

CONTEC

Comissão de Normalização
Técnica

SC-02

Tanks and Pressure
Vessels

**Additional Requirements for
Pressure Vessels for Hydrogen
Service**

Revalidation

Revalidated in 03/2022.

Additional Requirements for Pressure Vessels for Hydrogen Service

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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Introduction

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

Foreword

This Standard is the English version (issued in 05/2014) of PETROBRAS N-1704 REV. D 05/2013. 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 establishes additional requirements for the design, fabrication and erection of carbon steel pressure vessels, with or without clad, for H₂ Service.

1.2 Pressure vessels for hydrogen service shall comply with all of the requirements set forth in standards PETROBRAS [N-253](#), [N-268](#), [N-269](#), [N-466](#) e [N-1707](#), besides the criteria established in this Standard. In case of conflict, the criteria in this Standard shall prevail.

1.3 This Standard shall be used with the standard API [RP 941](#), and, in case of conflict, the requirements of this Standard shall prevail.

1.4 For pressure vessels fabricated in materials different from carbon steel, the requirements of basic design specific documents mentioned in RM of the pressure vessel and the General Requirements described in Section 7 of this Standard shall be followed.

1.5 This Standard applies to pressure retaining parts of pressure vessel in contact with fluid, resulting in the characterization of "H₂ Service".

1.6 In heat exchangers, when only one of the circulating fluids fits in the "H₂ Service" classification, the requirements of this Standard shall only apply to parts in contact with such fluid.

1.7 This Standard applies to pressure vessel designs started as of its date of issuance.

1.8 This Standard contains Technical Requirements and Recommended Practices.

2 Normative References

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

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

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

PETROBRAS [N-253](#) - Projeto de Vaso de Pressão;

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

PETROBRAS [N-269](#) - Montagem de Vaso de Pressão;

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

PETROBRAS [N-1593](#) - Ensaio não Destrutivo - Estanqueidade;

PETROBRAS [N-1594](#) - Ensaio não Destrutivo - Ultrassom em Solda;

PETROBRAS [N-1595](#) - Ensaio não Destrutivo - Radiografia;

PETROBRAS [N-1596](#) - Ensaio não Destrutivo - Líquido Penetrante;

PETROBRAS [N-1597](#) - Ensaio não Destrutivo - Visual;

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

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

PETROBRAS [N-1859](#) - Qualificação de Consumíveis de Soldagem;

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

API [RP 941](#) - Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants;

ASME [BPVC Section II - Part A-1](#) - Boiler and Pressure Vessel Code - Section II - Ferrous Material Specifications (Beginning to SA-450) Materials;

ASME [BPVC Section II - Part A-2](#) - Boiler and Pressure Vessel Code - Section II - Ferrous Material Specifications (SA-451 to End) Materials;

ASME [BPVC Section II - Part A - SA-105/SA-105M](#) - Standard Specification for Carbon Steel Forgings for Piping Applications;

ASME [BPVC Section II - Part A - SA-106/SA-106M](#) - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service;

ASME [BPVC Section II - Part A - SA-234/SA-234M](#) - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service;

ASME [BPVC Section II - Part A - SA-266/SA-266M](#) - Standard Specification for Carbon Steel Forgings for Pressure Vessel Components;

ASME [BPVC Section II - Part A - SA-388/SA-388M](#) - Standard Practice for Ultrasonic Examination of Steel Forgings;

ASME [BPVC Section II - Part A - SA-516/SA-516M](#) - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service;

ASME [BPVC Section II - Part A - SA-578/SA-578M](#) - Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications;

ASME [BPVC Section II - Part C](#) - Specifications for Welding Rods, Electrodes, and Filler Metals - Materials;

ASME [BPVC Section V](#) - Boiler and Pressure Vessel Code - Section V - Nondestructive Examination;

ASME [BPVC Section VIII Division 1](#) - Boiler and Pressure Vessel Code - Section VIII - Division 1: Rules for Construction of Pressure Vessels;

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

ASME [BPVC Section IX](#) - Boiler and Pressure Vessel Code - Section XI - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators Welding and Brazing Qualifications;

ASTM [A262](#) - Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels;

ASTM [A833](#) - Standard Practice for Indentation Hardness of Metallic Materials by Comparison Hardness Testers;

ASTM [A1038](#) - Standard Test Method for Portable Hardness Testing by the Ultrasonic Contact Impedance Method;

ASTM [E10](#) - Standard Test Method for Brinell Hardness of Metallic Materials;

ASTM [E384](#) - Standard Test Method for Knoop and Vickers Hardness of Materials;

BS [EN 10160](#) - Ultrasonic Testing of Steel Flat Product of Thickness Equal or Greater than 6 mm (Reflection Method).

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 document, the following terms and definitions are applicable.

3.1

minimum PWHT

Specified heat treatment, considering all fabrication heat treatments provided in construction and assembly phases of pressure vessel, including the final PWHT

3.2

maximum PWHT

Specified heat treatment, considering all fabrication heat treatments provided in construction and assembly phases of pressure vessel, including the final PWHT and, at least, an additional PWHT, for further use of PETROBRAS

NOTE It is recommended the provision of a PWHT for repair during fabrication. **[Recommended Practice]**

3.3

simulated PWHT

Heat treatment performed on test specimens to check on the influence of PWHTs performed in the raw material acquisition, welding procedure qualification, manufacturing, erection, maintenance phases, on the mechanical properties of base metals, consumables and welds

4 Symbols or Acronyms

CE	- Carbon Equivalent;
NDT	- Non-destructive Test;
WPS	- Welding Procedure Specification;
RT	- Radiographic Test;
HB	- Brinell Hardness;
HV	- Vickers Hardness;
PT	- Penetrant Test;
INMETRO	- Instituto Nacional de Metrologia, Qualidade e Tecnologia;
OAC	- Conformity Assessment Body;
OCP	- Product Certification Body;
MT	- Magnetic Particle Test;
RM	- Material Requisition;
WPQR	- Welding Procedure Qualification Record;
SBAC	- Sistema Brasileiro de Avaliação de Conformidade;

PWHT	- Post Weld Heat Treatment;
UT	- Ultrasonic Test;
HAZ	- Heat Affected Zone.

5 Service Indication

5.1 All technical design, fabrication and erection documents for pressure vessels shall include the indication: "HYDROGEN SERVICE". The partial hydrogen pressure shall also be indicated to complement the other data of the equipment.

5.2 The pressure vessel nameplate shall also include the indication: "HYDROGEN SERVICE".

6 Hydrogen Service Classification

The equipment in H₂ service shall be characterized by the responsible for basic design, considering the following factors:

- a) H₂ content;
- b) total pressure;
- c) partial H₂ pressure;
- d) temperature.

7 General Requirements

7.1 For any vessel in hydrogen service, all pressure retaining parts shall have fully killed carbon steel as the minimum quality of materials. This requirement does not apply to heat exchanger tubes.

7.2 For hydrogen partial pressures over 90 MPa (917 kgf/cm²), a clad or a solid wall of austenitic stainless steel shall be used.

7.3 All heat exchange tubes shall be seamless.

7.4 When clad plate is used, the base material shall also be selected for hydrogen service.

7.5 The tube to tubesheet connection in heat exchangers shall be made by full strength weld, as defined in ASME [BPVC Section VIII Division 1](#) UW-20.2 (a) or in ASME [BPVC Section VIII Division 2](#) paragraph 4.18.10.2(a), given that:

- a) Figure UW-20.1 (a) and Figure 4.18.13 (a) are not allowed;
- b) for Figures UW-20.1 (b), (c) and (d), and Figures 4.18.13 (b), (c) and (d), the bevel shall be "J-type";
- c) Figure UW-20.1 (b) and Figure 4.18.13 (b) are only applied to vertical exchangers.

7.6 All welds of pressure retaining parts and internal accessories shall be of full penetration type. When the use of full penetration weld is not technically feasible, the constructive detail shall be submitted to prior approval of PETROBRAS.

NOTE The use of constructive details resulting in crevices in contact with fluid is not allowed.

7.7 For external accessories welded to shell, the entire space confined by welds shall be ventilated by an external hole of $\varnothing 1/8"$.

7.8 For nozzle necks fabricated from plates, the same requirements for pressure retaining part plates are applied.

7.9 Threaded connections are prohibited.

7.10 No weld may be performed after PWHT, even when it is allowed by the Design Code.

7.11 The use of slip-on flanges is not allowed in any situation. All flanges shall be welding neck or long welding neck. For flanges of 14" diameter or larger, the use of ring type flanges is allowed, as long as the connection weld between the flange on neck or on tube is of full penetration type, as shown in Figure 2-4 (7) of ASME [BPVC Section VIII Division 1](#), APP 2. Small nozzles ($D < 2"$) shall be long welding neck.

7.12 Nozzle reinforcements shall be of one of the types shown in Figure UW-16.1 (c), (d), (e), (f) and (g) or according to Figure UHT 18.1 of ASME [BPVC Section VIII Division 1](#), or Table 4.2.10 details (3), (4) and (6), and Table 4.2.13 (all details) of code ASME [BPVC Section VIII Division 2](#).

7.13 All external nozzles connected to piping shall have finishing of face according to standard PETROBRAS [N-76](#).

7.14 All nozzles not connected to any piping shall be flanged and closed with blind flange, whatever their diameter or purpose is. If there is a valve in nozzle, the valve shall also be closed with blind flange. Flanges with pressure class 600 or higher shall have face for ring-type joint.

8 Raw Material Requirements

8.1 General

8.1.1 For pressure vessels with toughness requirement, the pressure retaining part materials (ex: plates, forgings, connections etc.) shall be tested after minimum and maximum PWHT simulations, and the mechanical properties of ASME [BPVC Section II Part A-1](#) and [BPVC Section II Part A-2](#) (tensile strength, yield strength and elongation) shall be met. The toughness values shall comply with the values established in ASME [BPVC Section VIII Division 1](#) or [Section VIII Division 2](#).

8.1.2 For pressure vessels with toughness requirement, the welding consumables shall be tested after minimum and maximum PWHT simulations, and shall comply with the same base metal properties specified in 8.1.1.

8.2 Plates

- a) the plates shall be made of carbon steel ASME [BPVC Section II - Part A - SA-516/SA-516M](#), supplied in fully killed condition;
- b) plates shall be preferably normalized; however, cooling rates above those obtained by air cooling are allowed, as long as the plates are subsequently tempered in temperature range from 595 °C to 705 °C;
- c) the following chemical composition restrictions are applicable:
 - carbon equivalent:
 - thicknesses ≤ 25 mm: maximum CE = 0.43
 - thicknesses > 25 mm: maximum CE = 0.45

Carbon Equivalent Formula (CE):

$$CE = C + \frac{Mn}{6} + \frac{(Cr + Mo + V)}{5} + \frac{(Ni + Cu)}{15}$$

- other elements:
 - Nb + V ≤ 0.015%

8.2.1 UT Test

Plates shall be inspected according to BS [EN 10160](#) class S2 / E4.

8.2.2 Clad Carbon Steel Plates

If clad plates are used, including coatings by weld overlay, the fabrication shall comply with PETROBRAS [N-1707](#) standard, and the base material plate shall meet the same requirements indicated in item 8.2.

8.3 Forgings, Pipes and Piping Accessories

- a) any accessory manufactured from plates shall meet the requirements listed in item 8.2 (ex.: seamed pipes manufactured from plates);
- b) other accessories shall comply with the specifications of ASME [BPVC Section II - Part A - SA-105/SA-105M](#), [SA-106/SA-106M](#), [SA-234/SA-234M](#) and [SA-266/SA-266M](#), with supplementary requirements:

8.3.1 Chemical composition limits

- a) carbon ≤ 0.30 %;
- b) carbon equivalent (CE calculation as defined in item 8.2.1):
 - Thicknesses ≤ 25 mm: maximum CE = 0.43
 - Thicknesses > 25 mm: maximum CE = 0.45

NOTE For forgings, consider the greater thickness.

8.3.2 All forgings shall be manufactured by hot forging, or by hot forging and then normalized.

8.3.3 The hardness of forgings, pipes and pipe accessories shall comply with the respective specification ASME [BPVC Section II Part A-1](#) and [Part A-2](#). However, the hardness shall be below 237 HB.

8.3.4 All forgings with nominal inside diameter $\geq 12"$ shall be 100 % UT tested, in accordance with ASME [BPVC Section II - Part A - SA-388/SA-388M](#), with straight beam and angle beam techniques. For straight beam examination, the sensitivity shall be established by the bottom reflection technique, and for the angle beam by a 60° V notch. Rejection levels shall be as specified in the applicable appendix of the ASME [BPVC Section VIII Division 1](#).

8.4 Bolts and Nuts

When in contact with fluid containing H₂, bolts and nuts shall have hardness below 237 HB.

8.5 Welding Consumables

8.5.1 The purchase, receipt, and acceptance of welding consumables shall meet the requirements of standard PETROBRAS [N-133](#).

8.5.2 For pressure vessels with toughness requirement, the welding consumable qualification shall comply with standard PETROBRAS [N-1859](#) for welding consumables with property assured in the lot.

8.5.3 For other cases, the welding consumable qualification shall comply with standard PETROBRAS [N-1859](#) for welding consumables for general application.

8.5.4 For welding consumables applied in Brazil, certified by an OCP, such as the OAC accredited by INMETRO under SBAC, the trademark does not constitute an essential variable for welding procedure qualification.

8.5.5 For welding consumables applied abroad, the trademark constitutes an essential variable for welding procedure qualification.

8.5.6 The welding consumable supplier shall define the conditions for treatment, storage, handling, use and control of welding consumables. The requirements of standard PETROBRAS [N-133](#) shall be met as minimum conditions.

9 Post Weld Heat Treatment

9.1 All pressure vessels shall undergo PWHT.

9.2 The PWHT procedure shall be prepared and submitted to PETROBRAS, in accordance with standard PETROBRAS [N-268](#) or PETROBRAS [N-269](#).

9.3 The PWHT procedure shall comply with code ASME, except that the level temperature shall be between 620 °C and 640 °C. The raw material supplier, after presentation of technical reason to PETROBRAS in advance, may propose the use of lower temperatures which ensure the mechanical properties of tension, toughness and hardness specified in this Standard.

9.4 When clad plates are used, stabilized austenitic stainless steels or low carbon content steels approved in ASTM [A262](#) Practice E Intergranular Corrosion Test shall be used, including for welding procedure qualification. In this case, the requirements of standard PETROBRAS [N-1707](#) shall also be considered.

10 Welding Procedure Qualification

10.1 Welding procedure qualification shall be performed in accordance with the Design Code of the pressure vessel (example: ASME [BPVC Section VIII Division 1](#) and [Division 2](#), [BPVC Section IX](#)) and standard PETROBRAS [N-133](#), and documented as per PETROBRAS [N-2301](#). The material used for procedure qualification shall meet at least the requirements of item 8.2.1.

10.2 For welding procedure qualification, the carbon equivalent of the base material shall be considered an essential variable, allowing a range of ± 0.03 in relation to the one used in qualification.

10.3 The procedure qualification tests shall also comply with the requirements set forth in Table 1.

Table 1 - Welding Procedure Qualification Requirements

Test	Condition of Simulated PWHT (see NOTE 5)
Chemical analysis (see NOTE 1)	Minimum or maximum PWHT
Hardness (see NOTE 2)	Minimum and maximum PWHT
Tension (see NOTE 3)	Minimum and maximum PWHT
Bending	Minimum and maximum PWHT
Impact (when applicable, see NOTE 4)	Minimum and maximum PWHT
ASTM A262 Practice E Test (clad plates or weld overlay)	Maximum PWHT
<p>NOTE 1 The chemical composition of deposited metal shall be checked and comply with ASME BPVC Section II - Part C for base metal and, when applicable, for coating.</p> <p>NOTE 2 Hardness testing of test specimens for qualification shall be performed in accordance with the hardness profile suggested by standard PETROBRAS N-133, according to the bevel to be used, and the hardness values shall not exceed:</p> <p>a) weld metal: maximum of 200 HB (if measured according to ASTM E10 or A833) or average of 210 HV5 and maximum of 248 HV5 for individual value (if measured according to ASTM A1038 or E384 for bench hardness tester);</p> <p>b) HAZ: average of 210 HV5 and maximum of 248 HV5 for individual value (if measured according to ASTM A1038 or E384 for bench hardness tester).</p> <p>NOTE 3 Acceptance criterion according to ASME BPVC Section IX;</p> <p>NOTE 4 The need for an impact test shall be checked in accordance with ASME BPVC Section VIII Division 1 or Division 2.</p> <p>NOTE 5 Perform two different WPQRs, one for maximum PWHT condition (if a simulation of PWHT is required – see 8.1 of this Standard) and another for minimum PWHT condition.</p>	

10.4 The total time of each PWHT may be simulated in one single cycle (single level).

10.5 All welding procedure qualification tests shall be monitored, performed and approved by qualified personnel, in accordance with requirements of standard PETROBRAS [N-133](#).

11 Non-destructive Tests (NDT)

11.1 NDT Procedure Qualification

NDT procedures and inspectors shall be qualified according to the requirements of standards PETROBRAS [N-1593](#), [N-1594](#), [N-1595](#), [N-1596](#), [N-1597](#) and [N-1598](#).

11.2 Radiographic Test

11.2.1 All welds subjected to pressure, in contact with fluid containing H₂, shall be 100 % RT, in accordance with the requirements of ASME [BPVC Section V](#). Acceptance criteria shall comply with the specification in UW-51 of ASME [BPVC Section VIII Division 1](#) or Part 7 of ASME [BPVC Section VIII Division 2](#).

11.2.2 For butt welds subjected to pressure, the use of UT instead of radiography is allowed, as long as it complies with ASME [BPVC Section VIII Division 2](#) paragraph 7.5.5 or ASME [BPVC Section VIII Division 1](#) UW-51 (a)(4), with the Code Case 2235. In this case, the manufacturer shall submit the procedure for prior approval of PETROBRAS.

11.2.3 Welds subjected to pressure not covered in item 11.2.2, and which may not be satisfactorily radiographed, shall undergo UT test, in accordance with item 11.3.

11.2.4 Other welds that may not be satisfactorily radiographed or UT tested shall be identified in inspection plan, which shall be submitted for prior approval of PETROBRAS. The inspection procedure shall have the following tests, internally and externally:

- a) PT, for carbon steel;
- b) PT, for austenitic stainless steel or clad carbon steel with austenitic stainless steel.

11.3 Ultrasonic Test

11.3.1 All welds inspected by UT shall use an automatic inspection system (whether motorized or not) which is able to provide reproducible tests and with permanent digital record of 100 % of weld volume (ToFD + Echo Pulse or Phased Array). A copy of all files with their original acquisition extension, with the viewer program, shall be delivered to PETROBRAS.

NOTE All blocks used for sensitivity calibration (reference block) of UT test shall be identified and supplied with the pressure vessel.

11.3.2 All nozzle welds Category D (according to UW-3 of ASME [BPVC Section VIII Division 1](#)), shall be 100 % UT tested (Phased Array). Rejection levels shall be as specified in Appendix 12 of ASME [BPVC Section VIII Division 1](#) or in paragraph 7.5.4 of ASME [BPVC Section VIII Division 2](#), as applicable. For nozzles having diameter $\leq 4"$, the test may be performed by conventional manual UT (Echo Pulse) and the manufacturer shall submit a procedure to PETROBRAS for previous approval.

NOTE As an additional requirement, any group of aligned linear indications shall not be considered as acceptable if any indication of this group has individual amplitude greater than 50 % of the reference level, and an aggregate length exceeding "t" in a length of "12 x t", except when the distance between successive imperfections exceeds "6 x L", where "t" is the weld thickness and "L" is the length of the longest imperfection in the group.

11.3.3 In heat exchanger, the main flange weld, if ring-type, shall be 100% UT tested. The acceptance criterion shall be the same expressed in item 11.3.2. The same principle is valid for flanges of pressure vessel.

11.3.4 For clad plates, the UT shall be performed after forming, according to ASME [BPVC Section II - Part A - SA-578/SA-578M](#) level C and supplementary requirement S1.

11.4 Magnetic Particle Test and Penetrant Test

11.4.1 Pressure vessels shall undergo the magnetic particle or liquid penetrant test in all its welds after its first construction plasticizing, which means, after PWHT.

11.4.2 When the execution of MT is not possible, the PT shall be performed. This replacement is only possible after analysis and approval of PETROBRAS.

11.4.3 For clad pressure vessels, the PT shall be performed in the clad restoring area, in accordance with PETROBRAS [N-1596](#).

12 Hardness

12.1 Hardness testing shall be performed in accordance with PETROBRAS [N-268](#).

12.2 Hardness measurement shall be performed, whenever possible, on the surface in contact with the process fluid. If the access is impractical, such as in vessels or pipes with small diameter, the measurement may be performed by the opposite side, as long as the welding procedure has been qualified for this situation.

12.3 After PWHT, perform hardness measurements in finished welds of pressure vessel:

- a) a hardness reading shall be performed for each 3 meters of weld;
- b) at least two readings shall be taken per longitudinal bead and per circumferential bead. the hardness measurement in circumferential joint shall be made in all crossings with longitudinal welds;
- c) at least one reading shall be taken per nozzle in flange-neck weld, and one in neck-shell/head weld;
- d) at least one reading shall be taken for each WPS used;
- e) one reading in each region of removal of temporary welds.

NOTE Each reading shall have 1 point in weld metal, 2 points in each HAZ, and 1 point in base metal.

12.4 Hardness values shall be in accordance with Table 1.



12.5 The maximum allowed removal of metal, when preparing the surface, shall correspond to a layer of 0.5 mm thick.

12.6 If a hardness reading above the maximum specified value is reached, the manufacturer shall:

- a) notify PETROBRAS about this reading;
- b) perform 3 additional hardness tests in this area: if any value exceeds the maximum specified value, the weld shall be rejected.

NOTE The measuring arrangement shall be approved by PETROBRAS.

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

[illegible]