

Steam Fire-Tube Boiler

Procedure

This Standard replaces and cancels its previous revision.

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

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

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

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

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

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CONTEC

Comissão de Normalização
Técnica

SC - 22

Utility 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.

Foreword

This Standard is the English version (issued in 05/2012) of PETROBRAS N-2309 REV. C 04/2011. 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 sets out the conditions required for supplying of stationary, automatic, compact, steam fire-tube boiler, as well as its auxiliary equipment for PETROBRAS onshore facilities, such as: refineries, terminals, production plants, power plants and thermal power plants.

1.2 This Standard applies to procedures started from the date of its issuance.

1.3 This Standard contains Technical Requirements and Recommended Practices.

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 13 ([NR-13](#)) - Caldeiras e Vasos de Pressão;

Norma Regulamentadora nº 26 ([NR-26](#)) - Sinalização de Segurança;

PETROBRAS [N-2](#) - Anticorrosive Coating of Industrial Equipment;

PETROBRAS [N-76](#) - Materiais de Tubulação para Instalações de Refino e Transporte;

PETROBRAS [N-133](#) - Welding;

PETROBRAS [N-313](#) - Electrical Induction Motor;

PETROBRAS [N-314](#) - Painel de Baixa Tensão Centro de Controle de Motores;

PETROBRAS [N-442](#) - Pintura Externa de Tubulações em Instalações Terrestres;

PETROBRAS [N-906](#) - Bombas Centrífugas para Serviços Médios;

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

PETROBRAS [N-1550](#) - Pintura de Estrutura Metálica;

PETROBRAS [N-1618](#) - Material para Isolamento Térmico;

PETROBRAS [N-1735](#) - Pintura de Máquinas, Equipamentos Elétricos e Instrumentos;

PETROBRAS [N-2250](#) - Caldeira Flamotubular - Folha de Dados;

ABNT [NBR 11096](#) - Caldeiras Estacionárias Aquotubulares e Flamotubulares a Vapor - Terminologia;

ABNT [NBR 12177-1](#) - Caldeiras Estacionárias a Vapor - Inspeção de Segurança - Parte 1: Caldeiras Flamotubulares;

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

ASME [BPVC Sec I](#) - Boiler and Pressure Vessel Code - Section I - Rules for Construction of Power Boilers;

ASTM [A 36/A36M](#) - Standard Specification for Carbon Structural Steel;

ASTM [A 178/A178M](#) - Standard Specification for Electric-Resistance-Welded Carbon Steel and Carbon-Manganese Steel Boiler and Superheater Tubes;

ASTM [A 192/A192M](#) - Standard Specification for Seamless Carbon Steel Boiler Tubes for High-Pressure Service;

ASTM [A 283/A283M](#) - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates;

ASTM [A 285/A285M](#) - Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength;

DIN [EN 10220](#) - Seamless and Welded Steel Tubes - Dimensions and Masses per Unit Length.

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

3 Terms and Definitions

For purposes of this document terms and definitions of ABNT [NBR 11096](#) are applied.

4 General Description

4.1 Every boiler shall form a compact unit, preferably supported on a single suitable metal structure, such as skid-mounted, where all auxiliary equipment included in the scope of supply shall be arranged as well. This unit shall be supplied in full and factory-assembled.

4.2 The boilers shall be automatic, cylindrical, horizontal, and ready for the operation, by making only connections to electricity, fuel, water, drain, steam, stack and interconnections of the electrical panel and fan.

4.3 In general the boilers shall be provided with the following systems:

- a) body:
 - side;
 - combustion chamber;
 - mirror;
 - pipes;
 - insulation;
 - refractory;
- b) start-up system;
- c) combustion systems;
- d) safety and control systems;
- e) water supply systems;
- f) emergency systems;
- g) electrical control systems;
- h) forced draft systems;
- i) exhaust gas systems (ducts and stacks)
- j) fittings;
- k) optional equipment.

5 Project

5.1 General

5.1.1 The equipment shall be designed and manufactured in accordance with the standards and codes in Section 2 in force on the date of issuance of this Standard or afterwards.

5.1.2 The electric drives shall be drip and splash proof, and additional classifications shall be considered in the case of specific use of the equipment.

5.1.3 Emissions from boilers shall meet the applicable law restrictions in force at the municipal, state and federal levels.

5.1.4 The boilers shall be designed and built for continuous operation. The fire safety system shall meet ABNT [NBR 12313](#).

5.1.5 The automatic control range of steam production shall be at least from 33% to 100%.

5.1.6 Boilers shall be equipped with peep hole and inspection and cleaning access.

5.1.7 The boilers shall have a minimum refractory to minimize the number of maintenance. Use preferably wet-back boiler.

5.1.8 Components

Auxiliary equipment, instruments, valves, accessories and material essential to the operation of the boiler shall be requested from suppliers qualified by PETROBRAS.

5.1.9 The manufacturer shall inform the thermal efficiency of the boiler with the method of evaluation.

5.1.10 The manufacturer shall inform the total energy consumption for each boiler operating at maximum steam output, as well as the power consumption of draft fans, water pump, fuel pump, heaters and other loads part of the scope of supply for fire-tube boiler.

5.1.11 The Regulatory Standard no. 13 ([NR-13](#)), related to boiler design, shall be met in full. When the fuel to be used is a gas, combustion and fire safety systems shall comply with ABNT [NBR 12313](#).

5.2 Feed Water System

5.2.1 The manufacturer shall indicate the necessary water characteristics to ensure proper operation. Also, the maximum levels of electrical conductivity, total dissolved solids, suspended solids, pH, alkalinity, chlorides, total hardness, silica and organic matter shall be mentioned. The maximum allowable iron concentration in the feed water, points for monitoring corrosion before and after inlet of feed water (steam outlet line /low point and condensate return lines).

NOTE It is recommended that treatment for boiler water by means of chemicals to be injected into the feed water line of the boiler shall be provided. **[Recommended Practice]**

5.2.2 The water supply system shall be through a centrifugal pump (main system), a standby centrifugal pump with same main pump's capacity (emergency system) and device to control minimum and maximum level of boiler water. Two pumps shall be provided for each boiler (main and standby). The pumps shall be appropriate to the operating conditions specified in the Boiler Data Sheet and follow the recommendations in PETROBRAS [N-906](#).

5.2.3 Every boiler shall be provided with a bottom discharge valve (quick discharge-type) and sample system (water analysis) consisting of valve and container with cooling coil.

5.2.4 Every boiler shall be provided with vent valve at the top of its body to purge the air at cold start.

5.2.5 Every boiler shall be provided with connection (sleeve with plug) in the level indicator to allow periodic cleaning of bottom connecting pipe of this indicator to body of the boiler.

5.2.6 The chemical injection system shall be appropriate to the type of water to be supplied to the boiler. If necessary, metering shall be installed control water supplied to boiler.

5.3 Start-Up System

5.3.1 Every boiler shall be provided with automatic start-up system with ignition pilot and electrodes permanently installed with transformer, high voltage cable and push-button.

5.3.2 Every boiler shall be provided with start-up device with minimum fire, allowing only a minimum demand of fuel during this phase.

5.4 Combustion System

5.4.1 The burner shall be suitable to operating conditions and specified fuels.

5.4.2 If the specified fuel is fuel oil, the main burner shall have air atomization (for start-up) through electrically driven compressor and also steam atomization with automatic switching. If the specified fuel is oil and/or gas, the burner shall be dual type (oil or gas) or combined (oil and gas); changing burner when changing fuel is not allowed. Alternatively mechanical atomization shall also be specified, since proven effective.

5.4.3 If there is availability of gas, this fuel shall be used by the flame detection photocell. In this case the photocell shall be UV-type.

5.4.4 Every boiler shall be provided with an automatic combustion control system, able to maintain a constant vapor pressure at outlet of the boiler, at any load condition, by adjusting the flow rates of fuels and combustion air in accordance with the demand of vapor. This control system shall enable the automatic start-up and shutdown sequences, allowing these operations also in manual mode.

5.4.5 The combustion control system shall maintain the rate of burning corresponding to the load demand in order to minimize the automatic tripping of the burner (frequent stops). When the steam demand is below the minimum fire conditions, the boiler shall operate intermittently (on/off).

5.5 Safety and Control System

5.5.1 The safety and control system of the boiler shall be implemented by Programmable Logic Controller (PLC). In addition to the combustion control system, each boiler shall have level control system, steam pressure control and safety and interlocking system.

5.5.2 The level control shall maintain the boiler with constant water level automatically during boiler operation. It shall be provided with electrodes, emergency backup system, in case of failure of the normal system. The system shall operate in the feed water pumps (main and standby) and be interlocked to the safety system. It shall have visual level indicator (LG)

5.5.3 The steam overpressure safety system shall occur through maximum pressure switch and Maximum Allowable Working Pressure (MAWP) of the boiler set to maximum. Safety valves at the top of the boiler shall be provided in accordance with ASME [BPVC Sec I](#).

5.5.4 Every boiler shall be equipped with an interlocking and safety system in order to ensure the integrity of the equipment, operators and safety of operation during the stages of start-up, normal operation, emergency shutdown and normal shutdown, including protections to abnormal operating conditions.

5.5.5 The safety and control system shall shutdown the flow of fuel (boiler shutdown - trip), upon the occurrence of following abnormal events at least:

- a) failure of pilot ignition;
- b) failure of main flame;
- c) low pressure of combustion air (failure of draft);
- d) low fuel pressure;
- e) high fuel pressure;
- f) high steam pressure;
- g) power outage;
- h) very low water level;
- i) failure to supply instrument air.

5.5.6 If the boiler is equipped with an air / vapor fuel atomization system, and under normal operation condition there is no vapor, the air system shall be activated immediately (max 5 sec) without boiler shutdown.

5.5.7 When the boiler is operating, both main and pilot flame shall be supervised by electric photocell. The cell shall block the fuel upon possible failure of flame, shutdown the boiler operation and sound alarm.

5.5.8 At least the following alarms shall be provided and installed on the panel of each boiler:

- a) failure of pilot ignition;
- b) failure of main flame;
- c) low pressure of combustion air;
- d) low fuel pressure;
- e) high fuel pressure;
- f) very low water level;
- g) high water level;
- h) power outage;
- i) failure to supply instrument air;
- j) high steam pressure.

5.5.9 In principle, the major alarms (see 5.5.8) shall have auxiliary contact for remote indication in the control room of the unit.

5.5.10 Whenever there is a shutdown of fuel to boiler (trip), new start-up shall be given after the problem being solved and manual reset.

5.5.11 The operation sequence shall contain necessarily the following steps:

- a) pre-purge;
- b) pilot ignition;
- c) fuel to pilot;
- d) check pilot flame;
- e) opening of fuel valve;
- f) ignition is switched off;
- g) verification of main flame;
- h) release of modulation;
- i) post-purge (in case of failure or shutdown of the boiler).

5.5.12 Boiler PLC shall have non-volatile memory capable of retaining history of failures. It shall have the man/machine interface that allows viewing this history and current condition of combustion (status).

5.6 Emergency System

The emergency system shall be composed of emergency centrifugal pump with the same main pump's capacity (in case of failure of the main water pump) and water level electrodes for boilers with a vapor pressure less than or equal to 10.5 kgf/cm² man.

5.7 Forced Draft System

The forced draft system shall be composed of centrifugal fan to supply combustion air, provided with devices to control automatically the flow rate, actuated by the safety and control system of the boiler. The adjustment of combustion air can be done by air regulator (butterfly type) or variable speed of electric drive motor of the forced draft fan. It shall also be composed of the air distribution box in welded steel plates and minimum thickness of 3 mm.

5.8 Gas Exhaust System

5.8.1 The gas exhaust system shall be composed of ducts, welded and reinforced steel plates and self-supporting stacks for each boiler, with cover (China cap) in its end and minimum height of 6 m from the floor (if applicable environmental law requires). The stacks shall be provided with soot collector when using liquid fuel.

5.8.2 The system shall have pipe to collect the combustion gases.

5.9 Electrical Equipment

5.9.1 Electric Panel

The boiler power panel shall contain all the elements of controls and alarms for each boiler to be supplied in accordance with the recommendations in PETROBRAS [N-314](#), where applicable. It shall be suitable for indoor installation in altitude, temperature conditions and type of atmosphere (offshore, industrial, etc.) of the area of installation.

5.9.2 Engines

All engines shall be of induction-type, squirrel cage motor, with proper protection (housing), following the recommendations in PETROBRAS [N-313](#).

5.10 Instrumentation

Every steam generator shall be provided with at least the following indicator instruments:

- a) vapor pressure at outlets of the boilers;
- b) atomization fluid pressure (where applicable);
- c) water level;
- d) temperature of exhaust gases;
- e) temperature of fuel oil (where applicable);
- f) fuel pressure.

5.11 Name Plate

5.11.1 The equipment shall be identified with a stainless steel plate.

5.11.2 The following minimum data shall be printed in the boiler's plate:

- a) steam fire-tube boiler;
- b) manufacturer (name and address);
- c) model/type and serial number given by the manufacturer;
- d) equipment identification (TAG)

- e) year of manufacture;
- f) standard: ASME [BPVC Sec I](#) and year of publication;
- g) maximum continuous steam output (kg/h);
- h) normal working gauge pressure (kPa);
- i) normal working temperature (°C);
- j) MAWP - gauge pressure (kPa);
- k) project gauge pressure (kPa);
- l) project temperature (°C);
- m) gauge pressure hydrostatic test (kPa);
- n) empty weight (N);
- o) full weight (N);
- p) main fuel;
- q) secondary fuel (if applicable);
- r) heating area (m²);
- s) boiler class, according to a regulatory standard no. 13 ([NR-13](#)).

NOTE The plate shall be in a visible place as per regulatory standard no. 13 ([NR-13](#)).

6 Material

6.1 The boiler shall have reinforced structure provided with welded steel plates and pressurized combustion chamber. The materials used shall be accompanied by quality certificates.

6.2 The external finishing of the boiler in principle shall be made with carbon steel plates; in this case, the minimum thickness shall be 1.2 mm, covering the thermal insulation.

6.3 The specification for insulation shall be in accordance with PETROBRAS [N-1618](#).

6.4 The threaded fittings and top weld, as well as the types and finishing of flanges, shall be in accordance with the applicable piping specification, as per PETROBRAS [N-76](#), unless stated otherwise in Boiler Data Sheet.

6.5 The plates subject to pressure shall be of ASTM [A 285](#) Gr. C type, or equivalent, properly identified and certified.

6.6 The steel pipes shall be ASTM [A 178](#) Gr. A, ASTM [A 192](#) or DIN [EN 10220](#).

6.7 The ducts and stack shall be made of carbon steel plates of structural quality, minimum thickness of 5 mm (ASTM [A 283](#) Gr. C or similar) with a minimum corrosion allowance of 1.5 mm. The maximum project temperature for the metal for stack shall be 340°C.

6.8 The metal structure shall be made of carbon steel profiles of structural quality (ASTM [A 36](#)).

7 Manufacturing, Transport and Assembly

7.1 Manufacturing

7.1.1 Welding

7.1.1.1 Welds shall be performed in accordance with PETROBRAS [N-133](#).

7.1.1.2 The welds of the pressurized parts shall be of full penetration and fully radiographed and subject to heat treatment for stress relief.

7.1.2 Painting and Thermal Insulation

7.1.2.1 The boiler, piping, fittings and auxiliary equipment shall be supplied and painted according to the standards and colors prescribed in PETROBRAS standards, as shown in Table 1.

Table 1 - Painting of Boiler Parts

Part-component	Standard/condition	Note
Steam generator	PETROBRAS N-2 / (2)	Cold parts (Up to 120°C)
Steam generator	PETROBRAS N-2 / (5)	Hot parts (120°C to 600°C)
Piping	PETROBRAS N-442 / (2)	No thermal insulation (Up to 120°C)
Piping	PETROBRAS N-442 / (4)	With thermal insulation (80 °C to 500 °C)
Motors, pumps, compressors, fans	PETROBRAS N-1735 / (2)	(up to 60 °C)
Electrical panels and instrumentation equipment	PETROBRAS N-1735 / (2)	(up to 60 °C)
Stairs and metal structures	PETROBRAS N-1550 / (1)	(See Note 2)
NOTE 1 The colors of equipment and piping shall comply with the criteria in NR-26 and PETROBRAS N-1219 .		
NOTE 2 The alternative A for structures in indoor areas and use alternative B for other structures, according to PETROBRAS N-1550 .		

7.1.2.2 Auxiliary equipment and piping operating at temperature above 60°C shall receive thermal insulation and protected with corrugated aluminum plate in the straight sections.

7.1.2.3 In case of doubt on painting schemes and colors to be used in equipment and piping, PETROBRAS shall be consulted before any action.

7.2 Packaging and Transport

7.2.1 The manufacturer shall pack the equipment, auxiliaries and accessories with the necessary care to allow their transport to final destination.

NOTE Transport by the manufacturer may be optional, depending on the convenience of PETROBRAS.

7.2.2 The parts subject to atmospheric corrosion shall be properly secured. The packaging of the boiler shall be suitable to adverse weather conditions for a period of at least 12 months.

7.3 Assembly

The manufacturer shall provide schemes for final interconnection and assembly at facility, provide assembly supervision and services when requested by PETROBRAS.

8 Test and Inspection

8.1 General

8.1.1 Upon completion of assembly all tests required for the equipment under the supervision of the manufacturer shall be made by PETROBRAS. The manufacturer shall indicate in advance the tests to be carried out for approval by PETROBRAS.

8.1.2 The combustion and level control operation, safety and interlocking operation system, and auxiliary equipment operation shall be included in these tests.

8.1.3 In case of failure of the tests manufacturer shall make the necessary corrections and repairs, providing previously detailed procedures for repairs.

8.2 Performance and Acceptance Test

8.2.1 In addition to the tests required to verify mechanical and operation conditions of the unit and its auxiliaries, performance tests in order to verify the satisfactory operation of the boiler under the conditions specified in item "warranty" shall be carried out by boiler manufacturer, under PETROBRAS supervision.

8.2.2 Calculation methods for assessing the performance and the precautions to be observed in preparing and conducting boiler performance tests shall be primarily prescribed by ASME [BPVC Sec I](#).

8.2.3 The manufacturer shall indicate in the proposal procedures and tolerances (margin) for which the warranty items for performance shall be valid.

8.2.4 Since mechanical and performance tests meet all requirements in this Standard and applicable specifications, the boilers are considered accepted by PETROBRAS.

8.2.5 The following items shall be guaranteed by the manufacturer, at least:

- a) maximum continuous steam output in MAWP;
- b) efficiency referred to the Low Heat Value (LHV);
- c) output temperature of the gases;
- d) steam quality (title);
- e) excess air.

8.2.6 Reference data are reported in the Boiler Data Sheet (see PETROBRAS [N-2250](#)).

8.3 Initial Inspection

The initial inspection is part of the final tests and shall be performed by accredited person and in accordance with the requirements of ABNT [NBR 12177-1](#) and regulatory standard no. 13 ([NR-13](#)).

INDEX OF REVISIONS

REV. A

There is no index of revisions.

REV. B

Affected Parts	Description of Alteration
All	Revised

REV. C

[illegible]