

Manufacture and Erection of Water-Tube Boiler

Procedure

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 non-mandatory 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

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.

Foreword

This Standard is the English version (issued in 12/2021) of PETROBRAS N-1823 REV. D 12/2018. 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 conditions for the manufacture and erection of water-tube boiler, in petroleum and petrochemical industry installations, and in thermoelectric centrals.

1.2 For the requirements not referenced in this Standard use PETROBRAS [N-268](#).

1.3 This Standard does not include electric, dynamic systems, automation and safety systems.

1.4 This Standard is applied to manufacture and erection services beginning with its date of issuance.

1.5 This Standard only 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, Vasos de Pressão e Tubulação;

PETROBRAS [N-12](#) - Acondicionamento e Embalagem de Válvulas;

PETROBRAS [N-13](#) - Technical Requirements for Paintwork;

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

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

PETROBRAS [N-134](#) - Chumbadores para Concreto;

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

PETROBRAS [N-268](#) - Fabricação de Vaso de Pressão;

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

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

PETROBRAS [N-300](#) - Grounding Details Using Mechanical Connectors;

PETROBRAS [N-1593](#) - Non-Destructive Testing - Leak Test;

PETROBRAS [N-1594](#) - Non-Destructive Testing - Ultrasonic in Welds;

PETROBRAS [N-1595](#) - Non-Destructive Testing - Radiography;

PETROBRAS [N-1596](#) - Non-Destructive Testing - Penetrant Testing;

PETROBRAS [N-1597](#) - Non-Destructive Testing Visual Testing;

PETROBRAS [N-1598](#) - Ensaio Não Destrutivo - Partículas Magnéticas;

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

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

PETROBRAS [N-1644](#) - Construction of Reinforced Concrete Foundations and Structures;

PETROBRAS [N-1910](#) - Castable Lining Design;

PETROBRAS [N-2162](#) - Work Permit;

PETROBRAS [N-2568](#) - Revestimentos Metálicos por Aspersão Térmica;

PETROBRAS [N-2586](#) - Revestimentos Anticorrosivos Aplicados por Aspersão Térmica;

ABNT [NBR 5425](#) - Guia para Inspeção por Amostragem no Controle e Certificação de Qualidade;

ABNT [NBR 5426](#) - Planos de Amostragem e Procedimentos na Inspeção por Atributos;

ABNT [NBR 5427](#) - Guia para Utilização da Norma ABNT NBR 5426 - Planos de Amostragem e Procedimentos na Inspeção por Atributos;

ABNT [NBR 16137](#) - Ensaios não destrutivos – identificação de materiais por teste por pontos, espectrometria por fluorescência de raios X e espectrometria por emissão óptica;

API [RP 535](#) - Burners for Fired Heaters in General Refinery Services;

API [RP 578](#) - Material Verification Program for New and Existing Alloy Piping Systems;

ASME [B 31.1](#) - Power Piping;

ASME [B 31.3](#) - Process Piping;

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

ASME [BPVC - Section VII](#) - Recommended Guidelines for the Care of Power Boilers;

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

ASME [STS 1](#) - Steel Stacks;

DIN [EN 473](#) - Non-Destructive Testing - Qualification and Certification of NDT Personnel - General Principles.

ISO [8501-1](#) - Preparation of Steel Substrates before Application of Paints and Related Products - Visual Assessment of Surface Cleanliness - Part 1: Rust Grades and Preparation Grades of Uncoated Steel Substrates and of Steel Substrates after Overall Removal of Previous Coatings;

ISO [9712](#) - Non-Destructive Testing - Qualification and Certification of Personnel;

ISO/IEC [17024](#) - Conformity Assessment - General Requirements for Bodies Operating Certification of Persons;

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 Definitions

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

3.1

ASME BPVC - Section I

boiler system under the scope of ASME [BPVC - Section I](#)

3.2

ASME B 31

boiler system under the scope of standards ASME [B 31.1](#) or ASME [B 31.3](#)

3.3

Positive Identification of Materials (PIM)

determination of the chemical composition of the material by one of the methods defined in API [RP 578](#)

3.4

balance

any erection device used for lifting or moving thin pieces with the function of supporting them in various points, in order to avoid their deformation

3.5

panel

set of tubes united one to another, along the length, directly or through fins by means of welded joint, or linked to 2 common collectors

3.6

Maximum Allowable Working Pressure (MAWP)

the highest pressure value consistent with the design code, the resistance of the material used, the dimensions of the equipment and its operational parameters

3.7

Nondestructive Testing - NDT

NDT is any kind of testing of the material, which does not permanently change its physical, mechanical, chemical and dimensional properties. NDTs imply imperceptible or null damage

4 Nondestructive Tests Generals Conditions

In this Standard, some activities are repeatedly cited and shall be implicit that they are executed in accordance with the prescriptions of this Chapter.

NOTE The inspectors for nondestructive testing shall be certified according to ISO [9712](#). For qualifications abroad it shall be carried out by international independent entities complying with the requirements of ISO/IEC [17024](#) and operating according to ISO [9712](#) or DIN [EN 473](#), being a prior approval of PETROBRAS needed in that case.

4.1 Liquid Penetrant Test

Executed in accordance with PETROBRAS [N-1596](#).

4.2 Magnetic Particles Test

Executed in accordance with PETROBRAS [N-1598](#).

4.3 Ultrasonic Test

Executed in accordance with PETROBRAS [N-1594](#).

4.4 Radiograph Test

Executed in accordance with PETROBRAS [N-1595](#).

4.5 Visual test

Executed in accordance with PETROBRAS [N-1597](#).

4.6 Spot Test

Executed in accordance with ABNT [NBR 16137](#).

4.7 Leak Test

Executed in accordance with PETROBRAS [N-1593](#) or in conformity with the manufacturer procedure, since previously approved by PETROBRAS.

5 Manufacture Inspection

5.1 The thickness of the wall in all the major degree conformations parts of caps, cylindrical parts of the drum and bending curves of pipes. It shall be obeyed the following criterion:

Measured thickness \geq Minimum design thickness

5.2 It shall be verified if the out of roundness of bended tubes sets to tolerance specified in the boiler design.

5.3 The consumables for welding shall be according to PETROBRAS [N-133](#).

5.4 It shall be checked if the number of the run of received consumables for welding coincides with the number of the same constant in the certificates and if the certificates are in conformity.

5.5 During manufacture of the boiler's component or subcomponent the PIM shall be carried out in the following cases: steels alloy and stainless steels, according to API [RP 578](#) specifications, and be witnessed by a representative appointed by PETROBRAS.

5.6 For definition of welding inspection types and extension see Annex A.

5.7 For the boiler metal structures PETROBRAS [N-279](#) and [N-293](#) shall be attended.

5.8 Adjustment

5.8.1 The equipment sections or parts shall be adjusted within the following tolerances:

- a) spacing of pipe center line that possess only one symmetry plan, measured at its extreme points, in relation to the pipe symmetry plan in its theoretical position: 1/100 of pipe total length, but maximum of 5 mm (see Figure B.1);
- b) panel extreme pipes center line spacing, measured at its extremities, in relation to the theoretical position of the surface that contains the pipes center line (see Figure B.2);
 - broached panels: 1/200 of panel width;
 - welded panels: 1/50 of panel width;
- c) weld joints misalignment, except chimney, duct and metallic structure according to ASME BPVC - [Section I](#) or ASME [B 31.1](#) and [B.31.3](#).

5.8.2 The pipes or serpentines circumferential joints shall be spaced at least 500 mm from the nearest support or spacer.

5.9 Marking

Mark in the parts the coordinate axes indicative lines. The marking shall be made by proper means, such as puncture or scriber and detach with ink.

5.10 Bevels

According to PETROBRAS [N-268](#).

5.11 Broaching

5.11.1 A procedure for broaching of the tubes shall be presented, including at least the essential variables of Appendix HH of ASME BPVC - [Section VIII – Division 1](#).

5.11.2 Every broaching holes and extremities, internal and externally, of the pipes to be broached, shall be examined visually. They shall present rugosity specified in the design and be free of superficial defects. Are not admitted:

- a) scratches;
- b) kneading;
- c) corrosions;
- d) sharp edges.

5.11.3 In case the projection surpass the specified tolerance, the pipe excess shall be removed, before broaching, making the necessary corrections. The cares described in the manufacturer procedure shall be observed.

5.12 Welding

5.12.1 The welding shall be executed according to PETROBRAS [N-133](#) and the requirements added in 5.12.2 to 5.12.6.

5.12.2 The pre-heating and after-heating shall be applied:

- a) along all the welded joint or pointing in execution, comprehending the weld plus 75 mm each side;
- b) in drums seal welds, in a minimum ratio equal to 2,5 times the welding pipe diameter, and preferably, by the drum external side;
- c) by means of electrical resistance at joints with nominal diameter larger than 4", being admitted the gas heating for joints with nominal diameter up to 12", if used a ring that involves all the joint for this purpose.

5.12.3 The welds of the erection auxiliary devices, and other temporary welds, including the thermocouples fixation weld, shall be removed, without impact, after accomplishing their function and the site shall be inspected by liquid penetrant testing.

5.12.4 The welded joints that have superficial irregularities which may prejudice the interpretation of any non-destructive test, shall be rubbed. This requirement is obligatory for the fillet welds.

5.12.5 For metal base thickness re-established through the weld, shall be executed at this region the same non-destructive test foreseen for the nearest butt weld joint, which belongs to that metal base.

5.12.6 Welded Joints Tolerances

The welded joints and equipment welded sections, except chimney, ducts and metallic structures, shall be within the tolerances specified by ASME BPVC - [Section I](#) or ASME [B 31.1](#) and [B31.3](#) for welding reinforcement and misalignment.

5.13 Nozzles

5.13.1 The connections shall be located, adjusted and, after welding, be positioned within the tolerances presented below:

- a) projection: ± 3 mm in relation to the part surface;
- b) connection axes orientation: ± 3 mm;
- c) perpendicularity of the flange face in relation to the nozzle axes: $\pm 1/2^\circ$;
- d) orientation of the holes of linking flanges with the piping;
 - the vertical and main axes shall always pass by the middle of the interval between 2 adjacent holes of the flanges;
 - the maximum rotation of the flange holes in relation to the position indicated in the design: ± 1.5 mm;
- e) angular deviation of the nozzle axes: $\pm 1/2^\circ$.

NOTE See PETROBRAS [N-268](#), figure A.1.

5.13.2 The cap joint settling seat and the manhole of the drum, as well as the bolts (cases) shall be protected against mechanical damages and corrosion.

5.13.3 The connections threaded length shall attend ASME BPVC - [Section I](#), PG 39.5.

5.14 Conformation

5.14.1 For conformed parts evaluate the need for Heat Treatment according to Paragraphs PG-19 and PG-20 of ASME BPVC - [Section I](#).

5.14.2 For parts heat treated carry out Liquid Penetrant testing in conformed region.

5.15 Burner

The burner and the boiler must be compatible so as not to present the events listed below:

- a) structural vibration of the furnace caused by thermoacoustic phenomena,
- b) incidence of flames in the superheater and in the furnace.
- c) increase in the temperature of tubes, supports or other items beyond the limits specified for each material, in the furnace sections;

NOTE The burners to be installed can be evaluated following the points of attention recommended by API RP 535. [RECOMMENDED PRACTICE]

5.16 Painting and Coating

5.16.1 Components supplied with permanent painting shall attend the requirements of PETROBRAS [N-13](#).

5.16.2 Components supplied with anticorrosive coatings applied by heat aspersion shall attend the requirements of PETROBRAS [N-2568](#).

5.17 Refractory Application and Thermal Insulation

According to PETROBRAS [N-1617](#) and [N-1618](#).

6 Receiving Inspection in Erection Site

6.1 At the receiving of the Boiler or its components verify the Manufacture Inspection Reports, Non Conformity Reports (applicable case) and Manufacture Procedures.

6.2 It shall be checked if the sets that comprises the boiler are perfectly identified according to the manufacture drawings.

6.3 For items separately supplied and submitted to pressure, verify if the material used are identified according to the specification and the item of the boiler design.

6.4 At the receiving of steel alloy panels or stainless steel PIM testing shall be performed by sampling [NBR 5426](#) and [NBR 5427](#). All items separately supplied shall be verified by PIM testing after erection in the final site.

6.5 Inspect the bevels of the parts to be welded according to 5.10 of this Standard.

6.6 The consumables for welding shall be according to PETROBRAS [N-133](#).

6.7 It shall be checked if the number of the run of received consumables for welding coincides with the number of the same constant in the certificates and if the certificates are in accordance with the specifications.

6.8 Verify at the equipment supporting parts if the holes dimension and arrangement are compatible with the anchor bolts. Shall be checked especially, if the holes allow the equipment foreseen dilation, as defined in the design.

6.9 Verify if the holes working as vent are not plugged.

6.10 Verify in the fabrication report of the drums and headers, the conformity with the design of the following dimensions:

- a) hole diameter;
- b) groove positioning;
- c) groove depth;
- d) groove width.

6.11 Every broaching holes, and the internal and external surfaces of the pipe extremities to be broached, shall be visually tested and have finishing with no superficial defects, not being admitted the following imperfections:

- a) scratches;
- b) kneading;
- c) corrosion;
- d) sharp edges.

NOTE 1 Protect the holes and the pipe extremities against corrosion; use external plastic plug at the pipe extremities.

NOTE 2 The pipe surfaces to be tested shall extend to the length equal to the part to be broached plus 50 mm.

6.12 Every pipe and other pressure submitted parts shall be checked, by visual and/or dimensional test, which shall be free of:

- a) defects that cause a sharp transition on the parts surface;
- b) defect that reduces the part thickness under the value cited in 5.1;
- c) corrosion above the C degree of standard ISO 8501-1 for the following materials: carbon-steel, molybdenum alloy steel, chrome-molybdenum alloy steel and nickel alloy steel;
- d) any corrosion grade for stainless steel, nickel and nickel alloy.

NOTE The repairs, if necessary, shall be executed only with the PETROBRAS authorization.

6.13 The pipes and panels form and dimension shall be according to 9.6.

6.14 Verify if the equipment ducts reinforcements, used to increase their rigidity are installed according to the design.

6.15 Verify the equipment ducts concerning to the existing deformity, which shall attend the following tolerances:

- a) circular section duct:

- circularity in any transversal section: maximum diameter - minimum diameter $\leq 1\%$ nominal diameter;
- generatrix maximum spacing in relation to a straight template of 1 000 mm of length: 20 mm measured between template extremities (see Figure B.2);
- b) polygonal section duct:
 - difference between diagonals of any transversal section: larger diagonal minus minor diagonal $\leq 1\%$ nominal diagonal;
 - maximum spacing of any of the ducts faces in relation to the straight template of 1 000 mm length: 20 mm, measured between template extremities (see Figure B.2).

NOTE Carry out those activities mainly in the Receiving stage

6.16 Check the general state of the damper, which shall move freely. Verify the clearance for the damper dilation. Verify if there is sealing air for toxic gases.

6.17 Verify by visual test, if all the pipe or serpentine supports and locks are in good shape and with a good finishing, being presented without sharp edges and barb at the pipe supporting area.

6.18 Verify by sampling if soot blowers, burners, ventilators, air pre-heaters, expansion joint, valves, metal structures and their components etc., are in conformity with the design, as for:

- a) visual and dimensional testing;
- b) material certificates;
- c) measurement of hardness of heads (where applicable).

6.19 Verify if movable parts of "dampers", regulators, flow directors and fans move satisfactorily.

NOTE Verify the balancing of the rotating assemblage made by the manufacturer.

6.20 Verify the painting, refractory material and thermal insulators general conditions as for:

- a) painting: general visual inspection;
- b) desalter: visual inspection and hammer testing;
- c) thermal insulator: visual inspection, checking of fixation and humidity of insulating component.

6.21 Examine, visually the flanges faces to check the sealing seat state and standardization. It is not allowable any corrosion or kneading.

6.22 It shall be verified if the manufactured parts are being delivered with the packaging proper to assure its integrity and in case of valves if it attends PETROBRAS [N-12](#).

6.23 Verify if the markings of the parts' coordinate axes indicative lines were made by proper means.

7 Material Storage

In case the parts are not packed and protected, the perfect packing and protection for their storage shall be provided.

7.1 The flanges shall be with their sealing faces properly protected against mechanical damages and corrosion.

7.2 The tiny parts such as screws, clamps, cases, washers and gaskets shall be packed in boxes and kept indoor. The threads shall be previously protected against corrosion.

7.3 Special cares in storage shall be taken with the damper, soot blower, soot blower panel, fans and silencers, which shall be located indoors.

7.4 The chimneys or sections shall be stored in a way to avoid circularity loss and kneading of chimney shell, anti-vortex wings (anti-vibrating), and of structural reinforcements.

7.5 The expansion joints shall be stored and locked indoor, in a way to avoid any bellows deformation and shall be located indoors.

7.6 The refractory materials and thermal insulators shall be stored according to PETROBRAS [N-1617](#) and [N-1618](#).

7.7 The pipes, panels and serpentes shall be protected against corrosion and mechanical damages. Position the parts with inclination over sleeper to avoid contact to the ground and internal puddling. Special cares shall be taken in the long parts moving, to avoid warping. Use balances for lifting and/or moving the thin parts.

7.8 For all parts of the equipment, especially those cited in 7.4, 7.5 and 7.7, shall be used proper wedges in a way to keep the part, at least 30 cm away from the ground.

7.9 The welding consumables shall be stored according to PETROBRAS [N-133](#).

7.10 All valves shall be stored according to PETROBRAS [N-12](#). The flanged valves shall obey the specified in 7.1.

7.11 The stack, ducts and other parts must be stored in order to avoid mechanical damages in the refractories and thermal insulation, previously applied, and protected against weather.

8 Foundations

Before starting the equipment erection, a rigorous checking of the boiler foundation and base shall be done.

8.1 Certificates and Reports

8.1.1 Verify the conformity certificate of concrete base with prescriptions of PETROBRAS [N-1644](#), emitted by the base executor.

8.1.2 Verify if the report results attend the design specifications and the requirements of PETROBRAS [N-1644](#).

8.2 Level References

Verify if the level reference and the equipment erection area coordinates are in conformity with PETROBRAS [N-1644](#).

8.3 Anchor Bolts

8.3.1 Before and after the installation verify if the anchor bolts attend the design requirements, according to PETROBRAS [N-134](#), observing the following items:

- a) the anchor bolts threads edges shall be perfect, without any corrosion or kneading;
- b) each anchor bolt thread length shall always be equal to or longer than the nominal length;
- c) each anchor bolt thread diameter and type shall be according to the discriminated in the design;
- d) verify the anticorrosive protection where specified.

8.3.2 Clean anchor bolts cups (jackets and sleeves).

8.3.3 Grease anchor bolts for lubrication and protection against corrosion and install protection against mechanical damages.

8.4 Concrete Base Leveling

The base leveling shall be executed through the wedges placing. The wedges shall be sized and spaced in a way to support the equipment, taking in account the following requirements:

- a) at elevation, adopt a tolerance of ± 1 mm in relation to the design elevation and ± 2 mm tolerance for the chimney;
- b) the wedges shall be arranged near the anchor bolts, spaced approximately 25 mm from their jackets or sleeves, being totally contained at the supporting area;
- c) the wedge height (metal + mortar) shall be maximum 5 mm above the design foreseen height;
- d) after the equipment placing, the base plate and wedges shall have sufficient space for grouting execution.

8.5 Grouting

The grouting shall be executed before filling the equipment for the hydrostatic test and according to PETROBRAS [N-1644](#).

9 Erection

9.1 Equipment Base

9.1.1 Check if the skirt or supports have holes disposed in conformity to the anchor bolts and if they have dimensions compatible with the anchor bolts.

9.1.2 Check by confrontation between the equipment base dimensions and the anchor bolts spacing, if the equipment can expand according to the foreseen in the design.

9.2 Marking

Verify if the tolerances regarding the indicative lines of the coordinated axes of the parts are being obeyed.

9.3 Inspection Before Erection

9.3.1 Verify if the component did not suffer damages in the transport and/or movement between the receiving and the erection on field.

9.3.2 Verify if the settlement seats of the drum manhole (shell and cover) and the flanges of the safety valves connections shall be examined visually and shall be in good shape, free of any irregularity, and properly protected against mechanical effects and corrosion. The perpendicularity of the settlement seats in relation to the manhole center line or cover center line shall be within the tolerance of $\pm 1/4^\circ$.

9.4 Materials Defect Repairs

They shall be performed and inspected according to ASME [BPVC - Section I](#) or ASME [B 31.1](#) and [B.31.3](#). In case of repair with weld the inspection shall be according to 9.9.5 of this Standard.

9.5 Erection Auxiliary Devices

It shall attend PETROBRAS [N-133](#).

9.6 Adjustment

9.6.1 The equipment sections or parts shall be adjusted within the following tolerances:

- a) the tolerances referenced in 5.8.1 shall be obeyed for adjustments carried out during the erection;
- b) spacing of indicative lines of coordinate axis of the drum and of collector from the theoretic position: ± 2 mm;
- c) pipe or panel longitudinal warping, measured at any point of these, in relation to the theoretical position of each pipe center line: 1/75 of minor distance of measure point to the pipe extremities, but not superior to 50 mm;
- d) panel transversal warping, measured in its any transversal section, in relation to the straight line that passes by the center of each section pipe, the pipes being in their theoretical positions: 1/100 of distance from the measured point to the panel nearest extremity in the transversal section, not superior, however, to 5 mm;
- e) horizontal walls:
 - maximum differences between diagonals: 12 mm;
 - maximum differences between widths measured at the extremities: 8 mm;
- g) vertical walls: maximum verticality deviation of each adjusted section: 1/1 000 of the total adjusted height;

NOTE In case there is no reference of manufacturer, use the tolerances described above.

9.6.2 The pipes or serpentines circumferential joints shall be spaced at least 500 mm from the nearest support or spacer.

9.7 Bevels

According to PETROBRAS [N-268](#).

9.8 Broaching

9.8.1 The broaching holes and pipes extremities to be broached shall be cleaned in a way to eliminate any vestige of oil, humidity, grease, paint, oxid, scurfs and dirt of any kind. The cleaning shall be executed including the holes notches and, in pipes, shall extend at least in a distance equal to 2,5 times the broaching area extension.

9.8.2 The cleaning shall be made in a way not to reduce the pipe thickness or damage by introducing one of those defects cited in 9.8.4.

9.8.3 The above specified cleaning for the pipes applies equally to their external and internal surfaces, however, to the internal surface, the cleaning shall extend to a distance 1,5 times the broaching area extension.

9.8.4 Every broaching holes and extremities, internal and externally, of the pipes to be broached, shall be examined visually. They shall present rugosity specified in the design and be free of superficial defects. Are not admitted:

- a) scratches;
- b) kneading;
- c) corrosions;
- d) sharp edges.

9.8.5 The pipes to be broached shall be adjusted to the drum and collector within the following tolerances:

- a) pipe projection to the drum or collector interior in relation to the design measurement:
 ± 2 mm;
- b) pipe center line spacing, measured in any point of this, in relation to the theoretical position of the line: ± 2 mm.

9.8.6 In case the projection surpass the specified tolerance, the pipe excess shall be removed, before broaching, through cold cutting until reaching that tolerance. The cares of 9.8.1 and 9.8.2 shall be observed.

9.8.7 Wood spacers between the pipes rows shall be installed, as well as bracings at the pipes in a way to avoid the pipes rotation and axial dislocation during the broaching.

9.8.8 The broaching operation shall be executed right after the pipes cleaning and their adjustment to the drum and collector in a way to avoid that the areas formerly cleaned oxidate and have necessity to make a new surface preparation according to 9.8.1 and 9.8.2.

9.8.9 The broaching operation shall be executed according to the executor's erection procedure, which shall contain the essential variables as per ASME [BPVC - Section VIII - Division 1](#) - APPENDIX HH - paragraph HH - 7.

9.8.10 The broaches lubrication shall be done only using saponifiable vegetal grease or water dissolvable soluble type.

9.8.11 The pipes expansion and its control shall be done in a gradual way to avoid that the expansion happens beyond the foreseen limits by the executor's erection procedure.

9.8.12 In case of drum and collector, the pipes shall be broached along all its part extension, in a way to eliminate the possibility of clearance existence between the pipe and the cited parts. This requirement is not applicable when the parts possess a reduction, at their most extreme region, in such a way not to allow widening. Interrupt the broaching at 3 mm from the tube sheet edge of air pre-heater or the drum edge.

9.8.13 Whenever solicited the seal weld of the tubes on the drum, it shall be done by the drum internal side.

9.9 Welding

9.9.1 The welding shall be executed according to PETROBRAS [N-133](#) and additionally to the items listed below.

9.9.2 The pre-heating and after-heating shall be applied:

- a) along all the welded joint or pointing in execution, comprehending the weld plus 75 mm each side;
- b) in drums seal welds, in a minimum ratio equal to 2,5 times the welding pipe diameter, and preferably, by the drum external side;
- c) by means of electrical resistance at joints with nominal diameter larger than 6", being admitted the gas heating for joints with nominal diameter up to 12", if used a ring that involves all the joint for this purpose.

9.9.3 The pre-heating and after-heating temperature control shall be done through the measurements in all minimum region of pre-heating and after-heating specified, in a way described in PETROBRAS [N-133](#).

9.9.4 The welds of the erection auxiliary devices shall attend PETROBRAS [N-133](#).

9.9.5 Repairs shall be performed and inspected according to ASME [BPVC - Section I](#) or ASME [B 31.1](#) and [B 31.3](#). In case of repairs with weld, perform the same nondestructive testing foreseen in Annex A of this Standard, for the nearest top welded joint of the base metal in question.

9.10 Welded Joints Tolerances

The welded joints and equipment welded sections, except chimney, ducts and metallic structures, shall be within the tolerances specified by the ASME [BPVC - Section I](#) or ASME [B 31.1](#) and [B 31.3](#) for welding reinforcement and misalignment.

9.11 Nozzles

9.11.1 They shall be located, adjusted and, after welding, be positioned within the tolerances established in Annex A of PETROBRAS [N-268](#).

9.11.2 The flange joint settling seat and the manhole of the drum, as well as the bolts (cases) shall be protected against mechanical damages and corrosion.

9.12 Expansion Joints

Remove the locking systems of the expansion joints after total conclusion of the ducts system erection, including supporting and performance of smoke test.

9.13 Soot Blower

9.13.1 Fixed boom soot blowers shall be erected in such a way that the boom turn freely without excessive stress for the engine.

9.13.2 Retractable boom soot blowers shall be erected in such a way that the boom move freely without friction with the boiler pipes.

9.13.3 Soot blowers shall be erected in accordance with the procedure and follow-up of the manufacturer, which shall issue an erection report.

9.14 Burner

9.14.1 The burners shall be erected in accordance with the procedure and follow-up of the manufacturer, which shall issue an erection report.

9.14.2 A report shall be presented including report certifying conformity of the dimensions verified on field with those in the research cited in 5.15 of this Standard. The dimensional testing shall be carried out by certified professional.

9.15 Chimney and Ducts

The chimney and ducts sections adjustment for welding, shall be in accordance with the criteria of ASME [STS 1](#).

9.16 Refractory Application and Thermal Insulation

The Design and application of Refractory Material and Thermal Insulator shall attend PETROBRAS [N-250](#), [N-1617](#), [N-1618](#) and [N-1910](#).

9.17 Metal Structures in General

For the boiler metal structures PETROBRAS [N-293](#) shall be attended.

9.18 Safety Valve

9.18.1 The flanged safety valves shall be properly tested and calibrated on bench and installed only after hydrostatic test.

9.18.2 The welded safety valves shall be plugged with plug, supplied by the manufacturer, during the hydrostatic test of the boiler.

9.18.3 The safety valves shall be submitted to actual opening test after the boiler ignition and before they are in line with the steam distribution network. The actual test shall attend to ASME [BPVC - Section VII](#).

9.18.4 The details of the piping for condensate drainage from safety valve body shall be foreseen based on the manufacturer directions, aiming to assure personal safety.

9.19 Heat Treatment

9.19.1 The thermocouples fixing weld shall be executed according to the PETROBRAS [N-133](#).

9.19.2 Besides the requirements of this Standard attend ASME [B 31.1](#) and [B 31.3](#).

9.19.3 Avoid the contact of the galvanized parts and heated parts during the heat treatment.

9.19.4 The heat treatment temperatures, as well as the heating and cooling rates, and hardness measurement on cast and themically affected zones of the welded joint shall be according to ASME [BPVC - Section I](#) or ASME [B 31.1](#) and [B 31.3](#), as the case.

9.19.5 After the heat treatment the testing shall be carried out according to Annex A, of this Standard.

10 Erection Inspection

10.1 The nondestructive tests shall follow the welding progression.

10.2 Welded joints shall be inspected according to Annex A.

10.3 The repairs or changes of the welded joints shall be inspected in conformity with Annex A.

10.4 When inspection by welded joints sampling is carried out and any defect is detected, additionally inspect 2 joints of the same type for each joint rejected.

10.5 For chrome-molibdenum steel, stainless steel and nickel alloy parts, it is required that tests shall be made by means of magnetic particles or liquid penetrant.

10.6 Check if the conditions of the boiler electrical grounding attend the requirements of PETROBRAS [N-300](#).

10.7 Verify the balancing of rotary sets after erection, according to the manufacturer recommendations.

11 Hydrostatic Test

11.1 Procedure

The test shall be done according to the manufacturer hydrostatic test procedure, which shall contain, at least, the following information:

- a) test fluid with characteristics conform 11.5;
- b) test pressure calculation or designer document that specifies this pressure;
- c) limits of system to be tested, with blockings indication;
- d) test auxiliary installation scheme, with position indication of:
 - manometers;
 - vents and drains;
 - thermometers;
 - pumps (filling and pressurization);
 - valves;
 - filling and pressurization points;
- e) pressurization and depressurization speeds;
- f) description of the test execution, including safety precautions;
- g) conservation methods of the non-drainable areas.

11.2 Test Methods

For system ASME [BPVC - Section I](#), the prescriptions of 11.3 to 11.12 shall be followed. For system ASME [B 31.1](#) and [B 31.3](#), PETROBRAS [N-115](#) shall be followed.

11.3 Supports

Every temporary supports shall be removed as well as every definitive supports, installed before the equipment filling for the test. The spring supports shall be locked during the hydrostatic test. In special cases, the designer shall indicate which supports shall not be locked.

11.4 Painting, Thermal Insulation and Refractory Application

The equipment shall be tested before applying painting, thermal insulation and refractory at the welded joints region.

11.5 Test Fluid

Always use potable water. The adequate characteristics of the water pureness shall be defined by the designer. These characteristics shall always be controlled.

11.5.1 The water temperature shall be higher than 20 °C. In case the water temperature is near the minimum limit, thermometers shall be installed at the equipments lower region.

11.5.2 The chloride maximum content allowed in the water for the pipes test of austenitic stainless steel is 50 ppm.

11.6 Welding Prohibition

Do not weld at the equipment and at any electric contact part of the same, while the equipment contains water or other fluid.

11.7 Manometers

11.7.1 Use at least 2 manometers, being, one of them, recorder, obeying the prescriptions described in the 11.7.1.1 to 11.7.1.4.

11.7.1.1 At least 1 of the manometers shall be placed in a visible position to the test inspector, during all the pressurization and testing time.

11.7.1.2 The manometers shall be calibrated before the test start, admitting the validity of 3 months for the calibration.

11.7.1.3 The scale maximum value shall comprehend between 1,5 and 4 times higher than test pressure and preferably, be the double of the test pressure.

11.7.1.4 The minor scale division shall not surpass 5 % of the scale maximum indication.

11.7.2 Blockings between the manometers and the equipment shall be foreseen, to allow substitution, when necessary.

11.8 Equipment Protection

11.8.1 Install relief valve or rupture disc.

11.8.2 The pressure test may not exceed the limits defined in ASME [BPVC - Section I](#).

11.9 Safety and Access

11.9.1 The pressure test can only be executed, at least 48 hours after the last welding at the pressure submitted part and the equipment supporting part.

11.9.2 The personnel safety conditions shall be foreseen before starting the test according PETROBRAS [N-2162](#).

11.9.3 Conditions of access to the areas to be inspected during the test shall be foreseen.

11.10 Sealing Joints

In the hydrostatic test use sealing joints specified in the design.

11.11 Duration

11.11.1 The minimum time of equipment permanency on the pressure test is 30 minutes, before proceeding the equipment visual test. After the minimum time on pressure test, lower the pressure to MAWP and inspect the equipment.

11.11.2 Issue a test execution certificate, with the data of the test.

11.12 Boiler Preservation

11.12.1 The manufacturer shall present a Preservation procedure and the same shall be approved by PETROBRAS.

11.12.2 After Hydrostatic Test and before start of operation, follow the preservation (conservation or hibernation) recommendations of the manufacturer.

12 Smoke Test

The smoke test shall be executed in the boiler and boiler ducts.

NOTE The manufacturer shall present a procedure for smoke test and that shall be approved by PETROBRAS.

13 Regulatory Standard No. 13 (NR-13)

The manufacturer and the erector shall present the documents defined for in 13.1.6 of [NR-13](#).

14 Procedure for Boiler Hibernation

The erector shall follow the procedure for boiler hibernation prepared by the manufacturer and approved by PETROBRAS.

Annex A - Weld Inspection Requirements
Table A.1 - Weld Inspection Requirements

Item	Component	Types of joint	Types of welds	Type of inspection (see Note 2)
1	Drums ("steam drum, water drum")	Top	Bevel - longitudinal	Computerized ultrasound with register = 100 % Magnetic Particles = 100 % Hardness measurement – 20 % (see Note 5)
		Top	Bevel – rounded	
		Angle	Bevel – full penetration, e.g. nozzles (see figures PW-16.1 and PW-16.2 of ASME BPVC - Section I)	Conventional ultrasound = 100 % Magnetic particles = 100 % (see Note 1)
		Angle	Bevel – partial penetration, e.g. nozzles (see figures PW-16.1 and PW-16.2 of ASME BPVC - Section I)	Liquid penetrant = 100 %
		Angle	In angle of nozzles (see figure PW-16.1 and PW-16.2)	Liquid penetrant = 100 %
		Angle	In angle, at the pipe connection (see Note 1)	Liquid penetrant = 100 % Acceptance criterion = exempted from indication
		Angle	In bevel and in angle, from components not submitted to pressure	Liquid penetrant = 20 %
2	Piping integrated to boiler proper (characterized with "boiler proper") excepting "downcomers"	Top	Bevel – rounded	ASME BPVC - Section I, table PW-11 or radiography = 10 %, whatever is higher
		Angle	In bevel and in angle, from components not submitted to pressure	Liquid penetrant = 20 %
3	Tripping piping integrated to boiler proper (characterized with "boiler proper") "downcomers"	Top	Bevel – rounded	Computerized ultrasound with register = 100 % Magnetic Particles = 100 %
		Angle	In bevel and in angle, from components not submitted to pressure	Liquid penetrant = 100 %

Table A.1 - Weld Inspection Requirements (Continued)

Item	Component	Types of joint	Types of welds	Type of inspection (see Note 2)
4	Serpentine or boiler wall pipes ("boiler tubes, bundles") carbon steel	Top	Bevel – rounded	Radiography = 10 % Liquid penetrant = 10 % Liquid penetrant = 100 % for recoverer boiler [Heat Recovery Steam Generators (HRSG)]
		Angle	Bevel and in angle, at pipe – collector connection (see figures PW-16.1 and PW-16.2 of ASME BPVC - Section I)	Liquid penetrant = 10 % Liquid penetrant = 100 % for Heat Recovery Steam Generators (HRSG)
		Angle	In bevel and in angle, from components not submitted to pressure (e.g. fins)	Visual inspection = 100 %
5	Serpentine or boiler pipes ("boiler tubes, bundles") carbon steel	Top	Bevel - rounded	Radiation = 20 % Hardness measurement – 20 % (see Note 5) Liquid penetrant = 100 % IPM = 100 % (see Note 3)
		Angle	Bevel and in angle, at pipe - collector connection (see figures PW-16.1 and PW-16.2 of ASME BPVC - Section I)	Hardness measurement – 10 % (see Note 5) Liquid penetrant = 100 % IPM = 100 % (see Note 3)
		Angle	In bevel and in angle, from components not submitted to pressure (e.g. locks, supports, spacers)	Visual inspection = 100 % Liquid penetrant = 10 % IPM = 100 % (see Note 3)
6	Collectors ("headers") carbon steel	Top	Bevel – rounded	Computerized radiography and ultrasound with register = 100 % Magnetic Particles = 100 %
		Angle, type "corner joint"	Bevel – full or partial penetration(see Note 1)	Conventional ultrasound = 100 % Magnetic Particles = 100 % (see Note 1)
			Welds of different materials	Liquid penetrant = 100 %
		Angle	Bevel – partial penetration (e.g. nozzles) (see figures PW-16.1 and PW-16.2 of ASME BPVC - Section I)	Liquid penetrant = 100 %
		Angle	In angle of nozzles (see figures PW-16.1 and PW-16.2 of ASME BPVC - Section I)	Liquid penetrant = 100 %
		Angle	In bevel and in angle, from components not submitted to pressure	Liquid penetrant = 20 %

Table A.1 - Weld Inspection Requirements (Continued)

Item	Component	Types of joint	Types of welds	Type of inspection (see NOTE 2)
7	Collectors ("headers") carbon steel with heat treatment or steel alloy; Desuperheater	Angle, type "corner joint"	Bevel – full or partial penetration (see Note 1)	Computerized ultrasound with register = 100 % Magnetic particles = 100 % (see Note 1) Hardness measurement – 100 % (see Note 5) IPM = 100 % (see Note 3)
		Angle, type "corner joint"	Bevel – full or partial penetration (see Note 1)	Conventional ultrasound = 100 % Magnetic particles = 100 % (see Note 1), after heat treatment IPM = 100 % (see Note 3)
			Welds of different materials	Liquid penetrant = 100 % IPM = 100 % (see Note 3)
		Angle	Bevel – partial penetration (e.g. nozzles) (see figures PW-16.1 and PW-16.2 of ASME BPVC - Section I)	Liquid penetrant = 100 %
		Angle	In angle of nozzles (see figures PW-16.1 and PW-16.2 of ASME BPVC - Section I)	Liquid penetrant = 100 %
		Angle	In bevel and in angle, from components not submitted to pressure	Liquid penetrant = 100 %
8	Boiler external piping ("boiler external piping and joint" - figures PG-58.3.1 to PG-58.3.3 of ASME BPVC - Section I)	Top	Bevel – rounded	ASME B31.1 table 136.4 or radiography = 10 %, whatever is higher Liquid penetrant = 10 %
		Angle	Bevel – full penetration (e.g. nozzles) (see figures PW-16.1 and PW-16.2 of ASME BPVC - Section I)	Conventional ultrasound = 100 % Magnetic particles = 100 % (see Note 1)
		Angle	Bevel – partial penetration (e.g. nozzles) (see figures PW-16.1 and PW-16.2 of ASME BPVC - Section I)	Liquid penetrant = 100 %
		Angle	In angle of nozzles (see figures PW-16.1 and PW-16.2 of ASME BPVC - Section I)	Liquid penetrant = 100 %
		Angle	In bevel and in angle, from components not submitted to pressure	Carbon steel: visual inspection = 100 % Steel alloy or heat treatment magnetic particles = 100 % (see Note 1)

Table A.1 - Weld Inspection Requirements (Continued)

Item	Component	Types of joint	Types of welds	Type of inspection (see Note 2)
9	Non-boiler external piping ("non-boiler external piping and joint" - figures PG-58.3.1 to PG-58.3.3 of ASME BPVC - Section I)	All (top or angle)	All	According PETROBRAS N-115
10	Ducts	Top	Bevel - rounded and longitudinal	visual inspection = 100 % Liquid penetrant = 20 % for steel alloy
		Angle	In bevel and in angle, from components not submitted to pressure	visual inspection = 100 % Liquid penetrant = 100 % on supporting eye bolts
11	Chimney	All (top or angle)	All	According ASME STS 1. The field joints inspection shall be carried out at the same extent specified for manufacture joints
12	Metal structures	All (top or angle)	All	According PETROBRAS N-293
<p>NOTE 1 For welds in angle, where magnetic particles testing is not possible, liquid penetrant testing may be used.</p> <p>NOTE 2 For all types of welds visual inspection in 100 % of the length of the weld is compulsory.</p> <p>NOTE 3 The correct application of all steel alloy material shall be confirmed after erection through test by points or alloy analyzer (PIM - Positive Identification of Materials).</p> <p>NOTE 4 The acceptance criteria for NDEs shall be according to design code, except where otherwise indicated.</p> <p>NOTE 5 The following hardness limits are acceptable:</p> <ul style="list-style-type: none"> a) treated steel carbon and chrome-molybdenum steel alloys - see limits according to PETROBRAS N-268; b) chrome-molybdenum steel alloys, without heat treatment. Hardness consistent with that obtained during the qualification of welding procedure: tolerance $\pm 30\text{HB}/30\text{HV5}$ or HV10 in relation to the values obtained in the qualification of the procedure; c) austenitic stainless steels - do not require hardness testing. <p>NOTE 6 Acceptance criteria for NDE in accordance with the provisions under this Table, or according to the design where there is no indication.</p>				

Annex B - Figures

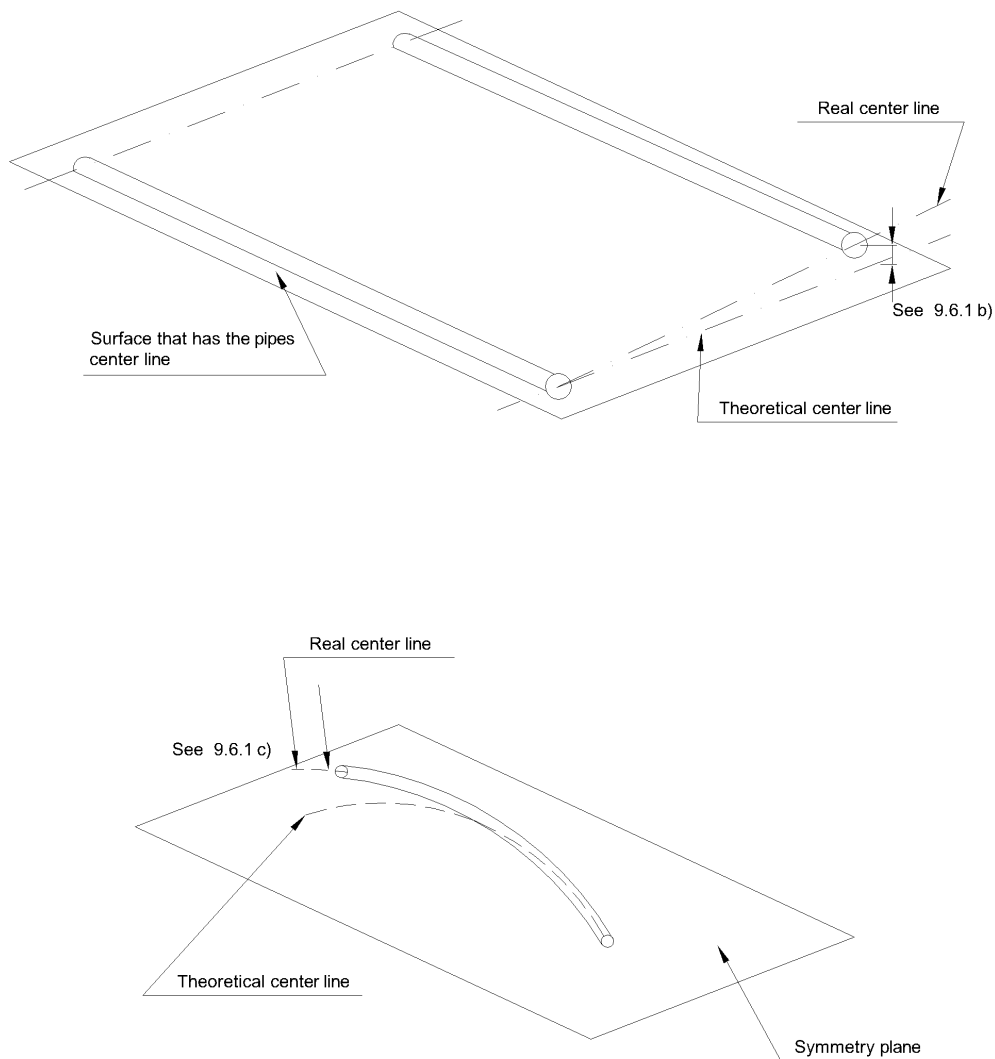


Figure B.1 - Spacing of the Pipes Center Line

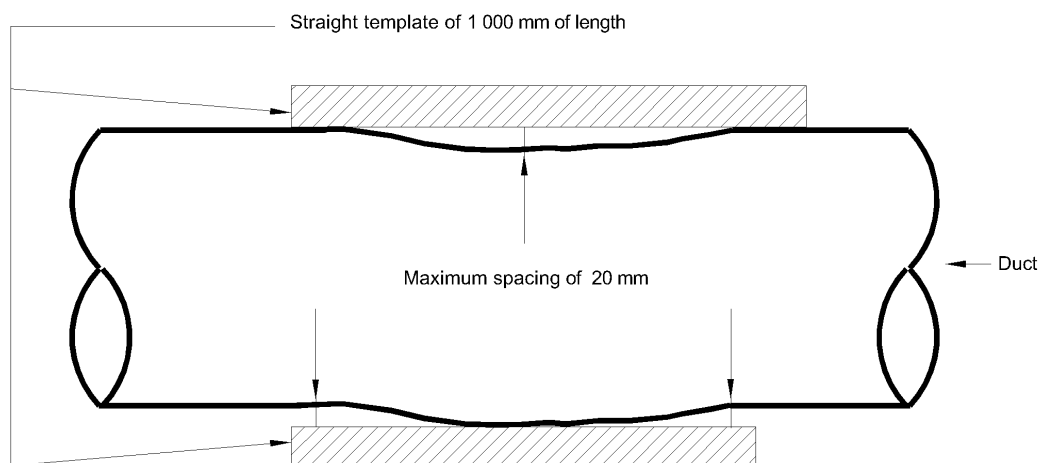


Figure B.2 - Maximum Spacing of Duct Generatrix or Face (See Item 5.20)

INDEX OF REVISIONS	
REV. A	
There is no index of revisions.	
REV. B	
Affected Parts	Description of Alteration
	Revalidation
REV. C	
Affected Parts	Description of Alteration
All	Revised
REV. D	
Affected Parts	Description of Alteration
1.5	Requirement change
2	Exclusion, inclusion and correction of the standards titles
3	Deletion of references, deletion of terms and revision in definition of terms. In item 3.7, revision of the definition, of "perceptible" to "imperceptible"
4.6	Normative reference change
5.12	Correction of numbering
5.12.3	Change of requirement (inclusion of "no impacts")
5.13.1 note	Change of reference to the figure, from "B.1" to "A.1"
5.15	Requirement change
6.4	Change of normative reference
6.12 b	Change of item reference from "5.2" to "5.1"
7.11	Requirement inclusion
9.12	Requirement change
9.14.2	Requirement change
12	Change in title and requirement
13	Change of reference to item of NR-13 from "13.1.6" to "13.4.1.6" and inclusion of requirement
Table A.1 item 5	Correction in the inspection type column, from "radiation" to "radiography"