PETROBRAS	**TECHNICAL SPECIFICATION**	Nº: I-ET-3010.2D-1200-200-P4X-010	
	CLIENT: AGUP		SHEET 1 of 34
	JOB: HIGH CAPACITY FPSO – GAS EXPORTATION ALL ELECTRIC		
	AREA: ATAPU 2 AND SÉPIA 2		
SRGE	TITLE: **TECHNICAL SPECIFICATION FOR HARD PIPE**		INTERNAL
			ESUP

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SUMMARY

1. OBJECTIVE

This specification defines the requirements for SELLER to perform the detailed design, procurement, fabrication, inspection, construction, installation, testing, commissioning, and pre-operation of the HARD PIPE SYSTEM for FPSO UNITS.

The hard pipe system shall include all accessories and appurtenances necessary to safely operate without interruption in an offshore production unit.

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

2. DEFINITIONS AND ABBREVIATIONS

In addition to general definitions set in reference \1\, 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

3. 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.

3.1 CLASSIFICATION RULES

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

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

3.2 CODES, STANDARDS AND REGULATIONS

In addition to rules and regulations set forth in reference \2\, 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
- 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 – 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 27509 – Compact flanged connections with IX seal ring

3.3 REFERENCE DOCUMENTS

The following documents are cited within this technical specification and therefore constitute requirements for the Hard Pipe System.

Ref. #	Doc. No.	Doc. Title
\1\	I-ET-3010.00-1200-940-P4X-002	General Technical Terms
\2\	I-MD-3010.2D-1200-940-P4X-004	Descriptive Memorandum – General
\3\	I-ET-3A26.00-1000-941-PPC-001	Metocean Data – Units and Production Systems - Santos Basin Central Cluster Region
	I-ET-3A36.00-1000-941-PPC-001	Metocean Data – Production System and Units - Northern Santos Basin Pre-Salt Fields
\4\	I-RL-3010.2D-1350-960-P4X-002	Motion Analysis
\5\	I-ET-3A50.00-1350-940-P56-001	FPSO Structures and Facilities for Riser System
	I-ET-3A40.03-1350-940-P56-001	
\6\	I-ET-3010.2D-1200-200-P4X-001	Piping Specification for Topsides
\7\	I-LI-3010.2D-5400-200-P4X-001	Line List - Topside
\8\	I-ET-3010.2D-1200-200-P4X-006	Requirements for Piping Stress Analysis
\9\	I-DE-3010.2E-1352-140-P4X-009	Hard-Pipe Supports Foundation and Side Shell Sheaves
\10\	I-ET-3010.00-1000-955-P4X-001	Welding
\11\	I-ET-3010.00-1200-217-P4X-001	Supplementary Specification to ISO18797-1
\12\	I-ET-3010.00-1200-956-P4X-002	General Painting
\13\	I-ET-3010.00-1000-970-P4X-002	Requirements for NDT
\14\	I-ET-3010.00-0000-970-P4X-001	Requirements for Procedures and Personnel Qualification and Certification
\15\	I-ET-3010.00-1200-200-P4X-116	Requirements for Bolted Joints Assembly and Management
\16\	I-ET-3010.00-1200-200-P4X-115	Requirements for Piping Fabrication and Commissioning
\17\	I-DE-3A50.00-1500-941-P56-001	Risers Supports Arrangements Conceptual Design – FPSO Balcony
	I-DE-3A40.03-1500-941-P56-001	
\18\	I-ET-3000.00-1500-251-PEK-001	High-Strength Low-Alloy Steel Fasteners for Subsea Applications

Appendix D lists additional documents that, although not directly cited within this technical specification, contain additional information that are relevant for the proper design of the Hard Pipe System.

3.4 CONFLICTING REQUIREMENTS

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

4. GENERAL REQUIREMENTS

4.1 SCOPE OF SUPPLY

The scope of supply shall include 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.

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 specified herein.
- Procurement of raw materials.
- Procurements of stud bolts & nuts, test/mock-up and 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

For Detailed Design development, SELLER shall consider the environmental conditions as stated in reference \3\.

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

For Detailed Design development, SELLER shall consider the vessel response analysis as stated in reference \4\.

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

Reasoning considerations can be provided by the SELLER in the design report where displacement is not deemed relevant to the design.

Relative displacement of the URB and LRB shall be considered for the hard pipe and flange design. 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

SELLER shall design and fabricate the complete system for a minimum lifetime of 30 years.

4.6 SELLER'S RESPONSIBILITY

SELLER shall assume sole contractual responsibility for the system.

SELLER'S responsibility shall also 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 BUYER.

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

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).

SELLER shall specify any limitations applicable to the transport and installation phase.

5. HARD PIPE SYSTEM SPECIFICATION

5.1 FUNCTIONAL DESCRIPTION

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.

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).

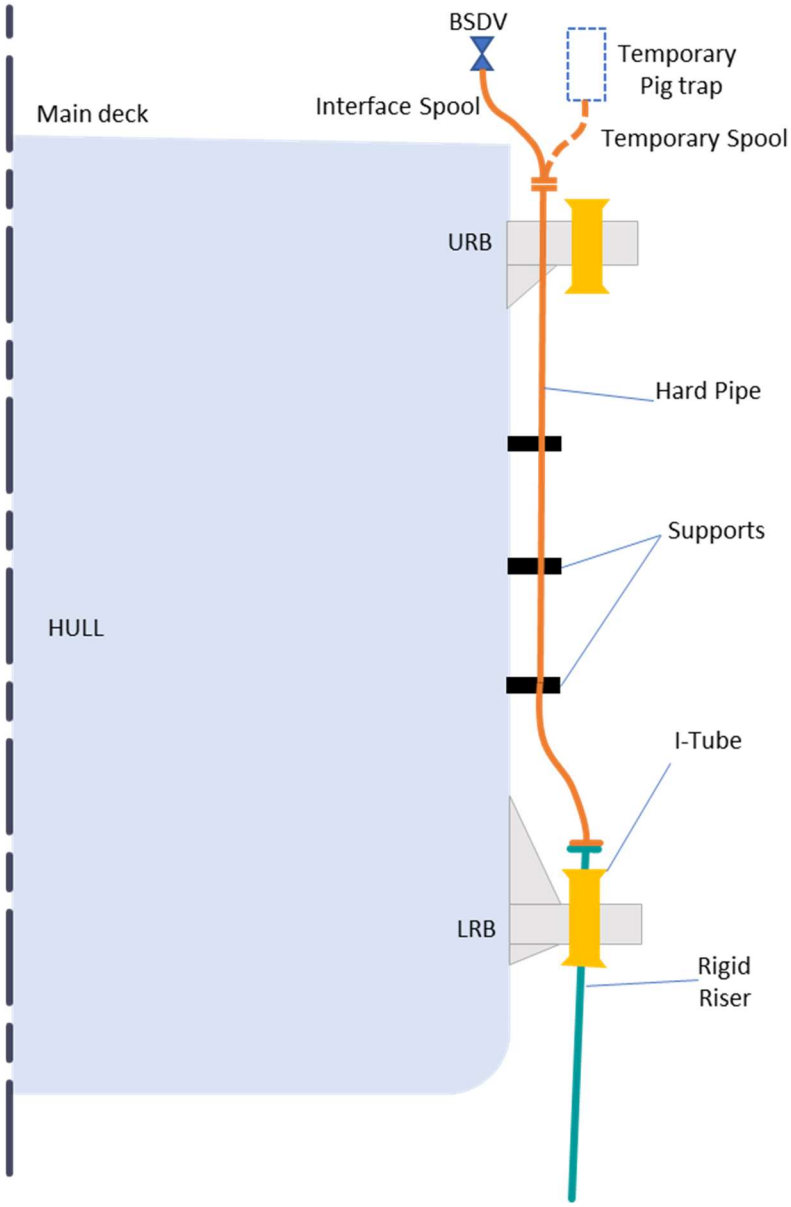

Figure 1 - Typical hard pipe configuration

The hard pipe design arrangement shall be such that enables the FPSO pull-in system to pull the risers from subsea to the FPSO balcony without requiring removal of the hard pipe from the hull supports. These may be achieved by rotating the hard pipe to a free pull-in area, as shown on Figure 2 below, or a similar design.

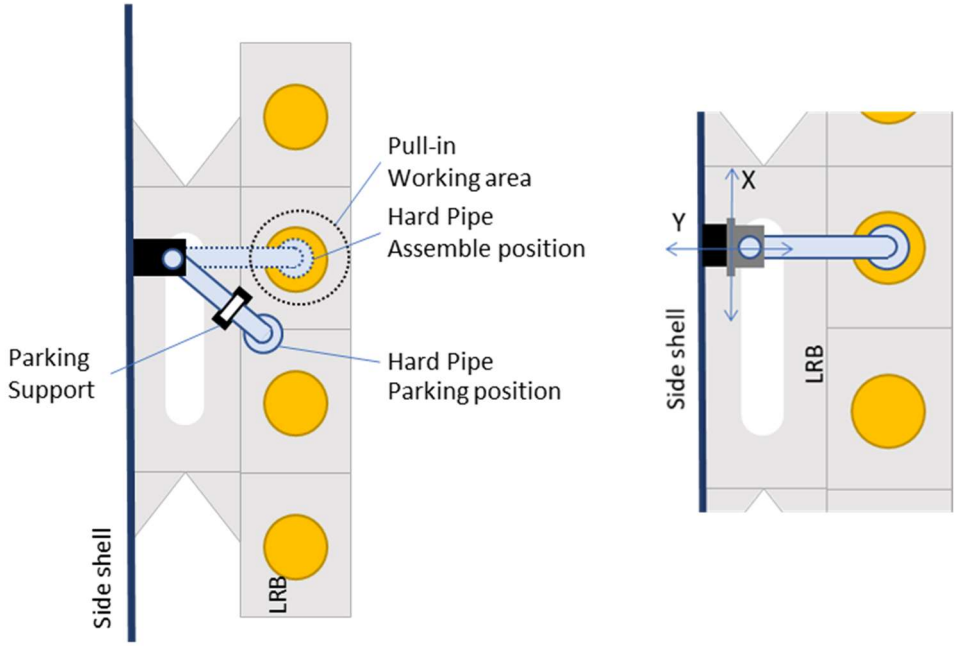

Figure 2 - Hard pipe parking position for pull-in operation

The hard pipe shall have no middle flange connections at the hull side. The hard pipe shall have flange at: (a) LRB to connect with rigid riser flange; (b) Above the URB to connect an interface spool; (c) At the BSDV to connect the interface spool with the platform system. In between these flanges all connections shall be butt type full penetration welds.

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 top side. Special tools that are needed to enable the movement of the hard pipe are within the scope of supply. When on parking position, the hard pipe shall be supported by a cradle support, appropriate for sea fastening and long-term parking.

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

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

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).

There are two typical riser approach directions to the LRB: The arrangement design shall consider these two possible approach directions (see Figure 3). Details on the locations and approaches may also be found on reference /17/.

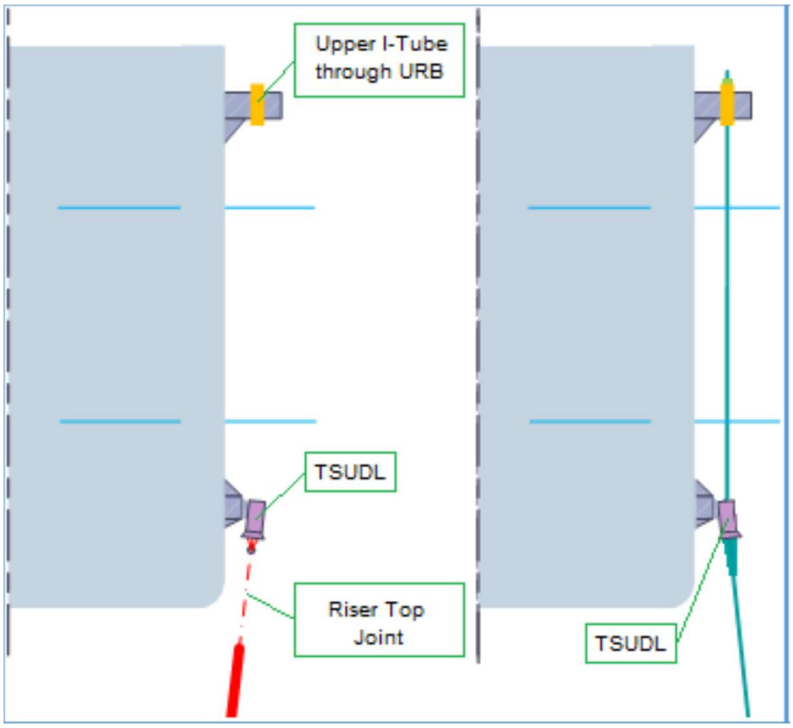

Figure 3 - Riser Support Tube Assembly (TSUDL & Upper I-Tube) (Illustrative)

5.2 HARD PIPE CONNECTION TO RIGID RISER

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 \5\.

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.

SELLER shall be responsible for mechanical design of the Swivel Flanges to meet the operating condition and design data specified in reference \5\.

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

Note 1: 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, an extra bolt length shall be provided to enable the tension tool engagement.

Note 2: API 15000 psi swivel flanges will always require customized design.

5.3 HARD PIPE CONNECTION TO INTERFACE SPOOL

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.

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 not follow the same pressure class of the lower hard pipe flange if this pressure class have been increased due to the high 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 rating may be changed to make it compatible to the BSDV.

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

5.4 TOP INTERFACE SPOOLS

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

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.

Interface spool lower flange end, size, bore and pressure rating shall be the same as for the rigid riser top flange.

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).

Note: the BSDV flanges usually follow the flange type from the connecting topside piping spec, but this may not be always the case. BSDV may be manufactured with either API 6A flanges, ASME flanges or ISO 27509 flanges (compact flanges). SELLER shall check this information for each hard pipe.

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.

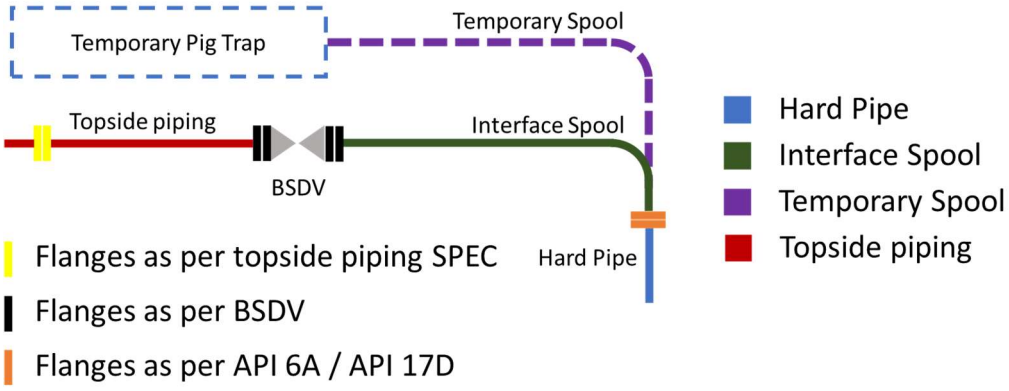

Figure 4 - Details on the flanges for hard pipe, interface spool and BSDV

5.5 TEMPORARY (PIG TRAP) SPOOLS

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.

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

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

The temporary PIG trap data will be supplied by BUYER.

5.6 BLIND FLANGES

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.

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

Blind flanges must be equipped with a test port, since it is predicted that the flange make-up will occur underwater, after the hard pipe functional test.

Note: test ports shall remain open during the flange make-up but shall be closed immediately after.

5.7 TOP SUPPORT ASSEMBLY

Top support assembly is in the URB. This support holds all 3 axial movements of the hard pipe. The hard pipe vertical load is hanged in this support (see Figure 5).

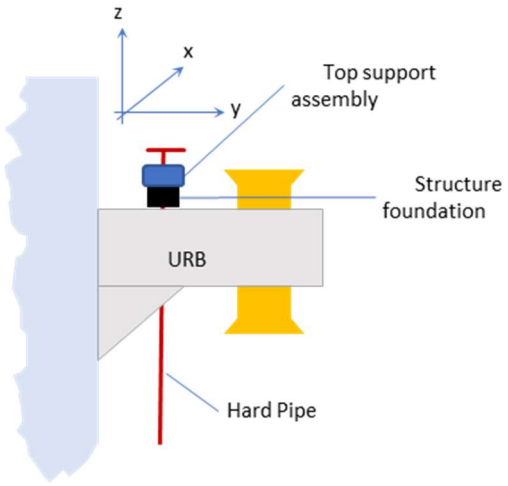

Figure 5 - Top support definition

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.

The top support shall also allow hard pipe rotation within its axis and shall be locked after alignment.

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.

Auxiliaries and outfitting shall be provided to make the top flange and alignment operation feasible.

5.8 HULL SIDE SUPPORT ASSEMBLY

These supports shall be mounted in structural foundation prepared at hull side shell (see Figure 6).

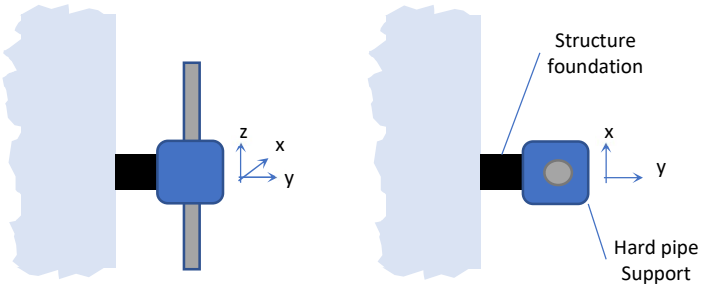

Figure 6 - Side shell support definition

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.

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

Auxiliaries and outfitting shall be provided to make the alignment operation feasible.

5.9 PARKING SUPPORT ASSEMBLY

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 make possible the pull in operation without removal of the hard pipe.

The parking position shall also be used during transit, sail away or when a flexible riser is used in the designated slot (see Figure 7 and Figure 8).

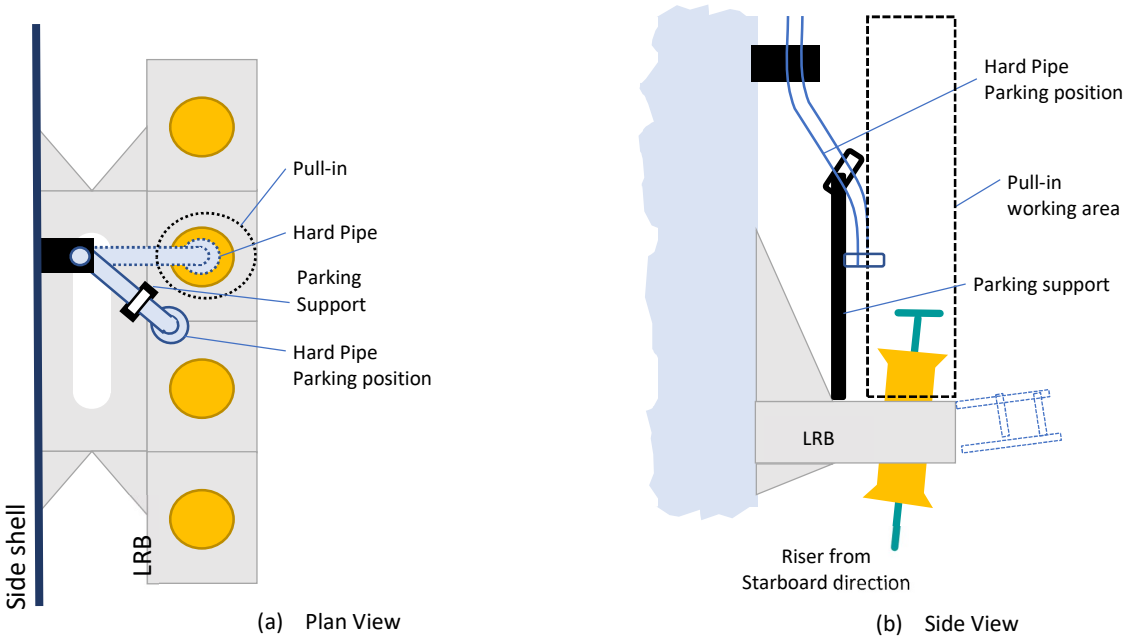

Figure 7 - Parking for pull-in operation at I-Tube.

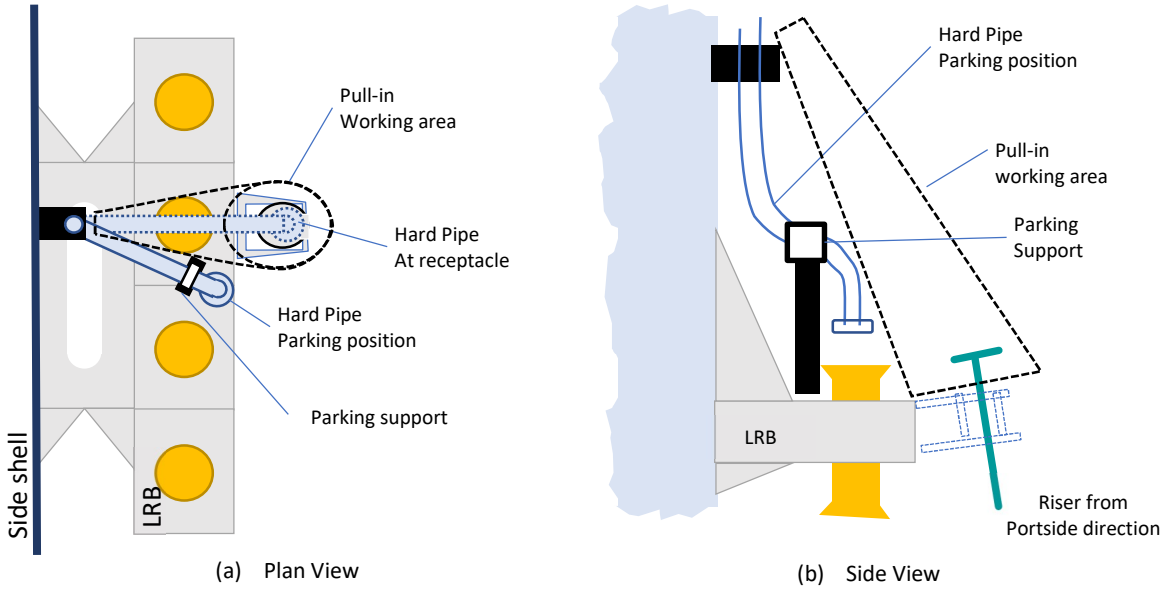

Figure 8 - Parking for pull-in operation at Receptacle.

5.10 RISER MOCK-UP

A rigid riser mock-up dummy shall be supplied to simulate the riser seated in the TSUDL or Conical Receptacle, along with its top flange in position to make-up connection.

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

Design parameters and requirements are designated in reference \5\.

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

5.11 HANDLING AUXILIARIES

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.

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.

Lifting lugs can be installed on the submerged 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.

6. HARD PIPE DESIGN

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

SELLER is responsible for obtaining all necessary certification for the design.

6.1 MECHANICAL AND PRESSURE DESIGN

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

General design conditions shall be taken from the topside line list (see reference \7\) and corresponding P&ID.

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).

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 7.1.3).

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 ASME B31.3. Operational, design and transit conditions shall be verified.

Hard pipe internal diameter maximum and minimum values shall be checked as prescribed in reference \5\.

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

6.2 HARD PIPE ROUTING

Hard pipe routing shall be performed as stablished in reference \5\. Isometric drawings shall be submitted for BUYER approval to check “piggability” of the system design.

6.3 HARD PIPE STRESS ANALYSIS

Hard pipe stress analysis shall be performed in accordance with reference \8\.

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

For hydrodynamic load calculation, pipe outside diameter shall be increased in each side by marine growth thickness informed on reference \3\. Its density shall also be considered.

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

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

6.4 HARD PIPE FATIGUE ANALYSIS

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.

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”.

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

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.

6.5 HARD PIPE SUPPORT DESIGN

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

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

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).

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.

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

Typical gap of 2mm shall be foreseen between support and hard pipe.

6.6 STRUCTURE SUPPORT FOUNDATION

Structural foundation in which hard pipe support is attached is specified in reference \9\.

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

6.7 RISER INTERFACE FLANGE

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

SELLER shall be responsible for the mechanical design of the Swivel Flanges so that it meets the operating condition and design data specified in reference \5\.

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

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

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.

Minimum thickness for the CRA layers is 3 mm. If weld overlay is applied, a minimum of two layers shall be deposited (see reference \10\ for details on the weld overlay process). Powder metallurgy is not an acceptable method for the cladding. Lining or any other non-metallurgical bond is not acceptable.

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

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

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

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

SELLER 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.

The materials shall have full traceability to its certificates.

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

The following sections give further details on the material requirements.

7.1 PIPE MATERIALS

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.

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

SELLER 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.

7.1.1 GENERAL QUALITY REQUIREMENTS

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).

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

7.1.2 SOUR SERVICE REQUIREMENTS

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).

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

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

7.1.3 TOUGHNESS REQUIREMENTS

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.

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

7.1.4 NDT REQUIREMENTS

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).

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

7.2 FLANGES, GASKETS AND BOLTS MATERIALS

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.

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.

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

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%.

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

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 (in accordance with reference \18\). 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.

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 reference \6\.

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.

7.3 CURVES AND BENDS MATERIALS

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.

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

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.

Internal diameter tolerance and ovality for both induction bends and manufactured curves shall be within the tolerances defined for PIGGING (see reference \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. SELLER 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.

7.4 PIPE SUPPORT MATERIAL

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

For the clamp type 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.

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.

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).

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.

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.

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

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.

7.5 COATINGS

Pipes and bends from the hard pipe system shall be externally coated with polychloroprene as per reference \11\. Field joints and repairs of the polychloroprene coating shall also be performed as per the same technical specification.

The surface of the pipe supports that contact the hard pipe shall also be coated with polychloroprene as per reference \11\ (see Appendix C).

The hard pipe flanges shall be externally coated with polychloroprene throughout the flange hubs. The remaining external surfaces of the flanges shall be coated as per reference \12\ , coating system 1 (see Figure 9).

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.

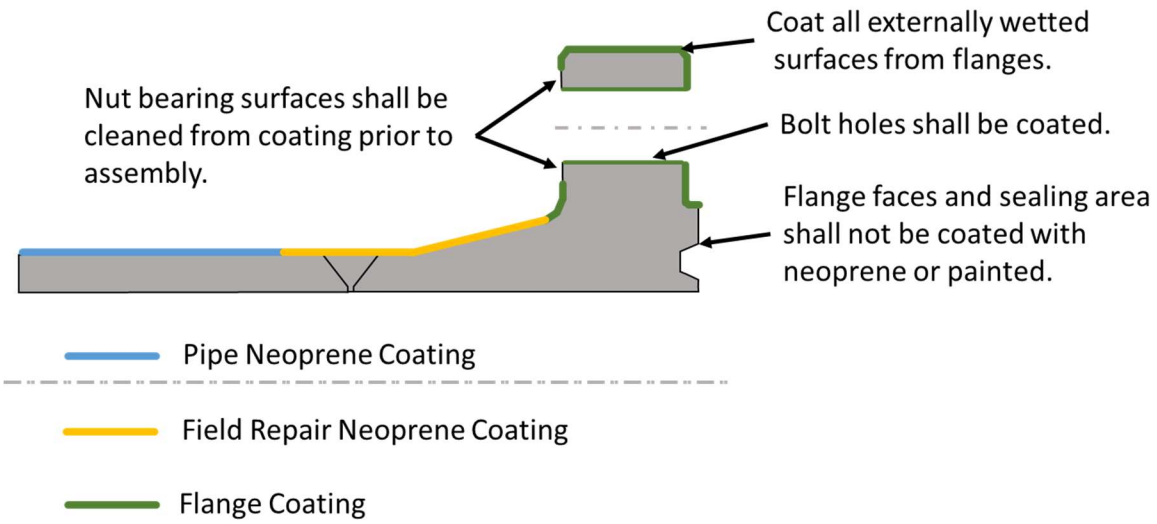

Figure 9 - Coating of Flanges

Flange edges shall be properly prepared (rounded) as required by the painting technical specification (reference \12\).

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.

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

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

Note 1: 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.

Note 2: The coating system 1 from reference \12\ is usually applied up to a maximum operating temperature of 80°C. If the operating temperature exceeds this value, the coating system may have to be changed. In this case SELLER shall propose a new coating system.

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

All welding activities, including the weld overlay deposition, shall be according to the requirements described in reference \10\.

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.

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.

Intermittent welds are not permitted in the supports.

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

NDT shall be according to the Design Code and reference \13\.

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.

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.

Personnel qualification and certification shall be in accordance with reference \14\.

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

8.2 BEND DIMENSIONS AND TOLERANCES

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 7.3 of this technical specification).

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.

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.

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

8.3 HARD PIPE ERECTION

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.

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.

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

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 BUYER.

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

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

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.

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

Except as approved by BUYER 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.

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

Testing shall be performed with fresh water and shall be in accordance with reference \16\.

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 \11\.

8.6 MARKING AND IDENTIFICATION

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 reference \5\.

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.

9. TESTING AND COMMISSIONING

9.1 GENERAL

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

SELLER is required to submit for BUYER 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.

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

SELLER 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.

The following inspections and checks shall be witnessed by BUYER 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.

SELLER 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

The following tests are also included in SELLER'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.

General guidance for each test is given below.

A detailed procedure shall be issued for each test.

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

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.

9.2.1 PIGGABILITY TEST

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

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.

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

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

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

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 reference \5\.

9.2.2 FUNCTIONAL TEST

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.

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 SELLER 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.

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.

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

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

9.2.3 ELECTRICAL CONTINUITY CHECKS

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.

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

9.2.4 LEAK TESTING

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

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 9.2.2 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.

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 reference \16\, and the exposed (not underwater) flanges shall be checked for its tightness with a Helium sniffer.

9.3 PRESERVATION

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.

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.

The preservation methodology shall be documented and submitted for BUYER approval.

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

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 treated to avoid any corrosion on the flange's internal crevices.

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.

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 3.1.

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). 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.

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 BUYER 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 I-ET-3010.00-1200-956-P4X-002 – GENERAL PAINTING, paint system 1.

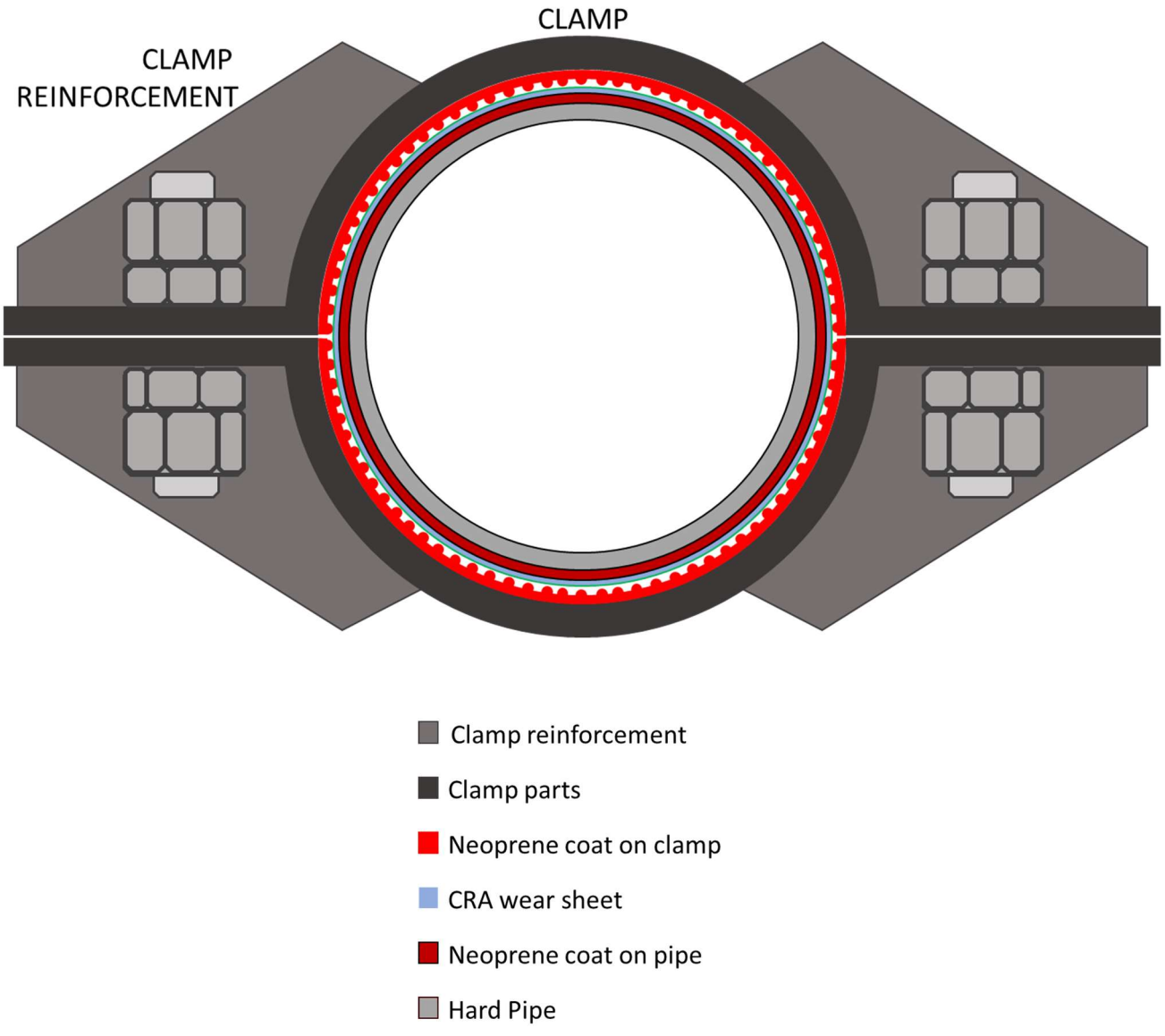

Figure C.1 – Cross section view of a typical “clamp” type support

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 SELLER's experience, but in any case, should not exceed 2 mm.

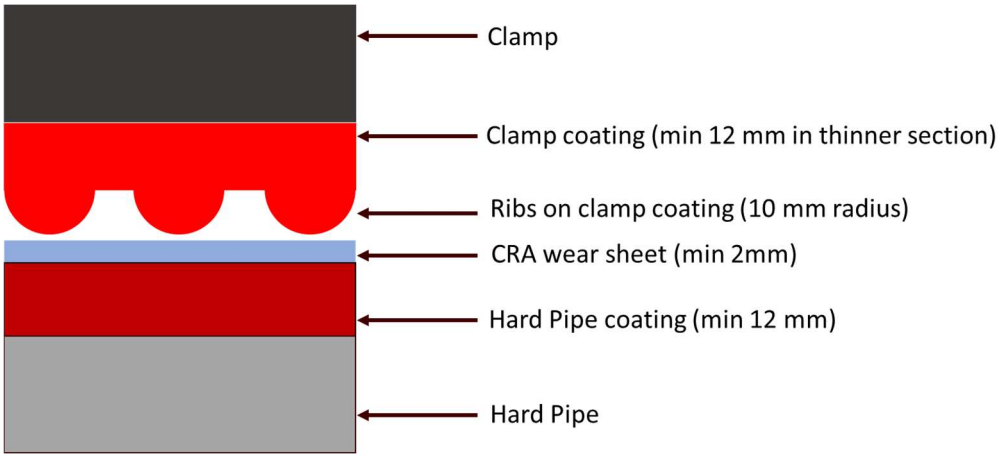

Figure C.2 – Close-up view of the coating configuration

"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.

APPENDIX D – PROJECT SPECIFIC ADDITIONAL REFERENCE DOCUMENTS

The following documents, although not directly cited within this technical specification, may contain additional information that are relevant for the proper design of the Hard Pipe System.

SELLER shall check whether the cited documents are within the contractual scope.

DR-ENGP-I-1.15	Color Coding
DR-ENGP-M-I-1.3	Safety Engineering
I-ET-3000.00-1200-940-P4X-001	Tagging Procedure for Production Units Design
I-ET-3010.00-1500-274-PLR-001	Riser Top Interface Loads Analysis
I-ET-3010.XX-1200-200-P4X-004	Requirements for Piping Support
I-ET-3010.XX-1200-200-P4X-005	Minimum Requirements for Piping Mechanical Design and Layout
I-ET-3010.XX-1351-140-P4X-001	Hull Structural Requirements
I-DE-0000.00-0000-140-P56-001	Riser Top Connector Mockup Geometry Reference
I-DE-3010.00-5140-700-P4X-003	Grounding Installation Typical Details
I-DE-3010.XX-1200-942-P4X-001	General Arrangement
I-DE-3010.XX-1210-944-P4X-XXX	Production / WAG Injection Well drawings
I-DE-3010.XX-1351-140-P4X-001	Hull General Notes and Typical Details
I-DE-3010.XX-1352-140-P4X-006	Upper Riser Balcony
I-DE-3010.XX-1352-140-P4X-007	Lower Riser Balcony
I-DE-3010.XX-1352-140-P4X-008	Hard-Pipe Supports and Side Shell Sheaves
I-DE-3010.XX-5400-94A-P4X-001	Area Classification – General