

On Service Process Fired Heater Inspection

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 - 23

Inspection of Systems and
Equipment in Operation

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 01/2014) of PETROBRAS N-2322 REV. C 08/2013. 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 required conditions for inspecting horizontal and vertical fired heaters, for hydrocarbon heating/vaporization.

1.2 This Standard is applicable to process fired heater inspection.

1.3 This Standard is applicable to inspections performed after its issuing date.

1.4 This Standard contains only Technical Requirements.

2 Normative References

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

PETROBRAS [N-1637](#) - Montagem de Forno;

PETROBRAS [N-1951](#) - Inspeção de Revestimentos de Concretos Refratários Submetidos à Operação;

PETROBRAS [N-2162](#) - Permissão para Trabalho;

PETROBRAS [N-2472](#) - Ensaio Não Destrutivo - Termografia;

API [STD 530](#) - Calculation Of Heater-Tube Thickness In Petroleum Refineries;

ASME [B 31.3](#) - Chemical Plant and Petroleum Refinery Piping.

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

3 Terms and Definitions

For the purposes of this Standard the definitions are adopted, of PETROBRAS [N-1637](#), complemented by 3.1 to 3.15.

3.1

vertical fired heaters

fired heaters which coils, in radiation region, are laid out vertically, as shown in Annex A

3.2

horizontal fired heaters

fired heaters which coils, in radiation region, are laid out horizontally. Typical fired heater types are shown in Annex A

3.3**radiation region**

fired heater region where heat exchange prevailingly takes place by radiation

3.4**convection region**

fired heater region where heat exchange predominantly takes place by convection

3.5**fired heater limits**

fired heater being equipment items interconnected to various systems of a process unit, consider the following limits when applying this Standard, as described in 3.5.1 to 3.5.4

3.5.1**coils**

flanges of the first outside block to the fired heater, inlet and outlet of fluid to be processed

3.5.2**air ducts**

the limit is comprised from air suction point from the atmosphere to the position where preheated air feeds the burners

3.5.3**stack gas ducts**

stack gas discharge ducts to the atmosphere, comprising the region between uptake and the smokestack

3.5.4**utilities piping**

auxiliary piping positioned downstream from the first general blocks

3.6**inspection in operation**

inspection performed without stopping equipment operation

3.7**general inspection**

inspection performed with equipment out of operation

3.8**uptake**

fired heater region located between the last convection outlet pipes and stack gas duct

3.9**return curve**

simple interconnection accessory between 2 adjacent pipes, in a same pass, normally deviating the flow by 180°

3.10

head

connection accessory between 2 adjacent pipes, normally deviating the flow by 180°. It is fitted with a removable plug allowing pipe cleaning and inspection

3.11

pipe support

a metal part fastened to the fired heater framework, having as a function to withstand the load imposed by the pipes

3.12

kingpost

pipe support tie rod to the roof, fastened to fired heater framework

3.13

mirror

special support type supporting various pipes in a single part. It may be extreme or intermediary if it is near the pipe end or not

3.14

damper

block or control valve for drawing stack gases

3.15

plenum or air gap

box involving burners, designed for distributing air properly

4 General Conditions

4.1 Inspection in Operation

4.1.1 A plan shall be established for the inspection of internal and external components, which may be checked in operation, according to the script contained in 5.1. This plan shall be carried out based on prior Inspection Reports.

4.1.2 Inspection in operation shall be performed at least with the following frequency:

Internal Visual Examination	- weekly;
External Visual Examination	- monthly;
Internal Thermographic Inspection	- semiannual;
External Thermographic Inspection	- annual.

NOTE The frequency of these inspections may be changed according to equipment operation history, according to the technical analysis performed by the Qualified Professional (PH).

4.2 General Inspection

4.2.1 A plan shall be established for the inspection of internal and external components, according to the script contained in 5.2.

4.2.2 It shall be performed every scheduled equipment downtime, according to its history.

4.3 Preparation for a General Inspection

The following items shall be complied prior with every general inspection:

- a) prior inspection reports;
- b) non-destructive test plan;
- c) necessary drawings for following up inspection;
- d) inspection materials and equipment (according to Annex B);
- e) design modifications.

4.4 Safety Requirements

Prior to starting inspection, it shall be verified if the existing conditions allow the performance of the tasks safely, according to specifications contained in PETROBRAS [N-2162](#).

5 Inspection Script

5.1 Inspection in Operation

- a) check fired heater operating conditions, and eventual abnormal occurrences;
- b) check the existence of a flame incidence and deformation in pipes;
- c) check the refractory state for collapse;
- d) check physical conditions of pipe supports;
- e) check physical conditions of plates, structures, ducts, smokestacks and platforms, as to painting, corrosion and deformations;
- f) check physical condition of cleaning system;
- g) check physical conditions of fired heater outside lines;
- h) check columns and beams of external platform structure and footbridges, for corrosion and mechanical damage such as: deformations, cracks, unleveling and loose bolted connections;
- i) check foundations for settlements and fullness and/or concrete base breakage and ironware exposure to corrosion;
- j) check the occurrence of abnormal temperature spots in the components through a thermographic inspection, according to PETROBRAS [N-2472](#);
- k) check through convection inspection windows possible soot accumulation and/or refracting materials that may block gas passage with consequent positive pressure in radiation chamber.
- l) check the temperatures of coils through Skin-Points;
- m) check the temperatures of combustion chamber (radiation), convection and gas outlet (stack) through thermocouples.

5.2 General Inspection

5.2.1 General Considerations

All relevant observations shall be recorded through photos, sketches and if necessary collecting ash and corrosion product sample, which allow, after analysis, corrosive process identification. In fired heaters where there are heads, mark plugs and chucks with traces of leakage. In fired heaters where it is necessary to wash and neutralize pipes in order to prevent corrosion occurrences, washing deficiency and pH on steel surface after neutralization shall be checked.

5.2.2 Burners

- a) check air inlet control ferrule drive to blowtorches and the need for lubricating them;
- b) check restraining plates of diffuser cone refractory blocks of blowtorches in relation to thickness reduction and cambering as well as secondary diffuser cone supporting block ring;
- c) inspect refractory blocks in relation to cracks and erosion;
- d) inspect oil, steam, gas and pilot pens, as well as the spray chamber and sprayer, in relation to corrosion and erosion;
- e) inspect oil and gas nozzles for hole diameters and angles;
- f) check the state of burner fastening bolts;
- g) perform pneumatic tightness test on gas line in order to check valve tightness;
- h) perform a hydrostatic test on oil and steam line hoses, in order to check the existence of leaks;
- i) check dimensional and positioning compliance of burner components after assembly, in relation to design; special attention shall be paid to assembly alignment, leveling and centering.

5.2.3 Air and Stack Gases Ducts

- a) inspect plates in relation to corrosion and the need for repair and/or painting;
- b) inspect thermal and refractory insulation of ducts and plenum;
- c) inspect expansion joints of ducts in relation to corrosion; deformation and/or breakages;
- d) check physical and drive conditions of airflow and stack gas control systems;
- e) inspect side plates, of plenum bottom and ceiling in relation to deformations and warps;
- f) inspect air preheating system, checking physical conditions of their components.

5.2.4 Outside Lines to Fired Heater

- a) perform thickness measuring in pre-determined points of load inlet and outlet lines; including connections;
- b) perform thickness measuring and hammer test of fuel, damping steam, residual gas and steam lines to soot blowers;
- c) remove for internal visual inspection eventual sections of outlet lines and valves;
- d) inspect flange cases and nuts and valves of outside lines to fired heater (visual examination and hammering) and joint laying seat for physical conditions (when there is access);
- e) check thermal insulation state;
- f) special attention shall be paid to damping steam lines; partially remove insulation of these lines for hammer test thickness measuring and checking corrosion under the insulation.

5.2.5 Radiation Chamber

5.2.5.1 Hydrocarbon Coil

- a) visually inspect pipes for the existence of grooves or notches, cracks, corrosion or wear in passage region by mirrors, localized warps and deformation, outside oxidation due to high temperature;
- b) hammer pipes for checking the existence of an oxide layer and/or coke formation internally;
- c) perform pipe thickness measuring in previously determined points and marked in relation to a fixed coil referential, determining corrosion rates; pay attention so that perchance existing oxide layers will be actually removed;
- d) perform thickness measuring (sweeping) in outside generators of return curves in fired heaters with this type of connection;
- e) perform thickness measuring in regions where, by visual inspection and hammering or since there are favorable conditions to corrosion, there is a thickness loss possibility;

- f) perform, when necessary, diameter, hardness, arrow measuring and metallography assessment of pipes;
- g) in fired heaters using heads request plug opening of the last 2 heads of each pass; pipes presenting hot spots in operation shall have their plugs open for checking coke occurrence;
- h) for fired heaters with heads internally inspect pipes after washing and blowing by using appropriate lighting devices; checking coke removal and that there has been no damage to the pipe and head sealing seats;
- i) When required, perform a pig cleaning, decoking with steam air decoking technique, or any other suitable coke removal methods.

NOTE If draining removes a large or abnormal amount of coke in one pipe, neighboring pipes also shall be internally inspected.

- j) in fired heaters using heads, assess the incidence of corrosion, in pipe chuck region, by measuring inside thickness;
- k) internally inspect open heads and other under suspicion, as well as pipe sealing welds, if any, for the occurrence of cracks; pay attention to mechanical damage in sealing set chuck region;
- l) inspect crossbars and head lugs or curves with magnetic particles;
- m) check pipe supports and their lashings for thickness loss by corrosion, cracks and breakages;
- n) inspect mirrors, wall thermocouples, temperature indicator wells and gas intakes for analysis;
- o) inspect pipe guides located in lower radiation curves in relation to their corrosion, and inspect welding region with the curve, for the case of vertical fired heaters; also check free displacement of pipe guides;
- p) in pipes having return curve with no internal visual access, the amount of coke shall be assessed through a gammagraphy.

NOTE In case of fired heaters subject to naphthenic corrosion, inspect with gammagraphy by sampling the welds of the last radiation coil tubes, for internal corrosion.

5.2.5.2 Refractory

- a) inspect refractory and thermal insulation, paying attention to cracks, loosening, anchoring and lining breakdown by chemical action, according to PETROBRAS [N-1951](#);

NOTE When insulating coating is of fibro-ceramic mat, it shall be checked for impregnation by ashes, damage and state of anchorages.

- b) check refractory coating of covers and head box walls; also check conditions tight joints in asbestos of these covers, (inspection criteria according to PETROBRAS [N-1951](#));
- c) check physical conditions of cone support rod protection refractory coating, if any (applicable to vertical fired heaters only);
- d) inspect radiation dome thermal insulation, in relation to scaling and for the state of fastening system (applicable to vertical fired heaters only).

5.2.5.3 Plates

Perform external visual inspection, checking:

- a) holes in plates by corrosion;
- b) external painting conditions of plates.

5.2.5.4 Cone/Sleeve

- a) perform visual inspection on cast nozzle as well as on cone plates, disks and sleeve, checking these components in relation to cracks and thickness losses; also check, wedges and joint clamps of cone cast plates; cone supporting rods shall be inspected with a Liquid Penetrant;
- b) inspect "lugs" where component supporting rods are fastened;
- c) inspect rolled plates for warps, warps and breakages in bolted connection regions.

5.2.5.5 Protection System

- a) check serviceability of firing windows;
- b) inspect damping steam system;
- c) check cables and electric ground fastening.

5.2.6 Convection Chamber

5.2.6.1 Hydrocarbon Coil

- a) visually inspect pipes for grooves or flutes, cracks, corrosion or wear in passage region by mirrors, localized warps and deformations, outside oxidation due to high temperature;
- b) check the state of pipes for deformations, wears in cleaner region, generalized or localized corrosion and wear by abrasion, near pipe supports; in case of pinned pipes remove some pins for measuring pipe thickness;
- c) request plug opening of some heads for checking the existence of coke; make thickness measuring on return curves;
- d) check pipe supports, mirrors, rods and sleeve plates for loss of thickness, cracks or breakages;
- e) inspect mirrors, wall thermocouples, temperature indicator wells and gas intakes for analysis, for corrosion and cracks;

5.2.6.2 Steam Coil

- a) perform thickness measuring and hammering, on pipes and curves;
- b) visually inspect pipes and curves for corrosion, cracks, deformation and wear by abrasion, near supports.

5.2.6.3 Soot Blowers

- a) remove soot blowers for mechanical overhaul;
- b) inspect booms, nozzles, supports and steam valves for physical conditions, check steam valves for their tightness.

5.2.6.4 Refractory

- a) inspect refractory and thermal insulation, paying attention to cracks, scaling, loss of anchoring and coating breakdown by chemical action, according to PETROBRAS [N-1951](#); when coating, insulator is of fibro-ceramic mat, it shall be checked for impregnation associated with moisture and the state of its anchoring;

NOTE Pay attention to soot blower region where deterioration is more intense, due to condensate leakage.

- b) check sealing between mirrors and pipes and curve box and head covers.

5.2.6.5 Plates

- a) perform visual inspection and hammer test for assessing regions to be repaired;
- b) check deflector plates for warps, support and corrosion;
- c) inspect soot blower sleeves for corrosion and cracks in welds with fired heater plates and refractory protection plates;
- d) check conditions of outside plate painting.

5.2.7 Uptake and Smokestack

- a) perform outside visual inspection and hammering on plates;
- b) perform hammering on smokestack section union screws and remove two of these for inspection;
- c) check bearings, cables, guides and damper drive;
- d) check refractory for cracks, scaling, loss of anchoring and loss of thickness;
- e) examine the damper plate, its shaft and settling seat for loss of thickness by corrosion and deformations; check incidence of corrosion on internal ends of damper shaft, due to gas condensation, check that the damper is not suffering interferences;
- f) check expansion joints for sealing, cracks, deformations and corrosion;
- g) check conditions of ladders, platform and existing hoisting devices on the smokestack;
- h) check lightning rod cables and electrical connections and smokestack grounding;
- i) check physical conditions of vent covers, if any.

5.2.8 Head Box/Curves

- a) inspect plates of boxes, covers, as well as structural beams;
- b) inspect containment plates (pads) of thermal isolation and chamber floor plates;
- c) check mirrors in relation to cracks and displacements;
- d) check mirror support rings in relation to cracks, deformations and thickness reduction;
- e) check the state of insulating concrete for deformations and drops.

6 Acceptance Criteria

6.1 Refractory Materials

All services shall be performed in accordance with the acceptance criteria of PETROBRAS [N-1951](#).

6.2 Coil

- a) all thicknesses found shall be over the minimum design thickness calculated according to API [STD 530](#) added by corrosion over-thickness predicted for the next campaign;
- b) in the event that localized deformations (oranges) are found, perform thickness measuring after removing oxide and check the existence of internal deposit;
- c) lengthwise deformation shall not approach deformed pipe of the neighboring pipe or refractory wall less than 1/5 of its outside diameter; the pipe shall not approach either the flame so as to surpass the flame circle defined in design; pipes that, by deformation, are removed from supports, transferring excessive load to adjacent supports shall be rejected; horizontal pipes that are removed one diameter in a 20-diameter length shall be condemned; for vertical pipes a greater deformation are admitted provided that prior recommendations are met;
- d) all hydrostatic tests shall be conducted according to ASME [B 31.3](#);
- e) coked pipes shall be replaced whenever, for any reason, decoking cannot be performed;

NOTE 1 These criteria shall be applied for pipes in cold condition, (as defined in Annex C).

NOTE 2 The criteria defined in paragraph c) shall be adopted whenever there is no specific design or operating unit recommendation.

- f) remaining coke from the decoking operation shall be assessed according to Annex D criteria.

6.3 Supports

Supports shall not present cracks or loss of thickness at critical points.

6.4 Burners

All burners shall be aligned, leveled, centralized and regulated according to design.

6.5 Soot Blowers

They shall be aligned and overhauled, with no steam and condensate leak through the block valve.

6.6 Wall Thermocouples

They must be tested by instrumentation, before going into fired heater operation.

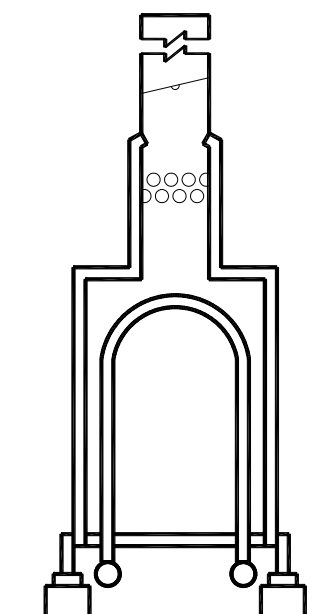
6.7 Dampers

They shall run properly when driven.

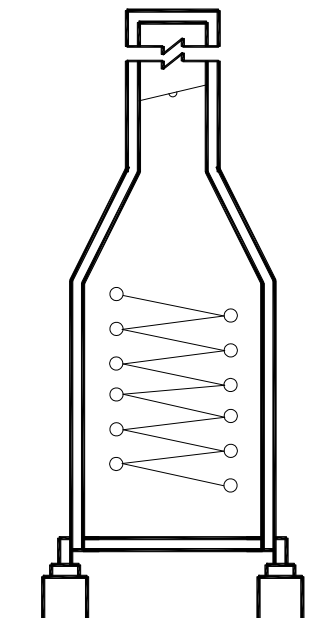
6.8 Damping Steam Pipes

Steam shall be admitted for checking obstruction or leaks by blocks.

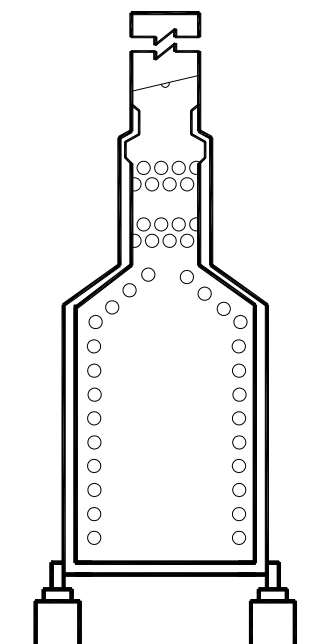
Annex A - Figure



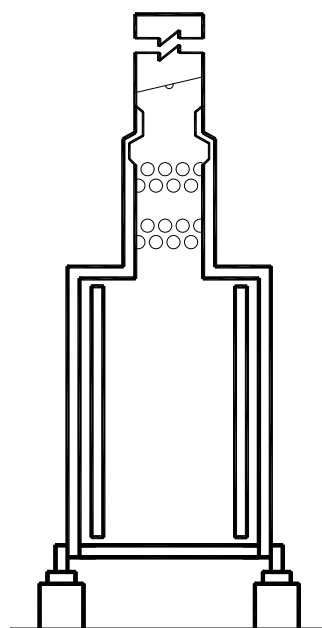
Box furnace
w/ arch coil



Cylindrical furnace
w/ helical coil



Cabin furnace with
horizontal coil



Cabin furnace with
vertical coil

Figure A.1 - Typical Types of Fired heaters

Annex B - List of Tools and Equipment

- 1 - 300-gram Ball Peen Hammer.
- 2 - Scraper.
- 3 - Thickness Meter by Ultrasound.
- 4 - Sandpaper.
- 5 - Stiletto.
- 6 - Caliper Rule.
- 7 - Portable Hardness Device.
- 8 - Measuring Tape.
- 9 - Litmus Paper (Ph).
- 10 - Flashlight.
- 11 - Caliper.
- 12 - Magnetic Particles Test Device.
- 13 - Mirror.
- 14 - Liquid Penetrant Test Material.
- 15 - Magnet.
- 16 - High-Intensity Headlight with Battery.
- 17 - Camera.
- 18 - Industrial Marker.
- 19 - Crayon.
- 20 - Boroscope/Fibroscope
- 21 - Thermography Device.

Annex C - Figure

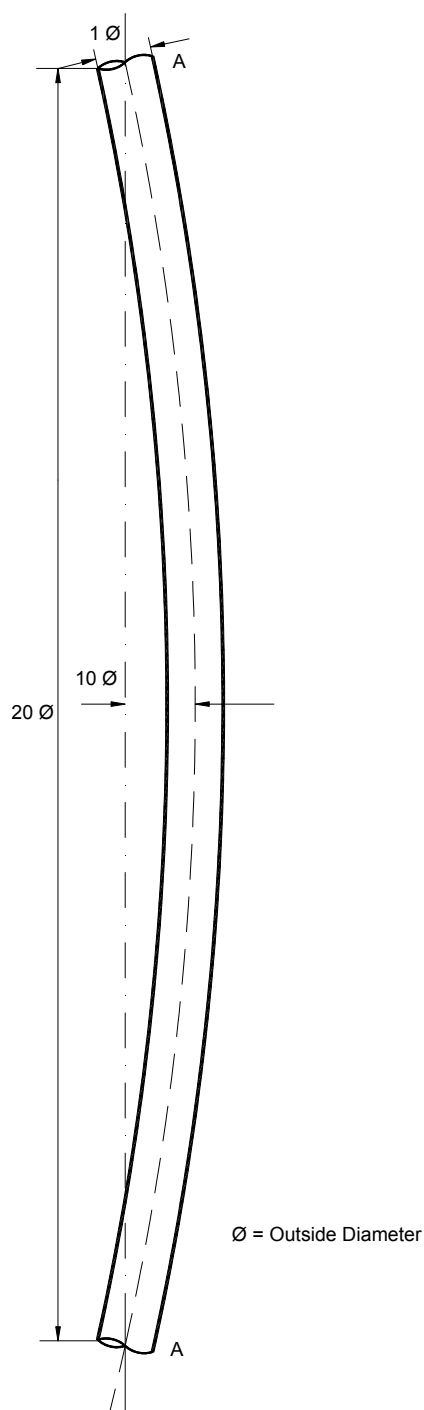


Figure C.1 - Pipe Deformation Acceptance Criteria in Cold Condition

Annex D - Decoking Acceptance Criteria

D.1 Steam Air Decoking

D.1.1 Radiographic Inspection

- a) evenly distributed coke layer: admissible thickness ≤ 3 mm;
- b) localized coke layer and not subject to flame incidence: admissible thickness ≤ 8 mm.

D.2 Decoking with Turbine

D.2.1 Pipes with Wall Thickness $\leq 6,0$ mm

D.2.1.1 Radiographic Inspection

Evenly distributed or localized coke layer: admissible thickness < 2 mm.

D.2.1.2 Visual inspection

- a) pipe generator turned toward the flame and top: spaced small coke islands, approximate size (50 mm x 50 mm);
- b) pipe generator turned toward the wall and bottom: spaced small coke islands, approximate size (50 mm x 50 mm).

D.2.2 Pipes with Wall Thickness $> 6,0$ mm

D.2.2.1 Radiographic Inspection

Evenly distributed or localized coke layer: admissible thickness ≤ 3 mm.

D.2.2.2 Visual inspection

- a) pipe generator turned toward the flame and top: spaced small coke islands, approximate size (50 mm x 100 mm);
- b) pipe generator turned toward the wall and bottom: spaced small coke islands, approximate size (70 mm x 100 mm).

INDEX OF REVISIONS

REV. A

There is no index of revisions.

REV. B

Affected Parts	Description of Alteration
	Revalidacion

REV. C

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