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## INTRODUCTION

This Specification establishes the technical requirements for tubing and fitting to be supplied to **PETROBRAS**' FPSOs. This specification complements IOGP S-716 and its amendments (IOGP 716 IRS and IOGP 716 QRS).

This technical specification is written as an overlay to IOGP S-716 (version 1.0), matching the same numbers of section and subsections. If the section (or subsection) of the document IOGP S-716 needs a modification, this specific section is identified with: **Added** (added to section or add new section), **Replaced** (part of or entire section) and **Deleted** (section removed).

In addition to the requirements of this technical specification, **CONTRACTOR** shall follow all the requirements of the Exhibit I (Scope of Work), as well as Exhibit III (Directives for Engineering Execution), Exhibit IV (Directives for Construction and Assembly), Exhibit V (Directives for Procurement), Exhibit VI (Directives for Planning and Control), Exhibit VII (Directives for Quality Management System) and Exhibit VIII (Directives for Commissioning Process).

### 1 Scope (Items Added)

**b.1) Small bore tubing system components suitable for use in pressures up to at least 15,000 psi (medium pressure). All requirements regarding design, material selection, installation, inspection & testing, marking and preservation & packing are applicable. It is also indicated where medium pressure components shall be used even in the conditions described in item b from JIP33 S-716.**

#### 1.1 Conflicting Requirements (Added)

In case of conflicting requirements between this technical specification and other applicable document (legislation, standard, OWNER technical specification etc), a formal technical query shall be issued to OWNER, seeking clarification.

#### 1.2 Interdisciplinary Interfaces (Added)

The application of this document demands interactions between several disciplines creating interfaces, which are inherent to a production plant. Interfaces can exist in any item of this



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technical specification. However, where interfaces of great impact were identified, the term [INTERDISCIPLINARY INTERFACE] is used, followed by the abbreviations of the interacting disciplines. Below is a list of all possible discipline abbreviations:

- i. ARC: Architecture;
- ii. ARR: Arrangement;
- iii. COM: Commissioning;
- iv. ELE: Electrical;
- v. HSE: Health, Safety and Environment;
- vi. HVAC: Heating, Ventilation and Air-conditioning;
- vii. MEC: Mechanical;
- viii. NAV: Naval Architecture;
- ix. PIP: Piping;
- x. PRO: Process;
- xi. SNAV: Marine Systems;
- xii. TBM: Turbo Machinery;
- xiii. 3D: Project Automation and 3D Modeling.

**2 Normative References (References Added)**

Below are added references

Energy Institute – Guidelines for the Avoidance of Vibration Induced Fatigue Failure in Process Pipework



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ASME BPVC SEC IX, section ix qualification standard for welding, brazing, and fusing procedures; welders; brazers; and welding, brazing, and fusing operators - welding, brazing and fusing qualifications

**3 Terms and Definitions (Items Added)**

**3.6 (Added)**

**TUTU**

Topside Umbilical Termination Unit

**3.7 (Added)**

**pigtail**

Device made on the impulse line tube with a minimum of 2 ½ turns used to allow greater differential movement between two connection items, such as a control instrument tubing off a flow line able to accommodate the main line movement



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## 4 DESIGN

### 4.2 Sizing

#### 4.2.1.1 (Added)

Only imperial sizes shall be used for tubing and fittings.

#### 4.2.2.1 (Added)

Tubing diameter and wall thickness shall be determined taking into account:

- The design pressure of respective equipment/pipe in case of impulse lines or the setpoint pressure of respective PSV when small bore tubes are used as process conduit such as chemical injection line, hydraulic distribution line and pneumatic distribution line. These pressures are referred as Design Pressure;
- The Pressure of Leak Test required in items 7.3 and 7.4;
- The Tube Maximum Recommended Working Pressure defined by tubing manufacturer or fitting manufacturer;
- The minimum internal diameter defined by ISO 2186 for impulse lines and the internal diameter for systems that transfer fluids (e.g. hydraulic distribution, instrument air pneumatic distribution, chemical injection etc) that is determined to limit fluid velocity, pressure drop etc.

Taking all above into account, the tube wall thickness shall be determined in the following manner:

- Maximum Recommended Working Pressure  $\geq 1.1 \times$  Design Pressure, for Pneumatic Leak Test; or
- Maximum Recommended Working Pressure  $\geq 1.5 \times$  Design Pressure, for Hydraulic Leak Test.

In other words, the tube shall never be submitted to a pressure above its maximum recommended working pressure stated by either tubing or fitting manufacturer.

#### 4.2.2.2 (Added)

Tubing for fusible plug network shall be according with item 5.1.1.3.

### 4.3 Small bore tubing


### 4.4 Small bore tubing system components

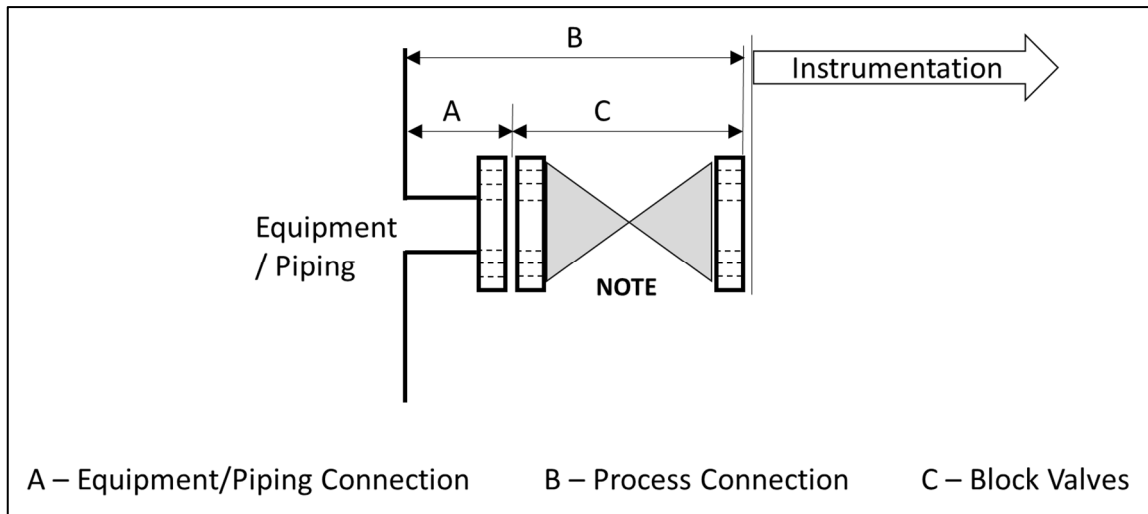
#### 4.4.1 General

##### 4.4.1.1.1 (Added)

Tubing fittings rated for 15,000 psi shall be male thread nut with double ferrule technology.



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<p><b>4.4.1.1.2 (Added)</b></p> <p>Cone and Thread Fitting only acceptable for application above 15,000 psi.</p> <p><b>4.4.1.2.1 (Added)</b></p> <p>Connections of tubing system components shall be of male thread nut with double ferrule technology and rated for at least 15,000 psi shall be used for following cases:</p> <ul style="list-style-type: none"> <li>— Chemical injection lines (CNI) interconnected to TUTU plate and TUTU plate bulkhead connections;</li> <li>— Chemical injection lines (CNI) for toxic fluid (such as H<sub>2</sub>S scavenger, O<sub>2</sub> scavenger, glycol etc) with design pressures equal or greater than 15,000 kPa (2,175.6 psi);</li> <li>— Downstream Injection compressor inlet shutdown valve, including the upstream impulse line of differential pressure measurement for inlet SDV pressure equalization;</li> <li>— Downstream export compressor discharge;</li> <li>— For any service at design pressures equal or above 33,000 kPa (4,786.2 psi).</li> </ul> <p><b>4.4.2 Instrument air manifolds</b></p> <p><b>4.4.2.4.1 (Added)</b></p> <p>The maximum pressure drop from instrument air distribution header to consumer shall be determined as follows:</p> <ul style="list-style-type: none"> <li>— The pressure drop between instrument air distribution header and distribution manifold shall be a maximum of 10 kPa (1.45 psi). <b>[INTERDISCIPLINARY INTERFACE][PRO, TBM, ELE, I&amp;A, PIP]</b></li> <li>— The pressure drop between distribution manifold and consumer shall be a maximum of 20 kPa (2.9 psi). <b>[INTERDISCIPLINARY INTERFACE][PRO, TBM, ELE, I&amp;A, PIP]</b></li> </ul> <p><b>4.4.3 Instrument tubing valves</b></p> <p><b>4.4.3.1.1 (Added)</b></p> <p>Item 4.4.1.1 shall be taken into account when defining tubing valves for the services described in item 4.4.1.2.1.</p> <p><b>4.4.3.3.1 (Added)</b></p> <p>Referred Primary isolation in item 4.4.3.3 is represented as figure 1_BR below, item C, where single or double block is defined by piping and process (systems) specifications.</p>			



**NOTE:** The use of single or double blockage must be done according to piping and process specifications

Figure 1\_BR: Primary isolation for instrumentation

**4.4.3.4.1 (Added)**

In item 4.4.3.4, when the process fluid is flowing inside tubing (e.g. chemical injection lines, hydraulic distribution lines), the use of instrument tubing valves are permitted.

**4.7 Vibration and thermal effects**

**4.7.1 (Added)**

Tubing supports in areas subjected to vibration shall be placed adjacent to fitting such as unions, tees, etc., in addition to the spacing given in Table 4. Supports should be placed as close to bends as possible.

**4.7.4 (Added)**

Tubing run must be designed using isometric drawings as per item 6.1.7 to represent above requirements and to optimize the number of supports.



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## 5 Material selection

### 5.1.1 (Added)

The tubing material for general services shall be 316L or 316/316L dual certified, being both with minimum 2.5% Molybdenum content.

#### 5.1.1.1 (Added)

For sour service the tubing materials to be used, from table 2 of JIP33 S-716, are listed below:

- Alloy 254 (6Mo) (ASTM:A269, UNS:S31254);
- 25Cr Super Duplex SS (ASTM:A789/A789M, UNS:S32750/S32760);

#### 5.1.1.2 (Added)

For tubing installed inside or that cross regions prone to be in contact with sea water or seawater spray shall use the following materials from table 2 of JIP33 S-716:

- Alloy 254 (6Mo) (ASTM:A269, UNS:S31254);
- 25Cr Super Duplex SS (ASTM:A789/A789M, UNS:S32750/S32760);

As minimum, following locations are defined as regions where tubes are prone to be in contact with sea water or seawater spray and are not subject to discussion:

- Main Deck;
- Upper Riser Balcony;
- Forecastle Deck;
- Poop Deck;
- Mooring Balcony;
- Diving Stations;
- Ballast Tanks;
- Cofferdams/Void Spaces;
- Bottom of Engine Room;
- Bottom of Pump Room;
- Modules with deluge, even if the deluge is in part of the module;
- Levels below regions with deluge where floor is grated.



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**5.1.1.3 (Added)**

The material of tubing for fusible plug network shall be Alloy 254 (6Mo) (ASTM:A269, UNS:S31254), regardless of its location of installation. The size shall be 3/8 in and 0.049 in of wall thickness.

NOTE: This tube size was used to determine the maximum fusible plug length. For more details see I-ET-3010.00-1200-800-P4X-013, chapter 20.

**6 Installation**

**6.1 General**

**6.1.2.1 (Added)**

The manufacturer in item 6.1.2 shall be understood as the tubing/fittings manufacturer.

**6.1.4.1 (Added)**

The connections assembly must foresee space to allow the handling of assembling tools.

**6.1.7 (Added)**

All tubing lines (tubing runs) shall be designed through isometric documents representing support details. This is applicable to any tube run, such as, and not limited to, impulse lines, hydraulic and pneumatic distribution, sample line and chemical injection lines. This design shall optimize the number of supports while complying with every requirement.


**6.1.7.1 (Added)**

On Isometric, medium pressure components shall state the torque values based on the manufacturer's recommendations and a torque report for medium pressure fittings shall be issued.

**6.1.8 (Added)**

Tubing shall be in sticks (straight rods) with a minimum length of 6 meters and maximum length of 12 meters.

Impulse lines shall be constructed using tube sticks without unions and with no welds such as orbital weld. Coiled tubing can be used for impulse lines provided conditions of item 6.1.8.1.

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The use of coils is restricted and item 6.1.8.1 determines where coiled tubing can be used.

#### 6.1.8.1 (Added)

Provided coiled tubing are straighten using tube straightener machine, it can be used for:

- Impulse lines: shall not have no OD/OD joint connections (e.g., straight fitting, elbows etc) and no welds such as orbital weld;
- Pneumatic distribution between the instrument air distribution manifold and the consumers;
- Hydraulic feed between the solenoid rack and the consumers;
- Chemical injection lines;
- Lines for manual sample collection.

#### 6.1.8.2 (Added)

In process lines, hydraulic fluid distribution, instrument air fluid distribution and chemical injection lines, it is acceptable the use of tubing connected through welds provided that:

- Welds shall be orbital type and done automatically by specialized machine;
- It is mandatory the use of purge gas in all steps;
- The welds are subjected to inspection by non-destructive test according to applicable inspection level;
- The welding procedure specific for this purpose shall be qualified as per ASME BPVC SEC IX.
- Only trained and certified welders on the type of acceptable welding procedure.

### 6.2 Small bore tubing system installation

#### 6.2.1 Tube routing

##### 6.1.2.1.1 (Added)

In item 6.2.1.2 the sentence “routed separately from cables” shall be understood as not in the same tray, angle or channel.

##### 6.2.1.5.1 (Added)

Tube run constructed as per item 4.3.1.1.1 reduce the risk of leakage.



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### 6.2.2 Supports

#### 6.2.2.1.1 (Added)

For impulse lines with working pressure equal or above 100 barg (10,000 kPag / 1450.37 psig) with linear total length less than spacing for supports established in table 4 shall have at least one intermediate support point.

#### 6.2.2.3 (Added)

Straight tubes should not be used between two rigid connections, because of the high stresses imposed when the tube expands or contracts. Tubing run must have curves to allow expansion and contraction and relative motion between rigid connections. Supports must be located to allow for expansion and contraction.

#### 6.2.2.4 (Added)

In addition, proper support minimizes the danger of recoil and line whip in the event of tubing failure caused by excessive pressure.

#### 6.2.2.4.1 (Added)

Towards pressure source (e.g., from instrument to process connection), an additional support shall be installed 500 mm downstream every fitting (union, tee, adaptor, reduction etc). This support can be a support already foreseen by another criteria.

#### 6.2.2.5 (Added)

All concentrated mass upon tubing, e.g., valve, gauge and instrument, shall be supported.


## 7 Inspection and testing

### 7.2.1 (Added)

The certificate shall be in accordance with API RP 578.

### 7.7.1 (Added)

In additional to the standard performance test, Compression fittings for each tubing material and size combination shall be type test qualified for the supplementary performance tests listed below in accordance with ASTM F1387:2019, 13.2 and ASTM F1387:2019, Table S1.1

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- S2 - Thermal Cycling Test;
- S7 - Fire Test;
- S8 - Vibration Test.

#### 7.7.2 (Added)

- The certification of test results shall be provided with compression fitting qualified to minimum and maximum wall thickness range as well as minimum and maximum pipe or tube outside diameter. Interpolation is acceptable in accordance with ASTM F1387:2019. Extrapolation is not acceptable.

#### 7.10.1 (Added)

Air particle purity class 3 in accordance with ISO 8573-1:2010 is also acceptable.

## 9 Preservation and packing

#### 9.3 (Added)

Tubing bars should be stored in a sheltered location. It can be arranged on shelves as long as they prevent warping, contamination and deformation, and can also be stored on the floor as long as they are far from the ground, supported on sleepers or platforms. The maximum stacking must meet the manufacturer's recommendation.

#### 9.4 (Added)

Stainless steel materials, nickel or titanium alloys and their alloys must be stored, handled and processed totally segregated from other materials, in order to avoid the risk of contamination.

#### 9.5 (Added)

Tubing shall be preserved using a clear varnish-like product as coating, which shall be applied upon receiving items at warehouse and touched-up after installation; during all Construction & Assembly and Commissioning period this coating shall be maintained and restored upon coming off. A specific document procedure shall be issued.