

CONTEC

Comissão de Normalização
Técnica

SC-02

Tanks and Pressure
Vessels

Presentation of Pressure Vessel Design

Revalidation

Revalidated in 10/2022.

Title of Norma Regulamentadora nº 13 (NR-13) changed to "Caldeiras, Vasos de Pressão, Tubulações e Tanques Metálicos de Armazenamento"

Presentation of Pressure Vessel Design

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 System 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 System that uses this Standard. It is characterized by imperative nature.

For adoption of the Standard, the effective deadline for implementation to replace the previous review is up to 180 days from the date of its publication. If the Department of PETROBRAS System that is applying the Standard understands that it is not possible to implement it within this period, it must register an Implementation Plan within 180 days defining the necessary actions and the respective deadlines.

The definition of the effective deadline for implementing the requirements of this Standard, when it is referenced in contracts for the provision of services and acquisition of goods, is the exclusive prerogative of PETROBRAS.

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 specific application. The alternative adopted shall be approved and registered by the Department of PETROBRAS System that uses this Standard. It is characterized by verbs of a nonmandatory nature. It is indicated by the expression: **[Recommended Practice]**.

For the continuous improvement of the Standard, copies of the records of technical-managerial decisions prepared by the Departments of PETROBRAS System that may contribute to the improvement of this Standard are requested to be sent to the Authoring Subcommittee.

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Introduction

The PETROBRAS Technical Standards are prepared by Working Groups (WG), formed by experts from the PETROBRAS System, commented and voted on by the PETROBRAS System Units and approved by the Authoring Subcommittees (SC). The PETROBRAS Technical Standard is subject to review at any time by the SC and must be re-analyzed every 5 years to be revalidated, revised or canceled. PETROBRAS Technical Standards are prepared in accordance with PETROBRAS Technical Standard N-1. To see the collection, see PETROBRAS Technical Standards Catalog. ([click here](#))

CONTEC

Comissão de Normalização
Técnica

SC - 02

Tanks and
Pressure Vessels

Foreword

This Standard is the English version (issued in 04/2024) of PETROBRAS N-266 REV. G 10/2015 revalidated in 10/2022. 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 covers the requirements for presentation of pressure vessel design, prepared in accordance with PETROBRAS [N-253](#).

1.2 This Standard is applicable to vessels designed as of its date of issuance.

1.3 This Standard contains only Technical Requirements.

2 Normative References

The documents listed below are essential for the application of this document. For dated references, only the mentioned editions apply. For undated references, the most recent editions of the aforementioned documents are applied.

[NR-13](#) - Caldeiras, Vasos de Pressão, Tubulações e Tanques Metálicos de Armazenamento;

Resolução CONMETRO [Nº 12](#) de 12/10/1988 - Adoção do Quadro Geral de Unidades de Medida e Emprego de Unidades do Sistema Internacional de Unidades;

PETROBRAS [N-75](#) - Abbreviations for Industrial Designs;

PETROBRAS [N-253](#) - Pressure Vessel Design;

PETROBRAS [N-268](#) - Pressure Vessel Fabrication;

PETROBRAS [N-269](#) - Pressure Vessel Assembly;

PETROBRAS [N-381](#) - Engineering Technical Documents Templates;

PETROBRAS [N-466](#) - Projeto de Trocador de Calor Casco e Tubo;

PETROBRAS [N-1281](#) - Projeto, Fabricação e Montagem de Esfera;

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

PETROBRAS [N-1492](#) - Trocador de Calor Casco e Tubo - Folha de Dados;

PETROBRAS [N-1500](#) - Pressure Vessel - Data Sheet;

PETROBRAS [N-1520](#) - Storage Sphere - Data Sheet;

PETROBRAS [N-1556](#) - Vaso de Pressão - Requisição de Material;

PETROBRAS [N-1557](#) - Trocador de Calor - Requisição de Material;

PETROBRAS [N-1586](#) - Air Cooler - Data Sheet;

PETROBRAS [N-1704](#) - Additional Requirements for Pressure Vessels for Hydrogen Service;

PETROBRAS [N-1706](#) - Requisitos Adicionais para Vaso de Pressão em Serviço com H₂S Úmido;

PETROBRAS [N-1707](#) - Projeto de Vaso de Pressão com Revestimento;

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

PETROBRAS [N-1817](#) - Resfriador a Ar - Requisição de Material;

PETROBRAS [N-1858](#) - Projeto e Fabricação de Resfriador a Ar;

PETROBRAS [N-1862](#) - Projeto e Fabricação de Acessórios Internos de Vasos, Torres e Reatores;

PETROBRAS [N-2054](#) - Acessórios Externos e Internos de Vaso de Pressão;

PETROBRAS [N-2090](#) - Internos para Vaso de Pressão - Requisição de Material;

PETROBRAS [N-2092](#) - Esfera de Armazenamento - Requisição de Material;

PETROBRAS [N-2301](#) - Elaboração da Documentação Técnica de Soldagem;

ASME - BPVC [Section VIII](#) - Rules for Construction of Pressure Vessels - Division 2 - Alternative Rules;

[TEMA](#) - Standards of the Tubular Exchanger Manufacturers Association.

3 Terms and Definitions

For the purposes of this Standard, the terms and definitions indicated herein are applicable.

3.1

analytical design

it is the thermal and process design, where there shall be the indication of: nature, makeup and the properties of all fluid streams in ward or outward of the vessel

3.2

mechanical design

it is the mechanical structural sizing of the pressure vessel. The mechanical design shall be based on the analytical design (process and thermal design) and on selection of materials

3.3

fabrication design

it is the complete detailing of vessels for fabrication, including assembly details and all definitions and data prescribed in this Standard

3.4

designer

company or organization responsible for preparing the mechanical design and/or fabrication design of the pressure vessel. In cases where the mechanical design and the fabrication design are each done by a different organization, the term "designer" applies to each of these entities

3.5

Material Requisitions (RM)

the RM of the pressure vessel is document that defines the scope of supply of the equipment

4 General Requirements

4.1 This Standard shall be referenced or attached to all RM or Contracts for the design or purchase of any pressure vessel.

4.2 The drawings and other documents comprising the mechanical design and fabrication design shall be prepared in accordance with PETROBRAS [N-381](#). All set or assembling drawings shall have the "north of design" coinciding with 0° direction of vessel orientation.

4.3 The abbreviations in PETROBRAS [N-75](#) and the welding terminology of PETROBRAS [N-1438](#) shall be used.

4.4 In all the design, the measurement units which are legal in Brazil shall be used, in accordance with CONMETRO's Resolution [N° 12](#). The use of English units is allowed only for specification of nominal pipe diameters and pipe fittings, laminated angles, bolts and nuts. The use of other units is allowed in parenthesis in sets with those already mentioned.

4.5 Drawings and other technical engineering documents shall be identified in accordance with PETROBRAS [N-1710](#), except as otherwise specified by PETROBRAS.

4.6 The RM shall be prepared in accordance with the form which is standardized by the PETROBRAS [N-1556](#), [N-1557](#), [N-1817](#), [N-2090](#), [N-2092](#). The RM shall indicate the review or the date of issuance of the mentioned standards. In case there is no mention, the issues which were in force at the date of applicable issuance or review by RM are applied.

4.7 The approval of the mechanical design or fabrication design by PETROBRAS or by any firm hired by PETROBRAS shall not eliminate or reduce the responsibility of the equipment designer, who shall always remain fully responsible for the design considering his scope of supply.

5 Presentation of Mechanical Design

5.1 The mechanical design shall comply with PETROBRAS [N-253](#), [N-466](#), [N-1281](#), [N-1704](#), [N-1706](#), [N-1707](#), [N-1858](#) e [N-1862](#), according to the case.

5.2 Drawings of the Mechanical Design

The drawings shall be prepared in accordance with the forms standardized by the PETROBRAS [N-1492](#), [N-1500](#), [N-1520](#) and [N-1586](#), including the details standardized by the PETROBRAS [N-2054](#) and [N-2159](#), containing at least the information described in from 5.2.1 to 5.2.37.

NOTE For heat exchangers, fluid information for both equipment circuits shall be supplied.

5.2.1 Vessel Service.

5.2.2 Indication of special service (examples: H₂S, H₂ etc.).

5.2.3 Fluids.

5.2.4 Fluid(s) Density(ies)

5.2.5 Normal Elevation of the operating level of the fluid (for vessels operating partially full).

5.2.6 Operating pressure and temperature.

5.2.7 Design pressure and temperature.

5.2.8 Hydrogen partial pressure (in the case of vessels for hydrogen service or with fluids containing hydrogen).

5.2.9 Minimum Design Metal Temperature (MDMT)]: design and calculated.

5.2.10 Set pressure of pressure relief valve for overpressure protection.

5.2.11 MAWP - Maximum Allowable Working Pressure.

5.2.12 Part which limits the MAWP (shells, heads, nozzles and others).

5.2.13 Hydrostatic test pressure, measurement point and test location (factory or field).

5.2.14 Standards or codes for design, fabrication, inspection and test of equipment, with indication of edition and addenda.

5.2.15 Corrosion allowance (for each service and each material).

5.2.16 Quantity, diameter, thickness, distances and layout of tubes in the tube bundle.

5.2.17 Number of passes in shell side and tube side

5.2.18 Number, cross-section and arrangement of baffles and impingement baffles.

5.2.19 Type of tube-to-tubesheet joint.

5.2.20 Postweld Heat Treatments required and for which parts.

5.2.21 Impact test: required or not, with indication of parts to which they are applied, and the standard to be complied and the test temperature.

5.2.22 Joint efficiencies adopted for each pressurized parts.

5.2.23 Welding examinations: type of exam, extension (partial or total), indicating the parts to which they are applied.

5.2.24 Indication of thermal insulation or refractory lining, specifying material, thickness and purpose.

5.2.25 Indication of anti-corrosive lining, specifying material and thickness.

5.2.26 Weights of equipment when empty without removable internals, when in operation and when full of water; weights of internal and external parts and weights of insulation and refractory linings and maximum shear force and maximum moments over the base.

5.2.27 Diagram of loads on foundations, containing:

- a) magnitude, orientation and direction of all forces and moments imposed by the equipment on its foundations in any situation of normal or occasional operation, during the hydrostatic test, assembly and maintenance; these forces and moments shall refer to 3 orthogonal coordinate axes, one of the axes coinciding with the vessel's centerline;
- b) amplitude and frequency of vibrations transmitted to the foundations, if applicable.

NOTE Loads due to field hydrostatic testing, in the operating position, shall be reported even when [NR-13](#) exempts the field hydrostatic test.

5.2.28 Supply requirement of the equipment: one-piece or sectioned.

5.2.29 Complete specification of all vessel materials (shell and head) and all vessel parts and accessories (fittings), such as: flanges, nozzles, supports, tubesheets and internal tubes, internal and external parts, bolts, gaskets and lining; the specification shall be done with the full identification according to the standardization organization (ABNT, ASME, ASTM, API and others), including class, type and grade of material.

5.2.30 Selection of the type of heads, if not defined due to process requirements.

5.2.31 Dimension of the vessel (diameters, thicknesses, lengths, curvature radii, distances, elevations and others), of accessories and of internal and external parts.

5.2.32 Dimensions and thicknesses of supports and base plates: skirt, legs, saddles, lugs and other supports.

5.2.33 Location, type and diameter of anchor bolts.

5.2.34 Locations (elevation, projection and orientation) of nozzles, manholes, instrument, internal and external parts, and others.

5.2.35 Nozzles List, containing: item, diameter, quantity, service description; flange pressure rating, thickness, flange type, flange face type.

5.2.36 Category of the pressure vessel according to [NR-13](#).

5.2.37 Location of skirt, legs, saddles or other supports of the equipment with the position and dimensions of the holes for anchor bolts.

5.3 Calculation Reports

Calculation reports shall contain at least the items described in from 5.3.1 a 5.3.19.

NOTE 1 All calculation notes shall clearly indicate the standards, calculation criteria and formulas adopted, as well as show the calculations clearly enough to allow them to be checked.

NOTE 2 For computer calculations through proprietary or commercial software, the following information shall be presented:

- a) name of the software;
- b) author of the software;
- c) programming language in which the software is written;
- d) description of the software, indicating all calculation methods and criteria used, including basic bibliographical references used and history of use, if any;
- e) description of print-outs of results, including all formats used and definition of all input and output variables;
- f) input data print-outs;
- g) print-outs of results;
- h) validation report for each software used.

5.3.1 Vessel's complete (structural) mechanical calculation, for internal and/or external pressure, including thicknesses and other dimensions:

- a) thicknesses due to internal or external pressure of: shells, heads, pipes, nozzle necks, tubesheets, transition parts;
- b) thicknesses and other dimensions of skirts, saddles, legs, tie rods, base plate, anchoring ring and anchor bolts;
- c) thicknesses and other dimensions of nozzle reinforcements, local pad reinforcements for concentrated loads and reinforcement rings for external pressure;
- d) flange dimensions (including blind flanges) for the shell of the equipment or for nozzles and manholes. The calculation of these flanges is not required for flanges conforming flange standard;
- e) thicknesses and other dimensions of supports of internals (trays, pans, beds and others);
- f) check of nozzle welds;
- g) torque for tightening flanged connections, in non-standardized flanges or when required.

NOTE Components subjected to a mechanical forming process, for example heads, shall be informed of the minimum thickness after forming.

5.3.2 Determination of joint efficiencies for welded joints.

5.3.3 Selection of flange type of nozzles and manholes, pressure rating, type of raised face, flange facing finishes and the gasket.

5.3.4 Calculation of wind loads.

5.3.5 Calculation of the natural period and maximum deflection for columns.

5.3.6 Calculation of Maximum Allowable Pressure (MAP) for new and cold condition.

5.3.7 Calculation of MAWP for hot and corroded condition.

5.3.8 Calculation of the hydrostatic test pressure, including in the operating position, even when [NR-13](#) exempts the field hydrostatic test.

5.3.9 Calculation of the weights of the vessel when empty, when in operation, when in shutdown and during a hydrostatic test.

5.3.10 Stress analysis on vessel nozzles, due to piping reactions and other external loads.

5.3.11 Stress analysis due to concentrated loads, such as: platform, piping supports or other loads.

5.3.12 Stress analysis with subsequent buckling analysis and/or fatigue, when required.

5.3.13 Calculation of nozzle displacement due to thermal expansion loads, when required.

5.3.14 Special analyses (example: dynamic and fluency), when required.

5.3.15 Determination of requirement for Postweld Heat Treatment with indication of PWHT temperature.

5.3.16 Determination of requirement for impact test with indication of temperature.

5.3.17 Calculation of the Minimum Design Metal Temperature (MDMT).

5.3.18 Calculation of displacement of internal parts due to thermal expansion loads, when applicable.

5.3.19 For equipment designed in accordance with ASME BPVC [Section VIII Division 2](#), there is always the requirement of an evaluation of need or exemption for fatigue analysis as per Part 5 of ASME BPVC [Section VIII Division 2](#), regardless of the amount of operation cycles, of shutdown and startup.

5.4 When a stress analysis using the finite element method is required, the analysis calculation report shall be sent for approval and contain at least the following information:

- a) description of the analysis:
 - type of analysis performed;
 - finite element program used and its version;
- b) input data for analysis:
 - design and operating conditions of the equipment;
 - specification of materials (including refractories and thermal insulation);
- c) model data:
 - description of the finite element model;
 - justification of the simplifications adopted (e.g. symmetry, plane state and others.);
 - types of elements used;
 - average size of the elements in the regions of interest and complete description of the criteria and controls adopted in defining the mesh;
 - material properties (varying with temperature when applicable);
 - plots of the geometric model;
 - loads and load case combinations in each simulated case (force loads, surface loads, inertia loads and others);
 - boundary conditions adopted in each simulated case (symmetry, anti-symmetry, contacts, coupling of degrees of freedom and others);

- plots showing the loads and boundary conditions.
- d) results:
 - plots and summary lists of results (displacements, stress components, principal stresses, equivalent stresses and others), for each case of loading combination defined for the model, identifying the maximum values obtained, considered important for analyzing the results, and compare them with the allowable limits;
 - the allowable stress shall be informed for each loading case;
 - demonstrate that some results obtained are compatible with analytical calculations, experimental data or literature results;
 - analysis conclusions for the assessed load case.

NOTE 1 Stress analysis using the finite element method shall be in accordance with the procedures of Part 5 of ASME BPVC [Section VIII Division 2](#). In the case of an equipment component constructed according to ASME BPVC [Section VIII Division 1](#), the allowable stress values shall correspond to those of Table 1A and 1B of ASME BPVC [Section II Part D](#).

NOTE 2 When there is a contractual document establishing the minimum requirements for preparing the stress analysis report, it shall be used as a complement to the requirements listed above.

5.5 When applicable, the mechanical design shall present specifications and procedures containing requirements or recommendations relative to:

- a) special processes of welding and examinations;
- b) special postweld heat treatments;
- c) special linings;
- d) unusual dimensional tolerances;
- e) welding or assembly sequence;
- f) special disassemblies;
- g) other requirements which are not covered by the standards.

6 Presentation of the Fabrication Design

6.1 Documents of the Fabrication Design

The fabrication design of pressure vessels shall include the following documents:

- a) drawings of the mechanical design, as in 5.2;
- b) diagram of loads over foundations, as in 5.2;
- c) calculation reports, as in 5.3;
- d) fabrication drawings, as in 6.2;
- e) detail drawings on welding and welding examinations, as in 6.3;
- f) specifications and procedures, as described in 5.4.

NOTE The assembly and fabrication documents shall be prepared according to PETROBRAS [N-268](#) e [N-269](#), respectively.

6.2 Fabrication Drawings

Drawings shall be made in as many views, cross-sections and details as necessary in order to show, at least, what is described in from 6.2.1 to 6.2.20.

6.2.1 Internal diameter and length of each cylindrical shell or reducer section.

6.2.2 Thicknesses of all shells, heads, nozzle necks and all other parts.

6.2.3 Type of heads and curvature radii of heads (when they are hemispherical or torispherical) and of the transition or reducer sections.

6.2.4 Dimensions and thicknesses of external or internal reinforcements.

6.2.5 Position, elevation, orientation and projection of all vessel nozzles and manholes.

6.2.6 Nominal diameter, type, pressure rating, facing and dimensional standard of all flanges, both on the vessel shell and on nozzles and manholes, in the case of standard flanges. In the case of non-standard flanges, all flange dimensions shall be included.

6.2.7 Nominal diameter, type, pressure rating, type of coupling and other nozzles for socket weld.

6.2.8 Dimensions and complete details of all nozzles for butt weld or other non-conventional types, and of other accessories.

6.2.9 Dimensions and thicknesses of skirts and legs for vertical vessels and spheres and of web plates and wear plates of saddles for horizontal vessels, as well as dimensions and thicknesses of base plates in any case. For saddles, it is necessary to indicate distance between saddles, number, dimensions and thicknesses of reinforcements and angles covered by the web plate and wear plate.

6.2.10 Quantity, diameter, projection and position of anchor bolts.

6.2.11 Position, elevation, orientation and detail drawing of all rings, lugs, bolts and other attachment devices of ladders, platforms, piping, instruments, thermal insulation, refractory lining and others.

6.2.12 Position, elevation, orientation and detail drawing of davits or other load lifting devices.

6.2.13 Location and type of all welds, including longitudinal and circumferential welds, welds on heads, flanges, nozzle necks, reinforcement plates, skirts, saddles, legs, internal and external parts and others. The details of all these welds shall be shown on the drawings referred to in 6.3.

6.2.14 Complete dimensions, thicknesses and all details of internal parts such as trays, support rings and supporting beams of trays, bubble caps, distributors, weirs, baffles, impingement baffles, tubesheets, tube bundles, internal supports, manholes, hatches and internal passages, internal lining and others.

6.2.15 Listing of all parts, duly identified on drawings, indicating specification of material, thickness, dimension and weight.

6.2.16 Drawings of ladders and platforms, when applicable.

6.2.17 Drawing of tools for opening of channel and removal of the special heat exchangers bundle, when applicable.

6.2.18 Drawing of the cage-type thermal insulation supporting device for pressure vessels (reactors) with restriction to welding supporting rings directly on their shell material.

6.2.19 Drawing of the sphere cooling system.

6.2.20 Drawing of the nameplate as in PETROBRAS standard.

6.3 6.3 Drawings and Details of Welding and Welding Examination

6.3.1 Documents shall be presented with a drawing, welding details and requirements for welding examination of all welds of the vessel. These documents shall be prepared in accordance with guidance from PETROBRAS [N-2301](#).

6.3.2 For the sphere, a detail drawing of the welding sequence to be used in its construction shall be presented, covering the welding of the shell, the nozzles and the structures.

INDEX OF REVISIONS

REV. A, B, C and D

There is no Index of Revisions.

REV. E

Items Revised	Summary of Changes
	Revalidated.

REV. F

Items Revised	Summary of Changes
All	General Revision

REV. G[illegible]