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1 OBJECTIVE

- 1.1 This specification establishes the minimum technical requirements for design, manufacture, and supply of Transformers for PETROBRAS Offshore Units.
- 1.2 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 60076	Power Transformers - All parts
IEC TS 60076-20	Power transformers – Part 20: Energy efficiency
IEC 60146-1-1	Semiconductor Convertors - General Requirements and Line Commutated Convertors - Part 1-1: Specification of Basic Requirements
IEC 60214-1	Tap-changers – Part 1: Performance requirements and test methods
IEC 60214-2	Tap-changers – Part 2: Application guide
IEC 60270	High-Voltage Test Techniques - Partial Discharge Measurements
IEC TR 60616	Terminal and tapping markings for power transformers
IEC 61378-1	Converter Transformers - Part 1: Transformers for Industrial Applications
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

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

2.2.2 IEEE – INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERING

C57.110	Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability when Supplying Nonsinusoidal Load Currents
C57.147	IEEE Guide for Acceptance and Maintenance of Natural Ester Insulating Liquid in Transformers

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2.2.3 LABOUR SECRETARY - MINISTRY OF ECONOMY - REGULATORY STANDARDS FOR OCCUPATIONAL SAFETY AND HEALTH NR-12 Segurança no Trabalho em Máquinas e Equipamentos						
2.2.4 ASTM – AMERICAN SOCIETY FOR TESTING AND MATERIAL B700 Standard Specification for Electrodeposited Coatings of Silver for Engineering Use						
2.2.5 IOGP – INTERNATIONAL ASSOCIATION OF OIL & GAS PRODUCERS S-720 Supplementary Specification to IEC 60076-1 Transformers						
2.3 REFERENCE DOCUMENTS						
[1] I-DE-3010.00-5140-741-P4X-001 - FUNCTIONAL UNITS BLOCK DIAGRAMS						
[2] I-ET-3010.00-1200-300-P4X-001 – NOISE AND VIBRATION CONTROL REQUIREMENTS						
[3] I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS						
[4] I-ET-3010.00-5140-700-P4X-002 – SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS						
[5] I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS						
[6] I-ET-3010.00-5140-700-P4X-007 – SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS						
[7] I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS						
[8] I-ET-3010.00-5140-712-P4X-001 - LOW-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS						
[9] I-ET-3010.00-5140-741-P4X-004 – SPECIFICATION FOR LOW-VOLTAGE GENERIC ELECTRICAL PANELS FOR OFFSHORE UNITS						
[10] I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE						
[11] I-ET-3010.00-5143-700-P4X-001 - ELECTRICAL SYSTEM PROTECTION CRITERIA						
[12] I-LI-3010.00-5140-700-P4X-001 - ELETRICAL EQUIPMENT DATA SHEET MODELS						
[13] I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST						

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3 EQUIPMENT

The following items shall have priority over similar ones which are included at Supplementary Specification to IEC 60076-1 Transformers IOGP JIP 33 S-720 (Annex). Annex shall be considered as Supplementary Specification to this document. The Supplementary Requirements is an IOGP (The International Association of Oil & Gas Producers) Specification which was prepared by a Joint Industry Project 33 Standardization of Equipment Specifications for Procurement. The Joint Industry Project 33 was organized by IOGP with support by the World Economic Forum (WEF).

3.1 GENERAL CONDITIONS

All General Equipment Conditions (Environmental Conditions, Heat Dissipation Characteristics, Motion and Inclination Limits Requirements, Vibration Limits Requirements, Hazardous Areas Requirements, Construction Requirements, Warning Labels for Electrical Equipment, Voltage Requirements, Frequency Requirements and EMC and RFI Requirements) not covered by this Specification, are defined, when applicable, in I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

3.2 GENERAL REQUIREMENTS

- 3.2.1 Transformers shall be sized for continuous duty and shall comply with the requirements of IEC 60076, IEC 62041, and IEC 61558. For sizing of transformers for non-linear loads, see also 3.7.
- 3.2.2 Unless otherwise stated in Project Documentation, all guaranteed values shall be established with measurement methods and shall comply with the tolerances foreseen on reference standards.
- 3.2.3 Transformers shall be installed as separate units with individual enclosures.
- 3.2.4 The general criteria informed in section 3 EQUIPMENT apply to all transformers informed in this specification.

3.3 SCOPE OF SUPPLY

- 3.3.1 The transformers shall be furnished with at least the following items:
 - a) Protection enclosure.
 - b) Finishing, terminals, and cable glands.
 - c) Accessories and tools recommended by manufacturer own experience.
 - d) Spare parts for the commissioning and pre operation periods.
 - e) Drawings and Technical Documentation.

3.4 CONSTRUCTION AND MECHANICAL REQUIREMENTS

3.4.1 CONSTRUCTION MATERIAL (TYPE)

- 3.4.1.1 Primary windings shall be moulded/encapsulated in epoxy resin under vacuum (cast-resin). Secondary (and tertiary if applicable) windings shall be moulded/encapsulated in epoxy resin under vacuum (cast-resin) or pre-impregnated with end-packing sealed with epoxy resin. Other solutions shall be submitted to PETROBRAS for approval.
- 3.4.1.2 Lighting transformers shall be dry type moulded in epoxy resin, encapsulated with glass fibre epoxy resin under vacuum or resin impregnated windings.
- 3.4.1.3 All transformers shall be dry type. Liquid cooled power transformers are accepted only as part of complete package, i.e.: electrical chlorination unit and oil dehydrator equipment.
- Note: When not defined in this Specification, the scope and definition is responsibility of Packager.
- 3.4.1.4 Transformers shall comply with Fire Behaviour Class F1, according to IEC 60076-11.
- 3.4.1.5 Transformer windings' coil material shall be made of copper or aluminium material. Other materials shall have Petrobras approval.

3.4.2 TEMPERATURE RISE, CLIMATIC AND ENVIRONMENTAL CLASSES


- 3.4.2.1 The permissible temperature rise referred to environmental conditions shall be as a maximum average, equal to 80°C for the outer winding(s) and 100°C for the inner winding(s), according to IEC 60076-11.
- 3.4.2.2 Transformers shall comply with, at least, Climatic Class C2, according to IEC 60076-11.
- 3.4.2.3 Transformers shall comply with, at least, Environmental Class E2, according to IEC 60076-11.


3.4.3 SHORT-CIRCUIT CURRENTS

- 3.4.3.1 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.
- 3.4.3.2 They shall be suitable for a short-circuit level, next to the primary terminals, equal to that of the supply panel busbar.

3.4.4 WINDINGS CHARACTERISTICS

- 3.4.4.1 The primary and secondary windings shall be at least F Temperature Class (155°C) insulation.
- 3.4.4.2 The MV (Medium-Voltage) and LV (Low-Voltage) windings shall be separated from each other.
- 3.4.4.3 The insulation resin shall be non-fire propagating and self-extinguishing and, in case of fire, shall not release toxic gases.
- 3.4.4.4 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.
- 3.4.4.5 Both windings shall have uniform insulation to permit their operation, indifferently, with grounded or insulated neutral systems.

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<p>3.4.4.6 Lifetime shall be at least 30 years.</p> <p>3.4.4.7 Maximum temperature after a short-circuit shall be under limits of IEC 60076-5.</p> <p>3.4.4.8 Medium-voltage transformers with secondary neutral isolated shall have an earthed shield between the primary and the secondary winding.</p> <p>3.4.5 ENCLOSURE</p> <p>3.4.5.1 Manufacturer shall supply a latticed protection enclosure, with suitable ventilation, for each transformer to protect against accidental contacts, with protection degree specified in I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.</p> <p>3.4.5.2 Transformers top and bottom sides shall allow easy natural ventilation keeping the specified protection degree.</p> <p>3.4.5.3 All power transformers shall be AN (air natural) cooled, unless otherwise specified in datasheet or in documents with higher priority level.</p> <p>3.4.5.4 The enclosure grating shall enable thermographic inspection of transformer windings and connections with no necessity to open the enclosure.</p> <p>3.4.5.5 Facilities for lifting of separated windings, core, complete transformers and for their horizontal displacements shall be supplied.</p> <p>3.4.6 FEEDING CABLES AND BUS TRUNKING</p> <p>3.4.6.1 All conducting parts at the high voltage side shall be insulated with resin.</p> <p>3.4.6.2 No stress shall be applied to bushings or terminations. These fixing devices shall be built of non-magnetic material.</p> <p>3.4.6.3 When copper/aluminium connections exist, these shall be encapsulated.</p> <p>3.4.6.4 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.</p> <p>3.4.6.5 For cables specification characteristics see electrical cables section in I-ET-3010.00-5140-700-P4X-002 – SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS.</p> <p>3.4.6.6 For bus trunking specification characteristics see busbar trunkings section in I-ET-3010.00-5140-700-P4X-007 – SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS.</p> <p>3.4.6.7 For optional EPOXY resin insulated bus bars specification characteristics see epoxy resin insulated bus bars section in I-ET-3010.00-5140-700-P4X-007 – SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS.</p> <p>3.4.7 NEUTRAL CONNECTIONS</p> <p>3.4.7.1 Transformer secondary neutral point shall be connected to a terminal accessible and clearly marked according to IEC TR 60616.</p>						

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3.4.8 NOISE LEVEL

3.4.8.1 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.

3.4.9 CONDUCTORS

3.4.9.1 Conductors of auxiliary circuits shall be of stranded copper, complying with requirements of item of electrical cables in I-ET-3010.00-5140-700-P4X-002 – SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS.

3.4.10 FACILITIES FOR GROUNDING

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

3.4.10.2 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 electrical cables section in I-ET-3010.00-5140-700-P4X-002 – SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS.

3.4.10.3 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.

3.4.11 TOOLS LIST

3.4.11.1 Manufacturer shall present a list of necessary tools for maintenance.

3.4.12 TERMINALS

3.4.12.1 Terminals shall be moulded in epoxy resin.

3.4.12.2 Terminals shall be silver-coated/silver-plated according to ASTM B700 with minimum thickness of 2.5µm.

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

3.5 ELECTRICAL REQUIREMENTS

3.5.1 LOSSES AND EFFICIENCY

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

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

3.5.2 SHORT-CIRCUIT IMPEDANCE

3.5.2.1 This value at rated frequency and at 115°C shall be indicated/confirmed on Datasheet.

3.5.2.2 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.

3.5.2.3 All short-circuit impedance values shall be calculated referenced to normal power, thus without forced ventilation increased power margins.

3.5.3 INRUSH CURRENT

3.5.3.1 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.

3.5.4 TYPE OF CONNECTION

3.5.4.1 Unless otherwise stated, the type of connection shall follow the indication presented on Table 1.

Table 1 - 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.

3.5.5 VOLTAGE TAPS

3.5.5.1 Unless otherwise stated in Datasheet, all transformers shall be provided with bolted links (no-load tap changing) at the higher voltage side with the taps presented in Table 2.

3.5.5.2 Tap changers shall be manually operated de-energized and shall comply with S-720 Supplementary Specification to IEC 60076-1 Transformers.

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

Table 2 - 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

3.5.6 TRANSFORMERS TESTS

3.5.6.1 Where indicated, according to Table 3, Type Tests (TT), Routine Tests (RT), and Special Tests (ST) shall be carried out for transformers following the reference standards and acceptance criteria.

3.5.6.2 Routine and Special Tests shall be carried-out to all transformers foreseen in the Unit.


3.5.6.3 Type tests shall be carried-out for the first batch of identical transformers.

Table 3 - 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	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 ⁽⁶⁾			X	IEC 60076-11 and IEC 60076-5
All Dry Type	Environmental tests ⁽⁶⁾			X	IEC 60076-11
All Types	Climatic tests ⁽⁶⁾			X	IEC 60076-11
All Types	Fire behaviour test ⁽⁶⁾			X	IEC 60076-11
All Types	Degree of protection of enclosure ⁽⁶⁾	X			I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS
⁽⁵⁾	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 ⁽⁷⁾			X	IEC 60076-1
All Types	Measurement of harmonics of the load current ⁽⁴⁾		X		IEC 60076-1 and IEC 61378-1
⁽⁵⁾	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 ($\tan \delta$) 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 3, they shall be presented to prior evaluation and approval by PETROBRAS.
 - 3) IEC 60076-11 only for dry type transformers.
 - 4) Only for transformers dedicated to non-linear loads.
 - 5) For all transformers with this equipment.
 - 6) Certified test reports for tests performed for similar equipment and approved and witnessed by Classification Society are accepted.
 - 7) One test for each type is acceptable.

3.5.6.4 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.

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3.6 POWER TRANSFORMERS						
<p>3.6.1 Power Transformers are the transformers with one or more Medium-Voltage (>1000V) windings that are not subject of 3.7, 3.8 or 3.9.</p>						
<p>3.6.2 Unless otherwise stated, all power transformers shall have the same connection type and phase displacement to permit parallel continuous operation.</p>						
<p>3.6.3 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.</p>						
<p>3.6.4 Unless otherwise stated, power transformers shall be furnished with at least the following items, additionally to items related on item 3.3.1:</p> <ul style="list-style-type: none"> a) Thermal protection relays (49 Function) for each secondary voltage side winding with as required in 3.6.8, 3.6.10, 3.6.11 and 3.6.12; 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. 						
<p>3.6.5 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 (unless otherwise stated in Project Documentation).</p>						
<p>3.6.6 The provision for future installation of cooling fans shall be provided considering no hot work, for example grinding and welding.</p>						
<p>3.6.7 When required, the fans motors of each transformer shall be fed by one LV MCC drawer. An alarm shall be sent in case of failure of the fan motors according to I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.</p>						
<p>3.6.8 The fan motors shall comply with I-ET-3010.00-5140-712-P4X-001 - LOW-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS. The fan motors shall be 440V 3ph 60Hz if distribution voltage level is 480V or 660V 3ph 60Hz if distribution level is 690V.</p>						
<p>3.6.9 Unless otherwise stated in Datasheet, power transformers shall have at least two RTD, platinum resistance temperature detectors type (PT100Ω @ 0°C), per phase in direct contact with 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.</p>						
<p>3.6.10 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:</p> <ul style="list-style-type: none"> • high temperature in windings - trip signal and • high temperature in windings - alarm signal. <p>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</p>						

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.

3.6.11 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.

3.6.12 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).


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


3.6.14 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.

3.6.15 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.

3.6.16 Power transformers shall be suitable to replacement of the coils, in case of damage, by disassembly from top side, being acceptable to remove parts of the transformer enclosure.

3.6.17 To allow coils disassembly and assembly from top side, the coil shall be split in two sections (reducing the necessary height).

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<p>3.6.18 Power transformers shall be suitable to replacement of the core, in case of damage. For the disassembly, it is acceptable to remove parts of the transformer enclosure.</p> <p>3.6.19 To allow core disassembly and assembly, the core shall be designed in sections (reducing the necessary height).</p> <p>3.6.20 If windings are connected by screws Manufacturer shall indicate in the proposal the periodicity of internal screw retightening. Manufacturer shall provide the necessary tools for it or indicate that the retightening are free of special tools. All screwed connections shall have devices to avoid loosening (lock/spring washers or Belleville spring washer, etc).</p>						
<p>3.7 TRANSFORMERS FOR NON-LINEAR LOADS</p> <p>3.7.1 Transformers dedicated to feed non-linear loads (rectifiers, VSD-FCs, UPSs, thyristors, etc.) shall comply with the requirements of IEC 61378-1.</p> <p>3.7.2 Transformers dedicated to feed line commutated converters (LCI) shall comply with the requirements of IEC 60146-1-1.</p> <p>3.7.3 Transformers to feed both, linear and non-linear loads shall comply with the requirements of IEC 60076-12 and IEEE C57.110.</p> <p>3.7.4 Unless otherwise stated in Datasheet, RTD location shall be the same as in section 3.6.9.</p>						
<p>3.8 DISTRIBUTION TRANSFORMERS WITH SECONDARY UP TO 240V</p> <p>3.8.1 Unless otherwise stated in project documentation, the rated voltages shall be 480-220V.</p> <p>3.8.2 They shall be assembled on metallic boxes.</p> <p>3.8.3 The transformers impedance shall be $Z = 4$ to 5%, unless otherwise informed in datasheet or project documentation.</p> <p>Note: Minimum short circuit impedance values are defined in IEC 60076-5.</p>						
<p>3.9 OIL DEHYDRATOR TRANSFORMERS</p> <p>3.9.1 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.</p> <p>3.9.2 For each Oil Dehydrator using A.C. technology, the following configurations are permitted:</p> <p>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.</p> <p>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.</p>						

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<p>3.9.3 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.</p> <p>3.9.4 These transformers shall have conformity certificates for operation in hazardous areas according to I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS and shall be fitted with pressure safety valves.</p> <p>3.9.5 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 3.9.11).</p> <p>3.9.6 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.</p> <p>3.9.7 Each transformer shall have an indicator panel with:</p> <ul style="list-style-type: none"> • 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). <p>3.9.8 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.</p> <p>3.9.9 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.</p> <p>3.9.10 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).</p> <p>3.9.11 Natural ester-based insulating liquids shall be used as cooling method and shall comply with IEEE 57.147. Other oil types shall be approved by PETROBRAS.</p> <p>3.9.12 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.</p> <p>3.9.13 The tap-changer operation shall be possible externally, with the tank closed.</p> <p>3.9.14 The secondary winding neutral terminal shall not be available.</p> <p>3.9.15 Transformer tank, tap changer, and secondary terminal boxes shall have oil level indicators.</p>			

3.9.16 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.

3.9.17 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.

3.10 PRE-MAGNETIZATION FOR POWER TRANSFORMERS

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

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

3.10.3 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.

3.10.4 Pre-Magnetization system shall be supplied individually for each Power Transformer.

3.10.5 The pre-magnetization device, if external to the transformer, shall have its construction design in agreement to I-ET-3010.00-5140-741-P4X-004 – SPECIFICATION FOR LOW-VOLTAGE GENERIC ELECTRICAL PANELS FOR OFFSHORE UNITS where applicable, if internal to the transformer, it shall follow section 3.4, where applicable.

3.10.6 The pre-magnetization control panel shall be externally installed as part of power transformer enclosure if pre-magnetization device is internal to the transformer.

3.10.7 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.

3.10.8 The pre-magnetization device shall be PLC controlled.

3.10.9 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.

- 3.10.10 A bypass switch shall be supplied to allow the main transformer energization without the pre-magnetization system.
- 3.10.11 The pre-magnetization device shall have suitable switching and protection devices according to manufacturer standards.
- 3.10.12 Unless otherwise defined in Project Documentation, the pre-magnetization device shall be a complete solution and dedicated for the assigned transformer.
- 3.10.13 Pre-magnetization system operation shall be included in power transformer factory acceptance tests.
- 3.10.14 Unless otherwise defined in Project Documentation, the control panel power supply shall be derived inside the power transformer enclosure from the primary side of an auxiliary transformer by an instrument transformer (Potential Transformer).
- 3.10.15 The auxiliary transformer of the Pre-Magnetization system shall have the same TAPs and connection group of the Power Transformers.
- 3.10.16 Pre-magnetization system shall be approved by PETROBRAS.

3.11 TRANSFORMER PROTECTION

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

4 MANUFACTURER DOCUMENTATION

4.1 DOCUMENTS TO PROPOSAL

The following documents and information shall be annexed to the proposal for the transformer and all related equipment and accessories:

- a) Documents list;
- b) Dimensional drawings including frontal view, upper view, estimated weight and thermal dissipation;
- c) Technical catalogues with information about all components;
- d) Manuals at least with: 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 and lifting heights;
- e) Forced ventilation system drawings with dimensions, weight, electrical wiring of fans, sensors, instruments and their circuits;
- f) Oil technical characteristics for operation and maintenance, if applicable;
- g) Spare parts list for two years of operation, including item, part number, quantity, description, MTBF and price for each part;
- h) Technical assistance prices and representative address;
- i) Transformer Data-sheet issued by PETROBRAS completely filled in with Manufacturer data with identification of the person responsible for the filling. This Data Sheet shall be submitted to PETROBRAS approval;

- j) List of applicable standards;
- k) Painting method;
- l) Inspection and test schedule, including acceptance criteria for each test;
- m) Other documents required in project documentation, including certificates.

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.

4.2 DOCUMENTS FOR APPROVAL

The following documents and information shall be submitted for PETROBRAS approval, after Packager definition, for the transformer and all related equipment and accessories:

- a) Documents list;
- b) Dimensional drawings including frontal and upper views, details, location of lifting eyelets and area for incoming cables, fixing base details;
- c) Dimensional drawings including frontal and upper views, weight and details of windings temperature control panel and forced ventilation power and control panels.
- d) Functional and on-line diagrams including demand and rated power of windings temperature control panel and forced ventilation power and control panels.
- e) Data-sheet of forced ventilation motors, if applicable.
- f) Weight and volume of each unit for transportation and total weight;
- g) Thermal dissipation at half load and full load;
- h) Package and transportation instructions;
- i) Identification plates;
- j) Detailed description of the equipment, including all accessories;
- k) Procedures during emergency conditions (including oil concerns, if applicable);
- l) Warranty certificate and declaration of availability of spare parts for 10 (ten) years;

4.3 DOCUMENTS AFTER APPROVAL

Assembly, Installation, Operation and Maintenance manuals shall be furnished, after documentation approval, containing at least the following information (including all requirement of NR-12):

- a) Data-sheet full-filled “as built”;
- b) Technical specifications for the transformer, all components and accessories, in accordance with the approved requirements (as built);
- c) List of standards followed for design, fabrication and tests;
- d) Detailed description of transformer and accessories;
- e) List of risks for operators during operation and maintenance;
- f) Storage, preservation and unpacking instructions in Portuguese language;
- g) Detailed lifting and handling procedures in Portuguese language;
- h) Installation and assembly instructions in Portuguese language;
- i) Operation instructions in Portuguese language;

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- j) Maintenance instructions, including list of necessary equipment, accessories and tools in Portuguese language;
- k) Spare parts lists;
- l) “As built” technical catalogue for all components;
- m) Complete test report, including type, routine and special tests;
- n) Components list, including at least, item, description, draw, unit, quantity and part number;
- o) Constructive details about baseplate fixation screws such as quantity, size, type and position in baseplate.

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

5 DATASHEET FORMS

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

6 ABBREVIATIONS AND ACRONYMS

AC	Alternated Current
AN	Air Natural
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE
CT	Current Transformer
DC	Direct Current
ET	Technical Specification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrotechnical and Electronic Engineers
LCI	Line Commutated Converters
LV	Low-Voltage
MTTR	Mean Time To Repair
MV	Medium-Voltage
PLC	Programmable Logic Controller
RT	Routine Test
RTD	Resistance Temperature Detector
ST	Special Test
TT	Type Test
UAM	Unit Alarm Malfunction
Un	Rated Voltage
UPS	Uninterruptible Power Supply
VSD	Variable Speed Drive
VSD-FC	Variable Speed Drive – Frequency Converter
VT	Voltage Transformer

7 ANNEX



Supplementary-Spe
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