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1. INTRODUCTION

This specification shall be read in conjunction with reference [14]. All recommendations of DNV-RP-B204 (reference [14]) <u>shall be considered mandatory</u>. Additional (AR) or modified requirements (MR) are mentioned along this specification. They shall be designated with the notation and meaning:

- [B204 x.x.x] XR: refers to reference [14] changed clause, XR shall be AR or MR.
- AR: new text shall be added to the clause; reference [14] requirement shall remain valid.
- **MR:** new text shall replace the comparable part of text in reference [14] clause, but the remaining part of the text remains valid.

1.1. OBJECTIVE

1.1.1. **[B204 – 1.2] AR -** The purpose of this document is to establish requirements for subsea equipment applications, adding, modifying, or deleting references. This document is applicable to all pressure containing surfaces of subsea equipment's such as PLETs, PLEMs, manifolds, subsea wellhead and tree equipment, ESDV, BCSS, SSAO, etc.

1.2. SCOPE

- 1.2.1. **[B204 1.3] MR -** All the scope mentioned in reference [14] shall apply, except jumpers. It comprises, for instance, girth welds between the components and weld overlay in: all components (such as bends, Tees, flanges, valves, connectors, etc.), part of piping (extensions and pup-pieces) or any other parts of a subsea equipment, submitted to internal pressure and in contact with the carried fluid. Any weldment of these equipment in other parts not submitted to internal pressure neither in contact with the carried fluid, shall follow the requirements of reference [3]. It does not comprise the scope of references [1] and [15], i.e., risers, flowlines and rigid jumpers.
- 1.2.2. [B204 1.3] AR Girth welds built in factory, by the same manufacturer of the subsea equipment, on the "DNV-ST-F101 code side" as per definition in [15]: figure 5-3 (see Figure 1) material-based or geometry-based code breaks, may be qualified according to reference [14] in conjunction with this specification, if the following bullets are satisfied. Reference [15] in conjunction with reference [1] are always applicable for them.

- not classified as "fatigue designated" (DNV-RP-B204 - reference [14]).

- geometry and material on both side of the girth weld also comply with component code.

- generally, the pup-piece of the MCV shall be considered the component where the code break is applicable. Either if the equipment is directly acquired by Petrobras or by EPCI partner, the weld between pup piece and line-pipe will be under the responsibility of the EPCI contractor, i.e., it will be part of DNV-ST-F101 (reference [15]) code break.





Figure 1: equipment code break (DNV-ST-F101 definition) – (a) material; (b) geometry

- 1.2.3. **[B204 1.3] AR –** The girth weld between the connector and the equipment shall be considered part of above definition.
- 1.2.4. **[B204 1.3] MR -** Jumpers, rigid spools and tie-ins shall follow weld and inspection requirements of reference [15] and respective pipeline PETROBRAS specification.

2. TERMS AND DEFINITIONS

2.1. VERBAL TENSES

- 2.1.1. **[B204 1.6.1] MR** Following meanings shall be considered for the verbal forms used throughout this document:
 - ShallMandatory requirementShouldPreferred requirementMayA permissible course of action within the limits of the document, to be
technically approved by PETROBRASMust notProhibited requirement

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2.2. DEFINITIONS

[B204 – 1.6.2] AR / MR

- 2.2.1. **Certification:** Third-party issue of a statement, based on a decision following review, that fulfilment of specified requirements has been demonstrated related to products, processes or systems. Review shall in this context mean verification of the suitability, adequacy and effectiveness of selection and determination activities, and the results of these activities, with fulfilment of specified requirements by an object of conformity assessment. (ISO 17000) **(AR)**
- 2.2.2. **CONTRACTOR:** Company directly awarded by PETROBRAS to supply components, pieces of equipment and/or full subsea installations. Provided that foreseen in the contract, the CONTRACTOR may award SUB-SUPPLIERS to deliver part of the contract scope. Depending on the situation, CONTRACTOR and SUB-SUPPLIER (or even the MANUFACTURER) may be the same entity. **(AR)**
- 2.2.3. **Temporary-use components:** Components or devices that are designated for use in the same campaign of installation and will be removed before the system starts operation, not remaining submerged. **(AR)**
- 2.2.4. **Third Party Certification:** Accredited independent organization that certifies and declares a product, service, person or system comply with technical requirements specified. **(AR)**
- 2.2.5. **MANUFACTURER:** Company that fabricates and is responsible for the acquisition and traceability of the raw material, as well as the manufacture. **(AR)**
- 2.2.6. **Manufacturing batch:** Batch from the same raw-material and manufactured with the same heat treatment regardless of the Purchase Order. **(AR)**
- 2.2.7. **Purchase Order:** Material supply request firmed between two (or more) of the following entities: PETROBRAS, CONTRACTOR and MANUFACTURER. **(AR)**
- 2.2.8. **Material Requisition:** Document issued by PETROBRAS to define the scope of supply of components, pieces of equipment, installations and/or projects. **(AR)**
- 2.2.9. Other definitions not covered herein or in reference [14]: clause 1.6.2 shall follow the same definitions of reference [15]: section 1, clause 1.6.2 or [15]: Appendix C, clause C.1.3 and PETROBRAS standard N-2301, reference [9], in this order (decree-sing) of precedence. (AR)

2.3. ABBREVIATIONS

[B204 – 1.6.4] AR

RM CEN Cu _{BM}	Material requisition European Committee for Standardization. Copper content of base metal
Симм	Copper content of weld metal
Cr _{BM}	Chromium of base metal
Сгум	Chromium of weld metal
ITP	Inspection and Test Plan
MDT	Minimum design temperature
Ni _{BM}	Nickel content of base metal.

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Ni_{WM} Nickel content of weld metal.

Other abbreviations not covered herein or in reference [14]: clause 1.6.4 - shall follow the same abbreviations of [15]: section 1, clause 1.6.3, and abbreviations is annexes of PETROBRAS standard [9], in this order (decreasing) of precedence.

3. **REFERENCES**

3.1. DOCUMENT PRIORITY AND CONFLICTS

[B204 – 1.4] AR

- 3.1.1. The documents referenced in 3.2 and 3.3 below are indispensable for the application of this document. Documents mentioned in 3.4 are mainly for reference.
- 3.1.2. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments), in force when the contract between PETROBRAS and CONTRACTOR was awarded, applies.
- 3.1.3. In case of conflict between requirements from this technical specification and from any other document, following (decreasing) precedence order shall apply, except when informed in specific items herein this document:
 - 1. PETROBRAS Material Requisition (RM).
 - 2. this technical specification + [14]
 - 3. any other relevant PETROBRAS document
 - 4. referenced codes and standards
- 3.1.4. Any doubt about the application of the previous orientations shall be clarified and registered by issuing a formal technical query to PETROBRAS.

3.2. TECHNICAL DOCUMENTS

[B204 – 1.5] AR

Ref.	Designation	Title	Ed.	Year
1	I-ET-0000.0000- 000-210-P9U-004	Welding and NDT of Submarine Rigid Pipeline, Risers and Pipeline Components		
2	I-ET-0000.0000- 000-210-P9U-005	Alternative Flaw Acceptance Criteria of Submarine Rigid Pipeline and Riser Welds		
3	ET-3000.00-1500- 600-PEK-005	Requisitos de Estruturas de Equipamentos Submarinos		
4	I-ET-0000.00-0000- 970-PSQ-001	Procedure and Personnel Qualification and Certification		
5	I-ET-0000.00-0000- 211-P9U-001	SAWL Pipes Requirements		

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Ref.	Designation	Title	Ed.	Year
6	I-ET-0000.00-0000- 211-P9U-002	Seamless (SMLS) Pipes Requirements		
7	I-ET-0000.00-0000- 219-P9U-001	Mechanically Lined Pipe (MLP) Requirements		
8	N-133	Welding	Ν	2017
9	N-2301	Preparation of Weld Technical Documentation	Е	2016
10	N-2941	Competências Pessoais em Atividades de Inspeção	Sept	2020
11	N-1597	Ensaio Não-Destrutivo Visual	Н	2021
12	N-1595	Ensaio Não Destrutivo – Radiografia	Н	2019
13	N- 2803	Ensaio Não Destrutivo – Ultrassom Computadorizado para Inspeção de Soldas	С	2021

3.3. CODES AND STANDARDS

[B204 – 1.5 - tables 1-1 and 1-2] AR - * The following list refers only to documents cited herein. The wider approach of tables 1-1 and 1-2 of reference [14] also applies.

Ref.	Designation	Title	Ed.	Year
14	DNV-RP-B204	Welding of subsea production system equipment	Sept	2021
15	DNV-ST-F101	Submarine pipeline systems	Dec	2021
16	ASME BPVC.IX	ASME Boiler and Pressure Vessel Code, Section IX: Welding and Brazing Qualifications		
17	ASME BPVC.V	ASME Boiler and Pressure Vessel Code, Section V: Nondestructive Examination		
18	ISO 9001	Quality management systems - Requirements		
19	API Spec Q1	Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry		
20	ISO 3834-2	Quality requirements for fusion welding of metallic materials - Part 2: Comprehensive quality requirements		
21	API 17P	Recommended Practice for Subsea Structures and Manifolds		
22	ISO 9712	Non-destructive testing — Qualification and certification of NDT personnel	Dec	2021
23	ISO 15156	Petroleum and natural gas industries — Materials for use in H2S-containing environments in oil and gas production — Part 1: General principles for selection of cracking-resistant materials	4	2020

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Ref.	Designation	Title	Ed.	Year
24	ISO 15156	Petroleum and natural gas industries — Materials for use in H2S-containing environments in oil and gas production — Part 2: Cracking-resistant carbon and low-alloy steels, and the use of cast irons	4	2020
25	ISO 15156	Petroleum and natural gas industries — Materials for use in H2S containing environments in oil and gas production — Part 3: Cracking-resistant CRAs (corrosionresistant alloys) and other alloys	4	2020
26	BS EN 10204	Metallic products - Types of inspection documents	4	2019
27	ASTM G48	Standard Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution	1	2020
28	DNVGL-RP-C203	Fatigue design of offshore steel structures		2019

3.4. OTHER REFERENCES

[B204 – tables 1-3] AR

Ref.	Designation	Title	Ed.	Year
29	ISO 13628	Petroleum and natural gas industries – Design and operation of subsea production systems – Part 1: General requirements and recommendations		
30	ISO 17000	Conformity assessment – Vocabulary and general principles		
31	ASME B31.3	Process Piping		
32	ASME B31.4	Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids		
33	ASME B31.8	Gas Transmission and Distribution Piping Systems		
34	ASTM 1038	Standard Test Method for Portable Hardness Testing by the Ultrasonic Contact Impedance Method		2019
35	ISO 4063	Welding and allied processes. Nomenclature of processes and reference numbers		2010

4. PROJECT REQUIREMENTS AND SERVICE CONDITONS

[B204 – Section 2] AR

4.1. According to subsea system RM and/or subsea equipment specific RM.



5. PARENT MATERIAL

5.1. ALL PRESSURE CONTAINING MATERIAL

- 5.1.1. **[B204 4.2.5] AR -** The material selection process shall consider restrictions on the following:
 - Maximum sulfur content shall be according to Table 8 of reference [21] as mandatory.
 - For sour service, maximum allowable hardness values shall comply with references [23], [24], [25], except when specified differently in Material Requisition (RM) or anywhere else. For carbon steels and low alloy steels for SSC region 3 of references [23] and [24], maximum hardness shall be limited to 230HV to provide maximum allowable hardness values of 250HV in weld metal and HAZ. HAZ of cladded C-Mn or low alloy back steel, complying with item 7.2.13, are exempted.
 - SSC and HIC testing are required for seamless C-Mn pipes and forged steels only if specified for SSC region 3 of environmental severity according to references [23] and [24]. SSC and HIC testing are required for all welded C-Mn pipes specified for sour service. Those tests are not required for parent material with alloy 625 clad.
 - When SSC / HIC tests are required, they shall be performed according to [6] for seamless components, including pipe, forging and hot induction bend, and according to [5] for welded components. For any other case, PETROBRAS shall be consulted. If any produced parent metal has PCM greater than 0.02 or CE greater than 0.03 (as applicable according to 4.2.5.4 of reference [14]) compared with PCM/CE of tested samples, a new SSC is required for the parent metal with highest PCM / CE.

6. QUALITY ASSURANCE AND QUALITY CONTROL

6.1. GENERAL

- 6.1.1. **[B204 3.1] AR -** During production, the supplier shall make available upon request all material certificates to PETROBRAS, including consumables, "type 3.1" according to reference [26] (see reference [14]: clause 4.2.7.1).
- 6.1.2. **[B204 3.1] AR -** CONTRACTOR shall provide a "Welded Joints Map" which includes the position and number of each welded joint in design drawings.
- 6.1.3. **[B204 3.2] MR -** Welders shall be certified according to reference [16] and this specification. Welding operators shall be certified according to reference [16] and this specification.

6.2. INSPECTION REQUIREMENTS

6.2.1. **[B204 – 3.3] MR** – Welding inspectors shall as a minimum be qualified and certified according to PETROBRAS standard reference [10]. Level 2 Welding Inspector qualified by the SNQC-PS, which is responsible for technical welding documentation, shall be

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specifically qualified in one of the following standards: [31], [32] or [33]. Inspector' level 2 shall also have minimum of 2 years of experience working with the above standards. All welding inspectors level 1 are required to demonstrate their skill to measure and record heat input of welds.

- 6.2.2. **[B204 3.6 and 6.1.4.1] MR** Personnel performing NDT, including visual inspection, shall be qualified and certified according to PETROBRAS standard reference [10]. For NDT and visual inspection, the certification shall be made by a recognized certification scheme based on reference [22] or the ASNT Central Certification Program (ACCP).
- 6.2.3. [B204 – 3.7] AR – The heat input of production welds shall be fully monitored. The heat input of at least 5% of the production welds of each DNV-RP-B204 WPS shall be recorded as following: all weld roots, hot and reinforcement passes; at least one bead of each filling layers in case there is no significant width variation between the beads of the respective layer; beads with different width compared to the remaining beads shall be recorded. For manual and semi-automatic welds, the first production weld of each different welder shall be monitored, including the records of at least root, hot pass and two fill beads (as applicable). If this partial record for each different welder is adopted, it shall not be part of the whole statistical sampling. The main welding parameters (voltage, amperage, travel speed, preheating and interpass temperature) shall be in the welding record report to be provided for PETROBRAS representative. If a mechanized/automatic production weld heat input record is out of the qualified range, production shall be stopped, the welding control shall be reevaluated until all parameters are again according to the approved WPS, the recorded production weld shall be rejected, and the recent production welds monitored shall be analyzed. If a partly mechanized or manual production weld heat input record is out of the qualified range, the welder shall be retrained, and the recorded production weld shall be rejected.
- 6.2.4. **[B204 3.8] MR** For a WPQR where the actual qualification is more than 5 years old, it shall be documented through production tests that a WPS based on the qualifying WPQR have been capable of producing welds of acceptable quality over a period. Such production tests are applicable only for forged material and they shall comprise with cross weld tensile and CVN tests specified for WPQT by reference [14]. They are not applicable for repair welds neither for weld overlay.
- 6.2.5. **[B204 6.1.4.3] MR -** Level 2 ultrasonic test operators testing welds in duplex and austenitic stainless steels and nickel alloys shall in addition have documented training in the testing of such welds and documented participation in the procedure validation.
- 6.2.6. **[B204 6.1.4.8] MR -** Level 2 personnel holding a current level 2 certificate in PAUT are eligible for qualification in full matrix capture (FMC) techniques if the additional requirements for training and experience given in Table 6-2 are fulfilled. PAUT, ToFD personnel shall comply with item 6.2.2.

7. FABRICATION

7.1. TECHNICAL REQUIREMENTS

7.1.1. **[B204 – 4.1] AR -** All works shall be carried out in accordance with requirements presented herein this technical specification and applicable requirements of PETROBRAS standard

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reference [8] mentioned at Table 1 below. Reference [8] items informed as not required are specified anywhere else in this specification or in reference [14], or otherwise are simply considered non-applicable. Whenever any requirement is expressed according to items informed in Table 1 and other part of reference [14] or this specification, and they are in conflict, the more stringent requirements shall prevail.

Required Items	Related Sub-Items exceptions
4.1	-
4.2	4.2.3, 4.2.4, 4.2.5
4.3	4.3.2, 4.3.6, 4.3.11
4.4	4.4.1.8, 4.4.2, 4.4.4
4.5	4.5.4, 4.5.11
4.6	-
4.7	4.7.2, 4.7.3
4.8 to 4.16	-
5.1	5.1.3.4, 5.1.4, 5.1.5, 5.1.9, 5.1.10
5.2	5.2.4, 5.2.9
5.3	5.3.4 (except sub-items 5.3.4.4.b, 5.3.4.4.c,
	5.3.4.5 that remains applicable), table 5, 5.3.5.2,
54 55 56 57 58 and 50	
5.4, 5,5, 5.0, 5.7, 5.8 and 5.9	-
5.10	5.10.4 (except sub-items 5.10.4.1, 5.10.4.2, $5.10.4.2 = 5.10.4.2$
	5.10.4.5.0, 5.10.4.3.0, 5.10.4.3.0, 5.10.4.4.0 and 5.10.4.5 that remains applicable) $5.10.5, 5.10.6$
	5.10.9 (except sub-items 5.10.9.1 that remains
	applicable), 5.10.10.1
5.12	5.12.4 (except sub-items 5.12.4.5, 5.12.4.6,
	5.12.4.7, 5.12.4.8 and 5.12.4.9 that remains
	applicable), 5.12.5 (except sub-items 5.12.5.4,
	5.12.5.5 and 5.12.5.6 that remains applicable),
	5.12.10 e 5.12.11
5.40	5.12.7 does not apply for CRAs in alloy 625
5.13	-
Annex A	
Annex B	B.2.4.3

Table 1: Required N-133 items and exceptions

- 7.1.2. **[B204 4.1] MR -** Welding procedure specifications (WPS) shall be prepared according to ASME BPVC.IX with the additional requirements given in reference [14] and this specification.
- 7.1.3. **[B204 4.1] MR -** For all WPS, the information listed in reference [14]: clause 4.1 are mandatory. No exception is made for old WPQR.
- 7.1.4. **[B204 5.1] AR –** If tack welding is performed, it shall be done with a filler metal equivalent to the root pass, and removal of the tack weld or its integration to the root weld shall be simulated during the procedure qualification program. If bullets are used, they shall be welded with the same weld consumable.
- 7.1.5. **[B204 4.2.1] AR -** In case of cut-out, a minimum distance of 25 mm from the bead edge shall be used, guaranteeing complete removal of the previous HAZ. It is acceptable to cut

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less than 25 mm providing a cut procedure is issued and approved by PETROBRAS (It may be part of the content of the "welding philosophy document), where it shall be established that a scratch all around 360° of the pipe circumference will be carried out, in such a way that this scratch can be only extinguished by mechanical tools (i.e., ink marks are not acceptable). After the cut, the full scratch shall have disappeared, and at least two macrographs, each one spaced 180° from each other, shall document that the entire HAZ has been removed. In no circumstance cuts with less than 10 mm from the weld toe will be accepted.

- 7.1.6. [B204 – 4.2.1] AR - Superficial hardness tests shall be performed to all production girth welds on carbon steel or low alloy equipment subject to sour service (regions 1, 2 and 3 of Figure 1 of reference [24]), with acceptance criteria according to item 7.2.11 (i.e., same of WPQT). If there are single hardness values in the different test zones (weld metal, HAZ, base material) that do not meet the requirement, retesting may be carried out on the same failed production weld and test zone, close to the area previously tested, after grinding and re-preparation of the tested surface. None of these additional hardness values shall exceed the maximum value. Field hardness tests shall be performed as follow. Hardness measurement shall be performed, whenever this is possible, at the surface in contact with the process fluid. If the access is not feasible, as in small diameter pipes, measurement may be performed on the opposite side and 250 HV shall be the acceptance criteria. To measure production girth welds hardness, a portable hardness tester should be used. The hardness tester method shall be based on Ultrasonic Contact Impedance (UCI) principle according to reference [34]. Only probes for HV5 or HV10 measurements are acceptable. Portable devices based on the "Leeb" (rebound) method and portable devices as "Poldi" or "Telebrineller" are not acceptable. Any UCI hardness testing instrument not meeting the requirements herein shall not be used. Valid and traceable calibration certificates of the hardness tester and the probe to be used shall be provided before use. Prior to each shift or work period, the portable equipment shall be verified by making at least five measurements on a standard reference block with valid and traceable certificate. The nominal hardness of such reference block shall be within ±20% of the respective acceptance criteria. At least 05 different measurements in the HAZ (of each material and welder) and other 05 in the weld metal shall be done and the average of each region shall be taken. At least one indention shall be located as close as possible to the fusion line, and the other four shall represent all HAZ microstructure. Hardness profile of figures B-3 and B-4 of reference [8] shall be used as reference. For this measurement, chemical attack to the joint is required to reveal the HAZ region. During the hardness measurements, other operations that may generate vibration on the same equipment are not allowed. Surface preparation shall be at least up to sandpaper grade # 180 for HV10 or # 220 for HV5. Contractor shall submit the hardness procedure for PETROBRAS approval (PETROBRAS representative is acceptable), before commence field measurements. These requirements are not applicable to cladded welds, where integrity of clad layer shall be maintained according to item 7.2.13 of this specification, neither to C-Mn welds submitted to HIC and SSC tests during WPQT.
- 7.1.7. **[B204 4.2.1] AR** Permanent steel backing shall not be used.
- 7.1.8. **[B204 4.2.1.6] MR -** Girth welded joints shall be spaced at least 150 mm from each other, or the sufficient length to allow full ultrasonic inspection, whichever is greater.
- 7.1.9. **[B204 4.2.1.6] AR -** Longitudinal welds shall be staggered at least 50 mm away from each other and located at the upper section of the pipe.



- 7.1.10. **[B204 4.2.2.1] AR -** The weld beads of the layers shall overlap the interface between the beads of the previously deposited layer, to avoid coincidence of interpass lack of fusion between layers.
- 7.1.11. **[B204 4.2.3.3] MR -** The buttering shall be made with low carbon low alloy steel filler metal prior to PWHT and girth welding. Special attention shall be given to the possible effects of using buttering filler metal with lower strength than the base metal. The use of Ni-based alloys for buttering of components requiring PWHT is prohibited to avoid failures under cathodic protection. The following requirements shall be also complied with:
 - pWPS and Qualification Plan, including buttering sequence, welding parameters, and heat treatment parameters, shall be submitted to PETROBRAS for approval.
 - A standard 30° bevel for buttered ends shall be used.
 - Charpy V-notch impact testing is always required. Notch locations for CVN of dissimilar interfaces shall comply with reference [14]: clause 5.4.7.2, and other requirements shall be according to reference [14]: clause 5.4.7 and this specification.
- 7.1.12. **[B204 4.2.3.4] AR -** The distance from the buttering fusion line to any girth weld repair shall not be less than 3 mm.
- 7.1.13. **[B204 4.2.4.3] AR –** Full scale resonant fatigue testing are only required if designed curve penalization is applicable due to corrosion fatigue environment effects in the specific project, or if fatigue demand exceeds S-N curve D of reference [28] for any surface.
- 7.1.14. **[B204 4.2.6] AR –** The use of PAW (reference [35] process 15) for cladding shall be submitted to PETROBRAS approval. FCAW (reference [35] process 136) and metal core GMAW (reference [35] process 138) are not acceptable for root and hot passes of girth welds and repairs where the ligament is lesser than 6mm. A non-slag-producing welding process shall be used for the root pass and hot pass on all single-sided girth welds in CRA.
- 7.1.15. [B204 4.2.7] AR For subsea equipment in C-Mn or low alloy steel (not cladded):
 - In water injection pipelines, welding consumables used for the root and hot pass of girth welds shall be selected to avoid preferential corrosion in the welded joints of pipelines. The following equation shall be used to determine if the weld metal is cathodic and base metal is not excessively anodic, in comparison with each other: Δ = 3.8*(%Cu_{base metal} %Cu_{weld metal}) + 1.1*(%Ni_{base metal} %Ni_{weld metal}) + 0.3. To avoid preferential corrosion, Δ should be preferably negative, nevertheless Δ<+0.3% is acceptable. Whenever the base metal has Cr in their composition the weld metal should have an equivalent Cr content. However, PETROBRAS shall be consulted for additional clarifications.
 - In gas pipelines submitted to the presence of water condensate, welding consumables used for the root and hot pass of girth welds shall be selected to avoid preferential corrosion the welded joints of pressure containing parts. The following two equations shall be used: $\Delta = 3.8^{*}(\%Cu_{BM} \%Cu_{WM}) + 1.1^{*}(\%Ni_{BM} \%Ni_{WM}) + 0.3$ and $\epsilon = 1,71-0,58^{*}(\%Ni_{BM} \%Ni_{WM}) 1,49^{*}(\%Cu_{base metal} \%Cu_{WM}) 1,36^{*}(\%Cr_{BM} \%Cr_{WM})$. To avoid preferential corrosion, parameter Δ should be in the range between -0.63 e +0.95 and parameter ϵ should be in the range between +1.0 and +2.4. For chemical compositions out of at least one of those ranges, PETROBRAS shall be consulted for approval.
 - In both equations, the chemical composition of Ni_{WM}, Cr_{WM} and Cu_{WM}, may be obtained from the deposited weld metal, but it is recommended to estimate it before WPQT.
- 7.1.16. **[B204 4.2.7] AR -** The use of welding consumables with suffix "G", as per the respective AWS specification or equivalent, requires PETROBRAS approval. They will be acceptable only if manufacturer specifies mechanical properties requirements for tensile and impact

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(CVN) testing and chemical composition, and all batches are tested according to reference [14]: clause 4.2.7.1. Diffusible hydrogen content of all welding consumables shall be according to reference [8], as applicable.

- 7.1.17. **[B204 4.2.7.4] AR –** the environmental conditions for welding consumables storage shall be at a minimum temperature of 20°C and at maximum 50% of humidity.
- 7.1.18. **[B204 4.2.7.5] AR –** Coated electrodes and low hydrogen fluxes shall be subjected to drying and conditions for keeping them dry in ovens meeting the requirements of 4.5.5 to 4.5.9 of reference [8] (see Table 1).
- 7.1.19. **[B204 4.2.7.7] AR –** The maximum ratio recycle/original SAW flux shall be 1:1.
- 7.1.20. **[B204 4.2.7.9] AR –** For girth welds with nickel-based filler metals, it is required to carry out:
 - Chemical analysis of the weld metal at 0.5 mm from the inner surface (after root reinforcement removal), maximum iron content shall be 10%;
 - Metallographic analysis of the weld metal in two different regions for single-side welded joints; one next to the inner surface and the other next to the outer surface; Metallographic analysis of the weld metal in three regions for double-side welded joints, one next to the root and the other two next to each face.
 - Methodology and criteria for the metallographic analysis: the surface to be examined shall be representative of the minimum clad / liner / overlay thickness specified for the component after machining; the microstructure examination shall be performed after any treatment; carry out metallographic examination by magnifying 400 times the weld metal CRA, HAZ and the base metal; micro-cracks at the CRA interface with the carbon steel / low alloy are not allowed; the material shall be free of carbides in the grain boundaries, nitrides and inter-metallic phases in the final condition (as welded or treated, as applicable).
- 7.1.21. **[B204 4.2.7.10] AR –** The chemical composition of overlay shall be within the specification limits according to the UNS for the specified overlay material.
- 7.1.22. **[B204 4.2.8.5] MR –** For welding cladded CS/LAS with Ni-based filler, the measured oxygen content shall not exceed 1000 ppm.
- 7.1.23. **[B204 4.2.9.5] MR –** The measurement locations, time for temperature equalization, time for measurement of preheat and preheat maintenance shall follow the requirements in PETROBRAS N-133, except as follow: interpass temperature shall be measured in the weld area where the next bead will be deposited and immediately before welding the next bead, as close as possible to the weld bevel, in such a way that will not contaminate the weld metal; the points of measurement preheating and interpass temperature, and distance from the longitudinal edge of the groove, shall be in the Welding Record Report of the WPQT; the points of measurement in production welds shall be representative of those used during qualification.
- 7.1.24. [B204 4.2.9.7 Table 4-2] MR Maximum interpass temperature:
 - girth welds* in API 5L linepipes up to SMYS =485MPa, welded with SAW, FCAW or SMAW and API 5L linepipes with SMYS greater than 485MPa, welded with any process = the maximum interpass temperature achieved during WPQT, limited to 315 °C. For GMAW and GTAW girth welds in API 5L linepipes up to SMYS =485MPa, greater interpass

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temperature may be achieved, limited to 400 °C, but it shall be submitted and approved by PETROBRAS.

- girth welds* in 625 alloy clad / lined linepipes = the maximum interpass temperature achieved during WPQT, limited to 250 °C in the filling passes and 150 °C in the root and hot passes. For GMAW and GTAW process, the limit for filling passes may be extended to 350°C, but it shall be submitted and approved by PETROBRAS.
- girth welds* in low alloy mentioned in table 3 and table 7 of reference [8] = the minimum preheat and maximum interpass temperature achieved during WPQT, limited to figures of reference [8]. Specific cases, previously qualified by supplier, may be submitted to PETROBRAS for technical analysis
- girth welds* in base material not listed in above bullets but comprised in reference [14]: table 4-2 = the maximum interpass temperature achieved during WPQT, limited to figures of reference [14]: table 4-2.
- CRA weld overlay = the maximum interpass temperature achieved during WPQT.

<u>Guidance note*</u>: for sake of clarity, "weld overlay" should not be understood as "girth welds".

7.1.25. **[B204 – 4.5.3.1] MR** - After excavation and prior to welding, the complete removal of the defect shall be confirmed by magnetic particle testing (MT) or penetrant testing (PT), as applicable and according to 7.4.4. Furthermore, regarding the inspection of the excavated area, the magnetic field in the excavated area shall be suitable for MT.

7.2. WELDING PROCEDURE SPECIFICATION AND QUALIFICATION

- 7.2.1. **[B204 5.1] MR -** Welding procedures shall be qualified according to reference [16], as applicable with the additional requirements given in reference [14] and this specification.
- 7.2.2. [B204 5.1] AR Contractor shall include in the preliminary WPSs (pWPSs) and WPQT welding records, all data necessary to support the final WPS, meeting all requirements and essential variables required by reference [16] or added by [14] or by this specification. Preliminary WPSs (pWPSs) may be issued for information, however, WPQT and WPS shall be issued for approval. Standard welding procedures, as provided in article V of reference [16] or equivalent, shall not be used unless qualified.
- 7.2.3. **[B204 5.3 and Table 5-1] MR -** Weld procedures shall be qualified according to reference [16]. In addition to the range of approval or essential variables stated in reference [16], the WPS requires a new qualification if the range of approval or the essential variables in reference [14]: Table 5-1 are exceeded. The following additional essential variables, shall apply to CS/LAS and CRA girth welds, including buttering (cladding not included), built in factory on the subsea equipment "DNV-ST-F101 code side" as defined in item 1.2.2 of this specification:
 - **[Wall thickness] MR** The thickness (t) of the weld coupon qualifies welding procedures as follows:
 - Non-sour services:
 - t < 25 mm; qualified from 0.75 t to 1.5 t
 - t > 25 mm; qualified for 0.75 t to 1.25 t

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- Sour services:
 - Qualified for 0.75 t to 1.25 t
- [Pipe/tube diameter] AR The smallest qualified diameter is equal to half the test coupon's diameter.
- **[Oscilation] AR -** The change from stringer bead to weave bead with oscillation of three times or more the diameter of the electrode / wire and vice-versa shall be considered as an essential variable.
- [Heat input per ASME BPVC.IX] MR For buttering, girth welds and small-bore welds in:
 - CS/LAS and non-duplex CRAs: any change exceeding the range between min. heat input -25% and max. heat input, split for root, hot pass, filling passes and cap. Heat input ranges along filling passes shall be split if not representative of any specific area (e.g. upper fill and lower fill).
 - Duplex stainless steel: any change exceeding the range min. heat input -15% and max. heat input, split for root, hot pass, filling passes and cap. Heat input ranges along filling passes shall be split if not representative of any specific area (e.g. upper fill and lower fill).
- [Chemical composition for Duplex] AR Change from lower than 24Cr to higher than 24Cr or vice-versa.
- 7.2.4. **[B204 Table 5-2] AR -** Specifically regarding repair procedures, the following are regarded as essential variables:
 - Change from internal to external repair, and vice-versa.
 - Change of cold excavation to hot excavation, but not the opposite.
- 7.2.5. **[B204 5.4.1.1] MR -** Mechanical testing shall be performed according to reference [16], with the additional requirements described in the subsections referenced in reference [14]: Table 5-3 and this specification.
- 7.2.6. [B204 5.4] AR For WPQT of carbon steel and low alloy (without internal CRA) in sour service conditions, HIC tests are not required. SSC tests are only required for welds specified for SSC region 3 of reference [23]. In such case, SSC tests shall be performed according to reference [5] or reference [6]. However, PETROBRAS shall be consulted with for additional clarifications. No SSC and HIC tests are required for WPQT of carbon steel and low alloy with internal alloy 625 clad.
- 7.2.7. **[B204 5.4.1.4] AR -** fracture mechanical testing is not required, unless in situations when fatigue or erosion may compromise the integrity of clad layer, and toughness of the remaining ligament becomes critical for the integrity, thus requiring a fracture check. In such cases, PETROBRAS shall be consulted.
- 7.2.8. **[B204 5.4.2.1] MR -** If any of the tests in reference [14]: Table 5-3 fails to meet the specified requirements, then retesting may be performed as described in reference [16].
- 7.2.9. **[B204 5.4.7.6] AR -** For alloy 625 weldments, the impact test temperature shall be at minimum design temperature (MDT) specified in PETROBRAS project documents.
- 7.2.10. **[B204 5.4.11.1] MR -** Hardness profile of figures B-1, B-2 and B-5 of reference [8] are required respectively for double sided welds, single sided welds and cladding. Hardness

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profile of figures B-3 and B-4 of reference [8] are required respectively for external and internal surfaces of production welds. Hardness profiles of reference [14]: clause 5.4.11 (figures 5-5, 5-8) may be accepted if HAZ hardness indentations are be entirely within the heat-affected zone: in all cases, a first indention shall be located as close as possible to, but the center point shall be no more than 0.5 mm (0.02 in) from the fusion line; a second and a third additional indentations shall be located within the HAZ, in the same hardness survey horizontal lines, 0.5 - 1.0 mm distant respectively from the previous HAZ indentations, thus testing coarse and fine grain HAZ. Since there is no specific hardness profile in reference [8] for weld buttering, the hardness profile of reference [14]: clause 5.4.11, figure 5-7, including the three aligned indentations in the HAZ, as required above, shall be adopted.

- 7.2.11. **[B204 5.4.11.7] MR -** For sour service, the hardness of the HAZ, base material and weld deposit shall comply with the requirements in respective parts of references [23], [24] and [25]. Furthermore, maximum allowed hardness criteria are following:
 - For C-Mn and low alloy steel and low alloys in non-sour service, in any part of welded joint, maximum hardness shall be limited to 325 HV.
 - For C-Mn and low alloy alloys in sour service, in any part of welded joint, maximum hardness shall be limited to 250 HV for inner surface and 275 HV for outer surface (except when region 3 of references [23] and [24] is specified, in such case item 5.1.1 shall apply).
 - For alloy 625 or other nickel-based alloys cladding, maximum hardness of deposited CRA shall be limited to 345 HV. Hardness requirements of cladded C-Mn back steel and HAZ between the back steel and the clad shall be 325 HV10, disregarding hardness and MPQT SSC/HIC test requirements of item 5.1.1.
- 7.2.12. **[B204 5.4.11.8] AR -** Technique and criteria for Rockwell-C hardness according to references [23], [24] and [25] are not acceptable within the HAZ.
- 7.2.13. **[B204 5.4.11.9] MR –** It shall be demonstrated and documented that cladding integrity is maintained over the design life for all components and girth welds. The integrity demonstration shall at least include fatigue, erosion, corrosion, fracture, and the rupture of the clad layer. The minimum clad thickness at the end of service life shall be informed. Sour service requirements for HAZ are not required for fully clad systems with demonstrated clad integrity. Hardness criteria of HAZ and base materials shall comply with item 7.2.11, and superficial hardness tests production girth welds are not applicable.
- 7.2.14. **[B204 5.4.14.1] MR -** For alloy 625 weld CRA and girth welds, chemical analysis shall be performed at 2.5 mm (0.125 in) or less from the original base metal surface. The iron content of alloy 625 shall not exceed 10%. Cladding layers ad thickness shall be according to reference [14]: clause 4.2.2.1 and item 7.1.10, assuring to be 0.5 mm thicker than the tested position.
- 7.2.15. **[B204 5.4.14.2] AR –** When the minimum clad thickness at the end of service life is less than 1.5 mm, PETROBRAS shall be consulted about the necessity of additional welding chemistry analysis in deeper positions.
- 7.2.16. **[B204 5.4.15.1] MR -** Corrosion testing according to reference [27], method A, is required for all Ni-based cladding in contact with the transported fluid in sour service conditions. The maximum weight loss shall be 4.0 g/m². The test temperature shall be 40°C for 24 hours (in polished condition) and there shall be no pitting at 20 X magnification.



7.3. WELDER QUALIFICATION AND PERFORMANCE CONTROL

- 7.3.1. **[B204 3.2] MR -** Welders and welding operators shall be qualified and certified according to reference [16]. Additionally, the chemical composition of the filler metal shall be separated in the three groups below. The change from one group to other shall be considered essential variable.
 - Group 1: A-No 1, 2, 3, 4, 5, 10,11 and12 (see reference [16]);
 - Group 2: A-No 6, 7, 8, 9 (see reference [16]);
 - Group 3: alloys compatible with alloy 625.
- 7.3.2. [B204 – 3.2] AR - The welder or welding operator gualification validity shall be six months (demonstrated by NDT) without an interruption of more than three months (demonstrated as per WPC). NDT demonstration is not applicable to WoL welding operators, unless the CRA is required to be inspected by advanced ultrassonic technique. A welder or welding operator performance control (WPC) shall be carried out and it shall be presented biweekly for PETROBRAS representatives according to reference [9]. The required performance shall be 2.5% or 75 mm in 3 m of tested welds, when the rate is calculated based in the defect length, the WPC shall start to reject just after which comes first, 3 m of tested welds or 75 mm of rejected length; 10% or 2 films of each 20 films, examined in sequence, when the rate is based in the number of radiographic films, the WPC shall start to reject just after which comes first, 20 examined films or 2 films with rejected welds. Independent if the welds will be repaired or cut, the WPC shall be considered necessary. In case Contractor proves that the cause of low performance in automatic or mechanized welds is related to a systematic error of the welding equipment and not due to a specific welding operator skill, the repair length may be excluded from the WPC. A gualification can be cancelled if the welder/welding operator show inadequate skill, knowledge or performance below the minimum required.

<u>Guidance Note</u>: the WPC is important to keep welders and welding operators attempt to produce good welds. Furthermore, in case of bad performance, their replacement or retraining is benefic in order to avoid rejected welds. The standard film length is 16", for different lengths the respective WPC criteria should be proportional.

7.4. INSPECTION AND NON-DESTRUCTIVE TESTING

- 7.4.1. [B204 –6.1.1.2] MR NDT procedure shall be submitted for PETROBRAS approval.
- 7.4.2. **[B204 Table 6.1] MR –** In case of redundancy or conflict between the standards listed in the table, the stricter requirement shall prevail. Additionally:
 - VT shall also comply with PETROBRAS reference [11].
 - PAUT on buttering and girth welds shall also comply with PETROBRAS reference [13].
 - RT shall also comply with PETROBRAS reference [12].
- 7.4.3. **[B204 6.1.4.1] MR –** See item 6.2.2.
- 7.4.4. **[B204 6.3] MR –** MT shall be the superficial non-destructive testing method whenever the joint material (weld, HAZ, parent metal) are ferromagnetic with 6% alloy elements maximum and there is suitable access. Other alloy elements percentual of ferromagnetic materials

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may be inspected by MT provided that the procedure qualification is demonstrated and evaluated for Petrobras. Otherwise, PT shall be used.

- 7.4.5. **[B204 6.3] AR –** If PT remote testing is the applicable surface technique, whenever the joint material cannot be magnetized and there is not suitable access, in addition to reference [17], the procedure shall comply with the following requirements:
 - The visual remote system used in conjunction with PT apparatus shall comply with PETROBRAS reference [11], item 4.4.
 - The apparatus that will be inserted for PT and visual remote testing (not including material used for surface preparation, cleaning, and removal of excess penetrant) shall not be in contact with examination surface.
 - PT remote testing shall be able to detect the discontinuities defined in the acceptance criteria.
- 7.4.6. **[B204 6.3] AR** A diagram or sketch indicating the overlapping and positioning on the part, according to the applicable technique, shall be included in the MT procedure.
- 7.4.7. **[B204 6.4.1.4] MR -** Load-bearing cladding shall be tested with minimum two angle beams transducers in addition to straight beam transducer. Angle beam scanning shall be performed transverse to the welding direction and, if applicable, transverse to start/stop positions also. The reference level for angle beam shall be set on a cladded reference block with Ø1.5 mm (0.0625 in) side-drilled holes in the fusion line and in the cladding. The reference line shall cover the whole depth to be tested. Transducers with focus distance suitable for the cladding thickness shall be used. The conventional angle beam technique shall be substituted for phased array technique in case of acceptance criteria that require height dimensions.
- 7.4.8. **[B204 6.4.2] AR -** The transfer correction shall be done whenever the reference block is not the object testing.
- 7.4.9. **[B204 6.4.2.5] AR** Welds in duplex, austenitic stainless steel, nickel alloy and for dissimilar metal joints shall not be tested by conventional UT. Only advanced ultrasonic techniques, e.g., phased array, FMC/TFM shall be used in these situations.
- 7.4.10. **[B204 6.4.2.6] AR** The grinding of weld reinforcement, when required, is fundamental for the reliability of the examinations, mainly for duplex, austenitic stainless steels, and nickel alloys, so it shall provide continuity, alignment, flatness in relation to the parent metal. Minimum designed clad and/or wall thickness shall be maintained as applicable.
- 7.4.11. **[B204 6.4.3] AR -** In addition to the essential variables established in the reference standards, for the procedure qualification of duplex, austenitic stainless steel, nickel alloy and dissimilar metal joints materials, the following items shall also be considered as essential variables and they shall be included into the procedure:
 - WPS/WPQR;
 - Weld metal alloy specification;
 - Welding process.
- 7.4.12. **[B204 6.4.3.3] AR** Alternative criteria shall not be used without PETROBRAS approval. Whenever an alternative acceptance criterion based in the flaw height and length is applicable, a PAUT qualification and validation program shall include the uncertainty (sizing error) analysis.

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- 7.4.13. **[B204 6.4.3.4] AR** If suspected porosity, exceeding 20% of the reference level, cannot be accurately characterized by PAUT, the area shall be evaluated by radiographic testing. Alternatively, ToFD technique may be used.
- 7.4.14. **[B204 6.9.4.1] MR –** RT shall be performed with X-ray. If the use of x-ray is limited, any alternative proposal shall be submitted and approved by PETROBRAS.

8. DOCUMENTATION

8.1. SUMMARY OF INFORMATION TO BE PROVIDED IN RM

8.1.1. Following table lists the information which is needed when using this technical specification and that shall be provided in the RM.

Table 2: Summary of information to be provided in RM

Seq	Description	Value	Unit	Remarks
1	Design code			
2	All component material			
3	Operational loads		MPa	
4	Corrosion fatigue penalization applicable to the environment (when applicable)			
5	MDT		°C	
6	SSC region of NACE MR0175/ISO-15156-1			

8.2. DOCUMENTS TO BE PROVIDED BY CONTRACTOR

8.2.1. Following documents shall be provided by CONTRACTOR regarding the equipment specified in this technical specification: Equipment WPSs and WPQT, including repair welds; Welded Joints Map; NDT procedure, if specifically required.

8.3. MANUFACTURER DATA SHEET

8.3.1. Following table lists the data which shall be provided by the manufacturer in the equipment/component data sheet. This table may be used as a template to the referred data sheet. The content of reference [9] shall be complied with.

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Table 3: Information to be provided by manufacturer

Seq	Description	Value	Unit	Remarks
1	Set of WPS and WPQT			
2	Set of WEII (relaxed for oversea made equipment)			
3	LQW			
4	WPC			
5	LJW			
6	Welded Joints Map			
7	Repair reports			
8	NDT procedures			
9	NDT reports			
10	ITP			