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	CLIENT:	SHEET 1 of 11	
	PROJECT:	CC : -	
	AREA:		
SRGE	TITLE:	<b>REQUIREMENTS FOR BOLTING MATERIALS</b>	NP-1
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DATE	MAR/20/2020	05/06/2020	09/11/2020	27/04/2022					
DESIGN	ESUP	ESUP	ESUP	ESUP					
EXECUTION	MARIANO	MARIANO	CSM0	CSM0					
CHECK	MONICA	MMARROIG	CJH4	CJH4					
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## 1 INTRODUCTION

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

“Bolting” and “bolt” are terms used in this document to collectively describe fasteners, including screws, nuts, bolts, washers, and studs. The use of the terms “bolt” or “bolting” includes all the materials listed above, unless otherwise specifically noted herein.

This specification applies to all bolting within the UNIT, including those used within equipment, piping systems and structural components.

This specification also applies to bolting materials that connect the internal parts of equipment, valves, instruments, and all other accessories that are connected to piping or equipment.

This specification also has requirements for bolting that are in the splash zone of the UNIT.

This specification does not apply to bolts for subsea application.

This specification also does not apply to high strength structural bolting or any other special application bolting to which more stringent requirements are set elsewhere.

Additional bolting grades, not referenced in this technical specification, may be specified where they are deemed necessary. In these cases, SELLER shall submit these new grades for BUYER approval, showing that they will have a superior performance when compared to the specifications herein defined.

## 2 NORMATIVE REFERENCES

The requirements of the following normative references shall be fulfilled, as well as the additional requirements herein listed.


### 2.1 CLASSIFICATION

MANUFACTURER/PACKAGER shall perform the work in accordance with the requirements of Classification Society.

### 2.2 CODES AND STANDARDS

The following codes and standards contain provisions, which, through reference in this text, constitute requirements for this specification. SELLER shall use the latest issue of the references unless otherwise agreed. Other recognized standards may be used, provided it can be shown that they meet or exceed the requirements of the standards referenced below.

- API TECHNICAL REPORT 21TR1: 2019 - Materials Selection for Bolting.
- API SPEC 20E:2021 - Alloy and Carbon Steel Bolting for Use in the Petroleum and Natural Gas Industries.
- API SPEC 20F:2021 - Corrosion Resistant Bolting for Use in the Petroleum and Natural Gas Industries.
- ASTM A193:2020 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High-Temperature or High Pressure Service and Other Special Purpose Applications.
- ASTM A194:2022 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
- ASTM A320:2022 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.

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- ASTM B841:2018 - Standard Specification for Electrodeposited Coatings of Zinc Nickel Alloy Deposits.
- ASTM B850:2022 - Standard Guide for Post-Coating Treatments of Steel for Reducing the Risk of Hydrogen Embrittlement.
- ASTM D6386:2022 - Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting.
- ASTM F1470:2019 - Standard Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection.
- ASTM F2329:2015 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
- ASTM F3125:2022 - Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength
- ISO 15156 Petroleum and natural gas industries — Materials for use in H<sub>2</sub>S-containing environments in oil and gas production. Parts 1, 2 and 3.
- ISO 898-1 - Mechanical properties of fasteners made of carbon steel and alloy steel Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread
- BS EN 10204 - Metallic products - Types of inspection documents.
- ASME B1.1 - Unified Inch Screw Threads.
- ASME B18.2.2 – Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange and Coupling Nuts (Inch Series).

Governmental codes, regulations, ordinances, or rules applicable to the equipment in Brazil shall prevail over the requirements of above specification, including reference codes and standards and/or this Technical Specification, but only in those cases where they are more stringent.

### 2.3 REFERENCE TECHNICAL SPECIFICATIONS

The following technical specifications contain additional requirements or information. The specific document number may vary, and SELLER shall use the document as applicable to the contract.


- I-ET-3010.00-1200-956-P4X-002 – GENERAL PAINTING.
- I-ET-3010.00-1352-130-P4X-001 – FLOOR GRATINGS, TRAY SYSTEMS AND GUARDRAILS MADE OF COMPOSITE MATERIALS.
- I-ET-3010.00-1200-940-P4X-002 – GENERAL TECHNICAL TERMS.

### 2.4 CONFLICTING REQUIREMENTS

In case of conflicting information between this Technical Specification and the referred applicable standards, the most stringent shall prevail.

In case of conflicting information between this Specification and other specific BUYER's document, a formal technical query shall be issued to BUYER seeking clarification.

Failure to observe this requirement may result in remedial work at SELLER expense.

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### 3 DEFINITIONS AND ABBREVIATIONS

#### 3.1 DEFINITIONS

Definitions are in accordance with the technical specification I-ET-GENERAL TECHNICAL TERMS, the ones contained in standard API TR 21TR1, and the following:

**splash zone**

the zone of the platform that is alternately in and out of the water because of the influence of tides, winds and seas. The actual extension depends on astronomical tide range plus the wave height and should be defined in Design Basis.

**pressure-containing**

part exposed to conveyed/contained fluids whose failure to function as intended would result in a release of conveyed/contained fluid to the environment.

**pressure-retaining**

part not exposed to conveyed/contained fluids whose failure to function as intended will result in a release of conveyed/contained fluid to the environment.

**PTFE**

polytetrafluoroethylene, synthetic fluoropolymer of tetrafluoroethylene

#### 3.2 ABBREVIATIONS

Abbreviations shall be as defined in standard API TR 21TR1.

### 4 FASTENER MATERIAL SELECTION

Fastener materials shall be selected in accordance with the general requirements of the applicable design code and the following additions.

#### 4.1 GENERAL APPLICATION

The requirements herein listed apply to all pressure-containing and pressure-retaining bolts within the platform.

Bolting applied to connecting the piping systems, equipment, valves, instruments and accessories with each other, shall always be fabricated to US customary units (inches series). Threads shall be in accordance with ASME B1.1 and nuts shall be in accordance with ASME B18.2.2.

Bolting applied to the internal assembly of parts of equipment, valves, instruments and accessories, and therefore are part of its specific design, may be fabricated to US customary units or to metric units.

Bolting materials for piping systems shall be as established in the applicable piping specification (SPEC sheets). The materials therein indicated are in general agreement with the requirements herein listed.

The general bolting material selection for bolt with diameters above 10mm shall be in accordance with the ASTM standards listed below (Table 1).

**Table 1 – General Bolting Material Selection**

Temperature Range (°C)	BOLT	NUT	Size Range (mm)	OBS
-46/+400	A 193 Grade B7	A 194 Grade 2H	≤ 100	(1)
	A 193 Grade B7M	A 194 Grade 2HM	≤ 100	(2)
-100/+400	A 320 Grade L7	A 194 Grade 7/S3	≤ 65	(3)
	A 320 Grade L7M	A 194 Grade 7/S3	≤ 65	(2)(3)
	A 320 Grade L43	A 194 Grade 7/S3	< 100	(3)
-29/+540	A 193 Grade B16	A 194 Grade 7	All	(4)
-196/+540	A 193 Grade B8M	A 194 Grade 8M/ 8MA	All	(4)(5)(6)

- (1) General application bolt. Minimum hardness shall not be less than 248 HBW or 24 HRC, i.e., not less than the minimum hardness of the bolt for size over 40 mm or M36.
- (2) Bolt for sour service. Minimum hardness shall not be less than 200 HBW or 93 HRB, i.e., not less than the minimum hardness of the bolt.
- (3) These grades shall be selected for low temperature service, when the applicable minimum design temperature is below the range permitted for the A 193 Grade B7 (from -100°C to -46°C).
- (4) This grade shall be selected for high temperature service, above the temperature range permitted for the A 193 Grade B7 (from 400°C to 540°C).
- (5) This grade shall be selected for extra low temperature service, when the applicable minimum design temperature is below the range permitted for the A 320 Grade L7 or A 320 Grade L43 (from -196°C to -100°C).
- (6) Type 316 bolts and nuts shall not be used at maximum operating temperature above 60°C if exposed to wet marine atmosphere. Alloy 718 may be considered as an alternative. Use 8MA with class 1 bolts.

Bolts with diameters below 10mm shall be stainless steel Type 316 (ASTM A 193 Grade B8M) for metal temperatures below 60°C based upon the maximum operating temperature. For metal temperatures greater or equal to 60°C materials resistant to stress corrosion cracking at the actual temperature shall be selected if the stressed parts are exposed to humid marine environmental conditions (alloy 718 may be considered as an alternative).


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

Bolting materials different from 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 BUYER approval shall be sought prior to application.

Bolts screwed into component bodies shall be of a material that is compatible with the body in respect to galvanic corrosion and in respect to galling, so that the connection shall keep its ability to be disassembled for maintenance.

The use of stainless steel grades that are prone to localized corrosion is prohibited. This is valid also for bolting within valves, instruments, equipment, and any other appurtenances or accessories that may have bolting exposed to the offshore environment. The following grades are examples of susceptible materials:

- ASTM A 193 Grades B8, B8N, B8T, B8LN (types 304, 304L and 321);
- ISO 3506 Grades A1, A2, and A3;

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- ASTM A 540 Grade 630 (S17400), 631 (S17700), and 635 (S17600).

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

The use of higher strength bolting (compared to the ones listed in Table 1) is not recommended. When the use of higher strength bolting is deemed necessary, BUYER approval shall be sought prior to application. In any case, the maximum hardness of the selected bolting material shall be limited to 35 HRC.

Bolts located on immersed areas of the platform (e.g., inside tanks, caissons and within equipment) shall be selected and/or coated so that they remain suitable for the intended service. SELLER shall propose the alternatives for each intended case (CRA material or coating). When coating is selected as the corrosion protection method, it shall be performed as established in I-ET-3010.00-1200-956-P4X-002 (GENERAL PAINTING).

Failure to observe these requirements may result in remedial work at SELLER's expense.

## 4.2 CRA BOLTING FOR SPECIAL APPLICATIONS

Alternative materials may be deemed necessary for bolting where the service requires higher corrosion resistance alloys.

The following materials may be applied, subject to the conditions herein stated:

- 25% Cr Super Duplex Stainless Steels (UNS S32750 or UNS S32760): In accordance with ASTM A 1082 (bolts and nuts). Shall not be specified if subject to cathodic protection potential. Maximum design temperature for chloride containing environments 110°C. Maximum design temperature for chlorides free environments 260°C.
- UNS N06625: In accordance with ASTM F468 Grade Ni625 (bolts) and ASTM F467 Grade Ni625 (nuts).
- UNS N07718: In accordance with ASTM F 2281. Shall be avoided if there is possibility of crevice corrosion. Shall not be specified as bolting material if subject to cathodic protection.

## 4.3 STRUCTURAL APPLICATIONS

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

Bolting for grating shall be according to I-ET-3010.00-1352-130-P4X-001 (Floor Gratings, Tray systems and Guardrails made of Composite Materials).

High strength steel bolts (such as ASTM F3125 grades A325 or A490, or ISO 898-1 class 8.8 and above) may be used but will require prior BUYER's approval.


## 4.4 SPLASH ZONE APPLICATIONS

Bolting that will be applied in the unit splash zone will be exposed to an extremely corrosive environment. Since the CP system is not capable of protecting the materials within this region, they must be selected from a high grade CRA material.

Bolting material specification shall be solution annealed nickel alloy 625 (ASTM F468 Grade Ni625 for bolts, ASTM F467 Grade Ni625 for nuts).

General quality requirements for these bolting materials shall be in conformance with API SPEC 20F, BSL-2, including the following:

- Qualification Testing (acceptance based on the applicable material specification).
- Limits of Bolting Qualification (including the amount of cold reduction).

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- Production of Qualified Bolts (including the Material Specification and the Manufacture Process Specification by the bolting manufacturer).
- Test Report.

Evidence of the above-mentioned requirements shall be supplied along with the material certificate.

Factory acceptance tests reports for these bolting materials shall include at least the following:

- a) Chemical analysis.
- b) Hardness.
- c) Metallography with microhardness profile measurement.
- d) Tensile tests.
- e) Visual and dimensional inspection.
- f) NDE.

Sampling for the tests listed above shall be as determined in API SPEC 20F.

Surface NDE need is not required. Volumetric NDE shall be applied for diameters above 2.5 in (as defined in API SPEC 20F).

All bolt and studs must have maximum hardness of 32HRC.


Microhardness in the root region of the threads: All bolts, studs and nuts must have the maximum individual microhardness of 400 HV measured in the region of the root of the threads. The Vickers microhardness must be conducted with a load of 100 grams and must be carried out from the root of the thread to about 2 mm deep, with 200 µm distance between indentations.

#### **4.5 OTHER APPLICATIONS**

Bolting that seems to fall outside the scope of the previous items (4.1 through 4.4) still need to follow the general quality requirements therein established, specially regarding the following:

- Galvanic corrosion.
- Galling.
- Thermal expansion coefficient difference.
- Corrosion resistance.
- Embrittlement phenomena.

Material selection for all bolting within the unit shall be performed accordingly. Applied coating on the selected bolting shall be as established in item 5. Failure to observe this requirement may result in remedial work at SELLER expense.

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## 5 COATING SPECIFICATION

Coatings as herein specified shall be applied to all fastener's materials within the selected group, including screws, nuts, bolts, washers, and studs. The use of the terms "bolt" or "bolting" includes all the materials listed above.

### 5.1 COATING FOR GENERAL APLICATION BOLTING

The requirements herein listed apply to all and every bolting material within the platform, except for bolting intended for structural application covered in item 0.

Coating for bolting materials shall be selected as follows:

- a) Stainless steel or other CRA bolting materials: no coating applied.
- b) Carbon / Low Alloy Steel bolting materials, applied to piping and equipment with design temperature above 260°C: no coating applied.
- c) Carbon / Low Alloy Steel bolting materials, applied to piping and equipment with design temperature at or below 260°C: zinc/nickel electroplating (see 5.1.1 below) or any other coating process with superior quality (previous BUYER approval is required in this case).

#### 5.1.1 Zinc/Nickel Electroplating

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

- a) Class 1 or Class 2 (5%Ni up to 16%Ni).
- b) Type B/E, Type C/E or Type D/E.
- c) Grade 10 (minimum thickness of 10 µm).

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 (or hardness above 31 HRC). This post-coating treatment is mandatory for all fasteners in ASTM A193 Grade B7 and ASTM A320 Grade L7 specifications. Evidence of the applied treatments shall be provided with due traceability.

#### 5.1.2 PTFE Coating

The use of fluoropolymer in lieu of the Zn-Ni plating is considered acceptable, but BUYER prior approval is required.


Approval will be dependent on the following factors:

- a) Technology to be used.
- b) Qualification of the coating specification and of the coating supplier.
- c) Selected pre-treatment and coating schemes dependence on the design temperatures.

In this case SELLER shall use different colors to identify the main bolt specification, as follows:

- a) A 193 Grade B7: Blue.
- b) A 320 Grade L7: Gray.
- c) A 320 Grade L43: Red.
- d) A 193 Grade B7M: Yellow.



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- e) A 320 Grade L7M: Green.
- f) A 193 Grade B16: Orange.

BOLT COATING APLICATOR shall be qualified per coating manufacturer in a Quality Approved Program. Alternatively, a BOLT COATING APLICATOR dully approved by SELLER in qualification program may be presented for BUYER evaluation.

A report of the bolt coating system application and tests shall be presented.

### 5.1.3 Hot Dip Galvanizing

The use of Hot Dip Galvanizing (HDG) for bolts for pressure-retaining and pressure-containing parts is not acceptable.

HDG is considered acceptable for bolts for non-pressure retaining and non-pressure containing applications (such as within instruments, actuators, or other accessories), when these parts are applied in a sheltered ambient (not exposed to the marine atmosphere) and the bolting temperature is expected to be lower than 60°C.

When applied, HDG shall be performed as predicted in ASTM F2329. Safeguarding and testing against embrittlement shall be performed as described in ASTM A 143 for parts made of steel with ultimate tensile strength equal or above 800 MPa (high strength steel bolts such as ASTM F3125 grades A325 or A490, or ISO 898-1 class 8.8 and above).

Mechanical galvanizing is not acceptable.

### 5.1.4 Cathodic Coating/Plating

The use of coatings that are cathodic with respect to the substrate (e.g., nickel plating) is not acceptable.

## 5.2 COATING FOR STRUCTURAL APPLICATIONS BOLTINGS

Carbon and low alloy steel bolting materials for structural applications may be coated as described in 5.1.1 above (Zinc/Nickel Electroplating) or may be galvanized as described in 5.1.3.

Stainless steel bolting material for structural applications shall not be coated.

Galvanized carbon and low alloy steel bolting materials shall be field painted after installation. The painting specification, according to I-ET-3010.00-1200-956-P4X-002 (GENERAL PAINTING), shall be suitable to the surface (ASTM D 6386 provides details on the preparation of galvanized surfaces preparation).

## 5.3 OTHER COATINGS


Coatings other than the ones herein specified may be applied, but they must be subject to BUYER approval. SELLER shall demonstrate, through testing and through previous successful application, that the proposed coating meets or exceeds the performance of the originally specified coating.

## 6 ADDITIONAL QUALITY REQUIREMENTS

Threads shall be formed by rolling (cold forming), and the roots shall be rounded. Machined threads (cut) are not acceptable.

For sour environments bolt materials selection shall comply with ISO 15156 requirements.

All bolts and nuts shall be supplied with certification according to EN 10204 Type 3.1. Satisfactory traceability shall be guaranteed between the material (mill) certificate, the coating application certificate, and the heat treatment reports.

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## 7 MANUFACTURING, INSPECTION AND TESTING

The quality requirements for the bolting materials shall be as follows:

- General application carbon a low alloy steel bolting: conforming to API SPEC 20E, BSL-1.
- General application CRA bolting: conforming to API SPEC 20F, BSL-2.
- Structural application bolting: as per the applicable ASTM standard.
- Bolting for splash zone application: as defined in item 4.4.

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

## 8 RECEIVING INSPECTING AND TESTING

Upon receiving and before application, the bolting materials shall be inspected and tested by SELLER to check the conformance with the herein specified requirements.

### 8.1 LOT DEFINITION

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

- 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.
- Continuous furnace: bolting or raw material of a single heat and diameter heat treated without interruption in a continuous charge.
- In any case, heat treatment performed in batches after coating implies in separated lots.

### 8.2 VISUAL INSPECTION

Every lot of bolting material received shall be checked visually upon receiving to verify its main characteristics, such as:

- Applicable marking (stamping).
- Diameter.
- Length.
- Thread type.
- General state when it comes to corrosion or damage.
- Coating integrity.

Bolting materials with no marking (stamping) as required by the applicable material specification shall be rejected.

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

### 8.3 TESTING

After the visual inspection, every lot of bolting material shall be tested as follows.

Sampling for the tests shall be as determined in ASTM F1470 (Standard Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection) as per the *Detection Process* level

At least the following tests shall be applied:

- Chemistry (including the bolting and the coating).
- Tensile strength (full size or machined specimen).
- Yield strength (full size or machined).

- Elongation / area reduction.
- Hardness.
- Impact.
- Plating/coating thickness.
- Salt spray test.

Acceptance criteria for all tests (except for the salt spray) shall be as the applicable ASTM standard.

The coating (Zn-Ni electroplating, HDG or PTFE) shall sustain over 1000hrs of ASTM B117 salt spray without red rust.

#### 8.4 APPROVAL/REJECTION

Bolting materials may only be considered as approved in the receiving inspection after all tests have been performed with satisfactory results.

Disposition of non-conforming lots shall be as established in ASTM F1470.

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

Note: This technical specification was revised with the contribution of the following specialists

ANDRÉ MARIANO	CSM0	SRGE/ESUP/EEA
LUCIANO ANDRE PIANA	CTM4	CENPES/PDIDP/TIA/TMI
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MONICA CUNHA MARROIG	CJH4	SRGE/ESUP/EEA