

## Uninterruptible Power System for Industrial Use

### Procedure

This Standard replaces and cancels its previous revision.

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

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

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

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

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

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## CONTEC

Comissão de Normalização  
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## SC - 06

Electricity

### Introduction

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## Foreword

This Standard is the English version (issued in 09/2013) of PETROBRAS N-2760 REV. A 11/2012. In case of doubt, the Portuguese version, which is the valid document for all intents and purposes, shall be used.

## 1 Scope

1.1 This Standard sets forth the minimum requirements which shall be complied supply of Uninterruptible Power Systems (UPS) for PETROBRAS facilities, according to national, international and foreign standards.

1.2 This Standard applies to UPS for industrial use with power exceeding 3 kVA.

1.3 This Standard applies to procedures started as of its date of issuance.

1.4 This Standard contains only Technical Requirements.

## 2 Normative References

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

PETROBRAS [N-329](#) - Bateria de Acumuladores (Storage Battery);

PETROBRAS [N-332](#) - Retificadores para Uso Industrial (Rectifiers for Industrial Use);

PETROBRAS [N-1219](#) - Colors (Cores);

ABNT [NBR 5410](#) - Instalações Elétricas de Baixa Tensão (Low Voltage Electrical Installations).

ABNT [NBR IEC 60439-1](#) - Conjuntos de Manobra e Controle de Baixa Tensão - Parte 2: Requisitos Particulares para Linhas Elétricas Pré-Fabricadas (Sistemas de Barramentos Blindados) (Low-voltage Switchgear and Controlgear Assemblies - Part 2: Particular requirements for Pre-Fabricated Electrical Lines [Shielded Busbar Systems]);

ABNT [NBR IEC 60529](#) - Graus de Proteção para Invólucros de Equipamentos Elétricos (código IP) (Degrees of Protection Provided by Enclosures (IP Code));

ISO [7779](#) - Acoustics - Measurement of Airborne Noise Emitted by Information Technology and Telecommunications Equipment;

ASTM [G21](#) - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi;

IEC [60068-2-6](#) - Environmental Testing - Part 2-6: Tests - Test FC: Vibration (Sinusoidal);

IEC [60068-2-27](#) - Environmental Testing - Part 2-27: Tests - Test Ea and Guidance: Shoc;

IEC [60146-2](#) - Semiconductor Converters - Part 2: Self-Commutated Semiconductor Converters Including Direct d.c. Converters;

IEC [61000-2-2](#) - Electromagnetic Compatibility (EMC) Part 2-2: Environment - Compatibility Levels for Low-Frequency Conducted Disturbances and Signaling in Public Low-Voltage Power Supply Systems;

IEC 61086-1 - Coatings for Loaded Printed wire Boards (Conformal Coatings) - Part 1: Definitions, Classification and General Requirements;

IEC 61378-1 - Converter Transformers - Part 1: Transformers for Industrial Applications;

IEC 62040-2 - Uninterruptible Power Systems (UPS) - Part 2: Electromagnetic Compatibility (EMC) Requirements;

IEC 62040-3 - Uninterruptible Power Systems (UPS) - Part 3: Method of Specifying the Performance and Test Requirements;

IEC CISPR 16-1-1 - Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods - Part 1-1: Radio Disturbance and Immunity Measuring Apparatus - Measuring Apparatus;

IEC CISPR 16-1-2 - Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods - Part 1-2: Radio Disturbance and Immunity Measuring Apparatus - Ancillary Equipment - Conducted Disturbances;

IEC CISPR 16-1-3 - Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods - Part 1-3: Radio Disturbance and Immunity Measuring Apparatus - Ancillary Equipment - Disturbance Power;

IEC CISPR 16-1-4 - Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods - Part 1-4: Radio Disturbance and Immunity Measuring Apparatus - Antennas and Test Sites For Radiated Disturbance Measurements;

IEC CISPR 16-1-5 - Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods - Part 1-5: Radio Disturbance and Immunity Measuring Apparatus - Specifications and Validation Procedures for Calts and Refs from 30 Mhz to 1 000 Mhz;

IEEE STD 485 - Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications;

IEEE STD 1115a - Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications.

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

### **3 Terms and Definitions**

For the purposes of this document, the following terms and definitions apply.

#### **3.1**

##### **AC (Alternating Current) Safe Busbar**

busbar fed by UPS output with controlled voltage and frequency which remains energized even with deterioration of the main AC source

#### **3.2**

##### **electrostatic shielding**

used to reduce interference between primary and secondary windings (capacitive coupling), thereby providing proper galvanic insulation. It is especially indicated where there is necessity for low leakage currents between windings, such as in those situations where electric noise is present on the mains or equipment. This shielding is comprised of a conductive layer between primary and secondary windings, which shall be connected to the grounding of the circuit and/or mains

**3.3**

**overload capacity**

output current capacity of the UPS exceeding to the permanent direct current at a given time, with the output voltage within the nominal range, in normal or stored energy mode

**3.4**

**100 % unbalanced load**

load in which 2 phases shall operate with linear load and rated current between phases or phase-neutral (if any), and third phase with no load

**3.5**

**linear load**

load with sinusoidal waveform and peak factor equal to square root of 2, or load which current is defined by ratio:  $I = V/Z$ , where I is the current in load, V is the feeding voltage, and Z is the load impedance (constant as a function of time and voltage)

**3.6**

**non-linear load**

load with sinusoidal waveform and peak factor different from square root of 2, or load in which Z impedance is not a constant as a function of time or voltage

**3.7**

**transfer switch**

mechanical switch used to connect / isolate the UPS from the load, or energize / de-energize the alternative source circuit

**3.8**

**static switch**

electronic device consisting of one or more switches used to transfer the power from the inverter to the alternative source

**3.9**

**alternative source**

the second power source which feeds the UPS via an alternative circuit or by-pass

**3.10**

**Main Source**

Source of energy that is normally available on a continuous basis and is usually supplied by an electric utility company, but is sometimes generated by the facility itself

**3.11**

**IMO**

it is abbreviature of International Maritime Organization, which is the United Nations specialized agency responsible for improving maritime safety and preventing pollution from ships

**3.12**

**Man Machine Interface (MMI)**

equipment responsible for receiving and treatment data from the UPS

**3.13**

**DC (Direct Current) Link**

Direct Current bus between the rectifier and the inverter input

**3.14****Operation Mode of Stored Energy or Battery In Operation**

Operation mode of UPS when fed under the conditions below:

- primary source disconnected or out of tolerance limits;
- DC energy storage system is discharging
- load is within its given range;
- output voltage is within its withstand range.

**3.15****Operation Mode by Alternative Circuit**

Operation status of UPS when it only supplies the load through alternative circuit

**3.16****Normal Operating Mode**

Stable operating mode which the UPS reaches when fed under the conditions below

- main power supply connected and within tolerance limits;
- storage battery is charged or recharging within the power recovery time;
- the operation is continuous or may be continuous;
- the phase synchronism is active, if any;
- the load is within the established range;
- the output voltage is within the established range;
- the alternative circuit, when used, is available and within the specified tolerance.

**3.17****Modu Code**

English acronym for “code for the construction and equipment of mobile offshore drilling units”. It refers to a set of requirements intended to ensure minimum operational safety standards compatible with the characteristics of drilling platforms

**3.18****alternative circuit**

circuit through which the alternative source power feeds the static switch or safe busbar of UPS through transfer switch

**3.19****TAC**

Field Acceptance Test

**3.20****TAF**

Factory Acceptance Test

**3.21****tropicalization**

an industrial treatment process against degradation of electronic and mechanical components, such as: fungus growth or oxidation due to high air relative humidity levels, which is aimed at ensuring proper functional performance of the components when subject to the peculiar environmental characteristics of regions having a tropical climate

**3.22****UPS**

It is abbreviation of Uninterruptible Power System. This system is constituted of a combination of converters, switches and devices of energy storage (accumulators battery, for example), with the purpose to keep the continuity of feeding for the load in the case of imperfection of the main supply

**3.23****THD**

It is abbreviation of Total Harmonic Distortion

**3.24****rms**

It is abbreviation of Root Meter Square

**3.25****RFI**

It is abbreviation of Radio Frequency Interference

**4 Specific Conditions**

4.1 Whenever there are discrepancies between the Data Sheet of Annex B and this Standard, the information contained in the Standard shall prevail.

4.2 The UPS shall be designed to be a stationary, fixed, and integrated equipment to be installed in an area that may only be accessed by qualified personnel.

4.3 The UPS shall be designed to be permanently connected.

4.4 The normal operation of the UPS shall be characterized by feeding load by inverter, synchronized with mains and with batteries on float charge. In the occurrence of abnormal conditions in the mains, the batteries shall assume the load. The load shall only be transferred to the by-pass via static switch if the batteries are discharged or an inverter failure occurs.

**5 General Conditions**

5.1 The UPS design shall have been sold for similar applications and with at least 3 years of successful operation. This history shall be witnessed by users. Prototypes or non-proven equipment will not be accepted.

5.2 The specific characteristics of the UPS are those indicated on the Data Sheet of Annex B, which, together with this Standard, is an integral part of the Material Requisition (RM).

5.3 The supplier shall fill all blank items on the Data Sheet of Annex B (technical data, list of standards used in the design, manufacturing, and testing as well as the list of tests) and return it to PETROBRAS duly authenticated.

5.4 The specific characteristics of each UPS are indicated on its respective Data Sheets, which are numbered according to each design. The blank form of these Data Sheets is standardized by Annex B of this Standard.

5.5 The UPS shall be designed, manufactured and tested in accordance with the provisions of this Standard and the recommendations of the publications mentioned in Section 2 of this Standard.

5.6 Any discrepancy or alternative presented by the bidder in relation to the conditions originally specified by PETROBRAS shall be clearly indicated in its bid in an item entitled "deviations from and alternatives to specifications".

5.7 When "deviations or alternatives" occur, the bid shall include matching references to the numbers of the corresponding paragraphs of this Standard, Data Sheet or RM.

5.8 If "deviations or alternatives" are not mentioned, the manufacturer's supply will be considered to be fully in accordance with the specifications.

5.9 Any conflicts that may occur between the requirements of this Standard and those set forth in the specifications, codes or reference standards, purchase orders or other design documents shall be reported to PETROBRAS. In such cases, no action shall be taken before one seeming for writing from PETROBRAS is emitted.

5.10 When the UPS is installed on offshore production units, it shall follow the recommendations of the classification societies. In the case of a floating type offshore unit, the inclination requirements specified in IMO and in the Modu Code shall also be observed.

5.11 The UPS shall be designed to provide a minimum mean time between failures (MTBF) of at least 180 000 hours and a maximum mean time to repair (MTTR), considering personnel qualified for repair beside the equipment with spares, at most 4 hours.

5.12 The manufacturer shall be responsible for supplying the UPS set with all components as specified in this Standard.

5.13 The UPS shall operate within, or in more severe, grid conditions established below, in normal operating mode, as per standard IEC [62040-3](#):

- a) input voltage variation:  $\pm 10$  % of rated voltage;
- b) input frequency variation:  $\pm 5$  % of rated frequency;
- c) ratio between negative and positive input sequence:  $\leq 5$  %;
- d) total voltage harmonic distortion rate: THD  $\leq 8$  %;
- e) individual harmonics, as defined in standard IEC [62040-3](#).

5.14 The UPS system specification shall be done alongside standard PETROBRAS [N-329](#), Storage Battery, since the storage battery sizing and recharge time are essential for sizing of UPS rectifier.

## **6 Environmental Conditions**

6.1 The equipment shall operate in a sheltered location and in a non-hazardous area.

6.2 Printed circuits in electronic modules of equipment shall be treated for protection against aggressive and salted environments (tropicalization) and corrosive gases (for example, gases containing sulfur or chlorine). Treatments shall consist of application of Class 2 reinforced protective,

in accordance with IEC [61086-1](#), and fungiproof, in accordance to ASTM [G21](#). The manufacturer shall inform in its proposal the processes used for this protection, subjected to PETROBRAS' approval.

6.3 The ambient temperature range is 0 °C to 40 °C. In this temperature range, the UPS shall operate with rated power. Above this range, the UPS shall remain operating, allowing a reduction in the output power

6.4 The relative air humidity is 95 %, with no condensation, at 25 °C.

6.5 The maximum altitude is 1 000 m, unless otherwise indicated on the Data Sheet of Annex B.

## **7 Constructive Characteristics**

### **7.1 General Characteristics**

7.1.1 The UPS specified by this Standard shall be VFI-S type, as per IEC [62040-3](#).

7.1.2 The UPS and its parts and components shall be manufactured in accordance with the recommendations of the standards mentioned in Chapter 2.

7.1.3 In an IT insulated system (see grounding system, according to ABNT [NBR 5410](#)), if the load distribution center is defined in the scope of supply, as per Chapter 11, it shall contain an insulation monitoring system capable of identifying the branch of the load with low isolation with more than two simultaneous faults.

7.1.4 The by-pass system shall be mounted in a separate compartment adjacent to the UPS cabinet.

7.1.5 The components and systems of the UPS shall be designed for continuous operation under rated output power conditions, considering allowable overload cycles of the UPS as well, without reduction of system capability.

7.1.6 The design of power and control circuits shall be developed so as to prevent a failure in a particular component or printed circuit board from propagating in cascading fashion or causing another failure in the other components or printed circuit boards.

7.1.7 The UPS shall be immune to the accumulation of electrostatic charges, voltage transients, voltage sags and electric noises caused by short circuit in the electrical system, switching of capacitor banks, startup of electric motors, and by lightning discharges, in accordance with the essential electromagnetic compatibility and immunity requirements specified in IEC [62040-2](#).

7.1.8 Insulators of bars, supports and joining parts shall be made of non-hygroscopic and nonflammable material.

7.1.9 Where indicated on the Data Sheet, the UPS shall be provided with heating resistors fed at 120 Vac, one for each vertical section or compartment. These resistors are fed by a source external to the UPS. They shall be protected by a thermomagnetic circuit breaker and automatically controlled by means of a thermostat with a maximum scale range of 60 °C.



7.1.10 The internal circuits of the UPS, excluding the circuits of heating resistors, shall be fed by redundant sources with feed from both, the safe DC busbar of the UPS and of the by-pass circuit.

7.1.11 Autotransformers shall not be used for adapting the UPS input or output voltage or by-pass voltage.

7.1.12 The efficiency of the rectifier/inverter assembly of the UPS, including isolation transformers, under any operating conditions, shall not be lower than the values specified in EC [62040-3](#).

7.1.13 The UPS shall include self-monitoring of hardware and software, continuously monitored, and any irregularity immediately detected shall cause a local signal and set off a remote alarm as specified in items 12.7 and 12.13.

7.1.14 The audible noise shall be  $\leq 75$  dBA, in accordance with IEC [62040-3](#).

7.1.15 In normal operating mode, the UPS shall remain in operation without the battery bank.

7.1.16 The parameterization of internal adjustments of the UPS shall allow modifications to be made by the user, with specific instructions being included in the installation, operation or maintenance manual.

7.1.17 The circuit fed by the alternative source shall contain a transformer as specified in Section 16.

## **7.2 Power Semiconductors**

Provision shall be made for a redundant forced ventilation system to keep power semiconductors within their allowable operating temperature limits. The fans of the system of forced ventilation shall be monitored on its functioning. The fan shall be able to be replaced with no need to de-energize the UPS, no loss of UPS functionalities and no risk for the equipment, facilities or people. In the eventuality of non-availability of one of them alarms shall be acted in accordance with 12.7.

## **7.3 Enclosure**

7.3.1 The degree of protection of the UPS shall be that indicated on the Data Sheet in accordance with ABNT [NBR IEC 60529](#).

7.3.2 The UPS shall be resistant to corrosion caused by the characteristic atmosphere of the installation site, as indicated on the Data Sheet of Annex B.

7.3.3 The treatment and paint system of metallic plates of the UPS shall present a high performance level for the environmental conditions indicated in this Standard and on the Data Sheet. The manufacturer shall present, together with its proposal, the treatment and paint system to be adopted.

7.3.4 The final finish color should be as specified on the Data Sheet. When the color is not specified, the light gray color corresponding to code 0065 of PETROBRAS [N-1219](#) shall be used.

7.3.5 The UPS shall be mounted on a self-supporting panel. (see Chapter 9 of this Standard).

7.3.6 The metal parts comprising the UPS that are not expected to be of the current-carrying type shall present electrical continuity and be connected to the ground busbar of the UPS. The doors shall have electrical continuity with the metallic structure of the UPS through flexible copper braid.

7.3.7 The ground busbar shall be located on the bottom inside part of the UPS, covering its entire extension and shall have a compression connector suitable for connecting a bare copper stranded ground wire with the nominal cross-section indicated on the Data Sheet of Annex B.

## **7.4 Identification**

7.4.1 Internal components and terminal blocks shall be identified. The wiring shall be identified according to the respective wiring diagrams.

7.4.2 The UPS identification plate shall be attached to the outside of the UPS and shall be made of series AISI 300 stainless steel. This plate shall contain at least the following data:

- a) manufacturer's name or brand name;
- b) supply voltage, number of phases, and rated frequency;
- c) rated power supply current;
- d) rated power in kVA and rated power factor;
- e) rated output voltage;
- f) rated output current;
- g) momentary current (overload) sustained for 60 seconds;
- h) serial number;
- i) model.

7.4.3 The panel shall be provided with a supplementary identification plate made of series AISI 300 stainless steel containing at least the following data:

- a) Petróleo Brasileiro S.A. - PETROBRAS;
- b) name of PETROBRAS department;
- c) project name;
- d) UPS-CA identification;
- e) RM number;
- f) Purchase and Service Order number (PCS);
- g) the contract number, in case the acquisition is made under a Turn Key, Lump Sum, and other similar types of contracts.

## **7.5 Printed Circuit Boards**

7.5.1 The components of the printed circuit boards shall have industrial quality level.

Boards, circuits and their components shall be protected so as to prevent fungus growth or the occurrence of damages due to local humidity, salinity, chlorine and sulfur.

## **7.6 Wiring and Connections**

7.6.1 The insulation of internal power and control cables shall have a flame-retardant chemical composition.

7.6.2 All points of wiring for external connection (input and output circuits) shall be functionally identified within the UPS, on each terminal block or power connection, including power, grounding, control and alarm cables.

7.6.3 Insulation and leakage distances shall be sized in accordance with ABNT [NBR IEC 60439-1](#), considering rated voltage V, overvoltage category III, pollution degree 3, material group 3A and non-homogeneous field.

## **7.7 Local Digital Control Panel**

7.7.1 The UPS shall have a local digital control panel on its front part to allow man/machine interface. This panel shall contain at least the following devices for operation and monitoring:

- a) "on" key;
- b) "off" key;
- c) parameter selection key;
- d) parameter and adjustment programming keys;
- e) key to increment functions or control values;
- f) key to decrement functions or control values;
- g) led indicating equipment is energized;
- h) digital alphanumeric display to indicate the variables described according to Chapter 12;
- i) UPS synoptic to indicate the status of system operation according to Chapter 12.

7.7.2 During the normal operation period, the display shall allow at least indication of the current, voltage, and frequency values. The values shall be input, output and internal actual values, as defined in block diagram of the UPS and in 12.6.

7.7.3 The data of the local control digital panel shall be stored in non-volatile memory so as to allow recovery of parameterization, alarms, and register of events even after the UPS has fully de-energized.

## **7.8 UPS Communication**

### **7.8.1 Physical Layer**

Interfaces shall be made available for connection between the UPS and MMI, according to Data Sheet of Annex B.

### **7.8.2 Link Layer**

The UPS shall communicate with the MMI using MODBUS protocol, unless otherwise specified on the Data Sheet.

## **7.9 Configuration**

7.9.1 The UPSs shall allow configuration and access to all parameters via man-machine interface, comprised of the elements specified in 7.7 and 12.9.

7.9.2 Any needed software for the configuration shall be provided to PETROBRAS with the UPS, at no expense. The configuration software shall be compatible with the Windows<sup>®1)</sup> operating system.

7.9.3 The configuration of the UPS via the serial port shall be implemented with the UPS in operation, without interrupting the AC safe busbar feed.

7.9.4 Configuration adjustments shall be implemented in the UPS in non-volatile memory.

7.9.5 Accesses for changing the configuration and for cleaning recorded data using any means shall be protected by a configurable password available to PETROBRAS. Provision shall be made for a password not to be required for reading UPS data.

## **7.11 Redundant Parallel Architecture**

7.11.1 If requested in Data Sheet of Annex B, the UPS to be supplied shall have redundant parallel architecture and present the performance requirements shown below:

7.11.1.1 The load shall be automatically and equally distributed among the UPS units.

7.11.1.2 If any failure occurs in one of the redundant UPS units, the load shall be automatically distributed among the other ones.

7.11.1.3 There shall be no single point of failure of the synchronism system affecting the other UPSs. It is not allowed a central module of load division control and synchronism external to redundant UPSs.

7.11.1.4 The technology shall be capable of operating with at least 5 UPS units in parallel with active load division. To add an UPS in parallel, it is not allowed to add hardware in the other UPSs, unless the interconnection by means of communication between the UPSs.

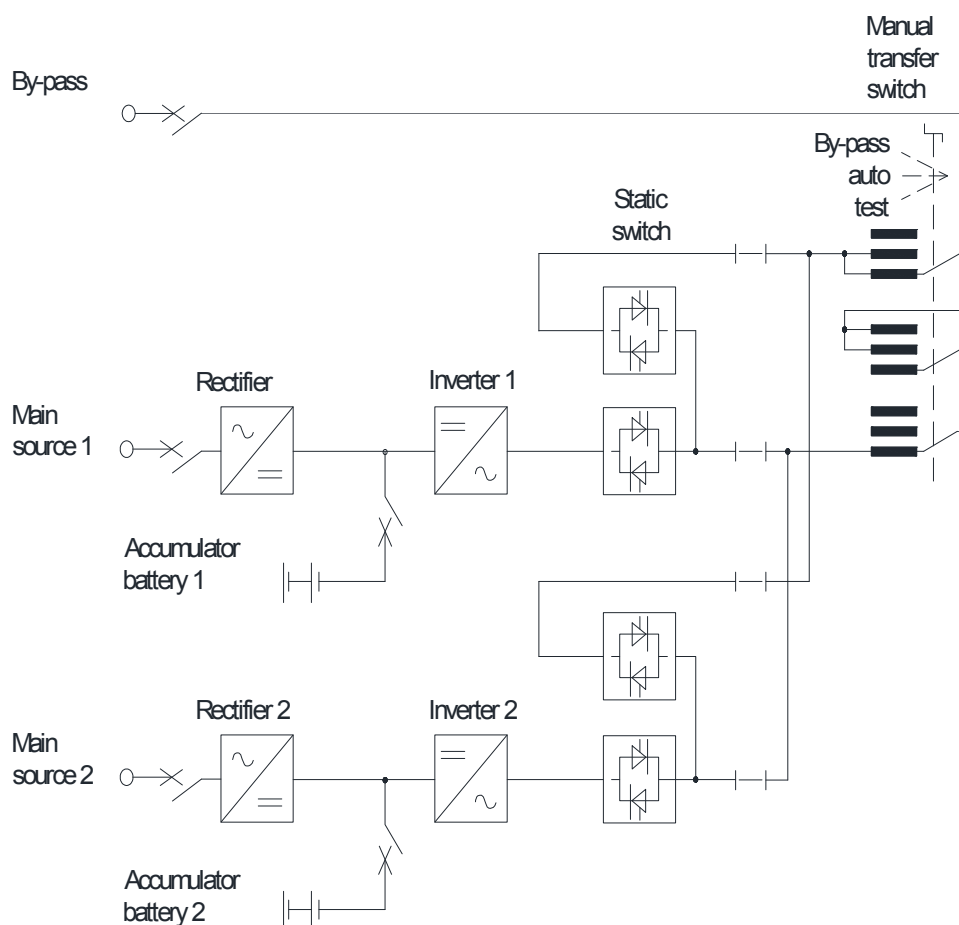
7.11.1.5 The redundant system with more than one UPS in parallel shall perform an active sharing of load and supply current equal to voltage.

7.11.1.6 The configuration of static switch shall comply with options defined in IEC 62040-3 and established as per Data Sheet between UPS with common or shared static switch.

**NOTE** The parallel connection of transformers from varied by-passes is a problem due to small impedance differences in each secondary winding. It is recommended to contact the manufacturer if the shared static switch topology is required. In the configuration of shared static switch, composed transfer switches shall not be used, since they add an unnecessary complexity.

7.11.1.7 The total number of redundant parallel UPSs and the load division is equal to "N + R" and shall be defined as per Data Sheet, where N is the number of individual UPS units required to withstand the load and R is the number of redundant UPS units.

<sup>1)</sup> Windows<sup>®</sup> é o nome comercial de um produto da Microsoft Corporation. Esta informação é dada para facilitar aos usuários desta Norma e não constitui um endosso por parte da PETROBRAS ao produto citado. Podem ser utilizados produtos equivalentes, desde que conduzam aos mesmos resultados.



**Figure 1 - Typical Configuration of Redundant Parallel UPS N = 1 and R = 1**

- NOTE 1 A typical configuration, in which 2 units in redundant parallel configuration shall withstand 100% of load each, is N = 1 and R = 1.
- NOTE 2 Another example of configuration, in which many redundant units add the required to withstand the load, for instance, 4 UPS in parallel and one redundant unit, is N = 4 and R = 1. In this case, there are 5 UPS in parallel relying on the redundant unit. In this configuration, each of the 5 units is sized to withstand 25 % of the load.
- NOTE 3 Figure 1 represents a typical configuration of scope of supply of redundant parallel UPS N = 1 and R = 1, and does not establish a supply standard. The application in a design shall be thoroughly studied so as to adapt the configuration of the equipment being purchased to local standards and installation site needs.

## 8 Input Supply Characteristics

8.1 The UPS shall meet the grid requirements, as per 5.13, unless otherwise indicated in the Data Sheet of Annex B.

8.2 Unless otherwise indicated in Data Sheet of Annex B, the input supply shall be four-wire three-phase.

8.3 The negative-to-positive sequence ratio shall not exceed 5 %.

8.4 The short-circuit level in the UPS feed panel shall be as indicated on the Data Sheet of Annex B.

## **9 Characteristics of Fed Load**

9.1 The fed load by the UPS has non-linear characteristics with a minimum peak factor of 3, typically comprised of switch mode power supplies, with power factor usually between 0,6 and 1.

9.2 The UPS shall be sized to continuously supply the load of 100 % of the nominal apparent power.

## **10 Output Characteristics**

10.1 The output voltage shall be as specified on the Data Sheet of Annex B.

10.2 The frequency shall be 60 Hz  $\pm$  3 Hz synchronized with the alternative source or  $\pm$  0,05 Hz by an internal crystal oscillator.

10.3 The inverter shall limit the total harmonic distortion of output voltage for less than 3 % of the total RMS with 100 % of linear load, or less than 5 % RMS with 100 % of non-linear load. The individual harmonic distortion shall not exceed 3 %. In the by-pass mode, the harmonic distortion shall be equal to or less than the input supply voltage distortion.

10.4 The UPS shall have output voltage characteristics under conditions involving change in mode of operation (normal/stored energy/by-pass) and under conditions involving application of load increase or decrease, and shall comply with 10.4.1 and 10.4.2.

10.4.1 Static voltage regulation shall be better than  $\pm$  1 % of the efficient nominal voltage under any normal operating conditions.

10.4.2 Unless otherwise specified in the Data Sheet, the output voltage dynamic performance curves of the UPS shall remain, according to IEC 62040-3, within the limits CCC equal to 111 for change of operation mode, degree of linear load and degree of non-linear load.

10.5 The UPS shall withstand temporary overloads of 150 % of the rated current for a period of 1 minute, and of 125 % of the rated current for a period of 10 minutes. This overload condition shall be tested considering the UPS supplying rated power and with the internal temperature stabilized in both the normal and stored energy modes of operation.

10.6 The UPS, when three-phase type is specified, shall provide a phase angle between voltages of  $120^\circ \pm 1^\circ$  for balanced loads and  $120^\circ \pm 3^\circ$  for 100 % unbalanced loads, in the normal and stored energy mode of operation.

10.7 The UPS, when three-phase type is specified, shall withstand 100 % of load unbalancing in continuous duty, keeping an unbalance of the output voltage at  $\pm$  5 %, at the most in the normal and stored energy operation mode.

## **11 Load Distribution Panel**

If established in Data Sheet of Annex B, the UPS manufacturer shall be responsible for supplying the load distribution panel. The description, drawing and requirements are defined in a separated specification to be supplied by PETROBRAS.

## **12 Protection, Metering, Control and Signaling**

12.1 The protection in the UPS inputs shall operate for short circuit, overvoltage and overcurrent conditions.

12.2 The UPS shall inhibit the rectifier by high DC voltage or by short circuit at the rectifier output.

12.3 The UPS shall disconnect the battery bank when operated by final battery discharge voltage adjustment. If the batteries reach the discharge limit recommended by the manufacturer, the static switch shall transfer to the alternative source provided the synchronism conditions are fulfilled. Otherwise the power delivered to the load shall be interrupted.

12.4 The UPS shall inhibit the inverter by continuous voltage outside limits, by overload and by inverter failure. The inverter shall limit the current to the overload values and if the specified time is exceeded, it shall transfer to the alternative source, when synchronized, and within the specified voltage limits.

12.5 The UPS shall inhibit transfer by loss of synchronism with the alternative source, with the frequency being transferred to reference of internal oscillator.

12.6 The UPS shall contain an alphanumeric digital display to indicate voltage, frequency, current, historical register of faults, display of local alarms, adjustment parameter values:

- a) main source input - voltage;
- b) alternative source input - voltage, frequency;
- c) direct current branch - rectifier output voltage and current, battery current, battery open circuit voltage;
- d) inverter output - voltage, current and frequency.

12.7 The diagnosed failures shall be available in accessible memory through digital communication described in item 7.8, and shall be contained in the summary of alarms:

- a) main source undervoltage;
- b) main source overvoltage;
- c) abnormal rectifier;
- d) DC undervoltage;
- e) DC overvoltage;
- f) rectifier overload;
- g) alternative source undervoltage;
- h) alternative source overvoltage;
- i) synchronism under abnormal conditions;
- j) out of synchronism;
- k) abnormal / blocked static switch;
- l) abnormal inverter;
- m) inverter overload;
- n) inverter output undervoltage;
- o) inverter output overvoltage;
- p) self-monitoring failure detection;
- q) battery disconnected;
- r) battery discharging;
- s) static switch transferred to alternative source;
- t) manual transfer to alternative source;
- u) earth leakage in DC link (optional Data Sheet);
- v) earth leakage in safe busbar of consumers (optional Data Sheet);

- w) UPS ventilation failure;
- x) inhibition reload for gas detection in the batteries room (optional Data Sheet)

12.8 The UPS shall store in non-volatile memory historical register of the last 50 events at least. The man-machine interface shall allow the reading of failures and events described in Chapter 12.

12.9 The UPS shall have a synoptic panel to show system operations, indicating at least the following:

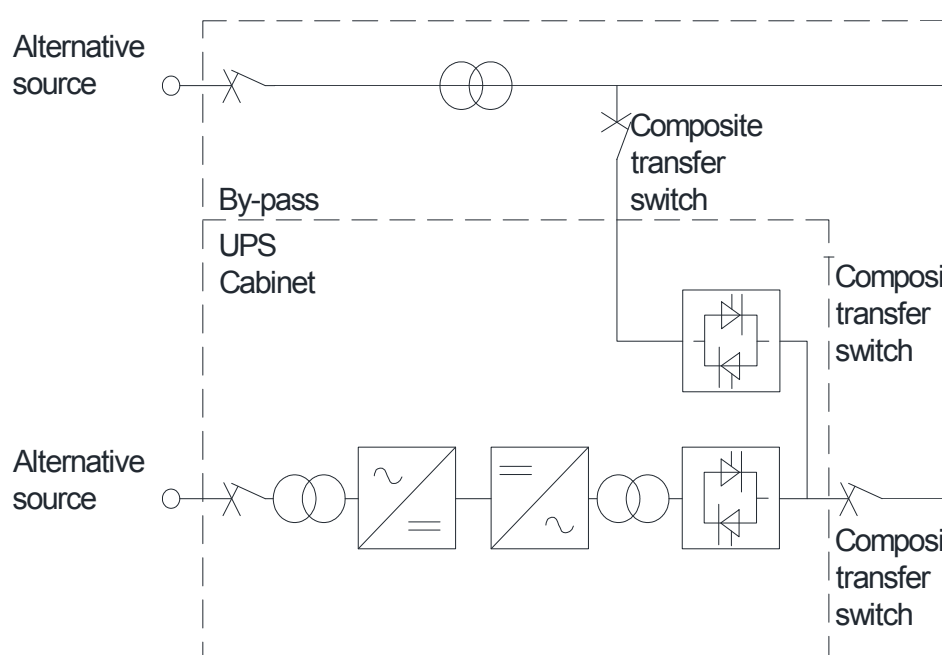
- a) presence of voltage in main source and within normal parameters;
- b) rectifier in operation;
- c) direct current busbar energized and within normal parameters;
- d) battery on float charge;
- e) battery discharging;
- f) inverter in operation;
- g) presence of voltage in alternative source and within normal parameters;
- h) normal static switch;
- i) load fed by inverter;
- j) load fed by main source;
- k) load fed by alternative source.

12.10 The UPS shall have a circuit breaker for the main source input and one for the alternative source input.

12.11 The UPS shall have manual static switch control on the front part of the UPS cabinet to allow selection of the alternative source or inverter output. If the UPS is synchronized with the alternative source, it shall promote transfer without interrupting the power delivered to the loads.

12.12 The UPS shall have a transfer switch with single command "make before break" type or composite with simple switches to allow removal of the UPS for maintenance, as defined in Data Sheet of Annex B. If the UPS is synchronized with the alternative source, the operation of this switch shall not cause interruption of power delivered to the loads. When indicated in Data Sheet of Annex B, the single command switch shall have an intermediate test position between normal and alternative positions, so as to feed the safe AC busbar and static switch input by alternative source. When a composite transfer switch is defined in Data Sheet of Annex B, it shall be made of simple switches, as per Figure.





**Figure 2 - Composite Transfer Switch**

12.13 The UPS shall have at least remote alarms of battery feeding the load, load fed by the alternative source and summary of failures. These alarms shall be made available through voltage-free SPDT dry contacts with capacity of 0,5 A, 250 Vac / 125 Vdc, with inductive load ( $L/R = 0,04$  s).

12.14 If the UPS manufacturer is responsible for supplying the load distribution panel, as established in Chapter 11, it shall also be responsible for coordinating the protection of the entire system.

### 13 Static Switch

13.1 The static switch of the UPS shall implement the immediate transfer of load from the inverter to the alternative source without interruption in case of overload, voltage outside limits, protection of battery or by manual operation command. The synchronism transfer shall take place in a time of 4 ms or shorter by inverter failure or overload. Out of synchronism, the transfer time shall be at least 1 cycle (16,66 ms).

13.2 The static switch of the UPS shall implement transfer up to 4 ms from the alternative source to the inverter, for recovery to within normal conditions or by manual operation, without interruption in power delivered to the loads, in those situations in which the voltage of the alternative source and of the UPS are normal and synchronized.

13.3 The static switch shall be sized to continuously withstand an overload current of 125 % of the rated current of the UPS. It shall also withstand an overload of 200 % of the rated current of the UPS for 30 s and withstand for 100 ms a current value of 1 000% of rated current.

### 14 Rectifier

The technical requirements for performance are established according to PETROBRAS [N-332](#).

## **15 Inverter**

15.1 The inverter bridge or the inverter stage shall be switched at high frequency by pulse width modulation using appropriate semiconductors.

15.2 The inverter output voltage shall allow adjustment of  $\pm 5$  % of the rated voltage.

## **16 Transformers**

16.1 Transformers used in input and by-pass shall have independent windings, between the primary and secondary, and tertiary where applicable.

16.2 Transformers shall be of the dry type and terminals of the bolt and eye type.

16.3 Sizing of the transformer due to the harmonic content generated by the UPS shall be in accordance with IEC [61378-1](#).

16.4 The transformer of alternative source shall have taps in accordance with the Data Sheet, and have grounded electrostatic shielding and dumping system in order to minimize vibration transmission for the UPS. If the UPS output is three-phase, the transformer beside the static switch shall have its primary in delta.

## **17 Technical Documentation**

### **17.1 With Proposal**

17.1.1 Detailed calculation notes shall be provided, according to IEEE [STD 485](#) and [STD 1115a](#), showing the reasons of the selected battery according to the discharge profile shown on the Data Sheet of Annex B by PETROBRAS.

17.1.2 It shall be informed the maximum heat dissipation to the environment of the group of equipment and components in the various possibilities of operation (normal mode, full load, with battery being recharged; or stored energy mode, or alternative source supply mode).

17.1.3 The battery recharging cycles shall be informed in the form of waves at 25 °C.

17.1.4 The characteristic of voltage versus current of the battery current limiting circuit shall be informed;

17.1.5 Catalogs of parts and components of the UPS, containing the characteristics and technical specifications.

17.1.6 Block diagram, identifying the basic systems of the UPS and their interconnections.

17.1.7 Dimensional drawings of the front and side views and cross-sectional area of the UPS, with approximate dimensions.

17.1.8 List of technical standards applicable to design, fabrication and testing, referring to the country of origin of the technology followed by the manufacturer, complementing the list of technical standard of Chapter 2 of this Standard.

17.1.9 Data Sheet fully completed and authenticated by the manufacturer, including the spaces referring to the standards applicable to design, fabrication and testing of the UPS.

17.1.10 Quality control plan to be followed, containing at least the tests required by this Standard, complemented by those proposed by the manufacturer.

NOTE This test plan shall be detailed, containing all phases and procedures to be followed and implemented during the construction of the UPS, and indicating the reference standards used and their respective items.

17.1.11 List of spare parts as required in the RM, with description of part numbers and respective unit prices.

17.1.12 Complete and detailed plate treatment and painting system, including chemical and physical performance rates.

17.1.13 Estimated weight of the UPS.

17.1.14 List of deviations or alternatives to specifications.

17.1.15 If requested in the Data Sheet of Annex B, the UPS manufacturer shall present a list of similar equipment supplied with at least 3 years of operation. Prototypes and untested equipment are not accepted.

17.1.16 The UPS manufacturer shall present a copy of demanded Type Tests in Data Sheet or as established in item 18.

## **17.2 After AFM**

Technical documentation which shall be submitted for approval or information, containing at least the information in the following items:

- a) dimensional drawings of views and cross-sections, including the free space for entrance and exit of power and grounding cables, heat dissipation value and weight of UPS;
- b) drawings showing location, dimensions and types of UPS attachment device;
- c) functional, control and wiring (interconnection) diagrams, indicating all terminal strips, including those needed for interconnection to other equipment or systems outside the manufacturer's scope of supply, clearly showing the identified terminals;
- d) drawings of input and output terminal strips of power and command circuits;
- e) list of all UPS components, including, as a minimum, description, quantity and complete coding of the manufacturer;
- f) one-line power diagram;
- g) power interface drawings;

- h) technical specifications of UPS as well as all components and accessories requested in accordance with:
  - all approved requirements of the original proposal;
  - all revisions made at the time of technical clarifications and/or technical report;
- i) list of spare parts with description of respective part-numbers of the component manufacturer.

### **17.3 After Final Approval of Drawings**

17.3.1 After final approval of all documents mentioned in the preceding item, the manufacturer shall submit the documentation specified below in optical medium and with a paper copy, also subject to comments. Manuals shall be drawn up in Portuguese or English and organized in accordance with the following criterion:

- a) diagrams and physical arrangements of electronic cards;
- b) detailed description of operation of electronic cards, including waveforms and adjustments;
- c) specification of adjustments required for the UPS;
- d) assembly and installation manual, containing at least the following information:
  - procedures for storage of UPS and any spare components;
  - procedures and details for assembly and mechanical installation of UPS and accessories;
  - procedures and details of electrical power and grounding connections;

17.3.2 An operations manual in Portuguese in optical medium and with a paper copy, containing at least the following information, shall be provided:

- a) description of UPS;
- b) theoretical fundamentals;
- c) commissioning instructions;
- d) procedures for implementation of adjustment and parameterization functions;
- e) list of error messages, occurrence conditions and the respective corrective actions;
- f) operational procedures in failure and trip events;

17.3.3 A preventive and corrective maintenance manual in Portuguese, in optical medium and with a paper copy, containing at least the following information, shall be submitted:

- a) description of circuit operation, with their respective waveforms;
- b) procedures for execution of internal adjustments;
- c) detailed procedures for adjustments and tests, as well as list of materials and resources needed for execution thereof;
- d) maintenance procedures to be followed for each failure symptom presented;
- e) fault finding methods, using the information obtained from the self-diagnostic system and testing and measurement instruments;
- f) diagrams and identification of internal components, terminal blocks, and printed circuit boards;
- g) list of components, containing their commercial identifications, brands and models;
- h) connection and wiring diagrams;
- i) layout drawings of the UPS;
- j) technical catalogs with characteristic data of the accessories specified, “as supplied”;
- k) copy of “as manufactured” drawings;
- l) Data Sheet duly filled out “as purchased” and/or “as built”;
- m) copy of all reports on tests performed on the UPS.
- n) technical specifications of UPS, as well as all components and accessories used, in accordance with:
  - all approved requirements of the original proposal;
  - all revisions made at the time of technical clarifications and/or technical report.

#### 17.4 Requirements for Presentation of Documents

Documents, drawings and manuals shall be prepared, as a minimum, in 210 mm x 297 mm paper size, in a legible manner, each one containing at least the following information:

- a) identification of PETROBRAS department or Unit;
- b) PETROBRAS equipment identification number;
- c) RM number;
- d) Purchase Order - PCS number.

**NOTE** For each drawing or document, on the right side of each page, near and above the manufacturer's stamp, a 15 cm x 4 cm rectangle shall be left in blank to be subsequently completed by PETROBRAS.

#### 18 Tests

The tests applicable to the UPS-CA are listed in Table 1, and the test descriptions shall be checked in Annex A, Test Definition. TAF and TAC tests to be presented are marked as per Data Sheet of Annex B or as below.

**Table 1 - List of Tests**

Test	TYPE	TAF	TAC
<b>Preliminary tests</b>			
Control and monitoring signals		X	X
Check of interconnection cables		X	X
Test of UPS auxiliary devices		X	X
Light load test		X	X
<b>UPS input feed tests</b>			
AC input voltage tolerance in permanent condition	X	X	
Input voltage frequency variation	X	X	
Inrush current	X		
<b>UPS output characteristics - static condition</b>			
Output - normal mode - no load	X	X	
Output - normal mode - rated load	X	X	
Output - stored energy mode - no load	X	X	
Output - stored energy mode - rated load	X	X	
Unbalanced output voltage test	X	X	
Output voltage dc component and zero sequence	X	X	
Output - normal operation mode - overload	X	X	
Output - stored energy operation mode - overload	X	X	
Reference non-linear load charge output distortion – normal mode and stored energy mode	X	X	
<b>Short-circuit</b>			
Short-circuit - no transfer to static switch and no short-circuit elimination	X	X	
Short-circuit - with transfer to static switch and with short-circuit elimination	X	X	
<b>UPS output dynamic tests</b>			
Linear loads	X	X	
Non-linear loads	X	X	
Stored energy and restored energy tests			X
Restored energy time at 90% of capacity			X
Input efficiency and power factor	X	X	
<b>Emission, radio frequency interference supportability and conducted noise tests</b>			
Emission	X		
Immunity (electromagnetic susceptibility)	X		

**Table 1 - List of Tests (Continued)**

<b>Test</b>	<b>Type</b>	<b>TAF</b>	<b>TAC</b>
<b>Synchronization tests</b>			
Synchronization time	X	X	
Phase angle	X	X	
Variation in alternative source frequency	X	X	
<b>Failure simulation in UPS in parallel redundancy</b>			
Failure in one of redundant parallel system units	X		X
Shutdown of one of redundant parallel system units	X		X
<b>Transfer test</b>			
Operation in synchronism with alternative source – manual operation for transfer	X	X	X
Operation in synchronism with alternative source – automatic operation for transfer	X	X	X
Operation out of synchronism with alternative source – manual operation for transfer	X	X	X
Operation out of synchronism with alternative source – automatic operation for transfer	X	X	X
Division of current in parallel or redundant parallel	X		X
Test of ripple (residual wave) current in battery	X		
Harmonic components test	X	X	
Temperature rise test	X	X	
<b>Static switch test</b>			
Overload tests	X		
Overvoltage tests	X		
<b>Non-electrical tests</b>			
<b>Environmental tests</b>			
<b>Vibration and shock test</b>			
Shock test	X		
Free drop test	X		
Connector vibration and shock test	X		
Audible noise	X		

## **Annex A - Definition of Tests**

### **A.1 General Conditions**

A.1.1 The tests defined in this Annex shall be performed in each unit of the UPS assembly. More than one UPS assembly shall only be used in tests of division of current in parallel or redundant parallel and failure of one of the redundant parallel system units.

A.1.2 The linear load to be used in all tests described shall be resistive, with tolerance of 5% and power factor  $\geq 98\%$ . The load shall have dynamic response under  $20\text{ ms} \pm 5\%$ , after the temperature stabilizes.

A.1.3 Measurement equipment and instruments used in test shall:

- a) have calibration certificates;
- b) have sufficient pass band to accurately measure real efficient values (True RMS) of wave forms which may be other than fundamental sinusoid, in order words, with significant harmonic content.

A.1.4 The recording instrument (Ex.: Oscilloscope with memory or oscillograph) shall have at least 4 galvanically insulated channels, CAT III (600 Vac), with x10, x100 voltage probes, current probes for 10 /100 /1 000 A, precision 0,2% and accuracy 3,5 digits.

### **A.2 Tests**

#### **A.2.1 Preliminary Tests**

The tests described in this subsection shall be performed so as to check the correct assembly of the equipment before the main tests.

##### **A.2.1.1 Control and Monitoring Signals (IEC 62040-3)**

The operation of indications and signals shall be checked in all performed tests. Gauge tests shall be performed in all measurement equipment items of UPS, including components for remote measuring through industrial networks. The manufacturer shall supply means to perform these measurements.

##### **A.2.1.2 Check of Interconnection Cables (IEC 62040-3)**

The test shall be performed after connecting the functional units which comprise the full UPS. This test shall be performed in factory and at the installation site if there is any disassembling of equipment for transport. The document used to check the connections shall be attached to the test documentation.

##### **A.2.1.3 Test of UPS Auxiliary Devices (IEC 62040-3)**

Functionalities of the UPS auxiliary devices, such as lighting, cooling, pumps, vents, alarms, and optional devices, shall be checked in the light load test or during other tests.

**A.2.1.4 Light Load Test (IEC 62040-3)****A.2.1.4.1 Test Condition**

This test shall be performed to check if the UPS is correctly connected and if all functions are operating. The tests below shall be performed with or without AC.

**A.2.1.4.2 Measurements and Checks**

- output voltage and frequency;
- operation of everything with controls, alarms, event logs, measurements and other means required for proper operation of the UPS.

**A.2.1.4.3 Acceptance Criterion**

The UPS functionalities shall be in accordance with the manufacturer's manual.

**A.2.2 UPS Input Feed Tests (IEC 62040-3)**

The UPS shall be in normal operating mode with rated output active power load. The input feed shall come from a variable voltage/frequency generator, which output impedance able to keep the voltage wave form within the limits of IEC 61000-2-2. In tests in which the frequency variation is not required, the UPS may be fed by electrical power grid.

**A.2.2.1 AC Input Voltage Tolerance in Permanent Condition (IEC 62040-3)****A.2.2.1.1 Test Condition**

With the UPS in normal operation mode and rated input frequency, the input voltage shall be adjusted to the minimum and maximum values of tolerance range specified by IEC 62040-3 and this Standard ( $\pm 10$  % of rated voltage), until the UPS stabilizes.

**A.2.2.1.2 Measurements and Checks**

A.2.2.1.2.1 The output voltage shall be measured and its tolerance registered in maximum and minimum input voltages.

A.2.2.1.2.2 When the UPS design prevents the normal operation mode over  $\pm 10$  % of rated feed voltage, changing the operation to stored energy, the recorded value shall be the voltage before the change.

**A.2.2.1.3 Acceptance Criterion**

The equipment shall operate normally and without damaging itself.



### **A.2.2.2 Input Voltage Frequency Variation (IEC 62040-3)**

#### **A.2.2.2.1 Test Condition**

A.2.2.2.1.1 Adjust the generator frequency that is feeding the UPS in 60 Hz, keep the recording instrument in the UPS output so as to record the synchronism input and output values with the network (generator).

A.2.2.2.1.2 Vary it slowly (1 Hz/s) until less than 57 Hz and notice that, when it reaches 57 Hz, the synchronism with grid shall be disconnected, and the UPS shall operate by its local oscillator, keeping the output in 60 Hz  $\pm$  0.05 Hz.

A.2.2.2.1.3 Return it slowly (1 Hz/s) until 57 Hz, notice the synchronism of inverter with grid (Generator), record with oscillograph, keep increasing the frequency slowly (1 Hz/s) until reaching more than 63 Hz, and notice that, when reaching 63 Hz the synchronism with grid shall be disconnected, and the UPS shall operate by its local oscillator, keeping the output in 60 Hz  $\pm$  0,05 Hz.

A.2.2.2.1.4 The test in A.2.2.1 shall be repeated with the input voltage frequency adjusted to specified limits ( $\pm$  5 % of rated frequency) alongside the input voltage variations.

**NOTE** It is considered that a decrease in frequency does not coincide with an increase in line voltage, and vice-versa.

#### **A.2.2.2.2 Measurements and checks:**

When the output voltage frequency of UPS is synchronized with the input voltage frequency, the synchronism range shall be checked. The free running frequency shall be recorded for non-synchronous conditions. It shall be checked the moment in which there is loss of synchronism with the grid, when the inverter starts working through the local oscillator of inverter.

**NOTE** The output frequency tolerance range shall be checked in temperature rise test, for specified input voltage variation range and specified load variation range. When the frequency is determined only by the internal oscillator, this range may be checked for the control equipment (oscillator) along the temperature range.

#### **A.2.2.2.3 Acceptance Criterion**

Within the defined synchronism range, the UPS shall not transfer to by-pass. When the total input frequency range exceeds the defined synchronism range, the UPS output shall revert to free running internal oscillator operation.

### **A.2.2.3 Inrush Current (IEC 62040-3)**

#### **A.2.2.3.1 Test Condition**

A.2.2.3.1.1 The Inrush current test shall be performed under two input voltage fault conditions:

- after a lack of input voltage for more than 5 minutes;
- after a lack of input voltage of 1s;

A.2.2.3.1.2 The test shall be performed with no battery and no load.

A.2.2.3.1.3 The UPS-CC shall be energized 10 times asynchronously and randomly for each condition of lack of voltage, so as to determine the worst case condition of inrush current:

- in units coupled to a transformer, when energized in zero voltage point;
- for resistive or capacitive loads, in peak of voltage wave form of input feed, or near it;

A.2.2.3.1.4 For this test, initial current surges due to energizing of RFI capacitors in input filters with duration under 1ms shall be ignored;

A.2.2.3.1.5 High frequency current transformers shall be used for oscillographic record;

A.2.2.3.1.6 For this test, it shall be considered the manufacturer's standard complete UPS, excluding voltage adapting transformers requested for specific use.

#### **A.2.2.3.2 Measurements and Checks**

A.2.2.3.2.1 Oscillographic record of UPS Inrush current.

A.2.2.3.2.2 Oscillographic record of voltage at the moment of closing the switch energizing the UPS, used as a trigger reference.

#### **A.2.2.3.3 Acceptance Criterion**

Maximum RMS Inrush current shall not exceed 15 x Irated, and the duration shall not be longer than two cycles.

### **A.2.3 UPS Output Characteristics - Static Condition (IEC 62040-3)**

#### **A.2.3.1 Output - Normal Mode - No Load (IEC 62040-3)**

##### **A.2.3.1.1 Test Condition**

UPS operating in normal operation mode, with no load and with rated input voltage and frequency.

##### **A.2.3.1.2 Measurements and Checks**

Measure the output voltage and voltage of fundamental and harmonic components.

##### **A.2.3.1.3 Acceptance Criterion**

A.2.3.1.3.1 Output voltage:  $\leq 10\%$  (synchronized with the grid) and  $\pm 1\%$  (not synchronized with the grid) of rated voltage.

A.2.3.1.3.2 Output voltage frequency  $\pm 5\%$  (synchronized with the grid) and  $\pm 0,05$  Hz (not synchronized with the grid) of rated frequency.

A.2.3.1.3.3 Output voltage harmonics: THD  $\leq$  3 %;

#### **A.2.3.2 Output - Normal Mode - Rated Load (IEC 62040-3)**

##### **A.2.3.2.1 Test Condition**

UPS operating in normal operation mode, with 100 % of active rated load and with rated input voltage and frequency.

##### **A.2.3.2.2 Measurements and Checks**

Measure the output voltage and voltage of fundamental and harmonic components.

##### **A.2.3.2.3 Acceptance Criterion**

A.2.3.2.3.1 Output voltage:  $\pm$  10 % (synchronized with the grid) and  $\pm$  1 % (not synchronized with the grid) of rated voltage.

A.2.3.2.3.2 Output voltage frequency  $\pm$  5 % (synchronized with the grid) and  $\pm$  0.05 Hz (not synchronized with the grid) of rated frequency.

A.2.3.2.3.3 Output voltage harmonics: THD  $\leq$  3 %

#### **A.2.3.3 Output - Stored Energy Mode - No Load (IEC 62040-3)**

##### **A.2.3.3.1 Test Condition**

UPS operating through batteries, with no load.

##### **A.2.3.3.2 Measurements and Checks**

Measure voltage, frequency and their fundamental and harmonic components.

##### **A.2.3.3.3 Acceptance Criterion**

A.2.3.3.3.1 Output voltage:  $\pm$  1 % of rated voltage.

A.2.3.3.3.2 Output frequency  $\pm$  0.05 Hz of rated frequency (by internal oscillator).

A.2.3.3.3.3 Output voltage harmonics: THD  $\leq$  3 %

**A.2.3.4 Output - Stored Energy Mode - Rated Load (IEC 62040-3)****A.2.3.4.1 Test Condition**

Apply a resistive load equal to 100 % of active rated power of UPS in output.

**A.2.3.4.2 Measurements and Checks**

A.2.3.4.2.1 In continuous duty, in starting condition of battery discharge, measure the voltage, frequency and fundamental and harmonic components in output.

A.2.3.4.2.2 Record the output voltage with no load and full load, check calibration.

A.2.3.4.2.3 Notice the parameters above until the UPS shuts down due to battery undervoltage.

A.2.3.4.2.4 Record the total time, voltage calibration and worst fundamental and harmonic levels, which shall not exceed the values stated by the manufacturer.

**NOTE** For UPS with batteries with storage time under 10 minutes, it is allowed to connect an additional battery to keep the test stable and allow the measurement. This test requires instrumentation with sufficient time scan to observe the voltage decrease over battery time.

**A.2.3.4.3 Acceptance Criterion**

A.2.3.4.3.1 Charged battery:

- output voltage with no load within the tolerance;
- output voltage with load within the tolerance;
- calibration ( $\pm 1$  %);
- output voltage harmonics: THD  $\leq 3$  %.

A.2.3.4.3.2 Final charge battery:

- output voltage with load within the tolerance;
- calibration ( $\pm 1$  %);
- output voltage harmonics: THD  $\leq 3$  %.

**A.2.3.5 Unbalanced Output Voltage Test (IEC 62040-3)****A.2.3.5.1 Test Condition**

A.2.3.5.1 The output voltage unbalance in three-phase output UPS shall be checked under conditions of load with balanced rated active power, and also under conditions of 100% unbalanced load.

A.2.3.5.2 The test shall be performed:

- in normal operation mode;
- in stored energy mode, fully charged and final discharge. Battery voltage simulations are allowed for this test.

**A.2.3.5.2 Measurements and Checks**

Output voltages between phases and phase-neutral (if any) shall be observed and recorded. The voltage unbalance shall be given in a voltage unbalance index or voltage unbalance factor, as per IEC 60146-2. Phase angle deviations shall be determined by calculation from the values of voltages between phases and phase-neutral.

**A.2.3.5.3 Acceptance Criterion**

The result shall be within the specified voltage and angle tolerance specifications, without losing synchronism with the by-pass grid and without switching to the static switch. The UPS shall withstand 100 % of load unbalancing in continuous duty, keeping an unbalance of the output voltage at  $\pm 5\%$ . The UPS shall provide phase angle between voltages of  $120^\circ \pm 1^\circ$  for balanced loads, and  $120^\circ \pm 3^\circ$  for 100 % unbalanced loads.

**A.2.3.6 Output Voltage DC Component and Zero Sequence (IEC 62040-3)****A.2.3.6.1 Test Condition**

UPS operating in normal operation mode, with no load and with rated input voltage and frequency. If the UPS output is three-phase, the zero sequence component of this voltage shall be measured.

**A.2.3.6.2 Measurements and Checks**

Output voltages between phases and phase-neutral (if any) shall have an oscillographic record.

**A.2.3.6.3 Acceptance Criterion**

The DC component of output voltage shall be under 0,1% of the AC rms value. If there is a neutral, there shall be no zero sequence component in output voltage.

**A.2.3.7 Output - Normal Operation Mode - Overload (IEC 62040-3)****A.2.3.7.1 Test Condition**

The UPS shall provide rated active power and with stabilized internal temperature in normal operation mode. The static switch shall be blocked for transfer. The test shall be considered for each inverter. Apply overload of 150 % of the rated current for a period of 1 minute, and of 125 % of the rated current for a period of 10 minutes.

**A.2.3.7.2 Measurements and Checks**

- output voltage;
- frequency;
- output current;
- local and remote alarms of “inverter overload”;
- event log of UPS..

**A.2.3.7.3 Acceptance Criterion**

Local and remote alarm, indicating “inverter overload”, but the output voltage and frequency shall remain within the nominal range (keep the voltage static calibration and frequency calibration of  $\pm 0,05$  Hz) for the minimum time indicated above. The UPS shall not have any damage, nor equipment shutdown due to overheating. The event shall be memorized, allowing only the manual reset of the alarm.

**A.2.3.8 Output - Stored Energy Operation Mode - Overload (IEC 62040-3)****A.2.3.8.1 Test Condition**

The UPS shall provide rated active power and with stabilized internal temperature in stored energy operation mode. The static switch shall be blocked for transfer. The test shall be considered for each inverter. Apply overload of 150 % of the rated current for a period of 1 minute, and of 125 % of the rated current for a period of 10 minutes.

**A.2.3.8.2 Measurements and Checks**

- output voltage;
- frequency;
- output current;
- local and remote alarms of “inverter overload”;
- event log of UPS..

**A.2.3.8.3 Acceptance Criterion**

Local and remote alarm, indicating “inverter overload”, but the output voltage and frequency shall remain within the nominal range (keep the voltage static calibration and frequency calibration of  $\pm 0,05$  Hz) for the minimum time indicated above. The UPS shall not have any damage, nor equipment shutdown due to overheating. The event shall be memorized, allowing only the manual reset of the alarm.

**A.2.3.9 Reference Non-Linear Load Charge Output Distortion – Normal Mode and Stored Energy Mode (IEC 62040-3)****A.2.3.9.1 Test Condition**

With the UPS operating in normal mode (existing AC input), apply to UPS output a set of reference non-linear load charge so as to obtain apparent output power for the UPS under test. After performing the measurements, repeat the test, stopping the input feed from rectifier so as to force a transition to stored energy operation mode.

**A.2.3.9.2 Measurements and Checks**

A.2.3.9.2.1 Oscillographic record of output voltage of UPS in continuous duty conditions.

A.2.3.9.2.2 Record the waveform of output voltage and its harmonic content.

#### **A.2.3.9.3 Acceptance Criterion**

The waveforms of output voltage wave, its fundamental and harmonic content for both test conditions shall not exceed the established values ( $THD \leq 5\%$ ). In addition, the DC voltage of the reference non-linear load capacitors shall be measured to ensure that its value remains within the limits calculated by the formula of standard IEC 62040-3 for the  $U_c$  parameter.

#### **A.2.4 Short-Circuit**

##### **A.2.4.1 Short-circuit - No Transfer to Static Switch and No Short-Circuit Elimination (IEC 62040-3)**

###### **A.2.4.1.1 Test Condition**

A.2.4.1.1.1 UPS providing rated active power and with stabilized internal temperature in normal operation mode, with no availability for Static Switch to transfer the load to other power source.

A.2.4.1.1.2 The test shall be considered for each inverter.

A.2.4.1.1.3 Apply full short-circuit to AC output of UPS indefinitely. For UPS with three-phase output, it shall be applied phase-phase or phase-neutral short circuit, if neutral is available.

A.2.4.1.1.4 The test shall be fully repeated, simulating stored energy with fully charged battery, and shall present the same results.

###### **A.2.4.1.2 Measurements and Checks**

A.2.4.1.2.1 Oscillographic record of UPS output voltage and current.

A.2.4.1.2.2 Record on event log of UPS.

###### **A.2.4.1.3 Acceptance Criterion**

- local and remote alarm, indicating “short-circuit in inverter”;
- UPS shall not be damaged;
- interruption of AC output of UPS;
- UPS shall protect itself, not causing fuse blowing or opening of circuit breakers;
- the event shall be memorized, not disappearing after normalization.

##### **A.2.4.2 Short-Circuit - With Transfer to Static Switch and with Short-Circuit Elimination (IEC 62040-3)**

###### **A.2.4.2.1 Test Condition**

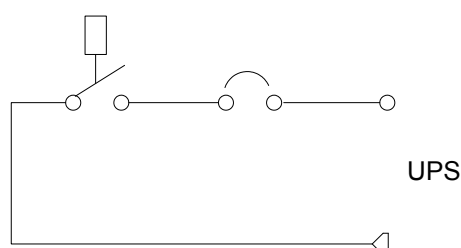
A.2.4.2.1.1 UPS providing rated active power and with stabilized internal temperature in normal operation mode, with availability for Static Switch to transfer the load to other power source.

A.2.4.2.1.2 The test shall be considered for each inverter.

A.2.4.2.1.3 Apply full short-circuit to AC output of UPS for a time determined by fuse or circuit breaker. The fuse or circuit breaker sizing shall be as such that their opening time in short-circuit current of inverter exceeds the transfer time to the by-pass.

A.2.4.2.1.4 Apply according to Figure A.1. For UPS with three-phase output, a phase-phase short-circuit shall be applied. For UPS with three-phase-ground output, it shall be applied phase-ground short-circuit.

A.2.4.2.1.5 The test shall be fully repeated in the stored energy with fully charged battery, and shall present the same results.



**Figure A.1 - Test Circuit**

#### **A.2.4.2.2 Measurements and Checks**

- oscillographic record of UPS output voltage and current;
- record the operation of protective devices, short-circuit current peak and short-circuit current in permanent duty, with its duration;
- the event shall be memorized, allowing only the manual reset of the alarm;
- local and remote alarm of “short-circuit in inverter”;
- interruption of AC output of UPS;
- event log of UPS;
- the UPS shall transfer to By-Pass.

#### **A.2.4.2.3 Acceptance Criterion**

- local and remote alarm, indicating “short-circuit in inverter”;
- UPS shall not be damaged;
- after eliminating the circuit, the UPS shall return to normal mode (return to normal operation mode of inverter with rated voltage and frequency) in a maximum of 200 ms;
- the event shall be memorized, not disappearing after normalization.

### **A.2.5 UPS Output Dynamic Tests**

#### **A.2.5.1 Linear Loads**

##### **A.2.5.1.1 Change of Operation Mode - Normal to Stored Energy - Linear Load (IEC 62040-3)**

##### **A.2.5.1.1.1 Test Condition**



- the tests described in this sub-item shall be performed with assistance of a variable voltage generator connected to three-phase input of UPS rectifier;
- the tests described in this sub-item shall be performed at 0 %, 50 % and 100 % of rated active power of UPS, in minimum and maximum input voltage conditions of rectifier and alternative source. These tests shall be performed in the conditions described in A.2.5.1.1.1.1 to A.2.5.1.1.1.3.

#### **A.2.5.1.1.1.1 Input Voltage Variation of Rectifier**

The UPS rectifier shall operate normally, keeping the DC busbar within normal operation conditions, when the rectifier input voltage varies within the voltage range of at least  $\pm 10$  % of specified nominal value. Out of the range (minimum of  $\pm 10$  % or higher, specified by the manufacturer), the rectifier shall remain inhibited, being the DC busbar (batteries) responsible for supplying energy to inverter and to output, respectively.

#### **A.2.5.1.1.1.2 Failure of Alternative Input AC Source**

The load shall be originally fed by the inverter branch. The static switch shall operate normally within the admissible range of variation of alternative source. The variation range value is  $\pm 5$  % of voltage. Two observations shall be performed. The first is a variation within the admissible range, in which the static switch shall operate normally without indicating failure and without any transfer. The second is a variation of alternative voltage out of the specified range. In this case, the failure alarm shall occur, the inverter shall lose its synchronism, and no transfer shall take place in static switch.

#### **A.2.5.1.1.1.3 Simultaneous Failure of Rectifier and Alternative Input AC Sources**

In failure of AC branches of rectifier and alternative input, the inverter output shall feed the output with no voltage or frequency variation. The respective failure alarms shall be activated and the battery (or DC source) energy shall supply the load at this time. The inverter shall return to rated frequency at a maximum rate of 1 Hz/s.

#### **A.2.5.1.1.2 Measurements and Checks:**

- oscillographic record of UPS output voltage;
- oscillographic record of UPS output current.

#### **A.2.5.1.1.3 Acceptance Criterion**

The output voltage and frequency shall remain within the specified limits. The UPS shall not be damaged.

### **A.2.5.1.2 Change of Operation Mode - Stored Energy to Normal - Linear Load (IEC 62040-3)**

#### **A.2.5.1.2.1 Test Condition**

The test consists of checking the return of rectifier AC feed with UPS in operation. The UPS shall be operating through the inverter branch. The test shall be performed by switching on the rectifier input feed and observing the output voltage and frequency.

#### **A.2.5.1.2.2 Measurements and Checks**

Oscillographic record of UPS output voltage.

**A.2.5.1.2.3 Acceptance Criterion**

The output voltage and frequency shall remain within the specified limits.

**A.2.5.1.3 Change of Operation Mode - Normal to By-Pass - Linear Load (IEC 62040-3)****A.2.5.1.3.1 Test Condition**

With the UPS operating in normal mode, apply an overload on it, as per tests A.2.3.7 and A.2.3.8, without the by-pass inhibition of the mentioned tests, and check the transfer of operation mode through inverter to by-pass operation. The testes shall be repeated within the voltage and frequency variation ranges informed by the manufacturer for automatic change of operation mode.

**A.2.5.1.3.2 Measurements and Checks**

Oscillographic record of input and output voltages, currents and frequency of UPS at the moment of overload application until voltage and current stabilization through the by-pass.

**A.2.5.1.3.3 Acceptance Criterion**

Local and remote alarm, indicating "overload in inverter"; output voltage and frequency shall remain within the nominal range ( $\pm 5\%$  of Voltage and  $\pm 0.05$  Hz frequency). The UPS shall not be damaged or overheated. The event shall be memorized, allowing only the manual reset of the alarm. The maximum acceptable interruption of output voltage in the change of operation mode shall be 4 ms. In the entire tolerance range indicated by the manufacturer for input voltage and frequency variation, there shall be change of operation mode.

**A.2.5.1.4 Degrees of Load - Linear Load (IEC 62040-3)****A.2.5.1.4.1 Test Condition**

With the UPS operating under conditions of A.2.3.1 (Output - normal mode – no load), apply a degree of resistive load equal to 100 % of output active power.

**A.2.5.1.4.2 Measurements and Checks**

A.2.5.1.4.2.1 Oscillographic record of UPS output voltage.

A.2.5.1.4.2.2 Reduce load to 0 %. Repeat previous measurements at the moment of disconnection, and compute the value which shall remain within the established limits.

A.2.5.1.4.2.3 Repeat the test 10 times and consider the worst case result.

**A.2.5.1.4.3 Acceptance Criterion**

According to Static and Dynamic Regulation established.

**A.2.5.1.3 Change of Operation Mode - Normal to By-Pass and Return to Normal - Linear Load.**  
(IEC 62040-3)**A.2.5.1.5.1 Test Condition**

With the UPS operating normally (with AC grid, operation through inverter, and rated active load with 100 % capacity), perform load transfer command to by-pass. Then, interrupt the feed to by-pass.

**A.2.5.1.5.2 Measurements and Checks**

Record the waveform, on the load, during return transfer from it to inverter output.

**A.2.5.1.5.3 Acceptance Criterion**

Transfer time shorter than 4 ms.

NOTE To perform this test, the UPS shall have this facility.

**A.2.5.2 Non-Linear Loads****A.2.5.2.1 Change of Operation Mode – Normal to Stored Energy - Reference Non-Linear Load (IEC 62040-3)****A.2.5.2.1.1 Test Condition**

The tests described in this sub-item shall be performed with assistance of a variable voltage generator connected to three-phase input of UPS rectifier. The tests described in this sub-item shall be performed at 0 %, 50 % and 100 % of rated active power of UPS, in minimum and maximum input voltage conditions of rectifier and alternative source. These tests shall be performed in the conditions described in A.2.5.2.1.1.1 to A.2.5.1.1.3.

**A.2.5.2.1.1.1 Input Voltage Variation of Rectifier**

The UPS rectifier shall operate normally, keeping the DC busbar within normal operation conditions, when the rectifier input voltage varies within the voltage range of at least  $\pm 10$  % of specified nominal value. Out of the range (minimum of  $\pm 10$  % or higher, specified by the manufacturer), the rectifier shall remain inhibited, being the DC busbar (batteries) responsible for supplying energy to inverter and to output, respectively.

**A.2.5.2.1.1.2 Failure of Alternative Input AC Source**

- a) The load shall be originally fed by the inverter branch. The static switch shall operate normally within the admissible range of variation of alternative source. The variation range value is  $\pm 5$  % of voltage;
- b) Two observations shall be performed. The first is a variation within the admissible range, in which the static switch shall operate normally without indicating failure and without any transfer. The second is a variation of alternative voltage out of the specified range. In this case, the failure alarm shall occur, the inverter shall lose its synchronism, and no transfer shall take place in static switch.

**A.2.5.2.1.1.3 Simultaneous Failure of Rectifier and Alternative Input AC Sources**

- a) in failure of AC branches of rectifier and alternative input, the inverter output shall feed the output with no voltage or frequency variation. The respective failure alarms shall be activated and the battery (or DC source) energy shall supply the load at this time;
- b) the inverter shall return to rated frequency at a maximum rate of 1 Hz/s.

**A.2.5.2.1.2 Measurements and Checks**

- a) oscillographic record of UPS input and output voltage;
- b) oscillographic record of UPS output current.

**A.2.5.2.1.3 Acceptance Criterion**

The output voltage and frequency shall remain within the specified limits. The UPS shall not be damaged.

**A.2.5.2.2 Change of Operation Mode - Stored Energy to Normal - Reference Non-Linear Load (IEC 62040-3)**

Repeat the change of operation mode test of A.2.5.1.2 using 100 % of reference non-linear load, and the same measurements, checks and acceptance criteria.

**A.2.5.2.3 Degrees of Load - Normal Mode - Reference Non-Linear Load (IEC 62040-3)****A.2.5.2.3.1 Test Condition**

A.2.5.2.3.1.2 With the UPS in normal operation mode, apply a reference non-linear load as per item A.2.3.9, adjusted to obtain 33 % of rated output apparent power as base load.

A.2.5.2.3.1.3 In permanent duty conditions, apply, at the moment of waveform peak of output voltage, an additional reference non-linear load adjusted to 33 % of rated output apparent power.

A.2.5.2.3.1.4 When applying the additional load, record the transitional deviations of output voltage waveform.

A.2.5.2.3.1.5 When applying the additional load, record the transitional deviations of output voltage waveform. With 66 % of initial load, apply, apply, at the moment of waveform peak of output voltage, a degree of the remaining 33% of reference non-linear load, and repeat the measurements of output voltage waveform.

A.2.5.2.3.1.6 In permanent duty conditions, switch off 33 % of reference non-linear load at the moment of waveform peak of output voltage. At the moment of disconnection, repeat the measurements of output voltage waveform.

A.2.5.2.3.1.7 Repeat the switch off of the next degree of 33% of reference non-linear load to return the base load, and record the transitional deviations of output voltage waveform.

**A.2.5.2.3.2 Measurements and Checks**

Oscillographic record of transient performance during change of operation mode.

**A.2.5.2.3.3 Acceptance Criterion**

According to Static and Dynamic Regulation established.

**A.2.5.2.4 Degrees of Load - Stored Energy Mode - Reference Non-Linear Load (IEC 62040-3)****A.2.5.2.4.1 Test Condition**

Repeat the tests as per A.2.5.2.2 in stored energy mode, simulating the minimum and maximum battery voltage.

**A.2.5.2.4.2 Measurements and Checks**

Oscillographic record of transient performance during change of operation mode.

**A.2.5.2.4.3 Acceptance Criterion**

The UPS may not transfer to by-pass and the static and dynamic calibration shall remain within the limits established in this specification.

**A.2.6 Stored Energy and Restored Energy Tests (IEC 62040-3)****A.2.6.1 Restored Energy Time at 90 % of Capacity (IEC 62040-3)****A.2.6.1.1 Test Condition**

At the end of the stored energy time test (IEC 62040-3), apply again the input feed in UPS and operate in normal mode, input rated voltage, and active and apparent output rated powers.

**A.2.6.1.2 Measurements and Checks**

After the end of recharge time defined by the manufacturer (10 hours, 0.1C10), measure the input and output voltages, currents and active powers.

**A.2.6.1.3 Acceptance Criterion**

When the input current reaches the internal balance, it indicates the end of energy restoring time. It shall be checked if the current provided by rectifier supplies 100 % of inverter load, as well as keeps the batteries charged until reaching 90 %.

**A.2.7 Input Efficiency and Power Factor (IEC 62040-3)****A.2.7.1 Test Condition**

A.2.7.1.1 Stable input conditions shall be reached. The following charge conditions shall be imposed to UPS:

- apply charge of 100% rated active power;
- apply charge of 100% of reference non-linear load.

A.2.7.1.2 For this test, it shall be considered the manufacturer's standard complete UPS, excluding voltage adapting transformers requested for specific use.

**A.2.7.2 Measurements and Checks**

Record the following input and output parameters for each load condition established in test condition:

- current;
- voltage;
- active power.

**A.2.7.3 Acceptance Criterion**

The efficiency shall be better than the established in Table A.1:

**Table A.1 - Efficiency for UPS VFI-S of 3 kVA or More**

<b>Voltage of direct current branch</b>	<b>Minimum acceptable efficiency</b>
< 120 Vdc	80 %
120 Vdc to 220 Vdc	86 %
220 Vdc to 360 Vdc	88 %
> 360 Vdc	91 %

**A.2.8 Emission, Radio Frequency Interference Supportability and Conducted Noise Tests (IEC 62040-3 e 62040-2)****A.2.8.1 Definitions****A.2.8.1.1 Ambient**

A.2.8.1.1.1 First Ambient: Ambient with residences, commercial installations and small industries directly connected to public low-voltage grid without intermediate transformer.

A.2.8.1.1.2 Second Ambient: Ambient with all commercial and industrial installations not connected to public low-voltage grid used for residential purposes.

**A.2.8.1.2 Category**

Category C3: This category includes UPS with output current over 16 A, intended to the second ambient. These UPS are adequate for use in industrial and commercial installations with minimum distance of 30 m from buildings classified as first ambient. Category C3 UPS shall comply with the emission and immunity limits, as mentioned in IEC [62040-2](#).

**A.2.8.1.3 Test Condition**

According to definitions of IEC [62040-2](#), the UPS listed in this document are Category C3 and belong to the Second Ambient.

**A.2.8.2 Emission IEC [62040-3](#)****A.2.8.2.1 Test Condition**

A.2.8.2.1.1 Tests shall be performed with the UPS in the following conditions:

- rated input voltage;
- in normal operating mode and stored energy mode;
- load resulting in the highest levels of emission.

A.2.8.2.1.2 The installation site conditions shall not cause deviations due to pre-existing emissions in site and to emissions caused by equipment fed by the UPS. Measurements shall be taken in operating mode that produces the highest emission in frequency range.

**A.2.8.2.2 Acceptance Criterion**

Ensure that disturbances generated by UPS in normal operation do not reach level which may prevent other equipment items from operating as intended.

A.2.8.2.2.1 Interference in feeding terminals:

- shall not exceed the limits established in IEC [62040-2](#);
- the UPS shall reach both the Average and Quasi-peak limits, using a detector receptor of Average and Quasi-peak;
- the detector receptors of Average and Quasi-peak shall comply with the series IEC CISPR 16 ([16-1-1](#), [16-1-2](#), [16-1-3](#), [16-1-4](#) and [16-1-5](#));
- if the average limit is found when using a detector receptor of quasi-peak, the test unit shall be deemed to comply with both limits, and the measurement with the detector receptor of average is not necessary;
- if the measurement reading of receptor shows fluctuations near to the limit, the reading shall be observed for at least 15 s at each measurement frequency; the higher reading shall be recorded, except for one brief high and isolated reading, which shall be ignored.

A.2.8.2.2.2 Interference in a.c. output:

- it shall not exceed the limits established in IEC [62040-2](#), for UPS over 100 A. For smaller UPS, it is allowed an increase of + 14 dB in values indicated in IEC [62040-2](#);
- these limits are only applied to UPS in which the output cable length may exceed 10 m.

#### A.2.8.2.2.3 Electromagnetic Emission:

- shall not exceed the limits established in IEC 62040-2;
- measurement methods shall be those established in IEC 62040-2.

### A.2.8.3 Immunity (Electromagnetic Susceptibility)

#### A.2.8.3.1 Test Condition

Tests shall be performed with the UPS in the following conditions:

- rated input voltage;
- operations in normal mode;
- linear load in rated output power.

#### A.2.8.3.2 Acceptance Criterion

The UPS comply with criteria established in IEC 62040-2.

### A.2.9 Synchronization Tests

#### A.2.9.1 Synchronization Time (IEC 62040-3)

##### A.2.9.1.1 Test Condition

Synchronization time is the time the inverter takes to synchronize with the alternative source. The test shall be performed with inverter on, alternative source off, and with frequency and voltage within the acceptable limits (voltage  $\pm 10\%$  and frequency  $\pm 5\%$ ). Start timing from the moment the alternative source is switched on until it synchronizes. Perform the reverse operation, that is, with alternative source on and inverter off, and start timing the synchronism from the switching on command to inverter.

NOTE Ten tests shall be performed and the longest time shall be considered.

##### A.2.9.1.2 Measurements and Checks

Output voltage and frequency of inverter and by-pass.

##### A.2.9.1.3 Acceptance Criterion

Maximum value = 30 s.

#### A.2.9.2 Phase Angle (IEC 62040-3)

##### A.2.9.2.1 Test Condition

Phase angle is the phase difference in degrees between the inverter output and the alternative input. The test shall be performed with load in output from zero until the rated active power. The UPS shall be operating through the inverter, synchronized with the alternative source.



**A.2.9.2.2 Measurements and Checks**

Oscillographic record of alternative input and UPS output voltages.

**A.2.9.2.3 Acceptance Criterion**

Maximum value =  $8^\circ$  (considering output voltage maximum tolerance of  $\pm 1\%$ )

**A.2.9.3 Variation in Alternative Source Frequency (IEC 62040-3)****A.2.9.3.1 Test Conditions**

A.2.9.3.1.1 The inverter shall be able to keep itself synchronized within a variation rate of alternative source. The variation limits of alternative source so that the inverter is kept synchronized shall be comprised within the admissible frequency range of Brazilian electric system (frequency statism).

A.2.9.3.1.2 The value used is  $\pm 5\%$ , therefore, the limits or working range shall be comprised in  $\pm 3$  Hz. The variation rate so that the inverter is kept in synchronism shall be defined by the manufacturer. Estimated value 1 Hz/s.

**A.2.9.3.2 Measurements and Checks**

A.2.9.3.2.1 Oscillographic record of alternative input and UPS output voltages.

A.2.9.3.2.2 Output voltage frequency.

**A.2.9.3.3 Acceptance Criterion**

The UPS shall remain synchronized with the by-pass during test.

NOTE The tests above shall be performed with assistance of a variable frequency generator connected to the alternative voltage input of UPS.

**A.2.10 Failure Simulation in UPS in Parallel Redundancy (IEC 62040-3)****A.2.10.1 Failure in One of Redundant Parallel System Units****A.2.10.1.1 Test Condition**

A.2.10.1.1.1 This test aims at observing the transients (voltage and frequency) in output waveform at the moment one of the redundant parallel system units fails. Low and high impedance defects shall be simulated, as per IEC 62040-3. Perform this test with rated apparent load of UPS.

A.2.10.1.1.2 The test shall be performed with rated active load applied to the UPSs.

A.2.10.1.1.3 Power System Test: Remove the control signal from one semiconductors of the inverter bridge.

A.2.10.1.1.4. Control System Test: Actuate the temperature sensor of the inverter bridge.

#### **A.2.10.1.2 Measurements and Checks**

- oscillographic record of UPS output voltage and frequency;
- check of UPS alarms.

#### **A.2.10.1.3 Acceptance Criterion**

A.2.10.1.3.1 The voltage or frequency variation shall be within the defined static and dynamic calibration range.

A.2.10.1.3.2 The unit(s) without inserted defect shall take the load, while the unit with inserted defect shall be inhibited, informing the inserted defect by the alarms.

A.2.10.1.3.3 The alarm shall characterize the inserted defect correctly.

A.2.10.1.3.4 There shall be no actuation of static switch.

#### **A.2.10.2 Shutdown of One of Redundant Parallel System Units**

##### **A.6.1.1 Test Condition**

This test is similar to the previous case (A.2.10.1), however, the simulation shall be performed by shutting down the redundant parallel system units. The test shall be performed with rated active load applied to the UPSs.

#### **A.2.10.2.2 Measurements and Checks**

A.2.10.2.2.1 Oscillographic record of UPS output voltage and frequency.

A.2.10.2.2.2 Check of UPS alarms.

#### **A.2.10.2.3 Acceptance Criterion**

A.2.10.2.3.1 The voltage or frequency variation shall be within the defined static and dynamic calibration range.

A.2.10.2.3.2 The remaining unit(s) shall take the load, while the unit that was shut down shall inform the inserted defect by the alarms.

A.2.10.2.3.3 The alarm shall characterize the inserted defect correctly.

A.2.10.2.3.4 There shall be no actuation of static switch.

**A.2.11 Transfer Test (IEC 62040-3)****A.2.11.1 Operation in Synchronism with Alternative Source - Manual Operation to Transfer****A.2.11.1.1 Test Condition**

With the output fed by inverter branch, perform the transfer to by-pass through the manual command switch. The static switch shall switch to by-pass. This test shall be performed in 10 points, considering the two most critical points. Perform this test for 0 %, 50 % and 100 % of rated linear load of UPS.

**A.2.11.1.2 Measurements and Checks**

Oscillographic record of UPS output voltage and frequency.

**A.2.11.1.3 Acceptance Criteria**

A.2.11.1.3.1 No frequency variation shall be observed in output waveform within the established limits.

A.2.11.1.3.2 Tolerance: variations under 1 regarding the fundamental sinusoidal signal and observed (transient) variations under 10 % of the real value at the moment of switching.

A.2.11.1.3.3 No test of this item shall have interruption of output voltage above 4 ms.

**A.2.11.2 Operation in Synchronism with Alternative Source - Automatic Operation to Transfer****A.2.11.2.1 Test Condition**

With the output fed by inverter branch, perform the transfer to by-pass through total shut down of inverter. A way to perform this test is by shutting down the battery circuit breakers, and then turning off the rectifier. This test shall be performed in 10 points, considering the two most critical points. Perform this test for 0 %, 50 % and 100 % of rated linear load of UPS.

**A.2.11.2.2 Measurements and Checks**

Oscillographic record of UPS output voltage and frequency.

**A.2.11.2.3 Acceptance Criteria**

There shall be no interruption of output voltage above 4 ms.

**A.2.11.3 Operation out of Synchronism with Alternative Source - Manual Operation to Transfer****A.2.11.3.1 Test Condition**

A.2.11.3.1.1 With the UPS feeding the loads by the inverter branch, try to perform the manual transfer of static switch to by-pass.

A.2.11.3.1.2 In laboratory, this test shall be performed by varying the by-pass frequency out of operational range of UPS.

A.2.11.3.1.3 The test shall be performed with rated active load applied to the UPS.

#### **A.2.11.3.2 Measurements and Checks**

Oscillographic record of UPS output voltage and frequency.

#### **A.2.11.3.3 Acceptance Criteria**

The UPS shall not allow this transfer.

### **A.2.11.4 Operation Out of Synchronism with Alternative Source – Automatic Operation to Transfer**

#### **A.2.11.4.1 Test Condition**

A.2.11.4.1.1 Loads shall be operating by the inverter branch and without synchronism between inverter and by-pass. The test shall be performed by causing a failure in inverter branch (the battery shall be turned off, followed by the rectifier).

A.2.11.4.1.2 The test shall be performed with reference rated active load.

#### **A.2.11.4.2 Measurements and Checks**

Oscillographic record of UPS output voltage and frequency.

#### **A.2.11.4.3 Acceptance Criteria**

The transfer shall take place in a specific time of 1 cycle (16,66 ms). This time is required so that the DC component of consumer circuits decreases to a low value in module and, even in the worst situation (180 °) of phase difference between inverter and alternative source, the switching shall not generate degrees of current high enough to turn off protections of critical feeding switchboards.

NOTE UPS feeding motor loads, the dead time for switching the static switch out of synchronism shall be specified as a function of X/R variable of the system.

### **A.2.12 Division of Current in Parallel or Redundant Parallel (IEC 62040-3)**

#### **A.2.12.1 Test Condition**

A.2.12.1.1 It shall preferably use load division by current.

A.2.12.1.2 Perform the test in each phase and in all balanced phases, with 100 % of rated active load, and repeat with non-linear loads.

A.2.12.1.3 The Test comprises 3 steps:

- a) 1<sup>st</sup> step: with all modules in parallel, observe if the current is unbalanced;
- b) 2<sup>nd</sup> step: turn off 1 or more modules (preferably the master, as the case may be) and observe if the current is divided among the others;
- c) 3<sup>rd</sup> step: return the module to operation, and observe if the division returned to the previous condition.

**NOTE** Request the maximum values of unbalance in worst conditions with linear and non-linear load.

### **A.2.12.2 Measurements and Checks**

With a oscillograph, record the currents and voltages in all modules each time a module is turned off and on.

### **A.2.12.3 Acceptance Criteria**

The unbalance of current between modules shall be lower than 5 %.

## **A.2.13 Test of Ripple (residual wave) Current in Battery (IEC 62040-3)**

### **A.2.13.1 Test Condition**

The test shall be performed with rated active load applied to the UPS, with stabilized internal temperature and disconnected battery. In three-phase UPS, the phases shall operate with 100 % unbalanced loads.

### **A.2.13.2 Measurements and Checks:**

Voltage, current and ripple in direct current bar.

### **A.2.13.3 Acceptance Criterion**

A.2.13.3.1 The output voltage ripple of the rectified shall not exceed effective 1 % with disconnected battery.

A.2.13.3.2 The current ripple shall not exceed 5 % with connected battery of same internal impedance value of the original equipment for the specified capacity.

## **A.2.14 Harmonic Components Test (IEC 62040-3)**

### **A.2.14.1 Test Conditions**

A.2.14.1.1 The test shall be performed with linear rated load applied to the UPS.

A.2.14.1.2 The AC input power supply shall be within the specified limits.

**A.2.14.2 Measurements and Checks****A.2.14.2.1 Input Voltage and Current****A.2.14.2.2 Individual Harmonics and Input Current THD.****A.2.14.3 Acceptance Criterion**

As per criteria established in IEC [62040-3](#).

**A.2.15 Temperature Rise Test****A.2.15.1 Test Condition**

The temperature rise test of the UPS shall be performed in the most critical condition to the equipment. The UPS-CC to be tested shall have its temperature stabilized. AC input for the rectifier shall be in the minimum value within the admissible range of normal operation of the rectifier. The DC busbar voltage shall be in the minimum operating limit of inverter (final discharge voltage of each rectifier element times the number of elements). The test shall be performed with linear rated load applied to the UPS.

**A.2.15.2 Measurements and Checks**

The output voltage shall remain within the admissible range of normal operation, as specified. Temperature conditions of UPS cabinets shall be monitored. All critical components of UPS (inverter bridge, transformers, power supply electrolytic capacitors, rectifier bridge, etc.) shall be monitored.

**A.2.15.3 Acceptance Criterion**

The internal temperature rise of electronic components, added to the ambient temperature of 40 °C, shall not exceed 80 % of its industrial line tolerance range used by the manufacturer.

**A.2.16 Static Switch Test****A.2.16.1 Overload Tests (IEC [62040-3](#))****A.2.16.1.1 Test Condition**

- apply 125 % rated current overload;
- apply 200 % rated current overload for 30 s;
- apply 1 000 % rated current overload for a period of 100 ms.

**A.2.16.1.2 Measurements and Checks**

Oscillographic record of output voltage and current.

**A.2.16.1.1.3 Acceptance Criterion**

The static switch shall not have any damage, nor equipment shutdown due to overheating.

**A.2.16.2 Overvoltage Tests (IEC 62040-3)**

Perform test as established in IEC 62040-3.

**A.2.17 Environmental Tests (IEC 62040-3)**

Storage and operating tests under adverse weather conditions (cold, moist heat, dry heat, etc.) shall be performed as per IEC 62040-3.

**A.2.18 Vibration and Shock Test (IEC 62040-3)****A.2.18.1 Shock Test (IEC 62040-3)****A.2.18.1.1 Test Condition**

Before the test, the electrical characteristics of UPS shall be checked. During the test performance, the UPS shall not be operating. The UPS shall be subjected to two shock pulses of half sine of 15 g, with nominal duration of 11 ms, in the three plans. The test method indicated in IEC 60068-2-27 shall be followed. No measurement shall be done during test.

**A.2.18.1.2 Measurements and Checks**

Perform new electrical measurements as per IEC 62040-3. Check for physical damage and distortion of component parts.

**A.2.18.1.3 Acceptance Criterion**

Measurements shall be the same checked before testing.

**A.2.18.2 Free Drop Test (IEC 62040-3)**

This test shall be performed as described in IEC 62040-3.

**A.2.18.3 Vibration and Shock Test of Connectors (IEC 60068-2-6 and 60068-2-27)****A.2.18.3.1 Test Condition**

All connectors used in all equipment items comprising the power supply critical systems shall comply with the tests, in accordance with IEC 60068-2-6 for sinusoidal vibration test, and with IEC 60068-2-27 for shock test. The equipment manufacturer shall supply the test report of used connectors. When the report is issued by a third-party laboratory, this shall be registered in the official bodies of the country of origin. If the report is issued by the manufacturer itself, PETROBRAS shall perform an initial inspection to authorize the supplying of the given connectors. Parameters for the tests above are described on Tables A.2 and A.3.

**Table A.2 - Sinusoidal Vibration Test - IEC 60068-2-6**

Frequency Range	5 Hz to 150 Hz
Cross-Over Frequency	25 Hz
Displacement amplitude below cross-over frequency	2 mm
Acceleration amplitude above cross-over frequency	5 g
Axes	X, Y, Z
Length of the test	2 hours in each axis

**Table A.3 - Shock Test - IEC 60068-2-27**

Pulse form	Half-wave
Peak acceleration	5 g
Corresponding length of rated pulse	50 ms
Number of shocks in each of the six directions	3
Axis	X, Y, Z (positive and negative)

**A.2.18.3.2 Measurements and Checks**

A.2.18.3.2.1 Measure contact resistance before and after testing.

A.2.18.3.2.2 Monitor the opening of contacts during the test.

**A.2.18.3.3 Acceptance Criterion**

After performing the tests, the contact resistance shall be under 150 % of the resistance measured before testing. There shall be no opening of contacts above 1  $\mu$ s.

**A.2.19 Audible Noise (IEC 62040-3 and ISO 7779)****A.2.19.1 Test Condition**


A.2.19.1.1 Measurements shall be performed in normal and stored energy operation modes, and values shall be determined in acoustic decibels (dBA) 1 meter far from the equipment. The measurement shall be done with normal input voltage and rated linear load in permanent condition.

A.2.19.1.2 In equipment items with automatic fans, the fans shall be turned on. Sound alarms shall not be considered in measurement. The measurement method specified in ISO 7779 shall be used, considering the equipment use position.

**A.2.19.2 Acceptance Criterion**


UPS acoustic noise level under 75 dBA.



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