºC and shall have undergone burn-in tests.

4.24.8 All points of wiring for external connection (input and output circuits) shall be functionally identified within the inverters on each terminal block or power connection, including power cables, grounding, controls, signals and alarms.

4.24.9 Control conductors shall be grouped in terminal blocks exclusively used for this purpose. Cables and terminal blocks shall be properly identified according to the wiring diagrams. If spare control circuits are foreseen, terminal blocks shall also have spare terminal blocks.

4.24.10 Inverters shall have a local digital HMI (human machine interface) on its front side to allow man/machine interface and user friendly dialog. This panel shall contain at least the following devices for operation and monitoring:

a) selector switch or parameter definable option for selection of mode of operation (LOCAL/REMOTE).

b) START switch.

c) STOP switch.

d) parameter selection switches.

e) parameter and adjustment programming switches.

f) key for increment of functions or control values.

g) key for decrement of functions or control values.

h) signalling LED indicating energized equipment.

i) digital alphanumeric display to indicate:

(i) current.

(ii) fault diagnosis.

(iii) alarms.

(iv) self-supervision system messages. and

(v) adjustment parameter values.

4.24.11 Inverters shall have at least Input, and Output signals listed in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

4.24.12 All inverters shall include network interfaces and shall follow 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 regarding architecture and Ethernet communication protocols. The inverters network interface shall be used for control and monitoring signals, parameterization, and programming.

4.24.13 For inverters, 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.

4.24.14 All inverters expected to receive ESD or other wet signals from A&C or Package Control Panels shall have interposing relays with enough quantity to convert discrete 24 VDC signal in discrete voltage-free signal.

4.24.15 Inverters controls shall be microprocessor-based and contain at least the following functions:

a) selectors.

b) alarm functions.

c) network communication with automation system.

d) monitoring and diagnostics.

e) input and output functions.

4.24.16 For inverters connected via network communication with Electrical System and A&C, the discrete and analogical signals above may be changed to network signals.

4.24.17 Inverters shall permit in its programming and configuration at least the following basic adjustments:

a) up and down voltage x time ramps, programmable, capable of being started from the external reference command.

b) programming of automatic re-start function, after a trip or undervoltage event.

4.24.18 Inverters shall have at least the following protections:

a) disconnection of inverters due to internal defect.

b) Inverters overload.

c) lack of output phase.

d) monitoring of temperature of power semiconductor stages, with alarm and trip signalling.

e) D.C. overvoltage.

f) D.C. undervoltage.

g) A.C. overvoltage.

h) A.C. undervoltage.

i) ground fault.

j) short-circuit at output.

4.24.19 If in continuous operation, inverters shall provide electronic protection to its feeding panel or load.

4.24.20 Inverters shall comply with requirements of item 3.10.

4.24.21 If in continuous operation, inverters shall be built in such a manner that total harmonic distortions (THD) for voltage and current do not exceed the values recommended in standard IEEE 519, under the worst normal operating conditions.

4.24.22 Inverters shall be tested according to IEC 60146-2, IEC 60533, and IEC 61000.

4.24.23 For inverters feeding panels or loads installed in hazardous areas Zone 1 or Zone 2 and outdoors motors that are turned on during ESD-3P or ESD-3T condition, the entire set shall be certified to this location taking into consideration the inverter type and the frequency variation range, according to requirements of IEC 60079.

4.24.24 For inverters feeding essential panels or essential loads not installed in hazardous areas Zone 1, protection function “ground fault” (50GS) shall be disabled or inhibited in built in inverters protection, for isolated or high impedance systems.

4.24.25 When the inverters are installed in a separate panel, the moulded-case circuit-breaker and the IR (Intelligent Relays) shall be installed within D.C. feeding panel. All other components shall be installed in the fixed panel.

4.24.26 When the inverters are installed outside the D.C. panel, a separate panel shall be supplied for this purpose. This panel shall be fixed mounting type, protection degree IP-42, with circuits separated in compartments according to forms 3b or 4b according to IEC 61439-1 and with access for installation and maintenance from the front side. It shall be acceptable use of wall mounted inverters separate from this panel, since the minimum protection degree of the soft-starter is IP-41.

4.24.27 Inverters shall have electrical and mechanical properties complying with the calculated short-circuit level.

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

4.24.29 Manufacturer shall provide complete manuals and documentation. MTTR shall be informed.

Note: At least, two copies in English language and two copies in Brazilian Portuguese language shall be provided for all reference manuals. 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.

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

4.25 POWER CAPACITORS AND CAPACITOR BANKS

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

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

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

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

4.25.5 Manufacturer shall provide complete manuals and documentation. MTTR shall be informed.

Note: At least, two copies in English language and two copies in Brazilian Portuguese language shall be provided for all reference manuals. 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.

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

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

4.26 LIGHTNING AND SURGE ARRESTERS

4.26.1 Lightning and surge arresters shall comply with IEC 60099, IEC 61643, and IEC 62305.

4.26.2 Lightning and surge arresters' material requirements shall comply with NFPA 780, Class II.

4.26.2.1 All copper air terminals shall be 12.7 mm.

4.26.2.2 Stained copper cables shall be used for System of Electrical Protection against Atmospheric Discharges, SPDA, aluminium cables are forbidden.

4.26.2.3 Stainless steel or bronze connectors are allowed for SPDA if requirements of NFPA 780 chapter 10 are met.

4.26.2.4 Main SPDA conductors and down SPDA conductors shall have insulation according to NFPA 780, IEC 61892-6 and IEC 60092-401.

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

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

4.26.4 Manufacturer shall provide complete manuals and documentation. MTTR shall be informed.

Note: At least, two copies in English language and two copies in Brazilian Portuguese language shall be provided for all reference manuals. 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.

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

4.27 SURGE PROTECTIVE DEVICES

4.27.1 Surge Protective Devices (SPD) shall only be used in insulated or high impedance electrical systems as indicate in NFPA 70.

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

4.27.3 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.

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

4.28 INSTRUMENT TRANSFORMERS

4.28.1 Instrument transformers shall comply with IEC 61869.

4.28.2 Electronic instrument transformers shall comply with IEC 61869-10 and IEC 61869-11.

4.28.3 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.

4.28.4 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.

4.28.5 Voltage Transformers shall be dry-type.

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

4.29 REACTORS

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

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

4.29.3 Manufacturer shall provide complete manuals and documentation. MTTR shall be informed.

Note: At least, two copies in English language and two copies in Brazilian Portuguese language shall be provided for all reference manuals. 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.

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

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

4.30 MOTOR ACTUATED VALVES

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

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

4.30.3 Manufacturer shall provide complete manuals and documentation. MTTR shall be informed.

Note: At least, two copies in English language and two copies in Brazilian Portuguese language shall be provided for all reference manuals. 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.

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

5 MATERIALS

5.1 GENERAL

5.1.1 All electric material shall have high quality regarding dielectric rigidity, mechanical, thermal and chemical resistance, following in a strictly manner the standards used for its fabrication.

5.1.2 All material employed shall be non-hygroscopic, flame retardant and resistant to corrosion caused by a saline atmosphere environment with the presence of moisture and contact with hydrocarbons.

5.1.3 Protecting treatments, including galvanic treatment sand paints, shall not include sealing joints, for which only neutral Vaseline or silicon grease shall be used.

5.1.4 The hot galvanizing by immersion shall have the following minimum characteristics:

a) for thickness ≥ 3mm: 78μm (550g/m^2).

b) for thickness < 3mm: 50μm (350g/m^2).

c) screws, washers, etc. ≥ 10mm: 50μm.

d) screws, washers, etc. < 10mm: 36μm.

5.1.5 Materials for equipment to be installed in hazardous areas (with certification Ex) shall follow the IEC 60079 standards.

5.1.6 Unless otherwise stated, all threaded joints shall be taper type, NPT with standardized tolerances, according to ASME B1.20.1. Cylindrical threaded joints shall be acceptable for lighting fixtures, for control boxes for push-buttons and signalling, for floodlights and for power socket-outlets. Cylindrical threaded joints for other applications shall be submitted to PETROBRAS approval. For equipment installed in hazardous areas, the threads shall comply with the requirements of IEC 60079-0.

5.1.7 All screws, nuts and washers shall be made of bichromatized steel or AISI-316L stainless steel. For application in cable trays and cable trays supports only AISI-316L stainless steel shall be used.

5.1.8 The connectors for power and control cables shall be made of electrolytic copper with tin coat, as ASTM-B1, B2, B3, B8, B33, or ASTM B846, and shall not be of welded type.

5.1.9 The connectors for grounding cables either shall be made of:

- Electrolytic copper with tin coat, as ASTM-B1, B2, B3, B8, B33, or ASTM B846, or.
- Naval Bronze of classic marine, high-strength and corrosion-resistant alloy C462 or C464.

Both materials shall not be of welded type.

5.1.10 In order to avoid electrolytic corrosion, contacts between different metallic materials shall be prevented. Galvanic insulation shall be implemented where contact between different metallic materials is necessary.

5.1.11 Required by NFPA 780, with the exception of bimetallic connectors, direct contact between metals which galvanic potential differs by more than 0.5 V shall not be permitted.

5.1.12 Aluminium equipment shall be mounted on cast steel structure with a 5 mm rubber or neoprene insulation joint in between and with stainless steel AISI-316L bolts and nuts.

5.1.13 All equipment and components made in aluminium shall be in accordance with the alloy specifications as follows:

a) ASTM-B26/B26M specification, ANSI 356.0 alloys for sand castings.

b) ASTM-B108/B108M specification, ANSI 359.0 alloy for permanent mould castings.

c) ASTM-B221 specification, 6063 or 6351 alloy for extruded bars, rods, wires, profiles, and tubes.

5.1.14 For aluminium superstructures that are provided with insulating material between aluminium and steel in order to prevent galvanic action, the washers or the terminals used to connect grounding cables shall be made of Cupal, according to DNV-OS-D201.

5.1.15 The use of aluminium casing for electrical equipment and accessories is not allowed for outdoor areas.

5.2 NON-METALLIC MATERIALS

5.2.1 Manufacturer shall furnish the certificates of prototype, issued by a recognized Testing Laboratory, as indicated in Table 16. Certificates shall be homologated by a recognized Brazilian Entity and submitted to PETROBRAS and Classification Society approval.

5.2.2 Tests of Table 16 are dispensable, for unmanned area, if the component has a conformity certificate proving that it is adequate to hazardous area installation, issued by a recognized Testing Laboratory and approved by Classification Society.

5.2.3 For cable tray see 5.3. Tests of Table 16 are not applicable.

5.2.4 For boxes manufactured in Brazil, acceptance tests of flammability in accordance with UL 94 shall be carried out.

5.2.5 Non-metallic materials shall have flame self-extinguishing and non-fire propagating properties.

5.2.6 Non-metallic materials shall have a maximum FSI (Flame Spread Index) value of 25 according to ASTM E84 or a maximum burned distance of 30 mm at 10 seconds according to ASTM D635.

Table 16 - Non-Metallic Test Specimens - All Areas.

Tests	Standards	Plugs and Socket-Outlets	Junction Boxes, Push-Buttons Stations	Lighting Fixtures	Lighting Panels(2)	Cable Fittings (Glands)
Toxicity Index (1)	DEF STAN 07-247	X	X	X	X	-
Smoke Specific Density Generated by Solid Materials (1)	ASTM E662	X	X	X	X	-
Traction in Plastic	ISO 527 ASTM D790	X	X	X	X	X
Flexure in Plastic	ISO 178 ASTM D790	X	X	X	X	X
Water Absorption in Plastic	ISO 62	X	X	X	X	X
Resistance to Sunlight (Ultraviolet Rays)	ISO 4892	X	X	X	X	X
Resistance to Impact	ISO 179-1 ASTM D256	X	X	X	X	X
Resistance to Chemical Agents	ASTM D543	X	X	X	X	X
Accelerated Aging	IEC 60216-1 IEC 60216-2	X	X	X	X	X
Flammability	UL 94	X	X	X	X	-
Comparative Index of Superficial Resistance	ASTM D257	X	X	X	X	-
Vertical Burning-Stake	IEC 60332-3-10	-	-	-	-	-
Flame-Retardation	IEC 60092-101	-	-	-	-	-
Volume Resistivity	IEC 62631-3-2	-	-	-	-	-
Surface Resistivity	IEC 62631-3-2	-	-	-	-	-
Surface Resistance	IEC 62631-3-2	-	-	-	-	-

Notes:
1. Only for manned area. Manned areas are those occupied 24 hours a day, like control room and accommodations.
2. Only for external areas application.

5.3 CABLE TRAYS

5.3.1 CABLE TRAYS GENERAL REQUIREMENTS

5.3.1.1 Cable trays include the following types: ladders trays, troughs, channel trays, solid bottom trays, and other similar structures.

5.3.1.2 Cable trays components include sections of cable trays, sections of channel trays, section of ladder trays, support fittings, assembly fittings, and other accessories of cable trays.

5.3.1.3 Cable trays and their accessories shall not present crushing, sharp edges or seams which can damage the external cover or cable insulation during launching or can cause damages to the health or physical integrity of personnel.

5.3.1.4 All cable tray transition parts shall be industrial made, project and dimensioned for the cable sizes loads required. The use of "in field" built transition parts are not accepted.

5.3.1.5 When cables are subjected to mechanical impacts, proper additional protection by covers shall be foreseen.

5.3.1.6 Cable trays cover material shall be of the same material and the same thickness of cable trays they are protecting.

5.3.1.7 In external areas, for vertical sections, i.e., flare cable trays, each piece of cable trays coverings shall have a heavy duty cover clamp to avoid lid loosening and falling. The heavy duty cover clamps shall be made of stainless steel AISI-316L or carbon steel painted according to item 3.6.3.

5.3.2 Manufacturers shall provide means to avoid electrolytic corrosion caused by contact of dissimilar materials.

5.3.3 CABLE TRAY USE LOCATION

5.3.3.1 INTERNAL AREAS

5.3.3.1.1 Cable trays for internal areas shall be stainless steel AISI-316L.

5.3.3.1.2 The use of non-metallic cable tray is forbidden.

5.3.3.2 EXTERNAL AREAS

5.3.3.2.1 Cable trays for external areas shall be stainless steel AISI-316L or heavy-duty, non-metallic, manufactured in composite material reinforced with fiberglass.

5.3.3.2.2 For heavy-duty non-metallic cable trays and protective casings, the following conditions apply:

- It shall not be allowed in external areas which, according to the Fire Propagation Study, may reach temperatures higher than the maximum temperature of use defined by Manufacturer. In this case, stainless steel AISI-316L shall be used.

  Explanation notes:

  The Fire Propagation Study define the maximum temperature values that can be reached in case of fire in all process unit modules.

  The non-metallic cable trays and protective casings have a maximum temperature value to which strength capabilities are still under acceptance.

In case of Fire Propagation Study defines a temperature for specific area that is equal to or above limit values defined for non-metallic cable trays and protective casings temperature, stainless steel AISI-316L shall be used.

- It shall comply with minimum Fire Integrity Level defined in Table 17.
  Explanation notes:

  This table is based in ABNT NBR 15708-3 and ASTM F3059. In case of any divergency between these standards the most restrictive applies.

Table 17 - Criteria for Application of Non-Metallic Cable Trays and Protective Casings.

Area	Minimum Fire Integrity Level
Turbogenerators and Turbo-compressor hoods, moto-generators and moto-compressors rooms, boilers, and furnaces	Level 2
Engine room (cargo pump areas)	Use not allowed
Chain lockers	Level 2
Oil storage tanks	Level 2
Fuel oil tanks	Level 2
Ballast water tanks	Level 2
Cofferdams, void spaces, double bottoms, pipe tunnels, etc.	Use not allowed
Control rooms, inside accommodation, offices	Use not allowed
Embarkation stations on inflatable life rafts, lifeboats, rescue boats, muster stations, in open deck areas	Level 2
Decks between process modules, access catwalks, access ladders, skids of equipment, process plant and utilities, flare access, riser balcony	Level 2
Decks between process modules, access catwalks, access ladders, skids of equipment, process plant and utilities, turret's (including pull in deck), flare access, riser balcony	Level 2
Motor pump hoods for firefighting pump	Level 2
Other closed areas, not described above	Use not allowed

5.3.4 NON-METALLIC CABLE TRAYS

5.3.4.1 Heavy-duty, non-metallic cable trays, manufactured in composite material reinforced with fiberglass, shall comply with the following requirements.

5.3.4.1.1 It shall be designed complying with requirements of ABNT NBR 15708-4, ASTM F3059, and IACS No. 73.

In case of any divergency between these standards the most restrictive applies.

5.3.4.1.2 It shall be moulded by pultrusion process.

5.3.4.1.3 It shall have the following electrical characteristics:

- Volume resistivity level below 10^5 ohms.m.
- Surface resistivity below 1MΩ (10^6 ohms).
- Resistance to earth from any point not exceeding 1MΩ (10^6 ohms).

5.3.4.1.4 Type approval procedure shall be according to IACS No. 73.

5.3.4.2 The definition of Fire Integrity Level for non-metallic cable trays shall be done using the criteria defined for non-metallic floor grating in ABNT NBR 15708-3 and ASTM F3059. See Table 17.

5.3.4.3 Non-metallic cable trays shall be tested according to ABNT NBR 15708-1, ABNT NBR 15708-4, and IACS No. 73, considering the following minimum test list:

- Impact Resistance Test
- Safe Working Load (SWL) Test
- Flame Retardant Test
- Smoke and Toxicity Test
- Resistivity Test

5.3.4.4 It shall be acceptable acrylic and phenolic alternatives for non-metallic cable-trays and accessories.

5.3.4.5 Composite materials for offshore non-metallic cable trays installations shall have a Class Society type approval certificate that attest that it complies with indicated standards.

5.3.4.6 The reports of all tests required by ABNT NBR 15708-1, ABNT NBR 15708-4, and IACS No. 73, as well as the tests to obtain the type approval certificates shall be submitted to PETROBRAS.

5.3.5 CABLE TRAYS SUPORT STRUCTURES

5.3.5.1 Cable trays supports shall be made of stainless steel AISI-316L or HDG (hot dipped galvanized) steel painted according to item 3.6.3.

5.3.5.2 These supports shall be welded to structure, as required in I-DE-3010.00-5140-700-P4X-002 - POWER INSTALLATION TYPICAL DETAILS. For welding procedures refer to, I-ET-3010.00-1200-955-P4X-001 - WELDING.

5.3.5.3 It is acceptable the use of welded pin technologies and assembled stainless steel AISI-316L structures for support of cable trays if:

5.3.5.3.1 It is provided that the structural loads generated by cables, trays and unit movement are correctly dimensioned and submitted to PETROBRAS evaluation and approval.

5.3.5.3.2 It is used for lighting cable trays, in a maximum of three cable trays per support (i.e.: normal, emergency, essential) and not bigger than 50 mm.

5.3.5.3.3 It is used for power cable trays, not hanging, not bigger than 50 mm, only for control or instrumentation purposes.

5.3.5.3.4 It is used for telecom cable trays following telecommunication systems requirements. For more information see Telecommunication documents.

5.3.5.3.5 All other application cases for welded pin technologies and assembled stainless steel AISI-316L structures for support of cable trays shall be submitted to PETROBRAS evaluation and approval.

5.4 PHASE AND GROUNDING BARS

They shall be of electrolytic copper.

5.5 SEALS FOR CABLES PASSAGE ON HAZARDOUS AREAS FLOORS AND BULKHEADS

5.5.1 MULTI CABLE TRANSIT – CONVENTIONAL TYPE WITH BLOCKS (MCT)

5.5.1.1 MCTs (Multi Cable Transit) shall follow IEC 61892-6 and be standard type, with passage frame, insert blocks, spare blocks, stay plates, compression plates, end packing, etc.

5.5.1.2 Maximum individual frame dimensions shall be 120 mm width and 240 mm height (S-8). Combination frames can be used since each one of the component frames is within above mentioned limits.

5.5.1.3 MCTs shall have test certificate issued by Official Laboratory or Certifying Entity, to application on A-60 bulkheads without fire stop blanket over the blocks.

5.5.1.4 MCTs blocks shall be multi-diameter type, adjustable to accommodate a range of cable diameters with a solid central plug. Spare blocks shall be solid type.

5.5.1.5 Each MCT shall have at least 20% of spare blocks.

5.5.1.6 MCT installed below the worst damage waterline, as defined in IMO MODU CODE, shall be designed to support the column foreseen hydrostatic pressure. These MCTs shall have Certificated Test Reports considering minimum pressure of 4 bar.

5.5.1.7 MCTs shall be type-approved by Classification Society.

5.5.1.8 MCTs shall have certificates issued by an Official Laboratory or Certifying Entity when are applied in hazardous areas.

5.5.1.9 Carbon steel MCT frames shall not be used.

5.5.1.10 For external areas, only stainless steel MCT frames shall be used.

5.5.1.11 If not defined by specific document, for specific purposes or internal areas, MCT frames material shall be previously approved by PETROBRAS.

5.5.2 FLEXIBLE RAPID SEALING SYSTEM

5.5.2.1 This system shall be standard type, consisting of split insert cable sleeves and hollows, non-split filler sleeves (160 mm length) and a fire-resistant sealant, based on a single thermal expansive (5 to 10 times expansion capacity) component silicone compound. The colour of the sleeves and sealant shall be dark grey, as defined in ABNT NBR 6493. The type of sleeve shall be marked in yellow on the sleeves. The sealant cartridges shall be coded with batch number, date of manufacturing and its validity.

5.5.2.2 The conduit frame shall have a depth of 200 mm with maximum dimensions of 600 x 300mm. The frames may be constructed in rectangular or circular shape. For specific cases, e.g., higher pressure levels, Manufacturer shall indicate the limitation of frame dimensions.

5.5.2.3 The sealant shall be applied in a thickness of 20 mm at each side of penetration.

5.5.2.4 The size of penetration shall be in accordance with IMO Resolution A.754 (18), not exceeding a filling rate of 40%. The shape of the conduit frame shall be designed according to the project requirements.

5.5.2.5 Materials shall be supplied by the Manufacturer having test certificate issued by Official Laboratory or Certifying Entity. The Flexible Rapid Sealing System shall be installed without extra fire stop blanket at the exposed side around the coaming and in front of the penetration when applied in A-60 bulkheads. No extra insulation shall be needed in front of the penetration when applied in decks.

5.5.2.6 Insert and filler sleeves (160mm) shall have a wall thickness of 3, 4 or 5 mm depending on the size of the sleeves.

5.5.2.7 Insert sleeves to be placed around each of the ducted cables (spare sleeves) shall be of the non-split type. Each penetration shall have 20% spare space for later extensions to be filled with filler sleeves.

5.5.2.8 Flexible Rapid Sealing System installed below the worst damage waterline, as defined in IMO MODU CODE, shall be designed to support the foreseen column hydrostatic pressure. For pressures up to 4 bar the conduit frame shall have individual dimensions of 120x280mm. The frames can be combined in larger dimensions, provided that the individual frame dimensions are not exceeded.

5.5.2.9 The installation of the Flexible Rapid Sealing System shall be permitted in watertight decks, damage area and columns void space provided that the frame size is dimensioned and certified for the required pressure rating.

5.5.2.10 The wire tights used to fix the sleeves around the cables shall not be of metallic material. These wire tights or strips shall be preferable made of nylon. This is to prevent heating caused by inductive current on metallic wire tights.

5.5.2.11 Flexible Rapid Sealing Systems shall be type-approved by Classification Society.

5.6 CABLE GLANDS

5.6.1 Cable gland shall follow IEC 62444.

5.6.2 Cable gland materials shall be selected in order to avoid electrolytic corrosion caused by contact of dissimilar materials.

5.6.3 Cable glands material shall follow the requirements of Table 18:

Table 18 - Cable Gland Material

Enclosure Material	Cable Gland Material
Stainless Steel	Stainless Steel AISI-316L
Cast Iron	
Aluminium (3)	Aluminium (3)
FRP (Fiber Reinforced Plastic)	Aluminium (3)
	Nylon (1)
	Naval Bronze (2)
	Stainless Steel AISI-316L
Stainless Steel, Naval Bronze	Naval Bronze (2)

Notes: 1) Nylon cable glands shall be accepted only up to maximum size 1", with metallic plate (made of Stainless Steel AISI-316L, Aluminium or Naval Bronze (2)) for grounding, with internal locknut and if they are certified as Ex e or Ex n.
2) Naval Bronze shall be classic marine, high-strength and corrosion-resistant alloy C462 or C464.
3) Aluminium shall follow section 5.1.13.

5.6.4 Threaded joints shall comply with item 5.1.6.

5.6.5 Cable glands for installation at non threaded holes of removable plates or steel sheet enclosures shall have cylindrical thread with locknut.

5.6.6 Cable glands for armoured cables shall be metal type and the metallic pair shall not create an electrolytic corrosion in case of dissimilar metallic material. Stainless steel and copper armour shall use Stainless Steel Cable glands.

5.7 POWER SOCKET-OUTLETS

5.7.1 Power socket-outlet enclosures shall be made of FRP (Fibre Reinforced Plastic) according to item 5.2.

5.7.2 For standardization of plug use, all socket-outlets shall be “Ex de”, except for accommodation areas.

5.7.3 For standardization and operational safety all Ex outlets shall be from the same manufacturer.

5.7.4 They shall be fitted with the corresponding plugs.

5.7.5 Threaded joints shall comply with item 5.1.6.

5.7.6 Power socket-outlets for 480V circuits shall be provided with blocking switches.

5.7.7 All outdoor Ex de socket-outlets shall have an incorporated Ex d disconnect switch, interlocked with the plug to prevent insertion or extraction with the energized socket.

5.7.8 Power socket-outlets for 480V circuits shall be four (04) poles, three-phase + ground type and rated for 63A. Power socket-outlets for diving equipment shall be rated for 125A.

Note: All three-phase sockets of the unit shall have the same phase-sequence to prevent an unexpected engine reversal. The phase-sequence R > S > T shall be clockwise.

5.7.9 Each power socket-outlet in 480V shall be furnished with three (03) spare plugs.

5.7.10 For circuits up to 127V, the capacities for socket-outlets shall be 250V, three poles, phase + neutral + ground, 16A. Each socket outlet shall be furnished with ten (10) spare plugs.

5.7.11 For two-phase circuits above 127V up to 240V, the capacities for socket-outlets shall be 250V, three poles, two phases + ground, 16A. Each socket outlet shall be furnished with ten (10) spare plugs.

5.7.12 For three-phase circuits above 127V up to 240V, the capacities for socket-outlets shall be 250V, four poles, three phases + ground, 32A. Each socket outlet shall be furnished with ten (10) spare plugs.

5.7.13 The mechanical protection degree shall be kept and guaranteed with the plug inserted and with the plug extracted.

5.7.14 Socket-outlets for accommodation areas shall comply with standardization defined by ABNT NBR 14136, and IEC 60309 where applicable.

5.8 JUNCTION BOXES

5.8.1 Junction boxes enclosures shall be made of stainless steel AISI-316L, or of non-metallic materials according to item 5.2.

5.8.2 Junction boxes for use in hazardous areas shall follow section 3.5 and shall be “Ex e”, according to 3.6.5.

5.8.3 They shall be provided with terminal blocks when required for interconnection.

5.8.4 All metallic junction boxes shall comply with painting criteria of item 3.6.3.

5.8.5 For non-metallic junction boxes painting is not required.

5.8.6 In order to comply with the standardization all Ex junction boxes shall be provide by the same manufacturer.

5.9 UMBILICAL POWER CABLE JUNCTION BOX

5.9.1 For the umbilical topside termination, it shall be supplied a topside junction box or single core cable splices. Both cases shall include the field assembly after the umbilical installation.

5.9.2 The scope of supply shall include a power junction box (PJB) suitable for operation in hazardous area classified Zone 2, Group IIA, Class T3 according to IEC 60079. The PJB shall be certified by INMETRO as well as the certification authority nominated by PETROBRAS after the umbilical purchase order.

5.9.3 For applications with maximum operational VSD output voltage lower than 11 kV, the PJB protection shall be “Ex e” (Increased Safety) according to IEC 60079-7.

5.9.4 For applications with maximum operational VSD output voltage equal or greater than 11 kV, the PJB protection shall be “Ex d” (Flameproof) according to IEC 60079-0.

5.9.5 The minimum degree of protection provided by the PJB enclosure shall be IP56 according to IEC 60529.

5.9.6 The junction box shall provide the electrical connection between the respective protection, made of Stainless Steel AISI 316L and suitable to earth the metallic armour under outer jacket.

5.9.7 For the surface cables, PETROBRAS shall be consulted, after the Umbilical purchase order.

5.9.8 Cable glands for all incoming cables shall be part of the scope of supply. Cable glands shall be compatible with the PJB hazardous area protection type and degree of protection, made of Stainless Steel AISI 316L and suitable to earth the metallic armour under outer jacket.

5.9.9 The PJB internal space, layout and insulated cable connections and components shall be compatible with the umbilical electrical power cable specifications, the respective PETROBRAS RM, and the IEC 60079 applicable parts. Each phase connection inside de PJB shall be easily identified with the same identification used in each umbilical power single core cable.

5.9.10 The PJB shall allow disconnection and reconnection of surface and subsea power cables maintaining its protection type and degree of protection. The PJB shall allow the performance of insulation resistance measurements of each of these cables when disconnected. The supplier shall provide procedures for safety disconnection and reconnection of surface and subsea cables.

5.10 CONTROL BOXES FOR PUSH-BUTTONS AND SIGNALLING

5.10.1 Control boxes for push-buttons and signalling installed in hazardous areas and external area equipment shall be Ex de type.

5.10.2 Control boxes for push-buttons and signalling shall be made of non-metallic materials according to item 5.2.

5.10.3 Push-buttons for ON (START) function shall be without release (return after push). Push-buttons for OFF (STOP) function shall be with release (retain after push).

5.10.4 Push-buttons for OFF (STOP) function shall have means for locking with padlock in OFF (STOP) positions.

5.10.5 All field push-button shall have a load tag and a load identification or push-button function identification. Identification plate shall be in black acrylic engraved with white letter for equipment installed indoors or in stainless steel AISI-316L for equipment installed outdoors.

5.10.6 Push-buttons for ON (START) function shall have a clear protective cover in order to avoid involuntary operation, as defined in NR-12.

5.11 TERMINAL LUGS AND TERMINAL BLOCKS FOR CABLES

5.11.1 Terminal lugs shall be suitable for naval use, shall be anti-vibration type and assembled on support profiles ("C" channels).

5.11.2 In order that neither destruction nor deformation of wires forming the cable occurs, terminal lugs shall be of indirect press over the conductor.

5.11.3 They shall have a minimum capacity of 20A/600V and shall be made of steatite or melamine insulation, not containing toxic or organic substances.

5.11.4 It shall not be accepted more than one cable connected to each terminal. In case of necessity of connection of more than one cable at the same point, it shall be used one terminal lug for each cable and these terminal lugs shall be connected by metallic bridge bars.

5.11.5 Jumpers between terminals through external conductors shall not be accepted in terminal blocks. For this purpose, metallic bridge bars shall be used.

5.11.6 The terminals strips shall be installed in order to guarantee enough space to perform the cable terminations, easy access to terminals and easy reading of the identification rings.

5.11.7 The terminals strips shall be numbered with progressive numbers and codified as per electrical diagram indications.

5.12 CABLE CLEATS

5.12.1 The material of cable cleats, straps, saddles, or bands shall comply with Classification Society requirements and IEC 61914.

5.12.2 The cleats installed outdoors, in naturally ventilated areas and wash down areas, shall be made of stainless steel, AISI-316L.

5.12.3 Trefoil cable cleats for single core power cables shall be approved for the potential short-circuit stress.

5.12.4 Cable cleat tests shall follow IEC 61914.

5.12.5 The use of plastic material bands or straps is not allowed for fixing electrical cables.

5.13 ELECTRICAL CABLES

5.13.1 GENERAL

5.13.1.1 This section requirement applies only to electrical cables.

5.13.1.1.1 For Automation and Instrument cables I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

5.13.1.1.2 For telecommunication cables see Telecommunication documents.

5.13.1.1.3 For Automation and Instrument cables and telecommunication cables see specific Classification Society applicable requirements.

5.13.1.2 The minimum requirements for the design, fabrication, and tests of electric cables, shall be in accordance with hereby indicated and with standards IEC 61892-4, IEC 60092-350, 353, 354, 376, IEC 60332-1 parts 2 and 3, IEC 60332-3-22 and when required, according to IEC 60331 parts 11 and 21.

5.13.1.3 Electrical cables smoke emissions shall comply with IEC 61034-2 and with low toxic emissions defined in IEC 60754-1 and IEC 60754-2.

5.13.1.4 Cables installed in or crossing hazardous areas shall additionally comply with requirements of IEC 61892-1 and IEC 61892-7.

5.13.1.5 Cables connecting VSD-FCs to motors shall additionally comply with requirements of IEC TS 60034-25.

5.13.1.6 Electric cables shall be proper for installation in environments subjected to humidity, salinity and with hydrocarbons chemical action.

5.13.1.7 For floating units, all cables shall be “type-approved” by Classification Society.

5.13.1.8 Cable splices shall be avoided. If necessary, cable splices shall agree with IEC 61892-7.

5.13.1.9 Power cables used in variable frequency drive and similar non-linear-loads applications shall also comply with IEEE 1580 recommended guidelines, where it is applicable.

5.13.2 CONSTRUCTIVE CHARACTERISTICS

5.13.2.1 All cables shall be naval type, with compact filling and circular section, flame spread behaviour according to IEC 60332-3-22 Category A.

5.13.2.2 Cables shall be suitable to operate under voltage levels shown on project documentation, with following classes:

a) 150/250(300) V - for control and signalling isolated systems with rated voltage up to 150V or up to 220 V for bolted grounded neutral systems (according to IEC 60092-376).

b) 450/750 V - for control and signalling isolated systems with rated voltage up to 450V or for bolted grounded neutral systems with rated voltage up to 750V,

c) 0.6/1.0 kV - for lighting, protection, heating and power systems category B or C (without automatic trip for ground faults) with rated voltage up to 600V, and for lighting, protection, heating and power systems category A (automatic trip for ground faults) with rated voltage up to 700V, according to IEC 61892-4 and IEC 60092-352.

d) 1.8/3.0 kV - for heating and power systems with rated voltage above 600 V up to 1.8 kV.

e) 3.6/6 kV - for power systems with rated voltage up to 4.16 kV.

f) 6/10 kV - for power systems with rated voltage up to 6.6 kV.

g) 8.7/15 kV - for power systems category A according to IEC 61892-4 and IEC 60092-352 (automatic trip for ground faults) and with rated voltage up to 13.8 kV.

h) 12/20 kV - for power systems category B or C according to IEC 61892-4 and IEC 60092-352, (without automatic trip for ground faults) with rated voltage up to 13.8 kV.

5.13.2.3 Cables outer sheath (protective cover) colour shall be:

5.13.2.3.1 For grounding cables, the combination green-and-yellow according to IEC 60445.

5.13.2.3.2 For intrinsically safe apparatus (IS circuits), light blue, according to IEC 60079-11.

5.13.2.3.3 For three phase A.C. cables, brown-black-grey according to IEC 60445.

Note: Any two-phase variation of the three-phase system may use any combination of the colours indicated above, according to IEC 60445.

5.13.2.3.4 For single phase A.C. cables, brown or black, according to IEC 60445.

5.13.2.3.5 For D.C. positive conductor, red, according to ABNT NBR 5410.

5.13.2.3.6 For D.C. negative conductor, black, according to ABNT NBR 5410.

5.13.2.4 The outer sheath (protective cover) for cables exposed to sun light shall be protected against degradation by UV radiation and shall comply with UL 1581 Section 1200. Equivalent certification issued by other recognized laboratory shall be submitted to PETROBRAS approval.

5.13.2.5 The “minimum curvature radius” for multi-core armoured cables shall not exceed ten times their rated diameter and for single-core armoured cables shall not exceed twelve times their rated diameter.

5.13.2.6 Cables for circuits that shall operate under fire conditions (systems for firefighting, fire and gas detection, alarm, public address, shut-down, emergency switch-off, emergency lighting, etc.), cables that feed essential and emergency services that are installed in hazardous areas, and cables crossing machinery space category A, as defined by SOLAS, shall be certified for circuit integrity under fire conditions, according to IEC 60331. These cables and related brackets may also be painted with specific products intended to keep their integrity for the expected fire and time conditions. The test reports of these products and the application procedures shall be subjected to PETROBRAS approval.

5.13.2.7 The shields for medium-voltage cables shall be sized for at least 20A.

5.13.2.8 Power cables shall be proper for continuous operation, with maximum copper temperature not exceeding of 90ºC.

5.13.3 CONSTRUCTIVE FORMATION

5.13.3.1 Cables shall have the following formation sequence:

a) Stranded circular non-compacted conductor, Class 2 according to IEC 60228, formed by tinned copper, soft temper.

Note 1: flexible conductors, Class 5 according to IEC 60228, may be accepted if the same ampacity (current rating) and voltage drops are considered.

Note 2: compacted conductor shall be accepted only if:

(i) comply with requirements above.

(ii) conduction capacity in Amperes at conductor nominal temperature 90°C (environmental temperature is 45°C as defined in Table 1) is equal or superior to the conduction capacity defined in IEC 61892-4 (a comparative table is required).

(iii) Manufacturer shall prove that the curvature radius complies with in IEC 61892-6 and cable installations affected by the proposal will not need any modifications (a comparative table is required).

(iv) Manufacturer shall prove that cable impedance values are similar to those of non-compact cables and electrical studies will not be affected (a comparative table is required).

(v) there will not be any impact, modification, or any need of change in any previous contracts, services, activities, and etc., resulting of this modification.

b) Insulation:

- HF-EPR (halogen-free ethylene propylene rubber) or HF-XLPE (halogen-free cross-linked polyethylene reticulate) for accommodations.
- EPR, HEPR, XLPE or PVC for control and signal cables installed inside panels.
- EPR, HEPR or XLPE for other areas.

c) Filling: polychloroprene or halogen free materials.

d) Shield or Braid:

- Non-magnetic using copper, bronze, or brass threads for single-core cables in A.C. system and D.C. system with high ripple content.
- Low irradiation, non-magnetic for single-core cables between VSD-FCs and motors.
- Low irradiation, metallic for multi-core cables between VSD-FCs and motors.
- Metallic for each pair in multicore cables for IS (intrinsically safe) circuits. For type-approved multicore cables for IS circuits, the individual shields are not required.
- Common metallic for cables for IS (intrinsically safe) circuits.
- Multiple cables for discrete signals (on/off) shall have at least overall shielding.
- Multiple cables (multiterns or multiquad) for analogical signals shall have individual shielding by pair (tern or quad) and also, the general shielding involving the whole set. All shielding, individual or general shall have a drain wire.

e) Armour:

- Galvanized steel threads braid protected by anti-corrosive cover for multi-core signal or power cables installed in, or crossing, hazardous areas Zone 0 or Zone 1, and for other cables when required by Classification Society.
- Copper or other non-magnetic metal threads braid protected by anti-corrosive cover for single-core cables installed in, or crossing, hazardous areas Zone 0 or Zone 1, and for other cables when required by Classification Society.
- Galvanized steel shall be used for multi-core signal or power cables

- Copper or other non-magnetic metal threads braid protected by anti-corrosive cover shall be used for single-core cables.
- Armour cables shall be installed in, or near:
  i. cargo handling or cargo storage areas.
  ii. permanent maintenance areas.
  iii. main deck areas near human transit walkways.
  iv. submerse, non-movable bilge pumps, as defined in IEC 60092-201.
  v. other defined locations as required by Classification Society.

f) Outer sheath insulation (protective cover) type shall be as below, according to IEC 60092-360:

- SHF1 – for accommodation and internal areas without hydrocarbon.
- SE or SH or SHF2 – for external areas with hydrocarbon.
- ST2 or SE or SHF2 – for external areas without hydrocarbon.

5.13.3.2 For cables to be installed only inside the accommodation areas, all materials used on their formation shall be halogen free.

5.13.3.3 Control cables shall be shaped according to the quantity of conductors per cable, standardized as 3. 5. 7. 10. 15 or 20 conductors per cable.

5.13.3.4 In control cables where there is traffic of analogue signals and in control cables with interface/interconnection with PLC, control cables shall follow the specification of cables for instruments, with twisted pair, individual shielding for each pair and general shielding under the outer cover.

5.13.4 FLARE CABLE SPECIFIC REQUIREMENTS

5.13.4.1 These requirements are applicable to all cables installed in high temperature used for flare ignition, thermocouple, or similar applications, but not data bus protocol cables.

5.13.4.2 Cable conductor shall be 27% nickel-plated copper (27% NPC) to reduce corrosion in high heat environments and extends cable life.

5.13.4.3 Cable shall have a mica wrap to provide strong dielectric properties and good tensile strength and to resist heat and harsh chemicals such as alkali and acids.

5.13.4.4 Cable shall be suitable for virtually all flare stack igniter applications and be voltage rated for up to 25 kV.

5.13.4.5 Cable for power and control shall be voltage rated 0.6/1 kV.

5.13.4.6 Cable shall provide superior heat and voltage protection and resistance to chemicals and weather an also flexibility through high voltage silicone mica insulation system.

5.13.4.7 Cable shall provide insulation and jacketing protection in the most extreme temperature environments rated from 250°C up to an extreme of 800°C.

Note: Cable minimum and maximum temperature ratings shall comply with project requirements.

5.13.4.8 Cable shall provide braided fiberglass over-coated with a fluoropolymer to provide additional weather and chemical protection based in a fluoropolymer or fiberglass jacketing system, or a combination of both systems.

5.13.5 OPTICAL FIBER CABLES AND ACCESSORIES

5.13.5.1 Optical fiber cables used in network systems shall be according requirements of IEC 60794 and IEC 60793 including maximum temperature operation of 85ºC (IEC 60793-1-52).

5.13.5.2 All other requirements for optical fiber cables and accessories shall comply with I-ET-3010.00-5520-888-P4X-001 - AUTOMATION PANELS.

5.13.6 NETWORK CABLES AND ACCESSORIES

All network cables characteristics, construction and accessories shall comply with I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE.

5.14 LIGHTING FIXTURES AND FLOODLIGHTS

5.14.1 GENERAL REQUIREMENTS

5.14.1.1 All lighting fixtures and floodlights shall use LED lamps.

5.14.1.2 All lighting fixtures and floodlights shall be complete, with sockets and accessories.

5.14.1.3 All accessories, like hinges, lockers, bolts, and nuts shall be of bichromatized steel or stainless steel AISI-316L. Threaded joints shall comply with item 5.1.6.

5.14.1.4 All outdoor lighting fixtures and floodlights shall be certified for marine use.

5.14.1.5 All indoor lighting fixtures and floodlights in accommodation modules and offices, shall be certified to be installed in rooms with ceiling B-15 class.

5.14.1.6 Lighting fixtures and floodlights shall follow requirements of IEC 61892-6.

5.14.2 LIGHTING FIXTURES

5.14.2.1 Lighting fixtures with incorporated battery, shall have local indication LEDs for ON (normal) and FAILURE (mains power failure or battery fault) conditions.

Note: lighting fixtures with incorporated battery shall only be used in few specific locations and previously approved by PETROBRAS.

5.14.2.2 It shall not be acceptable “Ex n” lighting fixtures, see Table 19.

5.14.2.3 Pendant Lighting fixtures shall be provided with an extra safeguarding against falling down if the screwed connections loosen, as required in IEC 61892-6.

Note: For Lighting fixtures, it shall be used stainless steel cable AISI 316.

5.14.2.4 In order to comply with the standardization all Ex Lighting fixtures shall be provide by the same manufacturer.

5.14.2.5 LIGHTING FIXTURES FOR INDOOR INSTALATIONS

5.14.2.5.1 Lighting fixtures for battery rooms shall be “Ex e” or “Ex de”, proper for Zone 1, Group IIC, T1, see Table 19.

5.14.2.5.2 All Lighting fixtures for indoor installations shall be fabricated in stainless steel AISI-316L, or carbon steel with ALUZINC coat. As defined in 5.14.1.5, in accommodation modules and offices they shall be certified B-15 class.

5.14.2.5.3 Lighting fixtures used indoors shall be embodied-mounted type, recessed, with mirror reflectors and anodized diffuser wings.

5.14.2.5.4 Lighting fixtures for workbenches shall have diffuser wings and reflectors, in order to not cause inconvenient obfuscation, reflex and excessive shadows.

5.14.2.6 LIGHTING FIXTURES FOR OUTDOOR INSTALLATIONS

5.14.2.6.1 All Ex lighting fixtures installed in external areas, process plant area and pump room shall be of the same type, meeting the requirements of item 3.5.9.

5.14.2.6.2 As defined in 3.5.9 lighting fixtures installed in external safe areas, that shall be kept operating during emergency shutdown ESD-3P and ESD-3T shall be certified for installation in hazardous areas Zone 1 Group IIA temperature T3.

5.14.2.6.3 All lighting fixtures (normal and essential) installed outdoors shall be suitable to operate in hazardous areas Zone 1 Group IIA T3, even if located in non-hazardous areas. These lighting fixtures shall be “Ex e” or “Ex de” type, see Table 19.

5.14.2.6.4 For outdoor installations, lighting fixtures in FRP or stainless steel AISI-316L shall be used.

5.14.2.7 LIGHTING FIXTURES WITH LED LAMPS

5.14.2.7.1 Lighting fixtures with LED lamps shall comply with IEC 62722-2-1.

5.14.2.7.2 LED (Ex) lamps lighting fixtures shall comply with IEC 60079-28.

5.14.2.7.3 All LED lighting fixtures shall have diffuser wings, reflectors, or other means, in order to not cause inconvenient obfuscation.

5.14.2.7.4 Lighting fixtures with high reliability, long life LED lamps, type-approved by Classification Society, shall be provided for the following systems:

- Aircraft obstruction warning system.
- Navigation aid signalling system.
- Helideck signalling system (including windsock and status lights).
- Muster stations lights.
- Emergency generator and auxiliary generator starting and control panels lights.
- Firefighting pumps starting and control panels lights.
- Lifeboat and rescue boat embarkation stations lights.

5.14.3 FLOODLIGHTS

5.14.3.1 All essential floodlights shall be suitable to operate in hazardous areas Zone 1 Group IIA T3 as of IEC 61892-1 and IEC 61892-7. These floodlights shall be “Ex e” or “Ex de” type, see Table 19.

5.14.3.2 Floodlights for lifeboat landing areas (sea level) shall have quick restart and long lifetime.

5.14.3.3 Floodlights shall be provided with an extra safeguarding against falling down if the screwed connections loosen, as required in IEC 61892-6.

Note: For Floodlights, it shall be used stainless steel AISI 316 safety net.

5.14.3.4 Floodlights to support offloading operations shall comply with the requirements of items 5.15.1 and 5.15.3. They shall be fitted with LED lamps (IEC 62722-2-1 and IEC 60079-28).

5.14.3.5 FLOODLIGHTS FOR INDOOR INSTALATIONS

5.14.3.5.1 All floodlights for indoor installations shall have corrosion resistant seamless housings made of seawater resistant aluminium (copper free aluminium) or carbon steel with ALUZINC coat. As defined in 5.14.1.5, in accommodation modules and offices they shall be certified B-15 class.

5.14.3.5.2 When LED lamps floodlights are be used for internal areas, they shall have diffuser wings, reflectors, or other means, in order to not cause inconvenient obfuscation.

5.14.3.5.3 Fluorescent lamps, incandescent lamps, or self-ballast mercury and mercury vapour lamps shall not be used.

5.14.3.6 FLOODLIGHTS FOR OUTDOOR INSTALLATIONS

5.14.3.6.1 As defined in 3.5.9 floodlights installed in external safe areas, that shall be kept operating during emergency shutdown ESD-3P and ESD-3T shall be certified for installation in hazardous areas Zone 1 Group IIA temperature T3.

5.14.3.6.2 All floodlights installed outdoors shall be suitable to operate in hazardous areas Zone 1 Group IIA T3, even if located in non-hazardous areas, see Table 19.

5.14.3.6.3 For outdoor installations, all floodlights shall have corrosion resistant seamless housings made of stainless steel AISI-316L.

5.14.4 SUMMARY OF HAZARDOUS CLASSIFICATION

For lighting fixtures and floodlights the Ex hazardous classification by zone is defined in Table 19.

Table 19 – Lighting fixtures and Floodlights Ex Classifications by Zone.

AREA CLASSIFICATION	LIGHTING EQUIPMENT	NORMAL LOADS	ESSENTIAL LOADS	EMERGENCY LOADS	BATTERY ROOM
Internal, safe area non hazardous	Lighting Fixture (LED)		Ex e or Ex de	Ex e or Ex de	Ex e or Ex de (Zona 1 IIC T1)
	Floodlights (LED)		Ex e or Ex de	Ex e or Ex de	Ex e or Ex de (Zona 1 IIC T1)
External areas non classified	Lighting Fixture (LED)	Ex e or Ex de (Zona 1 IIA T3)	Ex e or Ex de (Zona 1 IIA T3)	Ex e or Ex de (Zona 1 IIA T3)	
	Floodlights (LED)	Ex e or Ex de (Zona 1 IIA T3)	Ex e or Ex de (Zona 1 IIA T3)	Ex e or Ex de (Zona 1 IIA T3)	
Zone 2	Lighting Fixture (LED)	Ex e or Ex de (Zona 1 IIA T3)	Ex e or Ex de (Zona 1 IIA T3)	Ex e or Ex de (Zona 1 IIA T3)	
	Floodlights (LED)	Ex e or Ex de (Zona 1 IIA T3)	Ex e or Ex de (Zona 1 IIA T3)	Ex e or Ex de (Zona 1 IIA T3)	
Zone 1	Lighting Fixture (LED)	Ex e or Ex de (Zona 1 IIA T3)	Ex e or Ex de (Zona 1 IIA T3)	Ex e or Ex de (Zona 1 IIA T3)	

5.15 RESCUE AND SEARCHLIGHTS

5.15.1 Rescue and searchlights shall be corrosion resistant, strong construction, protection degree according to Table 3, completely sealed, provided with heat radiators and suitable to operate on structures subject to vibration and winds up to 50 m/sec.

5.15.2 Searchlights shall be supplied complete with LED or halogen lamp of 2kW, 220V, and with local controlgear, including an ON/OFF switch. This controlgear shall be duly interconnected to the searchlight through flexible metal conduit.

5.15.3 Searchlights shall be manually operated and allow movement within the following angles:

a) rotation angle / pan angle minimum: 270º.

b) elevation angle / tilt up: 60º.

c) depth angle / tilt down: 75º.

5.15.4 If otherwise, project documentation makes a request for motor controlled search lights:

5.15.4.1 The effective light emission sectors shall be circular and reach vertically and horizontally at least 6°, as required by IMO RESOLUTION MSC.81(70).

5.15.4.2 The optical light axis of searchlights shall be capable of being panned at least 175° horizontally to either side and tilt minimum 30° downward and minimum 30° upward, starting from the zero position, as required by ISO 17884:200.

5.15.5 Any searchlight located in classified area shall have its switch inhibited by gas presence sensor installed within 1 meter or less of the searchlight position or by A&C gas detection alarm. Inhibition of blocking overrun may be allowed in control room only.

5.15.6 Rescue and searchlights shall have IMO certificate approval, complying with IMO RESOLUTION MSC.81(70), as defined in NORMAM-05/DPC. This is requested by Portaria nº 21/DPC de 29/01/2020.

5.16 LAMPS

5.16.1 The use of incandescent and fluorescent lamps is not allowed. See section 5.18.

5.17 BALLAST FOR LIGHTING (CANCELLED)

5.17.1 CANCELLED.

5.18 LED LAMPS

5.18.1 GENERAL REQUIREMENTS

5.18.1.1 LED lamps shall follow IEC 62722-2-1, IEC 62612, and IEC 62717.

5.18.1.2 LED modules lifetime and lumen output over life shall be informed according to IEC 62717 and dimensioned to life expectancy defined in applications where it is used.

5.18.1.3 Minimum efficiency required shall be 85%.

5.18.1.4 Strobe effect is not allowed, and it shall have a low blurring.

5.18.1.5 Led casing shall be colourless or white matte.

5.18.1.6 Maximum surface temperature shall be 200°C at environment temperature between -20°C and 40°C.

5.18.1.7 Temperature colour shall be between 5000 K and 6000 K (Cool white).

5.18.1.8 LED luminous Efficiency shall be 120 lm/W or superior.

5.18.1.9 LED Lamps shall be linear with double pin connectors.

5.18.1.10 Minimum time warranty shall be 4 years.

5.18.1.11 Lifetime shall be superior to 50.000 h at 40°C (see temperatures defined in Table 1 for application location reference) with a minimum luminous flux of 70% at the end of this period.

5.18.1.12 The tests reports indicated in IEC 62612 shall be informed for linear LED lamps that have an embedded drive.

5.18.1.13 Linear lamps may not have their functionality compromised by the burning of LED units.

5.18.2 EX LED LAMPS

5.18.2.1 Led lamps for Ex applications shall be certified as component (U).

5.18.2.2 Led Ex lamps shall comply with IEC 60076-28 and IEC 60079-7.

5.18.2.3 EPL shall be compatible to EPL Gb.

5.18.3 LED LAMPS DRIVERS

5.18.3.1 LED Drivers shall comply with IEC 60079 and IEC 62717.

5.18.3.2 LED Drivers shall have minimum protection degree IP 54.

5.18.3.3 LED Drivers shall have EPL compatible with EPL Gb luminaires.

5.18.3.4 Maximum surface temperature shall be 200°C, at environment temperature between -20°C and 40°C.

5.18.3.5 Minimum time warranty shall be 4 years (>35040 h).

5.18.4 FOR EX LED DRIVERS

5.18.4.1 EX LED drivers for Ex applications shall be certified for use in hazardous type explosive atmospheres.

5.18.4.2 LED POWER DRIVER

5.18.4.2.1 Power driver and electronic components requirements shall:

- Allow driver supply voltage fluctuation of ± 10% of nominal voltage.
- Have a minimum voltage surge protection: 2.0 kV between phases and 2.0 kV between phase and ground.
- Built-in electronic system for active control of the LED power supply chain and correction of the power factor.
- Harmonic content according to the requirements and limits of the IEC 61000-3-2 standard: 1.1.17 class C.

- THD (Total Harmonic Distortion) driver: < 15%.
- Driver power factor: > 0.95.
- Efficiency of electronic Power modules (driver): greater than 85%.
- Short circuit protection, over current, over voltage and over temperature.
- Natural convection cooling.

5.19 LAMPS SOCKETS

5.19.1 Sockets shall be according to those indicated for LED lamps.

5.19.2 Sockets shall be anti-vibration type and suitable for naval use.

5.20 LIGHTING POLES AND LIGHTING SUPPORT STRUCTURES

5.20.1 All lighting poles and lighting supporting structures shall comply with the STRUCTURAL REQUIREMENTS SPECIFICATON.

5.20.2 These structures shall be designed so the electrical equipment installed on them shall comply with the mandatory requirements of electrical equipment's for motion and inclination limits, in 3.3, and for vibration limits, in 3.4.

5.21 CONDUITS

5.21.1 Conduits shall be of galvanized steel and supplied painted according to item 3.6.3.

5.21.2 Conduits to be applied on hazardous areas shall be SCHEDULE 40, seamless.

5.21.3 For other areas, including indoor living quarters, conduits shall be medium seamless type.

5.21.4 All conduits shall have their paint finished after their installation.

5.22 ANALOGUE TRANSDUCERS

5.22.1 When required, to transmit analogue signals (voltage, current, power, power factor, etc.) to A&C through Electrical System Automation Panel, it shall be used transducers with rated output signal 4-20mA.

5.22.2 When transducers require auxiliary voltage, it shall be used 220VDC, when control voltage is obtained from D.C. UPS or 120VAC for other cases.

5.23 HEAT TRACING

5.23.1 Equipment and material for heat tracing shall comply with the requirements of IEC 60519 and IEC 62395.

5.23.2 Equipment and material for heat tracing in hazardous areas shall additionally comply with the requirements of IEC 60079-30 parts 1 and 2.

5.23.3 PVC insulate cables susceptible to damage at low temperatures shall be avoided or freeze protection provided as required in IEC 62395.

6 ANNEXES - DATASHEET FORMS

6.1 The Datasheets shown in annexes are models and do not refer to any equipment. The manufacturer shall fill in a Datasheet for each equipment.

6.2 For equipment without Datasheet model in annexes, Manufacturer shall fill in Datasheets according to its own standard and submit to PETROBRAS approval.

6.3 All existing data sheet templates are available at I-LI-3010.00-5140-700-P4X-001 - ELETRICAL EQUIPMENT DATA SHEET MODELS.

7 ANNEX I – ABBREVIATIONS AND ACRONYMS

A&C	Automation and Control System
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE
CT	Current Transformer
DPC	Departamento de Portos e Costas
EPR	Ethylene Propylene Rubber
ESA	Electrical System Automation
ESD	Emergency Shutdown
ET	Technical Specification
FPSO	Floating, Production, Storage and Offloading Unit
FSO	Floating, Storage and Offloading Unit
HF-EPR	Halogen-Free Ethylene Propylene Rubber
HF-XLPE	Halogen-Free Cross-Linked Polyethylene Reticulate
HMI	Human-Machine Interface
Icm	Rated Short-Circuit Making Capacity
Ics	Rated Service Short-Circuit Breaking Capacity
Icu	Rated Ultimate Short-Circuit Breaking Capacity
Icw	Rated Short Time Withstand Current
IEC	International Electrotechnical Commission
IED	Intelligent electronic device
IE	Instrumentation Earth Grounding
IEEE	Institute of Electrotechnical and Electronic Engineers
INMETRO	Instituto Nacional de Metrologia Normalização e Qualidade Industrial
Ir	Rated current
IR	Intelligent Relay
IS	Intrinsically Safe Grounding
ISO	INTERNATIONAL STANDARDIZATION ORGANIZATION
LED	Light Emitting Diode
MCC	Motor Control Centre

MCCB	Moulded-Case Circuit-Breaker
MCT	Multi cable transit
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
NEMA	National Electrical Manufacturers Association
PBJ	Power Junction Box
PE	Protective Earth Grounding
PF	Power Factor
PJB	Power Junction Box
PVC	Polyvinyl Chloride
QR CODE	Quick Response Code
RCD	Residual Current Protective Device
RFID	Radio Frequency Identification
RM	Material Requisition
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
UAM	Unit Alarm Malfunction
UAS	Unit Alarm Shutdown
Ue	Rated Operational Voltage
Ui	Rated Insulation Voltage
Uimp	Rated Impulse Withstand Voltage ()
Un	Rated Voltage
UPS	Uninterruptible Power Supply
VSD	Variable Speed Drive
VSD-FC	Variable Speed Drive – Frequency Converter
VT	Voltage Transformer
XLPE	Cross-Linked Polyethylene Reticulate
HDG	Hot Dipped Galvanized