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1. OBJECTIVE

This specification defines the requirements for CONTRACTOR to perform the detailed design, procurement, fabrication, inspection, construction, installation, testing, commissioning, and pre-operation of the HARD PIPE SYSTEM for a BOT contract.

Design requirements and material selection requirements within this document shall be adhered to, unless CONTRACTOR shows that they are not viable within the project scope. Alternative requirements may be proposed in this case and are subject to PETROBRAS approval.

2. NORMATIVE REFERENCES

The following standards and documents include provisions, which, through reference in this text, constitute requirements of this technical specification. Latest issue of the references shall be used 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.

2.1 CLASSIFICATION SOCIETY RULES

2.1.1 Relevant Class Rules shall apply. Refer to Project General Conditions and Data Specification for nominated Classification Society.

2.1.2 CONTRACTOR's responsibilities include documents submission to the certifying authority as described in the latest edition of their rules for equipment for offshore facilities.

2.2 CODES, STANDARDS AND REGULATIONS

The following codes and standards are applicable to the Hard Pipe System.

API STD 6A	Specification for Wellhead and Tree Equipment
API 5L	Line Pipe
API 5LD	CRA Clad or Lined Steel Pipe
API STD 17D	Design and Operation of Subsea Production Systems, Subsea Wellhead and Tree Equipment
API TR 6AF	Technical Report on Capabilities of API Flanges Under Combinations of Load
API SPECIFICATION 20F	Corrosion-resistant Bolting for Use in the Petroleum and Natural Gas Industries
ASME B16.9	Factory-Made Wrought Buttwelding Fittings
ASME B31.3	Process Piping

ASME BPVC Section VIII Division 2	Boiler and Pressure Vessel Code. Rules for Construction of Pressure Vessels, Alternative Rules
ASME BPVC Section V	Nondestructive Examination
ASME PCC-1	Guidelines for Pressure Boundary Bolted Flange Joint Assembly
ASTM F467	Standard Specification for Nonferrous Nuts for General Use
ASTM F468	Standard Specification for Nonferrous Bolts, Hex Cap Screws, Socket Head Cap Screws, and Studs for General Use
DNVGL-RP-C203	Fatigue Design of Offshore Steel Structures
DNVGL-RP-C205	Environmental Conditions and Environmental Loads
DNVGL-ST-F201	Dynamic Risers
EN 10204	Metallic Products - Types of inspection documents
ISO 15156, all parts	Petroleum and Natural Gas Industries, Materials for use in H2S Containing Environments in Oil and Gas Production
ISO 15590-1	Petroleum and Natural Gas Industries, Induction Bends, Fittings and Flanges for pipeline Transportation Systems, Part 1: Induction Bends
ISO 18797-1	External corrosion protection of risers by coatings and linings Part 1: Elastomeric coating systems-polychloroprene or EPDM
IOGP S-705	Welding of Pressure Containing Equipment and Piping
IOGP S-715	Coating and Painting for Offshore, Marine Coastal and Subsea Environments

2.3 CONFLICTING REQUIREMENTS

In case of conflicting requirements between this technical specification and other cited references, the most stringent shall prevail. If necessary, CONTRACTOR may revert to PETROBRAS for clarification.

3. DEFINITIONS AND ABBREVIATIONS

The following abbreviations are used in this specification.

3D	Bending radius of three times the nominal diameter
BSDV	Boarding Shut Down Valve
CRA	Corrosion Resistant Alloy
FPSO	Floating Production Storage and Offloading
HAZ	Heat Affected Zone
HAZOP	Hazard and Operability Study
ITP	Inspection and Test Plan

LRB	Lower Riser Balcony
NDT	Non-Destructive Testing
P&ID	Piping & Instrumentation Diagram
PAUT	Phased Array Ultrasonic Testing
PT	Dye Penetrant Testing
SLWR	Steel Lazy Wave Riser
SMYS	Specified Minimum Yield Strength
TSUDL	Unified Diverless Support Tubes
URB	Upper Riser Balcony
VIV	Vortex Induced Vibration

4. GENERAL REQUIREMENTS

4.1 HARD PIPE SCOPE

4.1.1 The hard pipe scope within the unit includes all components required to interconnect a Steel Lazy Wave Riser (or Rigid Riser) from the Lower Riser Balcony (LRB) through the Upper Riser Balcony (URB) to the platform BSDV located on the unit topside. System components are such as, but not limited to, pipes, flanges, bends, blind flanges, spools, supports, mock-up, handling appliances and appurtenances for testing, installation, and commissioning.

4.1.2 Design and manufacture of hard pipe shall consist of the following as minimum:

- Complete mechanical design and calculation.
- Production of drawings and any other documentation as herein specified.
- Procurement of raw materials.
- Procurements of stud bolts & nuts, test/mock-up, temporary spools, blind flanges, and gaskets.
- Incorporation of independent inspection authority requirements if so requested.
- Testing and certification of materials as required.
- Fabrication, examination, inspection, and testing of the systems.
- Commissioning and preservation.

4.2 ENVIRONMENTAL CONDITIONS

4.2.1 For Detailed Design development, CONTRACTOR shall consider the environmental conditions as stated in the contractual documents (METOCEAN data, where available).

4.2.2 Environmental loads shall be established in accordance with DNVGL-RP-C205 and DNVGL-ST-F201, whereas 100 years return period sea state shall be used for design and operational condition and 1 year return period shall be used for fatigue design condition.

4.3 VESSEL RESPONSE ANALYSIS

4.3.1 For Detailed Design development, CONTRACTOR shall consider the vessel response analysis as stated in the contractual documents.

4.3.2 Accelerations and displacements due to hull movement shall be included in the design loads.

4.3.3 Reasonings and considerations can be provided by the CONTRACTOR in the design report where displacement is not deemed relevant to the design.

4.3.4 Relative displacement of the URB and LRB shall be considered for the hard pipe and for flange designs. Those displacements shall be studied and included in the design cases as required.

4.4 LOADS AND RESTRICTIONS

Loads and load cases shall be designated in accordance with ASME B31.3. In addition, the following load cases must also be considered.

- Vessel displacement/acceleration.
- Environmental loads due to wave and current.
- Riser imposed displacement.
- Marine growth.
- Dynamic contribution from riser pressure cycles.

4.5 DESIGN LIFETIME

CONTRACTOR shall design and fabricate the complete system for the minimum lifetime contractually defined.

4.6 CONTRACTOR'S RESPONSIBILITY

4.6.1 CONTRACTOR'S responsibility for the Hard Pipe System shall include, but is not limited to:

- Technical responsibility for the entire scope of supply.
- Resolving all engineering questions and/or problems relating to design and manufacture.
- All coordination with manufacturers and collection of all details, drawings, calculations, and data to achieve optimum design and full submission of the documents requested in the specification.
- Submit for review and approval for the classification society as well as resolve all issues appointed by the classification society.
- Providing details as requested of any sub-vendors relating to design and manufacture.
- Supervision of fabrication, examination, installation, testing, and commissioning activities, if performed by others.
- Provide adequate training for the operation personnel.
- Attend HAZOP meetings arranged by PETROBRAS.

4.6.2 Any exclusion and/or alternative to what is specified in this Technical Specification, including the use of any CONTRACTOR's standard and/or exclusive technology, shall be presented in a Deviation List, subject to PETROBRAS acceptance during the clarification phase, preceding the proposal presentation. Otherwise, the requirements herein will be considered as "Agreed," and therefore required to be fulfilled.

4.6.3 Adequate preservation of the system shall be provided to protect the system prior to the start of operation (corrosion protection as well as mechanical protection, as deemed necessary).

4.6.4 CONTRACTOR shall specify any limitations applicable to the installation phase.

5. HARD PIPE SYSTEM SPECIFICATION

5.1 FUNCTIONAL DESCRIPTION

5.1.1 The hard pipe system includes the components to interconnect the rigid riser (SLWR) to the topside platform boarding shutdown valve (BSDV) or to a temporary PIG trap.

5.1.2 The system components are mainly pipes, bends, flanges, and supports which lay mostly outside the hull shell therefore directly subjected the sea splash zone (see Figure 1).

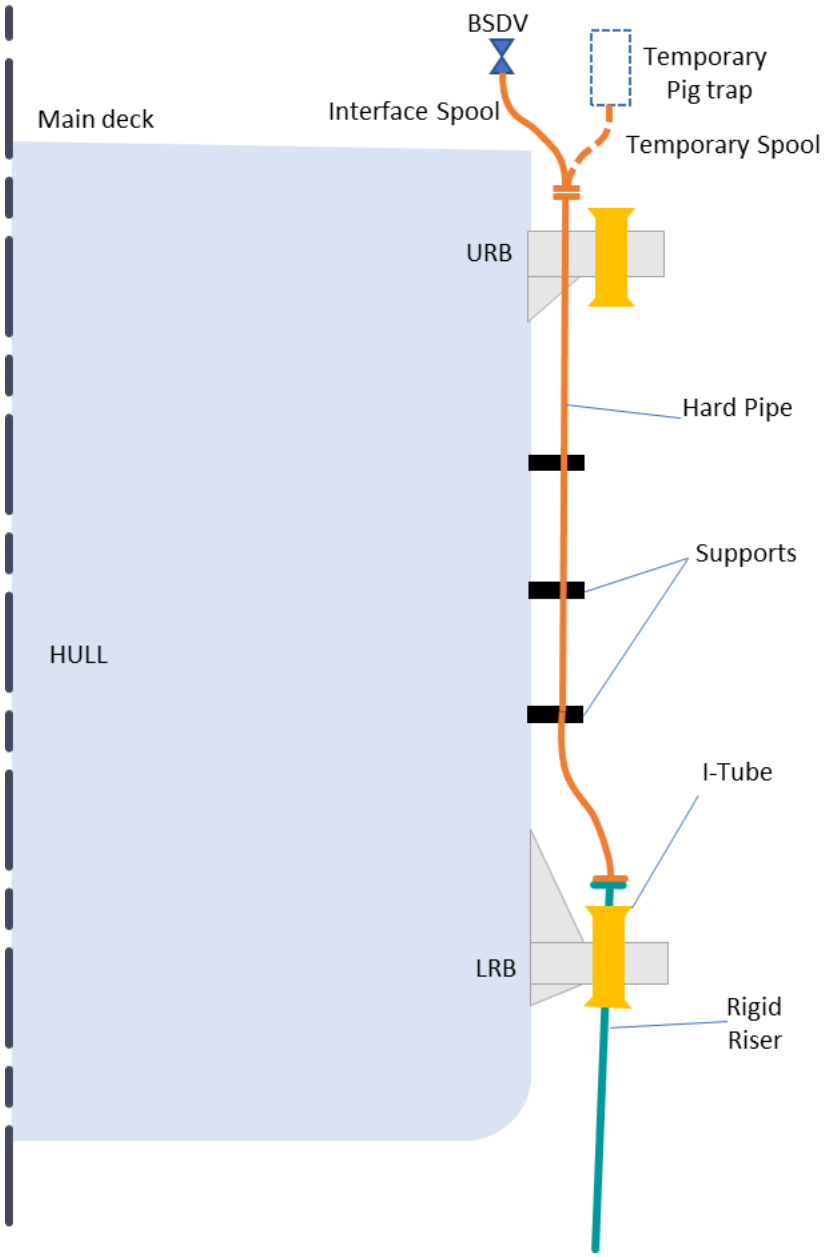


Figure 1 - Typical hard pipe configuration.

5.1.3 The hard pipe design arrangement shall be such that enables the FPSO pull-in system to pull the risers from subsea to the FPSO LRB without requiring removal of the hard pipe from the hull supports. This shall be achieved by rotating the hard pipe to a free pull-in area (parking position), as shown on Figure 2 below, or a similar design (different designs shall be approved by PETROBRAS).

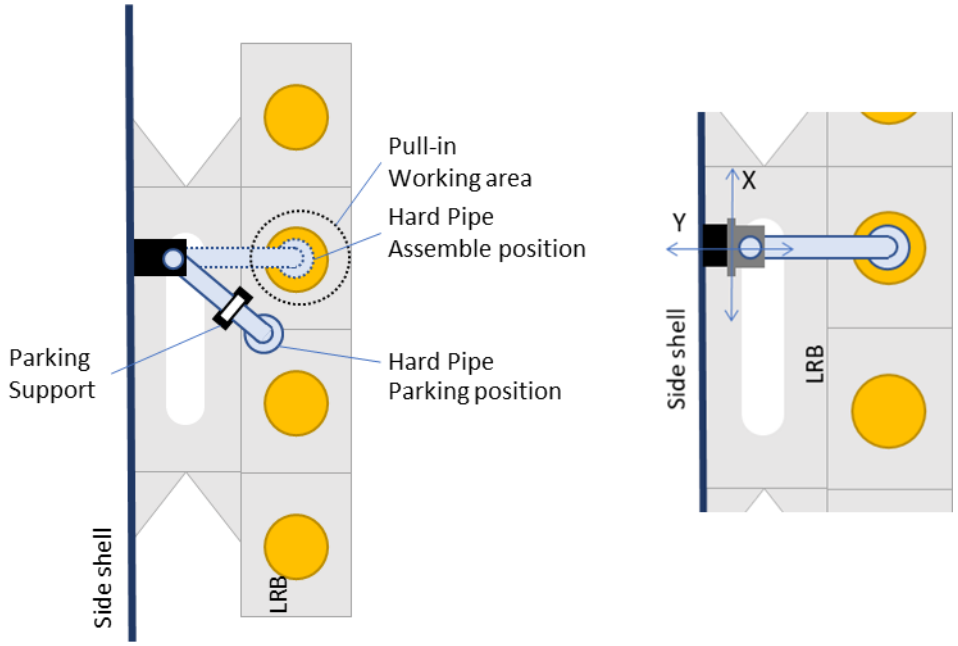


Figure 2 - Hard pipe parking position for pull-in operation.

5.1.4 The hard pipe shall have no middle pipe flange connections at the hull side. The hard pipe shall have flange connections at the following locations:

a) At the LRB (lower end of the hard pipe), to connect with rigid riser flange.

b) Above the URB (upper end of the hard pipe), to connect to an interface spool (see Figure 1).

c) At the BSDV (topside of the unit), to connect the interface spool with the platform piping system.

5.1.5 In between the flanges cited above all connections shall be butt type full penetration welds.

5.1.6 The procedure to move the hard pipe from its parking position to the operation position, aligned with the riser, shall be done with auxiliaries from the top side. When on parking position, the hard pipe shall be supported by a cradle type support, appropriate for sea fastening and long-term parking.

5.1.7 The hard pipe hull side shell supports shall permit adjustments in X-Y directions (see Figure 2) such that riser flange make-up can be done within the assembly tolerances.

5.1.8 The hard pipe top support at URB shall permit adjustments in X-Y-Z directions such that riser flange make-up can be done within the assembly tolerances.

5.1.9 The hard pipe is subjected to pigging operations for both cleaning and inspection activities. These operations may be performed from the platform pigging system or using a temporary pigging assembly in the URB (temporary PIG trap, see Figure 1).

5.1.10 There are two typical riser approach directions to the LRB: The arrangement design shall consider these two possible approach directions (see Figure 3).

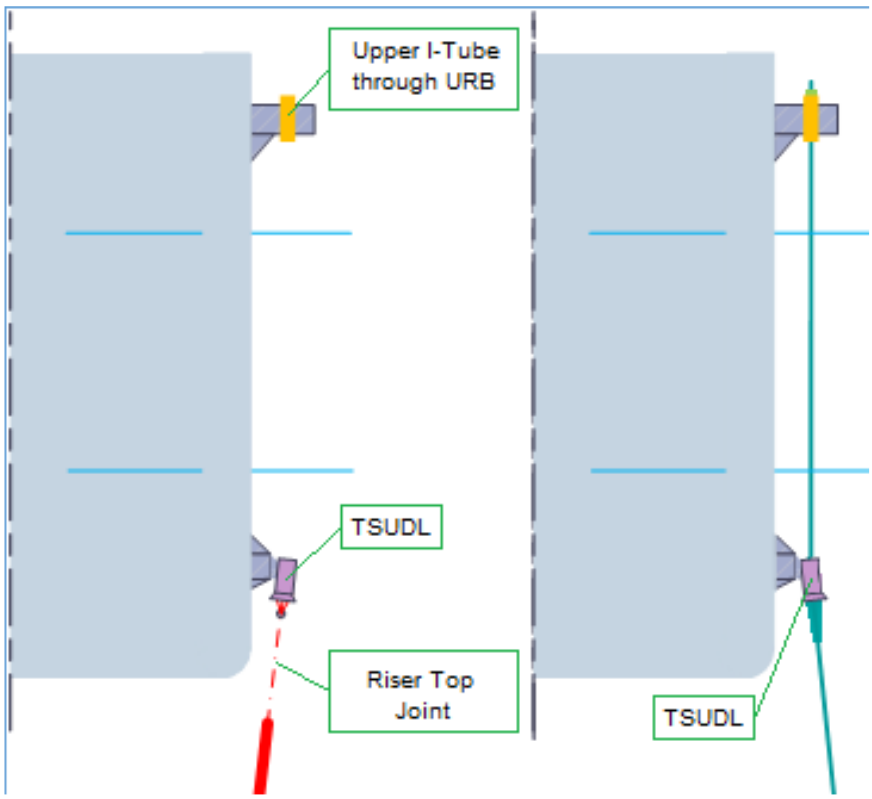


Figure 3 - Riser Support Tube Assembly (TSUDL & Upper I-Tube) (Illustrative)

5.2 HARD PIPE CONNECTION TO RIGID RISER

5.2.1 The hard pipe lower interface flange shall be designed (end, size, bore and pressure rating) to match the rigid riser top flange as specified in reference the technical specification for Structures and Facilities for the Riser System (document to be supplied by PETROBRAS).

5.2.2 Hard pipe lower interface flange shall be of the swivel type, custom designed as API SPEC 17D type 17SV. The gasket shall be of the BX type as per API SPEC 6A.

5.2.3 CONTRACTOR shall be responsible for mechanical design of the Swivel Flanges to meet the operating condition and design data specified in the technical specification for Structures and Facilities for the Riser System, including all applicable external loads.

5.2.4 Flange seal ring gasket, bolts and nuts are part of hard pipe scope of supply.

Note: bolt length shall be compatible with the flange assembly procedure to be applied later. Since hydraulic bolt tensioning is the required method for these flanges, extra bolt length shall be considered to enable the tension tool engagement.

5.3 HARD PIPE CONNECTION TO INTERFACE SPOOL

5.3.1 At the URB, the hard pipe top flange shall be according to API SPEC 6A, type API 6BX. The gasket shall be of the BX type as per API SPEC 6A. This flange shall be equipped with a test port.

5.3.2 Hard pipe top flange end, size, bore and pressure rating shall be the same as for the rigid riser top flange specification.

Note: pressure class rating of the hard pipe top flange may eventually not follow the same pressure class of the lower hard pipe flange, since the rigid riser top flange may have been selected on a higher pressure class due to the pull-in loads. This may be detected when the pressure class rating of the BSDV on the topside is lower than the rigid riser top flange pressure class rating. In this case the hard pipe top flange pressure rating may be changed to make it compatible with the BSDV.

5.3.3 Flange seal ring gasket, bolts and nuts are part of hard pipe scope of supply.

5.4 TOP INTERFACE SPOOLS

5.4.1 At the URB, an interface spool is required to connect the hard pipe from the URB to the BSDV (see Figure 4).

5.4.2 Interface spool lower flange (connects to the hard pipe top flange at the URB) shall be swivel type, custom designed as API SPEC 17D type 17SV. Flange end, size, bore and pressure rating shall be the same as for the hard pipe top flange.

5.4.3 Interface spool upper flange (connects to the topside BSDV) type, end, size, bore and pressure rating shall be the same as for the BSDV itself (see Figure 4). This flange shall be equipped with a test port.

5.4.4 The interface spool shall be designed as one of the following:

- As per the hard pipe, with all technical requirements as detailed in this technical specification.
- As per topside piping spec. In this case design, fabrication, materials, coatings, inspection, testing, commissioning, and all other technical requirements shall be as specified for the topside piping to which it connects.

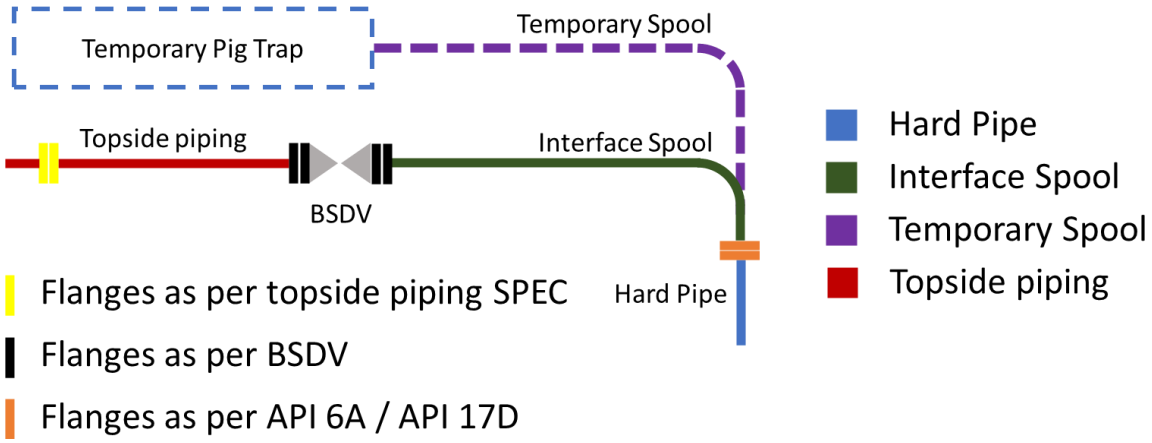


Figure 4 - Details on the flanges for hard pipe, interface spool and BSDV.

5.5 TEMPORARY (PIG TRAP) SPOOLS

5.5.1 Unless otherwise informed, during the commissioning stage a temporary PIG trap will be used for the commissioning of gas exportation hard pipe, therefore, a temporary connection spools shall be foreseen (within CONTRACTOR scope of supply) to interconnect the cited hard pipe to the temporary PIG trap.

5.5.2 Temporary PIG trap spool connection to the hard pipe shall follow the hard pipe upper flange details (see item 5.3).

5.5.3 Temporary PIG trap spool connection to the PIG launcher/receiver shall follow the PIG trap dimensional details.

5.5.4 The temporary PIG trap data will be supplied by PETROBRAS.

5.6 BLIND FLANGES

5.6.1 Blind flanges shall be supplied for all hard pipe lower interface flanges (which will later connect to the rigid riser top flange). The blind flanges end, size, bore and pressure rating shall be the same as for the hard pipe lower interface flange to which it connects.

5.6.2 These blind flanges may be used for the system pressure testing.

5.6.3 These flanges must be installed after the hard pipe has been approved in the functional test and has been put back at the parking position for sail-away, so that proper preservation of the system can be performed.

5.6.4 Blind flanges must be equipped with a test port.

Note: It is always a possibility that the blind flange assembly may happen at a later stage of the vessel commissioning, and therefore it may eventually be performed on a submerged condition. Test ports shall remain open during any underwater flange make-up and shall be closed immediately after it.

5.6.5 Blind flanges must be equipped with a threaded plug. This plug will be used later during the hard pipe commissioning phase to help remove seawater from within.

Note 1: Since the blind flange must be in accordance with the required pressure class, the threaded plug addition shall be backed up with enough flange reinforcement (the modified flange shall be properly calculated).

Note 2: the threaded plug need not be placed in the center of the flange. Since it will be used to empty the hard pipe from the seawater that has entered during the testing and commissioning phases, an off-center position (oriented with the pipe lower section, see Figure 5) will make it better suited for its purpose.

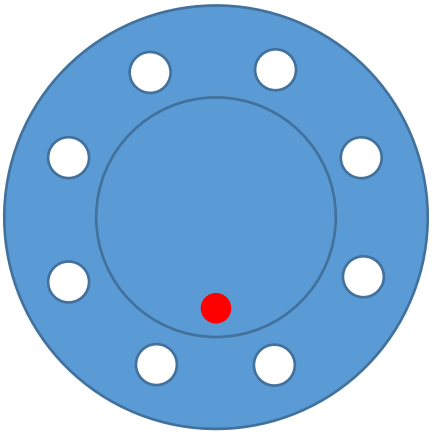


Figure 5 - Threaded plug (red) recommended position on the blind flange.

5.7 TOP SUPPORT ASSEMBLY

5.7.1 Top support assembly shall be located in the URB. This support shall hold all 3 axial movements of the hard pipe. The hard pipe vertical load is hanged in this support (see Figure 6).

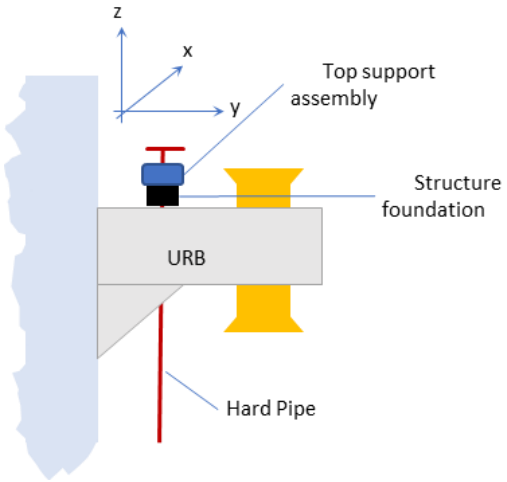


Figure 6 - Top support definition.

5.7.2 The top support shall be adjustable to allow movement of hard pipe position during the hard pipe installation phase. The support shall permit up to 50 mm lateral adjustment in each longitudinal (X), transversal (Y), and vertical (Z) directions for fine alignment of the rigid riser interface flange.

5.7.3 The top support shall also allow hard pipe rotation within its axis and shall enable locking after final alignment.

5.7.4 During hard pipe alignment process it shall be possible to raise the hard pipe enough distance from its original position to safely rotate without risk of damaging the rigid riser top flange during alignment approach.

Note: Recommended minimum 1000 mm lift of the hard pipe system before rotating.

5.7.5 Auxiliaries and outfitting shall be provided to make the hard pipe rotation and flange alignment operations feasible.

5.8 HULL SIDE SUPPORT ASSEMBLY

5.8.1 These supports shall be mounted in structural foundation prepared at hull side shell (see Figure 7).

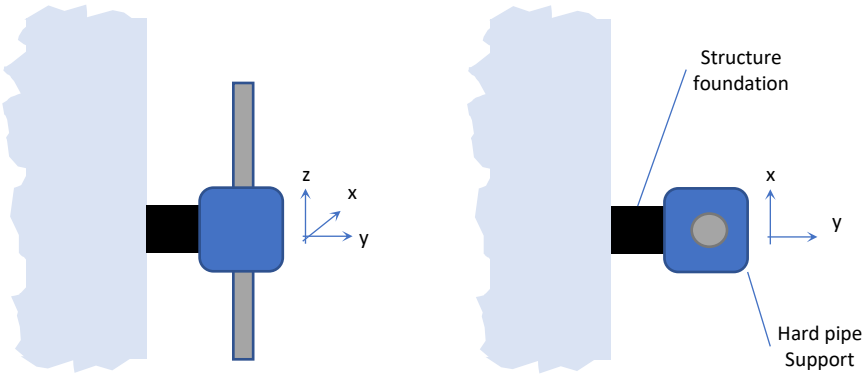


Figure 7 - Side shell support definition.

5.8.2 The hull side support shall be adjustable to allow movement of hard pipe position during the hard pipe installation phase. The support shall permit up to 50 mm lateral adjustment in each longitudinal (Y) and transversal (X) directions for fine alignment of the riser interface flange.

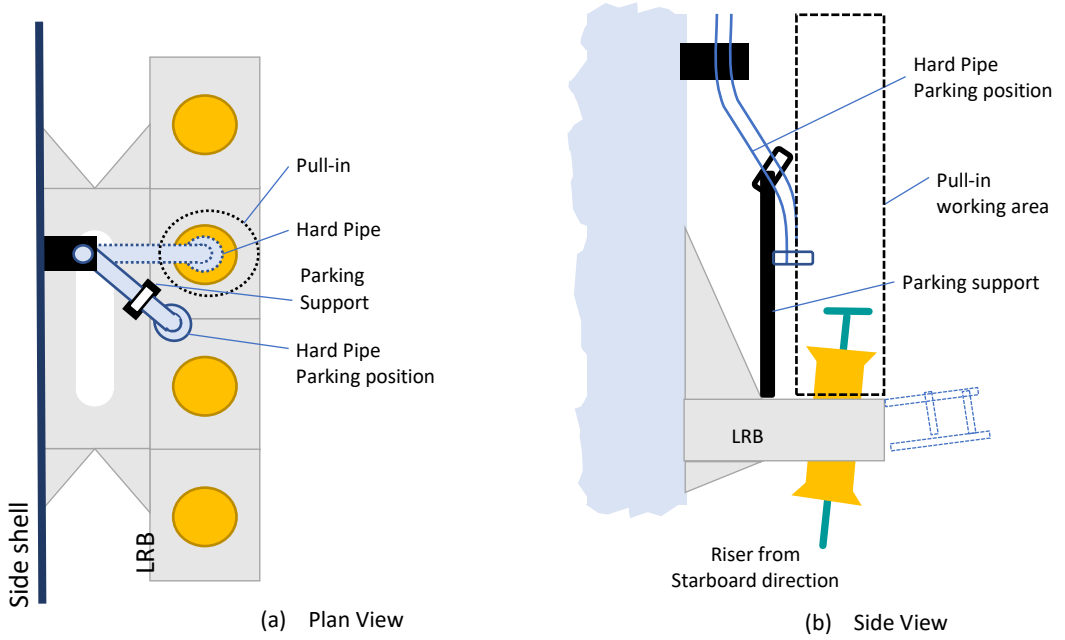
5.8.3 The hull side support shall also allow hard pipe rotation within its axis.

5.8.4 Auxiliaries and outfitting shall be provided to make the hard pipe rotation and flange alignment operations feasible.

5.9 PARKING SUPPORT ASSEMBLY

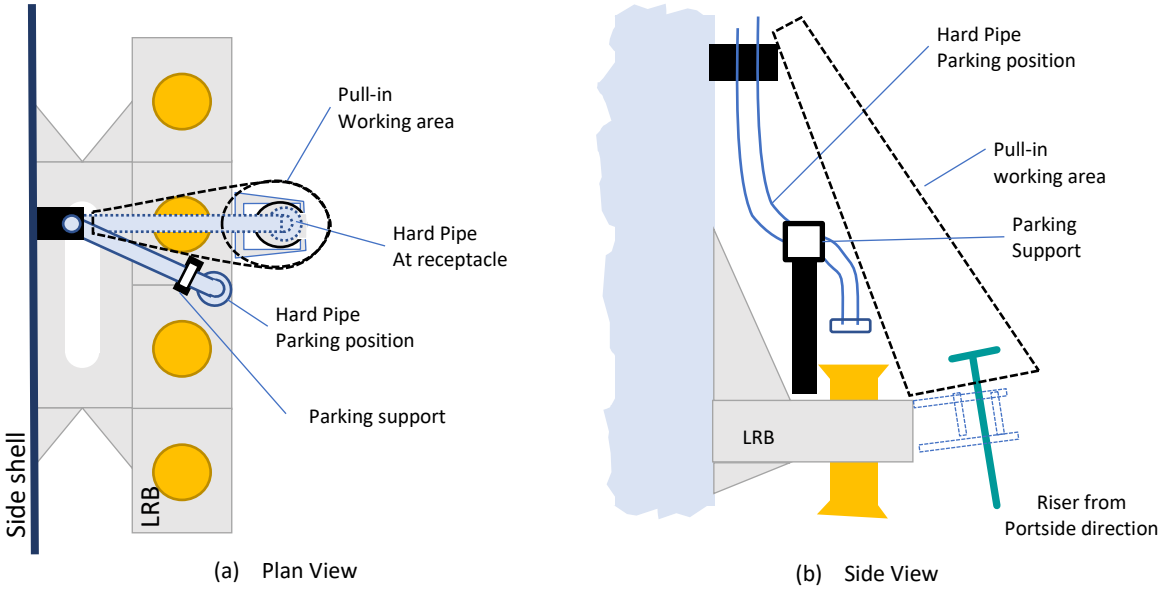
5.9.1 Recessed at the LRB a parking support assembly shall be placed such that the hard pipe can be positioned outside the area of pull-in and adequately secured to enable the pull-in operation without removal of the hard pipe.

5.9.2 The parking position shall also be used during transit, sail away or when a flexible riser is used in the designated slot (see Figure 8 and Figure 9).



(a) Plan View (b) Side View

Figure 8 - Parking for pull-in operation at I-Tube.



(a) Plan View (b) Side View

Figure 9 - Parking for pull-in operation at Receptacle.

5.10 RISER MOCK-UP

5.10.1 A rigid riser mock-up dummy shall be used to simulate the riser seated in the TSUDL or Conical Receptacle, along with its top flange in position to test the make-up of the connections.

5.10.2 The mock-up dummy insert shall fit the rigid riser support and replicate azimuth, departure angle, and flange position of riser top assembly.

5.10.3 Design parameters and requirements are designated in technical specification for Structures and Facilities for the Riser System.

5.10.4 Mock-up shall present a test port to enable leak testing and underwater assembly of the flanged connection.

5.11 HANDLING AUXILIARIES

5.11.1 Handling auxiliaries may be installed on the hard pipe to help erect it in place, as well as to properly move the system from its parking position to its assembling position.

5.11.2 Lifting lugs, shall not be installed in the splash zone area of the hard pipes as this would result in a local breakdown of the polychloroprene external coating of the hard pipe.

5.11.3 Lifting lugs can be installed on the submerged (permanently wet) area of the hard pipe, since this region will be protected by the cathodic protection potential, or on the dry hard pipe sections above the splash zone.

Note: Due to the natural flexibility of the hard pipe assembly, the lower flange may bend downwards during the lift-to-rotate operations. This may result in a misalignment of the lower flange face when compared to the matting flange (either the mock-up flange during commissioning activities, or the riser top flange after the pull-in operation). To avoid any flange face damage (as the flange faces would slide over each other), it is important to correct this misalignment before lowering the hard pipe. An auxiliary lifting lug installed close to the lower flange may help to avoid this condition.

6. HARD PIPE DESIGN

6.1 GENERAL

6.1.1 CONTRACTOR shall submit to PETROBRAS evidence (calculation reports) of the hard pipe design, which shall be performed in accordance with the requirements herein listed.

6.1.2 CONTRACTOR is responsible for obtaining all necessary certification for the design.

6.1.3 Hard pipe system calculations and drawings shall be submitted to PETROBRAS for approval.

6.2 MECHANICAL AND PRESSURE DESIGN

6.2.1 The hard pipe mechanical and pressure design shall be performed in accordance with ASME B31.3 code.

6.2.2 General design conditions shall be taken from the topside line list and corresponding P&ID.

6.2.3 The rigid riser top design conditions, as defined by the applicable subsea documentation, shall also be checked, as they may have additional requirements that may influence the system design (e.g., cyclic loads for fatigue evaluation).

6.2.4 Low temperature conditions due to topside or riser blowdown/depressurization events shall also be checked, as they may determine the minimum design temperature, and therefore the toughness requirement to be met by the base materials and the weld procedures (see item 7.2.6).

6.2.5 Loads shall be in accordance with item 4.4 of this technical specification. All loads therein listed shall be properly classified and combined in conformance with the design criteria from the selected design code. Operational, design and transit conditions shall be verified.

6.2.6 Hard pipe internal diameter maximum and minimum values shall be checked as prescribed in the technical specification for Structures and Facilities for the Riser System.

6.2.7 An external corrosion allowance of 6 mm shall be added to the minimum calculated thickness of all components that are located below the URB.

6.3 HARD PIPE ROUTING

Hard pipe routing shall be performed as stablished in the technical specification for Structures and Facilities for the Riser System. Isometric drawings shall be submitted for PETROBRAS approval to check the “piggability” of the system design.

6.4 HARD PIPE STRESS ANALYSIS

6.4.1 Hard pipe stress analysis shall be performed.

6.4.2 Hydrodynamic loads (wave and current) acting on the hard pipe system shall be included in the stress analysis.

6.4.3 For hydrodynamic load calculation, pipe outside diameter shall be increased in each side by marine growth thickness informed on the METOCEAN data technical specification. Its density shall also be considered.

6.4.4 Reports and calculation shall be provided for operational, design and transit conditions loading.

6.4.5 Vortex induced vibration (VIV) analysis shall be performed. Remedial actions shall be taken where necessary, subject to PETROBRAS approval.

6.5 HARD PIPE FATIGUE ANALYSIS

6.5.1 The hard pipes shall be checked for fatigue. Pressure variations, temperature variations, slug flow, impinging waves and sea current are foreseen fatigue conditions that shall be assessed.

6.5.2 DNV RP-C-203 standard shall be used for the fatigue analysis. The following S-N curves shall be selected:

- Hard pipe outer surface, at welds (weld toe hot spot): “D” S-N curve for “seawater with cathodic protection”.
- Hard pipe outer surface, away from the welds: “C” S-N curve for “seawater with cathodic protection”.
- Hard pipe inner surface, at welds (weld root hot spot): “F3” S-N curve for “air”.
- Hard pipe inner surface, away from the welds: “C” S-N curve for “air”.

6.5.3 A Design Fatigue Factor of 10 shall be used (DFF=10).

6.5.4 Due consideration to misalignment, eccentricity, and other geometrical features shall be taken in account for the fatigue evaluation, as predicted in DNV RP-C203. Maximum allowable internal misalignment shall be limited to 1.0 mm.

6.6 HARD PIPE SUPPORT DESIGN

6.6.1 Support shall be calculated to withstand the most stringent loads combination due to pipe, wave, currents, and hull movement.

6.6.2 Hydrodynamic loads (wave and current) acting over the support shall be included in the stress analysis.

6.6.3 Pipe stress analysis results shall be an input for the support design along with the design considerations and loads used (e.g., wave, slamming, hull displacement, thermal loads).

6.6.4 Bolts and nuts shall be loosened during pull-in operation for support position adjustment. The designer shall include means to prevent nuts to be completely unscrewed.

6.6.5 Pipe clamp shall have a wear/insulation coat to secure pipe (polychloroprene coating, with same specification as for the hard pipes themselves).

6.6.6 Typical gap of 2mm minimum shall be foreseen between clamp support and the hard pipe.

6.7 STRUCTURE SUPPORT FOUNDATION

6.7.1 Loads for structural foundation shall be indicated in the Stress Analysis Report.

6.8 RISER INTERFACE FLANGE

6.8.1 The loads on the hard pipe lower flange that connects to the rigid riser shall be determined and compared to flange admissible loads.

6.8.2 CONTRACTOR shall be responsible for the mechanical design of the Swivel Flanges so that it meets the operating condition and design data specified in the technical specification for Structures and Facilities for the Riser System.

6.8.3 Finite Element Stress analysis shall be done to assure flange proper design in accordance with ASME BPVC Section VIII Division 2.

6.8.4 Flange rating charts for bending moment, axial load, pressure, and bolt make-up torque shall be issued as in API TR 6AF.

7. MATERIAL SELECTION

7.1 GENERAL

7.1.1 The main material of construction for the hard pipes shall be seamless high strength carbon steel, with SMYS 450 MPa or higher, with internal CRA clad of UNS N06625.

7.1.2 Minimum thickness for the CRA layers is 3 mm. If weld overlay is applied, a minimum of two layers shall be deposited. Powder metallurgy is not an acceptable method for the cladding. Lining or any other non-metallurgical bond is not acceptable. Maximum iron content on the weld overlay shall be limited to 10% in weight.

7.1.3 The cladded pipes and accessories shall fulfill the requirements from API 5LD.

7.1.4 The hard pipe system, and therefore all its components (pipes, bends, flanges), shall be externally coated with polychloroprene (neoprene).

7.1.5 CONTRACTOR shall submit a detailed material list, including all pipes, flanges, bolts, gaskets, bends, accessories, supports and other accessories and components, for PETROBRAS approval prior to the manufacturing activities.

7.1.6 CONTRACTOR is responsible for obtaining all necessary certification for the components and the work being performed.

7.1.7 CONTRACTOR shall supply all materials certificates, as well as all the applicable records for the work performed, including inspections, tests, and qualification activities, as detailed in the approved Quality Plan.

7.1.8 The materials shall have full traceability to its certificates.

7.1.9 The material certificates and inspection documents shall be issued in accordance with EN 10204 Type 3.2 and shall confirm compliance with this specification.

7.1.10 The following sections give further details on the material requirements.

7.2 PIPE MATERIALS

7.2.1 The main material of construction for the hard pipes shall be high strength carbon steel (SMYS 450 MPa or higher, such as API 5L Grade X65), with internal CRA clad of UNS N06625.

7.2.2 General quality requirements for the pipe materials shall be consistent with the design standard (see item 6.1), and the following additional requirements.

7.2.3 CONTRACTOR shall consult with the mill/pipe supplier whether the intended specification is able to retain its mechanical properties after all fabrication steps (e.g., welding, post weld heat treatment, bending and coating application), to be consistent with the system design. It is recommended that any fabrication activities be performed at a temperature at least 40°C below the mill tempering temperature of the base material.

7.2.4 GENERAL QUALITY REQUIREMENTS

7.2.4.1 API 5L pipes shall as a minimum be in accordance with the quality level determined by API 5L specification for PSL-2 pipes. All API pipes shall also be supplied in accordance with Annex J of API 5L (PSL 2 Pipe Ordered for Offshore Service).

7.2.4.2 When using pipes from specifications other than API 5L CONTRACTOR shall demonstrate that the requirements indicated above are met or exceeded.

7.2.5 SOUR SERVICE REQUIREMENTS

7.2.5.1 The hard pipes shall be considered as under sour service, and therefore all the requirements of ISO 15156 part 2 shall be met for the base materials (high strength carbon steel), and all the requirements of ISO 15156 part 3 shall be met for the weld overlay (N06625 CRA overlay).

7.2.5.2 API 5L pipes shall also be supplied in accordance with Annex H of API 5L (PSL 2 Pipe Ordered for Sour Service).

7.2.5.3 When using pipes from specifications other than API 5L CONTRACTOR shall demonstrate that the requirements indicated above are also met or exceeded.

7.2.6 TOUGHNESS REQUIREMENTS

7.2.6.1 Materials shall be tested for its toughness at -40°C unless a minimum design temperature below -40°C is specified on other contractual document or is calculated during the detail design phase. In this case the minimum temperature for the toughness test shall be the new specified/calculated temperature.

7.2.6.2 Coupon orientation, acceptance criteria, and other test requirements shall be as determined by the material specification and the design standard.

7.2.7 NDT REQUIREMENTS

7.2.7.1 All API 5L pipes shall as a minimum be in accordance with Annex K of API 5L (Nondestructive Inspection for Pipe Ordered for Sour Service, Offshore Service, and/or Service Requiring Longitudinal Plastic Strain Capacity).

7.2.7.2 When using pipes from specifications other than API 5L CONTRACTOR shall demonstrate that the requirements indicated above are also met or exceeded.

7.3 FLANGES, GASKETS AND BOLTS MATERIALS

7.3.1 All flanges within the hard pipe and within the top interface spool shall be manufactured in accordance with API 6A or API 17D and shall conform to the chemical composition and mechanical properties therein stablished.

7.3.2 The transition on internal diameter from flange to pipe end shall be tapered with a maximum of 15° slope with reference to centerline of pipe.

7.3.3 All flanges shall also be supplied with internal CRA clad of UNS N06625.

7.3.4 CRA clad for flanges shall extend to all internally wet surfaces, including the sealing areas and the flange raised face. Sealing area overlay hardness shall achieve a minimum of 220 HB, with a maximum iron content of 5%.

7.3.5 Gaskets shall also be selected in UNS N06625 CRA. Maximum hardness for the gasket shall be limited to 195 HB (92 HRB).

7.3.6 Studs and bolts for the hard pipe lower flange (which connects to the rigid riser at the LRB) shall be selected so that they are similar to those used on the rigid riser itself. Unless otherwise stated, fasteners specification shall be as follows:

- Bolts ASTM A320 Grade L7 (up to 2½" bolt diameter) or Grade L43 (above 2½" bolt diameter)
- Nuts ASTM 194 Grade 4 or Grade 7.

7.3.7 Studs and bolts for the interface spool flanges (on the URB, connecting on one side to the hard pipe and on the other side to the topside BSDV) shall be selected in accordance with topside piping specification.

7.3.8 General quality requirements, sour service requirements, toughness requirements and NDT requirements that are applied to the pipe materials (items 7.1.1 through 7.1.4) are also applicable to the flange materials, i.e., sour service material grades and the appropriate temperature class shall be selected from API 6A and API 17D.

7.4 CURVES AND BENDS MATERIALS

7.4.1 Accessories (curves and bends) shall be manufactured from specifications of similar chemical composition compared to the pipe material, and similar mechanical properties. They shall also be supplied with internal CRA clad of UNS N06625.

7.4.2 Hot induction bending shall be performed as predicted in ISO 15590-1, with the additional requirements from Appendix A of this technical specification.

7.4.3 Manufactured curves as per ASME B16.9 may be used in lieu of the induction bend where 3D curves are indicated, if all the requirements applicable for the bends are fulfilled, such as:

- Chemical composition limits.
- Mechanical tests, including toughness.
- Hardness limits (including through thickness).
- Cladding thickness.
- General dimensional control and tolerances.
- Surface and volumetric NDT.
- Microstructure evaluation and corrosion tests.

7.4.4 Internal diameter tolerance and ovality for both induction bends and manufactured curves shall be within the tolerances defined for PIGGING (see the technical specification for Structures and Facilities for the Riser System).

7.4.5 General quality requirements, sour service requirements, toughness requirements and NDT requirements that are applied to the pipe materials (items 7.1.1 through 7.1.4) are also applicable to the curves and bends materials, including the requirements from API 5LD.

Note: Pipe materials usually lose a fraction of its mechanical properties during hot operations, such as the induction bending. CONTRACTOR shall consult with the mill/pipe supplier if the intended specification is able to retain its properties after bending, to be consistent with the system design. Eventually this may require the use of thicker mother pipes when compared to the straight sections of the hard pipe.

7.5 PIPE SUPPORT MATERIAL

7.5.1 Hard pipe support shall be manufactured from carbon steel (strength and toughness grades are determined by the structural typical drawings).

7.5.2 For hard pipe supports, electrical continuity shall be guaranteed in between all parts of the support so that they will be continuously protected by the cathodic protection system of the unit. Electrical jumpers, when applied as the means to guarantee electrical continuity, shall have a redundancy (at least two jumpers for each connection in between parts). The use of any methods that break the component coating as a mean to provide electrical continuity in the supports is not acceptable (such as toothed washers).

7.5.3 The surface of the pipe supports that contact the hard pipe shall be coated with polychloroprene (neoprene) to avoid wear of the hard pipe coating. The polychloroprene coating specification for the clamps is the same as for the hard pipe.

7.5.4 In between the support polychloroprene coating and the pipe polychloroprene coating a CRA wear sheet shall be placed to reduce the friction coefficient. This wear sheet shall be manufactured from a 2mm thickness minimum of any of the following materials:

- 6 Mo Austenitic Stainless Steel.
- 25 Cr Super Duplex Stainless Steel.
- Cu-Ni 90-10.
- 65-35 nickel-copper (Monel 400).

7.5.5 The CRA intermediate plate shall be vulcanized to the hard pipe coating and shall extend for at least 100 mm on each side of the pipe support contact area.

7.5.6 All bolts within the pipe support shall be of UNS N06625 CRA material. Details on the material specification can be found in APPENDIX B – BOLTING SPECIFICATION FOR PIPE SUPPORTS.

7.5.7 Collar washers shall be used for protection against wear and tear of the structural support coating when bolts are tightened.

7.5.8 Typical details of the clamp type support can be found on APPENDIX C – TYPICAL HARD PIPE SUPPORT. The drawings therein are meant for illustration purposes only, especially regarding the intermediate sheet placing and the "rib" pattern of the support polychloroprene coating.

7.6 COATINGS

All organic coatings shall be performed in conformance with IOGP S-715. All polychloroprene coatings shall be performed in conformance with ISO 18797-1.

7.6.1 Pipes and Bends

Pipes and bends from the hard pipe system shall be externally coated with polychloroprene as per ISO 18797-1. Field joints and repairs of the polychloroprene coating shall also be performed as per the same technical specification.

Note: The polychloroprene coating may be used up to a maximum operating temperature of 90°C. If the operating temperature exceeds this value, the coating specification may have to be changed to ethylene propylene diene monomer (EPDM). This is valid to both the hard pipe system and the clamp type supports, unless a study is performed and shows that the clamp coating temperature will be within the polychloroprene range.

7.6.2 Pipe Supports

The surface of the pipe supports that contact the hard pipe shall also be coated with polychloroprene as per ISO 18797-1 (see Appendix C).

7.6.3 Flanges

7.6.3.1 The hard pipe flanges shall be externally coated with polychloroprene throughout the flange hubs. The remaining external surfaces of the flanges shall be coated with organic coat suitable for seawater submerged environment, subject to cathodic protection (see Figure 10 and Figure 11).

7.6.3.2 Due to the high temperature of the polychloroprene vulcanization process, flange coating shall preferably be applied after the application of the polychloroprene coating over the weld connecting the flange to the pipe/bend.

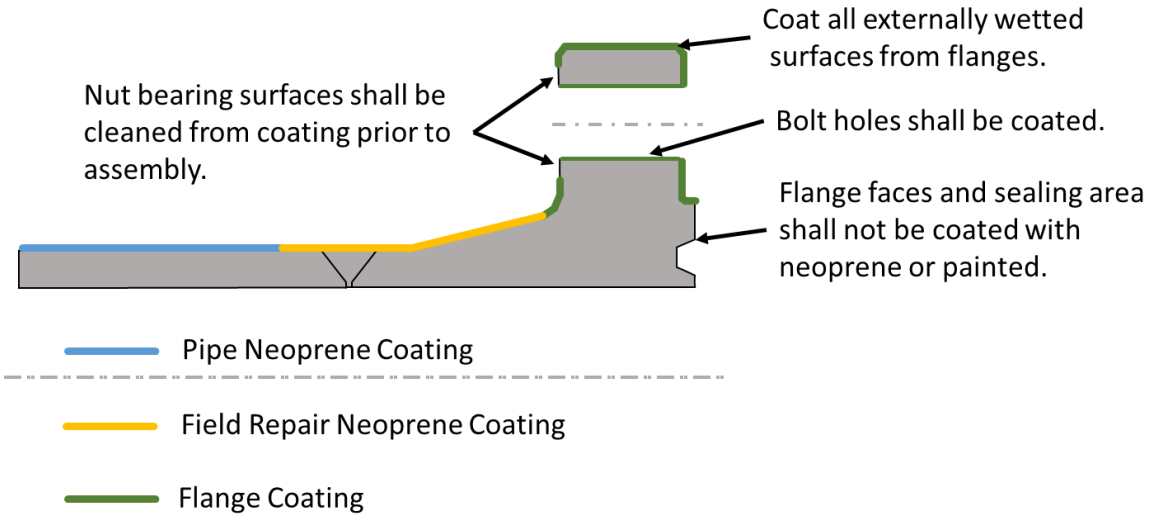


Figure 10 - Coating of Flanges

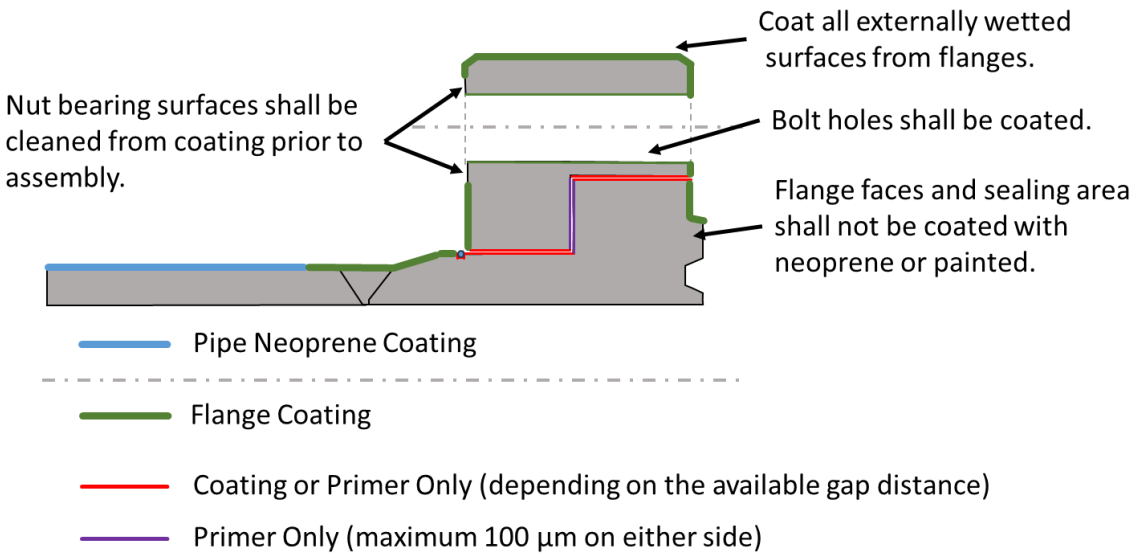


Figure 11 - Coating of Swivel Flanges

7.6.3.3 Flange edges shall be properly prepared (rounded) as required by the coating application procedure.

7.6.3.4 Coating inside the bolt holes need not comply with minimum thickness requirements from the coating system, as they are intended solely to diminish the hydrogen charging on the flange material due to the cathodic protection.

7.6.3.5 Nut bearing surfaces shall not have any coating, as this would compromise the bolts preload during the assembly stage.

7.6.3.6 Flange faces and sealing areas shall not be coated with polychloroprene or painted, as this would compromise the sealing capacity of the flange.

7.6.3.7 For swivel flanges the gap in between the ring and the hub shall also be coated. If the dimensional constrains of the gap limit the application of the whole coating scheme, at least 300 µm of coating primer shall be applied on either side. Exception to this coating thickness is the compression region where the ring rests over the hub, where a maximum thickness of 100 µm is allowed on either side.

8. FABRICATION AND ASSEMBLY REQUIREMENTS

General quality requirements for the fabrication and assembly, including the welding and the NDT activities, shall be consistent with the design standard (see item 6.1), with the addition of the requirements herein listed.

8.1 WELDING AND WELDING INSPECTION

8.1.1 All welding activities, including the weld overlay deposition, shall be according to the requirements described in IOGP S-705.

8.1.2 Welding shall be carried out with procedures and welders qualified in accordance with the selected design code and additional requirements stated in contractual technical specifications. Welding shall not be performed before qualified welding procedures specification have been approved.

8.1.3 All pressure retaining welds shall be full penetration type and shall be subject to a post weld heat treatment (PWHT). Parameters for the heat treatment shall be as defined in the design code.

8.1.4 Intermittent welds are not permitted in the supports.

8.1.5 In preparation for welding cladded materials the maximum allowable internal misalignment shall be limited to 1.0 mm.

8.1.6 NDT shall be according to the Design Code.

8.1.7 Final examination (NDT) for acceptance purposes shall be carried out after completion of the required PWHT and before the applications of painting, coating, and before the pressure testing.

8.1.8 All hard pipe butt welds (full penetration girth welds) shall at least be inspected as follows:

- 100% volumetric inspection with PAUT.
- 100% superficial inspection with PT.
- 100% visual inspection (both external and internal. Internal visual inspection may require the use of borescope).
- 100% hardness test.

8.1.9 Acceptance criteria for the NDT shall be as defined in ASME B31.3 for Severe Cyclic Conditions.

8.2 BEND DIMENSIONS AND TOLERANCES

8.2.1 Induction bends shall be manufactured in accordance with ISO 15590-1 and Appendix A of this technical specification, or in accordance with ASME B16.9 (see item 7.4 of this technical specification).

8.2.2 The wall thickness of the finished bend shall be measured by ultrasonic means at one diameter intervals along the inner and outer radius of the bend between tangent points. At the free ends of the tangent lengths, the wall thickness shall be measured by caliper at four equally spaced points around the circumference.

8.2.3 The diameter shall be measured at the start or stop of the bend locations and at all points throughout the bent portion to ensure compliance with the required tolerances. The internal diameter at any location shall not be less than the minimum specified inside diameter of the hard pipe system (see item 6.1). Conformity with this requirement shall be demonstrated by freely passing without assistance, an approved gauging device.

8.2.4 CONTRACTOR shall provide records of all the applicable examinations as required by Appendix A.

8.3 HARD PIPE ERECTION

8.3.1 Handling of the hard pipes shall be performed with due care to avoid damage to the polychloroprene coating. Lifting can only be performed by the installed lugs. Lifting shall not be performed by ropes, slings, chains, straps, or any handling accessories on the coated surfaces.

8.3.2 After erection, the hard pipe shall be adjusted against the mock-up piece. This step can be performed in the dry dock and intends to make sure that the flanges make-up tolerances will be achieved.

8.3.3 The mock-up positioning for this fit-up is of great importance, and therefore it shall be witnessed by PETROBRAS representative. A dimensional report shall be issued and shall include the actual measured dimensions for each mock-up-to-hard pipe assembly combination.

8.3.4 The mock-up piece position that needs to be achieved shall be in accordance with the data provided at Riser Support Arrangement document, issued by PETROBRAS.

Note: The Riser Support Arrangement will be delivered to CONTRACTOR with the Notice to Proceed in accordance to Exhibit I of the Contract.

8.3.5 The fit-up against the mock-up above may be executed at the dry dock or at a later stage in accordance with CONTRACTOR construction strategy.

8.3.6 After the fit-up has been approved, any hard pipe welds that were only tacked can be finally welded and the applicable NDT can be performed, followed by the PWHT.

8.3.7 All bolting operations for the flanges shall be performed as predicted in ASME PCC-1.

8.3.8 After PWHT the hard pipe shall be subject to the pressure testing (see item 8.4), followed by the field joint coating (see item 8.5).

8.4 PRESSURE TESTING

8.4.1 Except as approved by PETROBRAS inspector and Classification Society, the hard pipe system shall be presented for pressure testing with uncoated weld joints. Previously successfully pressure tested weld joints may be coated for the system pressure test.

8.4.2 Pressure testing of the hard pipe may be performed against the mock-up or against the blind flange.

8.4.3 Testing shall be performed with fresh water and shall be in accordance with the design code.

8.4.4 Interface spools shall preferably be pressure tested along with the connecting hard pipe.

8.5 FIELD JOINT COATING

Field application of the polychloroprene coating system shall be performed after approval of the required NDT and after the pressure test. Coating application and repair shall be performed as stablished in reference ISO 18797-1.

8.6 MARKING AND IDENTIFICATION

8.6.1 Bas-relief mark-up shall be done in 3 points of each hard pipe: close to the rigid riser flange, at middle, and close to the top flange end. The mark-up shall be painted in a contrasting color and shall identify the subsea wells and slot position. Requirements are set forth in the technical specification for Structures and Facilities for the Riser System.

8.6.2 Bas-relief mark-up shall also be done in one position of each hard pipe top interface spool to identify the subsea wells and slot position.

8.7 CATHODIC PROTECTION AND ELECTRICAL CONTINUITY

8.7.1 Electrical continuity shall be guaranteed for all components that are part of the hard pipe lower flange (swivel type), either during its connection to the blind flange or its connection to the rigid riser. This is essential to guarantee that all components (including swivel flange ring, bolts and nuts), will share the potential of the vessel cathodic protection system.

8.7.2 After the hook up of the hard pipe to the rigid riser, the electrical continuity can be achieved by using toothed washers (or similar component) in between the flange back surface and the nuts, since this washer will promote a local break down of the flange coating. The washers shall be applied to all bolts of the flanged joints, on both sides of the joint.

8.7.3 Prior to the hook up with the rigid riser, when the lower blind flange is installed, the hard pipe will be essentially insulated from the vessel cathodic protection system, and therefore jumpers shall be installed connecting both. These jumpers may be installed on either the hard pipe lower flange (swivel hub) or the blind flange. Redundance shall be provided for the jumpers. The remaining components (swivel ring, bolts and nuts) shall be electrically connected also by the used of toothed washers (or similar component)

8.7.4 The washers shall be of 316 stainless steel (or any better stainless steel grade).

8.7.5 The combination of the flange coating system, washer design, and assembly method shall be properly tested and demonstrated to PETROBRAS, in order to show that the electrical continuity can be achieved throughout all components.

9. TESTING AND COMMISSIONING

9.1 GENERAL

9.1.1 In addition to the proper inspection, testing and commissioning requirements set up in the contract documentation the following requirements shall be met by CONTRACTOR.

9.1.2 CONTRACTOR is required to submit for PETROBRAS approval an Inspection and Test Plan (ITP) for all parts and activities of the hard pipe system prior to commencement of work, along with a schedule.

9.1.3 Inspections and tests herein listed (see item 9.2) shall be performed at CONTRACTOR's yard in the presence of PETROBRAS representative.

9.1.4 CONTRACTOR is responsible for the overall compliance of the system when it comes to the Classification Society requirements, including certificates, work examinations and tests, as well as inspection activities.

9.1.5 The following inspections and checks shall be witnessed by PETROBRAS representative:

a) Verification of construction materials for conformity with the specification requirements.

b) Reports for all NDT performed on the pressure retaining parts (PAUT of girth welds, thickness measurements, dye penetrant test, hardness tests, and so on).

c) Review of Inspection and Test Records.

d) A visual examination noting:

- That the thickness of the pressure retaining parts meets or exceeds the design thickness.
- Any repairs.
- Thickness of applied coatings.
- The general appearances, materials, workmanship, and standard of finish.
- Dimensional check.

9.1.6 CONTRACTOR shall issue an Inspection Release Certificate (IRC) only after completion of all required inspections and tests and after the manufacturing data-books have been issued and approved.

9.2 TESTING AND EXAMINATION

9.2.1 The following tests are also included in CONTRACTOR's scope and shall be considered as additional to tests and examination elsewhere required on the contract technical specification for piping activities:

a) Piggability Test.

b) Functional test.

c) Electrical continuity checks.

d) System leak test.

9.2.2 General guidance for each test is given below.

9.2.3 A detailed procedure shall be issued for each test.

9.2.4 By the end of each test a report with the results and the acceptance criteria shall be issued, which shall be submitted for PETROBRAS approval.

9.2.5 Examination requirements from the selected design standard which are more restrictive than the ones herein listed shall be performed in addition to the specification above.

9.2.6 PIGGABILITY TEST

9.2.6.1 This test is relevant for checking the overall internal tolerance of the hard pipes for the passage of PIGGING devices.

9.2.6.2 This test shall be able to detect internal out of roundness, reduced internal diameters, weld protrusions, and any other defects that could interfere with the PIGGING operations later.

9.2.6.3 CONTRACTOR is responsible to procure or contract a testing device capable to provide evidence for gauging. The testing device shall be submitted for PETROBRAS approval.

9.2.6.4 This test shall be performed after the mechanical completion, as soon as reasonably possible, before the unit sail-away.

Note: PETROBRAS recommend the testing to be executed at dry dock after hydrostatic test, but it is up to CONTRACTOR to determine the test schedule in accordance with the overall project schedule within the window given above.

9.2.6.5 The internal diameter at any location shall not be less than the minimum specified inside diameter. Details on the requirements for the internal diameter tolerance can be found in the technical specification for Structures and Facilities for the Riser System.

9.2.7 FUNCTIONAL TEST

9.2.7.1 A full functional test of completed package shall be executed to assure satisfactory operation of all functionalities foreseen to assemble the hard pipe over the riser in the same away as is expected for the offshore phase.

9.2.7.2 The testing procedure shall contain at least the following activities:

-Demonstrate hard pipe lifting and rotating from parking position to riser make-up position.

-Seating the hard pipe over the riser mock-up piece.

-Proper make-up of the hard pipe flange against the riser mock-up piece.

-Leak test (as given in item 9.2.4)

-Dismantle the flanged joint, rotate the hard pipe back to parking position for sail away.

Note: For underwater make-up CONTRACTOR shall take care to open the leak test port of the flange to allow any entrapped water to be released during make-up torque. After conclusion of the activities the leak test port shall be proper closed.

9.2.7.3 Except for the riser mock-up, all the equipment and auxiliaries to the execution of the functional test and the leak test shall be the same as those that will be available for the offshore phase.

9.2.7.4 The functional test shall be executed before the unit sail-away, and after finishing the lifting campaign, with the unit already floating.

9.2.7.5 The report of the test shall contain the results of the flange alignment, checked before make-up in accordance with the acceptance criteria.

9.2.8 ELECTRICAL CONTINUITY CHECKS

9.2.8.1 After assembly (field erection), the electrical continuity shall be verified for all installed wiring, jumpers, and earthing cables. This test shall also be performed before the unit sail-away.

9.2.8.2 Electrical continuity shall be again verified on the hard pipe supports after any disassembly operation is performed.

9.2.9 LEAK TESTING

9.2.9.1 A leak test to assure proper flange make-up and tightness shall be executed in concomitance to the functional test.

9.2.9.2 The first part of the test is a local leak test performed on the lower flange, against the mock-up piece, through the test port (as already described in 9.2.7 above). This test shall be performed immediately after the flange make-up against the mock-up piece. The test equipment may be selected in accordance with the fluid and pressure rating and may be a portable manual hydraulic pump or a portable nitrogen bottle. Tightness shall be verified through bubble formation or due to pressure drop.

9.2.9.3 The second part of the test shall occur after the local leak test has been approved, where a more comprehensive test shall be performed in the hard pipe, by pressurizing the whole system. This second test aims for checking the tightness of the remaining flanged joints and shall be performed with a Nitrogen-Helium mixture. This test shall be executed in accordance with ASME BPVC Section V, Article 10, Mandatory Appendix IV, and the exposed (not underwater) flanges shall be checked for its tightness with a Helium sniffer.

9.3 PRESERVATION

9.3.1.1 After completing all tests on the hard pipe, the lower flange of the hard pipe (which connects to the rigid riser) shall be closed with the blind flange (see item 5.6). Material for the blind flange shall be compatible with the hard pipe flange, including the CRA on the sealing areas.

Note: in case of underwater assembly of the blind flange it shall be equipped with a test port, which shall remain open during the flange make up.

9.3.1.2 The other extremity of the hard pipes shall also be properly covered and protected to properly protect the system against corrosion and/or mechanical damage.

9.3.1.3 The preservation methodology shall be documented and submitted for PETROBRAS approval.

Note: preservation of the hard pipe swivel flange must be performed with extra care to avoid "locking" it due to oxidation.

9.3.1.4 Untreated sea water shall not be allowed to stay inside the hard pipe for period longer than 90 days. Since the ingress of untreated sea water cannot be avoided during submerged flange make up (for both blind flange installation and final riser connection) the trapped water shall be properly removed (through the threaded plug on the blind flanges) or properly treated to avoid any corrosion on the flange's internal crevices.

9.3.1.5 The addition of oxygen scavengers to the contained seawater is an acceptable alternative This scavenger solution injection may be performed from the topside of the unit, and the volume/concentration of the solution shall be based on the expected untreated seawater contained volume.

9.3.1.6 For periods shorter than 90 days there is no need to treat the contained sea water.

APPENDIX A – HOT INDUCTION BENDS

A.1. SCOPE

This Appendix specifies the technical delivery conditions for bends made by the hot induction bending process for use within a pressure containing piping system.

A.2. GENERAL

Final product after bending shall have mechanical properties of the base material and corrosion resistance properties of the CRA overlay that are equivalent to the pipes to which they are connected to on the piping system.

The induction bending process of pipe shall be performed according to requirements given by ISO 15590-1, quality level PSL2, including Annex B requirements (PSL 2S bends ordered for sour service), and the additional requirements of this Appendix.

Hot forming by induction heating, bending, and quenching down to room temperature by water spray does not usually require a new heat treatment provided the process is successfully qualified and tested as required by this Appendix.

At no time, prior to or during bending, shall the pipe contact low melting temperature materials such as zinc, copper, brass, or aluminum.

A.3. ESSENTIAL VARIABLES

The essential variables of the MPS qualification shall be in accordance with ISO 15990-1 except that the modifications specified in Table A.1 shall apply, additionally, any change of the clad welding procedure shall be an essential variable.

Table A.1 — Essential variables

Essential variable	**Maximum permissible variations**
Bend radius, R	For all radii: Qualifies all larger radii, but no less
Forming velocity	± 2,5 mm/min or ± 10 %, whichever is the greatest

A.4. MPS QUALIFICATION BEND TESTING

Each bend group, as defined by the essential variables referenced above shall be qualified in accordance with ISO 15590-1 and this Appendix before commencement of production bending.

The test requirements defined in Table A.2 shall be applied along with the test requirements of ISO-15590-1.

Test samples for micrographic examination, bend test and corrosion test shall be from same locations as the tensile samples.

Except where otherwise stated in this section, the testing, inspection methods and acceptance criteria shall be as required for the applicable mother pipe specification of the same steel grade and UNS No.

Dimensional control and tolerances shall be in accordance with ISO 15590-1.

If full heat treatment, involving an austenitization and tempering or solution annealing process, is applied after the induction bending operation, the bend shall be destructively tested in compliance with the mother pipe specification. If the mother pipe is delivered in as welded condition the extent of destructive testing shall include the same test as specified for the weld procedure qualification by the mother pipe specification.

Table A.2 — Additional testing to ISO 15590-1 of MPS qualification test for clad pipe[a]

Type of tests	CS Clad	Test conditions and acceptance criteria
Tensile	T	According to the mother pipe specification
Charpy V-notch (CVN)	T	
Through thickness hardness (Including HAZ if applicable)	T[b, f]	
Surface hardness[c]	T and P	
Microstructure	T[d]	
Corrosion	N	
Bend test	T[e]	ASME IX
Surface NDT	T and P	[f]
Bend body (UT) transverse defects	T and P	[g]
Bend body (UT) laminations	P	
Residual magnetism ends	P	

a For definition of N, M, O, T and P see ISO 15590-1.

b The clad layer and interface to carbon or low-alloyed steel shall be tested in accordance with ASME IX.

c Surface hardness testing shall be performed according to ISO 15590-1 and with devices agreed upon

d The cladding thickness shall be verified by destructive testing at the extrados location. The cladding thickness shall be minimum of 3 mm after bending.

e For clad pipe bends the MPS qualification shall repeat the mechanical testing from the clad WPQR, i.e. side bend and hardness tests, ref. ISO 10423 PSL3.

f For all bends, independent of material type, the bend body shall be visual and surface inspected according to ISO 15590-1.

g The cladding of carbon or low-alloyed steel shall be 100% inspected with LP and bond line integrity with UT per API 6A/ISO 10423 PSL 3.

A.5. DELIVERY CONDITION

All bends shall be delivered in white pickled and passivated condition.

A.6. BEND DOCUMENTATION

The MPS test report shall be issued in accordance with EN 10204 Type 3.2.

The documentation dossier shall include the following test reports:

- MPS qualification test report
- NDT test report
- Starting pipe material certificate
- Dimensional test report

APPENDIX B – BOLTING SPECIFICATION FOR PIPE SUPORTS

Bolting that will be applied to the hard pipe supports will be exposed to an extremely corrosive environment (splash zone and the green water zone beneath the upper riser balcony). Since the CP system is not capable of protecting the materials within this region, they must be selected from a high grade CRA material as follows (not applicable for bolts that will be submerged 100% of its life).

B.1 Bolting Material Specification

Bolt/Nut: ASTM F468 Grade Ni625 / ASTM F467 Grade Ni625 (solution annealed).

B.2 Technical Requirements

Bolts and nuts shall be in conformance with API SPEC 20F, BSL-2, including the following requirements:

- Qualification Testing (acceptance based on the applicable material specification).
- Limits of Bolting Qualification (including the amount of cold reduction).
- Production of Qualified Bolts (including the Material Specification and the Manufacture Process Specification by the bolting manufacturer).
- Test Report.

B.3 Factory Acceptance Tests

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.

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.

APPENDIX C – TYPICAL HARD PIPE SUPPORTS

The following images are meant to help illustrate the polychloroprene coating on both the hard pipe and the clamps type supports.

Alternative designs may be submitted for PETROBRAS approval.

Figure C.1 is a "cross section" view of the clamp, revealing the "rib" like configuration of the polychloroprene coating on the clamp side, as opposed to the "plain" configuration of the polychloroprene coating on the hard pipe side. The "ribs" shall be oriented parallel with the axis of the clamp.

Except for the clamp contact area, which is to be coated with polychloroprene, all other surfaces of the supports shall be coated as stablished in IOGP S-715.

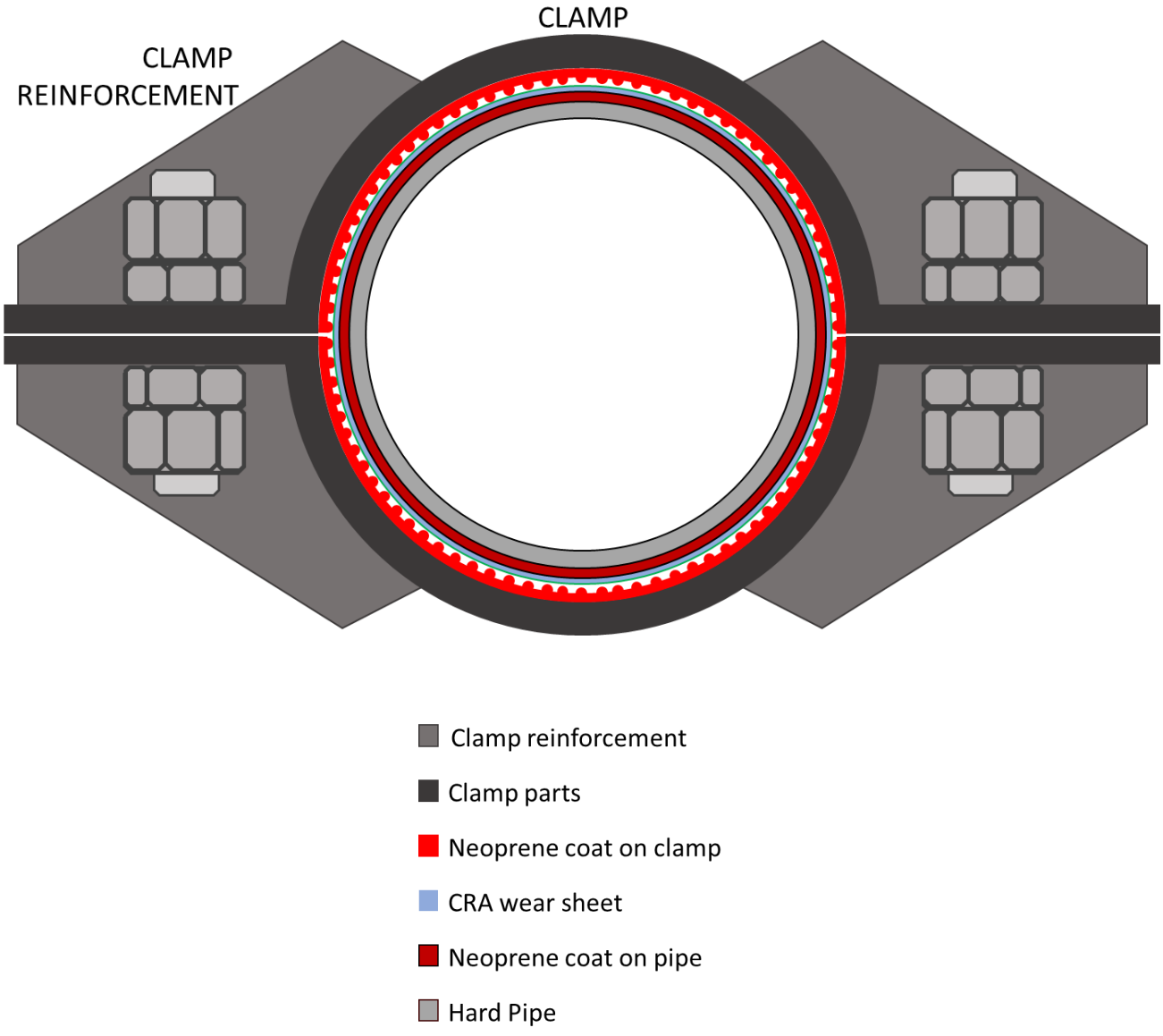


Figure C.1 – Cross section view of a typical "clamp" type support

Figure C.2 shows a close-up view of the C.1 cross section at the 12:00 o'clock area. The minimum thicknesses of the polychloroprene coating of both the clamp side and on the hard pipe side shall be 12 mm.

On the clamp side, on top of the 12 mm minimum thickness a "rib" like pattern of polychloroprene shall be applied. The "ribs" shall have a 10 mm radius, and the space in between the rib edges shall be within 16 to 18 mm.

The CRA wear sheet shall be placed in between the clap coating and the hard pipe coating. The minimum thickness of this wear sheet shall be 2mm. The wear sheet shall be properly vulcanized to the hard pipe polychloroprene coating.

Note: a small gap in between the CRA wear sheet and the "ribs" may facilitate the field assembly later. The same gap will also reduce the vertical loads on the clamps from the flexibility analysis, enabling them to act as guides (as they were supposed to). For these reasons, a gap should be added to the dimensions herein shown. The gap dimension shall be based on CONTRACTOR's experience, but in any case, should not exceed 2 mm.

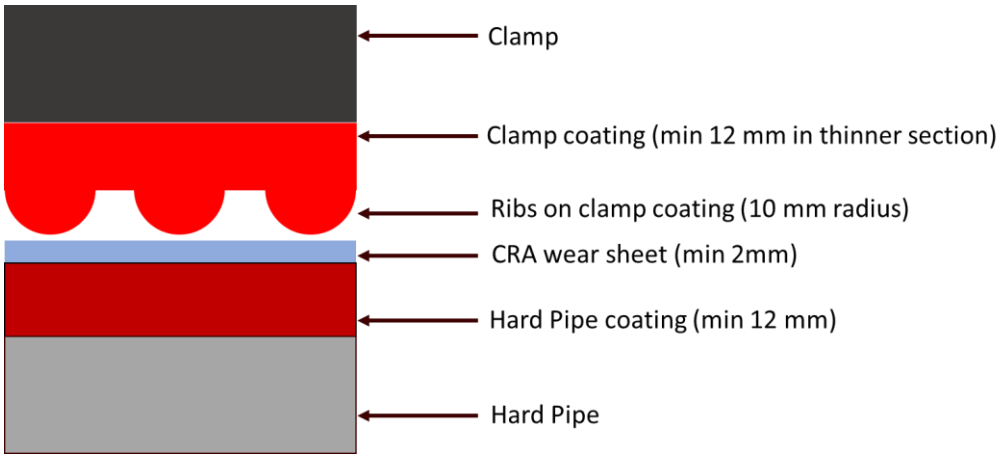


Figure C.2 – Close-up view of the coating configuration

"Anchor" type supports need not have a CRA wear sheet applied since no relative motion in between the parts should happen. The polychloroprene coating on the "anchor" type support is still mandatory, as lateral loads (e.g., from waves) could cause premature failure of the hard pipe coating against a bare steel support.

Sharp edges of the supports (both "clamp" type and "anchor" type) where polychloroprene is applied shall be rounded by grinding (10 mm radius minimum) to help prevent premature mechanical failure of the hard pipe coating due to the same cited lateral loads.