

**CONTEC**Comissão de Normalização  
Técnica**SC-22**

Utilities Equipment

**Steam Generator for Injection in Oil Well****2<sup>nd</sup> Amendment**

This is the 2<sup>nd</sup> Amendment to PETROBRAS N-2252 REV. D, incorporated the 1<sup>st</sup> amendment and it is used to alter the text of the Standard in the parts indicated below:

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

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

**CONTENTS OF THE 1<sup>st</sup> AMENDMENT - 04/2014****- Section 2:**

Replace the ABNT NBR 8441 by ABNT [NBR IEC 60034-5](#).

**- Subsection 9.8.11:**

Alteration of the text.

**- Subsection 13.4:**

Alteration of the text.

**CONTENTS OF THE 2<sup>nd</sup> AMENDMENT - 03/2016****- Section 2:**

Replace the PETROBRAS N-313 by PETROBRAS [N-2919](#).

Replace the PETROBRAS N-1278 by Manual de Sinalização para Ambientes Industriais e Marítimos da PETROBRAS.

Replace the PETROBRAS N-2668 by PETROBRAS [N-76](#).

Replace the ABNT NBR 5175 by ABNT [NBR 5175:2014](#).

Replace the ANP/INMETRO nº 1 de 19/06/2000 by Portaria ANP/INMETRO nº 1 de 10/06/2013.

Include of ABNT [NBR 15367:2006](#) and ABNT NBR [17094:2013](#).

**- Subsection 10.5.6:**

Alteration of the text.

# **Steam Generator for Injection in Oil Well**

## **Specification**

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 - 22**

Utilities Equipment

## **Introduction**

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

## Summary

Foreword.....	4
1 Scope.....	4
2 Normative References.....	4
3 Submittal of the Technical Proposal and the Design .....	7
3.1 General.....	7
3.2 Documents of the Technical Proposal .....	7
3.3 Design Documents.....	7
3.4 Design Books .....	8
3.5 Book of Technical Manufacturing Documents .....	8
3.6 Instruction Manuals for Installation, Operation and Maintenance.....	8
4 Design and Operation Conditions .....	9
5 Equipment Description .....	9
6 Convection Zone .....	10
7 Radiation Zone .....	11
8 Transition Zone.....	12
9 Auxiliary Systems .....	13
9.1 Feed Water System.....	13
9.2 Water Pre-Heater .....	13
9.3 Steam System.....	14
9.4 Liquid Fuel System.....	14
9.5 Fuel Gas System.....	15
9.6 Utility Steam System .....	15
9.7 Compressed Air System .....	16
9.8 Burner.....	16
9.9 External Piping and Valves .....	17
10 Instrumentation and Control .....	18
10.1 General.....	18
10.2 Generator Control System .....	19
10.3 Totalization .....	19



10.4 Indicators.....	19
10.5 Interlocking, Security and Alarm .....	20
11 Control Panel.....	23
11.1 General.....	23
11.2 Engines Control Center (CCM) .....	25
11.2.1 System Electrical Characteristics.....	25
11.2.2 Applicable Standards .....	25
11.2.3 Constructive Characteristics .....	25
11.2.4 Equipment Characteristics .....	27
12 Metallic structure .....	28
13 Miscellaneous.....	28
14 Painting.....	29
15 Conditioning.....	30
15.1 Factory Acceptance Test .....	30
15.2 Packaging and Transportation .....	30
15.3 Handling and Storage .....	30
15.4 Preservation .....	30
15.5 Consumable, Spare Parts and Special Tools .....	30
15.6 Training .....	31
15.7 Technical Support .....	31
16 Packaging, Conditioning and Transportation .....	31
17 Assembly.....	31
18 Pre-operation and Start-up.....	31
Annex A - Figure.....	33

### Figures

Figure 1 - Adapter for Pig Launching and Receiving .....	10
Figure A.1 - Schematic Drawing of the Steam Generator and Auxiliary Systems .....	33

### Tables

Table 1 - Indicators for Process Variables .....	20
Table 2 - Painting of Boiler Parts.....	29

## FOREWORD

This Standard is the English version (issued in 07/2012) of PETROBRAS N-2252 REV. D 10/2011. 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 establishes the required minimum conditions for supply of steam generators for injection in land oil wells. Other technical requirements which are needed for the specific supply of the steam generator shall be included in the equipment's Technical Specification.

1.2 A steam generator for injection in land oil wells is understood as being the watertube steam generator with a single pass and one or more coils, with forced circulation both of water and air, with one or more burners, mounted on a stationary or moving skid.

1.3 This Standard applies to provisions initiated as of the date of its issuance.

1.4 This Standard contains Technical Requirements and Recommended Practice.

## 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.

Norma Regulamentadora nº 10 (NR-10) - Segurança em Instalações e Serviços em Eletricidade;

Norma Regulamentadora nº 13 (NR-13) - Caldeiras e Vasos de Pressão;

Norma Regulamentar nº 26 (NR-26) - Sinalização de Segurança;

Portaria ANP/INMETRO nº 1 de 19/06/2013 - Medição de Petróleo e Gás Natural;

Portaria INMETRO/MDIC 179 de 18/05/2010 - Requisitos de Avaliação da Conformidade de Equipamentos Elétricos e Eletrônicos para Atmosfera Explosivas;

Portaria INMETRO/MDIC 243 de 04/09/2009 - Requisitos de Avaliação da Conformidade para Motores Elétricos de Indução Trifásicos Rotor Gaiola de Esquilo;

Manual de Sinalização para Ambientes Industriais e Marítimos da PETROBRAS;

PETROBRAS N-2 - Anticorrosive Coating of Industrial Equipment;

PETROBRAS N-13 - Technical Requirements for Paintwork;

PETROBRAS N-57 - Projeto Mecânico de Tubulações Industriais;

PETROBRAS N-58 - Graphic Symbols for Process and Engineering Flowsheets;

PETROBRAS N-59 - Símbolos Gráficos para Desenhos de Tubulação;

PETROBRAS N-76 - Piping Materials for Refining and Transportation Plants;



PETROBRAS [N-115](#) - Fabricação e Montagem de Tubulações Metálicas;

PETROBRAS [N-116](#) - Sistemas de Purga de Vapor em Tubulações e Equipamentos;

PETROBRAS [N-250](#) - Installation of High Temperature Thermal Insulation;

PETROBRAS [N-279](#) - Design of Steel Structures;

PETROBRAS [N-293](#) - Manufacture and Assembly of Metallic Structures;

PETROBRAS [N-314](#) - Low-Voltage Panel Motor Control Center;

PETROBRAS [N-381](#) - Execution of Drawing and Other General Technical Documents;

PETROBRAS [N-442](#) - External Painting of Piping for Onshore Facilities;

PETROBRAS [N-550](#) - Design of High-Temperature Thermal Insulation;

PETROBRAS [N-898](#) - Símbolos Gráficos e Designações para Diagramas Elétricos;

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

PETROBRAS [N-1438](#) - Terminologia Soldagem;

PETROBRAS [N-1521](#) - Identification of Industrial Equipment;

PETROBRAS [N-1522](#) - Identificação de Tubulações Industriais;

PETROBRAS [N-1550](#) - Metallic Structure Painting;

PETROBRAS [N-1617](#) - Application of Refractory Castable;

PETROBRAS [N-1618](#) - Thermal Insulation Material;

PETROBRAS [N-1665](#) - Burner - Data Sheet;

PETROBRAS [N-1674](#) - Projeto de Arranjo de Instalações Industriais Terrestres de Petróleo, Derivados, Gás Natural e Álcool;

PETROBRAS [N-1710](#) - Coding of Technical Engineering Documents;

PETROBRAS [N-1728](#) - Castable Refractory;

PETROBRAS [N-1735](#) - Painting of Electrical Equipment, Machines and Instruments;

PETROBRAS [N-1857](#) - Electrical Resistance Trace Heating System for Industrial Applications - Design, Installation, Inspection, and Maintenance Procedures;

PETROBRAS [N-1882](#) - Criteria for Development of Instrumentation Designs;

PETROBRAS [N-1883](#) - Presentation of Instrumentation/Automation Design;

PETROBRAS [N-1910](#) - Presentation of Instrumentation/Automation Design;

PETROBRAS [N-1997](#) - Electrical Networks in Cable Tray Systems - Design, Installation, and Inspection;

PETROBRAS [N-2040](#) - Preparation, Presentation and Management of Electrical Design Documents;

PETROBRAS [N-2154](#) - Classificação de Áreas para Instalações Elétricas em Regiões de Perfuração e Produção;

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

PETROBRAS [N-2802](#) - Folhas de Dados de Instrumentação Coletânea;

PETROBRAS [N-2833](#) - Forms and Lists for Instrumentation Designs;

PETROBRAS [N-2919](#) - Motores Elétricos Trifásicos de Indução ou Síncronos;

ABNT [ISO/TS 29001](#) - Indústrias do Petróleo, Gás Natural e Petroquímica - Sistemas de Gestão da Qualidade Específicos do Setor - Requisitos para Organizações de Fornecimento de Produtos e Serviços;

ABNT [NBR 5175:2014](#) - Números das Funções dos Dispositivos de Manobra, Controle e Proteção de Sistemas de Potência;

ABNT [NBR 5410](#) - Instalações Elétricas de Baixa Tensão;

ABNT [NBR 5597](#) - Eletroduto de Aço-Carbono e Acessórios, com Revestimento Protetor e Rosca NPT;

ABNT [NBR 12177-2](#) - Caldeiras Estacionárias à Vapor - Inspeção de Segurança - Parte 2 - Caldeiras Aquatubulares;

ABNT [NBR 12313:2000](#) - Sistema de Combustão - Controle e Segurança para Utilização de Gases Combustíveis em Processos de Baixa e Alta Temperatura;

ABNT [NBR 13970](#) - Segurança de Máquinas - Temperatura de Superfícies Acessíveis - Dados Ergonômicos para Estabelecer os Valores Limites de Temperatura de Superfícies Aquecidas;

ABNT [NBR 14039](#) - Instalações Elétricas de Média Tensão de 1,0 kV a 36,2 kV;

ABNT [NBR 15367:2006](#) - Máquinas Elétricas Girantes - Motores de Indução - Marcação de Cabos Terminais e Sentido de Rotação;

ABNT [NBR 15827](#) - Válvulas Industriais para Instalações de Exploração, Produção, Refino e Transporte de Produtos de Petróleo;

ABNT [NBR 17094-1:2013](#) - Máquinas Elétricas Girantes - Motores de Indução Parte 1: Trifásicos;

ABNT [NBR IEC 60034-5](#) Máquinas Elétricas Girantes - Parte 5: Graus de Proteção Proporcionados pelo Projeto Completo de Máquinas Elétricas Girantes (Código IP);

ABNT [NBR IEC 60439-1](#) - Conjuntos de Manobra e Controle de Baixa Tensão Parte 1: Conjuntos com Ensaio de Tipo Totalmente Testados (TTA) e Conjuntos com Ensaios de Tipo Parcialmente Testados (PTTA);

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

ABNT [NBR ISO 9001](#) - Sistemas de Gestão da Qualidade;

IEC [61131-1](#) - Programmable Controllers - Part 1: General Information;

IEC [61131-2](#) - Programmable Controllers - Part 2: Equipment Requirements and Tests;

IEC [61131-3](#) - Programmable Controllers - Part 3: Programming Languages;

IEC [61131-5](#) - Programmable Controllers - Part 5: Communications;

IEC [61508-1](#) - Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems - Part 1: General Requirements;



ANSI/ISA [5.1](#) - Instrumentation Symbols and Identification;

ANSI/ISA [7.0.01](#) - Quality Standard for Instrument Air;

API [RP 555](#) - Process Analyzers;

ASME BPVC [Section I](#) - Rules for Construction of Power Boilers;

ASME BPVC [Section VIII - Division 1](#) - Rules for Construction of Pressure Vessels;

ASME [PTC 4](#) - Fired Steam Generators;

ISA [18.1](#) - Annunciator Sequences and Specifications;

NFPA [85](#) - Boiler and Combustion Systems Hazards Code Effective.

**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 SUBMITTAL OF THE TECHNICAL PROPOSAL AND THE DESIGN**

#### **3.1 General**

All technical documents shall be coded in accordance with PETROBRAS [N-1710](#) and shall be submitted in accordance with PETROBRAS [N-58](#), [N-59](#), [N-381](#), [N-898](#), [N-1438](#), [N-1521](#), [N-1522](#), [N-1883](#) and [N-2040](#), ABNT [NBR 5175:2014](#) and [NBR 15827](#).

#### **3.2 Documents of the Technical Proposal**

A technical proposal shall be provided in three copies, containing, among other documents, the complete list of the imported and the nationalized parts, indicating the material and its respective sub-providers, and requiring the acceptance tests made by classification company.

**NOTE 1** Sub-providers shall be listed on the PETROBRAS Registry and, in case they are not, they shall be ranked by the vendor as per the criteria established by PETROBRAS.

**NOTE 2** The foreigner and national sub-providers' Quality Management System shall adhere to the requirements established by ABNT [ISO/TS 29001](#) and shall meet ABNT [NBR ISO 9001](#).

#### **3.3 Design Documents**

**3.3.1** The required documents for approval of the design shall be submitted in three copies. Two copies shall be provided certified, and the other shall be electronic.

**3.3.2** At least the following documents shall be submitted in order for the design to be approved:

- a) list of the design documents;
- b) Fully completed Data Sheet of the steam generator;
- c) Data Sheet - equipment, instruments and piping;
- d) Data Sheet of the burner, completed as in PETROBRAS [N-1665](#);
- e) Data Sheet of electric induction engines, completed as in PETROBRAS [N-2919](#).
- f) Data Sheets of frequency converters, completed as in PETROBRAS [N-2547](#);
- g) Data Sheets of instruments, control valves, safety valves and relief valves, completed as in PETROBRAS [N-2802](#);
- h) process flowchart;
- i) engineering flowchart;



- j) process description;
- k) area classification plant;
- l) arrangement plant;
- m) piping plant;
- n) instrument location plant;
- o) table with the summary of the variables with their respective set-points;
- p) calculation memories;
- q) burner design;
- r) dimensional drawing: views, sections and details of the steam generator;
- s) drawings of the finned tubes;
- t) set of drawings of refractories;
- u) assembly drawings;
- v) instrument list (as in PETROBRAS [N-2833](#));
- w) basic interconnection scheme for instruments;
- x) wiring diagram;
- y) functional diagram;
- z) diagrams of the automatic control grids;
- aa) listing of analog and digital Inlets/Outputs;
- ab) description of logic and automation with a logic diagram and a cause & effect diagram;
- ac) drawing of the steam generator's monitoring architecture, automatic control, safety and automation;
- ad) dimensional drawing and bill of materials of the local control panel;
- ae) software of the programmable equipment;
- af) key one line electric diagram;
- ag) dimensional drawing and bill of materials of the "Engines Control Center" (CCM) electrical panel;
- ah) scheme for assembly and final interconnection where it will be installed.

### 3.4 Design Books

These shall contain copies of every design document which has been approved by PETROBRAS, certified by the manufacturer and as built. This book shall be provided in two hard copies and in an electronic third copy.

### 3.5 Book of Technical Manufacturing Documents

It should contain all quality certificates of the materials used, the chemical and mechanical tests, the compliance certificates for work in explosive atmospheres (Ordinance INMETRO / [MDIC 179/2010](#)) or the statement of the Product Certification Office (PCO) accredited by INMETRO of all equipment, accessories, and electric and electronic instruments for potentially explosive atmospheres under conditions of flammable vapors and gases, a compliance certificate to be used to mark high-yield engines (Ordinance INMETRO/[MDIC 243/2009](#)), reports of visual inspection, dimensional inspection and non-destructive tests, application procedure of the refractory and painting procedure, also indicating location of weld repairs, qualification of welders and welding procedures, inspection plans, tests and others. This book shall be provided in two hard copies and in one electronic one copy.

### 3.6 Instruction Manuals for Installation, Operation and Maintenance

3.6.1 It shall contain the description of the process, the start-up and stoppage sequences, emergency stoppage, operation and pre-operation procedures, logs of the sub-providers, instructions for maintenance of the steam generator itself and others.

3.6.2 All electrical instruments shall be fitted with their respective electronic schematic diagrams and service manuals (maintenance). For programmable devices, in addition to these documents, the application program shall also be provided.

3.6.3 These manuals shall be provided in three hard copies and in one electronic copy. Manuals shall be written in Portuguese. For foreign suppliers, in addition to the Portuguese version (except for logs of sub-providers) the English version shall be provided .

## **4 Design and Operation Conditions**

### **4.1 Capacity**

The following capacities are standardized:

- a) 4,4 MW (15 MMBtu/h);
- b) 7,3 MW (25 MMBtu/h);
- c) 14,6 MW (50 MMBtu/h);
- d) 29,2 MW (100 MM/Btu/h).

**NOTE** Whenever necessary, different capacities may be specified on the equipment's Technical Specification.

### **4.2 Maximum Working Pressure**

The following pressures (manometric) are standardized:

- a) 10 340 kPa (1 500 psi);
- b) 17 230 kPa (2 500 psi).

**NOTE** Whenever necessary, different pressures may be specified on the equipment's Technical Specification.

### **4.3 Minimum Thermal Efficiency**

A thermal efficiency of at least 88 % shall be used, as in ASME [PTC 4](#).

### **4.4 Life Cycle**

A life cycle of at least 25 years is established.

4.5 Capacity, maximum steam pressure, steam quality, the type of fuel, electrical feeds, feeding water quality and the work schedule shall be determined on the technical specification.

**NOTE** The generator's minimum capacity shall be between 25 % and 30 % of the rated capacity.

### **4.6 Design Standards**

The steam generator shall be designed as in ASME BPVC [Section I](#).

## **5 Equipment Description**

5.1 The steam generator (see Annex A) is made up of at least:

- a) convection zone;
- b) radiation zone;

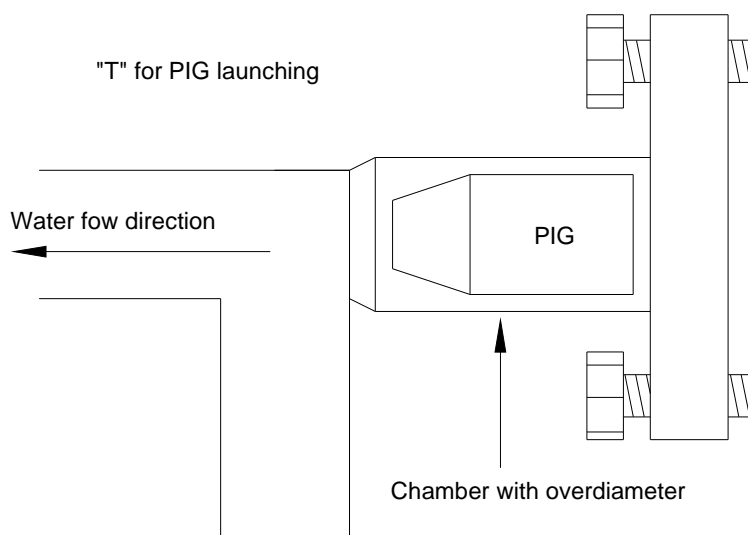
- c) auxiliary systems;
- d) power and control panels.

5.2 The set shall be mounted on a skid and at least split (when stationary) with lifting eyes in order to facilitate handling and maintenance. All piping (drain, electric piping, instrument air and others) shall preferably be mounted on the outer part of the skid, in order to facilitate maintenance.

## 6 Convection Zone

6.1 The convection zone shall be designed for horizontal or vertical flow of gases and countercurrent flow of water. For each coil, input and output connections individually flanged shall be provided.

6.2 It is recommended installing facilities for launching and receiving pig for internal cleaning of each coil. It is suggested the installation of an adapter according to Figure 1, which consists of a "T" that has, at one end, an internal diameter greater than the internal diameter of the steam generator piping (chamber with overdiameter) and is closed with a blank flange. **[Recommended Practice]**



**Figure 1 - Adapter for Pig Launching and Receiving**

6.3 It is recommended that the convection zone is formed by horizontal, plain and finned tubes connected in series by means of 180° curves, with ASTM A234 WPB specification. **[Recommended Practice]**

6.3.1 It is recommended that the three rows of finned tubes subjected to higher temperatures of the exhaust gases are provided with stainless steel fins. **[Recommended Practice]**

6.3.2 For finned tubes, there must be contact of, at least, 95 % between each fin and the tube, ensuring an adequate heat transfer to the thermal efficiency set forth in this Standard.

6.4 The maximum temperature outside the chamber, and the method and criteria for its measurement, shall meet PETROBRAS [N-550](#), ABNT [NBR 12177-2](#) and ABNT [NBR 13970](#).

6.5 If the convection zone is vertical, there shall be two side doors, one on each side for access to allow cleaning operations. The doors are lined with ceramic fiber mat, according to PETROBRAS [N-1618](#).

6.5.1 These doors are sealed with gaskets to prevent leakage of gases, and the primary seal is applied through internal inclined surfaces.

6.5.2 The stationary generators shall be provided with a device that facilitates the opening, with lifting eyes on its upper part and suspended by pulleys on the chamber structure, to allow the displacement of the doors towards the horizontal axis of the chamber (retractable door).

6.6 The interconnection curves of the tubes shall be outside the zone of heat exchange, i.e., the zone of gas flow. Points must be provided with Ø 3/4" plug for internal inspection, in a curve of each group of tubes layer of the convection zone (at least at four points).

6.7 It is recommended that the coupling of the convection zone to the interconnection pipeline or to the radiation zone is done by means of screws in the structure, and mounting sleeves and high temperature resistant gaskets. **[Recommended Practice]**

6.8 It is recommended that the lining of the convection chamber mirror is made of class A refractory concrete insulation. **[Recommended Practice]**

NOTE If that recommendation is implemented, PETROBRAS [N-1617](#), [N-1728](#) and [N-1910](#) shall be adopted.

6.9 Two doors shall be provided at the ends to allow access to the curves. These doors shall be screwed, lined with ceramic fiber and provided with a device to facilitate the opening and lifting eyes on its upper part.

NOTE It is recommended that the generators with vertical convection chamber are provided with a device that facilitates the opening, with lifting eyes on its upper part and suspended by pulleys on the chamber structure, to allow the displacement of the doors towards the direction transverse to the chamber. **[Recommended Practice]**

6.10 A gas exhaust stack shall be provided bolted to the structure of the convection zone (with high temperature resistant gasket), consisting of pipes and steel plates welded and reinforced and protected against the ingress of rainwater. It shall be provided a sampling tube of the stack gases in an easily accessible location, which makes it possible to collect from the skid.

## 7 Radiation Zone

7.1 The radiation zone (furnace) shall consist of a horizontal carbon steel cylinder, thermally lined preferably with ceramic fiber. ASTM A106B steel horizontal tubes, whether straight or plain, shall be placed longitudinally to the zone, along its entire internal perimeter and connected in series at their ends by 180° curves (which are within the radiation area) of short radius, of ASTM A 234 WPB steel. The pipes must be supported along its length by cast alloy steel brackets. The burner(s) shall be mounted at the end of the furnace, providing a horizontal flame.

7.2 It is recommended installing facilities for launching and receiving pig for internal cleaning of each coil. It is suggested the installation of the same adapter as described in 6.2 of this Standard. **[Recommended Practice]**

NOTE If the steam generator does not have pre-heater, it is not necessary to install that adapter before the radiation zone, being permitted the installation of only one before the convection zone, according to 6.2.

7.3 It is recommended that the burner refractory block is segmented into refractory castable. **[Recommended Practice]**

NOTE If that recommendation is implemented, PETROBRAS [N-1617](#), [N-1728](#) and [N-1910](#) shall be adopted.

7.4 The maximum temperature outside the chamber, and the method and criteria for its measurement, shall meet PETROBRAS [N-550](#), ABNT [NBR 12177-2](#) and ABNT [NBR 13970](#).

7.5 It is recommended that the radiation zone is provided with two rectangular peep holes, allowing the vision with both eyes of the profile of the main flame and with, at least, one eye of the profile of the pilot flame. These peep holes shall be installed on the front part for monitoring the furnace. **[Recommended Practice]**

7.6 It is recommended that a drain nozzle with threaded cap shall be installed on the bottom of the radiation chamber. Drain pipes with globe valve shall be installed on the coil. **[Recommended Practice]**

7.7 The design of the radiation chamber shall consider that, in case of need of repair of a tube, the removal of the burner, or the furnace tube bundle, is not necessary.

## **8 Transition Zone**

It is recommended that the transition zone (interconnection pipeline), if any, meets the requirements mentioned in 8.1 to 8.7. **[Recommended Practice]**

8.1 Be made of steel plate and lined with ceramic fiber, according to PETROBRAS [N-1618](#) **[Recommended Practice]**.

8.2 Be bolted to the convection zone and to the radiation zone. **[Recommended Practice]**

8.3 Be provided with water drainage and manhole for the inspection of down pipes of the convection zone and the access to the radiation zone. **[Recommended Practice]**

8.4 Be provided with a rectangular peep hole, allowing the inspection (with both eyes) of the internal part of the radiation zone, with minimum dimensions of 10 cm x 10 cm so that the thermographic inspection may be performed in the Radiation coils. They shall be positioned in such a way that that it allows to inspect 100 % of the Radiation coils. **[Recommended Practice]**

8.5 Be provided with a metal platform, on its top part, with antiskid plate floor, joint to the structure, with metal handrail and stairs up to the ground. **[Recommended Practice]**

8.6 Be provided with drain nozzle, bronze gate valve, of quick release. **[Recommended Practice]**

8.7 Be provided with a manhole with minimum dimension of 500 mm, internally insulated with ceramic fiber, according to PETROBRAS [N-1618](#), with the same wall thickness, fixed with screws and davit. **[Recommended Practice]**

## 9 Auxiliary Systems

The main auxiliary systems that compose the equipment are:

- a) feed water system;
- b) steam system;
- c) fuel conditioning system;
- d) compressed air generation system.

### 9.1 Feed Water System

The water feed is made in the skid limit of the steam generator. It shall be designed to overcome the back pressure equal to the maximum steam outlet pressure in addition to the system load losses. The flow rate shall be consistent with the capacity of the generator and with the maximum amount of heat released by the burner.

9.1.1 When there is feed pump, it is recommended that it presents the following characteristics:  
**[Recommended Practice]**

- a) positive displacement type;
- b) alternative without forced lubrication of the pistons, with gaskets suitable for local conditions of the water;
- c) multiple belt coupling with tension adjustment;
- d) protection for the belts with access door allowing the exchange of the belts without removing of protector;
- e) driven by electric motor;
- f) pulsation dampeners for suction and discharge;
- g) flanged connections and Pressure Safety and Relief Valve (PSV);
- h) the shutters of the feed pump valves are provided in a suitable material to preserve their seating;
- i) the feed pump head is made of aluminum bronze and the pistons are made of ceramic material;
- j) the pulsation dampener of the pump discharge is spherical, with no moving parts and without the need for damping fluid.

**NOTE** When necessary, the electric motor shall be controlled by frequency converter specified according to PETROBRAS [N-2547](#).

9.1.2 A check valve shall be installed and an automatic shut-off valve system shall be installed in series with the check valve to prevent the steam from returning to the feed water system, due to unscheduled shutdowns, mainly for power shortage. If there is any pump, the valve shall be installed on its discharge side.

9.1.3 The internal materials of the check valves and the discharge valves of the feed pump shall be suitable to prevent the steam from returning from the generator at any moment.

### 9.2 Water Pre-Heater

9.2.1 The equipment shall be equipped with a pre-heater when there is need to raise the temperature of the generator feedwater before the convection section, so that its tubes are at an outside temperature above the dew point of the flue gases.

9.2.2 The pre-heater shall be thermally insulated, according to PETROBRAS [N-250](#), [N-550](#) and [N-1618](#).

9.2.3 It is recommended that the pre-heater is a double-pipe and flanged heat exchanger. **[Recommended Practice]**

### **9.3 Steam System**

9.3.1 Shut-off valves and check valves shall be placed on the generator output, as well as at least two pressure safety and relief valves, flanged, specified and assembled according to the requirements of ASME BPVC [Section I](#), which shall have its discharge lines to a place safe for the operators, with a drain hole.

9.3.2 At the steam outlet line there shall be exist a bypass with blow-down valve.

9.3.3 It is recommended that the steam outlet pipes are dimensioned in order to allow a minimum loss of load; they shall also be full flow tubes. **[Recommended Practice]**

9.3.4 The steam outlet line, as well as the blow-down valve, shall be installed at the level of the skid in order to facilitate the operation.

9.3.5 The sampling of the liquid phase of the steam outlet shall be made through a system of collection and cooling of the sample.

9.3.6 The internal materials of the check valves, at the steam generator output, shall be suitable to prevent the steam from returning from the generator at any moment.

9.3.7 The steam generator shall be provided with an online system for determining the quality of steam and indicating the percentage by weight in the Human-Machine Interface (HMI).

### **9.4 Liquid Fuel System**

9.4.1 It is recommended to use fuel oil or treated petroleum. **[Recommended Practice]**

9.4.2 The system, when required, shall be supplied complete for each generator and mounted in an easily accessible location to allow its maintenance.

9.4.3 The system shall be designed to adjust the temperature of the liquid fuel, indicated in the Data Sheet of the equipment, to the temperature required by the burner.

9.4.4 The system consists of:

- a) double basket filter to permit cleaning, without stopping the unit, or changing fuel;
- b) gear pump with pressure safety and relief valve and electric motor;
- c) a heating system to adjust the fuel to the viscosity conditions required by the burner;
- d) low intensity electric heaters for the unit start-up;
- e) pressure control of the liquid fuel by pump bypass and automatic throttle valve to control the oil flow rate in order to facilitate the start-up;
- f) Automatic shut-off valves for liquid fuel (two are to be used) and other controls and information necessary for the proper operation of the burner, according to NFPA [85](#);



- g) metering of instantaneous flow rate and cumulative volume of liquid fuel, according to ANP/INMETRO nº 1 de 10/06/2013.

NOTE 1 It is recommended that the heating system includes a steam heater (or hot water) and also one or more electric heaters. **[Recommended Practice]**

NOTE 2 When necessary, an additional subsystem of electrical resistance trace, designed according to PETROBRAS N-1857, shall be included in the system for conditioning the liquid fuel to the temperature required by the burner.

9.4.5 The liquid fuel pressure (gauge) delivered in the pump suction is, at least, 9,8 kPa (0,1 kgf/cm<sup>2</sup> = 1,421 psi), considering the pump mounted on the steam generator skid.

## 9.5 Fuel Gas System

9.5.1 The fuel gas system shall be designed according to ABNT NBR 12313:2000 to receive gas with gauge pressure from 138 kPa to 242 kPa (20 psi to 35 psi) and consists of:

- a) pressure regulating valve to meet the pressure variation in the inlet;
- b) line filter for removing solid matters that may be dragged with the gas, eliminating problems of control;
- c) metering of fuel gas flow rate, according to ANP/INMETRO nº 1 de 10/06/2013;
- d) control of gas flow rate in accordance with the capacity of the generator;
- e) feeding system of the pilot flame with two fuel gas automatic shut-off valves and one automatic discharge valve (vent) with bubbler and depressurization according to NFPA 85;
- f) feeding system of the main flame with two fuel gas automatic shut-off valves and one automatic discharge valve (vent) with bubbler. Depressurization according to NFPA 85;
- g) automatic shut-off valves driven by electric actuators: shall be automatic shutdown type;
- h) redundancy for closing the gas control valve in case of operation of the gas shut-off valve, where applicable.

NOTE 1 Exceptionally, when the value of the gas pressure available in the area differs from this item 9.5.1, the Technical Specification of the equipment shall set the pressure range.

NOTE 2 It is recommended that the automatic shut-off valves are only open manually. **[Recommended Practice]**

NOTE 3 The fuel gas system shall be adequate to meet the gas composition defined in the technical specification.

NOTE 4 It is recommended that the primary element for flow measurement is orifice plate type. **[Recommended Practice]**

9.5.2 The gas scrubber, when part of the scope of steam generator supply, shall be instrumented to ensure the gas supply interruption at high level.

9.5.3 An electronic pressure transmitter of fuel gas supply shall be provided for the indication in HMI.

9.5.4 The need for installation of explosion venting devices in gas consumer equipment shall be considered, according to 3.4.6 of ABNT NBR 12313:2000.

## 9.6 Utility Steam System

When required, a steam outlet shall be provided for the use in the liquid fuel heater system for liquid fuel and for atomization system. This system consists of:

- a) system for reducing the steam pressure at the generator outlet to the usage pressure in the liquid fuel atomization and heater;



- b) condensate separator to remove water from steam, preventing problems in the atomization, with automatic purger. The condensate purge system shall meet the requirements of PETROBRAS [N-116](#);
- c) flexible connections to eliminate transmission of vibration;
- d) steam intake control valves in the liquid fuel heater;
- e) control valve of atomization steam pressure;
- f) flanged safety valve after pressure reduction device;
- g) safety in atomization system.

## 9.7 Compressed Air System

If the compressed air system is part of the scope of steam generator supply, the requirements mentioned in 9.7.1 to 9.7.3 shall be fulfilled:

9.7.1 The unit shall be self-sufficient in air for atomization, instruments and water treatment (if necessary). This system consists of:

- a) rotary or alternative air compressor, with flow rate control, driven by electric motor, sized to meet the start-up and operating conditions of the whole system;
- b) surge vessel with capacity compatible with the instrument air compressor, designed according to the requirements of ASME BPVC [Section VIII - Division 1](#) and meeting the regulatory norm No. 13 ([NR-13](#));
- c) safety valve on the discharge side;
- d) set of components for complete removal of oil, dirt and moisture to ensure the quality of air to the instrument;
- e) pre and post-filtering stations with bypass.

9.7.2 The automatic sensing of the compressor demand for compressed air shall be by a pressure transmitter, in the air distribution network.

NOTE When necessary, the electric motor shall be controlled by frequency converter specified according to PETROBRAS [N-2547](#), modulated by the pressure transmitter mentioned in 9.7.2.

9.7.3 The compressed air system for instrumentation shall meet ANSI/ISA [7.0.01](#).

## 9.8 Burner

9.8.1 The burner shall be suitable for the specified type of fuel. In relation to liquid fuel, it shall be of the type of atomization with auxiliary flow, whether air or steam.

9.8.2 It is recommended that, in the units up to 7,3 MW (25 MMBtu/hr), the fan is directly attached to the burner; and, in the units above 14,6 MW (50 MMBtu/hr), the fan is mounted separated from the burner. **[Recommended Practice]**

9.8.3 The selection of the burner shall be made so that the flame does not reach the tubes in any capacity.

9.8.4 The burner shall direct the fuel and air to the burning section, in such a way that promotes a stable and adjustable flame profile and efficient combustion throughout its operating range.

9.8.5 The burner shall consist of:

- a) burner nozzle with air or air and steam atomization;
- b) pilot flame system;
- c) Ignition system;
- d) air and fuel automatic control system;
- e) flange connection to the generator;
- f) combustion air fan driven by electric motor;
- g) ultraviolet flame detection system with self-checking;
- h) high temperature thermocouple on the burner;
- i) automatic start and safety sequencer shall have safety integrity level certificate SIL-3, according to IEC 61508-1;
- j) optionally, automatic cleaning system of the burner nozzle, in case of shutdown;
- k) pressure control and security of the atomizing flow;
- l) Valve, with remote activation, to enable the replacement of atomizing air with steam with the indication: air - air/steam - steam;
- m) peep hole for inspecting the flame.

NOTE 1 the provisions of items a), j), k) and l) apply only to the liquid fuel burner.

NOTE 2 It is recommended that the combustion control system comprises the measurement of combustion air and O<sub>2</sub> excess. **[Recommended Practice]**

NOTE 3 Regarding the provisions of item f), it is recommended that, when required, the electric motor is controlled by frequency converter as specified in PETROBRAS N-2547, modulated by air/fuel ratio PID automatic controller and interlocked by the start and safety sequencer. **[Recommended Practice]**

NOTE 4 It is recommended that the fan mentioned in item f) is instrumented with vibration monitoring system, for alarm, with IP 65 enclosure, inhibition with logic start and manual or remote reset with reset coil at 120 V/60 Hz. **[Recommended Practice]**

9.8.6 The fuel for the pilot shall be fuel gas.

9.8.7 It is recommended that the fan air suction is placed above the cover of the skid with guardrail with adequate spacing to prevent the entry of foreign elements into the combustion air. **[Recommended Practice]**

9.8.8 It is recommended that the fan motor is directly supported on the Steam Generator skid using elastomer dampener (cushion). The blower air outlet shall contain a flexible joint (canvas) for connecting to the steam generator air inlet. **[Recommended Practice]**

9.8.9 It is recommended that the motor fan air support and condition systems enable it to be installed or removed with the fan coupled to the motor. **[Recommended Practice]**

9.8.10 It is recommended that the coupling of the fan to the motor is performed by taper bushing. **[Recommended Practice]**

9.8.11 It is recommended that the blower drive motor has four poles, with synchronous speed of 1 800 RPM, and standard housing according to ABNT NBR IEC 60034-5. **[Recommended Practice]**

## 9.9 External Piping and Valves

9.9.1 The piping shall be designed in accordance with PETROBRAS N-57 and manufactured and assembled according to PETROBRAS N-115.

9.9.2 The pipes shall be of the type ASTM A106 Grade B carbon steel and the connections shall be ASTM A 234 Grade WPB steel.

9.9.3 1 1/2" manual valves, and larger, shall be flanged.

9.9.4 The flanges of the high pressure lines shall be ring joint type.

9.9.5 The control valves shall be flanged, except in low pressure and diameter lines, where the manufacturer's standard is threaded valve.

9.9.6 All piping welds subject to high pressure shall be inspected in accordance with PETROBRAS [N-115](#).

9.9.7 The hot oil and steam lines shall be thermally insulated according to PETROBRAS [N-250](#) and [N-550](#).

9.9.8 All valves shall be identified by signs according to "Manual de Sinalização para Ambientes Industriais e Marítimos da PETROBRAS" and PETROBRAS [N-76](#).

NOTE The plates standard shall be required in the technical specification.

## **10 INSTRUMENTATION AND CONTROL**

### **10.1 General**

10.1.1 The instrumentation system shall be designed according to PETROBRAS [N-1882](#).

10.1.2 The P&I Diagrams shall represent all instruments of the steam generator, even those provided with equipment or compact unit (package), and the equipment or compact unit shall be clearly marked.

10.1.3 The monitoring and control system shall be electronic with standardized signs.

10.1.4 All instruments shall have housing compatible with the classification of the area where they were installed, according to PETROBRAS [N-1882](#) and [N-2154](#).

NOTE It is recommended that, in the case of electrical contacts, they shall be hermetically sealed.  
**[Recommended Practice]**

10.1.5 All instruments should have a plate attached to the instrument, with the manufacturer's technical data.

10.1.6 The instrument tag shall be on a plate non-attached to the instrument, according to ANSI/ISA [5.1](#).

10.1.7 The instruments shall be mounted directly on the equipment skid, which suffer from vibration problems.

10.1.8 The cables are conducted through cable trays, according to the requirements of PETROBRAS N-1997. **[Recommended Practice]**

10.1.9 The installation of instruments in locations that make the maintenance of other equipment difficult shall be avoided.

## **10.2 Generator Control System**

10.2.1 The generator shall have the following automatic controls:

- a) steam pressure control;
- b) feedwater flow rate control (see Note 1);
- c) fuel pressure control;
- d) steam quality control (see Note 2);
- e) O<sub>2</sub> excess control (see Note 3);
- f) t pre-heating water temperature control, where applicable (see Note 4);
- g) liquid fuel temperature control, if applicable.

NOTE 1 When the generator has more than one coil, it shall have an individual control so that the flow rate is distributed equally.

NOTE 2 The quality of the generated steam is automatically maintained by measuring the fuel required in relation to the feedwater flow rate, and maintaining the air/fuel ratio constant.

NOTE 3 It is recommended that an on-line O<sub>2</sub> analyzer system shall be provided, by sending a signal to adjust the fuel gas flow rate to the burner. The on-line gas analyzer system shall meet the requirements of API RP 555. **[Recommended Practice]**

NOTE 4 It is recommended that the water pre-heater bypass is provided, preferably automatic, to permit adjustments in the temperature of feedwater of the convection zone. **[Recommended Practice]**

NOTE 5 It is recommended that the calculation of the steam quality is made using the orifice plate and the algorithm is implemented in the Programmable Logic Controller (PLC). **[Recommended Practice]**

10.2.2 All control valves shall be dimensioned so that they are not subjected to excessive differential pressure, avoiding cavitation.

10.2.3 The implementation of automatic control system shall be made through locally installed devices, and with output to the supervisory system, for remote monitoring.

## **10.3 Totalization**

There shall be the following:

- a) totalization of feedwater flow rate, located on the front part of the control panel (HMI);
- b) totalization of fuel flow rate, located on the front part of the control panel (HMI);
- c) totalization of combustion air flow rate, located on the front part of the control panel (HMI)
  - if applicable.

## **10.4 Indicators**

At least the following indicators shall be provided for the process variables listed in Table 1.

**Table 1 - Indicators for Process Variables**

Number	Process Variable
1	Feedwater pump suction pressure
2	Feedwater pump discharge pressure
3	Feedwater flow rate
4	Water temperature at the pré-heater inlet
5	Pre-heater outlet temperature
6	Pre-heater outlet pressure
7	Outlet pressure at the convection section
8	Outlet temperature at the convection section
9	Inlet temperature at the radiation section
10	Steam temperature at the generator outlet
11	Steam pressure at the generator outlet
12	Radiation chamber internal pressure
13	Exhausted gas temperature at the convection inlet (see Note 5)
14	Tube temperature at the radiation section (see Note 4)
15	Exhaust gas outlet temperature
16	Flame Intensity
17	Combustion air pressure
18	Fuel gas feed pressure (see Note 5)
19	Fuel pressure at the burner inlet
20	Fuel gas pressure at the pilot inlet
21	Fuel oil pump discharge pressure (see Note 5)
22	Fuel temperature (see Note 5)
23	Utility steam pressure (see Note 5)
24	Atomization fluid pressure (see Note 5)
25	Air compressor discharge pressure (see Note 5)
26	Air pressure at the dehumidifier outlet (see Note 5)
27	Steam quality
28	Burner temperature
29	Fuel flow rate
30	Combustion air flow rate (see Note 5)
31	O <sub>2</sub> content in exhaust gases
<p>NOTE 1 Each indicator shall be located on the panel or field, according to the Technical Specification.</p> <p>NOTE 2 The local indicators of temperature and pressure shall be located so as to allow the soil reading.</p> <p>NOTE 3 Different levels of access to operation and maintenance variables shall be provided in HMI.</p> <p>NOTE 4 If the equipment has more than one coil, they shall be monitored individually.</p> <p>NOTE 5 When required by technical specification.</p>	

## 10.5 Interlocking, Security and Alarm

10.5.1 The generator shall be protected by safety valves, flanged according to ANSI B16.2, and selected and sized according to ASME Code.

10.5.2 The generator shall have a system for flame detection, and burner protection and interlock with safety integrity level certificate SIL-3, according to IEC 61508-1, aiming to turn the burner on and off in the correct and safe sequence, as well as inspect the flame during the operational phase, according to NFPA 85.

10.5.3 The system for flame detection, and burner protection and interlock shall be solely performed by the flame controller. This system consists of, at least, the following parts:

- a) combustion controller connected to the PLC so that there is a perfect synchronization between the controller and interlock made by PLC;
- b) ultraviolet flame detector;
- c) pre-purge timing as specified in NFPA 85 (only implemented in flame programmer);
- d) pilot flame shut-off valves;
- e) main flame shut-off valves;
- f) ignition electrode.

10.5.4 The post-purge timing shall be performed by the PLC.

10.5.5 The manufacturer shall provide a schedule-type chart, with the work sequence of flame protection system, with times determined based on the steam generator design.

10.5.6 The following faults shall shut down the burner, and generate visual and audible alarm in the HMI:

- a) flame failure (BSL);
- b) high temperature tubes (TSH);
- c) high temperature steam (TSH);
- d) high pressure steam (PSH);
- e) low pressure steam (PSL); timing during the start-up;
- f) high temperature burner (TSH);
- g) High temperature exhaust gases (TISH);
- h) low water flow rate (FSL);
- i) low pressure pump suction (PSL);
- j) low pressure combustion air (PSL);
- k) high pressure fuel gas (PSH) (see Note 1);
- l) low pressure fuel gas (PSL) (see Note 1);
- m) low pressure atomization (PSL) (see Note 1);
- n) high pressure atomization (PSG) (see Note 1);
- o) low pressure instrument air (PSL);
- p) low pressure fuel oil (PSL) (see Note 2);
- q) low temperature fuel oil (TSL) (see Note 1);
- r) open burner (ZSL);
- s) Automatic gas shut-off valves open during the start-up (see Note 1);
- t) power shortage;
- u) Low pressure pump lubrication (PAL);
- v) fan vibration (see Note 1);
- y) high temperature of the fuel oil electric heater (TSH) (see Note 1);
- x) steam high quality;
- w) low combustion air flow rate (FSL) (see Note 1);
- z) closure of the automatic shut-off valve of pump's booster (in this case the water feed pump shall also be stopped by interlock);
- aa) high pressure liquid fuel (see Note 1);
- ab) low pressure liquid fuel (see Note 1);
- ac) high pressure pilot gas (see Note 1);
- ad) main combustible liquid valve open during the start-up (see Note 1);
- ae) low content of O<sub>2</sub> (see Note 2).

NOTE 1 When applicable.

NOTE 2 When specified.

10.5.7 The interlock and control system of the generator shall only allow a new start-up after the inspection performed by the operator and removal of faults mentioned in 10.5.6.

10.5.8 The security system shall not allow the automatic start-up of the generator after a power shortage and never before the pre-purge.

10.5.9 It is recommended that there is output to an audible alarm that sounds every time that the alarm system goes off, with adjustment for parameterization of the alarm time. **[Recommended Practice]**

10.5.10 The status and phases mentioned in 10.5.10.1 and 10.5.10.2 shall be signaled on the panel/HMI and on the supervisory one:

10.5.10.1 Status:

- a) panel on/off;
- b) feedwater pump on/off;
- c) blower on/off;
- d) air compressor on/off (see Note);
- e) air dryer on/off (see Note);
- f) fuel oil pump on/off (see Note);
- g) burner on high/low heat;
- h) full limits;
- i) fuel gas automatic shut-off valve opened/closed (see Note);
- j) liquid fuel automatic shut-off valve opened/closed (see Note);
- k) automatic shut-off valve of pump's booster open/closed;
- l) emergency shutdown;
- m) local/remote operation;
- n) Burner released/locked;
- o) selection of liquid/gas fuel (see Note);
- p) atomization air/vapor/both (see Note).

NOTE When required by technical specification.

10.5.10.2 Phases:

- a) pre-purge;
- b) Pre-ignition;
- c) pilot;
- d) low heat;
- e) normal operation;
- f) post-purge;
- g) idle generator.

NOTE Each phase shall have the total elapsed time.

10.5.11 The alarms shall follow the sequences ISA-F3M and ISA-F3B of ISA 18.1. At least the last twenty alarms shall be recorded.



10.5.12 The two automatic shut-off valves of the main fuel line shall be of the type that, in the event of failure of its drive system, they shut down in favor of operational safety. The sealing of the valves shall be completely tight. They shall be flanged.

10.5.13 The steam generator shall have safety interlocks controlled by switch, configured in the PLC through the signals of transmitters specific to the interlock system (4 mA to 20 mA). It shall have the position of the contacts always closed when in normal operation.

## **11 Control Panel**

### **11.1 General**

11.1.1 The PLC shall meet the series of standards IEC 61131 Parts 1, 2, 3 and 5 and the Supervisory System, when required, shall meet the Technical Specification of PETROBRAS.

11.1.2 The control panel shall have housing with degree of protection appropriate for operating conditions.

NOTE The degree of protection recommended is IP-55W. **[Recommended Practice]**

11.1.3 It is recommended that the wiring inside the panel is made using 1.0 mm<sup>2</sup> gauge wire and that all wiring relating to electronic signals (4 mA - 20 mA) and 24 VDC command is sent separate from the power signal and 220 VDC command, if applicable. **[Recommended Practice]**

11.1.4 It is recommended that all terminal boards referring to input or output, analog and digital signals, are of the type terminal/fuse, with signaling through open fuse LEDs. **[Recommended Practice]**

11.1.5 All cabinets or racks of the PLCs shall have at least 20 % of spare slots, considering the total number of slots used.

11.1.6 In the front part of the control panel, there shall be a local HMI, through which the operator may monitor and control the entire process.

11.1.6.1 It is recommended that the HMI is provided with monitor and a membrane keypad, degree of protection IP-55W, and is fully configurable. **[Recommended Practice]**

11.1.6.2 It is recommended that all inspected and controlled alarms and variables are accessible through the HMI, such as adjusting the set points, PID parameters, timers and counters. **[Recommended Practice]**

11.1.6.3 It is recommended that information about the sensors is displayed, such as temperatures, pressures, flow rates and alarm history. **[Recommended Practice]**

11.1.7 The HMI shall be protected against the incidence of sunlight, so as to enable easy reading of the screen.

11.1.8 The control panel and the CCM should be self-supporting and totally independent of each other, with back door, front door (without instruments).

NOTE 1 It is recommended that the set of panels has degree of protection IP-55 W and is equipped with a sheet steel cover, 14 USG gauge, removable, and with the same paint scheme of the steam generator. **[Recommended Practice]**

NOTE 2 If that recommendation is implemented, ABNT [NBR IEC 60529](#) shall be adopted.

11.1.9 They shall be located within the outer contour of the main skid, near one side, with the front part pointing outwards, but without rigid mechanical connection with the skid in order to avoid problems arising from vibrations.

11.1.10 For stationary generators, the skid shall be provided with slots to allow the installation of the control panel and the CCM.

11.1.11 Terminal strips and "tail" beams of cables also numbered shall be provided for connection/disconnection facilitated.

11.1.12 In the control panel venting shall be considered the temperature of the equipment, ambient temperature, and the fact that the panel is exposed to sun during a part of the day.

11.1.13 The interconnection wiring between the control panel and the CCM shall be sectioned into two panels by means of numbered terminal boards to be approved by PETROBRAS.

11.1.14 All transducers connected to process piping shall be mounted externally to the control panel.

11.1.15 The control panel shall have in its inside a fluorescent lamp with guardrail, which turns on when the door opens, and a 2F + T bipolar socket.

11.1.16 It is recommended that the conduit that reach the panel shall enter through the front part of the panel. **[Recommended Practice]**

11.1.17 The external arrangement of the panel shall consider the ergonomic criteria.

11.1.18 All instruments of the panel shall be identified by plates with the respective "TAG" recorded according to ANSI/ISA-[5.1](#), subject to the approval of PETROBRAS.

NOTE The plates standard shall be required in the technical specification.

11.1.19 It is recommended that the indicating and signaling instruments mounted on the panel, except for the drivers, shall be mounted before a door with a glass peep hole (or polycarbonate) on the panel. It is recommended that the glass has 6 mm thickness. **[Recommended Practice]**

NOTE The panel shall be painted according to PETROBRAS [N-1735](#).

11.1.20 It is recommended that the access for the instrument maintenance shall be made through the front part of the panel by means of the back door. **[Recommended Practice]**

11.1.21 The grounding system of the control panel shall be constituted of two ground bus bars. one ground bus bar isolated for shield connection of instrumentation cables and another ground bus bar non-isolated for connecting to the ground bus bar of the electric panel of CCM.

11.1.22 The electronic instruments installed in the panel shall be resistant to radio frequency interference in electrical maneuvers.

## **11.2 Engines Control Center (CCM)**

### **11.2.1 System Electrical Characteristics**

- a) voltage: 480 V, 60 Hz, three-phase solidly grounded;
- b) three-phase symmetrical short-circuit current according to technical specification;
- c) grounding scheme defined according to ABNT [NBR 5410](#) or technical specification.

### **11.2.2 Applicable Standards**

- a) PETROBRAS [N-314](#);
- b) ABNT [NBR 5410](#);
- c) ABNT [NBR IEC 60529](#);
- d) ABNT [NBR IEC 60439-1](#).

### **11.2.3 Constructive Characteristics**

11.2.3.1 The CCM shall be cabinet type, solid construction, made of hot-rolled plates, of a thickness not exceeding 2,66 mm (12 USG gauge), conveniently reinforced in order to avoid deformations under load of the elements mounted on the doors; the CCM panel is provided with minimum compartmentalisation 3b according to ABNT [NBR IEC 60439-1](#).

11.2.3.2 All joints shall be made from cadmium plated screws.

11.2.3.3 The side parts of the panels shall be removable, as well as the top.

11.2.3.4 The doors of the motor control center containing the components of 480 V shall be electrically connected to the structure of the motor control center, through copper braid.

11.2.3.5 The CCM has on its bottom part a 11 USG gauge plate, facing to the front and rear plates so that it is possible to attach it by means of an intermediate base welded to the panel fixing structure.

11.2.3.6 The bus bar shall be isolated by electrolytic copper through shrink pipe and have silver connection. The identification of the connections shall be through painting according to ABNT [NBR 14039](#).

- a) phase A - green;
- b) phase B - yellow;
- c) phase C - violet;
- d) ground - black.

11.2.3.7 The CCM shall have a copper grounding bus bar, with connectors, also of copper, for ground connection via copper cable.

11.2.3.8 The CCM and its components, except as otherwise indicated, shall be designed for insulation class 600 V nominal and 2,2 kV of power industrial frequency for 1 minute.

11.2.3.9 In the wiring shall be used flexible conductors (it is recommended stranding 5), formed of soft copper wire, insulation for 450 V/750 V, 70 °C, black, 2,5 mm<sup>2</sup> minimum gauge and 1,5 mm<sup>2</sup> minimum gauge for voltage circuit. They shall be fungus resistant and fire retardant.

11.2.3.10 The conductors shall housed in plastic cable trays, where applicable. Each cable tray shall contain only wiring of its own circuit, except those intended for the interconnection of circuits. The cable trays shall be dimensioned according to the following criteria:

- a) number of conductors: up to 30;
- b) minimum area: 1 500 mm<sup>2</sup>;
- c) recommended dimensions: 30 mm x 50 mm.

11.2.3.11 Where the cable trays are not applicable, harness tied by means of clips or spiral type tape, Spiral Tube, shall be used. Each harness shall contain wiring of its own circuit, limited to a maximum of twenty conductors. The harness shall be fixed individually on the panels, so as not to cause efforts in the connections with the apparatus and can be removed without interfering with the establishment of others.

11.2.3.12 All conductor connections are made through pre-insulated compression terminals, adopting the following criteria:

- a) "PIN" type: connection to single-pole or similar terminals with connection of a single conductor;
- b) "FORK" type: connection to end fitting by means of fitted screws with connection of a single conductor;
- c) "RING" type: connection to end fitting by means of fitted screws with connection of two conductors, as well as TC circuits.

11.2.3.13 In the terminal strips and all devices are accepted at most two conductors per terminal block and a terminal block for each lug. Partition plates shall be used to divide the terminal groups relating to different external wires.

11.2.3.14 The terminals are identified in block letters on both sides, according to wiring diagrams, with labels and label holders for every type of terminal. Identifications without label holders will be accepted when the label holders are not applicable and where the identification is made with hard material and attached to the terminals. All ends of the conductors shall be identified by means of rings containing at least the code of the terminals to which the ends are connected.

11.2.3.15 The panel shall be resistant to corrosion caused by moisture and atmosphere of the installation location. The anti-corrosive treatment shall comply with PETROBRAS [N-1735](#) and the finishing final color shall be in accordance with the code 0065 (light gray) of PETROBRAS [N-1219](#).

11.2.3.16 It is recommended that, for each motor starter set, is provided a reset button for the thermal relay. **[Recommended Practice]**

#### 11.2.4 Equipment Characteristics

All shutdown devices provided in the CCM shall have devices for sectioning electrical circuits with features for blocking and preventing re-energizing, in compliance with the regulatory norm in No. 10 (NR-10).

11.2.4.1 The main circuit breaker shall be three-pole, in molded case, simultaneous action in the three poles, operation under load, fixed mounting, with manual control via front lever, fitted with thermomagnetic relays. Characteristics:

- a) voltage rating..... 660 V;
- b) rated voltage ..... 480 V;
- c) breaking capacity ..... given by PETROBRAS.

11.2.4.2 The circuit breaker for motors shall be three-pole, in molded case, simultaneous action in the three poles, operation under load, base fixation, with manual control via front lever, fitted with magnetic relays against short circuit. Characteristics:

- a) voltage rating..... 660 V;
- b) rated voltage ..... 480 V;
- c) breaking capacity ..... given by PETROBRAS.

11.2.4.3 The control fuse shall Diazed type, complete with base.

11.2.4.4 The contactors shall be three-pole, dry, rugged, mount on vertical surfaces and have the following characteristics:

- a) voltage rating..... 600 V;
- b) frequency ..... 60 Hz;
- c) control voltage..... 120 V.

11.2.4.5 The overload relays shall be thermal, with manual reset through button and have the following characteristics:

- a) voltage rating..... 600 V;
- b) frequency ..... 60 Hz.

11.2.4.6 The control transformers shall be dry, for indoor installation, with the following characteristics:

- a) voltage rating..... 600 V;
- b) frequency ..... 60 Hz;
- c) voltage ratio..... 480 V/120 V.

11.2.4.7 The auxiliary relays shall be compact, of high quality, rugged, mounted on vertical surfaces, and have the following characteristics:

- a) voltage rating..... 600 V;
- b) frequency ..... 60 Hz;
- c) voltage..... 120 V.

11.2.4.8 The voltage transformers shall be dry, for indoor installation, with the following characteristics:

- a) voltage rating..... 600 V;
- b) frequency ..... 60 Hz;
- c) voltage ratio..... 480 V/120 V.

11.2.4.9 The variable indicating shall be digital, 96 mm x 96 mm in size and indicate single phase and three phase voltages, phase currents, single phase and three phase active, reactive and apparent voltages, 0,5 % accuracy.

11.2.4.10 The current transformers shall be dry, for indoor installation, with the following characteristics:

- a) voltage rating..... 600 V;
- b) frequency ..... 60 Hz;
- c) rated secondary current ..... 5 A.

11.2.4.11 Two-pole/single-pole circuit breaker is molded, with thermomagnetic trip, base fixation, with the following characteristics:

- a) voltage rating..... 500 V;
- b) rated voltage ..... 220 V/240 V;
- c) rated current..... 20 A;
- d) symmetric Icc in 240 V ..... given by PETROBRAS.

11.2.4.12 The transformer of Auxiliary Services and Lighting shall be dry, encapsulated in epoxy resin, for indoor installation, with ratio 480/220-127V at 60 Hz.

## 12 Metallic structure

12.1 The metallic structure shall be designed, constructed and assembled according to PETROBRAS [N-279](#) and [N-293](#) and considering the loads of the steam generator and all the accessories on the structure, added to the overload.

12.2 The structure shall be calculated to resist the lifting performed by the respective eyes. The transport and the operation shall be done with the structure fully supported.

12.3 The dimensions and weights provided for the combination shall be indicated on the indication plate of the steam generator.

## 13 Miscellaneous

13.1 The unit shall be designed to operate outdoors, in non-classified area; it is provided with rain protection for equipment such as burner panel, compressor and water pump.

13.2 The area where the equipment is located, such as pump, compressor and panel, shall be well lit to operate this equipment.

**NOTE** It is recommended that the fluorescent lamps are high-efficiency industrial type, category A of the Brazilian Labeling Program (PBE), and they shall resistant to the vibration of the equipment area where they are installed. **[Recommended Practice]**

13.3 All instruments located outside the panel shall have degree of protection IP 65 according to ABNT [NBR IEC 60529](#) and the criteria established in PETROBRAS [N-1882](#).

13.4 The electric motors and junction box shall have degree of protection IP 55W according to ABNT [NBR IEC 60529](#), with bearings and grease fitting, winding temperature rise 80°C, insulation class F, with threaded shaft end, meeting PETROBRAS [N-2919](#) and ABNT [NBR IEC 60034-5](#).

NOTE If the electric motor is driven by frequency converter, it shall have two temperature sensors PT100 type per winding with junction box opposite to the power junction box and connected to the frequency converter protection module.

13.5 The conduits shall be made of hot galvanized iron, SCH 40, seamed, according to ABNT [NBR 5597](#).

13.6 All components of the steam generator shall have an identification plate containing the main characteristics of the components.

13.7 It is recommended that, for vibration source equipment, measures are taken to mitigate the vibration to acceptable levels. **[Recommended Practice]**

13.8 The maximum noise level is determined according to PETROBRAS [N-1674](#).

## 14 PAINTING

The painting should be in accordance with the standards PETROBRAS [N-2](#), [N-13](#), [N-442](#), [N-1550](#) and [N-1735](#).

14.1 The steam generator, piping, accessories and auxiliary equipment shall be provided and painted according to the patterns and colors set forth in PETROBRAS standards, as shown in Table 2.

**TABLE 2 - PAINTING OF BOILER PARTS**

Component-part	Condition/standard	Note
Steam generator	2 / PETROBRAS <a href="#">N-2</a>	Cold parts (up to 120 °C)
Steam generator	5 / PETROBRAS <a href="#">N-2</a>	Hot parts (120 °C to 600 ° C)
Piping	2 / PETROBRAS <a href="#">N-442</a>	Without thermal insulation (up to 120°C)
Piping	4 / PETROBRAS <a href="#">N-442</a>	With thermal insulation (80 °C to 500 ° C)
Motors, pumps, compressors, fans	2 / PETROBRAS <a href="#">N-1735</a>	(up to 60°C)
Electrical and instrumentation equipment and panels	2 / PETROBRAS <a href="#">N-1735</a>	(up to 60°C)
Stairs and metallic structures	1 / PETROBRAS <a href="#">N-1550</a>	(See Note 3)
<p>NOTE 1 Auxiliary piping and equipment that operate at a temperature above 60 °C shall be thermally insulated and protected with corrugated aluminum plate in the straight sections.</p> <p>NOTE 2 The colors of the equipment and piping shall meet the criteria established in <a href="#">NR-26</a> and PETROBRAS <a href="#">N-1219</a>.</p> <p>NOTE 3 The alternative A for structures in sheltered areas and use alternative B for other structures (PETROBRAS <a href="#">N-1550</a>).</p>		

14.2 In case of doubt regarding the paint schemes and colors to be used in the equipment and piping, PETROBRAS shall be consulted before any initiative.

## **15 Conditioning**

### **15.1 Factory Acceptance Test**

The following documented acceptance test shall be executed on the steam generator:

- a) visual inspection (including painting);
- b) dimensional inspection;
- c) hydrostatic test;
- d) water tightness test;
- e) electrical wiring insulation and instrumentation;
- f) voltage applied to the electrical wiring;
- g) electrical/pneumatic wiring continuity;
- h) functional test for electric charge;
- i) functional test for compressed air system;
- j) functional test for control panel and motor control center;
- k) functional test for water feed circuit;
- l) functional test for burner;
- m) performance test of the generator feed pump;
- n) tests of software installed on the Programmable Logic Controller (PLC);
- o) instrumentation grid tests.

### **15.2 Packaging and Transportation**

The manufacturer shall package the modules, auxiliary equipment and accessories of the steam generator meeting at least the following requirements:

- classify and identify the components based on the fragility and care needed for the type of transportation;
- ensure the integrity of the components in the specific delivery point;
- protect from rain and bad weather effects;
- protect parts subject to atmospheric corrosion.

### **15.3 Handling and Storage**

The manufacturer shall provide handling, storage and preservation procedures of the steam generator components, also during the assembly and pre-operation.

### **15.4 Preservation**

The manufacturer shall ensure the equipment preservation during the execution of the activities performed at factory described in 15.1, 15.2 and 15.3. In order to perform the necessary preservation activities after the delivery of the equipment in the delivery point, the manufacturer shall provide a documented procedure in which will be defined, distinctly, the preservation conditions in the following situations: equipment in the storage location, assembled equipment and equipment in operation.

### **15.5 Consumable, Spare Parts and Special Tools**

When established in the technical specification, the manufacturer shall provide a list of consumable, spare parts and special tools distinctly to commissioning activities and for two year operation.



## **15.6 Training**

When established in the technical specification, the manufacturer shall provide training to operators and equipment maintenance team and other representatives of PETROBRAS, which shall be consolidated in a Training Plan to be provided to PETROBRAS.

## **15.7 Technical Support**

When established in the technical specification, the manufacturer shall provide technical support during the phases of assembly and start-up of the equipment.

## **16 Packaging, Conditioning and Transportation**

16.1 The manufacturer shall prepare and deliver a conditioning procedure of the steam generator for transportation, storage and cure of refractory.

16.2 The manufacturer shall provide the package of modules, auxiliary equipment and accessories of the steam generator, taking special care for multimodal transportation.

16.3 All parts subject to atmospheric corrosion shall be properly protected. The steam generator package shall be appropriate to its protection against rain and bad weather effects for, at least, 12 months.

## **17 Assembly**

The manufacturer shall provide schemes for assembly and final interconnection in the installation location.

17.1 It is recommended that, after the assembly, PETROBRAS shall execute all the tests required for the equipment, under the manufacturer's inspection. The manufacturer shall previously indicate the tests to be performed, for the approval of PETROBRAS. Combustion control operation, safety system operation, interlocking and auxiliary equipment operation shall be included in the tests. **[Recommended Practice]**

**NOTE** In case of failure of the tests, the manufacturer shall provide the necessary corrections and repairs, previously providing the detailed procedures for the repairs.

17.2 The inspection is part of the final tests on field and it shall be performed by authorized person and in accordance with the provisions of ABNT [NBR 12177-2](#) and the regulatory norm No. 13 ([NR-13](#)).

## **18 Pre-operation and Start-up**

18.1 The manufacturer shall prepare and provide procedure for acceptance and performance test of the steam generator, in pre-operation phase, considering the acceptance criteria set forth in this Standard. The procedure for the acceptance and performance test shall meet ASME [PTC 4](#).

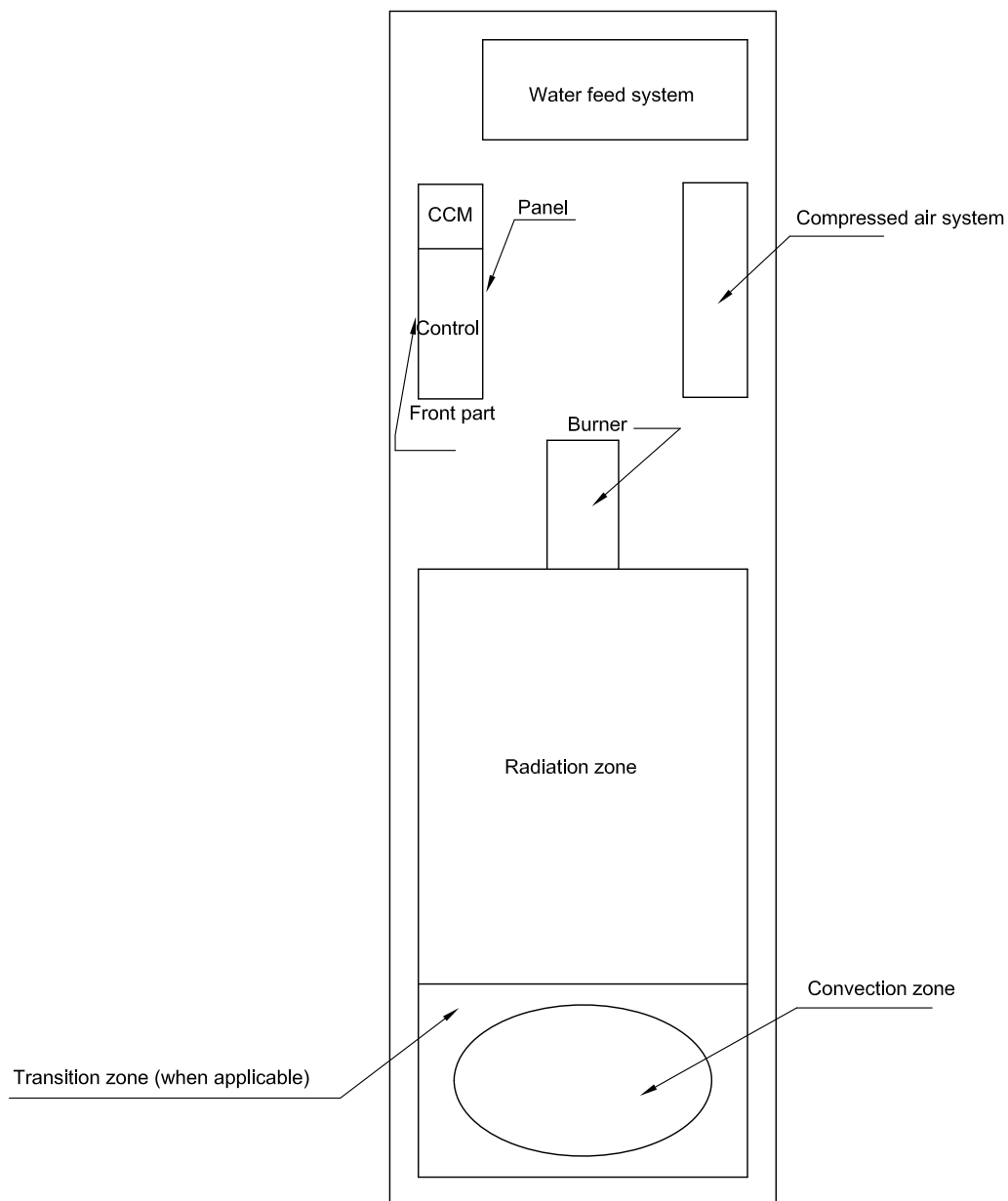
18.2 The manufacturer shall execute the acceptance test on field, in compliance with the procedure approved by PETROBRAS. The acceptance and performance test shall confirm the capacity specified for design data and parameters.

18.3 The manufacturer shall prepare and deliver the procedure for refractory cure.

18.4 Function test:

- a) hydrostatic test;
- b) water tightness test;
- c) electrical wiring insulation and instrumentation;
- d) voltage applied to the electrical wiring;
- e) electrical/pneumatic wiring continuity;
- f) functional electric charge test;
- g) functional test for compressed air system;
- h) functional test for control panel and motor control center;
- i) functional test for water feed circuit;
- j) functional test for burner;
- l) performance test of the generator feed pump;
- m) test of software installed on PLC;
- n) instrumentation grid tests;
- o) thermal insulation test.

**Annex A - Figure**



**Figure A.1 - Schematic Drawing of the Steam Generator and Auxiliary Systems**

[illegible]

## Foreword

This Standard is the English version (issued in 07/2012) of PETROBRAS N-2252 REV. D 10/2011. 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 establishes the required minimum conditions for supply of steam generators for injection in land oil wells. Other technical requirements which are needed for the specific supply of the steam generator shall be included in the equipment's Technical Specification.

1.2 A steam generator for injection in land oil wells is understood as being the watertube steam generator with a single pass and one or more coils, with forced circulation both of water and air, with one or more burners, mounted on a stationary or moving skid.

1.3 This Standard applies to provisions initiated as of the date of its issuance.

1.4 This Standard contains Technical Requirements and Recommended Practice.

## 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.

Norma Regulamentadora nº 10 (NR-10) - Segurança em Instalações e Serviços em Eletricidade;

Norma Regulamentadora nº 13 (NR-13) - Caldeiras e Vasos de Pressão;

Norma Regulamentar nº 26 (NR-26) - Sinalização de Segurança;

Portaria ANP/INMETRO nº 1 de 19/06/2000 - Medição de Petróleo e Gás Natural;

Portaria INMETRO/MDIC 179 de 18/05/2010 - Requisitos de Avaliação da Conformidade de Equipamentos Elétricos e Eletrônicos para Atmosfera Explosivas;

Portaria INMETRO/MDIC 243 de 04/09/2009 - Requisitos de Avaliação da Conformidade para Motores Elétricos de Indução Trifásicos Rotor Gaiola de Esquilo;

PETROBRAS N-2 - Anticorrosive Coating of Industrial Equipment;

PETROBRAS N-13 - Technical Requirements for Paintwork;

PETROBRAS N-57 - Projeto Mecânico de Tubulações Industriais;

PETROBRAS N-58 - Graphic Symbols for Process and Engineering Flowsheets;

PETROBRAS N-59 - Símbolos Gráficos para Desenhos de Tubulação;

PETROBRAS N-115 - Fabricação e Montagem de Tubulações Metálicas;

PETROBRAS N-116 - Sistemas de Purga de Vapor em Tubulações e Equipamentos;

PETROBRAS [N-250](#) - Installation of High Temperature Thermal Insulation;

PETROBRAS [N-279](#) - Design of Steel Structures;

PETROBRAS [N-293](#) - Manufacture and Assembly of Metallic Structures;

PETROBRAS [N-313](#) - Motor Elétrico de Indução;

PETROBRAS [N-314](#) - Low-Voltage Panel Motor Control Center;

PETROBRAS [N-381](#) - Execution of Drawing and Other General Technical Documents;

PETROBRAS [N-442](#) - External Painting of Piping for Onshore Facilities;

PETROBRAS [N-550](#) - Design of High-Temperature Thermal Insulation;

PETROBRAS [N-898](#) - Símbolos Gráficos e Designações para Diagramas Elétricos;

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

PETROBRAS [N-1278](#) - Numerals and Letters for Identification Equipment;

PETROBRAS [N-1438](#) - Terminologia Soldagem;

PETROBRAS [N-1521](#) - Identification of Industrial Equipment;

PETROBRAS [N-1522](#) - Identificação de Tubulações Industriais;

PETROBRAS [N-1550](#) - Metallic Structure Painting;

PETROBRAS [N-1617](#) - Application of Refractory Castable;

PETROBRAS [N-1618](#) - Thermal Insulation Material;

PETROBRAS [N-1665](#) - Burner - Data Sheet;

PETROBRAS [N-1674](#) - Projeto de Arranjo de Instalações Industriais Terrestres de Petróleo, Derivados, Gás Natural e Álcool;

PETROBRAS [N-1710](#) - Coding of Technical Engineering Documents;

PETROBRAS [N-1728](#) - Castable Refractory;

PETROBRAS [N-1735](#) - Painting of Electrical Equipment, Machines and Instruments;

PETROBRAS [N-1857](#) - Electrical Resistance Trace Heating System for Industrial Applications - Design, Installation, Inspection, and Maintenance Procedures;

PETROBRAS [N-1882](#) - Criteria for Development of Instrumentation Designs;

PETROBRAS [N-1883](#) - Presentation of Instrumentation/Automation Design;

PETROBRAS [N-1910](#) - Presentation of Instrumentation/Automation Design;

PETROBRAS [N-1997](#) - Electrical Networks in Cable Tray Systems - Design, Installation, and Inspection;

PETROBRAS [N-2040](#) - Preparation, Presentation and Management of Electrical Design Documents;

PETROBRAS [N-2154](#) - Classificação de Áreas para Instalações Elétricas em Regiões de Perfuração e Produção;

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

PETROBRAS [N-2668](#) - Industrial Valves;

PETROBRAS [N-2802](#) - Folhas de Dados de Instrumentação Coletânea;

PETROBRAS [N-2833](#) - Forms and Lists for Instrumentation Designs;

ABNT [ISO/TS 29001](#) - Indústrias do Petróleo, Gás Natural e Petroquímica - Sistemas de Gestão da Qualidade Específicos do Setor - Requisitos para Organizações de Fornecimento de Produtos e Serviços;

ABNT [NBR 5175](#) - Código Numérico das Funções dos Dispositivos de Manobra, Controle e Proteção de Sistema de Potência;

ABNT [NBR 5410](#) - Instalações Elétricas de Baixa Tensão;

ABNT [NBR 5597](#) - Eletroduto de Aço-Carbono e Acessórios, com Revestimento Protetor e Rosca NPT;

ABNT [NBR 12177-2](#) - Caldeiras Estacionárias à Vapor - Inspeção de Segurança - Parte 2 - Caldeiras Aquatubulares;

ABNT [NBR 12313:2000](#) - Sistema de Combustão - Controle e Segurança para Utilização de Gases Combustíveis em Processos de Baixa e Alta Temperatura;

ABNT [NBR 13970](#) - Segurança de Máquinas - Temperatura de Superfícies Acessíveis - Dados Ergonômicos para Estabelecer os Valores Limites de Temperatura de Superfícies Aquecidas;

ABNT [NBR 14039](#) - Instalações Elétricas de Média Tensão de 1,0 kV a 36,2 kV;

ABNT [NBR 15827](#) - Válvulas Industriais para Instalações de Exploração, Produção, Refino e Transporte de Produtos de Petróleo;

ABNT [NBR IEC 60034-5](#) Máquinas Elétricas Girantes - Parte 5: Graus de Proteção Proporcionados pelo Projeto Completo de Máquinas Elétricas Girantes (Código IP);

ABNT [NBR IEC 60439-1](#) - Conjuntos de Manobra e Controle de Baixa Tensão Parte 1: Conjuntos com Ensaio de Tipo Totalmente Testados (TTA) e Conjuntos com Ensaio de Tipo Parcialmente Testados (PTTA);

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

ABNT [NBR ISO 9001](#) - Sistemas de Gestão da Qualidade;

IEC [61131-1](#) - Programmable Controllers - Part 1: General Information;

IEC [61131-2](#) - Programmable Controllers - Part 2: Equipment Requirements and Tests;

IEC [61131-3](#) - Programmable Controllers - Part 3: Programming Languages;

IEC [61131-5](#) - Programmable Controllers - Part 5: Communications;

IEC [61508-1](#) - Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems - Part 1: General Requirements;

ANSI/ISA [5.1](#) - Instrumentation Symbols and Identification;

ANSI/ISA [7.0.01](#) - Quality Standard for Instrument Air;

API [RP 555](#) - Process Analyzers;

ASME BPVC [Section I](#) - Rules for Construction of Power Boilers;

ASME BPVC [Section VIII - Division 1](#) - Rules for Construction of Pressure Vessels;

ASME [PTC 4](#) - Fired Steam Generators;

ISA [18.1](#) - Annunciator Sequences and Specifications;

NFPA [85](#) - Boiler and Combustion Systems Hazards Code Effective.

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 Submittal of the Technical Proposal and the Design**

#### **3.1 General**

All technical documents shall be coded in accordance with PETROBRAS [N-1710](#) and shall be submitted in accordance with PETROBRAS [N-58](#), [N-59](#), [N-381](#), [N-898](#), [N-1438](#), [N-1521](#), [N-1522](#), [N-1883](#) and [N-2040](#), ABNT [NBR 5175](#) and [NBR 15827](#).

#### **3.2 Documents of the Technical Proposal**

A technical proposal shall be provided in three copies, containing, among other documents, the complete list of the imported and the nationalized parts, indicating the material and its respective sub-providers, and requiring the acceptance tests made by classification company.

NOTE 1 Sub-providers shall be listed on the PETROBRAS Registry and, in case they are not, they shall be ranked by the vendor as per the criteria established by PETROBRAS.

NOTE 2 The foreigner and national sub-providers' Quality Management System shall adhere to the requirements established by ABNT [ISO/TS 29001](#) and shall meet ABNT [NBR ISO 9001](#).

#### **3.3 Design Documents**

3.3.1 The required documents for approval of the design shall be submitted in three copies. Two copies shall be provided certified, and the other shall be electronic.

3.3.2 At least the following documents shall be submitted in order for the design to be approved:

- a) list of the design documents;
- b) Fully completed Data Sheet of the steam generator;
- c) Data Sheet - equipment, instruments and piping;
- d) Data Sheet of the burner, completed as in PETROBRAS [N-1665](#);
- e) Data Sheet of electric induction engines, completed as in PETROBRAS [N-313](#).
- f) Data Sheets of frequency converters, completed as in PETROBRAS [N-2547](#);
- g) Data Sheets of instruments, control valves, safety valves and relief valves, completed as in PETROBRAS [N-2802](#);
- h) process flowchart;
- i) engineering flowchart;



- g) metering of instantaneous flow rate and cumulative volume of liquid fuel, according to Portaria ANP/INMETRO nº 1.

NOTE 1 It is recommended that the heating system includes a steam heater (or hot water) and also one or more electric heaters. **[Recommended Practice]**

NOTE 2 When necessary, an additional subsystem of electrical resistance trace, designed according to PETROBRAS N-1857, shall be included in the system for conditioning the liquid fuel to the temperature required by the burner.

9.4.5 The liquid fuel pressure (gauge) delivered in the pump suction is, at least, 9,8 kPa (0,1 kgf/cm<sup>2</sup> = 1,421 psi), considering the pump mounted on the steam generator skid.

## 9.5 Fuel Gas System

9.5.1 The fuel gas system shall be designed according to ABNT NBR 12313:2000 to receive gas with gauge pressure from 138 kPa to 242 kPa (20 psi to 35 psi) and consists of:

- pressure regulating valve to meet the pressure variation in the inlet;
- line filter for removing solid matters that may be dragged with the gas, eliminating problems of control;
- metering of fuel gas flow rate, according to Portaria ANP/INMETRO nº 1;
- control of gas flow rate in accordance with the capacity of the generator;
- feeding system of the pilot flame with two fuel gas automatic shut-off valves and one automatic discharge valve (vent) with bubbler and depressurization according to NFPA 85;
- feeding system of the main flame with two fuel gas automatic shut-off valves and one automatic discharge valve (vent) with bubbler. Depressurization according to NFPA 85;
- automatic shut-off valves driven by electric actuators: shall be automatic shutdown type;
- redundancy for closing the gas control valve in case of operation of the gas shut-off valve, where applicable.

NOTE 1 Exceptionally, when the value of the gas pressure available in the area differs from this item 9.5.1, the Technical Specification of the equipment shall set the pressure range.

NOTE 2 It is recommended that the automatic shut-off valves are only open manually. **[Recommended Practice]**

NOTE 3 The fuel gas system shall be adequate to meet the gas composition defined in the technical specification.

NOTE 4 It is recommended that the primary element for flow measurement is orifice plate type. **[Recommended Practice]**

9.5.2 The gas scrubber, when part of the scope of steam generator supply, shall be instrumented to ensure the gas supply interruption at high level.

9.5.3 An electronic pressure transmitter of fuel gas supply shall be provided for the indication in HMI.

9.5.4 The need for installation of explosion venting devices in gas consumer equipment shall be considered, according to 3.4.6 of ABNT NBR 12313:2000.

## 9.6 Utility Steam System

When required, a steam outlet shall be provided for the use in the liquid fuel heater system for liquid fuel and for atomization system. This system consists of:

- system for reducing the steam pressure at the generator outlet to the usage pressure in the liquid fuel atomization and heater;

9.9.2 The pipes shall be of the type ASTM A106 Grade B carbon steel and the connections shall be ASTM A 234 Grade WPB steel.

9.9.3 1 1/2" manual valves, and larger, shall be flanged.

9.9.4 The flanges of the high pressure lines shall be ring joint type.

9.9.5 The control valves shall be flanged, except in low pressure and diameter lines, where the manufacturer's standard is threaded valve.

9.9.6 All piping welds subject to high pressure shall be inspected in accordance with PETROBRAS [N-115](#).

9.9.7 The hot oil and steam lines shall be thermally insulated according to PETROBRAS [N-250](#) and [N-550](#).

9.9.8 All valves shall be identified by signs according to PETROBRAS [N-1278](#) and [N-2668](#).

NOTE The plates standard shall be required in the technical specification.

## **10 Instrumentation and Control**

### **10.1 General**

10.1.1 The instrumentation system shall be designed according to PETROBRAS [N-1882](#).

10.1.2 The P&I Diagrams shall represent all instruments of the steam generator, even those provided with equipment or compact unit (package), and the equipment or compact unit shall be clearly marked.

10.1.3 The monitoring and control system shall be electronic with standardized signs.

10.1.4 All instruments shall have housing compatible with the classification of the area where they were installed, according to PETROBRAS [N-1882](#) and [N-2154](#).

NOTE It is recommended that, in the case of electrical contacts, they shall be hermetically sealed.  
**[Recommended Practice]**

10.1.5 All instruments should have a plate attached to the instrument, with the manufacturer's technical data.

10.1.6 The instrument tag shall be on a plate non-attached to the instrument, according to ANSI/ISA [5.1](#).

10.1.7 The instruments shall be mounted directly on the equipment skid, which suffer suffer from vibration problems.

10.5.2 The generator shall have a system for flame detection, and burner protection and interlock with safety integrity level certificate SIL-3, according to IEC 61508-1, aiming to turn the burner on and off in the correct and safe sequence, as well as inspect the flame during the operational phase, according to NFPA 85.

10.5.3 The system for flame detection, and burner protection and interlock shall be solely performed by the flame controller. This system consists of, at least, the following parts:

- a) combustion controller connected to the PLC so that there is a perfect synchronization between the controller and interlock made by PLC;
- b) ultraviolet flame detector;
- c) pre-purge timing as specified in NFPA 85 (only implemented in flame programmer);
- d) pilot flame shut-off valves;
- e) main flame shut-off valves;
- f) ignition electrode.

10.5.4 The post-purge timing shall be performed by the PLC.

10.5.5 The manufacturer shall provide a schedule-type chart, with the work sequence of flame protection system, with times determined based on the steam generator design.

10.5.6 The following faults shall shut down the burner, and generate visual and audible alarm in the HMI:

- a) flame failure (BSL);
- b) high temperature tubes (TSH);
- c) high temperature steam (TSH);
- d) high pressure steam (PSH);
- e) low pressure steam (PSL); timing during the start-up;
- f) high temperature burner (TSH);
- g) High temperature exhaust gases (TISH);
- h) low water flow rate (FSL);
- i) low pressure pump suction (PSL);
- j) low pressure combustion air (PSL);
- k) high pressure fuel gas (PSH) (see Note 1);
- l) low pressure fuel gas (PSL) (see Note 1);
- m) low pressure atomization (PSL) (see Note 1);
- n) high pressure atomization (PSG) (see Note 1);
- o) low pressure instrument air (PSL);
- p) low pressure fuel oil (PSL) (see Note 2);
- q) low temperature fuel oil (TSL) (see Note 1);
- r) open burner (ZSL);
- s) Automatic gas shut-off valves open during the start-up (see Note 1);
- t) power shortage;
- u) Low pressure pump lubrication (PAL);
- v) fan vibration (see Note 1);
- y) high temperature of the fuel oil electric heater (TSH) (see Note 1);
- x) steam high quality;
- w) low combustion air flow rate (FSL) (see Note 1);
- z) closure of the automatic shut-off valve of pump's booster (in this case the water feed pump shall also be stopped by interlock);
- aa) low combustion air flow rate;
- ab) high pressure liquid fuel (see Note 1);
- ac) low pressure liquid fuel (see Note 1);
- ad) high pressure pilot gas (see Note 1);
- ae) main liquid valve open during the start-up (see Note 1);
- af) low content of O<sub>2</sub> (see Note 2).

13.4 The electric motors and junction box shall have degree of protection IP 55W according to ABNT [NBR IEC 60529](#), with bearings and grease fitting, winding temperature rise 80°C, insulation class F, with threaded shaft end, meeting PETROBRAS [N-313](#) and ABNT [NBR IEC 60034-5](#).

NOTE If the electric motor is driven by frequency converter, it shall have two temperature sensors PT100 type per winding with junction box opposite to the power junction box and connected to the frequency converter protection module.

13.5 The conduits shall be made of hot galvanized iron, SCH 40, seamed, according to ABNT [NBR 5597](#).

13.6 All components of the steam generator shall have an identification plate containing the main characteristics of the components.

13.7 It is recommended that, for vibration source equipment, measures are taken to mitigate the vibration to acceptable levels. **[Recommended Practice]**

13.8 The maximum noise level is determined according to PETROBRAS [N-1674](#).

## 14 Painting

The painting should be in accordance with the standards PETROBRAS [N-2](#), [N-13](#), [N-442](#), [N-1550](#) and [N-1735](#).

14.1 The steam generator, piping, accessories and auxiliary equipment shall be provided and painted according to the patterns and colors set forth in PETROBRAS standards, as shown in Table 2.

**Table 2 - Painting Of Boiler Parts**

Component-part	Condition/standard	Note
Steam generator	2 / PETROBRAS <a href="#">N-2</a>	Cold parts (up to 120 °C)
Steam generator	5 / PETROBRAS <a href="#">N-2</a>	Hot parts (120 °C to 600 ° C)
Piping	2 / PETROBRAS <a href="#">N-442</a>	Without thermal insulation (up to 120°C)
Piping	4 / PETROBRAS <a href="#">N-442</a>	With thermal insulation (80 °C to 500 ° C)
Motors, pumps, compressors, fans	2 / PETROBRAS <a href="#">N-1735</a>	(up to 60°C)
Electrical and instrumentation equipment and panels	2 / PETROBRAS <a href="#">N-1735</a>	(up to 60°C)
Stairs and metallic structures	1 / PETROBRAS <a href="#">N-1550</a>	(See Note 3)
<p>NOTE 1 Auxiliary piping and equipment that operate at a temperature above 60 °C shall be thermally insulated and protected with corrugated aluminum plate in the straight sections.</p> <p>NOTE 2 The colors of the equipment and piping shall meet the criteria established in <a href="#">NR-26</a> and PETROBRAS <a href="#">N-1219</a>.</p> <p>NOTE 3 The alternative A for structures in sheltered areas and use alternative B for other structures (PETROBRAS <a href="#">N-1550</a>).</p>		

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

PETROBRAS [N-2668](#) - Industrial Valves;

PETROBRAS [N-2802](#) - Folhas de Dados de Instrumentação Coletânea;

PETROBRAS [N-2833](#) - Forms and Lists for Instrumentation Designs;

ABNT [ISO/TS 29001](#) - Indústrias do Petróleo, Gás Natural e Petroquímica - Sistemas de Gestão da Qualidade Específicos do Setor - Requisitos para Organizações de Fornecimento de Produtos e Serviços;

ABNT [NBR 5175](#) - Código Numérico das Funções dos Dispositivos de Manobra, Controle e Proteção de Sistema de Potência;

ABNT [NBR 5410](#) - Instalações Elétricas de Baixa Tensão;

ABNT [NBR 5597](#) - Eletroduto de Aço-Carbono e Acessórios, com Revestimento Protetor e Rosca NPT;

ABNT [NBR 8441](#) - Máquinas Elétricas Girantes - Motores de Indução de Gaiola, Trifásicos, Fechados - Correspondência entre Potência Nominal e Dimensões;

ABNT [NBR 12177-2](#) - Caldeiras Estacionárias à Vapor - Inspeção de Segurança - Parte 2 - Caldeiras Aquatubulares;

ABNT [NBR 12313:2000](#) - Sistema de Combustão - Controle e Segurança para Utilização de Gases Combustíveis em Processos de Baixa e Alta Temperatura;

ABNT [NBR 13970](#) - Segurança de Máquinas - Temperatura de Superfícies Acessíveis - Dados Ergonômicos para Estabelecer os Valores Limites de Temperatura de Superfícies Aquecidas;

ABNT [NBR 14039](#) - Instalações Elétricas de Média Tensão de 1,0 kV a 36,2 kV;

ABNT [NBR 15827](#) - Válvulas Industriais para Instalações de Exploração, Produção, Refino e Transporte de Produtos de Petróleo;

ABNT [NBR IEC 60034-5](#) Máquinas Elétricas Girantes - Parte 5: Graus de Proteção Proporcionados pelo Projeto Completo de Máquinas Elétricas Girantes (Código IP);

ABNT [NBR IEC 60439-1](#) - Conjuntos de Manobra e Controle de Baixa Tensão Parte 1: Conjuntos com Ensaio de Tipo Totalmente Testados (TTA) e Conjuntos com Ensaio de Tipo Parcialmente Testados (PTTA);

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

ABNT [NBR ISO 9001](#) - Sistemas de Gestão da Qualidade;

IEC [61131-1](#) - Programmable Controllers - Part 1: General Information;

IEC [61131-2](#) - Programmable Controllers - Part 2: Equipment Requirements and Tests;

IEC [61131-3](#) - Programmable Controllers - Part 3: Programming Languages;

IEC [61131-5](#) - Programmable Controllers - Part 5: Communications;

IEC [61508-1](#) - Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems - Part 1: General Requirements;

9.8.5 The burner shall consist of:

- a) burner nozzle with air or air and steam atomization;
- b) pilot flame system;
- c) Ignition system;
- d) air and fuel automatic control system;
- e) flange connection to the generator;
- f) combustion air fan driven by electric motor;
- g) ultraviolet flame detection system with self-checking;
- h) high temperature thermocouple on the burner;
- i) automatic start and safety sequencer shall have safety integrity level certificate SIL-3, according to IEC 61508-1;
- j) optionally, automatic cleaning system of the burner nozzle, in case of shutdown;
- k) pressure control and security of the atomizing flow;
- l) Valve, with remote activation, to enable the replacement of atomizing air with steam with the indication: air - air/steam - steam;
- m) peep hole for inspecting the flame.

NOTE 1 the provisions of items a), j), k) and l) apply only to the liquid fuel burner.

NOTE 2 It is recommended that the combustion control system comprises the measurement of combustion air and O<sub>2</sub> excess. **[Recommended Practice]**

NOTE 3 Regarding the provisions of item f), it is recommended that, when required, the electric motor is controlled by frequency converter as specified in PETROBRAS N-2547, modulated by air/fuel ratio PID automatic controller and interlocked by the start and safety sequencer. **[Recommended Practice]**

NOTE 4 It is recommended that the fan mentioned in item f) is instrumented with vibration monitoring system, for alarm, with IP 65 enclosure, inhibition with logic start and manual or remote reset with reset coil at 120 V/60 Hz. **[Recommended Practice]**

9.8.6 The fuel for the pilot shall be fuel gas.

9.8.7 It is recommended that the fan air suction is placed above the cover of the skid with guardrail with adequate spacing to prevent the entry of foreign elements into the combustion air. **[Recommended Practice]**

9.8.8 It is recommended that the fan motor is directly supported on the Steam Generator skid using elastomer dampener (cushion). The blower air outlet shall contain a flexible joint (canvas) for connecting to the steam generator air inlet. **[Recommended Practice]**

9.8.9 It is recommended that the motor fan air support and condition systems enable it to be installed or removed with the fan coupled to the motor. **[Recommended Practice]**

9.8.10 It is recommended that the coupling of the fan to the motor is performed by taper bushing. **[Recommended Practice]**

9.8.11 It is recommended that the blower drive motor has four poles, with synchronous speed of 1 800 RPM, and standard housing according to ABNT NBR 8441. **[Recommended Practice]**

## 9.9 External Piping and Valves

9.9.1 The piping shall be designed in accordance with PETROBRAS N-57 and manufactured and assembled according to PETROBRAS N-115.



13.4 The electric motors and junction box shall have degree of protection IP 55W according to ABNT [NBR IEC 60529](#), with bearings and grease fitting, winding temperature rise 80°C, insulation class F, with threaded shaft end, meeting PETROBRAS [N-313](#) and ABNT [NBR 8441](#) and ABNT [NBR IEC 60034-5](#).

**NOTE** If the electric motor is driven by frequency converter, it shall have two temperature sensors PT100 type per winding with junction box opposite to the power junction box and connected to the frequency converter protection module.

13.5 The conduits shall be made of hot galvanized iron, SCH 40, seamed, according to ABNT [NBR 5597](#).

13.6 All components of the steam generator shall have an identification plate containing the main characteristics of the components.

13.7 It is recommended that, for vibration source equipment, measures are taken to mitigate the vibration to acceptable levels. **[Recommended Practice]**

13.8 The maximum noise level is determined according to PETROBRAS [N-1674](#).

## 14 Painting

The painting should be in accordance with the standards PETROBRAS [N-2](#), [N-13](#), [N-442](#), [N-1550](#) and [N-1735](#).

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**Table 2 - Painting of Boiler Parts**

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Piping	4 / PETROBRAS <a href="#">N-442</a>	With thermal insulation (80 °C to 500 ° C)
Motors, pumps, compressors, fans	2 / PETROBRAS <a href="#">N-1735</a>	(up to 60°C)
Electrical and instrumentation equipment and panels	2 / PETROBRAS <a href="#">N-1735</a>	(up to 60°C)
Stairs and metallic structures	1 / PETROBRAS <a href="#">N-1550</a>	(See Note 3)
<p>NOTE 1 Auxiliary piping and equipment that operate at a temperature above 60 °C shall be thermally insulated and protected with corrugated aluminum plate in the straight sections.</p> <p>NOTE 2 The colors of the equipment and piping shall meet the criteria established in <a href="#">NR-26</a> and PETROBRAS <a href="#">N-1219</a>.</p> <p>NOTE 3 The alternative A for structures in sheltered areas and use alternative B for other structures (PETROBRAS <a href="#">N-1550</a>).</p>		