

CONTECComissão de Normalização
Técnica**SC-06**

Electricity

Power Transformers**1st Amendment**

This is the 1st Amendment to PETROBRAS N-2928, and it is used to alter the text of the Standard in the part(s) indicated below:

NOTE 1 The news pages with the performed amendments are placed in its corresponding positions.

NOTE 2 The amended pages, indicated the date of the amendment, are placed at the end of this standard, in chronological order, and shall not be used.

CONTENTS OF THE 1st AMENDMENT - 06/2014**- Subsection 1.1:**

Alteration of the text.

- Subsection 3.1.7:

Exclusion of the text.

- Subsection 3.1.16:

Inclusion of the text.

- Subsection 3.5:

Exclusion of the text.

- Subsection A.4.2:

Alteration of the text.

- Subsection A.4.3:

Alteration of the text.

Power Transformers

Specification

CONTEC

Comissão de Normalização
Técnica

SC - 06

Electricity

The CONTEC - Authoring Subcommittee provides guidance on the interpretation of this Standard when questions arise regarding its contents. The Department of PETROBRAS that uses this Standard is responsible for adopting and applying the sections, subsections and enumerates thereof.

Technical Requirement: A provision established as the most adequate and which shall be used strictly in accordance with this Standard. If a decision is taken not to follow the requirement ("non-conformity" to this Standard) it shall be based on well-founded economic and management reasons, and be approved and registered by the Department of PETROBRAS that uses this Standard. It is characterized by imperative nature.

Recommended Practice: A provision that may be adopted under the conditions of this Standard, but which admits (and draws attention to) the possibility of there being a more adequate alternative (not written in this Standard) to the particular application. The alternative adopted shall be approved and registered by the Department of PETROBRAS that uses this Standard. It is characterized by verbs of a nonmandatory nature. It is indicated by the expression: **[Recommended Practice]**.

Copies of the registered "non-conformities" to this Standard that may contribute to the improvement thereof shall be submitted to the CONTEC - Authoring Subcommittee.

Proposed revisions to this Standard shall be submitted to the CONTEC - Authoring Subcommittee, indicating the alphanumeric identification and revision of the Standard, the section, subsection and enumerate to be revised, the proposed text, and technical/economic justification for revision. The proposals are evaluated during the work for alteration of this Standard.

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The use of this Standard by other companies / organizations / government agencies and individuals is the sole responsibility of the users.."

Introduction

PETROBRAS Technical Standards are prepared by Working Groups - WG (consisting specialized of Technical Collaborators from Company and its Subsidiaries), are commented by Company Units and its Subsidiaries, are approved by the Authoring Subcommittees - SCs (consisting of technicians from the same specialty, representing the various Company Units and its Subsidiaries), and ratified by the Executive Nucleus (consisting of representatives of the Company Units and its Subsidiaries). A PETROBRAS Technical Standard is subject to revision at any time by its Authoring Subcommittee and shall be reviewed every 5 years to be revalidated, revised or cancelled. PETROBRAS Technical Standards are prepared in accordance with PETROBRAS Technical Standard [N-1](#). For complete information about PETROBRAS Technical Standards see PETROBRAS Technical Standards Catalog.

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Foreword

This Standard is the English version (issued in 10/2013) of PETROBRAS N-2928 REV. 0 12/2012. In case of doubt, the Portuguese version, which is the valid document for all intents and purposes, shall be used.

1 Scope

1.1 This Standard sets out the requirements for purchasing dry or insulating liquid- immersed transformers with power above 500 kVA for use in PETROBRAS' facilities.

1.2 This Standard does not apply to:

- a) dry power transformers for lighting and instrumentation systems; for these cases, PETROBRAS [N-2201](#) shall be used;
- b) transformers supplying exclusively to frequency converters; for these cases, PETROBRAS [N-2547](#) shall be used.

1.3 The application of this Standard does not exempt from following rules from public bodies that shall be complied by the equipment, components, services and installations. The rules from Regulating Standards of the Ministry of Labor and Ministerial Ordinances prepared by Inmetro, containing the Compliance Assessment Requirements (RAC) for equipment, components and services, may be as examples of rules from public bodies.

1.4 This Standard applies to procedures beginning from its date of edition.

1.5 This Standard contains only Technical Requirements.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document applies.

PETROBRAS [N-2201](#) - Dry Transformer for Lighting or Instrumentation Systems;

PETROBRAS [N-2547](#) - Frequency Converter for Speed Control of Electric Motor Up To 660 VAC;

ABNT [NBR IEC 60156](#) - Líquidos Isolantes - Determinação da Rigidez Dielétrica à Frequência Industrial;

ABNT [NBR IEC 60450](#) - Medição do Grau de Polimerização Viscosimétrico Médio de Materiais Celulósicos Novos e Envelhecidos para Isolação Elétrica;

ABNT [NBR IEC 60529](#) - Graus de Proteção para Invólucros de Equipamentos Elétricos (Código IP);

ISO [4624](#) - Paints and Varnishes - Pull-Off Test for Adhesion;

ISO [12944-1](#) - Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 1: General Introduction;

ISO [12944-2](#) - Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 2: Classification of Environments;

ISO 12944-3 - Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 3: Design Considerations;

ISO 12944-4 - Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 4: Types of Surface and Surface Preparation;

ISO 12944-5 - Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 5: Protective Paint Systems;

ISO 12944-6 - Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 6: Laboratory Performance Test Methods;

ISO 12944-7 - Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 7: Execution and Supervision of Paint Work;

ISO 20340 - Paints and Varnishes - Performance Requirements for Protective Paint Systems for Offshore and Related Structures;

ANSI/ASME B1.20.1 - Pipe Threads, General Purpose (Inch);

ASTM D924 - Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids;

ASTM D971 - Standard Test Method for Interfacial Tension of Oil against Water by the Ring Method;

ASTM D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration;

IEC 60068-1 - Environmental Testing - Part 1: General and Guidance;

IEC 60068-2-14 - Environmental Testing - Part 2-14: Tests - Test N: Change of Temperature;

IEC 60076-1 - Power Transformers - Part 1: General;

IEC 60076-2 - Power Transformers - Part 2: Temperature Rise for Liquid-immersed Transformers;

IEC 60076-3 - Power Transformers - Part 3: Insulation Levels, Dielectric Tests and External Clearances in Air;

IEC 60076-4 - Power Transformers - Part 4: Guide to the Lightning Impulse and Switching Impulse Testing - Power Transformers and Reactors;

IEC 60076-5 - Power Transformers - Part 5: Ability to Withstand Short Circuit;

IEC 60076-6 - Power Transformers - Part 6: Reactors;

IEC 60076-10 - Power Transformers - Part 10: Determination of Sound Levels;

IEC 60076-11 - Power Transformers - Part 11: Dry-type Transformers;

IEC 60076-13 - Power Transformers - Part 13: Self-protected Liquid-Filled Transformers;

IEC 60076-16 - Power Transformers - Part 16: Transformers for Wind Turbine Applications;

IEC 60076-21 - Power Transformers - Part 21: Standard Requirements, Terminology, and Test Code for Step-Voltage Regulators;

IEC 60146-1-3 - Semiconductor Convertors - General Requirements and Line Commutated Convertors - Part 1-3: Transformers and Reactors;

IEC 60214-1 - Tap-Changers - Part 1: Performance Requirements and Test Methods;

IEC 60247 - Insulating Liquids Measurement of Relative Permittivity, Dielectric Dissipation Factor (Tan) and d.c. Resistivity;

IEC [60567](#) - Oil-Filled Electrical Equipment - Sampling of Gases and Analysis of Free and Dissolved Gases - Guidance;

IEC [60599](#) - Mineral Oil-impregnated Electrical Equipment in Service - Guide to the Interpretation of Dissolved and Free Gases Analysis;

IEC [60814](#) - Insulating Liquids - Oil-Impregnated Paper and Pressboard - Determination of Water by Automatic Coulometric Karl Fischer Titration;

IEC [61000-4-3](#) - Electromagnetic Compatibility (EMC) - Part 4-3: Testing and Measurement Techniques - Radiated, Radio-Frequency, Electromagnetic Field Immunity Test;

IEC [61000-4-4](#) - Electromagnetic Compatibility (EMC) - Part 4-4: Testing and Measurement Techniques - Electrical Fast Transient/Burst Immunity Test;

IEC [61000-4-5](#) - Electromagnetic Compatibility (EMC) - Part 4-5: Testing and Measurement Techniques - Surge Immunity Test;

IEC [61000-4-6](#) - Electromagnetic Compatibility (EMC) - Part 4-6: Testing and Measurement Techniques - Immunity to Conducted Disturbances, Induced by Radio-Frequency Fields;

IEC [61181](#) - Mineral Oil-Filled Electrical Equipment - Application of Dissolved Gas Analysis (DGA) to Factory Tests on Electrical Equipment;

IEC [61378-1](#) - Converter Transformers - Part 1: Transformers for Industrial Applications;

IEC [61892-3](#) - Mobile and Fixed Offshore Units - Electrical Installations - Part 3: Equipment;

IEC [TR 60616](#) - Terminal and tapping markings for Power Transformers;

IEC [TS 60076-14](#) - Power Transformers - Part 14: Design and Application of Liquid-Immersed Power Transformers using High-Temperature Insulation Materials;

IEC [TS 61639](#) - Direct Connection between Power Transformers and Gas-Insulated Metal-Enclosed Switchgear for Rated Voltages of 72,5 kV and above;

IEEE [STD C57.12.90](#) - Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers;

IEEE [STD C57.12.91](#) - Test Code for Dry-Type Distribution and Power Transformers;

IEEE [STD C57.110](#) - Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability When Supplying Nonsinusoidal Load Currents.

NOTE For documents referred in this Standard and for which only the Portuguese version is available, the PETROBRAS department that uses this Standard should be consulted for any information required for the specific application.

3 Common Requirements for Dry or Insulating Liquid-Immersed Transformers

3.1 General Conditions

3.1.1 The general characteristics of power transformers shall comply with the requirements specified in IEC [60076-1](#).

3.1.2 The insulation levels, dielectric tests and external clearance in air shall comply with the requirements of IEC [60076-3](#).

3.1.3 Lightning impulse and switching impulse tests shall comply with the requirements of IEC [60076-4](#).

3.1.4 The characteristics of power transformers to withstand circuit-breakers shall comply with the requirements of IEC [60076-5](#).

3.1.5 Power reactors shall comply with requirements of IEC [60076-6](#).

3.1.6 Power transformers shall be designed, sized and tested in order to comply with the requirements of noise level determination indicated in IEC [60076-10](#).

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3.1.8 Power transformers to be applied in wind turbines shall comply with requirements of IEC [60076-16](#).

3.1.9 The tap changers of power transformers shall comply with requirements of performance and test methods of IEC [60214-1](#).

3.1.10 Markings of terminals and connections of power transformers shall comply with the requirements of IEC [TR 60616](#).

3.1.11 Power transformers to be used in industrial applications with frequency converters shall be designed, sized and manufactured in order to comply with the requirements of IEC [61378-1](#) or IEEE [STD C57.110](#).

3.1.12 Power transformers and reactors to be applied in frequency converter systems shall comply with the requirements of IEC [60146-1-3](#).

3.1.13 Transformers to be applied in offshore units shall also comply with the criteria established in IEC [61892-3](#).

3.1.14 Direct connections between power transformers and metal enclosed gas-insulated switching assemblies, for rated voltages of 72,5 kV or above, shall comply with the requirements of IEC [TS 61639](#).

3.1.15 Unless otherwise specified in Data Sheet, the power transformer shall be suited to the following cooling temperatures, according to definitions of IEC [60076-1](#):

- a) at any time: 40 °C;
- b) average of the hottest month: 35 °C;
- c) yearly average: 25 °C.

3.1.16 If the on-line monitoring and diagnosis system is required in Data Sheet, Annex A shall be used for specification of system.

3.2 Constructive Characteristics

3.2.1 Unless otherwise specified in Data Sheet, the transformer shall be able the continuous power increase of at least 25 %, with forced cooling in operation.

3.2.2 Transformer primary or secondary terminals or bushings shall be supplied with fittings, bolts, nuts and washers suitable for connection to cables or busbars indicated in Data Sheet. When the connection to a busbar trunk is specified, terminals suitable for this purpose shall be supplied, and PETROBRAS shall submit the busbar trunk drawings so that the required adjustments are made.

3.2.3 Unless otherwise specified in Data Sheet, the three-phase transformer with primary winding connected in delta and secondary winding connected in star shall have angular displacement of 30°, and the star winding voltage shall be delayed regarding the other winding (Dyn1).

3.2.4 All metallic parts (auxiliary switchboard, high and low-voltage boxes, main tank lid, etc.) shall be interconnected in the main metallic structure (tank or casing) of transformer through copper flexible cable or copper rope.

3.2.5 It shall be provided one or more fittings for grounding of metallic parts of transformer. The fitting shall be located near the bottom of transformer, and shall be suitable to bare copper cable, with nominal section defined in Data Sheet.

3.2.6 Any connection point performed through threaded input for conduit shall have NPT thread, according to ANSI/ASME [B1.20.1](#).

3.2.7 When required in Data Sheet, the cable glands for monopolar cables shall be made of non-magnetic material. The plate on which the cable gland set belonging to a same monopolar cable circuit shall be assembled shall also be made of non-magnetic material.

3.2.8 The identification plate of transformer shall be made of corrosion-resistant material, made of stainless steel AISI 300, and contain, in addition to the information required by IEC [60076-1](#), the following data:

- a) PETRÓLEO BRASILEIRO S.A - PETROBRAS;
- b) Material Requisition (RM) number;
- c) Purchase Order (PC) or Purchase Order of Goods and Services (PCS) number;
- d) as an alternative to b) and c, the contract number, in cases of purchase built in global price contract (Turn Key, Lump Sum, etc.).

NOTE 1 The data contained from a) to d) may be included in identification plate or additional plate, made of the same material of the main plate.

NOTE 2 An additional plate, made of the same material of the main one, shall be supplied with PETROBRAS identification number of the transformer.

3.2.9 Cables connected between the transformer accessories and auxiliary switchboard shall be protected against mechanical damage by using rigid or flexible metallic conduits. They shall also be compatible with the temperature expected for the places they pass through.

3.2.10 All accessories mounted on transformer, such as: Indicating instruments with contacts, sensors, relays, CTs, etc. shall have their respective control cables connected to an auxiliary switchboard located in an easy accessible position. At least 40 mm (1 1/2") NPT sleeves shall be supplied, according to ANSI/ASME [B1.20.1](#), welded on the lower part of auxiliary switchboard.

3.2.11 When there is incompatibility between different types of signs conducted by control cables, which may generate noises, more than one auxiliary switchboard shall be provided, where these compatible signs shall be grouped. Alternatively, a single auxiliary switchboard may be used, as long as segregation and shielding elements are provided, as well as proper clearances inside the switchboard, so as there is no interference between circuits.

3.2.12 Unless otherwise specified in Data Sheet, electrical contacts of accessories intended for alarm, signaling or shutting down shall be of reversible type.

3.2.13 All indicating instruments installed in transformer shall be assembled in a visible and easily accessible place, so as to allow good reading.

3.2.14 The minimum degree of protection of auxiliary switchboard and accessories provided with the transformer shall be at least IP 21 for dry transformers and IP 54 for insulating liquid-immersed transformers, according to ABNT [NBR IEC 60529](#).

3.2.15 When required in Data Sheet, the no-voltage tap changer shall comply with the requirements of IEC [60214-1](#).

3.2.16 The transformer shall be provided with lifting points.

3.3 Conditions for Transformers that also Supply Non Sinusoidal Loads

3.3.1 A transformer which load current has high harmonic content requires special care regarding the determination of its rated power and constructive characteristics, observing the recommendations of IEC [61378-1](#) or IEEE [STD C57.110](#).

NOTE According to IEC [60076-1](#), non-sinusoidal load currents with current harmonic factor above 0,05 pu are considered special working conditions, and require special care regarding the construction and determination of rated values.

3.3.2 PETROBRAS shall inform the non-sinusoidal load type and/or load harmonic content in Data Sheet.

3.3.3 Studies about the loss increase of transformers due to presence of harmonics and respective loss increase factors mentioned in IEC [61378-1](#) or IEEE [STD C57.110](#) shall be performed.

3.3.4 Transformers shall be submitted to temperature rise test, in compliance with the procedures defined in IEC [61378-1](#) or IEEE [STD C57.110](#), in addition to tests required in Data Sheet.

3.4 Protective Paint System for Installation in Industrial and Offshore Environments

3.4.1 The transformer shall be submitted to a protective paint system and constructive characteristics, so as they are suitable for installation in industrial and aggressive environments, typical in oil and petrochemical industry facilities, attacked by acid gases with sulfur compounds, including offshore facilities and facilities in environments with atmospheric corrosion by particulate material and with corrosive compounds.

3.4.2 The constructive characteristics of transformer shall have proper performance regarding the resistance to corrosion caused by environmental characteristics and/or special service conditions of the location where it shall be installed, as specified in Data Sheet.

3.4.3 Unless otherwise specified in Data Sheet, the protective paint system of transformers shall be suitable to the following corrosivity categories, according to requirements of ISO [12944-2](#):

- a) category C5-I - very high corrosivity (industrial environments);
- b) category C5-M - very high corrosivity (offshore environments).

3.4.4 Preparation of surfaces to be painted shall comply with the requirements of ISO [12944-4](#).

3.4.5 The paint system used for the transformer, including specification of paints and dry film thickness (DFT) of primers and topcoats shall comply with the requirements of ISO [12944-5](#).

3.4.6 Unless otherwise specified in Data Sheet, the required durability range and the performance evaluation of the paint system necessary to comply with requirements of corrosivity categories C5-I/C5-M specified in ISO [12944-2](#), shall comply with the M (Medium) durability requirements indicated in ISO [12944-5](#), regarding a minimum period between 5 and 15 years. For transformers to be applied offshore with corrosivity category C5-M, the applicable requirements of ISO [20340](#) shall be also complied with.

3.4.7 Performance checks of protective paint system of transformers shall be according to requirements of ISO [12944-6](#).

NOTE At least the results of adhesion (ISO [4624](#)), heaving, oxidation (rusting), cracking, scaling and corrosion tests after risk shall be presented.

3.4.8 Unless otherwise specified in Data Sheet, the final topcoat color of transformer shall be code Munsell No. 6.5.

NOTE The criteria mentioned in 3.4 apply to both transformer and their accessories (switchboards, boxes, radiators, motors, instruments, expansion tanks, etc.).

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4 Insulating Liquid-Immersed Transformers

4.1 General Characteristics

4.1.1 The temperature rise characteristics in insulating liquid-immersed power transformers shall comply with the requirements of IEC [60076-2](#).

4.1.2 Self-protected liquid-filled transformers shall be designed, sized and tested so as to comply with the requirements of IEC [60076-13](#).

4.1.3 The design and application characteristics of insulating liquid-immersed power transformers using insulating materials suitable for high temperatures shall comply with the requirements of IEC [TS 60076-14](#).

4.1.4 The general electrical, mechanical, performance requirements and test procedures for step-voltage regulators immersed in insulating liquid shall comply with IEC [60076-21](#).

4.1.5 When specified in Data Sheet, current transformers shall be of bushing-type and shall have their secondary circuits interconnected to auxiliary switchboard. If a current transformer for neutral is required, it shall be window or bushing-type, and shall have their connecting terminals interconnected to the auxiliary switchboard. Technical characteristics of supplied current transformers shall be indicated in Data Sheet.

NOTE Current transformers shall be supplied with their secondary terminals short-circuited.

4.1.6 Bushing Protection Boxes

4.1.6.1 When required in Data Sheet, bushing protection boxes of primary, secondary or both windings shall have minimum degree of protection of IP-54, according to ABNT [NBR IEC 60529](#).

4.1.6.2 Box seals and all other transformer covers shall be made from elastomer gaskets, resistant to attack by products and fumes typical of the installation site and to sunlight exposure. For dry transformers, the seals shall be made of neoprene or rubber, which shall be resistant to deformation.

4.1.6.3 Bushing protection boxes of primary and secondary windings shall have bolted closures or key locking closing. Closures shall be fitted with hinges that allow it to be opened by rotating about its vertical axis, except for boxes connected to busbar trunks, which shall have flanged inspection hole cover.

4.1.6.4 If the Data Sheet established that the transformer shall be connected to the busbar trunk, the flange of respective bushing protection box shall have compatible dimensions and holes, providing its interconnection to the busbar trunk..

4.1.6.5 Unless otherwise specified in Data Sheet, the protection box corresponding to the transformer grounded side shall have an additional 40 mm (1 1/2") NPT sleeve, according to ANSI/ASME [B1.20.1](#), welded to the bottom of the box, intended for passage of the system grounding cable. If it is a star connection, the sleeve shall be positioned under the neutral bushing.

4.1.6.6 Specific Requirements for Protection Boxes with Cable Inlet

4.1.6.6.1 Whenever the Data Sheet specifies that a given side of transformer shall be interconnected to electrical system through cables, and this side has operation voltage above 1000 V, the respective bushing protection box shall have enough space for installation of muffles or terminations for cables. Supports and internal fixing elements which may be necessary for supporting cables shall be supplied by the manufacturer of transformer. A connector shall be also supplied for grounding of the power cable shielding, which shall be located inside the bushing protection box.

4.1.6.6.2 When specified in Data Sheet, muffles or terminations for cables shall be supplied by the manufacturer of transformer, and shall be suitable for type and nominal cross-section of cables specified in Data Sheet.

4.1.6.6.3 Unless otherwise specified in Data Sheet, cable inlet into the protection box shall be made through one of the following forms, as clearly specified in Data Sheet:

- a) sleeve(s) welded to a removable flange, bolted to the protection box, intended for connection of rigid conduit, flexible conduit or cable gland; the mentioned sleeve(s) shall have NPT thread, according to ANSI/ASME [B1.20.1](#);
- b) split pipe, called halfround, with proper dimensions, intended for facilitating the cable handling during the performance of muffles or terminations;

4.1.6.6.4 The halfround or sleeve(s) connection, mentioned in 4.1.6.6.3, to the bushing protection box of transformer shall be made through a removable flanged plate which allows the removal of transformers with no need to disassemble muffles or terminations. Unless otherwise specified, power cable inlets into bushing protection boxes shall be done through the bottom part of box.

4.1.6.6.5 The halfround shall have the same degree of protection of the protection box.

4.2 Insulating Liquid Characteristics

4.2.1 Unless otherwise specified in Data Sheet, the applied mineral oil shall preferably be LUBRAX Industrial LUBRAX AV 64 IN[®]¹⁾. If the insulating mineral oil is not the one mentioned above, the manufacturer shall supply the commercial standard of the offered insulating oil, as well as their physical-chemical characteristics, which quality shall be the same or better than the specified oil.

NOTE If the use of other types of insulating oils is required, the specification shall be detailed with the specification of transformer.

4.2.2 Power transformers with insulating liquid shall comply with the requirements of sampling and analysis of free and dissolved gases of IEC [60567](#).

4.2.3 Mineral oil-filled power transformers shall the requirements of factory tests for dissolved gas analysis, specified in IEC [61181](#).

4.3 Accessories

4.3.1 The list of accessories shall contain at least the content of Table 1, below:

1) LUBRAX Industrial AV-64 IN[®] is the commercial name of a kind of naphthenic insulating oil.. This information is provided to facilitate users in the use of this standard and does not constitute a recommendation of product cited by PETROBRAS. It can be used an equivalent product, since it leads to the same result.

Table 1 - Accessories for Insulating Liquid-Immersed Transformers

Maximum operation voltage (Um)	Um ≤ 36 kV		Um > 36 kV	
Rated power (kVA)	Sn < 5000	Sn ≥ 5000	Sn < 5000	Sn ≥ 5000
External oil level gauge	X	X	X	X
Winding temperature gauge	O	X	X	X
Oil temperature gauge	X	X	X	X
Pressure relief device	X	X	X	X
Gas detector relay Buchholz-type for non-sealed transformers	X	X	X	X
Auxiliary switchboard	X	X	X	X
Oil drain valve	X	X	X	X
Oil filter connections	X	X	X	X
Oil sampling device	X	X	X	X
Oil conservator for non-sealed transformers	X	X	X	X
Respirator with air dryer, whenever there is a conservator	X	X	X	X
Oil retention valves of radiators or heat exchangers, when detachable	O	X	X	X
Tank grounding	X	X	X	X
Means of lifting of active part of fully assembled transformers, closures, oil conservators and radiators	X	X	X	X
Fastening	X	X	X	X
Supports for jacks	X	X	X	X
Inspection hole	X	X	X	X
No-voltage tap changer	O	O	O	O
On-load tap changer			O	O
Sudden pressure relay for sealed transformers	X			
Forced ventilation system	O	O	O	O
Oil circulation gauges for forced circulation cooling				X
On-Line Monitoring and Diagnosis System				O
Caption: (X) - Mandatory; (O) - Optional (Shall be defined in specification).				

4.3.2 Sealing elements of auxiliary switchboard and accessories shall comply with the description in 4.1.6.2.

4.3.3 When required in Data Sheet, the pressure relief device shall be of a type that recovers its original operational condition automatically, using springs, after an internal overpressure in transformer, instead of devices designed to break.

NOTE 1 At least one auxiliary contact indicating the pressure relief device actuation shall be provided.

NOTE 2 It shall be provided, around the relief device, an oil or gas flow drive to the side of the transformer.

4.4 Transformers with Voltage Class of 36 kV or Below

Unless otherwise specified in Data Sheet, the transformer shall have at least four taps in the high voltage winding, besides the main one, corresponding to 2 x 2,5 %, which allow to reach rated power. If the number or range of taps specified in Data Sheet exceeds the value above, it shall be possible to reach rated power in any of the specified taps.

4.5 Transformers with Voltage Class Above 36 kV

4.5.1 The designation of transformer connection shall comply with the design characteristics and, if applicable, the requirements of electric utility company.

4.5.2 The minimum efficiency required for transformers, according to rated power in the last cooling stage (S_n) and the unity power factor, shall comply with the information below:

- a) $5 < S_n < 30$ MVA: 99,30 %;
- b) $30 \leq S_n < 50$ MVA: 99,40 %;
- c) $50 \leq S_n < 100$ MVA: 99,50 %;
- d) $100 \leq S_n < 200$ MVA: 99,60 %;
- e) $S_n \geq 200$ MVA: 99,70 %.

4.5.3 Local Control and Supervision System

4.5.3.1 The local control and supervision system of power transformer comprises the IED or the set of integrated IED responsible for perform all monitoring and control of on-load commutator system (see 4.5.4), of forced ventilation system, of temperature acquisition system, and the trip and alarm event acquisition system of transformer intrinsic protections.

4.5.3.2 All this system and their IED shall allow, both locally and remotely via communication network, the performance of the following functions:

- a) temperature monitoring and forced ventilation system:
 - monitoring of temperature variables;
 - monitoring of all events related to forced ventilation control;
 - selection of ventilation operation for local level, via front keypad of IED or for remote level via receiving commands through communication network;
 - selection of ventilation operation for manual or automatic conditions;
 - send commands to turn the forced ventilation on and off;
- b) transformer intrinsic protection and alarm system:
 - monitoring of alarm events;
 - monitoring of trip events;

4.5.3.3 The availability of control and supervision resources of transformer for control room shall be via communication network, in protocol IEC [61850](#).

4.5.4 On-Load Tap Changer (OLTC)

4.5.4.1 When required in Data Sheet, the OLTC shall comply with the requirements of IEC [60214-1](#), as well as other requirements contained in technical specification of the transformer.

4.5.4.2 The OLTC shall have local/remote and manual/automatic command switch.

4.5.4.3 The OLTC shall have resources for parallel operation, allowing master/slave and individual operations.

4.5.4.4 The OLTC shall be built with changer technology in insulating liquid-immersed vacuum bulb.

4.5.4.5 The OLTC contacts shall withstand at least 600,000 operations in full load, and 300,000 operations for the maintenance interval.

4.5.4.6 The OLTC shall have IED installed with the transformer, responsible for local control and monitoring function (ANSI 90 function).

4.5.4.7 OLTC Monitoring and Control Requirements:

- a) the IED shall comply with the requirements of protocol IEC 61850 for interfacing with electrical automation system;
- b) have inlets for tap position, line voltage and load current measurements;
- c) have local tap gauge and automatic/manual control of OLTC through front switchboard;
- d) have OLTC operations counter.

5 Dry Transformers

5.1 Dry power transformers shall be designed, sized and tested so as to comply with the requirements of IEC 60076-11.

5.2 Unless otherwise specified in Data Sheet, the transformer shall have at least four taps in the high voltage winding, besides the main one, corresponding to $\pm 2 \times 2,5 \%$, which allow reaching rated power. If the number or range of taps specified in Data Sheet exceeds the value above, it shall be possible to reach rated power in any of the specified taps.

5.3 When required in Data Sheet, the dry transformer for outdoor installation shall be installed inside a metallic box, with characteristics specified in Data Sheet. For indoor installation, it is allowed degree of protection IP00 with protection screen.

NOTE Occasional restrictions from classification societies for offshore installations shall be observed.

5.4 When the material used in encapsulation is resin, it shall be flame retardant, self-extinguishable and have low toxic gas emission content, according to IEC 60076-11.

5.5 Whenever there are copper-aluminum connections, these connections shall be encapsulated, or a bimetallic connector shall be used.

5.6 The core tie-down shall be designed so as to allow easy disassembling for replacement of windings at the installation site.

5.7 When single cables are used, fixing devices shall be built with non-magnetic material.

5.8 Unless otherwise specified, transformer shall be classified as C1 regarding climatic class, E2 regarding environmental class, and F1 regarding fire behavior, as per IEC 60076-11.

5.9 Transformers shall be supplied with a phase temperature sensor, located in direct contact with low voltage winding, in the hottest spot. If not specified in Data Sheet, sensors shall be of Pt100 type.

5.10 The list of accessories shall contain at least the content below:

- a) winding temperature gauge and controller;
- b) auxiliary switchboard;
- c) enclosure grounding, which shall be identified;
- d) fastening;
- e) support for jacks, which shall be identified;
- f) suspension of fully assembled transformer;
- g) suspension for active part;
- h) no-voltage tap changer.

6 Requirements for Inspection, Factory Acceptance Test (TAF), Field Acceptance Test (TAC) and Test and Inspection Plan of Power Transformers

6.1 Inspection, TAF and TAC of power transformers shall check at least the definitions below. For power transformers for offshore installation, the tests required by the respective Classification Society shall be also performed.

6.2 The transformer manufacturer shall present the PIT, after placing the Purchase Order (PC) with the documentation for approval, listing all routine, type and special tests that will be performed in factory (TAF), and also the tests to be performed in field (TAC), complying with the requirements of this Standard and in Data Sheet of the transformer.

6.2.1 The PIT shall indicate, with each routine, type or special test, the respective applicable Technical Standards, as well as the respective criteria and maximum and minimum acceptance ranges of each measurement to be taken during tests.

6.2.2 Before inspection, the PIT shall be approved by PETROBRAS.

6.3 It shall be checked if there is technical documentation about supplying, certified by the manufacturer and approved by PETROBRAS or by the responsible designer (including drawings, diagrams, manuals, certificates and accessory catalogs).

6.4 It shall be checked if there are certificates of calibration of instruments to be used in tests, issued by competent bodies, such as the Brazilian Calibration Network (RBC) in Brazil, or its equivalent abroad, and within their validity periods.

6.5 It shall be checked the dimensional characteristics of equipment, such as inner spaces of power terminal boxes, of auxiliary switchboard, and of bushing protection boxes, as well as their internals.

6.6 Accessories, components and auxiliary devices of transformer shall be checked.

6.7 Tests to be performed on transformer or evidenced by test reports shall be performed according to the standards specified in Data Sheet.

6.8 Tests of protective paint systems of transformer (housing, closures, radiators, auxiliary systems, accessories, etc.) shall be checked, according to the procedure specified in this Standard. This paint procedure check shall be performed in manufacturing inspection, based on analysis of paint test reports, issued by a qualified paint inspector, during the manufacturing process and stages before painting the transformer, its accessories and auxiliary systems.

6.9 Type tests required in Data Sheet shall be performed in a transformer produced from each set of identical transformers, to be defined by PETROBRAS.

6.10 Special tests required in Data Sheet shall be performed in all transformers.

6.11 When required in Data Sheet, it shall be accepted reports of certified tests performed in identical transformers, approved and witnessed by PETROBRAS.

7 Technical Documentation to be Submitted by the Manufacturer

7.1 General Requirements

7.1.1 The manufacturer shall define, when filling out the Data Sheet, other standards IEC also applied to supplying, in addition to those listed in Section 2. In case of conflicts, the requirements of standards explicitly mentioned in Section 2 shall prevail.

7.1.2 The Data Sheet of transformer is partially filled out and issued by PETROBRAS, and the manufacturer shall complete its filling. For each transformer identification number, there is a Data Sheet, which receives a specific identification for that application. The (blank) form used for issuance of Data Sheet of transformer is standardized in the Annexes.

7.1.3 Whenever there are discrepancies between the Data Sheet prepared by PETROBRAS and this Standard, the information contained in the former shall prevail.

7.2 Technical Documentation to be Submitted Together with the Bid

The technical documentation to be submitted with the bid shall contain, at least, the following information:

- a) preliminary drawing, containing main sizes of the transformer and its accessories;
- b) approximate weight of complete transformer;
- c) Data Sheet duly filled in and authenticated by supplier;
- d) initial magnetization current value of the transformer versus decrease time;
- e) catalogs containing all information and technical characteristics of protective, command, and signaling elements, as well as all other accessories required in Data Sheet;
- f) trade mark of insulating liquid offered, as well as its physical-chemical characteristics and reference standard, for insulating liquid-immersed transformers;
- g) list of technical standards applicable to this supply complementing the list in Section 2;
- h) specification of protective paint systems to be applied in all transformer components, as well as the respective test result reports (according to the requirements of ISO 12944 series);
- i) list of required spare parts, as per criterion defined in RM;
- j) list of type and special tests, when required in Data Sheet;
- k) time x current value in which windings withstand with no damage;
- l) thermal load generated by transformer at rated power and with additional power regarding the use for forced cooling, for dry transformers;
- m) transformer oversizing study, as per 3.3.3, if applicable;
- n) list of deviations of proposed transformer related to PETROBRAS' specification. Such deviations shall be evaluated by PETROBRAS.

7.3 Technical Documentation to be Submitted After the Purchase Order Placement

7.3.1 The technical documentation to be sent after purchase order placement shall be submitted for approval after the transformer purchase is performed.

NOTE Documents shall consider the bid information, with the technical clarifications supplied by the manufacturer, during the technical report.

7.3.2 The documents to be submitted shall contain at least the following information:

- a) transformer layout drawing, containing general sizes, views, constructive details, winding connection scheme, assembly schemes, and list of components;
- b) partial and total weight of transformer;
- c) location and details of bushing protection boxes;
- d) location, specifications and drawings of terminal bushings and their connectors;
- e) location and installation details of accessories and auxiliary equipment;
- f) location and details of auxiliary switchboard, indicating the internal layout of blocks;
- g) location and details of accessories for cable inlet, such as: halfround, threaded sleeves, etc.;
- h) location and sizing and constructive details of flanges;
- i) location and sizes of casing grounding terminals;
- j) location and details of transformer support, hoisting and fastening systems;
- k) control and interconnection diagrams;
- l) diagram and name plates;
- m) initial magnetization current value of the transformer;
- n) dimensional drawings, information sheet and current transformers saturation curves, if required in Data Sheet;
- o) dimensional drawings and technical characteristics of lightning arresters, if required in Data Sheet;
- p) complete documentation regarding the on-load tap changer and its accessories, if this device is required in Data Sheet;
- q) complete documentation regarding all transformer accessories, including dimensional drawings, technical specifications, operation descriptions, instructions for adjustment, electrical and interconnecting diagrams, etc.;
- r) Data Sheet with all items filled out, containing revisions resulting from the technical opinion;
- s) Inspection and Test Plan.

7.4 Transport, Preservation, Installation, Operation, Inspection, Maintenance and Repair Manuals

After final approval of all technical documentation established in 7.3, transformer manuals shall be supplied, containing, at least, the following information:

- a) Data Sheet duly filled out, containing "as built" transformer data;
- b) all documents certificated, supplied and listed in 7.3, as well as other complementary documents that the manufacturer deems necessary;
- c) storage and packing procedures for transformer, accessories supplied apart, as well as for spare parts;
- d) handling and transport procedures;
- e) assembly procedures;
- f) energizing procedures;
- g) operating procedures;
- h) preventive and corrective maintenance procedures for transformer, as well as for all the required accessories;
- i) detailed technical catalogs, containing technical information of all supplied accessories;
- j) result of all tests to which transformer was submitted during and after the manufacturing phase;
- k) results of all field tests and inspections.

Annex A - Power Transformer On-Line Monitoring and Diagnosis System

A.1 The main objectives of the on-line monitoring and diagnosis system to be supplied are the diagnosis and prognosis of power transformer status, reducing the failure risk, increasing the service life, and reducing the maintenance costs of these assets.

A.2 The monitoring and diagnosis system shall use an architecture comprising data acquisition, IED, data communication network and monitoring and diagnosis software.

A.3 Specification of Software Requirements for Monitoring and Diagnosis System

The monitoring and diagnosis software shall perform the following main functions:

- a) data communication with IED for on-line acquisition of measurements;
- b) storage of measurements in historical database, with configurable interval;
- c) treatment and crossing of measurements with engineering algorithms, to obtain useful information for diagnosis and prognosis of equipment status;
- d) generate diagnoses and prognoses of equipment status and suggest recommended actions;
- e) send automatic warnings to users in case of alarm conditions;
- f) enable multi-user access, with no simultaneous access limit;
- g) allow users to access remotely IED measurements, engineering algorithm information and diagnoses, prognoses and recommended actions, both online and stored in database;
- h) have open databases to users. The full ER (entity-relationship) model of all databases shall be provided;
- i) allow future expansion through interconnection of new sensors in the transformer already monitored;
- j) have a specialized system for generation of diagnoses, prognoses and recommended actions when alarm conditions are detected, using a rules-based system which shall be submitted to PETROBRAS' approval, containing at least the following functions:
 - diagnosis: indication of potential causes for alarm condition, obtained from processing the IED measurements and results of engineering algorithms, using the rules-based system;
 - prognosis: indication of possible consequences of evolution of diagnosed defect if no corrective action is taken;
 - suggested actions: indication of corrective actions for correction, neutralization or reduction of consequences of diagnosed defect.

A.4 Performance and Test Characteristics of IED to be Supplied with the Power Transformer

A.4.1 IED shall be designed, built and tested specifically for use in adverse conditions of switchyards, so as to withstand, with no damage, the performance of dielectric tests in transformer and/or bushings (applied voltage, impulse voltage, etc.) with IED fully installed and connected to transformer.

A.4.2 See IEC 60068-1, IEC 60068-2-14, IEC 61000-4-3, IEC 61000-4-4, IEC 61000-4-5 and IEC 61000-4-6 requirements to meet the proper functioning and reliability of the data generated and transmitted.

A.4.3 Be installed with appropriate protection to the installation location.

A.4.4 The supplier shall submit documentation proving that the IED is tested in this condition in transformer tests with 230 kV voltage level.

A.4.5 It shall withstand the maximum industrial class operation temperature of 85 °C, according to IEC [60068-2-14](#).

A.4.6 It shall have non-volatile internal memory for local storage of measurements and events.

A.4.7 It shall be able to receive electrical feed in 90 Vac/Vdc to 240 Vac/Vdc range.

A.5 On-line Monitoring and Diagnosis System to be Installed in Power Transformers

When the on-line monitoring and diagnosis system is required, the transformer shall be supplied with required sensors, according to the Data Sheet, applicable to all following functions:

- a) monitoring and diagnosis of bushings with voltage class of 145 kV or above;
- b) thermal monitoring and diagnosis of transformer;
- c) monitoring and diagnosis of gas and humidity dissolved in oil;
- d) monitoring and diagnosis of breaking of expansion tank membrane and pocket;
- e) monitoring and diagnosis of on-load tap changer (OLTC);

A.6 Technical Characteristics and Functions of Monitoring and Diagnosis System

A.6.1 Monitoring and diagnosis of bushings:

- a) ability to perform monitoring, diagnosis, and insulation diagnosis of bushings with voltage class of 145 kV or above;
- b) indication of three-phase phase-ground and phase-phase voltages, calculated based on measured leakage currents and bushing capacitance;
- c) simultaneous automatic adjustment of capacitance and tan delta alarms for all bushings, to facilitate commissioning;
- d) calculation of capacitance (pF/day) and tan delta (%/day) evolution trends, with extrapolation of remaining time for reaching alarm levels, in days;
- e) alarms for high capacitance and tan delta evolution trends if the number of remaining days for alarm is smaller than the programmed limit;
- f) alarms for leakage currents from high or very high bushings, with adjustable timing;
- g) calculation of capacitance variations of main bushing insulation, with maximum error of $\pm 0,5$ % of measurement;
- h) calculation of tan delta variations of main bushing insulation, with maximum error of $\pm 0,5$ % in absolute value;

A.6.2 Monitoring and diagnosis of OLTC:

- a) current measurements through window clip-on tap changes with disconnected core, facilitating installation and maintenance;
- b) oscillography of currents, voltages and power consumed by the engine during operations;
- c) weight memory for storage of oscillographies of, at least, the last 40 OLTC operations;
- d) monitoring and diagnosis of energy spent by the engine during operation, setting off alarms when high or low energy is used;
- e) calculation of changer engine torque signature during operation, comparing it to typical changer signature, setting off alarms when signatures are under or above the typical ones;
- f) function of automatic learning of typical changer torque signature, not requiring manual programming of typical signature;
- g) check of engine start-up current, setting off alarms due to high current;
- h) signature of typical time for changer operation, setting off alarms for long or short time;
- i) record of minimum and maximum engine voltages during change, setting off alarms for high or low voltages.

A.6.3 Monitoring and diagnosis of hydrogen and humidity in oil tank of transformer:

- a) measurement of hydrogen concentration dissolved in oil;
- b) measurement of relative saturation of water in oil, from 0 % to 100 %, and associated oil temperature;
- c) calculation of water content dissolved in insulating oil in ppm, converted at 20 °C, with solubility constants of water in oil programed by the user;
- d) calculation of relative saturation, converted for a reference temperature programed by the user;
- e) calculation of hydrogen concentration and water content evolution trends, in ppm/day, with extrapolation of remaining time in days to reach alarm levels;
- f) the hydrogen measurement shall not be influenced by other gases existing in oil, including carbon monoxide, methane and others, in order to avoid that high levels of other gases hide elevations in H₂ concentration.

A.6.4 Monitoring and diagnosis of expansion tank membrane:


- a) Each transformer shall be supplied with a supervision system for integrity of rubber/neoprene pocket or membrane from oil expansion tank of transformer;
- b) the system shall consist of one or more sensors installed in the membrane or pocket, on the side with contact with air;
- c) sensors shall be connected to the respective supervision relays, installed in the local switchboard of transformer;
- d) each relay shall have an alarm contact, to be actuated if the pocket or membrane breaks, when the oil touches the sensor.


A.6.5 Monitoring and diagnosis of oil temperature of transformer and of OLTC:

- a) monitoring and diagnosis of oil temperature of one, two or three windings;
- b) for self-calibrated inlets for Pt100-type sensors, two in each temperature IED, being 2 for redundant measurement of oil from transformer, 1 for oil from OLTC, and 1 back-up (room temperature and others);
- c) three inlets for load current measurement, with external clip-on tap changer, 0-10 A range;
- d) calculation of temperature of hot-spot of three windings.

A.6.6 Monitoring and diagnosis of humidity:


- a) the objective is to preserve charger oil characteristics by detecting and monitoring the oil contamination by humidity, avoiding a faster aging;
- b) connection inlet for Pt100-type room temperature sensor;
- c) calculation of relative saturation of water in oil, converted for a reference temperature programed by the user;
- d) calculation of relative saturation of water in oil, converted for room temperature;
- e) calculation of water content dissolved in oil, in ppm;
- f) calculation of evolution trend of water content in oil, in ppm/day;
- g) remote sensor, installed in contact with oil, able to withstand, with no damage, full vacuum and positive pressure of 0,1 MPa in connection to oil;
- h) measurement of relative saturation of water in oil, from 0 % to 100 %, and associated oil temperature.


		DATA SHEET				Nº				REV.	
		TITLE: Insulating Liquid-Immersed Power Transformer Voltage Class above 36 kV								SHEET 02 of 06	
1	BASIC INFORMATION				5.6.1.5	13		21		29	
					5.6.1.6	14		22		30	
1.1	PETROBRAS IDENTIFICATION (TAG) TF-				5.0.1.7	15		23		31	
					5.6.1.6	16		24		32	
12	MANUFACTURER				5.6.1.9	17		25		33	
					5.6.1.10	18		26		34	
13	YEAR OF MANUFACTURE				5.6.1.11	19		27		35	
					5.6.1.12	20		28		36	
14	MODEL				6	NO-LOAD CURRENT AND LOSSES					
15	SERIAL No.				6.1	EXCITATION CURRENT (SEE NOTE 5)					A
2	ENVIRONMENTAL CHARACTERISTICS				6.2	STARTING EXCITATION CURRENT					A
2.1	INDOOR INSTALLATION				6.3	REFERENCE TEMPERATURE					°C
22	COOLANT TEMPERATURE (SEE NOTE 1) 40 °C / 35 °C / 25 °C				6.4	NO-LOAD LOSSES (T _{REF})					W
2.3	ALTITUDE < 1000 m				6.5	ON-LOAD LOSSES (T _{REF})					W
3	BASIC CHARACTERISTICS				7	EFFICIENCY (%)					
3.1	CONSTRUCTIVE FORM					% LOAD		POWER FACT. = 1.0		POWER FACT. = 0.8	
3.2	WINDING TEMPERATURE RISE 55				7.1	100					
3.3	WINDING INSULATION THERMAL CLASS F				7.2	75					
34	INSULATING LIQUID TEMPERATURE RISE 55				7.3	50					
3.5	INSULATING LIQUID MINERAL OIL				7.4	25					
3.6	BRAND NAME LUBRAX AV-64 IN @				8	REGULATION (%)					
3.7	ACCESSIBLE NEUTRAL YES					% LOAD		POWER FACT. = 1.0		POWER FACT. = 0.6	
3.8	GROUNDING TYPE RESISTOR				8.1	100					
3.9	TOPCOAT COLOR Light gray - Munsel N 6.5				8.2	75					
3.10	TOTAL WEIGHT kg				3.3	50					
3.11	ACTIVE PART WEIGHT kg				8.4	25					
3.12	ACCESSORIES AND TANK WEIGHT kg				9	MAXIMUM VOLTAGES (INSULATION LEVELS)					
3.13	INSULATING LIQUID WEIGHT kg				9.1	PRIMARY					kV
3.14	INSULATING LIQUID VOLUME l				9.2	SECONDARY					kV
					9.3	TERTIARY					kV
					10	RATED WITHSTAND VOLTAGES					
4	RATED POWERS, VOLTAGES AND CURRENTS					TERMINAL	LIGHTNING IMPULSE (kV PEAK)		AT INDUSTRIAL FREQUENCY (kV EFFECTIVE)		
	TERMINAL	VOLTAGE (kV)	RATED POWER (kVA)		RATED CURR. (A)						
			NAT COOL.	FOR. COOL.	NAT COOL.	FOR. COOL.			FULL	CUT	
4.1	PRIM.						10.1	PRIMARY			
4.2	SEC						10.2	SECONDARY			
4.3	TERT.						10.3	TERTIARY			
4.4	NUMBER OF PHASES				10.4	NEUTRAL					
4.5	RATED FREQUENCY 60 Hz				11	SHORT-CIRCUIT IMPEDANCE					
5	WINDING CONNECTIONS					VOLTAGE RATIO (V)		Z% (T _{REF})			
5.1	TYPE Dyn1				11.1	PRIM-SEC					
5.2	POLARITY SUBTRACTIVE				11.2	PRIM-TERT					
5.3	PRIMARY D				113	SEC-TERT					
54	SECONDARY Y				12	MAXIMUM WITHSTAND SHORT-CIRCUIT CURRENT					
5.5	TERTIARY					TERMINAL	SYMMETRIC		ASYMMETRIC (kA)		
5.6	ON-LOAD TAP CHANGER						I (kA)	TIME (S)			
5.6.1	TAP	VOLTAGE (V)	TAP	VOLTAGE (V)	TAP	VOLTAGE (V)	12.1	PRIMARY			
5.6.1.1	1		5		9		12.2	SECONDARY			
5.6.1.2	2		6		10						
5.6.1.3	3		7		11		12.3	TERTIARY			
5.6.1.4	4		8		12						
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		DATA SHEET		Nº		REV.	
		TITLE: Insulating Liquid-Immersed Power Transformer Voltage Class above 36 kV				SHEET 03 of 06	
13	PRIMARY SIDE TERMINALS		17.2.4	DEGREE OF PROTECTION		IP 5 4	
13.1	QUANTITY		17.2.5	PLATE THICKNESS		mm	
13.2	SUPPLYING OF CONNECTOR FOR		18	TERMINAL PROTECTION BOX INLETS			
13.2.1	CABLE <input type="checkbox"/>	18.1		PRIMARY	HALFROUND (mm)	CONDUIT SLEEVE (mm)	QTY.
13.2.1.1	NOMINAL SECTION (mm ²)						
13.2.1.2	TYPE OF CABLE						
13.2.1.3	TERMINATION (INCLUDED IN SUPPLYING) YES	18.2	SECONDARY				
13.2.2	BUSBAR TRUNK <input type="checkbox"/>	13.3	TERTIARY				
13.2.2.1	BAR MATERIAL		18.4	CABLE GLAND (INCLUDED IN SUPPLYING) YES			
13.2.2.2	BAR DIMENSIONS (mm x mm x mm)		19	GROUNDING			
14	SECONDARY SIDE TERMINALS		19.1	HOUSING GROUND CONNECTOR		YES	
14.1	QUANTITY		19.2	FOR CABLE YES	QUANTITY		
14.2	SUPPLYING OF CONNECTOR FOR		19.3	FOR PLATE NO	QUANTITY		
14.2.1	CABLE <input type="checkbox"/>	20	FORCED COOLING EQUIPMENT				
14.2.1.1	NOMINAL SECTION (mm ²)		20.1	COOLING METHOD DESIGNATION			
14.2.1.2	TYPE OF CABLE		20.2	LOAD ADDITION WITH COOLING			
14.2.1.3	TERMINATION (INCLUDED IN SUPPLYING) YES		20.3	NUMBER OF VENTILATORS			
14.2.2	BUSBAR TRUNK <input type="checkbox"/>	20.4	AIR FLOW PER VENTILATOR m ³ /h				
14.2.2.1	BAR MATERIAL		20.5	VENTILATOR ROTATION rpm			
14.2.2.2	BAR DIMENSIONS (mm x mm x mm)		20.6	POWER OF EACH MOTOR kW			
15	TERTIARY SIDE TERMINALS		20.7	RATED VOLTAGE V			
15.1	QUANTITY		20.8	No. OF PHASES			
15.2	SUPPLYING OF CONNECTOR FOR		21	WINDING TEMPERATURE DEVICE		YES	
15.2.1	CABLE <input type="checkbox"/>	21.1	TEMPERATURE SENSOR				
15.2.1.1	NOMINAL SECTION (mm ²)		21.2	LOCAL TEMPERATURE GAUGE			
15.2.1.2	TYPE OF CABLE		21.3	REMOTE GAUGE SIGNAL 4 mA to 20 mA			
15.2.1.3	TERMINATION (INCLUDED IN SUPPLYING) YES		22	MOVEMENT			
15.2.2	BUSBAR TRUNK <input type="checkbox"/>	22.1	SUSPENSION		YES		
15.2.2.1	BAR MATERIAL		22.2	LOCOMOTION		STEERABLE WHEELS	
15.2.2.2	BAR DIMENSIONS (mm x mm x mm)		22.3	SUPPORTS FOR JACKS		YES	
16	NEUTRAL TERMINALS		23	INFORMATION ON NON-LINEAR LOADS			
16.1	QUANTITY		23.1	TYPE OF LOAD			
16.2	SUPPLYING OF CONNECTOR FOR		23.1.1	RECTIFIER		<input type="checkbox"/>	
16.2.1	CABLE <input type="checkbox"/>	23.1.1.1	POWER		kVA		
16.2.1.1	NOMINAL SECTION (mm ²)		23.1.1.2	No. OF PULSES			
16.2.1.2	TYPE OF CABLE		23.1.2	VOLTAGE SOURCE CONVERTER		<input type="checkbox"/>	
16.2.1.3	TERMINATION (INCLUDED IN SUPPLYING) YES		23.1.2.2	POWER		kVA	
17	ENCLOSURES AND BOXES		23.1.3	CURRENT SOURCE CONVERTER		<input type="checkbox"/>	
17.1	TRANSFORMER ENCLOSURE		23.1.3.2	POWER		kVA	
17.1.1	DEGREE OF PROTECTION IP 5 4		23.2	HARMONIC DISTRIBUTION OF CURRENT ATTACHED TO FD		<input type="checkbox"/>	
17.1.2	PLATE THICKNESS mm		23.3	OVERSIZING FACTOR			
17.2	TERMINAL PROTECTION BOX		24	OPTIONAL SYSTEMS			
17.2.1	PRIMARY		24.1	ON-LINE MONITORING AND DIAGNOSIS SYSTEM		NO	
17.2.2	SECONDARY		24.2				
17.2.3	TERTIARY		24.3				


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	DATA SHEET		Nº		REV.	
					SHEET 05 of 06	
	TITLE: Insulating Liquid-Immersed Power Transformer Voltage Class above 36 kV					
INSPECTION LIST AND TESTS TO BE PERFORMED / EVIDENCED						
INSPECTION AND TESTS		TAF			TAC	TEST PROCEDURE
		T	w	R		
29	VERIFICATION OF THE TECHNICAL DOCUMENTATION CERTIFIED BY THE MANUFACTURER	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	PETROBRAS NI-2928
30	VERIFICATION OF THE CALIBRATION CERTIFICATES OF TEST INSTRUMENTS	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PETROBRAS NI-2928
31	VISUAL INSPECTION AND VERIFICATION OF THE RATING PLATE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	PETROBRAS NI-2928
32	VERIFICATION OF THE PROTECTIVE PAINT SYSTEM (PERFORMANCE, ADHESION, CORROSION, COLOR)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO 12944-1, ISO 12944-2, ISO 12944-3, 12944-4, ISO 12944-5, ISO 12944-6, ISO-12944-7, ISO 20340 AND PETROBRAS NI-2928
33	DIMENSIONAL INSPECTION	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ACCORDING TO MANUFACTURER'S CERTIFIED DOCUMENTATION
34	VERIFICATION OF THE INTERNAL SPACE AND THE COMPONENTS OF POWER AND CONTROL TERMINAL BOXES	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ACCORDING TO MANUFACTURER'S CERTIFIED DOCUMENTATION
35	VERIFICATION OF THE DEGREE OF PROTECTION OF THE ENCLOSURES (IP CODE)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ABNT NBR IEC 60529
36	WINDING RESISTANCE (IN ALL TAPS)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IEC 60076-1
37	TRANSFORMATION RATIO (IN ALL TAPS)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IEC 60076-1
38	INSULATION RESISTANCE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IEC 60076-1
39	POLARITY	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1
40	ANGLE DISPLACEMENT AND SEQUENCE OF PHASES	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1
41	SHORT-CIRCUIT AND LOAD LOSS IMPEDANCE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1
42	NO-LOAD LOSSES AND EXCITATION CURRENT	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1
43	RATED WITHSTAND VOLTAGE AT INDUSTRIAL FREQUENCY	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1 IEC 60076-3
44	INDUCED VOLTAGE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-3
45	VERIFICATION OF OPERATION OF ACCESSORIES AND ON-LOAD TAP CHANGER (IF APPLICABLE)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
46	DISSIPATION FACTOR (TG DELTA) OF INSULATION AND CONDENSER BUSHINGS	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IEC 60076-1
47	TEMPERATURE RISE TEST (SEE NOTE 5)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-2
48	RATED WITHSTAND VOLTAGE OF LIGHTNING IMPULSE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-4
49	AUDIBLE NOISE LEVEL	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	IEC 60076-10
50	RADIOINTERFERENCE VOLTAGE LEVEL	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	IEEE C57.12.90
51	SHORT-CIRCUIT WITHSTAND	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	IEC 60076-5
52	POWER ABSORBED BY VENTILATOR MOTORS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
53	ZERO SEQUENCE IMPEDANCE IN THREE-PHASE TRANSFORMERS	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1
54	EXCITATION CURRENT HARMONICS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1
55	RESPONSE IN TERMINAL FREQUENCY AND IMPEDANCE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
56	CAPACITANCES BETWEEN WINDING AND GROUND AND BETWEEN WINDINGS	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
57	TRANSFERRED TRANSIENT VOLTAGE CHARACTERISTICS	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-3
58	INSULATING OIL TESTS (DIELECTRIC STIFFNESS, WATER CONTENT, LOSS FACTOR, INTERFACE VOLTAGE, NEUTRALIZATION INDEX)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	ASTM D971, ASTM D974, IEC 60614, ABNT NBR IEC 60156, IEC 60247, AND ASTM D924
59	CHROMATOGRAPHIC ANALYSIS OF GASES DISSOLVED IN INSULATING OIL	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IEC 60599
60	DEW POINT	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
61	PAPER POLYMERIZATION DEGREE	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ABNT NBR IEC 60450
62	TIGHTNESS AND RESISTANCE TO PRESSURE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1
63	INTERNAL VACUUM	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1
64		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
65		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
66		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
CAPTION: T - TEST TO BE EFFECTIVELY PERFORMED IN TRANSFORMER TO BE SUPPLIED. W - TEST WITNESSED BY AN INSPECTOR FROM PETROBRAS OR FROM COMPANY ASSIGNED BY PETROBRAS. PRESENTATION OF REPORT OF EQUIVALENT R - TRANSFORMER TYPE (SAME VOLTAGE, FREQUENCY, POWER).						
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FORM OWNED TO PETROBRAS N-2928 REV. 0 ANNEX B - SHEET 05/06.						

		DATA SHEET						Nº		REV.			
		TITLE: Insulating Liquid-Immersed Power Transformer Voltage Class above 36 kV								SHEET 01 of 06			
1	BASIC INFORMATION						5.6.1.5	13		21		29	
							5.6.1.6	14		22		30	
1.1	PETROBRAS IDENTIFICATION (TAG) TF-						5.6.1.7	15		23		31	
							5.6.1.8	10		24		32	
1.2	MANUFACTURER						5.6.1.9	17		25		33	
							5.6.1.10	16		26		34	
1.3	YEAR OF MANUFACTURE						5.6.1.11	19		27		35	
							5.6.1.12	20		26		36	
1.4	MODEL						6	NO-LOAD CURRENT AND LOSSES					
1.5	SERIAL No.						6.1	EXCITATION CURRENT (SEE NOTE 6) A					
2	ENVIRONMENTAL CHARACTERISTICS						6.2	STARTING EXCITATION CURRENT A					
2.1	INSTALLATION INTERNAL						6.3	REFERENCE TEMPERATURE °C					
2.2	COOLANT TEMPERATURE (SEE NOTE 1) 40 °C / 35 °C / 25 °C						6.4	NO-LOAD LOSSES (T _{REF}) W					
2.3	ALTITUDE <1000 m						6.5	ON-LOAD LOSSES (T _{REF}) W					
3	BASIC CHARACTERISTICS						7	EFFICIENCY (%)					
3.1	CONSTRUCTIVE FORM							% LOAD	POWER FACT. = 1.0		POWER FACT. = 0.6		
3.2	WINDING TEMPERATURE RISE 55						7.1	100					
3.3	WINDING INSULATION THERMAL CLASS F						7.2	75					
3.4	INSULATING LIQUID TEMPERATURE RISE 55						7.3	50					
3.5	INSULATING LIQUID MINERAL OIL						7.4	25					
3.6	BRAND NAME LUBRAX AV-64 IN @						8	REGULATION (%)					
3.7	ACCESSIBLE NEUTRAL YES							% LOAD	POWER FACT. = 1.0		POWER FACT. = 0.8		
3.8	GROUNDING TYPE RESISTOR						8.1	100					
3.9	TOP COAT COLOR Light gray - Munsel N 6.5						8.2	75					
3.10	TOTAL WEIGHT kg						8.3	50					
3.11	ACTIVE PART WEIGHT kg						8.4	25					
3.12	ACCESSORIES AND TANK WEIGHT kg						9	MAXIMUM VOLTAGES (INSULATION LEVELS)					
3.13	INSULATING LIQUID WEIGHT kg						9.1	PRIMARY kV					
3.14	INSULATING LIQUID VOLUME l						9.2	SECONDARY kV					
							9.3	TERTIARY kV					
4	RATED POWERS, VOLTAGES AND CURRENTS						10	RATED WITHSTAND VOLTAGES					
	TERMINAL	VOLTAGE (kV)	RATED POWER (kVA)		RATED CURR. (A)			TERMINAL	LIGHTNING IMPULSE (kV PEAK)		AT INDUSTRIAL FREQUENCY (kV EFFECTIVE)		
			NAT COOL.	FOR. COOL.	NAT COOL.	FOR. COOL.			FULL	CUT			
4.1	PRIM.						10.1	PRIMARY					
4.2	SEC						10.2	SECONDARY					
4.3	TERT.						10.3	TERTIARY					
4.4	NUMBER OF PHASES						10.4	NEUTRAL					
4.5	RATED FREQUENCY 60 Hz						11	SHORT-CIRCUIT IMPEDANCE					
5	WINDING CONNECTIONS							VOLTAGE RATIO (V)		Z 14 (T _{REF})			
5.1	TYPE Dyn1						11.1	PRIM-SEC					
5.2	POLARITY SUBTRACTIVE						11.2	PRIM-TERT					
5.3	PRIMARY D						11.3	SEC-TERT					
5.4	SECONDARY Y						12	MAXIMUM WITHSTAND SHORT-CIRCUIT CURRENT					
5.5	TERTIARY							TERMINAL	SYMMETRIC		ASYMMETRIC (kA)		
5.6	TAP CHANGER ON-LOAD								I (kA)	TIME (S)			
5.6.1	TAP	VOLTAGE (V)	TAP	VOLTAGE (V)	TAP	VOLTAGE (V)	12.1	PRIMARY					
5.6.1.1	1		S		9		12.2	SECONDARY					
5.6.1.2	2		6		10								
5.6.1.3	3		7		11		12.3	TERTIARY					
5.6.1.4	4		6		12								
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FORM OWNED TO PETROBRAS N-2928 REV. 0 ANNEX C - SHEET 02/06.													

		DATA SHEET		Nº		REV.		
							SHEET 03 of 06	
		TITLE: Insulating Liquid-Immersed Power Transformer Voltage Class above 36 kV						
13	PRIMARY SIDE TERMINALS		17.2.4	DEGREE OF PROTECTION IP 5 4				
13.1	QUANTITY		17.2.5	PLATE THICKNESS mm				
13.2	SUPPLYING OF CONNECTOR FOR		19	TERMINAL PROTECTION BOX INLETS				
132.1	CABLE <input type="checkbox"/>	16.1			HALFROUND (mm)	CONDUIT SLEEVE (mm)	QTY.	
13.2.1.1	NOMINAL SECTION (mm ²)							
13.2.1.2	TYPE OF CABLE			16.2	PRIMARY			
13.2.1.3	TERMINATION (INCLUDED IN SUPPLYING) YES	16.3	SECONDARY					
13.2.2	BUSBAR TRUNK <input type="checkbox"/>	16.4	TERTIARY					
13.2.2.1	BAR MATERIAL	18	CABLE GLAND (INCLUDED IN SUPPLYING) YES					
13.2.2.2	BAR DIMENSIONS (mm x mm x mm)	18	GROUNDING					
14	SECONDARY SIDE TERMINALS		18.1	HOUSING GROUND CONNECTOR YES				
14.1	QUANTITY		19.2	FOR CABLE YES QUANTITY				
14.2	SUPPLYING OF CONNECTOR FOR		19.3	FOR PLATE NO QUANTITY				
14.2.1	CABLE <input type="checkbox"/>	20	FORCED COOLING EQUIPMENT					
14.2.1.1	NOMINAL SECTION (mm ²)	20.1	COOLING METHOD DESIGNATION					
14.2.1.2	TYPE OF CABLE	20.2	LOAD ADDITION WITH COOLING					
14.2.1.3	TERMINATION (INCLUDED IN SUPPLYING) YES	20.3	NUMBER OF VENTILATORS					
14.2.2	BUSBAR TRUNK <input type="checkbox"/>	20.4	AIR FLOW PER VENTILATOR m ³ /h					
14.2.2.1	BAR MATERIAL	20.5	VENTILATOR ROTATION rpm					
14.2.2.2	BAR DIMENSIONS (mm x mm x mm)	20.6	POWER OF EACH MOTOR kW					
15	TERTIARY SIDE TERMINALS		20.7	RATED VOLTAGE V				
15.1	QUANTITY		20.8	No. OF PHASES				
15.2	SUPPLYING OF CONNECTOR FOR		21	WINDING TEMPERATURE DEVICE YES				
15.2.1	CABLE <input type="checkbox"/>	21.1	TEMPERATURE SENSOR					
15.2.1.1	NOMINAL SECTION (mm ²)	21.2	LOCAL TEMPERATURE GAUGE					
15.2.1.2	TYPE OF CABLE	21.3	REMOTE GAUGE SIGNAL 4 mA to 20 mA					
15.2.1.3	TERMINATION (INCLUDED IN SUPPLYING) YES	22	MOVEMENT					
15.2.2	BUSBAR TRUNK <input type="checkbox"/>	22.1	SUSPENSION YES					
15.2.2.1	BAR MATERIAL	22.2	LOCOMOTION STEERABLE WHEELS					
15.2.2.2	BAR DIMENSIONS (mm x mm x mm)	22.3	SUPPORTS FOR JACKS YES					
16	NEUTRAL TERMINALS		23	INFORMATION ON NON-LINEAR LOADS				
16.1	QUANTITY		23.1	TYPE OF LOAD				
16.2	SUPPLYING OF CONNECTOR FOR		23.1.1	RECTIFIER <input type="checkbox"/>				
16.2.1	CABLE <input type="checkbox"/>	23.1.1.1	POWER kVA					
16.2.1.1	NOMINAL SECTION (mm ²)	23.1.1.2	No. OF PULSES					
16.2.1.2	TYPE OF CABLE	23.1.2	VOLTAGE SOURCE CONVERTER <input type="checkbox"/>					
16.2.1.3	TERMINATION (INCLUDED IN SUPPLYING) YES	23.1.2.1	POWER kVA					
17	ENCLOSURES AND BOXES		23.1.3	CURRENT SOURCE CONVERTER <input type="checkbox"/>				
17.1	TRANSFORMER ENCLOSURE		23.1.3.1	POWER kVA				
17.1.1	DEGREE OF PROTECTION IP 5 4	23.2	HARMONIC DISTRIBUTION OF CURRENT ATTACHED TO FD <input type="checkbox"/>					
17.1.2	PLATE THICKNESS mm	233	OVERSIZING FACTOR					
17.2	TERMINAL PROTECTION BOX		24	OPTIONAL ACCESSORIES				
17.2.1	PRIMARY		24.1	CHECK VALVES FOR RADIATOR OIL NO				
17.2.2	SECONDARY							
17.2.3	TERTIARY							
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		DATA SHEET			Nº		REV.		
								SHEET 05 of 06	
		TITLE: Insulating Liquid-Immersed Power Transformer Voltage Class above 36 kV							
INSPECTION LIST AND TESTS TO BE PERFORMED / EVIDENCED									
INSPECTION AND TESTS		TAF			TAC	TEST PROCEDURE			
		T	W	R					
29	VERIFICATION OF THE TECHNICAL DOCUMENTATION CERTIFIED BY THE MANUFACTURER	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	PETROBRAS NI-2928			
30	VERIFICATION OF THE CALIBRATION CERTIFICATES OF TEST INSTRUMENTS	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PETROBRAS NI-2928			
31	VISUAL INSPECTION AND VERIFICATION OF THE RATING PLATE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	PETROBRAS NI-2928			
32	VERIFICATION OF THE PROTECTIVE PAINT SYSTEM (PERFORMANCE, ADHESION, CORROSION, COLOR)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO 12944-1, ISO 12944-2, ISO 12944-3, 12944-4, ISO 12944-5, ISO 12944-6, ISO-12944-7, ISO 20340 AND PETROBRAS NI-2928			
33	DIMENSIONAL INSPECTION	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ACCORDING TO MANUFACTURER'S CERTIFIED DOCUMENTATION			
34	VERIFICATION OF THE INTERNAL SPACE AND THE COMPONENTS OF POWER AND CONTROL TERMINAL BOXES	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ACCORDING TO MANUFACTURER'S CERTIFIED DOCUMENTATION			
35	VERIFICATION OF THE DEGREE OF PROTECTION OF THE ENCLOSURES (IP CODE)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ABNT NBR IEC 60529			
36	WINDING RESISTANCE (IN ALL TAPS)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IEC 60076-1			
37	TRANSFORMATION RATIO (IN ALL TAPS)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IEC 60076-1			
36	INSULATION RESISTANCE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IEC 60076-1			
39	POLARITY	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1			
40	ANGLE DISPLACEMENT AND SEQUENCE OF PHASES	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1			
41	SHORT-CIRCUIT AND LOAD LOSS IMPEDANCE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1			
42	NO-LOAD LOSSES AND EXCITATION CURRENT	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1			
43	RATED WITHSTAND VOLTAGE AT INDUSTRIAL FREQUENCY	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1 IEC 60076-3			
44	INDUCED VOLTAGE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-3			
45	VERIFICATION OF OPERATION OF ACCESSORIES	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>				
46	DISSIPATION FACTOR (TG DELTA) OF INSULATION	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IEC 60076-1			
47	TEMPERATURE RISE TEST (SEE NOTE 5)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-2			
46	RATED WITHSTAND VOLTAGE OF LIGHTNING IMPULSE (NOTE 5)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-4			
49	AUDIBLE NOISE LEVEL	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	IEC 60076-10			
50	RADIOINTERFERENCE VOLTAGE LEVEL	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	IEEE C57.12.90			
51	SHORT-CIRCUIT WITHSTAND	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	IEC 60076-5			
52	POWER ABSORBED BY VENTILATOR MOTORS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
53	ZERO SEQUENCE IMPEDANCE IN THREE-PHASE TRANSFORMERS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1			
54	EXCITATION CURRENT HARMONICS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1			
55	RESPONSE IN TERMINAL FREQUENCY AND IMPEDANCE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
56	CAPACITANCES BETWEEN WINDING AND GROUND AND BETWEEN WINDINGS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
57	TRANSFERRED TRANSIENT VOLTAGE CHARACTERISTICS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-3			
56	INSULATING OIL TESTS (DIELECTRIC STIFFNESS, WATER CONTENT, LOSS FACTOR, INTERFACE VOLTAGE, NEUTRALIZATION INDEX)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	ASTM D971, ASTM D974, IEC 60814, ABNT NBR IEC 60156, IEC 60247, AND ASTM D924			
59	CHROMATOGRAPHIC ANALYSIS OF GASES DISSOLVED IN INSULATING OIL	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IEC 69599			
60	DEW POINT	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
61	PAPER POLYMERIZATION DEGREE	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ABNT NBR IEC 69450			
62	SEALING CAPACITY AND RESISTANCE TO PRESSURE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1			
63	INTERNAL VACUUM	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1			
64		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
65		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
66		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
67		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
T -	TEST TO BE EFFECTIVELY PERFORMED IN TRANSFORMER TO BE SUPPLIED.								
W -	TEST WITNESSED BY AN INSPECTOR FROM PETROBRAS OR FROM COMPANY ASSIGNED BY PETROBRAS.								
R -	PRESENTATION OF REPORT OF EQUIVALENT TRANSFORMER TYPE (SAME VOLTAGE, FREQUENCY, POWER).								
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		DATA SHEET				Nº		REV.		
		TITLE: Dry Power Transformer						SHEET 02 of 05		
1	BASIC INFORMATION				5.6.1.4	4		V		
1.1	PETROBRAS IDENTIFICATION (TAG) TF-				5.6.1.5	5		V		
1.2	MANUFACTURER				5.6.1.6	6		V		
1.3	YEAR OF MANUFACTURE				5.6.1.7	7		V		
1.4	MODEL				6	NO-LOAD CURRENT AND LOSSES				
1.5	SERIAL No.				6.1	EXCITATION CURRENT (SEE NOTE 3) A				
2	ENVIRONMENTAL CHARACTERISTICS				6.2	STARTING EXCITATION CURRENT A				
2.1	INSTALATION INTERNAL				6.3	REFERENCE TEMPERATURE °C				
2.2	COOLANT TEMPERATURE (SEE NOTE 1) 40 °C / 35 °C / 25 °C				6.4	NO-LOAD LOSSES (T _{REF}) W				
2.3	ALTITUDE < 1000 m				6.5	ON-LOAD LOSSES (T _{REF}) W				
2.4	CLIMATIC CLASS C1				7	EFFICIENCY (%)				
2.5	ENVIRONMENTAL CLASS E2					% LOAD	POWER FACT. = 1.0		POWER FACT. = 0.8	
2.6	FIRE BEHAVIOR F1				7.1	100				
3	BASIC CHARACTERISTICS				7.2	75				
3.1	CONSTRUCTIVE FORM				7.3	50				
3.2	INSULATING MATERIAL				7.4	25				
3.3	WINDING INSULATION THERMAL CLASS				8	REGULATION (%)				
3.4	TEMPERATURE RISE 100°C					% LOAD	POWER FACT. = 1.0		POWER FACT. = 0.8	
3.5	ACCESSIBLE NEUTRAL YES				6.1	100				
3.6	GROUNDING TYPE RESISTOR				6.2	75				
3.7	TOPCOAT COLOR Light gray - Munsel N 6.5				6.3	50				
3.8	TOTAL WEIGHT kg				6.4	25				
3.9	ACTIVE PART WEIGHT kg				9	MAXIMUM VOLTAGES (INSULATION LEVELS)				
					9.1	PRIMARY kV				
					9.2	SECONDARY kV				
					9.3	TERTIARY kV				
4	RATED POWERS, VOLTAGES AND CURRENTS						10	RATED WITHSTAND VOLTAGES		
	TERMINAL	VOLTAGE (kV)	RATED POWER (kVA)		RATED CURR. (A)			TERMINAL	LIGHTNING IMPULSE (kV PEAK)	AT INDUSTRIAL FREQUENCY (kV EFFECTIVE)
4.1	PRIM.		NAT COOL.	FOR. COOL.	NAT COOL.	FOR. COOL.		FULL	CUT	
4.2	SEC						10.1	PRIMARY		
4.3	TERT.						10.2	SECONDARY		
4.4	NUMBER OF PHASES						10.3	TERTIARY		
4.5	RATED FREQUENCY 60 Hz						10.4	NEUTRAL		
5	WINDING CONNECTIONS						11	SHORT-CIRCUIT IMPEDANCE		
5.1	TYPE Dyn1							VOLTAGE RATIO (V)		Z% (T _{REF})
5.2	POLARITY SUBTRACTIVE						11.1	PRIM-SEC		
5.3	PRIMARY D						11.2	PRIM-TERT		
5.4	SECONDARY Y						11.3	SEC-TERT		
5.5	TERTIARY						12	MAXIMUM WITHSTAND SHORT-CIRCUIT CURRENT		
5.6	NO-VOLTAGE TAP CHANGER YES							TERMINAL	SYMMETRIC	
5.6.1	TAP		VOLTAGE					I (kA)	TIME (S)	
5.6.1.1	1		V				12.1	PRIMARY		
5.6.1.2	2		V				12.2	SECONDARY		
5.6.1.3	3		V				12.3	TERTIARY		
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		DATA SHEET		Nº		REV.	
		TITLE: Dry Power Transformer				SHEET 03 of 05	
13	PRIMARY SIDE TERMINALS			17.2.4	DEGREE OF PROTECTION IP 2 1		
13.1	QUANTITY			17.2.5	PLATE THICKNESS mm		
13.2	SUPPLYING OF CONNECTOR FOR			18	TERMINAL PROTECTION BOX INLETS		
13.2.1	CABLE <input type="checkbox"/>				HALFROUND (mm)	CONDUIT SLEEVE (mm)	QTY.
13.2.1.1	NOMINAL SECTION (mm ²)						
13.2.1.2	TYPE OF CABLE		18.1		PRIMARY		
13.2.1.3	TERMINATION (INCLUDED IN SUPPLYING) YES		18.2	SECONDARY			
13.2.2	BUSBAR TRUNK <input type="checkbox"/>		18.3	TERTIARY			
13.2.2.1	BAR MATERIAL		18.4	CABLE GLAND (INCLUDED IN SUPPLYING) YES			
13.2.2.2	BAR DIMENSIONS (mm x mm x mm)		19	GROUNDING			
14	SECONDARY SIDE TERMINALS			19	HOUSING GROUND CONNECTOR YES		
14.1	QUANTITY			19.1	FOR CABLE YES	QUANTITY	
14.2	SUPPLYING OF CONNECTOR FOR			19.2	FOR PLATE NO	QUANTITY	
14.2.1	CABLE <input type="checkbox"/>		20	FORCED COOLING EQUIPMENT			
14.2.1.1	NOMINAL SECTION (mm ²)		20.1	COOLING METHOD DESIGNATION			
14.2.1.2	TYPE OF CABLE		20.2	LOAD ADDITION WITH COOLING			
14.2.1.3	TERMINATION (INCLUDED IN SUPPLYING) YES		20.3	NUMBER OF VENTILATORS			
14.2.2	BUSBAR TRUNK <input type="checkbox"/>		20.4	AIR FLOW PER VENTILATOR m ³ /h			
14.2.2.1	BAR MATERIAL		20.5	VENTILATOR ROTATION rpm			
14.2.2.2	BAR DIMENSIONS (mm x mm x mm)		20.6	POWER OF EACH MOTOR kW			
15	TERTIARY SIDE TERMINALS			20.7	RATED VOLTAGE V		
15.1	QUANTITY			20.8	No. OF PHASES		
15.2	SUPPLYING OF CONNECTOR FOR			21	WINDING TEMPERATURE DEVICE YES		
15.2.1	CABLE <input type="checkbox"/>		21.1	TEMPERATURE SENSOR			
15.2.1.1	NOMINAL SECTION (mm ²)		21.2	LOCAL TEMPERATURE GAUGE			
15.2.1.2	TYPE OF CABLE		21.3	REMOTE GAUGE SIGNAL 4 mA to 20 mA			
15.2.1.3	TERMINATION (INCLUDED IN SUPPLYING) YES		22	MOVEMENT			
15.2.2	BUSBAR TRUNK <input type="checkbox"/>		22.1	SUSPENSION YES			
15.2.2.1	BAR MATERIAL		22.2	LOCOMOTION STEERABLE WHEELS			
15.2.2.2	BAR DIMENSIONS (mm x mm x mm)		22.3	SUPPORTS FOR JACKS YES			
16	NEUTRAL TERMINALS			23	INFORMATION ON NON-LINEAR LOADS		
16.1	QUANTITY			23.1	TYPE OF LOAD		
16.2	SUPPLYING OF CONNECTOR FOR			23.1.1	RECTIFIER <input type="checkbox"/>		
16.2.1	CABLE <input type="checkbox"/>		23.1.1.1	POWER kVA			
16.2.1.1	NOMINAL SECTION (mm ²)		23.1.1.2	No. OF PULSES			
16.2.1.2	TYPE OF CABLE		23.1.2	VOLTAGE SOURCE CONVERTER <input type="checkbox"/>			
16.2.1.3	TERMINATION (INCLUDED IN SUPPLYING) YES		23.1.2.1	POWER kVA			
17	ENCLOSURES AND BOXES			23.1.3	CURRENT SOURCE CONVERTER <input type="checkbox"/>		
17.1	TRANSFORMER ENCLOSURE			23.1.3.1	POWER kVA		
17.1.1	DEGREE OF PROTECTION IP		23.2	HARMONIC DISTRIBUTION OF CURRENT ATTACHED TO FD <input type="checkbox"/>			
17.1.2	PLATE THICKNESS mm		23.3	OVERSIZING FACTOR			
17.2	TERMINAL PROTECTION BOX						
17.2.1	PRIMARY						
17.2.2	SECONDARY						
17.2.3	TERTIARY						

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FORM OWNED TO PETROBRAS N-2928 REV. 0 ANNEX D - SHEET 03/05.

	DATA SHEET		Nº		REV.		
						SHEET	05 of 05
	TITLE: Dry Power Transformer						
INSPECTION LIST AND TESTS TO BE PERFORMED / EVIDENCED							
INSPECTION AND TESTS		TAF			TAC	TEST PROCEDURE	
		T	w	R			
27	VERIFICATION OF THE TECHNICAL DOCUMENTATION CERTIFIED BY THE MANUFACTURER	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	PETROBRAS NI-2928	
28	VERIFICATION OF THE CALIBRATION CERTIFICATES OF TEST INSTRUMENTS	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	PETROBRAS NI-2928	
29	VISUAL INSPECTION AND VERIFICATION OF THE RATING PLATE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	PETROBRAS NI-2928	
30	VERIFICATION OF THE PROTECTIVE PAINT SYSTEM (PERFORMANCE, ADHESION, CORROSION, COLOR)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	SERIES ISO 12944, 20340 AND PETROBRAS NI-2928	
31	DIMENSIONAL INSPECTION	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ACCORDING TO MANUFACTURER'S CERTIFIED DOCUMENTATION	
32	VERIFICATION OF THE INTERNAL SPACE AND THE COMPONENTS OF POWER AND CONTROL TERMINAL BOXES	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ACCORDING TO MANUFACTURER'S CERTIFIED DOCUMENTATION	
33	VERIFICATION OF THE DEGREE OF PROTECTION OF THE ENCLOSURES (IP CODE)	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	ABNT NBR IEC 60529	
34	WINDING RESISTANCE (IN ALL TAPS)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IEC 60076-1	
35	TRANSFORMATION RATIO (IN ALL TAPS)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IEC 60076-1	
36	INSULATION RESISTANCE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IEEE C57.12.91	
37	POLARITY	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1	
36	ANGLE DISPLACEMENT AND SEQUENCE OF PHASES	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1	
39	SHORT-CIRCUIT AND LOAD LOSS IMPEDANCE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1	
40	NO-LOAD LOSSES AND EXCITATION CURRENT	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1	
41	RATED WITHSTAND VOLTAGE AT INDUSTRIAL FREQUENCY (APPLIED VOLTAGE)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1	
42	INDUCED VOLTAGE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-3	
43	VERIFICATION OF OPERATION OF ACCESSORIES	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>		
44	DISSIPATION FACTOR (TG DELTA) OF INSULATION	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	IEC 60076-1 and IEEE STD C57.12.91	
45	TEMPERATURE RISE TEST (SEE NOTE 2)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-2	
46	RATED WITHSTAND VOLTAGE OF LIGHTNING IMPULSE (NOTE 2)	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	IEC 60076-4	
47	ENVIRONMENTAL TEST	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	IEC 60076-11	
46	CLIMATIC TEST	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	IEC 60076-11	
49	FIRE BEHAVIOR TEST	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	IEC 60076-11	
50	AUDIBLE NOISE LEVEL	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	IEC 60076-10	
51	RADIOINTERFERENCE VOLTAGE LEVEL	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		
52	INDUCED VOLTAGE WITH MEASUREMENT OF PARTIAL DISCHARGES	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-11	
53	SHORT-CIRCUIT TEST	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-5	
54	POWER ABSORBED BY VENTILATOR MOTORS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
55	ZERO SEQUENCE IMPEDANCE IN THREE-PHASE TRANSFORMERS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1	
56	EXCITATION CURRENT HARMONICS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	IEC 60076-1	
57		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
56		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
59	NOTES						
	NOTE 1 THE TEMPERATURE ARE, RESPECTIVELY: AT ANY TIME / HOTTEST MONTH AVERAGE / ANNUAL AVERAGE						
	NOTE 2 IT SHALL BE PERFORMED IN A TRANSFORMER PRODUCED FROM EACH SET OF IDENTICAL TRANSFORMERS, TO BE DEFINED BY PETROBRAS.						
	NOTE 3 VALUE REFERRING TO RATED CURRENT OF PRIMARY WINDING, MENTIONED IN ITEM 4.1, FOR NATURAL COOLING.						
CAPTION: T - TEST TO BE EFFECTIVELY PERFORMED IN TRANSFORMER TO BE SUPPLIED. W - TEST WITNESSED BY AN INSPECTOR FROM PETROBRAS OR FROM COMPANY ASSIGNED BY PETROBRAS. R - PRESENTATION OF REPORT OF EQUIVALENT TRANSFORMER TYPE (SAME VOLTAGE, FREQUENCY, POWER).							
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FORM OWNED TO PETROBRAS N-2928 REV. 0 ANNEX D - SHEET 05/05.							

Foreword

This Standard is the English version (issued in 10/2013) of PETROBRAS N-2928 REV. 0 12/2012. In case of doubt, the Portuguese version, which is the valid document for all intents and purposes, shall be used.

1 Scope

1.1 This Standard sets out the requirements for purchasing of single-phase dry or insulating liquid-immersed transformers with power above 1 kVA, and three-phase with power above 5 kVA, for use in PETROBRAS' facilities.

1.2 This Standard does not apply to:

- a) dry power transformers for lighting and instrumentation systems; for these cases, PETROBRAS N-2201 shall be used;
- b) transformers supplying exclusively to frequency converters; for these cases, PETROBRAS N-2547 shall be used.

1.3 The application of this Standard does not exempt from following rules from public bodies that shall be complied by the equipment, components, services and installations. The rules from Regulating Standards of the Ministry of Labor and Ministerial Ordinances prepared by Inmetro, containing the Compliance Assessment Requirements (RAC) for equipment, components and services, may be as examples of rules from public bodies.

1.4 This Standard applies to procedures beginning from its date of edition.

1.5 This Standard contains only Technical Requirements.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document applies.

PETROBRAS N-2201 - Dry Transformer for Lighting or Instrumentation Systems;

PETROBRAS N-2547 - Frequency Converter for Speed Control of Electric Motor Up To 660 VAC;

ABNT NBR IEC 60156 - Líquidos Isolantes - Determinação da Rigidez Dielétrica à Frequência Industrial;

ABNT NBR IEC 60450 - Medição do Grau de Polimerização Viscosimétrico Médio de Materiais Celulósicos Novos e Envelhecidos para Isolação Elétrica;

ABNT NBR IEC 60529 - Graus de Proteção para Invólucros de Equipamentos Elétricos (Código IP);

ISO 4624 - Paints and Varnishes - Pull-Off Test for Adhesion;

ISO 12944-1 - Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 1: General Introduction;

ISO 12944-2 - Paints and Varnishes - Corrosion Protection of Steel Structures by Protective Paint Systems - Part 2: Classification of Environments;

3.1.3 Lightning impulse and switching impulse tests shall comply with the requirements of IEC [60076-4](#).

3.1.4 The characteristics of power transformers to withstand circuit-breakers shall comply with the requirements of IEC [60076-5](#).

3.1.5 Power reactors shall comply with requirements of IEC [60076-6](#).

3.1.6 Power transformers shall be designed, sized and tested in order to comply with the requirements of noise level determination indicated in IEC [60076-10](#).

3.1.7 Self-shielded power transformers immersed in insulating liquid shall be designed, sized and tested in order to comply with the requirements of IEC [60076-13](#).

3.1.8 Power transformers to be applied in wind turbines shall comply with requirements of IEC [60076-16](#).

3.1.9 The tap changers of power transformers shall comply with requirements of performance and test methods of IEC [60214-1](#).

3.1.10 Markings of terminals and connections of power transformers shall comply with the requirements of IEC [TR 60616](#).

3.1.11 Power transformers to be used in industrial applications with frequency converters shall be designed, sized and manufactured in order to comply with the requirements of IEC [61378-1](#) or IEEE [STD C57.110](#).

3.1.12 Power transformers and reactors to be applied in frequency converter systems shall comply with the requirements of IEC [60146-1-3](#).

3.1.13 Transformers to be applied in offshore units shall also comply with the criteria established in IEC [61892-3](#).

3.1.14 Direct connections between power transformers and metal enclosed gas-insulated switching assemblies, for rated voltages of 72,5 kV or above, shall comply with the requirements of IEC [TS 61639](#).

3.1.15 Unless otherwise specified in Data Sheet, the power transformer shall be suited to the following cooling temperatures, according to definitions of IEC [60076-1](#):

- a) at any time: 40 °C;
- b) average of the hottest month: 35 °C;
- c) yearly average: 25 °C.

3.2 Constructive Characteristics

3.2.1 Unless otherwise specified in Data Sheet, the transformer shall be able the continuous power increase of at least 25 %, with forced cooling in operation.



- a) category C5-I - very high corrosivity (industrial environments);
- b) category C5-M - very high corrosivity (offshore environments).

3.4.4 Preparation of surfaces to be painted shall comply with the requirements of ISO [12944-4](#).

3.4.5 The paint system used for the transformer, including specification of paints and dry film thickness (DFT) of primers and topcoats shall comply with the requirements of ISO [12944-5](#).

3.4.6 Unless otherwise specified in Data Sheet, the required durability range and the performance evaluation of the paint system necessary to comply with requirements of corrosivity categories C5-I/C5-M specified in ISO [12944-2](#), shall comply with the M (Medium) durability requirements indicated in ISO [12944-5](#), regarding a minimum period between 5 and 15 years. For transformers to be applied offshore with corrosivity category C5-M, the applicable requirements of ISO [20340](#) shall be also complied with.

3.4.7 Performance checks of protective paint system of transformers shall be according to requirements of ISO [12944-6](#).

NOTE At least the results of adhesion (ISO [4624](#)), heaving, oxidation (rusting), cracking, scaling and corrosion tests after risk shall be presented.

3.4.8 Unless otherwise specified in Data Sheet, the final topcoat color of transformer shall be code Munsell No. 6.5.

NOTE The criteria mentioned in 3.4 apply to both transformer and their accessories (switchboards, boxes, radiators, motors, instruments, expansion tanks, etc.).

3.5 IED (Intelligent Electronic Device) Characteristics for Control and Monitoring of Power Transformer

3.5.1 IED shall be designed, built and tested specifically for use in adverse conditions of switchyards, so as to withstand, with no damage, the performance of dielectric tests in transformer and/or bushings (applied voltage, impulse voltage, etc.) with IED fully installed and connected to transformer.

3.5.2 IED shall comply with the technical requirements of IEC [60068-1](#), [60068-2-14](#), [61000-4-3](#), [61000-4-4](#), [61000-4-5](#) and [61000-4-6](#) so as meet the the proper functioning and reliability requirements of generated and transmitted data.

3.5.3 The IED shall be installed in enclosure with degree of protection suitable for the installation site.

3.5.4 The IED shall withstand the maximum industrial class operation temperature of 85 °C, according to IEC [60068-2-14](#).

3.5.5 The IED shall have non-volatile internal memory for local storage of measurements and events.

3.5.6 The IED shall be able to receive electrical supply in 90 Vac/Vdc to 240 Vac/Vdc range.

3.5.7 If the on-line monitoring and diagnosis system is required in Data Sheet, Annex A shall be used for specification of system.

Annex A - Power Transformer On-Line Monitoring And Diagnosis System

A.1 The main objectives of the on-line monitoring and diagnosis system to be supplied are the diagnosis and prognosis of power transformer status, reducing the failure risk, increasing the service life, and reducing the maintenance costs of these assets.

A.2 The monitoring and diagnosis system shall use an architecture comprising data acquisition, IED, data communication network and monitoring and diagnosis software.

A.3 Specification of Software Requirements for Monitoring and Diagnosis System

The monitoring and diagnosis software shall perform the following main functions:

- a) data communication with IED for on-line acquisition of measurements;
- b) storage of measurements in historical database, with configurable interval;
- c) treatment and crossing of measurements with engineering algorithms, to obtain useful information for diagnosis and prognosis of equipment status;
- d) generate diagnoses and prognoses of equipment status and suggest recommended actions;
- e) send automatic warnings to users in case of alarm conditions;
- f) enable multi-user access, with no simultaneous access limit;
- g) allow users to access remotely IED measurements, engineering algorithm information and diagnoses, prognoses and recommended actions, both online and stored in database;
- h) have open databases to users. The full ER (entity-relationship) model of all databases shall be provided;
- i) allow future expansion through interconnection of new sensors in the transformer already monitored;
- j) have a specialized system for generation of diagnoses, prognoses and recommended actions when alarm conditions are detected, using a rules-based system which shall be submitted to PETROBRAS' approval, containing at least the following functions:
 - diagnosis: indication of potential causes for alarm condition, obtained from processing the IED measurements and results of engineering algorithms, using the rules-based system;
 - prognosis: indication of possible consequences of evolution of diagnosed defect if no corrective action is taken;
 - suggested actions: indication of corrective actions for correction, neutralization or reduction of consequences of diagnosed defect.

A.4 Performance and Test Characteristics of IED to be Supplied with the Power Transformer

A.4.1 IED shall be designed, built and tested specifically for use in adverse conditions of switchyards, so as to withstand, with no damage, the performance of dielectric tests in transformer and/or bushings (applied voltage, impulse voltage, etc.) with IED fully installed and connected to transformer.

A.4.2 IED shall comply with the technical requirements of respective standards IEC so as meet the good operation and reliability requirements of generated and transmitted data.

A.4.3 It shall have degree of protection suitable for the installation form.

A.4.4 The supplier shall submit documentation proving that the IED is tested in this condition in transformer tests with 230 kV voltage level.