

CONTECComissão de Normalização
Técnica**SC-06**

Electricity

**Construction, Mounting and Conditioning of
Electrical Equipment****1st Amendment**

This is the 1st Amendment to PETROBRAS N-1614 REV. B and it is used to alter the text of the Standard in the part(s) indicated below:

NOTE 1 The new(s) page(s) with the performed amendment(s) is (are) placed in its corresponding position(s).

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 - 02/2014

- Chapter 2:

Excludes of PETROBRAS N-312, N-313, N-320, N-322, N-323, N-324, N-325, N-330, N-331, N-333, N-334, N-375, N-470, N-474, N-510, N-1534, N-1717, N-1718, N-1777, N-1786 and N-1911.

Includes of PETROBRAS [N-2817](#), [N-2919](#) and [N-2928](#).

Excludes of ABNT NBR-5116, NBR-5117, NBR-5119, NBR-5165, NBR-5168, NBR-5289, NBR-5309, NBR-5356, NBR-5376, NBR-5380, NBR-5383, NBR-5389, NBR-6509, NBR-6820, NBR-6821, NBR-7037, NBR-7094, NBR-7118, NBR-7565 and NBR-7566.

Includes of ABNT [NBR 5356-1](#), [NBR 5356-6](#), [NBR 5383-1](#), [NBR 5383-2](#), [NBR 17094-1](#), [NBR 17094-2](#), [NBR-IEC-60034-9](#) and [NBR-IEC-60060-1](#).

Excludes of ANSI C 37.9, C 37.9a, C 37.20, C 37.35, C50.10, C50.13, IEEE Std 113, Std 118 and NEMA R12.

Includes of IEC [62271-100](#), IEEE [Std C37.09](#), [Std C37.09a](#), [Std C37.20.1](#), [Std C37.35](#) and [C50.13](#).

Alteration of title of ASTM [D 877](#).

- Item 3.5:

Alteration of the Table.

- Itens 4.2.1.12, 6.2.1.1, 6.2.1.8, 6.2.7.1, 8.1.2, 8.2.3, 8.2.4, 8.2.8, 8.2.11 alíneas b) e c), 9.2.10 alínea o) e 9.2.13 alínea n):

Alteration of the texts.

CONTEC

Comissão de Normalização
Técnica

SC-06

Electricity

**Construction, Mounting and Conditioning of
Electrical Equipment**

Revalidation

Revalidated in 05/2012.

CONSTRUCTION, MOUNTING AND CONDITIONING OF ELECTRICAL EQUIPMENT

Procedure

This Standard replaces and cancels the previous revision.

This Standard is the Revalidation of the Previous Revision.

The Responsible CONTEC Subcommittee provides guidance on the interpretation of this Standard when questions arise regarding its contents. The Department of PETROBRAS that uses this Standard is fully responsible for adopting and applying the clauses thereof.

Mandatory Requirement: a provision established as being 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 the verb forms "shall", "it is necessary...", "is required to...", "it is required that...", "is to...", "has to...", "only ... is permitted", and other equivalent expressions having an imperative nature.

Recommended Practice (nonmandatory) 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 the verbal form "should" and equivalent expressions such as "it is recommended that..." and "ought to..." (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 Responsible CONTEC Subcommittee.

Proposed revisions to this Standard shall be submitted to the Responsible CONTEC Subcommittee, indicating the alphanumeric identification and revision of the Standard, the clause(s) to be revised, the proposed text, and technical/economic justification for revision. The proposals are evaluated during the work for alteration of this Standard.

"The present standard is exclusive ownership of PETRÓLEO BRASILEIRO S.A. - PETROBRAS, for internal use in the company, and any copy for external use or disclosure, without previous express authorization, implies unlawful act pursuant the relevant legislation through which the applicable responsibilities shall be imputed. The external circulation shall be regulated by a specific clause of Secrecy and Confidentiality, pursuant the terms of the intellectual and industrial property law"

CONTEC

Comissão de Normas
Técnicas

SC – 06

Electricity

Foreword

PETROBRAS technical standards are prepared by Working Groups – GTs (consisting of PETROBRAS specialists and PETROBRAS Subsidiaries specialists), are commented by Local Representatives (representatives of the Industrial Units, Engineering Projects, Technical Divisions and PETROBRAS Subsidiaries), are approved by Responsible Subcommittees SCs (consisting of specialists belonging to the same speciality, representing the various PETROBRAS Departments and PETROBRAS Subsidiaries), and approved by CONTEC General Assembly (consisting of representatives of the Superintendencies of the PETROBRAS Departments and PETROBRAS Subsidiaries that use PETROBRAS technical standards). A PETROBRAS technical standard is subjected to revision at any time by the Responsible Subcommittee and must be reviewed every five years to be revalidated, revised or cancelled. PETROBRAS technical standards are prepared in accordance with standard PETROBRAS N -1. For complete information about PETROBRAS standards see PETROBRAS Technical Standards Catalog.

BLANK PAGE

CONTENTS

BLANK PAGE2

BLANK PAGE4

1 SCOPE5

2 COMPLEMENTARY DOCUMENTS5

3 EQUIPMENT RECEIVING8

4 STORAGE AND PRESERVATION OF EQUIPMENT9

5 FOUNDATIONS AND BASES16

6 MOUNTING OF EQUIPMENT16

7 PRESERVATION AFTER MOUNTING.....23

8 TESTS28

9 PREPARATION START UP35

10 ACCEPTANCE AND REJECTION.....40

/1 SCOPE

BLANK PAGE

PREFACE

This Standard PETROBRAS N-1614 REV. B SEP/97 is the Revalidation of Standard PETROBRAS N-1614 REV. A AUG/84 the contents of which were not altered. This Standard is the English version (issued DEZ/99) of Standard PETROBRAS N-1614 REV. B - SEP/97.

1 SCOPE

This Standard establishes the minimum conditions required for receiving, construction, mounting and commissioning of the following types of electrical equipment for PETROBRAS's application;

- a) power transformers;
- b) reactors;
- c) grounding resistors;
- d) bus ducts;
- e) control panels, protection panels, signaling panels;
- f) auxiliary panels;
- g) rectifiers and inverters;
- h) batteries;
- i) circuit breakers for external mounting;
- j) instrument transformers for external mounting;
- k) dry disconnecting switches;
- l) oil immersed disconnecting units;
- m) capacitors;
- n) electrical generators;
- o) electrical motors.

2 COMPLEMENTARY DOCUMENTS

The following documents are referenced the text and contain valid rules for this Standard.

- PETROBRAS [N-314](#) - Painel de Baixa Tensão - Centro de Controle de Motores;
- PETROBRAS [N-316](#) - Painel de Baixa Tensão - Centro de Distribuição de Carga;
- PETROBRAS [N-317](#) - Painel de Media Tensão;
- PETROBRAS [N-319](#) - Duto de Barramento;

| | |
|------------------|---|
| PETROBRAS N-329 | - Bateria de Acumuladores; |
| PETROBRAS N-332 | - Carregador de Bateria; |
| PETROBRAS N-474 | - Resistor de Aterramento; |
| PETROBRAS N-1659 | - Redes e Equipamentos Elétricos - Folhas de Testes; |
| PETROBRAS N-2817 | - Painel de Média Tensão - Centro de Controle de Motores; |
| PETROBRAS N-2919 | - Motores Elétricos Trifásicos de Indução ou Síncronos; |
| PETROBRAS N-2928 | - Transformadores de Potência; |
| ABNT NBR-5060 | - Guia para Instalação e Operação de Capacitores de Potência; |
| ABNT NBR-5282 | - Capacitores de Potência; |
| ABNT NBR-5286 | - Corpos Cerâmicos de Grandes Dimensões Destinados a Instalações Elétricas; |
| ABNT NBR-5287 | - Pára-Raios de Resistor Não-Linear para Sistemas de Potência; |
| ABNT NBR-5289 | - Capacitores de Potência; |
| ABNT NBR-5356-1 | - Transformadores de Potência Parte 1: Generalidades; |
| ABNT NBR-5356-6 | - Transformadores de Potência Parte 6: Reatores; |
| ABNT NBR-5383-1 | - Máquinas Elétricas Girantes Parte 1: Motores de Indução Trifásicos - Ensaio; |
| ABNT NBR-5383-2 | - Máquinas Elétricas Girantes Parte 2: Motores de Indução Monofásicos - Ensaio; |

| | |
|--------------------------------------|---|
| ABNT NBR-6855 | - Transformador de Potencial; |
| ABNT NBR-6856 | - Transformador de Corrente; |
| ABNT NBR-6869 | - Determinação da Rigidez Dielétrica de Óleos Isolantes - Método dos Eletrodos de Disco; |
| ABNT NBR-7036 | - Recebimento, Manutenção e Instalação de Transformadores de Distribuição, Imersos em Líquidos Isolantes; |
| ABNT NBR-17094-1 | - Máquinas elétricas girantes - Motores de indução Parte 1: Trifásicos; |
| ABNT NBR-17094-2 | - Máquinas elétricas girantes - Motores de indução Parte 2: Monofásicos; |
| ABNT NBR-60034-9 | - Máquinas Elétricas Girantes. Parte 9: Limites de Ruído; |
| ABNT NBR-IEC-60060-1 | - Técnicas de Ensaio Elétricos de Alta Tensão Parte 1: Definições Gerais e Requisitos de Ensaio; |
| ASTM D 877 | - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes; |
| IEC 62271-100 | - High-Voltage Switchgear and Controlgear - Part 100: Alternating-Current Circuit-Breakers Edition 2.1; Consolidated Reprint; |
| IEEE - Std 32 | - Requirements Terminology, and Test Procedure for Neutral Grounding Devices; |
| IEEE - Std C37.09 | - Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis |
| IEEE - Std C37.09A | - Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis |
| IEEE - Std C37.20.1 | - Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear |
| IEEE - Std C37.35 | - Guide for the Application, Installation, Operation, and Maintenance of High-Voltage Air Disconnecting and Load Interrupter Switches |
| IEEE - Std C50.13 | - Cylindrical-Rotor 50 Hz and 60 Hz Synchronous Generators Rated 10 MVA and Above |
| IEEE - Std 43 | - Recommended Practice Testing Insulation Resistance of Rotating Machinery; |
| IEEE - Std 112 | - Test Procedure for Polyphase Induction Motors and Generators; |
| IEEE - Std 114 | - Test Procedure for Single-Phase Induction Motors; |
| IEEE - Std 115 | - Test Procedure for Synchronous Machines; |

NEMA - [MG1](#)
 NEMA - [SG4](#)

- Motors and Generators;
 - Alternating Current High-Voltage Circuit Breaker.

3 EQUIPMENT RECEIVING

3.1 Upon receipt of the equipment, the existence of the complete documentation thereof shall be checked, including factory test reports duly filled up.

3.2 It shall be checked whether the nameplate contains the data required in the design specification and applicable standards.

3.3 It shall be checked whether the data of the nameplate comply with those specified in the design and certified manufacturer drawings.

3.4 A visual inspection shall be made to check the integrity of all equipment and accessories thereof.

3.5 It shall be checked whether the characteristics of the equipment and accessories are in accordance with the design specifications, material requisitions, manufacturer drawings and standards listed in the TABLE 1 below, when applicable:

EQUIPAMENTS AND ACCESSORIES

| Equipment | Reference Standard |
|--|--|
| Terminal battery | PETROBRAS N-329 |
| Terminal blocks boxes | ABNT NBR-5282 |
| Capacitors | PETROBRAS N-332 |
| Low-voltage switchgear - Load distribution center | PETROBRAS N-316 PETROBRAS N-314 |
| Low-voltage panel - Motor control center | IEC 62271-100 PETROBRAS N-316 e PETROBRAS N-317 |
| Circuit breaker | PETROBRAS N-319 |
| Breakers for installation in panels | PETROBRAS N-2919 |
| Bus duct | |
| Three-phase induction or synchronous electrical motors | PETROBRAS N-317 e PETROBRAS N-2817 |
| Medium-voltage switchgear | |
| Arresters | ABNT NBR-5287 |
| Reactors | ABNT NBR-5356-6 |
| Instrument transformers | ABNT NBR-6855 e ABNT NBR-6856 |
| Power Transformers | PETROBRAS N-2928 |

3.6 In case the listed standards are not applicable, those according to which the equipment were manufactured shall be followed, provided that the design specifications are complied with.

4 STORAGE AND PRESERVATION OF EQUIPMENT

The requirements provided in General Conditions apply to all equipment listed in item 1. They shall be complemented by the specific conditions applicable to the equipment in reference, should they exist.

4.1 General Conditions

4.1.1 The electrical equipment and materials shall be stored in accordance with manufacturer's recommendations. In any case, the equipment shall be stored in a sheltered place, free from humidity, dust, corrosion agents and protected against mechanical damages, not directly laid on the ground and preferably kept with the original factory crating.

4.1.2 The original painting condition of the equipment shall be maintained, and when necessary the due repairs shall be performed according to the specified painting system.

4.1.3 When required by specific conditions, silica-gel shall be used in the internal compartments of the equipment, either blue or white silica-gel may be used, replacement being necessary upon evidence of humidity absorption, that is, when it gets the color pink or brown, accordingly. The bags of silica gel shall be marked with the date on which it was put inside the equipment.

4.1.4 All openings of the equipment shall be kept covered.

4.1.5 The equipment shall be kept in good condition of conservation and cleaning.

4.1.6 The gaskets of the equipment shall be kept in good conditions, replacement shall be provided when necessary.

4.1.7 The results of periodic measurements of equipment insulation resistance shall be compared against previously obtained measurements. The readings shall be corrected to the temperature of 40 °C.

4.1.8 The results of the periodic tests and checks for adequacy of preservation shall be recorded in appropriate forms, as well as the list of equipment used to perform the tests. The room temperature shall be recorded when measuring the insulation resistance.

4.1.9 The components and accessories of the equipment received separately shall be duly identified. They shall be clean, dry and sheltered places, protected against mechanical damages.

4.1.10 The procedures for storage and preservation of equipment including corrective actions shall cover the tasks foreseen in this Standard and in the recommendations of the manufacturer. They shall be specific for the materials and equipment concerned and shall cover at least the following topics:

- a) object;
- b) scope;
- c) applicable standards;
- d) description and method of the test or service;
- e) frequency of checks;
- f) specification of protective products;
- g) test equipment used;
- h) required tools;
- i) acceptance criteria;
- j) test parameters.

4.2 Specific Conditions

4.2.1 Power Transformers and Reactors

4.2.1.1 Transformers and reactors shall be stored in leveled position on wooden sleeper or board. They shall be protected against mechanical damage.

4.2.1.2 When transformers and reactors are received with their instruments and bushings already mounted on the equipment, such components shall be protected with wooden boxes.

4.2.1.3 The transformers and reactors stored outdoors shall be covered with plastic canvas.

4.2.1.4 Dry transformers and reactors shall be stored in a sheltered place. Cast epoxy insulated transformers shall be protected against solar radiation.

4.2.1.5 Silica gel shall be placed inside auxiliary panels and packages containing control devices. The color of the silica gel shall be checked monthly.

4.2.1.6 All inlets of HV and LV, auxiliary boxes shall be kept plugged. The same applies to flanged connections to radiators when said accessories are supplied separately.

4.2.1.7 The metal parts of bushings shall be protected with neutral mineral jelly (“Vaseline”).

4.2.1.8 The drums containing insulating oil shall be stored in horizontal mounting position, laying on beams swooden sleeper. They shall be arranged so as to have the top in the same horizontal line.

4.2.1.9 The inert gas pressure in transformers and reactors received under pressure shall be checked weekly. Pressure shall be kept within the values specified by the manufacturer.

4.2.1.10 The float of the oil level gauge shall be released from shipping supports before checking the oil level during the storage period.

4.2.1.11 The oil level and the existence of oil leakage in oil immersed transformers and reactors shall be checked monthly so as to keep, the oil level as specified by the manufacturer. Should it be necessary to replenish the oil level, the recommendations of item 6.2.1.7 of this Standard shall be followed. The insulating oil drain valves shall be kept closed with plugs.

4.2.1.12 Upon reception and at every six month intervals the insulation resistance of the windings of transformers and reactors shall be measured. The minimum acceptable value shall be of 15 M Ω /kV being the insulation level at 40 °C for oil immersed transformers and reactors. The values obtained shall be corrected to the temperature of 40 °C according to standard ABNT [NBR 7036](#). The measurement for transformers shall be made according to standard ABNT [NBR 5356-1](#).

4.2.1.13 Dry type or without oil transformers and reactors presenting low insulation shall be dried according to the instructions of manufacturer and standard ABNT [NBR 7036](#).

4.2.1.14 In oil-immersed transformers and reactors showing evidence of low insulation, the dielectric strength of the oil shall be measured according to item 6.2.1.8.

4.2.2 Grounding Resistors

4.2.2.1 All resistors shall be stored in leveled position on wooden sleeper or boards.

4.2.2.2 Grounding resistors manufactured for internal installation shall be stored in a sheltered place.

4.2.2.3 Grounding resistors stored on weather shall be covered with plastic canvas.

4.2.3 Control Panels, Protection Panels, Signaling Panels, Auxiliary Panels, Rectifiers and Inverters

4.2.3.1 Panels, inverters and rectifiers shall be stored in a clean, dry and sheltered place protected against mechanical damages.

4.2.3.2 Panels, rectifiers and inverters shall be placed on wooden gratings.

4.2.3.3 Silica gel shall be placed inside panels, rectifiers and inverters, as well as inside separately shipped packages of relays, instruments and electronic components. When the panels, rectifiers and inverters are fitted with electronic components, silica gel shall be put near these components. The use of silica gel is not mandatory in auxiliary panels not containing electromechanical control devices and in compartment of panels in which the space heaters resistance is always kept on.

4.2.3.4 The color of the silica gel shall be checked monthly.

4.2.3.5 The space heaters shall be kept on and the thermostats shall be set to 40 °C. The temperature inside the compartments of panels, rectifiers and inverters shall be checked monthly. The temperature readings shall be taken in the upper part of the compartments and it shall be higher than the room temperature.

4.2.3.6 Panels, rectifiers and inverters shall be covered with plastic canvas in case the package of the manufacturer does not show satisfactory protection conditions.

4.2.3.7 Upon reception and at each six-month interval an anti-oxidant product shall be applied to breaker mechanisms according to instructions of the manufacturer.

4.2.4 Storage Batteries

4.2.4.1 Since the receipt, the accumulator batteries shall be stored in leveled position in a sheltered, clean and dry place free from heat generating sources and solar radiation.

4.2.4.2 Battery cells supplied in steel containers shall be protected upon receipt with anti-oxidant oil.

4.2.4.3 The storage batteries shall be kept clean. Neutral mineral jelly ("Vaseline") shall be applied to the elements' terminals upon receipt and at each three-month intervals.

4.2.4.4 Alkaline batteries shall be stored dry and discharged. In case alkaline batteries happen to be received charged with electrolyte they shall be maintained in float operation, after checking the original amount of charge, according to the instructions of the manufacturer.

4.2.4.5 In alkaline batteries stored with electrolyte, the same shall be kept at the specified density. In addition, its level shall be maintained between maximum and minimum marks according to the instructions of the manufacturer.

4.2.4.6 Valve seats of alkaline batteries stored without electrolyte shall be kept sealed.

4.2.4.7 Acid batteries received with electrolyte and charged, shall be periodically charged or shall be kept floating, after checking the amount of charge according to instructions of the manufacturer.

4.2.4.8 The electrolyte acid batteries stored as instructed in item 4.2.4.7 shall be kept at the specified density. Its level shall be kept between maximum and minimum marks according to instructions of the manufacturer. When the level falls in such an extent to leave the plates exposed, the manufacturer shall be consulted prior to replenishment.

4.2.5 Circuit Breakers for Outdoor Installation

4.2.5.1 Circuit breakers and components subject to accumulation of dust shall be covered with plastic canvas.

4.2.5.2 Since the receipt, space heaters shall be kept on.

4.2.5.3 Upon receipt, the metal parts of the bushings shall be protected with a suitable anti-oxidant product according to the instructions of the manufacturer.

4.2.5.4 The moving metallic parts of the operating mechanism shall be lubricated upon reception and each 6 months according to the instructions of the manufacturer.

4.2.5.5 The level of insulating oil and the existence of oil leakage shall be checked upon receipt and monthly. The circuit breakers showing signs of leakage shall be repaired following the instructions of the manufacturer. Whenever necessary, the level shall be replenished with a compatible type of oil according to item 6.2.1.7.

4.2.5.6 When circuit breakers with instruments and bushings already assembled on the equipment, such components shall be protected with a wooden box.

4.2.5.7 Positive pressure must be kept on circuit breakers received with the poles assembly pressurized by inert gas. In case leakage is detected, corrective actions shall be taken according to the instructions of manufacturer.

4.2.5.8 The pressure of insulating gas cylinders shall be checked weekly since the date of receipt in order to verify the existence of leakage.

4.2.6 Instrument Transformers for Outdoor Installation

4.2.6.1 Instrument transformers shall be stored in a sheltered place.

4.2.6.2 Upon receipt and at each six month interval the insulation resistance of the transformers shall be measured. The minimum allowable value shall be 15 MΩ/kV being the insulation level at 40 °C. The values obtained shall be corrected to the temperature of 40 °C according to standard ABNT NBR 7036, Table 3.

4.2.6.3 Dry or without oil transformers presenting low insulation shall be dried according to the instructions of the manufacturer.

4.2.6.4 Oil immersed transformers showing low insulation shall have the dielectric strength of the oil measured according to item 6.2.1.8.

4.2.6.5 The oil level and the existence of leakage shall be checked upon receipt and monthly. Transformers showing evidence of leakage shall be repaired according to the instructions of the manufacturer. Whenever necessary, the level of insulating oil shall be replenished according to item 6.2.1.7.

4.2.7 Dry Disconnecting Switches

4.2.7.1 The disconnecting switches shall be stored in wooden crates in a dry and sheltered place since the receipt.

4.2.7.2 The moving and fixed contacts shall be protected against corrosion by applying anti-oxidant grease upon receipt and at each six month intervals.

4.2.7.3 Upon receipt and at each six month interval oil or grease lubricating system shall be refilled according to the instructions of the manufacturer.

4.2.8 Oil Immersed Disconnecting Units

4.2.8.1 The disconnecting units shall be stored leveled on wooden sleeper or boards in order to avoid the direct contact with the soil.

4.2.8.2 The disconnecting units stored outdoors shall be covered with plastic canvas.

4.2.8.3 All split-sleeve flanges and conduits entries shall be kept plugged.

4.2.8.4 The heating resistors shall be kept on.

4.2.8.5 Drums containing insulating oil shall be stored in horizontal mounting position, laying on beams. They shall be arranged so as to have the top plugs in the same horizontal line.

4.2.8.6 The inert gas pressure in disconnecting units received under pressure shall be checked monthly, and it shall be kept within the values specified by the manufacturer.

4.2.9 Capacitors

4.2.9.1 Capacitors shall be stored in leveled position in a sheltered place protected against mechanical damages.

4.2.9.2 The existence of leakage shall be checked upon receipt and at each six months.

4.2.9.3 The insulation resistance shall be measured upon receipt and at each six month interval according to standard ABNT NBR 5060.

4.2.10 Generators and Motors

4.2.10.1 Generators and electric motors must be stored in a sheltered place. Large equipment, or skid-mounted equipment, which have to be stored outdoors shall be covered with impervious canvas.

4.2.10.2 When equipment are supplied with their instruments already assembled such components shall be protected against mechanical damages with wooden boxes.

4.2.10.3 The rotor of equipment having sleeve bearings shall be kept locked.

4.2.10.4 The coupling, shaft end and other machined surfaces shall be kept protected with an anti-oxidant product applied each three months.

4.2.10.5 The oil reservoirs of the equipment bearings shall be kept filled up according to the instructions of the manufacturer.

4.2.10.6 In equipment provided with collector rings and brushes, clearances shall be ensured between the brushes and the rings according to the instructions of the manufacturer.

4.2.10.7 The heating resistors of the equipment shall be kept energized. Periodic inspections shall be provided in order to ensure the continuous functioning.

4.2.10.8 Each three months the insulation resistance of equipment windings shall be measured in accordance with standard IEEE Std 43. Equipment showing insulation resistance below the minimum value allowable shall be dried taking into account the instructions of the manufacturer. The minimum value is $(kV+1) M\Omega$, at 40 °C, kV being the insulation level of the equipment.

4.2.10.9 The rotor of the equipment shall be rotated manually each 15 days for about ten revolutions leaving it in a position different from the previous one. For equipment having oil lubricated bearings or sleeve bearings the instructions of the manufacturer shall be followed taking into account the necessity of pre-lubrication prior to running the machine.

5 FOUNDATIONS AND BASES

The requirements 5.1 and 5.2 are valid for all equipment listed in item 1.

5.1 Prior to installing the equipment on the base the existence of interference that can impair the interconnections of cables or conduits with the equipment shall be checked.

5.2 The positioning and dimensions of the foundations base, the positioning of mounting bolts, leveling, as well as the quotes and location of the incoming conduits must comply with the design drawings and specifications.

6 MOUNTING OF EQUIPMENT

The requirements provided in General Conditions apply to all equipment listed in item 1, and they shall be complemented with the specific conditions applicable to the equipment in reference, if any.

6.1 General Conditions

6.1.1 The contractor shall provide adequate means to be used in shipment and installation of the equipment on the their foundations. Recommendations of the manufacturers shall be followed.

6.1.2 Compliance with the design drawings and specifications, and recommendations of the manufacturer, as well as the mounting procedures previously approved shall be accomplished in all stages of equipment and accessories mounting, namely:

- a) foundation;
- b) alignment;
- c) fastening;
- d) leveling;
- e) final attachment;
- f) connections with cables, conduits, cable glands and other couplings;
- g) interconnection and identification of protection, measuring, signaling, heating, command, alarm and interlocking circuit.

6.1.3 Fastening devices for single cables in alternating current circuits shall be of non-magnetic material.

6.1.4 If necessary, gaskets shall be replaced. Additional gaskets shall be provided as necessary to cover points not foreseen due to manufacturing deficiencies.

6.1.5 Grounding and electric continuity between the several metal parts of the equipment and the connections thereof shall be provided in conformity with the design. A low impedance return path for fault currents shall be also assured.

6.1.6 The mounting procedures for equipment shall comply with the standards and recommendations of the manufacturers. They shall cover at least the following topics:

- a) object;
- b) scope;
- c) applicable standards;
- d) description and procedures for carrying out the services;
- e) required equipment and tools;
- f) acceptance criteria.

6.1.7 The mounting procedures shall be specific for the equipment involved.

6.1.8 After mounting the equipment, all threaded pieces and connections shall be properly re-tightened.

6.2 Specific Conditions

6.2.1 Power Transformers and Reactors

6.2.1.1 The documents mentioned in item 6.1.2, regarding the steps of equipment mounting shall be complemented by the procedures established in standards ABNT [NBR 7036](#).

6.2.1.2 There shall not be gaps or stresses between coupled parts, such as coupling flanges with bus ducts, connections with conduits and split-sleeves.

6.2.1.3 The grounding of transformer neutral shall be made employing conductors of size and insulation level as specified in the design.

6.2.1.4 In the connection of the bus to the transformer or reactor, the links shall be placed and tightened in order to keep the same spacing between them. The length of the bolts shall not impair the spacing between phases and phase-ground.

6.2.1.5 As to preparation and execution of transformer cable terminations the following items shall be observed:

- a) type and voltage level;
- b) phase sequence of the system;
- c) distance between phase and structure;
- d) position and fastening of the termination;
- e) connection of the grounding braid to the ground grid, in case of shielded or armored cables.

6.2.1.6 The accessories or parts thereof that have possibly been fastened or plugged for purposes of transportation shall be released.

6.2.1.7 For oil immersed equipment the filling or replenishment of oil level shall be performed according to manufacturer's recommendations using filter press. The dielectric strength of the insulating oil shall be previously measured according to item 6.2.1.8.

6.2.1.8 The dielectric strength of the insulating oil shall be measured according to standard ABNT-NBR-6869. The minimum value allowed shall be 30 kV. When the dielectric strength is lower than the minimum allowed, a treatment for recovery of the insulating oil shall be effected, according to the instructions of the manufacturer.

6.2.2 Grounding Resistors

The interconnection cable between transformer neutral bushing and grounding resistor must pass through the CT, if any.

6.2.3 Bus ducts

6.2.3.1 The path of bus ducts shall be checked as to possible interference prior to mounting.

6.2.3.2 If necessary, additional supports for bus ducts shall be installed.

6.2.3.3 Walls or bulkheads penetrations shall be sealed.

6.2.4 Control Panels, Protection Panels, Signaling Panels, Auxiliary Panels, Rectifiers and Inverters

6.2.4.1 The bus shall be checked as to alignment, connections, and fastening, distance between phases and phases and structure, according to manufacturer's drawings.

6.2.4.2 The mechanical adjustments of contactors having rated voltage greater than 480 volts and circuit breakers, except those of molded case type, shall be made according to manufacturer's recommendations.

6.2.4.3 The position and fastening of arc extinction chambers and separators shall comply with manufacturer's drawings.

6.2.4.4 The movement of circuit breakers and drawers, auxiliary contacts operating levers, limit switch and manual operation shall be checked as to proper motion and to mechanical behavior inside, careful attention shall be given to the engagement system.

6.2.4.5 The draw out mechanism shall be checked as to proper the motion.

6.2.4.6 All panel components shall be checked as to the characteristics thereof, fastening and/or engagement system, interconnections and grounding according to the design specifications and certified manufacturer's drawings.

6.2.4.7 The interconnection, terminations and identification of power and control circuits shall comply with the design specifications and manufacturer's drawings.

6.2.4.8 Compartment doors shall be checked as to proper opening and closing. They shall be adjust if necessary.

6.2.5 Storage Batteries

6.2.5.1 The support, installation of separators and insulators, number of cells and their interconnections between shall comply with the design specifications and manufacturer's instructions.

6.2.5.2 For alkaline batteries shipped dry, the electrolyte shall be prepared according to manufacturer's instructions. The cell containers shall be filled with the electrolyte only when the corresponding rectifier is considered ready to start applying equalizing charge or keeping the batteries floating, according to the manufacturer instructions. After addition of the electrolyte, the direct current system shall be tested according to item 8.2.5.

6.2.6 Circuit Breakers for Outdoor Installation

6.2.6.1 When mounting the circuit breaker the following items shall be checked such that they comply with the design specifications and manufacturer's drawings:

- a) bushings, insulators and capacitors;
- b) junction box, control panel and accessories;
- c) busbar fastening, wiring, identification, connections and interlocking;
- d) sight glass, thermometers, pressure gauges and pressure switch;
- e) valves and accessories;
- f) reservoirs and pressure systems;
- g) relative position of the poles, according to number stamped on the part.

6.2.6.2 Equipment immersed in oil, the filling or replenishment of oil level shall be performed according to provisions of item 6.2.1.7.

6.2.7 Dry Disconnecting Switches

6.2.7.1 Installation and mounting of the switch shall comply with the recommendations of the manufacturer, design specifications and standard IEEE C 37.35 where applicable.

6.2.7.2 Upon installation of the disconnecting switch the following items shall be checked such that they comply with the design specifications and manufacturer's drawings:

- a) insulator columns and supports;
- b) fastening, alignment and adjustments of blades, operating levers, clips and arc horns;

- c) grounding devices, auxiliary contacts, and junction and interconnection box;
- d) mechanism for manual or remote actuation and accessories;
- e) wiring, connections, identification and interconnection.

6.2.8 Oil Immersed Disconnecting Units

6.2.8.1 There shall not be gaps or stresses between coupled parts, such as conduits and half-pipes.

6.2.8.2 Upon mounting the disconnecting switch, the following items shall be checked such that they comply with the design specifications and manufacturer's drawings:

- a) gaskets and covers;
- b) bar insulators, "links" and passage insulators;
- c) distance between bars, between bars and housing and between the ends of each bar of the same phase with the "link" removed;
- d) alignment and position of movable and fixed contacts;
- e) vent, drain, level sight, space heater and thermostats;
- f) pressure relief valve, sample and filling valve;
- g) auxiliary contacts and limit switch;
- h) voltmeter, VT, CT and fuses;
- i) wiring, connections and interlocking;
- j) muffles, terminals and connections;
- l) grounding.

6.2.8.3 The filling or replenishment of oil level shall be performed according to the provisions of item 6.2.1.7.

6.2.9 Capacitors

6.2.9.1 In case of capacitors mounted in cubicles, mounting and connection of ventilation and exhaust systems shall comply with the recommendations of the manufacturer.

6.2.9.2 The capacitors shall be arranged so as to allow heat dissipation by radiation and convection. Adequate air circulation around each unit shall be provided.

6.2.10 Terminal Block Box

In case of boxes interconnected by conduits there shall not be gap or stress in the coupled parts.

6.2.11 Generators and Motors

6.2.11.1 The mechanical requirements relating to mounting, alignment, leveling, grading, coupling of motors and generators shall be in conformity with the mounting standards applicable to driven and driver equipment, respectively.

6.2.11.2 Equipment rotor having sleeve bearings shall be kept locked during any motion of the equipment.

6.2.11.3 For large size equipment in which the rotor comes separate from stator, the following shall be adopted:

- a) the winding, core installation shims and fans shall be inspected and, if necessary, the external cleaning of the rotor by means of dry air shall be performed prior to introduction in the stator;
- b) the clearances of the air gap shall be measured at points equally spaced apart (at least 4) in both ends of the stator and at several positions of the rotor.

6.2.11.4 The auxiliary systems below shall be mounted according to design specifications and manufacturer's drawings:

- a) excitation system;
- b) speed regulation system;
- c) voltage regulation system;
- d) surge protection system;
- e) grounding system;
- f) lubrication system;
- g) cooling system;
- h) fire protection system.

6.2.11.5 Upon the installation generators and motors the following items shall be checked such that they comply with the design specifications and manufacturer's drawings:

- a) covers, linings and sealing joints of the equipment;
- b) thermostats, pressure switches, water and oil level indicators and temperature sensors;
- c) distance between collecting rings;
- d) brush holder and brushes;
- e) space heater;
- f) vibration protection device;
- g) shaft axial displacement protection device;
- h) bearing grounding device.

7 PRESERVATION AFTER MOUNTING

The requirements prescribed in the general conditions apply to all equipment listed in item 1, and they shall be complemented with the specific conditions applicable to the equipment in reference, if any.

7.1 General Conditions

As to preservation, the requirements set forth in items 4.1.2 to 4.1.8 and item 4.1.10 of this Standard apply.

7.2 Specific Conditions

7.2.1 Power Transformers and Reactors

7.2.1.1 Silica gel shall be placed inside auxiliary panels having control devices. The color of the silica gel shall be checked monthly.

7.2.1.2 Monthly checks shall be provided in order to keep steady the level of the sealing liquid in the silica gel container.

7.2.1.3 The metallic parts of bushings, terminals, clips or connectors and contact areas of power fuses shall be protected with neutral mineral jelly ("Vaseline").

7.2.1.4 Level, temperature, pressure instruments, as well as those fitted with capillary tubes shall be protected with wooden box.

7.2.1.5 The oil level and the existence of oil leakage in oil immersed transformers and reactors shall be checked monthly, so as to keep the oil level as specified by the manufacturer. Should it be necessary to replenish the oil level, the recommendations of item 6.2.1.7 of this Standard shall be followed. The insulating oil drain valves must be kept closed with plugs.

7.2.1.6 The spare inlets shall be kept plugged with suitable devices to the area classification.

7.2.1.7 The insulation resistance of the windings of transformers and reactors must be measured each three months according to item 4.2.1.12.

7.2.1.8 Transformers and reactors shall be dried according to manufacturer's instructions and ABNT NBR 7036, Annex C, where applicable, whenever low insulation due to the absorption of humidity is detected.

7.2.1.9 The dielectric strength of the insulating oil shall be measured each three months according to item 6.2.1.8.

7.2.1.10 The bushings shall be protected with a spray of silicone based product when they are subjected to drip of paint or excessive accumulation of dust.

7.2.1.11 The bushings shall be inspected each three months as to the existence of cracks or damaged parts.

7.2.2 Bus Ducts

The heating resistor, if employed, shall be kept energized setting the thermostat to 40 °C.

7.2.3 Command Panels, Protection Panels, Signaling Panels, Auxiliary Panels, Rectifiers and Inverters

7.2.3.1 The heating resistors shall be kept on and the thermostats shall be set to 40 °C. The temperature inside the compartments of panels, rectifiers and inverters shall be checked monthly. The temperature reading shall be taken in the upper part of the compartments, and it shall be higher than the room temperature.

7.2.3.2 Silica gel shall be put inside panels, rectifiers and inverters. In special, when they are fitted with electronic components, the silica gel shall be placed near these components. The use of silica gel is not required in auxiliary panels not having electromechanical and electronic control devices and in compartments of panels in which the space heater is always kept on.

7.2.3.3 The color of the silica gel shall be checked monthly.

7.2.3.4 Panels subject to accumulation of dust or humidity from other services shall be covered with plastic canvas.

7.2.3.5 Panels, rectifiers and inverters shall be properly protected against mechanical damages.

7.2.3.6 Instruments, sight glasses and accessories installed in doors shall be individually and suitably protected.

7.2.3.7 Each six months an anti-oxidizer product shall be applied to the mechanisms of the circuit breakers according to the instructions of the manufacturer.

7.2.3.8 The spare inlets shall be kept plugged with suitable devices to the area classification.

7.2.4 Storage Batteries

7.2.4.1 Cells supplied in metallic containers shall be protected with anti-oxidant oil according to the instructions of the manufacturer.

7.2.4.2 Neutral Vaseline shall be applied to the batteries' terminals each 3 months.

7.2.4.3 Batteries shall be kept charged in floating and/or applying equalization charge according to the instructions of the manufacturer.

7.2.4.4 The electrolyte shall be kept at the specified density as well as between maximum and minimum marks.

7.2.4.5 When the electrolyte level of acid batteries is low enough to let part of the plates exposed to air, the manufacturer shall be consulted.

7.2.5 Circuit Breakers for Outdoor Installation

7.2.5.1 The heating resistors shall be kept on.

7.2.5.2 Metallic parts of bushings shall be protected with a suitable anti-oxidizer according to instructions of the manufacturer.

7.2.5.3 The moving metallic parts of the operating mechanism shall be lubricated each 6 months according to instructions of the manufacturer.

7.2.5.4 The oil level and the existence of oil leakage shall be checked monthly. Circuit breakers showing evidence of leakage shall be repaired following the instructions of the manufacturer. The level of insulating oil shall be replenished using a compatible type of oil according to item 6.2.1.7.

7.2.5.5 The bushings shall be protected with a spray of silicone based product when they are subjected to drip of paint or excessive accumulation of dust.

7.2.5.6 In gas-filled circuit breakers, the pressure of the insulating gas shall be measured monthly according to instructions of the manufacturer, to check the existence of gas leakage. When the insulating gas pressure is below the recommended value, it shall be restored using the instructions of the manufacturer.

7.2.5.7 The dielectric strength of the insulating oil shall be measured each three months according to item 6.2.1.8.

7.2.5.8 Connecting terminals shall be protected with anti-oxidizer paste.

7.2.6 Insulators and Lightning Arresters

Insulators and bushings must be protected with a spray of silicone based product when they are subjected to drip of paint or excessive accumulation of dust.

7.2.7 Instrument Transformers for Outdoor Installation

7.2.7.1 The insulation resistance shall be measured each six months between primary and ground, secondary and ground and between primary and secondary according to item 4.2.6.2.

7.2.7.2 The dielectric strength of the insulating oil shall be measured each six months according to item 6.2.1.8.

7.2.7.3 The oil level and the existence of oil leakage shall be checked and recorded monthly. Transformers showing evidence of leakage shall be repaired following the instructions of the manufacturer. The level of insulating oil shall be replenished using a compatible type according to item 6.2.1.7.

7.2.7.4 The bushings shall be protected with a spray of silicone based product when they are subjected to drip of paint or excessive accumulation of dust.

7.2.8 Dry Disconnecting Switches

7.2.8.1 The spare inlets shall be kept plugged with devices approved to the area classification.

7.2.8.2 The moving and fixed contacts shall be protected against corrosion applying anti-oxidant grease upon receipt and each six months.

7.2.8.3 Lubricating devices shall be provided with oil or grease each six months according to the instructions of the manufacturer.

7.2.8.4 In motor driven disconnecting switches the insulation resistance of motors shall be measured each six months after mounting. The minimum value acceptable shall be of 2 MΩ/kV at 40 °C.

7.2.8.5 The bushings shall be protected with a spray of silicone based product when they are subjected to drip of paint or excessive accumulation of dust.

7.2.9 Oil Immersed Disconnecting Units

7.2.9.1 All spare inlets shall be kept plugged with devices approved to the area classification.

7.2.9.2 Space heaters shall be kept on.

7.2.9.3 The insulation resistance between each phase and the other interconnected and grounded and between each phases and ground after replenishment with oil and each six months. The minimum value shall be of 2 MΩ/kV at 40 °C.

7.2.9.4 The oil level and the existence of oil leakage must be checked each six months, so as to keep the oil level as specified by the manufacturer. Should it be necessary to replenish the oil level, the recommendations of item 6.2.1.7 shall be followed. The insulating oil drain valves shall be kept closed with plugs.

7.2.9.5 The dielectric strength of the insulating oil shall be measured each six months according to item 6.2.1.8.

7.2.9.6 The operating mechanism shall be lubricated each six months.

7.2.10 Capacitors

7.2.10.1 Check for leakage shall be carried out each six months.

7.2.10.2 The insulation resistance of capacitors shall be measured each six months according to standard ABNT NBR 5060.

7.2.10.3 Neutral mineral jelly (“Vaseline”) shall be applied to the terminals of capacitors each 3 months.

7.2.11 Generators and Motors

7.2.11.1 When subject to excessive accumulation of humidity and dust, the equipment shall be covered with plastic canvas. The inlets not used shall be kept plugged.

7.2.11.2 Instruments mounted on the equipment, as well as devices having local command, shall be protected with wooden boxes.

7.2.11.3 The coupling, shaft end and other machined surfaces shall be kept protected with an anti-oxidant product applied each 3 months.

7.2.11.4 The oil reservoirs of the equipment bearings shall be kept with oil according to the instructions of the manufacturer.

7.2.11.5 In equipment provided with collector rings and brushes, clearances shall be ensured between the brushes and the rings, according to the instructions of the manufacturer.

7.2.11.6 The heating resistors of the equipment shall be kept energized and the functioning thereof shall be checked periodically in order to guarantee the continuous functioning.

7.2.11.7 The insulation resistance of equipment windings shall be measured in accordance with IEEE Std 43. Equipment showing insulation resistance below the minimum value allowable shall be dried taking into account the instructions of the manufacturer. The minimum value is $(kV+1) M\Omega$, at 40 °C, kV being the insulation level of the equipment.

7.2.11.8 The rotor of the equipment shall be rotated manually each 15 days for about ten revolutions leaving the shaft in a position different from the previous one. For equipment having oil lubricated bearings or sleeve bearings the instructions of the manufacturer shall be followed taking into account the necessity for pre-lubrication of the bearings prior to running the machine.

8 TESTS

8.1 General Conditions

8.1.1 Prior to performing the tests, a visual checking as to the conditions of installation and cleaning and of all equipment shall be made.

8.1.2 All tests shall be performed according to the requirements contained in design specifications, manufacturer's recommendations and the standards listed below, when applicable, including those according to which the equipment was manufactured:

- a) ABNT: [NBR-5060](#); [NBR-5286](#); [NBR-5356-1](#); [NBR-5356-6](#); [NBR-5383-1](#); [NBR 5383-2](#); [NBR-6855](#); [NBR-6856](#); [NBR-6869](#); [NBR 17094-1](#), [NBR 17094-2](#); [NBR IEC 60060-1](#), [NBR IEC 60034-9](#);

- b) ASTM: [D 877](#);
- c) NEMA: [MG1](#); [SG4](#);
- d) IEEE: [Std 32](#); [Std 43](#); [Std 112](#); [Std 114](#); [Std 115](#); [Std C37.09](#); [Std C37.09a](#); [Std C37.20.1](#); [C37.35](#); [Std C50.13](#).

8.1.3 The equipment test procedures must cover at least the following topics:

- a) object;
- b) scope;
- c) applicable standards;
- d) description and test method;
- e) test equipment used;
- f) tools required;
- g) acceptance criteria;
- h) test parameters.

8.1.4 The procedures shall cover the foreseen tests in this Standard and the recommendations of the manufacturer.

8.1.5 The procedures shall be specific for the equipment involved.

8.1.6 When performing the tests of insulation resistance, ohmic resistance and dielectric tests the room temperature shall be recorded.

8.1.7 When performing the dielectric tests, the relative humidity of the air shall be recorded.

8.1.8 After performing the tests, the one performing the tests shall issue a certificate containing attached thereto the specific test sheet for each equipment standardized by standard PETROBRAS [N-1659](#) having all data and results recorded.

8.2 Specific Conditions

8.2.1 Power Transformers and Reactors

They shall be subjected to the following checkouts:

- a) checking transformation ratio of transformers in all positions of tap changing switch using T.T.R., placing the tap in the design position afterwards;
- b) measuring the ohmic resistance of windings using the bridge method. For transformers the measurement shall be made with the switch in the position of highest tap;

- c) calibration of the temperature indicator using the standard thermometer;
- d) checking the pressure of the clips and continuity of transformer high voltage fuses;
- e) plotting of saturation curve of bushing CTs of transformers;
- f) measuring insulation resistance of transformer fuses supports;
- g) setting measurement, protection and signaling instruments;
- h) checking continuity of protection, measurement and signaling auxiliary circuits;
- i) measuring insulation resistance of the following items, if applicable:
 - protection, measurement and signaling auxiliary circuits;
 - fan motors;
 - bushing CTs;
 - high voltage fuses;
- j) simulating operation of sudden pressure rise relay or gas detection relay;
- l) checking direction of rotation of forced-air fans;
- m) simulating operation of all protection taking into account control, signaling, alarm and protection.

8.2.2 Grounding Resistors

They shall be subjected to the procedures listed below:

- a) measuring ohmic resistance, effecting correction to the reference temperature;
- b) measuring insulation resistance. The minimum acceptable value shall be 2 MΩ/kV;
- c) checking polarity of current transformer;
- d) plotting of saturation curve of CT, comparing against manufacturer's curve;
- e) checking continuity of power and control interconnections;
- f) injecting current in the circuit of CT and observation of relay operation;
- g) checking of transformation ratio of CT.

8.2.3 Bus Duct

They shall be subjected to the following checkouts:

- a) checking continuity of bus;
- b) measuring insulation resistance between phases and between phases and ground. The minimum value allowed shall be of 2 MΩ/kV;
- c) applying voltage to the bus of a voltage level equal to or greater than 5 kV according to standard ANSI C 37.20. The insulation resistance test shall be repeated after performing the dielectric tests;
- d) checking phase sequence.

8.2.4 Control Panels, Protection Panels, Signaling Panels and Auxiliary Panels

They shall be subjected to the following checkouts:

- a) manual operation of all components, assuring that all movable parts are being freely displaced without locking;
- b) checking the conditions of opening and closing of doors, as well as the withdrawal systems and barriers between busbar compartments and circuit breakers or contactors;
- c) checking doors opening locking under the condition of energized circuit;
- d) measuring wiring insulation resistance;
- e) checking polarity and continuity of current circuits;
- f) checking busbar continuity;
- g) measuring busbar insulation resistance between phases and between phase and ground;
- h) applying voltage to the busbar of panels of voltage level equal to or greater than 5 kV;
- i) measuring component insulation resistance after removing the electronic cards. The minimum allowed value shall be 2 MΩ/kV;
- j) checking continuity and pressure of the clips of power fuses;
- k) checking transformation ratio of CTs, VTs and polarity of CTs according to standards ABNT [NBR 6820](#) and [NBR 6821](#);
- l) plotting the saturation curve of protection CTs, except those connected to thermal relay and “ground sensor” protection;
- m) checking alignment of moving and fixed contacts of contactors having rated current above 100 A and circuit breakers, except those of molded case type;
- n) measuring contacts ohmic resistance of contactors having voltage greater than 480 V and circuit breakers, except those of molded case type;
- o) checking contact simultaneous opening and closing of contactors having voltage greater than 480 V and circuit breakers, except those of molded case type;
- p) measuring insulation resistance of electromechanical relays of contacts to ground, coils to ground, and between contacts edges. The minimum value allowed shall be 1 MΩ. The voltage during the test shall not be greater than 200 VDC;
- q) setting and calibration protection relays and plotting actuation curve on the taps and design time settings;
- r) setting of thermal relays and checking operating time in each phase and in the three phases with the elements in series;
- s) identification and seal of calibrated and adjusted relays;
- t) calibration of instruments;
- u) checking actuation of molded case circuit breakers injecting current above the rated value;
- v) checking tripping and closing time for circuit breakers intended to provide parallel operation of different generation systems, automatic transfer and reacceleration systems;
- w) performing operational test taking into account:
 - operation of changeover switch;
 - manual and automatic, local and remote operation of contactors and circuit breakers;
- x) performing simulated functional test involving control and protection taking into account signaling and interlocks;
- y) performing panel functional test effecting simulated operation of external circuits in the terminal blocks board. For the final functional test involving interconnections between equipment, the simulations shall be made directly on the control, protection and interlocking devices of the several equipment;

z) injection of current in CT circuits and checking the operation of the relays.

8.2.5 Rectifiers, Storage Batteries and Inverters

They shall be subjected to the following checkouts:

- a) checking opening and closing conditions of the doors;
- b) checking continuity and pressure of power fuses clips;
- c) checking the actuation of molded case circuit breakers injecting current above the rated one;
- d) calibration of measuring instruments;
- e) checking polarity of interconnections with batteries and consumers;
- f) performing operational tests of rectifiers and inverters observing:
 - operation of changeover switches;
 - signaling, interlocking and noise level;
 - functioning of exhaust and ventilation system;
- g) performing simulated operation test of direct current system protections;
- h) checking level and density of electrolyte in the batteries;
- i) checking tightness of connections between elements as well as polarity per element;
- j) adjusting of voltage, current and frequency of equipment;
- l) applying charge cycle in batteries according to the instructions of the manufacturer;
- m) checking the rectifiers as to components intended to keep the voltage in consumers and batteries within the limits established for the several load conditions such as drop diode unit, and charge status of batteries;
- n) performing rated capacity test of batteries according to instructions of manufacturer, effecting charging and recharging cycle;
- o) recording voltage out put and volts per cell, current and frequency for the several load conditions;
- p) measuring ripple voltage on consumer terminals with the batteries connected to the system and comparing against the specified values;
- q) simulating automatic transfer and operation of static switch and recording the waveform on the oscillograph.

8.2.6 Circuit Breakers for Outdoor Installation

They shall be subjected to the following checkouts:

- a) checking opening and closure of inspection windows and door of auxiliary control panel;
- b) measuring contact ohmic resistance comparing the obtained results against those provided by the manufacturer;
- c) measuring circuit breaker insulation resistance according to the instructions of the manufacturer. The obtained value shall be in accordance with that specified by the manufacturer; in case no other guideline is available, 10 000 MΩ at 20 °C shall be adopted as the minimum value;
- d) checking continuity of control wiring;
- e) checking simultaneity of closing and opening;

- f) checking opening and closing in test and operation positions, including observation of auxiliary contacts and limit switch operation, interlocking and signaling, control and alarm devices;
- g) calibration of direct acting relays and instruments;
- h) checking opening and closing time in case of circuit breakers intended to provide parallel operation of different generation systems, automatic transfer and reacceleration;
- i) actuating local and remote opening and closing command observing the behavior of the circuit breaker and the signaling;
- j) checking the operation of pneumatic system;
- l) checking the operation cycle with energy stored in the operating mechanism;
- m) checking the voltages of control auxiliary circuits, which shall be within the allowed range when the circuit breaker is locally and remotely operated.

8.2.7 Insulators and Lightning Arresters

They shall be subjected to insulation resistance measurement using Megger for voltage level up to 5 kV inclusive, and dielectric tests for higher voltage levels.

8.2.8 Protection and Measurement Transformers for Outdoor Installation

They shall be subjected to the checkouts listed below:

- a) checking polarity of protection CTs according to ABNT NBR 6821;
- b) measuring windings ohmic resistance of protection CTs;
- c) checking transformation ratio;
- d) plotting saturation curve of protection CTs;
- e) checking continuity of CTs secondary;
 - f) measuring insulation resistance. The minimum value allowed shall be 2 MΩ/kV.

8.2.9 Dry Disconnecting Switches

They shall be subjected to the checkouts listed below:

- a) measuring insulation resistance between each phase and the other interconnected and grounded phases. The minimum value acceptable must be of 2 MΩ/kV à 40 °C;
- b) measuring insulation resistance between the poles of each phase. The minimum value acceptable shall be of 2 MΩ/kV referred to 40 °C;
- c) checking and identifying phasing;
- d) measuring ohmic resistance of the contacts of each phase for switches of voltage level equal to or greater than 15 kV;
- e) measuring insulation resistance of command, protection and signaling wiring;
- f) checking opening and closing of main contacts;
- g) checking simultaneous closing operation both for local and remote command, observing the behavior of control, protection and signaling circuits.

8.2.10 Oil Immersed Disconnecting Units

They shall be subjected to the checkouts listed below:

- a) measuring of insulation resistance of busbar and switches;
- b) applying voltage to busbar with switch in the open position;
- c) measuring ohmic resistance of main contacts;
- d) alignment of movable and fixed contacts;
- e) checking electric continuity of alarm, command, protection and interlocking circuits;
- f) checking simultaneous opening and closing operation;
- g) checking feeder-grounding device;
- h) checking instrument transformers according to 8.2.8;
- i) adjusting measuring instruments, relays, thermostats and pressure switches;
- j) checking opening and closure observing the behavior of control, protection, and signaling and interlocking circuits.

8.2.11 Capacitors

They shall be subjected to the checkouts listed below:

- a) checking electric continuity of control circuits;
- b) applying 70 % of the voltage specified in ABNT [NBR 5282](#); the test procedure shall be in accordance with ABNT [NBR 5289](#);
- c) residual voltage test according to ABNT [NBR 5289](#).

8.2.12 Induction Motors and Direct Current Motors

They shall be subjected to the checkouts listed as follow:

- a) measuring ohmic resistance of windings using bridge in induction motors having rated voltage equal to or greater than 2,300 V;
- b) checking terminal connections in accordance with motor wiring diagram;
- c) checking continuity of temperature detectors internal to motor (RTD);
- d) testing and calibrating the control, protection and supply system in accordance with items 8.1 and 8.2.4 of this Standard;
- e) testing lubricating, refrigerating and pressurizing auxiliary systems, when applicable;
- f) measuring insulation resistance of machine surge protection device, when applicable;

Note: The remaining motor checks and tests shall be made after preparation for start up according to items 9.1, 9.2.10 and 9.2.11.

8.2.13 Generators and Synchronous Motors

They shall be subjected to the checkouts listed below:

- a) measuring windings ohmic resistance using bridge;
- b) measuring insulation resistance of insulated bearings, when applicable;
- c) checking continuity of temperature detectors internal to the machine (RTD);
- d) measuring insulation resistance of machine surge protection device, when applicable;
- e) checking terminal connections in accordance with machine wiring diagram;
- f) testing and calibrating command, protection and excitation system according to items 8.1 and 8.2.4;
- g) testing lubricating, refrigerating and pressurizing auxiliary systems, when applicable.

Note: The remaining machine checks and tests shall be made after preparation for start up according to items 9.1, 9.2.12 and 9.2.13.

9 PREPARATION TO START UP

The requirements provided in general conditions apply to all equipment listed in item 1, and shall be complemented with the specific conditions applicable to the equipment in reference, if any.

9.1 General Conditions

9.1.1 A general cleaning shall be effected in all equipment prior to start up.

9.1.2 All connections shall be checked and retightened if necessary.

9.1.3 The auxiliary circuits shall be energized checking whether the supply voltages are within the specified levels.

9.2 Specific Conditions

9.2.1 Power Transformers and Reactors

The following checkouts shall be effected:

- a) checking tap changer position, which shall be as specified in the design;
- b) measuring insulation resistance according to item 4.2.1.12;
- c) measuring dielectric strength of insulating oil if the time period between the last measurement and entry into operation is greater than one month according to item 6.2.1.8;
- d) checking the valve between gas relay and oil conservator, which shall be open as well as top and bottom butterfly valves of all radiators;

- e) checking internal pressure of sealed transformers, pressure shall be positive, otherwise, the transformer shall be pressurized according to manufacturer's instructions;
- f) reading primary and secondary voltages in transformers after energizing;
- g) observing noise level after energizing;
- h) observing the first hours of running taking into account the recommendations of the manufacturer.

9.2.2 Bus Ducts

The following checkouts shall be effected:

- a) inspecting the connections of "links" taking into account the distance between phases;
- b) measuring insulation resistance according to item 8.2.3 b);
- c) checking installation of gaskets and closing of inspection windows.

9.2.3 Control Panels, Protection Panels, Signaling Panels, Auxiliary Panels, Rectifiers and Inverters

The following checkouts shall be effected:

- a) checking installation of all bolts of covers of explosion proof equipment;
- b) checking whether the cards of electronic components are correctly placed and secured;
- c) checking after energizing the behavior and operation of change over switches and reading current and voltage in panel meters;
- d) checking phasing between busbars separated by interconnecting circuit breakers by means of measuring and comparing secondary voltages of VTs associated with each bus.

9.2.4 Circuit Breakers for Outdoor Installation

The following checkouts shall be effected:

- a) checking through the inspection windows the installation of components and the interior of auxiliary control panel;
- b) checking the settings of pressure switches of pneumatic system and insulating gas system;
- c) checking the existence of leakage in pneumatic and insulating gas systems;
- d) checking all electrical, pneumatic and insulating gas connections;
- e) measuring dielectric strength of insulating oil according to 6.2.1.8 if the time interval from the last measurement to the date of starting operation is greater than one month;
- f) observing the first hours of running after energizing.

9.2.5 Insulators and Lightning Arresters

Insulation resistance measurement using Megger for voltage level up to 5 kV inclusive, and applied voltage for higher voltage level shall be effected according to the design specification.

9.2.6 Measuring and Protection Transformers for Outdoor Installation

The following procedures shall be effected:

- a) checking continuity of current transformers secondary;
- b) measuring insulation resistance. The minimum value acceptable is 2 MΩ/kV at 40 °C;
- c) measuring dielectric strength of insulating oil according to 6.2.1.8, if the time interval from the last measurement to the date of starting operation is greater than one month.

9.2.7 Dry Disconnecting Switches

The measurement of insulation resistance of disconnecting switches between each phase and the other interconnected and grounded phases, and between the poles of each phase must be effected. The minimum acceptable value shall be of 2 MΩ/kV referred to 40 °C.

9.2.8 Oil Immersed Disconnecting Units

The following checkouts shall be effected:

- a) measuring dielectric strength of insulating oil according to 6.2.1.8, if the time interval from the last measurement to the date of starting operation is greater than one month;
- b) measuring insulation resistance of disconnecting switches between each phase and the other interconnected and grounded phases, and between the poles of each phase. The minimum value acceptable shall be of 2 MΩ/kV referred to 40 °C.

9.2.9 Capacitors

The following checkouts shall be effected:

- a) measuring insulation resistance of capacitors according to ABNT NBR 5060;
- b) observing the performance of ventilation and exhaust systems for capacitors installed in cubicles. The temperature shall not exceed that described in standard ABNT NBR 5060.

9.2.10 Induction Motors

The following checkouts shall be effected:

- a) replacement of grease in not shielded or not sealed ball or roller bearings;
- b) draining, flushing and filling oil in sleeve bearings according to specific manufacturer's instructions;
- c) examining the interior of motor, when there is inspection windows;
- d) checking the condition of sealing joints, replacing the damaged ones;
- e) rotating the motor manually after uncoupling;
- f) placing into operation lubricating, refrigerating and pressurizing auxiliary systems, when applicable;
- g) calibrating and adjusting local indicating instruments or instruments commanding alarm or tripping;
- h) measuring insulation resistance of windings according to standard IEEE Std-43. The minimum value shall be $(kV+1)M\Omega$, at 40 °C, kV being the insulation level of the equipment;
- i) checking power and control connections;
- j) registering in the oscillograph the starting current for motors having rated voltage equal to or greater than 2,300 V and low voltage motors having a starting time under load greater than 5 seconds;
- l) running the motor at rated voltage and unloaded, and observing its performance according to the following items;
- m) checking the direction of rotation, recording the number of revolutions and no load current;
- n) observing the temperature of bearings and windings during the first four hours of running;
- o) checking the noise level. In case of abnormal noise, measuring the noise level according to ABNT NBR 7566, and checking the allowable tolerance according to ABNT NBR 7565;
- p) measuring the vibration amplitude in motors having rated voltage equal to or greater than 2,300 V. Criteria according to standard NEMA MG1
- q) checking the correct position of magnetic center reference mark in machines having sleeve bearings after coupling.

9.2.11 Direct Current Motors

The following checkouts shall be effected:

- a) replacement of grease in not sealed roller bearings;
- b) examining the interior of motor, when there is inspection windows;
- c) checking the condition of gaskets, replacing the damaged ones;
- d) cleaning the commutator with appropriate solvent;
- e) position and adjusting commutator brushes;
- f) rotating the motor manually after uncoupling;
- g) calibrating and adjusting local indicating instruments or instruments which activate alarm or disconnection;
- h) measuring insulation resistance of windings according to standard IEEE Std-43. The minimum value shall be $(kV+1)M\Omega$, at 40 °C, kV being the insulation level of the equipment;
- i) checking power and control connections;
- j) running the motor with rated voltage and at no load, and observing the functioning according to the following items;
- l) checking the direction of rotation and speed variations;

- m) observing the temperature of bearings and windings in the first four hours of running;
- n) checking for sparking on brushes;
- o) checking for abnormal noise;
- p) checking vibration. In case of abnormal vibration, measuring of amplitude according to standard NEMA MG1.

9.2.12 Generators

The following checkouts shall be effected:

- a) replacement of grease in not sealed roller bearings;
- b) draining, flushing and filling oil in sleeve bearings according to specific manufacturer's instructions;
- c) examining the interior of motor, when there is inspection windows;
- d) checking the condition of gaskets, replacing the damaged ones;
- e) placing into operation lubricating, refrigerating and pressurizing auxiliary systems, when applicable;
- f) calibrating and adjusting local indicating instruments or instruments which activate alarm or tripping;
- g) measuring insulation resistance of windings according to standard IEEE Std-43. The minimum value shall be $(kV+1) M\Omega$, at 40 °C, kV being the insulation level of the equipment;
- h) checking power and control connections;
- i) running the generator at rated speed;
- j) plotting the characteristic curve of armature voltage as a function of unloaded excitation current for generators having power greater than 500 kW;
- l) observing wheather the machine matches the magnetic center according to reference marked in the shafts of machines having sleeve bearings during no load operation;
- m) registering in oscillograph and checking the wave form when unloaded and under rated voltage according to standard IEEE Std 115 for generators having power greater than 500 kW;
- n) applying rated load to generator and observing during the first four hours of running the temperature of windings and lubricating and refrigerating systems, when applicable. The design parameters are to be established as criteria;

- Note:
- 1) As to turbine driven machines, to which there is no availability of rated load at the time of testing, temperature rise tests may be tentatively accepted to be performed at 30 % the rated load. However, the final acceptance of the generating system shall be subject to full load test .
 - 2) Diesel motor driven generators shall be tested with full load before start up.
 - o) starting the biggest induction motor to be supplied by the generator in different foreseen load conditions of the generator;
 - p) testing sudden load application and rejection such as to fulfill the conditions of sudden load variation foreseen in the design;

- q) testing synchronization and parallelism between generating systems, when applicable. The generating systems shall share active and reactive loads according to established settings based upon design;
- r) setting the excitation system such as to keep the steady state and transient effects within the limits established in design;
- s) registering in oscillograph transient voltage and frequency variations arising from the tests foreseen in p) and q) of this item.

9.2.13 Synchronous Motors

The following checkouts shall be effected:

- a) replacement of grease in not sealed roller bearings;
- b) draining, flushing and filling oil in sleeve bearings according to specific manufacturer's instructions;
- c) examining the interior of motor, when there is inspection windows;
- d) checking the condition of sealing joints, replacing the damaged ones;
- e) placing into operation lubricating, refrigerating and pressurizing auxiliary systems, when applicable;
- f) calibrating and adjusting local indicating instruments or devices commanding alarm or disconnection;
- g) measuring insulation resistance of windings according to standard IEEE [Std-43](#). The minimum value $(kV+1) M\Omega$, at 40 °C, kV being the insulation level of the equipment;
- h) checking power and control connections;
- i) registering in the oscillograph the starting current;
- j) running the motor at rated voltage and no load, and observing the functioning according to the following items;
- l) checking the direction of rotation and measuring line and excitation current after synchronizing;
- m) watching the temperature of bearings and windings during the first four hours of running;
- n) checking the noise level. In case of abnormal noise, measuring the noise level according to ABNT [NBR 7566](#), and checking the allowable tolerance according to ABNT [NBR 7565](#);
- o) measuring the vibration amplitude according to standard NEMA [MG1](#);
- p) checking after coupling whether the shaft is matched to magnetic center reference mark in machines having sleeve bearings.

10 ACCEPTANCE AND REJECTION

Whenever the results of inspection and/or equipment do not fulfill the present Standard and the design specifications, the services shall be rejected and corrective actions shall be provided.

PREFACE

This Standard PETROBRAS N-1614 REV. B SEP/97 is the Revalidation of Standard PETROBRAS N-1614 REV. A AUG/84 the contents of which were not altered. This Standard is the English version (issued DEZ/99) of Standard PETROBRAS N-1614 REV. B - SEP/97.

1 SCOPE

This Standard establishes the minimum conditions required for receiving, construction, mounting and commissioning of the following types of electrical equipment for PETROBRAS's application;

- a) power transformers;
- b) reactors;
- c) grounding resistors;
- d) bus ducts;
- e) control panels, protection panels, signaling panels;
- f) auxiliary panels;
- g) rectifiers and inverters;
- h) batteries;
- i) circuit breakers for external mounting;
- j) instrument transformers for external mounting;
- k) dry disconnecting switches;
- l) oil immersed disconnecting units;
- m) capacitors;
- n) electrical generators;
- o) electrical motors.

2 COMPLEMENTARY DOCUMENTS

The following documents are referenced the text and contain valid rules for this Standard.

| | |
|-----------------|---|
| PETROBRAS N-312 | - Transformadores Imersos em Óleo, para Transmissão e Distribuição de Energia Elétrica; |
| PETROBRAS N-313 | - Motor Elétrico de Indução ; |
| PETROBRAS N-314 | - Painel de Baixa Tensão – Centro de Controle de Motores; |
| PETROBRAS N-316 | - Painel de Baixa Tensão – Centro de Distribuição de Carga; |
| PETROBRAS N-317 | - Painel de Media Tensão; |
| PETROBRAS N-319 | - Bus Duct; |
| PETROBRAS N-320 | - Quadro de Distribuição - Sistema Edison - Área Não Classificada; |
| PETROBRAS N-322 | - Unidade Desligadora a Óleo para Instalação ao Tempo; |
| PETROBRAS N-323 | - Chaves Seccionadoras Secas; |

| | |
|------------------|---|
| PETROBRAS N-324 | - Intertravamento Eletro-Mecânico “Kirk” para Unidade Desligadora Primária; |
| PETROBRAS N-325 | - Intertravamento Eletro-Mecânico para Chave Desligadora Primária com Dispositivo para Aterramento do Cabo Alimentador; |
| PETROBRAS N-329 | - Battery; |
| PETROBRAS N-330 | - Chaves de Controles Auxiliares para Chaves Desligadoras Primárias de Subestações com Primário Seletivo; |
| PETROBRAS N-331 | - Intertravamento Mecânico Tipo “Kirk” para Subestação com Primária Seletivo; |
| PETROBRAS N-332 | - Battery Charger; |
| PETROBRAS N-333 | - Quadro de Corrente Contínua; |
| PETROBRAS N-334 | - Intertravamento Mecânico Tipo “Kirk” para Unidade Desligadora Primária; |
| PETROBRAS N-375 | - Caixa de Blocos Terminais; |
| PETROBRAS N-470 | - Quadro de Distribuição – Sistema Trifásico – Área Não Classificada; |
| PETROBRAS N-474 | - Resistor de Aterramento; |
| PETROBRAS N-510 | - Painel de Baixa Tensão para Instalação em Área de Classe I, Grupo D, Divisão 2; |
| PETROBRAS N-1534 | - Quadro Distribuição - Sistema Edison – Área Classificada; |
| PETROBRAS N-1659 | - Redes e Equipamentos Elétricos – Folhas de Testes; |
| PETROBRAS N-1717 | - Quadro de Corrente Contínua – Área Classificada; |
| PETROBRAS N-1718 | - Quadro de Distribuição Sistema Trifásico – Área Classificada; |
| PETROBRAS N-1777 | - Painel de Baixa Tensão – Área Não Classificada Instalação ao Tempo; |
| PETROBRAS N-1786 | - Pára-raios de Linha; |
| PETROBRAS N-1911 | - Transformadores Secos para Transmissão e Distribuição de Energia Elétrica; |
| ABNT NBR 5060 | - Guia para Instalação e Operação de Capacitores de Potência; |
| ABNT NBR 5116 | - Máquinas de Corrente Contínua; |
| ABNT NBR 5117 | - Máquinas Síncronas; |
| ABNT NBR 5119 | - Reatores para Sistemas de Potência; |
| ABNT NBR 5165 | - Máquinas de Corrente Contínua – Ensaio Gerais; |
| ABNT NBR 5168 | - Reatores para Sistemas de Potência; |
| ABNT NBR 5282 | - Capacitores de Potência; |
| ABNT NBR 5286 | - Corpos Cerâmicos de Grandes Dimensões Destinados a Instalações Elétricas; |
| ABNT NBR 5287 | - Pára-Raios de Resistor Não-Linear para Sistemas de Potência; |
| ABNT NBR 5289 | - Capacitores de Potência; |
| ABNT NBR 5309 | - Pára-Raios de Resistor Não-Linear para Sistemas de Potência; |
| ABNT NBR 5356 | - Transformadores de Potência; |

| | |
|----------------|--|
| ABNT NBR 5376 | - Acumuladores Elétricos; |
| ABNT NBR 5380 | - Transformador de Potência; |
| ABNT NBR 5383 | - Máquinas Elétricas Girantes – Máquinas de Indução Determinação das Características; |
| ABNT NBR 5389 | - Técnica de Ensaios Elétricos de Alta Tensão; |
| ABNT NBR 6509 | - Eletrotécnica e Eletrônica – Instrumentos de Medição; |
| ABNT NBR 6820 | - Transformador de Potencial; |
| ABNT NBR 6821 | - Transformador de Corrente; |
| ABNT NBR 6855 | - Transformador de Potencial; |
| ABNT NBR 6856 | - Transformador de Corrente; |
| ABNT NBR 6869 | - Determinação da Rigidez Dielétrica de Óleos Isolantes – Método dos Eletrodos de Disco; |
| ABNT NBR 7036 | - Recebimento, Manutenção e Instalação de Transformadores de Distribuição, Imersos em líquidos Isolantes; |
| ABNT NBR 7037 | - Recebimento, Manutenção e Instalação de Transformadores de Potência, em Óleo Isolante Mineral; |
| ABNT NBR 7094 | - Máquinas Elétricas Girantes – Motores Elétricos de Indução; |
| ABNT NBR 7118 | - Disjuntores de Alta Tensão; |
| ABNT NBR 7565 | - Máquina Elétrica Girante – Limite de Ruído; |
| ABNT NBR 7566 | - Máquina Elétrica Girante – Nível do Ruído Transmitido Através do Ar – Método de Medição num Campo Livre Sobre um Plano Refletor; |
| ANSI C 37.20 | - Switchgear Assemblies, Including Metal Enclosed Bus; |
| ANSI C 37.9 | - Test Procedure for AC High-Voltage Circuit Breakers; |
| ANSI C 37.9a | - Supplement to Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis; |
| ANSI C 37.35 | - Guide for the Application, Installation Operation and Maintenance of High-Voltage Air Disconnecting and Load Interrupter Switches; |
| ANSI C 50.10 | - General Requirements for Synchronous Machines; |
| ANSI C 50.13 | - Requirements for Cylindrical Rotor Synchronous Generators; |
| ASTM D 877 | - Test for Dielectric Breakdown Voltage of Insulation Liquid Using Disk Electrical; |
| IEEE - Std 32 | - Requirements Terminology, and Test Procedure for Neutral Grounding Devices; |
| IEEE - Std 43 | - Recommended Practice Testing Insulation Resistance of Rotating Machinery; |
| IEEE - Std 112 | - Test Procedure for Polyphase Induction Motors and Generators; |
| IEEE - Std 113 | - Test Code for Direct-Current Machines; |
| IEEE - Std 114 | - Test Procedure for Single-Phase Induction Motors; |
| IEEE - Std 115 | - Test Procedure for Synchronous Machines; |
| IEEE - Std 118 | - Master Test Code for Resistance Measurement; |

| | |
|------------|---|
| NEMA - MG1 | - Motors and Generators; |
| NEMA - RI2 | - General Purpose and Communication Battery Chargers; |
| NEMA - SG4 | - Alternating Current High-Voltage Circuit Breaker. |

3 EQUIPMENT RECEIVING

3.1 Upon receipt of the equipment, the existence of the complete documentation thereof shall be checked, including factory test reports duly filled up.

3.2 It shall be checked whether the nameplate contains the data required in the design specification and applicable standards.

3.3 It shall be checked whether the data of the nameplate comply with those specified in the design and certified manufacturer drawings.

3.4 A visual inspection shall be made to check the integrity of all equipment and accessories thereof.

3.5 It shall be checked whether the characteristics of the equipment and accessories are in accordance with the design specifications, material requisitions, manufacturer drawings and standards listed in the TABLE 1 below, when applicable:

EQUIPMENT AND ACCESSORIES

| Equipment | Reference Standard |
|---|---|
| Storage battery | PETROBRAS N-329 |
| Terminal blocks boxes | PETROBRAS N-375 |
| Capacitors | ABNT NBR 5282 |
| Battery charger | PETROBRAS N-332 |
| Load center | PETROBRAS N-316 |
| Motors control center | PETROBRAS N-314 |
| Disconnecting switch | PETROBRAS N-323 |
| Circuit breakers | ABNT NBR 7118 |
| Circuit breakers for panel installation | PETROBRAS N-316 and PETROBRAS N-317 |
| Bus ducts | PETROBRAS N-319 |
| Synchronous machines | ABNT NBR 5117 |
| Direct current motors | ABNT NBR 5116 |
| Induction electric motors | PETROBRAS N-313 |
| Auxiliary panels | PETROBRAS N-320 , N-333 , N-470 , N-510 , N-1534 , N-1717 , N-1718 and N-1777 |
| Medium-voltage panels | PETROBRAS N-317 |
| Arresters | ABNT NBR 5287 |
| Reactors | ABNT NBR 5119 |
| Grounding resistor | PETROBRAS N-474 |
| Instrument transformers | ABNT NBR 6855 and ABNT NBR 6856 |
| Power transformers | PETROBRAS N-312 , NBR 5356 |
| Oil Immersed disconnecting unit | PETROBRAS N-322 |

4.2.1.7 The metal parts of bushings shall be protected with neutral mineral jelly (“Vaseline”).

4.2.1.8 The drums containing insulating oil shall be stored in horizontal mounting position, laying on beams swooden sleeper. They shall be arranged so as to have the top in the same horizontal line.

4.2.1.9 The inert gas pressure in transformers and reactors received under pressure shall be checked weekly. Pressure shall be kept within the values specified by the manufacturer.

4.2.1.10 The float of the oil level gauge shall be released from shipping supports before checking the oil level during the storage period.

4.2.1.11 The oil level and the existence of oil leakage in oil immersed transformers and reactors shall be checked monthly so as to keep, the oil level as specified by the manufacturer. Should it be necessary to replenish the oil level, the recommendations of item 6.2.1.7 of this Standard shall be followed. The insulating oil drain valves shall be kept closed with plugs.

4.2.1.12 Upon reception and at every six month intervals the insulation resistance of the windings of transformers and reactors shall be measured. The minimum acceptable value shall be of 15 M Ω /kV being the insulation level at 40 °C for oil immersed transformers and reactors. The values obtained shall be corrected to the temperature of 40 °C according to standard ABNT NBR 7036, Table 3. The measurement for transformers shall be made according to standard ABNT NBR 5380, item 4.4.

4.2.1.13 Dry type or without oil transformers and reactors presenting low insulation shall be dried according to the instructions of manufacturer and standard ABNT NBR 7036.

4.2.1.14 In oil-immersed transformers and reactors showing evidence of low insulation, the dielectric strength of the oil shall be measured according to item 6.2.1.8.

4.2.2 Grounding Resistors

4.2.2.1 All resistors shall be stored in leveled position on wooden sleeper or boards.

4.2.2.2 Grounding resistors manufactured for internal installation shall be stored in a sheltered place.

4.2.2.3 Grounding resistors stored on weather shall be covered with plastic canvas.

6.2 Specific Conditions

6.2.1 Power Transformers and Reactors

6.2.1.1 The documents mentioned in item 6.1.2, regarding the steps of equipment mounting shall be complemented by the procedures established in standards ABNT NBR 7036 and NBR 7037.

6.2.1.2 There shall not be gaps or stresses between coupled parts, such as coupling flanges with bus ducts, connections with conduits and split-sleeves.

6.2.1.3 The grounding of transformer neutral shall be made employing conductors of size and insulation level as specified in the design.

6.2.1.4 In the connection of the bus to the transformer or reactor, the links shall be placed and tightened in order to keep the same spacing between them. The length of the bolts shall not impair the spacing between phases and phase-ground.

6.2.1.5 As to preparation and execution of transformer cable terminations the following items shall be observed:

- a) type and voltage level;
- b) phase sequence of the system;
- c) distance between phase and structure;
- d) position and fastening of the termination;
- e) connection of the grounding braid to the ground grid, in case of shielded or armored cables.

6.2.1.6 The accessories or parts thereof that have possibly been fastened or plugged for purposes of transportation shall be released.

6.2.1.7 For oil immersed equipment the filling or replenishment of oil level shall be performed according to manufacturer's recommendations using filter press. The dielectric strength of the insulating oil shall be previously measured according to item 6.2.1.8.

6.2.1.8 The dielectric strength of the insulating oil shall be measured according to standard ABNT NBR 6869. The minimum value allowed shall be 30 kV. When the dielectric strength is lower than the minimum allowed, a treatment for recovery of the insulating oil shall be effected, according to the instructions of the manufacturer and standard ABNT NBR 7037, Annex B. The oil sample shall be obtained according to standard ABNT NBR 7037.

6.2.4.8 Compartment doors shall be checked as to proper opening and closing. They shall be adjust if necessary.

6.2.5 Storage Batteries

6.2.5.1 The support, installation of separators and insulators, number of cells and their interconnections between shall comply with the design specifications and manufacturer's instructions.

6.2.5.2 For alkaline batteries shipped dry, the electrolyte shall be prepared according to manufacturer's instructions. The cell containers shall be filled with the electrolyte only when the corresponding rectifier is considered ready to start applying equalizing charge or keeping the batteries floating, according to the manufacturer instructions. After addition of the electrolyte, the direct current system shall be tested according to item 8.2.5.

6.2.6 Circuit Breakers for Outdoor Installation

6.2.6.1 When mounting the circuit breaker the following items shall be checked such that they comply with the design specifications and manufacturer's drawings:

- a) bushings, insulators and capacitors;
- b) junction box, control panel and accessories;
- c) busbar fastening, wiring, identification, connections and interlocking;
- d) sight glass, thermometers, pressure gauges and pressure switch;
- e) valves and accessories;
- f) reservoirs and pressure systems;
- g) relative position of the poles, according to number stamped on the part.

6.2.6.2 Equipment immersed in oil, the filling or replenishment of oil level shall be performed according to provisions of item 6.2.1.7.

6.2.7 Dry Disconnecting Switches

6.2.7.1 Installation and mounting of the switch shall comply with the recommendations of the manufacturer, design specifications and standard ANSI C 37.35 where applicable.

6.2.7.2 Upon installation of the disconnecting switch the following items shall be checked such that they comply with the design specifications and manufacturer's drawings:

- a) insulator columns and supports;
- b) fastening, alignment and adjustments of blades, operating levers, clips and arc horns;

7.2.11.2 Instruments mounted on the equipment, as well as devices having local command, shall be protected with wooden boxes.

7.2.11.3 The coupling, shaft end and other machined surfaces shall be kept protected with an anti-oxidant product applied each 3 months.

7.2.11.4 The oil reservoirs of the equipment bearings shall be kept with oil according to the instructions of the manufacturer.

7.2.11.5 In equipment provided with collector rings and brushes, clearances shall be ensured between the brushes and the rings, according to the instructions of the manufacturer.

7.2.11.6 The heating resistors of the equipment shall be kept energized and the functioning thereof shall be checked periodically in order to guarantee the continuous functioning.

7.2.11.7 The insulation resistance of equipment windings shall be measured in accordance with IEEE Std 43. Equipment showing insulation resistance below the minimum value allowable shall be dried taking into account the instructions of the manufacturer. The minimum value is $(kV+1) M\Omega$, at 40 °C, kV being the insulation level of the equipment.

7.2.11.8 The rotor of the equipment shall be rotated manually each 15 days for about ten revolutions leaving the shaft in a position different from the previous one. For equipment having oil lubricated bearings or sleeve bearings the instructions of the manufacturer shall be followed taking into account the necessity for pre-lubrication of the bearings prior to running the machine.

8 TESTS

8.1 General Conditions

8.1.1 Prior to performing the tests, a visual checking as to the conditions of installation and cleaning and of all equipment shall be made.

8.1.2 All tests shall be performed according to the requirements contained in design specifications, manufacturer's recommendations and the standards listed below, when applicable, including those according to which the equipment was manufactured:

- a) ABNT: NBR 5060; NBR 5116; NBR 5165; NBR 5168; NBR 5286; NBR 5289; NBR 5309; NBR 5376; NBR 5380; NBR 5383; NBR 5389; NBR 6509; NBR 6820; NBR 6821; NBR 6869; NBR 7094; NBR 7565; NBR 7566;

- b) ANSI: C 37.9; C 37.9a; C 37.20; C 37.35; C 50.10; C 50.13;
- c) ASTM: D 877;
- d) NEMA: MG1; RI2; SG4;
- e) IEEE: Std 32; Std 43; Std 112; Std 113; Std 114; Std 115; Std 118.

8.1.3 The equipment test procedures must cover at least the following topics:

- a) object;
- b) scope;
- c) applicable standards;
- d) description and test method;
- e) test equipment used;
- f) tools required;
- g) acceptance criteria;
- h) test parameters.

8.1.4 The procedures shall cover the foreseen tests in this Standard and the recommendations of the manufacturer.

8.1.5 The procedures shall be specific for the equipment involved.

8.1.6 When performing the tests of insulation resistance, ohmic resistance and dielectric tests the room temperature shall be recorded.

8.1.7 When performing the dielectric tests, the relative humidity of the air shall be recorded.

8.1.8 After performing the tests, the one performing the tests shall issue a certificate containing attached thereto the specific test sheet for each equipment standardized by standard PETROBRAS N-1659 having all data and results recorded.

8.2 Specific Conditions

8.2.1 Power Transformers and Reactors

They shall be subjected to the following checkouts:

- a) checking transformation ratio of transformers in all positions of tap changing switch using T.T.R., placing the tap in the design position afterwards;
- b) measuring the ohmic resistance of windings using the bridge method. For transformers the measurement shall be made with the switch in the position of highest tap;

- c) calibration of the temperature indicator using the standard thermometer;
- d) checking the pressure of the clips and continuity of transformer high voltage fuses;
- e) plotting of saturation curve of bushing CTs of transformers;
- f) measuring insulation resistance of transformer fuses supports;
- g) setting measurement, protection and signaling instruments;
- h) checking continuity of protection, measurement and signaling auxiliary circuits;
- i) measuring insulation resistance of the following items, if applicable:
 - protection, measurement and signaling auxiliary circuits;
 - fan motors;
 - bushing CTs;
 - high voltage fuses;
- j) simulating operation of sudden pressure rise relay or gas detection relay;
- l) checking direction of rotation of forced-air fans;
- m) simulating operation of all protection taking into account control, signaling, alarm and protection.

8.2.2 Grounding Resistors

They shall be subjected to the procedures listed below:

- a) measuring ohmic resistance, effecting correction to the reference temperature;
- b) measuring insulation resistance. The minimum acceptable value shall be 2 M Ω /kV;
- c) checking polarity of current transformer;
- d) plotting of saturation curve of CT, comparing against manufacturer's curve;
- e) checking continuity of power and control interconnections;
- f) injecting current in the circuit of CT and observation of relay operation;
- g) checking of transformation ratio of CT.

8.2.3 Bus Duct

They shall be subjected to the following checkouts:

- a) checking continuity of bus;
- b) measuring insulation resistance between phases and between phases and ground. The minimum value allowed shall be of 2 M Ω /kV;
- c) applying voltage to the bus of a voltage level equal to or greater than 5 kV according to standard ANSI C 37.20. The insulation resistance test shall be repeated after performing the dielectric tests;
- d) checking phase sequence.

8.2.4 Control Panels, Protection Panels, Signaling Panels and Auxiliary Panels

They shall be subjected to the following checkouts:

- a) manual operation of all components, assuring that all movable parts are being freely displaced without locking;
- b) checking the conditions of opening and closing of doors, as well as the withdrawal systems and barriers between busbar compartments and circuit breakers or contactors;
- c) checking doors opening locking under the condition of energized circuit;
- d) measuring wiring insulation resistance;
- e) checking polarity and continuity of current circuits;
- f) checking busbar continuity;
- g) measuring busbar insulation resistance between phases and between phase and ground;
- h) applying voltage to the busbar of panels of voltage level equal to or greater than 5 kV;
- i) measuring component insulation resistance after removing the electronic cards. The minimum allowed value shall be 2 MΩ/kV;
- j) checking continuity and pressure of the clips of power fuses;
- k) checking transformation ratio of CTs, VTs and polarity of CTs according to standards ABNT NBR 6820 and NBR 6821;
- l) plotting the saturation curve of protection CTs, except those connected to thermal relay and "ground sensor" protection;
- m) checking alignment of moving and fixed contacts of contactors having rated current above 100 A and circuit breakers, except those of molded case type;
- n) measuring contacts ohmic resistance of contactors having voltage greater than 480 V and circuit breakers, except those of molded case type;
- o) checking contact simultaneous opening and closing of contactors having voltage greater than 480 V and circuit breakers, except those of molded case type;
- p) measuring insulation resistance of electromechanical relays of contacts to ground, coils to ground, and between contacts edges. The minimum value allowed shall be 1 MΩ. The voltage during the test shall not be greater than 200 VDC;
- q) setting and calibration protection relays and plotting actuation curve on the taps and design time settings;
- r) setting of thermal relays and checking operating time in each phase and in the three phases with the elements in series;
- s) identification and seal of calibrated and adjusted relays;
- t) calibration of instruments;
- u) checking actuation of molded case circuit breakers injecting current above the rated value;
- v) checking tripping and closing time for circuit breakers intended to provide parallel operation of different generation systems, automatic transfer and reacceleration systems;
- w) performing operational test taking into account:
 - operation of changeover switch;
 - manual and automatic, local and remote operation of contactors and circuit breakers;
- x) performing simulated functional test involving control and protection taking into account signaling and interlocks;
- y) performing panel functional test effecting simulated operation of external circuits in the terminal blocks board. For the final functional test involving interconnections between equipment, the simulations shall be made directly on the control, protection and interlocking devices of the several equipment;

- f) checking opening and closing in test and operation positions, including observation of auxiliary contacts and limit switch operation, interlocking and signaling, control and alarm devices;
- g) calibration of direct acting relays and instruments;
- h) checking opening and closing time in case of circuit breakers intended to provide parallel operation of different generation systems, automatic transfer and reacceleration;
- i) actuating local and remote opening and closing command observing the behavior of the circuit breaker and the signaling;
- j) checking the operation of pneumatic system;
- l) checking the operation cycle with energy stored in the operating mechanism;
- m) checking the voltages of control auxiliary circuits, which shall be within the allowed range when the circuit breaker is locally and remotely operated.

8.2.7 Insulators and Lightning Arresters

They shall be subjected to insulation resistance measurement using Megger for voltage level up to 5 kV inclusive, and dielectric tests for higher voltage levels.

8.2.8 Protection and Measurement Transformers for Outdoor Installation

They shall be subjected to the checkouts listed below:

- a) checking polarity of protection CTs according to ABNT NBR 6821;
- b) measuring windings ohmic resistance of protection CTs;
- c) checking transformation ratio;
- d) plotting saturation curve of protection CTs;
- e) checking continuity of CTs secondary;
- f) measuring insulation resistance. The minimum value allowed shall be 2 MΩ/kV.

8.2.9 Dry Disconnecting Switches

They shall be subjected to the checkouts listed below:

- a) measuring insulation resistance between each phase and the other interconnected and grounded phases. The minimum value acceptable must be of 2 MΩ/kV à 40 °C;
- b) measuring insulation resistance between the poles of each phase. The minimum value acceptable shall be of 2 MΩ/kV referred to 40 °C;
- c) checking and identifying phasing;
- d) measuring ohmic resistance of the contacts of each phase for switches of voltage level equal to or greater than 15 kV;
- e) measuring insulation resistance of command, protection and signaling wiring;
- f) checking opening and closing of main contacts;
- g) checking simultaneous closing operation both for local and remote command, observing the behavior of control, protection and signaling circuits.

8.2.10 Oil Immersed Disconnecting Units

They shall be subjected to the checkouts listed below:

- a) measuring of insulation resistance of busbar and switches;
- b) applying voltage to busbar with switch in the open position;
- c) measuring ohmic resistance of main contacts;
- d) alignment of movable and fixed contacts;
- e) checking electric continuity of alarm, command, protection and interlocking circuits;
- f) checking simultaneous opening and closing operation;
- g) checking feeder-grounding device;
- h) checking instrument transformers according to 8.2.8;
- i) adjusting measuring instruments, relays, thermostats and pressure switches;
- j) checking opening and closure observing the behavior of control, protection, and signaling and interlocking circuits.

8.2.11 Capacitors

They shall be subjected to the checkouts listed below:

- a) checking electric continuity of control circuits;
- b) applying 70 % of the voltage specified in ABNT NBR 5282; the test procedure shall be in accordance with ABNT NBR 5289;
- c) residual voltage test according to ABNT NBR 5289.

8.2.12 Induction Motors and Direct Current Motors

They shall be subjected to the checkouts listed as follow:

- a) measuring ohmic resistance of windings using bridge in induction motors having rated voltage equal to or greater than 2,300 V;
- b) checking terminal connections in accordance with motor wiring diagram;
- c) checking continuity of temperature detectors internal to motor (RTD);
- d) testing and calibrating the control, protection and supply system in accordance with items 8.1 and 8.2.4 of this Standard;
- e) testing lubricating, refrigerating and pressurizing auxiliary systems, when applicable;
- f) measuring insulation resistance of machine surge protection device, when applicable;

Note: The remaining motor checks and tests shall be made after preparation for start up according to items 9.1, 9.2.10 and 9.2.11.

8.2.13 Generators and Synchronous Motors

They shall be subjected to the checkouts listed below:

- a) replacement of grease in not shielded or not sealed ball or roller bearings;
- b) draining, flushing and filling oil in sleeve bearings according to specific manufacturer's instructions;
- c) examining the interior of motor, when there is inspection windows;
- d) checking the condition of sealing joints, replacing the damaged ones;
- e) rotating the motor manually after uncoupling;
- f) placing into operation lubricating, refrigerating and pressurizing auxiliary systems, when applicable;
- g) calibrating and adjusting local indicating instruments or instruments commanding alarm or tripping;
- h) measuring insulation resistance of windings according to standard IEEE Std-43. The minimum value shall be $(kV+1)M\Omega$, at 40 °C, kV being the insulation level of the equipment;
- i) checking power and control connections;
- j) registering in the oscillograph the starting current for motors having rated voltage equal to or greater than 2,300 V and low voltage motors having a starting time under load greater than 5 seconds;
- l) running the motor at rated voltage and unloaded, and observing its performance according to the following items;
- m) checking the direction of rotation, recording the number of revolutions and no load current;
- n) observing the temperature of bearings and windings during the first four hours of running;
- o) checking the noise level. In case of abnormal noise, measuring the noise level according to ABNT NBR 7566, and checking the allowable tolerance according to ABNT NBR 7565;
- p) measuring the vibration amplitude in motors having rated voltage equal to or greater than 2,300 V. Criteria according to standard NEMA MG1
- q) checking the correct position of magnetic center reference mark in machines having sleeve bearings after coupling.

9.2.11 Direct Current Motors

The following checkouts shall be effected:

- a) replacement of grease in not sealed roller bearings;
- b) examining the interior of motor, when there is inspection windows;
- c) checking the condition of gaskets, replacing the damaged ones;
- d) cleaning the commutator with appropriate solvent;
- e) position and adjusting commutator brushes;
- f) rotating the motor manually after uncoupling;
- g) calibrating and adjusting local indicating instruments or instruments which activate alarm or disconnection;
- h) measuring insulation resistance of windings according to standard IEEE Std-43. The minimum value shall be $(kV+1)M\Omega$, at 40 °C, kV being the insulation level of the equipment;
- i) checking power and control connections;
- j) running the motor with rated voltage and at no load, and observing the functioning according to the following items;
- l) checking the direction of rotation and speed variations;

- q) testing synchronization and parallelism between generating systems, when applicable. The generating systems shall share active and reactive loads according to established settings based upon design;
- r) setting the excitation system such as to keep the steady state and transient effects within the limits established in design;
- s) registering in oscillograph transient voltage and frequency variations arising from the tests foreseen in p) and q) of this item.

9.2.13 Synchronous Motors

The following checkouts shall be effected:

- a) replacement of grease in not sealed roller bearings;
- b) draining, flushing and filling oil in sleeve bearings according to specific manufacturer's instructions;
- c) examining the interior of motor, when there is inspection windows;
- d) checking the condition of sealing joints, replacing the damaged ones;
- e) placing into operation lubricating, refrigerating and pressurizing auxiliary systems, when applicable;
- f) calibrating and adjusting local indicating instruments or devices commanding alarm or disconnection;
- g) measuring insulation resistance of windings according to standard IEEE Std-43. The minimum value $(kV+1) M\Omega$, at 40 °C, kV being the insulation level of the equipment;
- h) checking power and control connections;
- i) registering in the oscillograph the starting current;
- j) running the motor at rated voltage and no load, and observing the functioning according to the following items;
- l) checking the direction of rotation and measuring line and excitation current after synchronizing;
- m) watching the temperature of bearings and windings during the first four hours of running;
- n) checking the noise level. In case of abnormal noise, measuring the noise level according to ABNT NBR 7566, and checking the allowable tolerance according to ABNT NBR 7565;
- o) measuring the vibration amplitude according to standard NEMA MG1;
- p) checking after coupling whether the shaft is matched to magnetic center reference mark in machines having sleeve bearings.

10 ACCEPTANCE AND REJECTION

Whenever the results of inspection and/or equipment do not fulfill the present Standard and the design specifications, the services shall be rejected and corrective actions shall be provided.

- c) exame do interior do motor, quando existir janelas de inspeção;
- d) verificação do estado das juntas de vedação, substituindo as danificadas;
- e) giro do motor manualmente, após o desacoplamento;
- f) colocação em operação dos sistemas auxiliares de lubrificação, refrigeração e pressurização, quando aplicável;
- g) aferição e/ou calibração dos instrumentos locais indicadores ou que comandem alarme ou desligamento;
- h) medição da resistência de isolamento dos enrolamentos, de acordo com a norma IEEE Std-43. O valor mínimo é $(kV+1)M \Omega$, a 40°C, sendo que kV é a classe de isolamento do equipamento;
- i) verificação das conexões de força e controle;
- j) registro, através de oscilógrafo, da corrente de partida para motores de tensão nominal igual ou superior a 2300 V e motores de baixa tensão que tenham tempo de partida em carga superior a 5 segundos;
- l) acionamento do motor, na tensão nominal e a vazio, e observação do funcionamento, de acordo com os itens a seguir;
- m) verificação do sentido de rotação, medição do número de rotações e corrente a vazio;
- n) acompanhamento da temperatura dos mancais e enrolamentos nas primeiras quatro horas de funcionamento;
- o) verificação do nível de ruído. No caso de ruído anormal, medição do nível de ruído, conforme ABNT NBR -7566, e verificação da tolerância admissível, conforme ABNT NBR-7565;
- p) medição da amplitude de vibração nos motores de tensão nominal igual ou superior a 2300 V. Critérios conforme norma NEMA MG1;
- q) verificação, após o acoplamento, da posição correta da marcação de referência do centro magnético, nas máquinas com mancais de bucha.

9.2.11 Motores de Corrente Contínua

Devem ser realizados os seguintes procedimentos:

- a) substituição da graxa dos mancais de rolamentos não selados;
- b) exame do interior do motor, quando existir janelas de inspeção;
- c) verificação do estado das juntas de vedação, substituindo as danificadas;
- d) limpeza do coletor com solvente adequado;
- e) abaixamento e ajustamento das escovas no coletor;
- f) giro do rotor manualmente, após o desacoplamento;
- g) aferição e/ou calibração dos instrumentos locais indicadores ou que comandem alarme ou desligamento;
- h) medição da resistência de isolamento dos enrolamentos, de acordo com a norma IEEE Std 43. O valor mínimo é $(kV+1) M \Omega$, a 40°C, sendo que kV é a classe de isolamento do equipamento;
- i) verificação das conexões de força e controle;
- j) acionamento do motor, na tensão nominal e a vazio, e observação do funcionamento, de acordo com os itens a seguir;
- l) verificação do sentido de rotação e da variação do número de rotações;

- o) partida do maior motor de indução previsto de ser alimentado pelo gerador, durante os testes da máquina, em diferentes situações previstas de carga do gerador;
- p) teste de aplicação e rejeição súbita de carga de forma a atender as condições de variação súbita de carga previstas em projeto;
- q) teste de sincronização e paralelismo, entre sistemas de geração, quando aplicável. Os sistemas de geração devem dividir cargas ativas e reativas conforme ajustes fixados com base no projeto;
- r) ajustes no sistema de excitação de forma a manter os parâmetros nominais e efeitos transitórios, observados nos testes, dentro dos limites estabelecidos em projeto;
- s) registro, por oscilógrafo, da tensão e da frequência nos transitórios decorrentes dos testes previstos em (o) e (p) deste item.

9.2.13 Motores Síncronos

Devem ser realizados os seguintes procedimentos:

- a) substituição da graxa dos mancais de rolamentos não selados;
- b) drenagem, lavagem e enchimento com óleo dos mancais de bucha, de acordo com as instruções específicas do fabricante;
- c) exame do interior da máquina, através das janelas de inspeção;
- d) verificação do estado das juntas de vedação, substituindo as danificadas;
- e) colocação em operação dos sistemas auxiliares de lubrificação, refrigeração e pressurização, quando aplicável;
- f) aferição e/ou calibração dos instrumentos locais indicadores ou que comandem alarme ou desligamento;
- g) medição da resistência de isolamento dos enrolamentos, de acordo com a norma IEEE Std 43. O valor mínimo é $(kV+1) M \Omega$, a 40°C, sendo que kV é a classe do isolamento do equipamento;
- h) verificação das conexões de força e controle;
- i) registro, por oscilógrafo, da corrente de partida;
- j) acionamento do motor, na tensão e rotação nominais e a vazio, e observação do funcionamento, de acordo com os itens a seguir;
- l) verificação do sentido de rotação e medição da corrente de linha e excitação, após sincronização;
- m) acompanhamento da temperatura dos mancais e enrolamentos, nas primeiras quatro horas de funcionamento;
- n) verificação do nível de ruído. No caso de ruído anormal, medição do nível de ruído, conforme ABNT NBR 7566, e verificação da tolerância admissível, conforme ABNT NBR-7565;
- o) medição da amplitude de vibração, conforme norma NEMA MG1;
- p) verificação, após o acoplamento, se o eixo está posicionado na marcação de referência do centro magnético, nas máquinas com mancais de bucha.