	TECHNICAL SPECIFICATION					No. I-ET-3000.00-1200-251-P4X-001				
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THIS FORM IS PART OF PETROBRAS N-381 REV. J ANNEX A – FIGURE A.1.										



1. SCOPE

1.1. This technical specification establishes the minimum requirements for materials selection and for coating specification for bolt material for top side and hull applications, as well as manufacturing and inspection requirements.

1.1.1. This specification applies to equipment, piping systems and structural components.

1.1.2. This specification does not apply to pumps, diesel engines, turbines and compressors, supplied as packaged systems. For these equipment the MANUFACTURER/PACKAGER shall guarantee suitable bolt material for class CX marine environment (according to the environment classification by ISO 12944-Part 2) for the specified design life of 25 years.

1.1.3. This specification does not apply to subsea facilities and other parts that are protected by a Cathodic Protection System.

1.2. Reference to bolt material in this technical specification includes fasteners, bolts, screws, studs, stud bolts, nuts and washers.

1.3. Additional bolting grades, not referenced in this technical specification, can be specified as needed, as long as the applicable requirements from this technical specification are applied.

2. REFERENCE DOCUMENTS AND STANDARDS

2.1. ASTM A 193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High-Temperature or High Pressure Service and Other Special Purpose Applications

2.2. ASTM A 194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both

2.3. ASTM A 320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service

2.4. ASTM B 841 - Standard Specification for Electrodeposited Coatings of Zinc Nickel Alloy Deposits

2.5. ASTM F 1940: 2007 - Standard Test Method for Process Control Verification to Prevent Hydrogen Embrittlement in Plated or Coated Fasteners

2.6. Norsok M-001 – Materials Selection

2.7. ISO 15156 Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production. Parts 1, 2 and 3

2.8. ISO 12944-Part 2 - Paints and varnishes -- Corrosion protection of steel structures by protective paint systems -- Part 2: Classification of environments

2.9. I-ET- GENERAL PAINTING (as applicable to the project)

2.10. I-ET- Floor Gratings, Tray systems and Guardrails made of Composite Materials.

2.11. API RP 578: 1999 - Material Verification Program for New and Existing Alloy Piping Systems

2.12. API Spec 20E - Alloy and Carbon Steel Bolting for Use in the Petroleum and Natural Gas Industries

2.13. API Spec 20F - Corrosion Resistant Bolting for Use in the Petroleum and Natural Gas Industries

2.14. BS EN 10204 - Metallic products - Types of inspection documents

3. BOLTING SELECTION

3.1. BOLTING FOR EQUIPMENT AND PIPING SYSTEMS

3.1.1. The general bolting material for bolt diameters above 10mm in piping systems and equipment shall be carbon and low alloy steel selected in accordance with the ASTM standards listed in Table 1 below. Bolts with diameters < 10mm shall be stainless steel Type 316 (B8M) for metal temperatures below 60°C based upon the maximum operating temperature.

TABLE 1- TEMPERATURE RANGE FOR BOLTING MATERIALS

Temperature Range (°C)	BOLT (According to ASTM)	NUT (According to ASTM)	Size Range (mm)
-100/+ 400	A 320 Grade L7	A 194 Grade 7/S3	≤ 65
	A 320 Grade L43	A 194 Grade 7/S3	< 100
-46/+400	A 193 Grade B7	A 194 Grade 2H	All
-29/+540	A 193 Grade B16 ^(a)	A 194 Grade 7	All
-196/+540	A 193 Grade B8M ^(b)	A 194 Grade 8M/ 8MA ^(c)	All

(a) Grade B16 is intended for high temperature service, outside the temperature range for Grade B7.

(b) Type 316 bolts and nuts shall not be used at maximum operating temperature above 60°C if exposed to wet marine atmosphere.

(c) Use 8MA with class 1 bolts.

3.1.2. The possibility of galvanic corrosion and the consequences of different thermal coefficients shall be considered when dissimilar metals are used in bolts and materials to be joined.

3.1.3. Bolting materials different than the ones listed in Table 1 may be necessary for specific applications. This will usually happen to guarantee compatibility with the materials being joined or where there is a limitation in the temperature or size range indicated in Table 1. In this case Petrobras approval shall be sought prior to application.

3.1.4. The alloys listed in Table 2 may be used for bolting where the service requires higher corrosion resistance or higher resistant material.

3.1.5. Bolts screwed into component bodies shall be of a material that is compatible with the body with respect to galling and the ability to disassemble the component for maintenance.

3.1.6. Titanium bolt materials coupled to carbon steel shall not be used due the risk of hydride embrittlement of titanium.

TABLE 2 - ALTERNATIVE CRA BOLTING MATERIAL FOR SPECIAL APPLICATIONS


Allowed CRA	Specification Requirements
25% Cr Super Duplex Stainless Steels (SDSS) •UNS S32750 •UNS S32760	<ul style="list-style-type: none"> • Material strength shall be equivalent to or higher than ASTM A 193 B7M and achieved by solution treatment. • Solution annealing is required on all cold worked components of 25% Cr SDSS. • Super duplex stainless steels shall not be specified as bolting material if subject to cathodic protection. • Maximum design temperature for chlorine containing environments $\leq 110^{\circ}\text{C}$. • Maximum design temperature for chlorines free environments $\leq 260^{\circ}\text{C}$.
High Nickel Alloys	Specification Requirements
•UNS N06625	<ul style="list-style-type: none"> • Hardness shall be limited to 35 HRC and alloy 625 shall be solution treated. • Microstructure and properties according ASTM B 446 for UNS N06625 GRADE 1. • Inconel 625 shall not be specified as bolting material if subject to cathodic protection.
•UNS N07718	<ul style="list-style-type: none"> • Alloy 718 shall be avoided if there is possibility of crevice corrosion. • Inconel 718 shall not be specified as bolting material if subject to cathodic protection • Microstructure and properties according API 6A 718, with some modifications: <ul style="list-style-type: none"> ➤ Maximum hardness shall be limited to 35 HRC. ➤ Only longitudinal direction (bolt axis) Charpy impact test. ➤ Qualification Test Specimen: sacrificial production bolt samples.

3.2. BOLTING MATERIALS FOR STRUCTURAL APPLICATIONS

3.2.1. Bolting materials for structural applications shall be as designated by the applicable structural technical specification.

3.2.2. Bolting for grating shall be according I- ET: Floor Gratings, Tray systems and Guardrails made of Composite Materials.

3.2.3. High strength steel bolts (such as ASTM A 325 or ASTM A 490) may be used, will require prior approval, upon request to the Petrobras project Engineering.

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4. COATING SPECIFICATION

4.1. COATING FOR PRESSURE VESSELS AND PIPING BOLTING

4.1.1. Bolting material (including washers) shall receive a suitable corrosion protection for marine atmosphere class C5-M according the environment classification by ISO 12944-Part 2.

4.1.2. For carbon steel and/or low alloy steel bolting material this coating shall be zinc/nickel electroplating or any other coating process with superior quality (previous Petrobras approval is required in this case).

4.1.3. The procedure for bolts, nuts and washers Zn-Ni coating shall be in accordance with ASTM B841 standard and the deposit classification is as follow:

- a) Class 1
- b) Type B and E
- c) ASTM Grade 8

4.1.4. Pretreatment according to ASTM B849 and post-coating treatment according do ASTM B850 shall be applied for parts made of steels with ultimate tensile strengths equal to or greater than 1000 MPa. Evidence of the applied treatments shall be provided.

4.1.5. Any bolt material which has an electroplating coat shall require a baking heat treatment for hydrogen removal just after the electroplating process. The effectiveness of this treatment must be done by the manufacturer according to ASTM F 1940: "Standard Test Method for Process Control Verification to Prevent Hydrogen Embrittlement in Plated or Coated Fasteners". Evidence of the applied treatments shall be provided.

4.1.6. Bolting material within equipment in connections that are not meant to be disassembled may be field painted (after installation) in order to protect them from marine corrosion. Painting shall be in accordance with the applicable painting technical specification (I-ET-GENERAL PAINTING applicable to the project).

4.1.7. Zinc coating shall not be used on stainless steels bolt materials, or for splash zone or subsea service.

4.2. COATING FOR STRUCTURAL APPLICATIONS BOLTINGS

4.2.1. Carbon and low alloy steel bolting materials for structural applications may be coated as described in 4.1 above, or may be Hot Dip Galvanized according to ASTM F 2923.

4.2.2. When galvanizing is used safeguarding and testing against hydrogen embrittlement shall be performed as described in ASTM A 143

4.2.3. High strength steel bolts (such as ASTM A 325 or ASTM A 490) shall not be galvanized due to the risk of hydrogen embrittlement.

4.2.4. Stainless steel bolting material shall not be coated.

4.2.5. Carbon and low alloy steel bolting materials, both galvanized and non-galvanized, shall be field painted (after installation). The painting specification, according to I-ET-GENERAL

PAINTING, shall be suitable to the surface (ASTM D 6386 provides details on the preparation of galvanized surfaces preparation).

5. ADDITIONAL REQUIREMENTS

5.1. Threads shall be formed by rolling (cold forming), and the roots shall be rounded. Machined threads (cut) are unacceptable.

5.2. For sour environments bolt materials selection shall comply with ISO 15156 requirements (lower hardness is usually required).

5.3. The design stresses in the bolt shall never exceed 70% of the Specified Minimum Yield Strength (SMYS), considering both the assembly and the operational loads at the applicable temperature.

5.4. All bolts and nuts shall be supplied with certification according to EN 10204 Type 3.1.

5.5. Fluoropolymer coatings in lieu of the coatings cited above may be used only when approved by PETROBRAS. When specified it shall be applied on top of a zinc based coating.

6. MANUFACTURING INSPECTION AND TESTING

6.1. In order to specify the applicable inspection and testing requirements for pressure retaining bolting material (excludes the structural application bolting) they shall be classified as detailed in Tables 3, 4, 5 and 6 below.

TABLE 3 – BOLT CATEGORY

Category	Service	Notes
I	Pressure retaining Bolts Gas: Explosive, flammable, toxic or CO2 supercritical	H2S content may classify gas as toxic.
II	Liquid: Explosive, flammable, oxidizing or toxic.	If fluid's vapour pressure equals to the maximum allowable temperature of the equipment or is 0,5 bar above normal atmospheric pressure, the fluid is classified as gas.
III	Other gases and liquids	Fluids other than I and II.

TABLE 4 – PRESSURE CATEGORY

Category	Pressure Class
1	150 and below
2	300 and 600
3	900 and 1500
4	2500 and higher

TABLE 5 - INSPECTION LEVELS FOR BOLTING

Pressure Category	Fluid Category		
	I	II	III
1	B	C	C
2	A	B	C
3	A	A	B
4	A	A	A

TABLE 6 - INSPECTION CLASSES

Class	Inspecting and Testing Level	Bolting Specification Level
A	Critical (Special) Bolting	BSL-2
B	Primary Bolting	BSL-1
C	Secondary Bolting	According to ASTM standard testing

6.2. Bolting Specification Levels (BSL) shall be as defined by API standards 20E and 20F. Bolting material assigned to a BSL shall be acquired attending all the applicable requirements from these two standards.

6.3. CRA bolting materials (except structural application bolting) shall always be considered as BSL-2 as per API 20F.

6.4. The bolting materials certificates issued by the manufacturer shall explicit that the components were manufactured in accordance with the applicable BSL.

6.5. Structural application bolting shall be inspected as per the applicable ASTM standard.

7. FIELD INSPECTING AND TESTING

7.1. For inspection purposes a LOT of bolting is defined as follows:


- a) Batch furnace: bolting or raw material of a single heat and diameter, heat treated together as a single austenitizing, quenching, tempering, and stress-relieving charge.
- b) Continuous furnace: bolting or raw material of a single heat and diameter heat treated without interruption in a continuous charge.
- c) In any case, heat treatment performed in batches after coating implies in separated lots.

7.2. Every lot of bolting material received for assembly shall be checked visually upon receiving in order to verify its main characteristics, such as:

- the applicable marking (stamping);
- diameter;
- length;
- thread type;
- general state when it comes to corrosion or damage;
- coating integrity.

7.3. All material certificates shall be checked against the applicable technical requirements.

7.4. A hardness test shall be performed in one sample from each lot received.

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7.4.1. If the obtained hardness is below the one stated in the manufacturer certificate (difference greater than 10%) one sample shall be taken from the lot and all applicable tests established by the material specification shall be performed (mechanical tests, chemical composition), as well as a metallographic evaluation of its microstructure and of the coating. Failure in any test implies in the rejection of the whole lot.

7.4.2. If the obtained hardness is above the one stated in the manufacturer certificate (difference greater than 5%) and a maximum hardness is established for the components (such as in H2S service) the lot is considered rejected.

7.5. Positive Material Identification shall be performed in one sample from each lot. This test intends to verify the chemical composition of the bolt and of the applied coating.

7.6. Bolting materials approved in the receiving inspection shall be protected against corrosion and stored in an area sheltered from inclement weather.

7.7. At any time Petrobras may require that a sample from any lot be tested (mechanical tests, chemical composition, or metallographic evaluation) in order to verify the attendance to the requirements listed herein.

PRELIMINARY