

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

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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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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.).

3.5 CANCELLED - AMENDMENT 06/2014

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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.