## ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS

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

The objective of this specification is to establish the main technical requirements for the design, supply and manufacturing of the electrical components and assembly of the Package Units for PETROBRAS offshore Units.

2. **DEFINITIONS**

2.1. “Unit” is defined as the FPSO (Floating Production Storage and Offloading), FSO (Floating Storage and Offloading), SS (Semi-Submersible) or Fixed Offshore Unit.

2.2. “Package Unit” or “Package” is defined as an assembly of equipment supplied interconnected, tested and operating, requiring only the available utilities from the Unit for the Package operation.

2.3. “Packager” is defined as the responsible for project, assembly, construction, fabrication, test and furnishing of the Package.

2.4. “Manufacturer” is defined as the responsible by fabrication of equipment or components internal to the Package.

2.5. “Module” is defined as the metallic structure suitable for lift and transport, where Packages and equipment will be installed, being supplied completely mounted and pre-commissioned.

2.6. “Module Supplier” is defined as the responsible for project, assembly, erection, construction, fabrication, test and furnishing of the Module.

2.7. “Hull Contractor” is defined as the responsible for all equipment, project, assembly, construction, fabrication, test, furnishing, installations and services related to Unit Hull.

2.8. “Bidder” is defined as the responsible for the lift, hook up, installation and integration of all Modules on the Unit Hull.

3. **REFERENCE DOCUMENTS, STANDARDS AND CODES**

3.1. **PETROBRAS Documents**

   [1] I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS

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

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

   [4] I-ET-3010.00-5140-741-P4X-003 - POWER PANEL FOR THYRISTORIZED HEATER FOR OFFSHORE UNITS

   [5] I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE
4. APPLICABLE STANDARDS AND RECOMMENDATIONS

4.1. The Package and its installations shall comply with all rules and regulations stated by Brazilian Authorities, Classification Society and International Standards. Following these mandatory requirements, the Package shall comply with requirements of documents listed in 3.1 (second priority in case of conflict). Any deviation shall be submitted to PETROBRAS approval.

4.2. During the design development and for equipment specification IEC standards (international standards) shall be used, all on their latest revisions.
4.3. Exceptionally, where it is clearly justifiable, ANSI, NEMA, IEEE and others recognized foreign standards may be used. Their use shall be restricted to specific cases and shall be previously approved by PETROBRAS.

5. GENERAL CONDITIONS

5.1. Packager is responsible for detailed electrical design and engineering within the Package and shall perform all functions required to interface with the design of electrical system, as well as guarantee the control and monitoring by A&C (Automation and Control System), when required.

5.2. All electrical installations within the Package shall be Packager responsibility. Packager is also responsible for supervising the installation of equipment that will be installed out of the Package skid, if any.

5.3. Packager shall clearly indicate on design documents the interface which will delimitate its scope of supply and Module Supplier scope of supply.

5.4. For electrical equipment, it shall be considered the reference temperatures stated in specific Technical Specification issued by PETROBRAS, documents included in its Material Requisition (RM), standard IEC 61892-1 and applicable rules and regulations of Classification Society.

6. ELECTRICAL INSTALLATIONS CHARACTERISTICS

6.1. Explanation about Loads Classification

6.1.1. The following definitions shall be considered for all Electrical Design:

6.1.1.1. **Essential Loads** are those loads that shall remain energized by Emergency Generation System during shutdown stop ESD3-T and during Main Generation System failure. Temporary black-out for these loads is acceptable after Main Generation shut-down until complete start of Emergency Generation. Essential Loads shall include:

- Loads defined as “loads essential for safety in an emergency”, with requirement to be “fed from emergency source of power in an emergency” by IMO MODU CODE or by Classification Society;
- Loads defined as “Essential Consumers for Safety” by DR-ENGP-M-I-1.3 - ENGENHARIA DE SEGURANÇA (HOLD).

6.1.1.2. **Emergency Loads** are those loads which shall remain energized by batteries (DC or AC UPS) during Emergency Generation System failure and Main Generation System failure. Temporary black-out for these loads is not acceptable. Emergency Loads shall include:

- Loads defined as “fed from transitional sources of power in an emergency” by IMO MODU CODE or by Classification Society;
- Loads defined as “Emergency Consumers” by DR-ENGP-M-I-1.3 - ENGENHARIA DE SEGURANÇA (HOLD).
6.1.1.3. **Normal Loads** are the loads not classified as Emergency Loads nor as Essential Loads. Normal loads shall remain de-energized during emergency shutdown ESD3-T.

6.2. Package Internal Electrical Installations Design

6.2.1. All electrical installations, equipment, materials and components which are part of the Package, shall comply with the requirements of the documents included in its Material Requisition (RM), I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS and I-DE-3010.00-5140-700-P4X-002 - POWER INSTALLATION TYPICAL DETAILS.

6.2.2. The application of electrical equipment, instruments and accessories on hazardous areas shall follow the requirements of IEC series 60079, 61892-6 and 61892-7, as well as have their conformity certificates according to INMETRO Portaria 179, May 18th 2010 and INMETRO Portaria 89, Feb 23rd 2012 and approved by Classification Society.

6.2.3. Electrical equipment and accessories installed in external safe or hazardous areas, which shall be kept operating during emergency shutdown ESD-3P or ESD-3T shall be certified for installation in hazardous areas Zone 1 Group IIA temperature T3 (IEC 61892-7).

6.2.4. All equipment and the outgoing feeders of the Package shall be supplied with connectors and terminals for power, control, heating and grounding.

6.2.5. Each Package shall have a field emergency stop push-button, located in safe area (area with easy access in case of emergency condition in Package) in Package skid, or closer to Package skid, to stop the Package, as required in NR-12.

6.3. External Electrical Power Supply

6.3.1. For FPSOs and FSOs Units the available electrical system voltages are according to Table 1.

<table>
<thead>
<tr>
<th>System Voltage</th>
<th>System Grounding</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>13800Vac 3ph 60Hz</td>
<td>High Impedance</td>
<td>Main Generation</td>
</tr>
<tr>
<td>4160Vac 3ph 60Hz</td>
<td>High Impedance</td>
<td>Main Generation</td>
</tr>
<tr>
<td>690Vac 3ph 60Hz</td>
<td>Ungrounded</td>
<td>Main Generation</td>
</tr>
<tr>
<td>480Vac 3ph 60Hz</td>
<td>Ungrounded</td>
<td>Main, Auxiliary or Emergency Generation</td>
</tr>
<tr>
<td>220Vac 3ph 60Hz</td>
<td>Ungrounded</td>
<td>Main, Auxiliary or Emergency Generation</td>
</tr>
<tr>
<td>220V/127Vac 3ph 60Hz</td>
<td>Solidly Grounded</td>
<td>Main, Auxiliary or Emergency Generation (only inside accommodation module)</td>
</tr>
<tr>
<td>220Vdc</td>
<td>Ungrounded</td>
<td>Batteries + Batteries Chargers</td>
</tr>
<tr>
<td>220Vac 3ph 60Hz</td>
<td>Ungrounded</td>
<td>DC-AC converters supplied by 220Vdc</td>
</tr>
<tr>
<td>125Vdc</td>
<td>Ungrounded</td>
<td>Batteries + Batteries Chargers</td>
</tr>
</tbody>
</table>

Notes: 1 - Only if specified in other project documents, usually for high power electrical heaters.
6.3.2. For Fixed and SS Units the available electrical system voltages are according to Table 2.

Table 2 – Electrical System Voltages and Grounding – Fixed or SS Unit

<table>
<thead>
<tr>
<th>System Voltage</th>
<th>System Grounding</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>13800Vac 3ph 60Hz</td>
<td>High Impedance</td>
<td>Main Generation</td>
</tr>
<tr>
<td>4160Vac 3ph 60Hz</td>
<td>High Impedance</td>
<td>Main Generation</td>
</tr>
<tr>
<td>690Vac 3ph 60Hz (1)</td>
<td>Ungrounded</td>
<td>Main Generation</td>
</tr>
<tr>
<td>480Vac 3ph 60Hz</td>
<td>High Impedance</td>
<td>Main, Auxiliary or Emergency Generation</td>
</tr>
<tr>
<td>220Vac 3ph 60Hz</td>
<td>Solidly Grounded</td>
<td>Main, Auxiliary or Emergency Generation</td>
</tr>
<tr>
<td>220V/127Vac 3ph 60Hz</td>
<td>Solidly Grounded</td>
<td>Main, Auxiliary or Emergency Generation</td>
</tr>
<tr>
<td>220Vdc</td>
<td>Ungrounded</td>
<td>Batteries + Batteries Chargers</td>
</tr>
<tr>
<td>220Vac 3ph 60Hz</td>
<td>Ungrounded</td>
<td>DC-AC converters supplied by 220Vdc</td>
</tr>
<tr>
<td>125Vdc</td>
<td>Ungrounded</td>
<td>Batteries + Batteries Chargers</td>
</tr>
</tbody>
</table>

Notes: 1 - Only if specified in other project documents, usually for high power electrical heaters.

6.3.3. Packages shall have external electrical power and control supply and internal control voltages, according to the ANNEX I. When the quantity of internal electrical loads is bigger than the quantity of external power supplies defined in ANNEX I, Packager shall provide internal power panel with starters (functional units) for each internal electrical load.

6.3.4. Unless otherwise stated in specific Technical Specification or Material Requisition, if a lighting system is required for the Package, external electrical power supply for normal and essential lighting shall be fed by Bidder, in 220Vac, 3ph, 60Hz, from Unit normal and essential lighting panels respectively.

6.3.5. Unless otherwise stated in specific Technical Specification or Material Requisition, if a lighting system is required for the Package, external electrical power supply for emergency lighting shall be fed by Bidder, in 220Vdc, from Unit emergency lighting panels.

6.3.6. Unless otherwise stated in specific Technical Specification or Material Requisition, external electrical power for navigation aid for Packages including equipment related to these systems shall be fed by Bidder, in 125Vdc, from Navigation Aid Distribution Panel of the Unit.

6.3.7. Unless otherwise stated in specific Technical Specification or Material Requisition, external electrical power for and aircraft warning lighting for Packages including equipment related to these systems shall be fed by Bidder, in 220Vac, from essential lighting panels of the Unit.

6.3.8. Unless otherwise stated in specific Technical Specification or Material Requisition, external electrical power for heating resistors for motors, MCC and Switchgears, shall be fed by Bidder in 220Vac 3ph 60Hz, from Unit normal lighting panels. Heating resistors for Control Panels shall be fed by Bidder in 220Vac 2ph 60Hz, from Unit normal lighting panels.

6.3.9. Lighting panels (normal, essential or emergency) internal to the Package shall be furnished by Packager.
6.3.10. Packages with external redundant UPS (or battery-charger) supply (according to ANNEX I) shall be fed with two redundant feeders, each one from a distinct Unit UPS (or battery-charger) distribution panel. The Package shall remain functional after a failure of anyone of the power supplies. For AC power supplies, since the Unit UPSs are not guaranteed to operate in synchronism, the Package shall have interlocks to avoid connection in parallel of these feeders inside the Package.

6.3.11. Available external autonomy of 220Vdc Unit UPS (control and lighting) is 30 minutes. Available external autonomy of 125Vdc Unit UPS (navigation aids) is 96 hours. These autonomy time shall not be exceeded. Any deviation shall be submitted to PETROBRAS approval. Inclusion of UPSs, or battery-chargers (and their batteries) in Package to increase autonomy shall be also submitted to PETROBRAS approval, due to impacts (area, weight, demand, heat dissipation, etc.).

6.3.12. Any other Package electric power or control voltage shall be obtained using a suitable converters installed internally to the Package.

6.3.13. For telecommunication packages, see Telecommunication documentation.

6.4. Electrical Installations Interfaces

6.4.1. The electrical interconnection (power, control, protection, lighting, heating, etc.) between equipment located in the same Package shall be sized, purchased and installed under the complete responsibility of the Packager.

6.4.2. Electrical material and equipment necessary for interconnection between the Package and the Module shall be furnished by Module Supplier. It shall be installed by Module Supplier under the supervision (technical assistance) of the Packager.

6.4.3. Unless otherwise stated in specific Technical Specifications or Material Requisition, the sizing, purchase and installation of electrical cables interconnecting equipment located in Packages physically separated shall be Module Supplier responsibility. The Packager shall inform all necessary data and approve the calculated cable.

6.4.4. Cables for external connections to Package shall be leaded to junction boxes supplied by Packager, located at the Package limits. There shall be independent junction boxes for systems with different voltages.

6.4.5. Exception is made for cables from the Unit panels feeding motor loads inside the Package, when the functional units for these motors are not in Package scope and for cables arising from generators inside the Package to the unit panels. These cables shall be furnished and installed by Bidder and shall be dimensioned until the power terminal box of the equipment (motors, or generators).

6.4.6. For internal loads supplied externally, the mechanical path from Package battery limits, for power, control, protection and heating cables shall be scope of Packager.

6.4.7. All Packages classified as normal loads shall be prepared to receive a digital voltage-free signal for emergency shutdown (ESD). (HOLD)

6.4.8. The design of the power and the control panels included in Packages shall consider a sufficient number of hardwired and network external communication and interface signals between Package and Electrical System, in order to comply with requirements of 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.
6.4.9. For each interface point, Packager shall guarantee full compatibility of type, voltage and grounding system, including, if necessary, converters and galvanic isolators for control signals.

6.5. Electrical Panels and MCC for Packages

6.5.1. Panels shall comply with safety requirements of Brazilian Labour Authority. Each panel shall be of metallic construction (structure and steel sheets), following the correspondent IEC rules.

6.5.2. Panels for control, lighting, UPS distribution and DC distribution shall comply with requirements of I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS. Panels for heating shall comply with I-ET-3010.00-5140-741-P4X-003 - POWER PANEL FOR THYRISTORIZED HEATER FOR OFFSHORE UNITS.

6.5.3. Panels shall be proper for the calculated short-circuit level at Package incoming point. Detailed Design shall inform these values to Packager.

6.5.4. Panels shall be provided with a general incoming circuit-breaker (moulded-case or power, according to Package power), current limiting type, for each external incoming power supply.

6.5.5. The incoming circuit-breaker handles shall allow padlocking in “off” position. The opening of door giving access to live parts shall be interlocked with main power disconnection.

6.5.6. Motor Control Centers (MCC) included in Packager scope of supply, shall comply with requirements of IEC 61439-1 and I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS. Any deviation from these specifications shall be submitted to PETROBRAS for approval.

6.5.7. For MCC included in Packager scope of supply, a short-circuit limiting reactor shall be installed in series with the MCC incoming feeder, which shall be sized and provided by Bidder. This short-circuit limiting reactor may be furnished loose or integrated in the MCC. It shall be evaluated, together by Bidder and Packager, the convenience or not to install this reactor integrated to the MCC.

6.5.8. Unless otherwise stated in project documentation, at power panels incoming point, the calculated thermal equivalent short-circuit current (Ith) for 1s shall be 18kA and the calculated peak short-circuit current (Ipk) shall be 52.5kA. Detailed Design shall confirm these values to Packager. This calculation shall consider the balance between short-circuit limits and voltage-drop during motor starting. MCC rated withstand currents shall comply with (be higher than) these values.

6.5.9. Shutdown circuits are to be arranged to operate independently from other monitoring, control and alarm systems.

6.5.10. Panels shall be designed to have frontal access for installation, maintenance and inspection with no necessity of rear access.

6.5.11. When installed outdoors, Panels shall be IP56W (where W means proper for corrosive saline damp and hot environment), constructed in stainless steel sheets AISI-316 or FRP (Fiber Reinforced Plastic) resistant to UV (Ultra Violet), installed in a protected area.
6.5.12. The internal partitioning of control panels of Package Unit shall use metallic barriers, at least in the form 3b of IEC 61439-1.

6.5.13. In order to separate the risk zone (power circuits) and to avoid human contact with live parts, as stated in NR-10 rules, insulated and transparent polycarbonate barriers shall be installed. Totally screwed plates shall not be used. Alert indicating plates shall be provided, with the indication of risk and the rated voltage of circuits, as stated in NR-10.

6.5.14. Low-voltage MCC included in Package scope of supply, with motor loads functional units, shall comply with the following additional requirements:

6.5.14.1. Unless otherwise stated in PETROBRAS documentation, Bidder for Topside installations or Hull Contractor for Hull installations, shall guarantee the starting of all motors included in the Package with maximum voltage drop at MCC busbar of 15% of MCC rated voltage. If this value cannot be reached by direct online start, and the motor is in safe area (non-classified area) a soft starter shall be provided by Bidder (or Hull Contractor), to be furnished loose, as an independent unit. Bidder (or Hull Contractor) shall be responsible to calculate and verify the motor starting voltage-drop, as stated on item 6.5.8.

6.5.14.2. For motors installed in hazardous area and for motors installed in external safe areas, but required to operate during ESD-3P or ESD-3T, when a soft starter is required to comply with voltage drop requirements, the supply of the set, motor and drive, shall be included in the Packager scope of supply, which shall also be responsible for the certification of this set. It shall be given preference to the use of circuit-breakers as protection devices for soft starters. The use of fuses shall only be considered if strictly indicated by manufacturer. Soft starter in these cases may be supplied loose, as an independent unit, or integrated in the MCC supplied by Packager.

Note: Standards require certificate of set (motor and soft starter) when the motor is certified for operation in hazardous areas. Packager shall supply the soft starter in these cases, being the only responsible to provide the certificate.

6.5.14.3. Requirements for soft-starters shall comply with I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

6.5.14.4. For redundant or dual loads, the control devices of each load shall be fed from independent circuits, internally separated by physical barriers, in order to avoid unavailability of both loads due to the same damage. The installation of starters for redundant or dual loads in geminated panels shall be accepted.

6.5.14.5. Panels shall be installed in areas free of vibration and far from heavy maintenance areas. It shall be avoided the installation of panels on the same skid of the driven/controlled equipment.

6.5.15. Any deviation from these requirements shall be submitted to PETROBRAS approval.
6.6. Safety Grounding Installation

Package internal safety grounding system (equipment, accessories, piping and structure) shall comply with the requirements of IEC 61892-6, IEC 60092-502, applicable Classification Society’s rules, I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS and I-DE-3010.00-5140-700-P4X-003 - GROUNDING INSTALLATION TYPICAL DETAILS. Besides these standards, for installations in hazardous areas, grounding requirements of IEC 61892-7 shall be complied with.

6.7. Lighting Installation

Package internal lighting equipment, when required, shall comply with the requirements of I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS and I-DE-3010.00-5140-700-P4X-001 - LIGHTING INSTALLATION TYPICAL DETAILS.

7. INSPECTION AND TESTS

7.1. Electrical components and equipment with Technical Specification or Data Sheet issued by Detailed Design and installed in Packages shall be inspected and tested according to the applicable reference documents.

7.2. All Electrical components and equipment installed in Packages in hazardous areas or installed in safe outdoors areas, but kept turned on during ESD-3P or ESD-3T situation, shall be individually inspected and tested, and Certification Reports shall be issued according to item 6.2.2 and 6.2.3.

7.3. Classification Society and PETROBRAS may witness and approve all tests.

7.4. Individual visual inspection shall be provided for each item.

7.5. General checking like humidity inside equipment, screw pressing of explosion proof enclosures, enclosures joint tightness, cables electrical continuity and insulation resistance test shall be provided.

7.6. When required, manufacturer shall perform inspections and tests during manufacturing process of the equipment, witnessed by PETROBRAS and Classification Society, in order to fulfil all requirements stated on tests lists detailed in the specifications and respective data sheets.

7.7. For type tests, certified test reports for tests performed in identical equipment and approved and witnessed by Classification Society are accepted.

8. SPARE PARTS AND TOOLS

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

8.2. Packager shall provide all unusual tools necessary for maintenance, assembly or disassembly of all electrical equipment.
9. DOCUMENTATION

9.1. A complete set of documentation, as required on Package Material Requisition (RM), shall be provided. These documents shall be issued for the Package and for internal equipment and components.

9.2. For Packages with power panel, Packager shall issue a protection coordination study including graphical plotting for all protective devices of the panel. The graphical plotting shall include equipment limit curves and points. The study shall include block diagrams for implemented logics and tables with configuration data (all configuration parameters) for all protective devices.

9.3. Packager shall provide complete documentation according to Brazilian Labour and Employment Ministry NR-10. This documentation shall be issued and signed by legally qualified personnel. The documentation shall include the items listed below and all items foreseen in NR-10:
   a) Conformity Technical Appraisal regarding applicable standards for all internal equipment and installations, including tests, inspections, and measurement reports;
   b) Project Technical Report, including internal protection, installation, safety grounding, etc.;
   c) Manuals with safety and health procedures and instructions regarding electrical equipment and installations;
   d) List with electrical and electronic equipment installed in hazardous areas, including for each equipment, the classification Ex, nameplate data, number of Conformity Certificate and name of entity that issued the certificate;
   e) Conformity Certificate for all electrical and electronic equipment proper for installation in hazardous areas, according to INMETRO Portaria nº 179, May 18th 2010 and Portaria nº 89, Feb 23rd 2012.

9.4. Packager shall present interface cables list and interconnection diagrams, clearly indicating the cables supplier (Packager, or Module Supplier, or Bidder).

9.5. Packages with programmable electronic devices shall issue documentation with the logic and the code source. One license for the access software for the code shall be included. All necessary access passwords shall be transferred to PETROBRAS.

9.6. Packages with configurable electronic devices shall issue documentation with all parameters settings. One license for the access software for configuration of the devices shall be included. All necessary access passwords shall be transferred to PETROBRAS.

9.7. Packager shall present a list of deviations from PETROBRAS documentation requirements.

9.8. Packager shall provide Package documentation in Portuguese, as required in NR-12, and in English languages.
10. ANNEX I

Annex I.xlsx