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1. INTRODUCTION

1.1. OBJECTIVE

The purpose of this technical specification is to describe the minimum requirements for the design, manufacturing, assembly, supply, installation, commissioning and tests of MOORING SYSTEM in conformance with relevant regulations and basic design documentation.

1.2. DEFINITIONS

PACKAGE: It is defined as an assembly of equipment supplied interconnected, tested and ready to operate, requiring only the available utilities from the Unit for the Package operation.

PACKAGER: It is defined as the responsible for project, assembly, construction, fabrication, testing and furnishing of the Package.

OWNER: PETROBRAS.

MOORING SYSTEM the package name.

All definitions are found on I-ET-3010.00-1200-940-P4X-002 – GENERAL TECHNICAL TERMS.

1.3. ABBREVIATIONS

AHTS	Anchor Handling Tug Supply Vessel (Mooring Installation Vessel)
CCR	Central Control Room
CS	Classification Society
FAT	Factory Acceptance Tests
FPSO	Floating Production Storage and Offloading Unit
HMPE Cable	High Modulus Polyethylene cable
LLLC Link	Specific type of mooring link, intended for mooring installation operations.
MAWP	Maximum Allowable Working Pressure
MBL	Minimum Braking Load
NDT	Non-Destructive Tests
SOS	Supervisory and Operation System
SOS-HMI	Human Machine Interface of SOS

2. NORMATIVE REFERENCES

2.1. INTERNATIONAL CODES, RECOMMENDED PRACTICES AND STANDARDS

PACKAGE equipment shall be designed and manufactured in accordance with the following codes and standards, if not mentioned otherwise.

- ANSI American National Standards Institute
- ASME American Society Of Mechanical Engineers
- EN European Standards
- IMO – International Maritime Organization
- ISO International Standard Organization
- VDE / IEC German National Electric Standard Codes / Internation Electrotechnical Commission
- Classification Society defined for the Hull scope.
- IMO MODU Code, 2009
- IACS W22 - Offshore Mooring Chain
- Bureau Veritas, NI604 - Fatigue of top chain of mooring lines due to in-plane and out-of-plane bendings
- ISO 1704 - Ships and marine technology — Stud-link anchor chains

2.2. BRAZILIAN CODES AND STANDARDS

- NR – Brazilian Federal Government Regulatory Norms (Normas Regulamentadoras NRs)
- NORMAM-201 – Normas da Autoridade Marítima para Embarcações Empregadas na Navegação em Mar Aberto;

2.3. CLASS APPROVAL AND CERTIFICATION

PACKAGE shall be designed, manufactured and tested according to the design reference documents, normative requirements and in accordance with the latest editions of Classification Society Rules, Regulations and Standards.

3. REFERENCE DOCUMENTS

3.1. FPSO BASIC DESIGN – SPECIFIC PROJECT DOCUMENTS

DOCUMENT NUMBER (*)	DOCUMENT NAME
HULL SYSTEMS	

I-DE- MOORING HYDRAULIC SYSTEM	MOORING HYDRAULIC SYSTEM
I-MD- DESCRIPTIVE MEMORANDUM - HULL SYSTEMS	DESCRIPTIVE MEMORANDUM - HULL SYSTEMS
I-DE- ENGINE ROOM CENTRAL FRESH WATER COOLING SYSTEM	ENGINE ROOM CENTRAL FRESH WATER COOLING SYSTEM
I-FD- ENGINE ROOM CENTRAL FRESH WATER COOLER (P-5120501A/B)	ENGINE ROOM CENTRAL FRESH WATER COOLER (P-5120501A/B)
GENERAL	
I-DE- GENERAL ARRANGEMENT	GENERAL ARRANGEMENT
I-DE- AREA CLASSIFICATION – GENERAL	AREA CLASSIFICATION – GENERAL
I-ET- METOCEAN DATA	METOCEAN DATA
I-RL- GENERAL SPECIFICATION FOR AVAILABLE UTILITIES	GENERAL SPECIFICATION FOR AVAILABLE UTILITIES
PIPING	
I-ET- PIPING SPECIFICATION FOR HULL	PIPING SPECIFICATION FOR HULL
I-ET- REQUIREMENTS FOR PIPING SUPPORTS	REQUIREMENTS FOR PIPING SUPPORTS
NAVAL	
I-FD- MOORING SYSTEM	MOORING SYSTEM
I-FD- MOORING DATA	MOORING DATA (SPECIFIC FIELD)
I-DE- MOORING LINES ARRANGEMENT	MOORING LINES ARRANGEMENT
I-DE- CAPACITIES PLAN	CAPACITIES PLAN
I-DE- TOWING ARRANGEMENT	TOWING ARRANGEMENT

I-RL- MOTION ANALYSIS	MOTION ANALYSIS
HULL STRUCTURE	
I-MD- DESCRIPTIVE MEMORANDUM - HULL STRUCTURE	DESCRIPTIVE MEMORANDUM - HULL STRUCTURE
I-DE- HULL GENERAL NOTES AND TYPICAL DETAILS	HULL GENERAL NOTES AND TYPICAL DETAILS
COMMISSIONING	
I-MD- COMMISSIONING DESCRIPTIVE MEMORANDUM	COMMISSIONING DESCRIPTIVE MEMORANDUM
MECHANICAL	
I-ET- MATERIAL SPECIFICATION FOR HEAT EXCHANGERS	MATERIAL SPECIFICATION FOR HEAT EXCHANGERS
INSTRUMENTATION AND AUTOMATION	
I-ET- AUTOMATION INTERFACE OF PACKAGE UNITS	AUTOMATION INTERFACE OF PACKAGE UNITS

Table 1 – Specific Project Reference Documents

(*) Note: these documents title and number may vary slightly from one project to another. Project's document list shall be consulted in order to verify the correct document number and title.

3.2. FPSO BASIC DESIGN - TYPICAL DOCUMENTS

DOCUMENT NUMBER	DOCUMENT NAME
GENERAL	
I-ET-3000.00-0000-940-P4X-002	SYMBOLS FOR PRODUCTION UNITS DESIGN
I-ET-3000.00-1200-940-P4X-001	TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN
CONSTRUCTION	
I-ET-3010.00-1200-955-P4X-001	WELDING

I-ET-3010.00-1000-970-P4X-002	REQUIREMENTS FOR NDT
I-ET-3010.00-1200-955-P4X-002	REQUIREMENTS FOR WELDING INSPECTION
I-ET-3010.00-0000-970-P4X-001	REQUIREMENTS FOR PROCEDURES AND PERSONNEL QUALIFICATION AND CERTIFICATION
I-ET-3010.00-1200-200-P4X-116	REQUIREMENTS FOR BOLTED JOINTS ASSEMBLY AND MANAGEMENT
I-ET-3010.00-1200-200-P4X-115	REQUIREMENTS FOR PIPING FABRICATION AND COMMISSIONING
I-ET-3010.00-1200-940-P4X-002	GENERAL TECHNICAL TERMS
MECHANICAL	
I-ET-3010.00-1200-300-P4X-001	NOISE AND VIBRATION CONTROL REQUIREMENTS
I-ET-3010.00-1200-451-P4X-001	REQUIREMENTS FOR SHELL AND TUBE HEAT EXCHANGER DESIGN AND FABRICATION
I-ET-3010.00-1200-456-P4X-001	REQUIREMENTS FOR PLATE HEAT EXCHANGER DESIGN AND FABRICATION
I-ET-3010.00-1352-130-P4X-001	FLOOR GRATINGS, TRAY SYSTEMS AND GUARDRAILS MADE OF COMPOSITE MATERIALS
PAINTING	
I-ET-3010.00-1200-956-P4X-002	GENERAL PAINTING
DR-ENGP-I-1.15	COLOR CODING
SAFETY	
I-ET-3010.00-5400-947-P4X-002	SAFETY SIGNALLING
DR-ENGP-M-I-1.3	SAFETY ENGINEERING GUIDELINE

PIPING	
I-ET-3010.00-1200-251-P4X-001	REQUIREMENTS FOR BOLTING MATERIALS
ELECTRICAL	
I-DE-3010.00-5140-700-P4X-003	GROUNDING INSTALLATION TYPICAL DETAILS.
I-ET-3010.00-5140-700-P4X-001	SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS
I-ET-3010.00-5140-700-P4X-002	SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS
I-ET-3010.00-5140-700-P4X-003	ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS
I-ET-3010.00-5140-700-P4X-007	SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS
I-ET-3010.00-5140-700-P4X-009	GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS
I-ET-3010.00-5140-712-P4X-001	LOW-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS
I-ET-3010.00-5140-741-P4X-004	SPECIFICATION FOR LOW-VOLTAGE GENERIC ELECTRICAL PANELS FOR OFFSHORE UNITS
I-ET-3010.00-5140-772-P4X-002	SPECIFICATION FOR LOW-VOLTAGE FREQUENCY CONVERTERS, SOFT-STARTERS AND INVERTERS FOR OFFSHORE UNITS
I-DE-3010.00-5140-797-P4X-002	ELECTRICAL SYSTEM AUTOMATION TYPICAL ACTUATION DIAGRAMS
INSTRUMENTATION AND AUTOMATION	

I-ET-3010.00-1200-800-P4X-002	AUTOMATION, CONTROL AND INSTRUMENTATION ON PACKAGE UNITS
I-ET-3010.00-1200-800-P4X-013	GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS
I-ET-3010.00-5500-854-P4X-001	MACHINERY MONITORING SYSTEM
I-ET-3010.00-5520-888-P4X-001	AUTOMATION PANELS
I-ET-3010.00-1200-800-P4X-015	REQUIREMENTS FOR TUBING AND FITTING (ALIGNED TO IOGP-JIP33 S-716)
NAVAL	
I-ET-3010.00-1350-960-P4X-001	DESIGN REQUIREMENTS – NAVAL ARCHITECTURE

Table 2 – Typical Reference Documents

4. DESIGN REQUIREMENTS

4.1. DESIGN CONDITIONS

4.1.1. PACKAGE Equipment shall be designed for a design life defined on specific project basic design and with a corrosive offshore environment without the need to replace any major component due to wear, corrosion, fatigue, or material failure.

4.1.2. PACKAGER shall design the equipment for the full range of operational conditions as specified in this technical specification.

4.1.3. PACKAGE Equipment shall be designed in accordance with the normative and design requirements set out in this specification and in compliance with the technical parameters indicated in the basic design reference documents stated in section 3.

4.2. SAFETY REQUIREMENTS

4.2.1. Personnel safety protection shall be provided according to Brazilian Regulatory Norms (NR) issued by Brazilian Government.

4.2.2. Warning signs in Brazilian Portuguese language shall be provided wherever there is a risk of personal injury.

4.2.3. Rotating equipment outer parts, such as pulleys, couplings, belts and flywheels, shall have rigid protection, manufactured with aluminum ASTM B211 and shall be capable of being easily removed.

4.2.4. In accordance with the requirements of SOLAS II-1, Regulation 3-5, and MSC.1/Circ. 1379, all equipment and material to be supplied by PACKAGER must be “asbestos free”.

4.2.5. Safety signalling shall be in full compliance with I-ET-3010.00-5400-947-P4X-002 – SAFETY SIGNALLING.

4.2.6. For additional safety requirements, refer to DR-ENGP-M-I-1.3 – SAFETY ENGINEERING GUIDELINE.

4.3. NOISE AND VIBRATIONS

4.3.1. Noise and vibrations limits shall comply with I-ET-3010.00-1200-300-P4X-001 – NOISE AND VIBRATION CONTROL REQUIREMENTS.

4.4. MOTIONS AND ACCELERATION

4.4.1. All equipment shall be able to withstand when the UNIT subjected to 100-year return period environmental conditions.

4.4.2. All equipment shall be able to operate when the UNIT subjected to 1-year return period environmental conditions.

4.4.3. All environmental conditions are defined in I-ET- METOCEAN DATA, at any draft from fully loaded to the minimum loaded / ballasted condition.

4.4.4. For the Hull loading conditions details and the maximum designed operational trim and heel inclinations refer to I-ET-3010.00-1350-960-P4X-001 – DESIGN REQUIREMENTS – NAVAL ARCHITECTURE.

4.4.5. For the design data and information regarding motion requirements, refer to I-RL- MOTION ANALYSIS.

4.4.6. PACKAGE is also to withstand inertial forces during transportation from construction site to the final offshore location.

5. PACKAGE SPECIFICATION AND TECHNICAL REQUIREMENTS

5.1. SCOPE OF SUPPLY:

5.1.1. For detailed scope of supply with equipment TAG (when applicable) and quantities, refer to I-FD- MOORING SYSTEM.

5.1.2. For the sake of clarity, the main Mooring System components and accessories are illustrated on *Figure 1 (*schematic only).

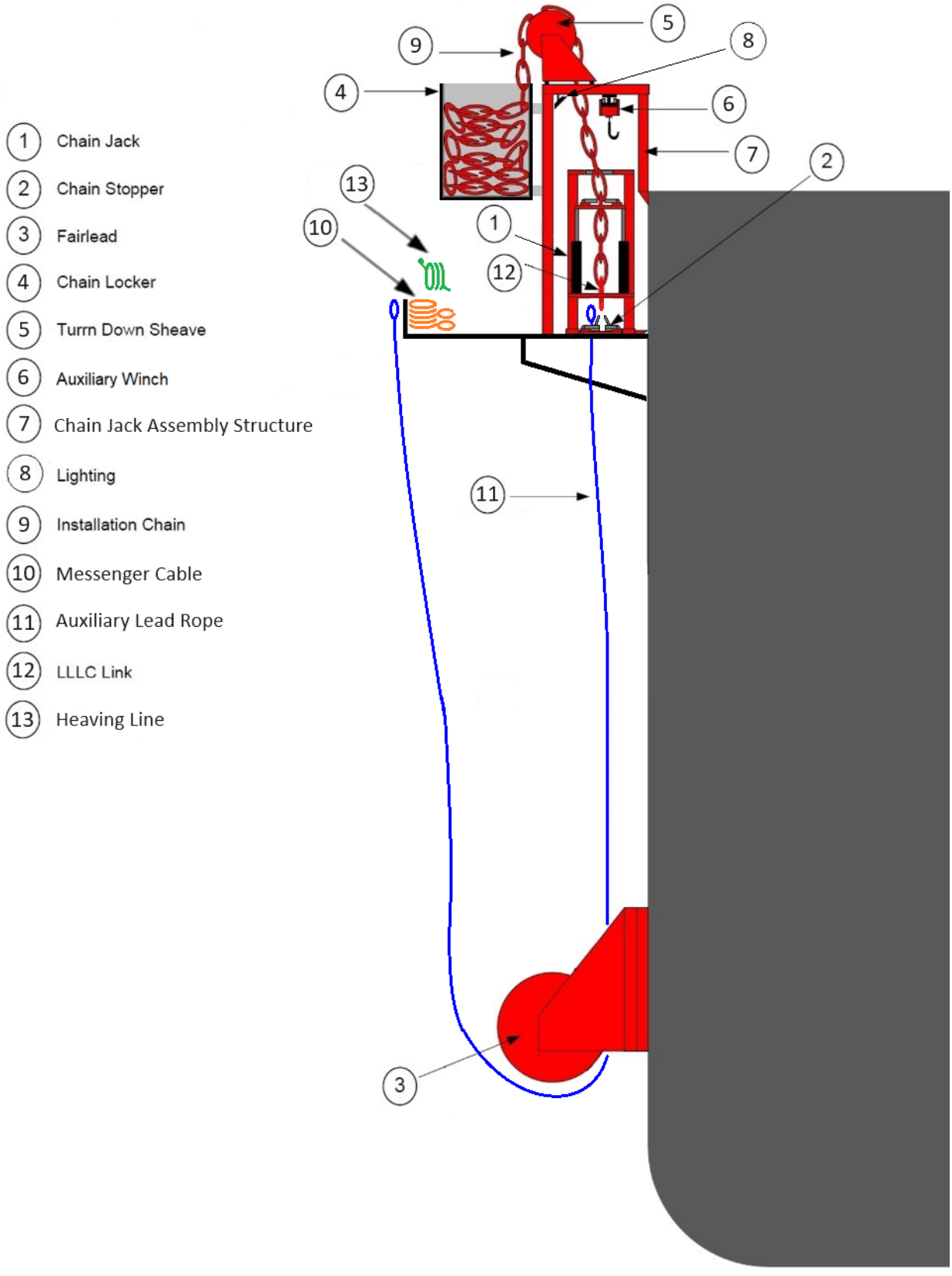


Figure 1 – Schematic arrangement of mooring system and components to be supplied.

5.1.3. It is also included in this PACKAGE four (4) Towing Retrieval Winches to assist on FPSO towing operations (for towline recovery from TUG Boat). Refer to I-FD-MOORING SYSTEM for equipment TAG and complimentary information.

- Note: Document I-DE- TOWING ARRANGEMENT shall be consulted for other towing equipment and accessories that shall be supplied by HULL SUPPLIER which are not included in this Technical Specification.

5.1.4. The PACKAGE scope shall include all required main, secondary and auxiliary mechanical hardware (hydraulic jacks, winches, deviation sheaves, fairleads, blocks, rollers, pad eyes, wire ropes, etc.), spare parts, temporary accessories, and materials, required for system operation (refer to 6.1.5 and 7.1.1), and that may not be listed on I-FD- MOORING SYSTEM.

5.1.5. All other parts or components required for the safe and full operation of the system.

5.2. EQUIPMENT LOCATION

5.2.1. MOORING SYSTEM will be installed on dedicated balconies near main deck elevation, 2 (two) at the forward (PS/SB) and 2 (two) at the stern (PS/SB). Document I-DE-GENERAL ARRANGEMENT shall be consulted for more details.

5.2.2. Hydraulic power unit for mooring system, Fwd/Aft, shall be installed at the Fore castle/Engine room, respectively.

5.2.3. MOORING SYSTEM hazardous area requirements shall comply with I-DE- AREA CLASSIFICATION – GENERAL.

6. TECHNICAL SPECIFICATION

6.1. GENERAL

6.1.1. The mooring lines pattern and FPSO Heading are shown on I-DE - MOORING LINES ARRANGEMENT.

6.1.2. The specific project data sheet I-FD - MOORING SYSTEM shall be consulted for the following information:

- Mooring lines top chain segment specification (diameter, MBL, etc.).
- Highest mooring line pre-tension at fairlead.
- Mooring equipment TAG and quantity.

6.1.3. All components of MOORING SYSTEM, including (but not limited to) fairlead, chain-jack, chain stopper, turn down sheave and chain locker, shall be suitable to operate with the mooring line top chain segment, as well as with the LLLC link to be used to connect top chain to the installation chain.

- Note: See item 6.18 for LLLC link specification.

6.1.4. The MOORING SYSTEM design shall take in consideration possible variation on mooring chain dimensions, according to standard IACS W22 and ISO 1704 acceptable tolerances.

6.1.5. The MOORING SYSTEM shall be designed to perform the following operations:

- Mooring lines hook-up, including but not limited to the tasks below:
  - to unlock the fairleaders (see item 6.3.11);
  - to transfer the Messenger Cable from FPSO to AHTS vessel;
  - To pay-out installation chain from chain locker to AHTS vessel. On this step of operation, the messenger cable and installation chain shall not be tensioned by AHTS vessel. Both shall be paid-out without tension by MOORING SYSTEM equipment;
  - To recover the installation chain and mooring line top segment from AHTS vessel;
  - To lock mooring line top segment on respective chain stopper.

    Note: Refer to Annex 1 for a general description of OWNER hook-up procedure outside Mooring Balcony. MOORING SYSTEM shall be suitable to operate according to this procedure.
- Mooring lines final tensioning;
- To discard the top chain excess from FPSO to AHTS vessel (these chains shall not remain in the chain locker after final tensioning operation);
- To pull-out the entire installation chain from chain locker to AHTS vessel and pull-in a new one;
- De-installation of the mooring lines.

6.1.6. PACKAGE/equipment Maximum Allowable Working Pressure (MAWP) shall be higher than the maximum pressure that may occur at PACKAGE/equipment inlet tie-in point.

6.1.6.1. In particular cases where it is not possible to comply with above requirement, it shall be included on PACKAGE scope of supply devices for pressure control together with devices for protection against over pressure, for example, a combination of a self-operated pressure reducing valve and a pressure relief valve.

- Note: This requirement (item 6.1.6) is also applicable for PACKAGE required utilities, such as, but not limited to, seawater/fresh water cooling, compressed air, diesel, nitrogen.

6.2. MOORING EQUIPMENT ARRANGEMENT AND DESCRIPTION

6.2.1. The mooring lines will be disposed in four bundles (starboard-bow, starboard-aft, portside-aft, portside-bow). There will be one mooring balcony for each bundle assembled on side-shell, near Main Deck elevation. The balconies shall be

designed to receive up to 7 mooring lines each.

6.2.2. Each mooring line shall enter the FPSO through a fairlead and be supported by a fixed chain stopper installed on the balcony deck.

6.2.3. One (1) movable chain jack with its own turn-down sheave on top (named as chain jack assembly) shall be supplied for each mooring balcony (a total of 4 chain jacks for the FPSO). The MOORING SYSTEM shall have permanent means to move the chain jack assembly through the balcony so that it can be positioned over each chain stopper of that bundle, to pay out or retrieve the Installation Chain or top chain, as required. The balconies and mooring equipment shall be designed so that there are no interferences with other structures in the FPSO.

6.2.4. MOORING SYSTEM shall be equipped with drag chains, which are devices for guiding and organizing the hydraulic flexible hoses connected to the movable part, while it moves. The drag chains shall be designed to reduce wear and stress on hoses, prevent entanglement, improve operator safety and efficiency during operation. It shall be possible to move the chain jack assembly to any mooring line of that bundle, without human intervention to distribute or accommodate the hydraulic flexible hoses.

6.2.5. It shall be provided at least one (1) chain locker (fixed or movable) per mooring bundle.

6.2.6. The movable structure of the MOORING SYSTEM shall properly move along the balcony and park, even when the chain locker is full of chain (in case of movable chain locker).

6.2.7. MOORING SYSTEM shall have means to fully discard all mooring lines stored in chain locker to an anchor handling tug supply vessel (AHTS) and to pull-in a new installation chain from AHTS to chain locker. There shall be a discard slot at the deck of each mooring balcony (additional to the slots that will be occupied by each mooring line), properly designed for such operations.

6.2.8. The fairleads, chain stoppers and chain jack assemblies shall be arranged in a way to avoid unnecessary wear on the chain links.

6.2.9. MOORING SYSTEM shall be provided with portable control panels on each balcony allowing to operate the system in front (and near) each chain stopper and on the platform above the chain jack assembly. For more details on see item 6.9.

6.2.10. Auxiliary handling devices shall be provided for each bundle to assist on mooring operations, as detailed on item 6.11.

6.3. FAIRLEAD

6.3.1. The MOORING SYSTEM shall have fairleads compatible with top chain segments of each mooring line, to be installed on FPSO hull side-shell, below each chain stopper.

6.3.2. The fairleads shall be eccentric type (azimuthal sheaves) and self-lubricated with docking points adapted for removal and/or installation.

6.3.3. Fairlead maximum operational azimuth angle (also known as pivot angle) shall be compatible with mooring lines pattern given by I-DE-MOORING LINES ARRANGEMENT.

6.3.4. As a minimum, Fairlead wrap angle shall be from 17 to 80 degrees (in relation to vertical). Refer to Figure 2 below.

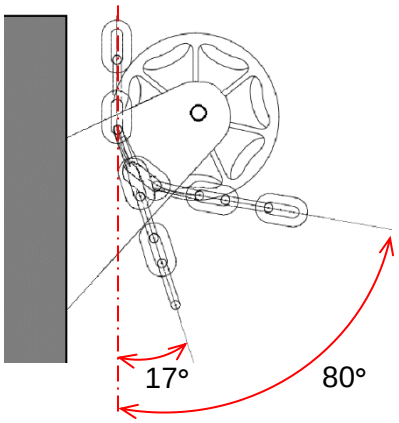


Figure 2 – Fairlead wrap angle.

6.3.5. The fairleads and its supporting structure shall be dimensioned considering a design load of at least 100% of the top chain MBL, applied according to azimuth angles and wrap angles mentioned on items 6.3.3 and 6.3.4, respectively. This condition shall not cause any damage to Fairlead or its supporting structure and the stress levels shall not exceed the Classification Society requirements.

- Note: If rules of selected Classification Society require a more stringent criteria, CS rules shall be followed.

6.3.6. Detailed stress calculations and fatigue calculations shall be carried out on fairleads in accordance with the CS rules.

6.3.7. The fairlead supporting structure shall minimize effects of slamming due to passage of waves.

6.3.8. The fairleads shall be suitable to operate with the chosen chain jack assembly arrangement and should not submit the chain links to severe bending or shear. In-plane and out-of-plane bending of the chains shall be demonstrated to be as low as possible. BV NI604 offers a guideline for such assessment. Other rules and guidelines may be adopted upon OWNER appraisal.

6.3.9. PACKAGER shall supply information documenting that the links will fit properly in the fairlead pockets without distortion, damage or excessive stresses which may initiate cracks or failures leading to reduced chain MBL (minimum breaking load) or design life.

6.3.10. The mooring chain handling between the chain stopper and the fairlead must occur without obstruction, with enough room to allow free passage of the mooring chain, both for retrieve and pay-out operations (with or without tension in the chain).

6.3.11. For the FPSO towing to site location, the fairleads shall be accommodated flipped backwards in relation to towing direction to minimize loads and stress due to wave passage. The fairlead locking mechanism shall be easily removable, on hook-up operation, from mooring balcony deck, without the need of climbers. Other procedures may be proposed, subject to OWNER's appraisal.

6.3.12. The rigging provided for unlocking the fairleads (cables, shackles, etc.) shall attend a safety factor of 10 times the necessary load to release the locking mechanism.

- Note: The necessary load to release fairlead locking mechanism shall be demonstrated on PACKAGER technical documents.

6.3.13. The fairleads and incoming mooring lines shall not constitute navigation hazards to other vessels.

6.4. CHAIN STOPPER

6.4.1. Hydraulically operated flapper-type chain stoppers shall be installed on mooring balcony, one per mooring line, on top of the hawse pipes.

6.4.2. The chain stopper shall have a load bearing capacity equal to 120% of the mooring line's top chain segment MBL (minimum breaking load).

Note: Mooring line top chain specification is defined in I-FD-MOORING SYSTEM.

6.4.3. The chain stopper shall be designed to support the chain in a manner to minimize chain wear.

6.4.4. The chain stopper shall be designed to allow the LLLC chain link to pass through.

6.4.5. PACKAGER shall supply information documenting that the links will fit properly in the chain stopper without distortion, damage or excessive stresses which may initiate cracks or failures leading to reduced MBL or design life.

6.4.6. Below each chain stopper there should be a cross-section opening, with dimensions compatible with top chain segment, to prevent torsion on the mooring line. The cross-section opening shall be provided with a chamfer at its lower side (minimum 20mm) to facilitate chain entrance, when hauling in by chain jack. Such structure shall not obstruct suitable passage of mooring line both on recovery and pay-out operations.

6.4.7. Detailed stress calculations and fatigue calculations shall be carried out on exposed chain stopper parts and chain link.

6.4.8. Any kind of technical failure or operational failures shall, under no circumstances, lead to uncontrolled chain pay-out.

6.5. CHAIN TENSION MONITORING SYSTEM

6.5.1. Each chain stopper shall be provided with a chain tension monitoring system. The chain tension signals shall be connected to Central Control Room (CCR) supervisory system and shall be available in the balcony's local control.

6.5.2. The tension measurement shall be made by compression load-cells or load-pins. Instrumented chain stopper paws (with strain gauges integrated on its body) are not accepted.

6.5.3. The load-cells or load-pins shall have backup gauges so that, in case of failure of the main circuit, it is possible to change the readings to the second circuit.

6.5.4. The load-cells or load-pins shall be designed, as a minimum, for the same load bearing capacity (and same safety factor) than the chain stopper.

6.5.5. Each load-cells or load-pins shall be calibrated by its manufacturer against a recognized standard and the calibration curves shall be informed on Mooring System documentation.

6.5.6. Accuracy of the chain tension monitoring system shall be within 5% in the range between 50% and 200% of the highest mooring line pre-tension. Outside this range larger tolerances can be accepted but should be discussed with OWNER.

6.5.7. Load-cells/load-pins operational limit (maximum admissible load without damaging its electronics) shall be 200% F.S. (full scale).

6.5.8. Each chain stopper, assembled with respective chain tension monitoring system, shall be load tested during FAT (factory acceptance tests), to demonstrate system accuracy as defined on item 6.5.6 above. A recognized calibration standard shall be followed.

Note 1: The load-cell or load-pin individual calibration certificate, issued by its manufacturer, does not exempt above test.

6.5.9. The tension monitoring system shall have alarms in case of rupture on any mooring line.

6.5.10. Chain Stopper design shall allow the replacement of load-cells or load-pins (for recalibration or repair), with mooring lines installed with pre-tension levels. The replacement procedure shall not require using the chain jack assembly to "lift" the mooring chain from the respective chain stopper (reducing the load on it), or to pay-out mooring line to an AHTS vessel. The tools needed for that replacement shall be included in the PACKAGER scope of supply. The load cells replacement procedure, including necessary tools and equipment, shall be presented to OWNER for appraisal.

6.6. CHAIN JACK ASSEMBLY

6.6.1. There shall be 1 (one) chain jack assembly for each mooring line bundle, in a total of 4 assemblies per FPSO.

6.6.2. Each vertical chain jack assembly shall consist of hydraulic jack, hydraulic chain grabbers, motorized turn-down sheave and the required foundations and components so each chain jack assembly is an individual unit, except of power supply.

6.6.3. The chain jack assembly shall be hydraulically operated, and auxiliary functions shall be hydraulically controlled.

6.6.4. The main task of the chain jack assembly is to pull the mooring chains from the fairleads to the chain locker and to perform the top tensioning of the mooring line. Also, the chain jack shall be able to pay-out mooring chain from the chain-locker to AHTS vessel.

6.6.5. A motorized turn-down sheave shall be located on top of the jacking mechanism, with means to safely guide the deployed chain to the deck for handling/cutting or to appropriately retrieve the chain to the locker for storage.

6.6.6. The mooring chain shall be guided safely in and out of the chain locker, through the turn down sheave, hydraulic jacks and chain stopper slot without the need of direct human interference.

6.6.7. The chain jack pull capacity shall be defined according to the mooring lines pre-tension levels and considering the environmental conditions for hook-up operations, friction losses, etc. The minimum dynamic amplification factor to be considered shall be 1.75 times the highest mooring line pre-tension, with FPSO at target position (no external forces), at minimum draft.

- Note: The specific project mooring lines pre-tension and minimum Chain Jack pull capacity are informed on I-FD- MOORING SYSTEM.

6.6.1. The chain jack assembly pull speed shall be at least 1.5 m/min at maximum load. The pay-out speed shall be at least 1.5 m/min. Both operations shall be executed in automatic mode.

6.6.2. The chain jack assembly structural strength is to be designed, as a minimum, to withstand a load of 100% of MLB of mooring line top chain and the stress levels shall not exceed the Classification Society requirements.

6.6.3. The stroke of the main cylinder rod shall have a margin of at least 50 mm in addition to the required design stroke. This aims to compensate for mooring chains or chain jack assembly dimensional variations.

6.6.4. Air bleed valves shall be provided to enable air bleeding and draining of the cylinders. The chain grabber latches shall be self-closing, in case of HPU failure.

6.6.5. In case of unexpected HPU shut down, the chain jack shall safely hold the tensioned chain.

6.6.6. Chain grabber latches and turn down sheave surfaces in contact with the chain shall be approximately 5% softer than the chain itself.

6.6.7. The turn down sheave minimum pull capacity (nominal) shall be 25T, with a minimum pay-out speed (at nominal pull capacity) of 5m/min. The turn down sheave shall be capable to pay out the installation chain to AHTS vessel, with chain jack flaps opened, considering 80m of chain out of the fairlead.

- Note: on this step of operation, installation chain or messenger cable shall not be tensioned by AHTS vessel (installation chain shall be paid out without tension).

6.6.8. MOORING SYSTEM shall have protection mechanisms to prevent damage on the turn-down sheave, its shaft and motorized system caused by excessive load on the sheave. For example, synchronism error that may cause the mooring line tension to be unloaded over the turn down sheave.

6.6.9. The motorized turn down sheave structure (the supporting structure, axis and the wheel itself) shall be designed to withstand, as a minimum, the load produced on these components when the motorized sheave is on brake maximum capacity. This is, if the capacity of motorized sheave brake is exceeded, the motorized sheave and its structural components shall not fail in this condition.

6.6.10. Turn-down sheaves pockets shall fit the LLLC chain link.

6.6.11. PACKAGER shall ensure that the turn down sheaves are designed and fabricated so that the mooring chain links are not exposed to severe bending and wear and that the turn down sheaves are well functioning within the chosen chain jack arrangement.

6.6.12. The motorized turn-down sheave, chain jack and fixed chain stopper shall operate in suitable synchronism with each other. An automatic / manual mode switch shall be provided. In automatic mode, the winch shall perform the step-by-step cycle of turn-down sheave, chain jack and fixed chain stopper, moving the chain in or out of the chain locker. In manual mode, the following controls shall be available:

- Chain Jack extend and retract.
- Upper and lower stoppers opening independently.
- Both stoppers open (lockable function).

6.6.13. The MOORING SYSTEM shall have proximity switches for chain stoppers flaps (or pawls) positioning. The system design shall consider possible variations on chain link dimensions (within acceptable tolerances as given by IACS W22 and ISO 1704).

6.6.14. The chain jack assembly shall be equipped with a drip pan to collect all oil from

any leakage. The drip pan shall have a sloped bottom and drain port.

6.7. EXCESS CHAIN DISCARD SLOT

6.7.1. Each Mooring balcony shall have a discard slot (additional to the slots that will be occupied by each mooring line) to allow pay-out or pull-in mooring chains to an AHTS vessel. This slot will be used to pay out top chain excess (on tensioning operation), or to replace the installation chain to/from AHTS vessel. Other discard arrangements may be proposed subject to OWNER's appraisal.

6.7.1.1. The discard slot shall be provided with a dedicated chain stopper device, with a minimum load bearing capacity of 125T. This chain stopper device shall be, hydraulic-type, remotely operated, and shall allow the passage of LLC links. It is not required tension monitoring system for this chain stopper device.

6.7.1.2. The discard slot shall not have a fairleader.

6.7.1.3. The discard slot shall be within reach of the chain jack assembly and be provided with dedicated supports for the chain jack assembly operation (for example, the use of turn down sheave and auxiliary winch).

6.7.1.4. The motorized turn down sheave shall be capable to pay-out a minimum of 80m of top chain out of the discard slot, with the stopper device fully open.

6.7.1.5. An Auxiliary Lead Rope (6.16) shall be pre-installed on the discard slot. One end fastened near the discard hole, passing through the discard hole, going underneath the balcony structure and up to the balcony guardrail, where the other end shall be fastened (see Figure 2 below). The purpose of this cable is leading a stronger messenger cable (for example, one liberated from mooring lines), through the path where the lead cable is pre-installed, and then using the messenger cable to transfer the excess chain (or installation chain) to the AHTS. The lead cable shall be installed in a way to avoid abrasion with the balcony structure.

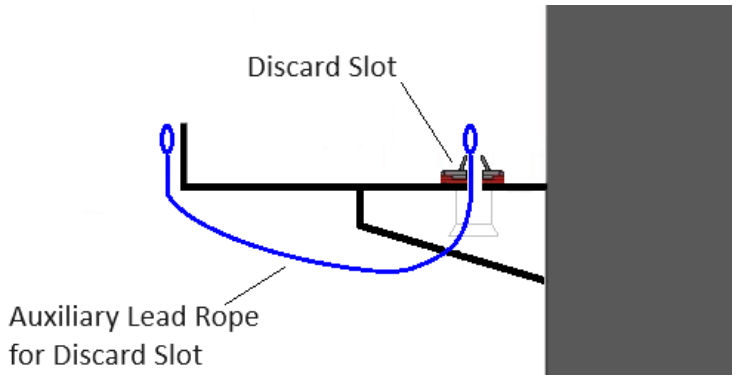


Figure 2 – Schematic arrangement of auxiliary lead rope for discard slot.

6.7.1.6. The discard slot shall have a chain pipe to guide the chain and avoid its contact/interference with the surrounding structure underneath balcony on pull-in/pull-out operations. If curves are required on chain pipe, they shall be of long radius to prevent chain to get stuck. As the discard slot does not have a fairlead,

the discard chain path is inclined towards the AHTS vessel (different than permanent mooring lines that have a vertical path to fairleads).

6.8. HYDRAULIC POWER UNIT (HPU)

6.8.1. Two (2) Hydraulic Power Units (HPUs) shall be supplied, one to feed stern mooring lines clusters (PS/SB), and the other to feed bow clusters (PS/SB).

6.8.2. It shall be possible to operate both HPUs independently. There should be no hydraulic communication between bow and stern units.

6.8.3. The HPUs shall be dimensioned and designed to comply with the following scenarios:

a. To drive one (1) chain jack assembly at full power, including all necessary auxiliary equipment defined by procedures.

b. To pay out installation chain to AHTS vessel at one balcony; and on the opposite balcony, simultaneously perform the skidding of chain jack assembly from one mooring line to another.

6.8.4. A minimum of 2 x 100% or 3 x 50% hydraulic pumps shall be provided on each HPU for redundancy.

6.8.5. The HPU electric motors rated voltage shall be according to I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.

6.8.6. The HPUs shall be suitable for operating in a marine environment and adapted to tropical weather.

6.8.7. The hydraulic distribution system from HPU to mooring bundles shall have appropriate double blocking valves (or other appropriate blocking mean) to allow isolating portside and starboard hydraulic systems. This shall allow to securely execute repairs in MOORING SYSTEM components of one side (for example starboard) while the system is normally operated in the other side (portside).

6.8.8. If HPUs are located at a lower level than the mooring equipment on PS/SB balconies, the hydraulic system design shall have means to avoid the overflow of the HPU hydraulic tank due to gravitational oil return from mooring equipment, hoses and piping.

6.8.9. HPU shall have a clear indication of its maximum and minimum allowed oil level.

6.8.10. Document I-DE- MOORING HYDRAULIC SYSTEM shall be revised on detailed design phase according to PACKAGER requirements and herein specifications.

6.8.11. HPU shall be provided with alarm and automatic shutdown in the event of a low level or high temperature of hydraulic oil in hydraulic tank.

6.8.12. MOORING SYSTEM shall have means of protection against hydraulic oil high pressure.

6.8.13. The HPU shall be provided with fresh water heat exchangers for hydraulic oil cooling.

6.8.13.1. Fresh water heat exchangers shall comply with following technical specifications:

- I-ET-3010.00-1200-451-P4X-001 - REQUIREMENTS FOR SHELL AND TUBE HEAT EXCHANGER DESIGN AND FABRICATION; or
- I-ET-3010.00-1200-456-P4X-001 - REQUIREMENTS FOR PLATE HEAT EXCHANGER DESIGN AND FABRICATION; together with I-ET- MATERIAL SPECIFICATION FOR HEAT EXCHANGERS.

6.8.14. The HPUs heat exchangers shall have higher hydraulic oil pressure than cooling fresh water pressure in all scenarios.

6.8.15. HPUs and its panels shall be arranged in locations with adequate space for maintenance as defined by PACKAGER.

6.8.16. HPU shall be designed according to its MANUFACTURER standards.

6.9. LOCAL CONTROLS

6.9.1. The MOORING SYSTEM shall be provided with one or more local portable control panels, on each balcony, capable to operate the system functions, such as, to operate the chain jack, motorized turn-down sheave and chain stopper. The controls shall be disconnectable and interchangeable between all four balconies.

6.9.2. As a general rule, the portable control shall reach in close distance and good view the respective equipment it is commanding. For example, the portable control that operates the chain jack and chain stopper shall reach the area around each chain stopper (in the balcony deck), and also the upper platform on the top of chain jack assembly.

6.9.3. The communication of portable controls with the system may be cabled or wireless. For wired controls, at least two backup cables shall be provided. In case of wireless option, the following shall be provided:

- A backup cabled communication.
- The antennas shall be arranged so that, for each mooring bundle, the whole balcony extension receives a strong and adequate signal for the portable controls. This arrangement shall consider the FPSO arrangement, the presence of other equipment, and possible interferences on communication link. The datasheet of antennas and cables shall be submitted for OWNER's appraisal. No signal decrease shall occur due to rain.

6.9.4. The portable control panels shall be provided with all necessary parameters and alarms for the system operation.

6.9.5. The portable control joystick shall have proportional speed control for pay-out or pull-in with an automatic return to the neutral position (brakes on after coming to a stop) and a dead band around the 'zero speed' position to avoid unintended movements.

6.9.6. The following controls and instrumentation shall be available on each mooring bundle. It is acceptable to have these parameters and alarms integrated on the portable control panels or in a dedicated local control console (LCC) for each bundle:

- Chain Jack haul in and pay out (note 1);
- Chain Jack mode indications;
- Fixed and Movable Chain Stoppers Open/Close (note 1);
- Motorized Turn Down sheave haul in, pay out (note 1);
- Chain stopper position;
- Selection of the winch to be operated;
- By-pass of the bitter end automatic stop of chain pay-out button, in glass protection;
- Chain speed;
- Chain tension measurement:
  - Static, in the stopper structure through load pins or cells;
  - Dynamic, using hydraulic pressure as parameter;
- Chain length measurement:
  - Chain outside fairlead;
  - Chain in locker, from chain jack winch;
- Emergency stop, in glass protection (note 1);
- HPU Pumps start and stop;
- HPU emergency shut down switch independent of other functions;
- LCC power switch; and
- Alarms:
  - High tension in the line (static or dynamic);
  - Low tension in the line (static or dynamic);
  - High oil temperature;
  - Low oil level;
  - Automatic stop of pay-out (bitter end near turn down sheave);
  - Max chain out (5 m before automatic stop)
  - Min chain out (10 m before outer end of chain reaches fairlead);
  - Chain stopper load cell error.

Note 1: For these functions, Local Control Panel shall be provided with analogic buttons (touch screen type not accepted).

6.9.7. After the end of guarantee period PACKAGER shall disclose to OWNER the password to access the PLC.

6.9.8. The MOORING SYSTEM local controls, panels, PLC and accessories shall be

designed with protection for the marine environment for requested design lifetime.

6.10. CHAIN LOCKER

6.10.1. At least four (4) fixed or movable chain lockers shall be provided, one for each mooring line bundle.

6.10.2. The chain lockers shall be located out of the hull (chain lockers inside the hull are not accepted) and on a non-hazardous zone, in order to avoid the risk of fire due to sparking generated by friction between mooring chains and the deck itself. Document I-DE- AREA CLASSIFICATION – GENERAL shall be verified.

6.10.3. The chain locker design shall take into account chain pile settling movements and avoid jamming and twisting. Its geometry shall be designed so that there is no need for human intervention to accommodate the mooring chain inside of it, both on pull-in and pay-out operations.

6.10.4. Each chain locker shall have a storage capacity of at least 300m (150m of installation chain plus 3 x 50m of top chain segments), without the need of manual distribution of chain inside the locker. This capacity shall be demonstrated by practical test to be executed on MANUFACTURER facilities or shipyard.

6.10.5. Chain locker shall have means for internal access by operators (to be used only in extraordinary situations).

6.11. AUXILIARY HANDLING DEVICES

6.11.1. For each bundle, MOORING SYSTEM shall be equipped with all necessary integrated handling devices, such as monorails, auxiliary winch, bitts, lugs, and handling hoists to comply with all MOORING SYSTEM operations, such as, mooring lines hook-up, tensioning and de-installation, as required by item 6.1.5.

6.11.2. One (1) Tugger (Auxiliary) Winch shall be provided with a minimum pull capacity of 25T. The minimum cable length is 100m. The PACKAGER shall verify and demonstrate that 100m is enough to perform all the way from the winch to the discard hole and pay out 70m of cable out of discard hole, and with a minimum of 5 turns on winch drum.

6.11.3. The MOORING SYSTEM shall be capable to pull-out the full length of the installation chain from chain locker to an AHTS vessel and to pull-in a new one (reverse operation). The Tugger (Auxiliary) Winch shall be suitable for this operation.

6.11.4. The final scope of supply will depend on mooring equipment arrangement and procedures adopted. Loose equipment, such as manual hoists, tirfor and slings, shall not be included.

6.12. MOORING BALCONY STRUCTURE, UTILITIES AND ARRANGEMENT

6.12.1. Mooring balcony shall be illuminated on its deck area and the MOORING SYSTEM equipment, including inside the chain lockers and around the positioned

chain jack to permit night hook-up operations. The illumination arrangement shall take special attention to prevent shadow zones behind the chain jack assembly and over the chain stopper (major working zone for operators).

6.12.2. The balcony deck shall be made of steel plates. Tubular deck is not accepted. The number of openings/covers shall be minimized to avoid obstacles for operators when moving.

6.12.3. Mooring balcony deck shall be provided with coamings (vertical barriers) on all sides and openings to prevent any hydraulic oil eventually leaked on deck to go to the sea.

6.12.4. HULL SUPPLIER shall provide adequate cathodic protection for the MOORING SYSTEM and balcony structure.

6.13. INSTALLATION CHAIN AND ACCESSORIES

6.13.1. All accessories listed in this item shall be supplied with due certificates issued by the MANUFACTURER and by a recognized Classification Society. Such certificates shall be properly stored and available on the date of FPSO sail away from SHIPYARD.

6.13.2. The quantities of each item are defined in I-FD - MOORING SYSTEM.

6.13.3. All mooring chains shall be supplied according to IACS W22 standard.

6.13.4. The installation chain shall have the same diameter as the mooring line top chain segment, as informed on I-FD - MOORING SYSTEM.

6.14. INSTALLATION CHAIN

6.14.1. Specification:

- Studless chain, R3 grade, length 150m, with common link on both ends;
- Diameter: same as mooring line top chain segment.

6.14.2. The Installation Chains shall be delivered installed on the Chain Lockers. The installation chain shall be put inside the chain locker using the MOORING SYSTEM itself, in order to prevent chain twist inside the locker, and also to test the system.

6.15. MESSENGER CABLE

6.15.1. Specification:

- Braided HMPE rope with 8 to 12 strands, with braided protective jacket of polyester.

- Eye type termination on both ends (one end shall be suitable to mount on LLLC link).
- Ultraviolet (UV) resistant.
- Minimum Break Load (MBL): 160T.
- Diameter: 60mm +/-1mm
- Length: 70m.

6.15.2. The Messenger Cables shall be delivered coiled on the balcony deck, near external guard rail (refer to Figure 1), aligned with each fixed chain stopper, under a protective cover from sun/rain direct exposure. During the hook up operation, the Messenger Cable will be connected to the Auxiliary Lead Rope (on guard rail end), using a soft shackle (6.17). The Auxiliary Lead Rope will be pulled through the fixed chain stopper, while the Messenger Cable will be paid out over the guardrail. When the first end of the Messenger Cable reaches the chain stopper, the soft shackle will be disconnected and the Messenger Cable will be connected to the Installation Chain with the LLLC link (6.18). The other end of the Messenger Cable will be sent to the AHTS using a Heaving Line (6.19).

6.16. AUXILIARY LEAD ROPE

6.16.1. Specification:

- Made of 100% polyester fiber.
- Eye type termination on both ends.
- Diameter: 26mm +/-1mm.
- Minimum Breaking Load (MBL): 10T.
- Ultraviolet (UV) resistant.
- Length:
  - For Mooring lines fixed chain stoppers: Length shall be enough to go from the fixed chain stopper, around the fairlead, and up to the balcony guardrail. See Figure 1 as reference.
  - For excess chain discard slot: Length shall be enough to go from the chain stopper device, underneath balcony, until the balcony guardrail (without tensioning the cable against balcony structure). See Figure 2 as reference.

6.16.2. The Auxiliary Lead Rope shall be delivered pre-installed, one end tied near the chain stopper (with a soft shackle (6.17) and backup rope), passing though the chain stopper, around the fairlead and the other end tied on the balcony guardrail (with a soft shackle (6.17) and backup rope). The function of the Auxiliary Lead

Rope is to lead the Messenger Cable through the path where the Lead Rope will be pre-installed. This sequence allows the Messenger Cable to remain coiled and preserved on balcony deck, avoiding abrasion and wear before hook-up operation.

6.17. SOFT SHACKLE

6.17.1. Specification:

- A standard soft shackle with protective cover (see Figure 3 as reference). Other types of connectors are not acceptable.
- The shackle shall be suitable for assembly Auxiliary Lead Rope end with Messenger Cable end. Also, connection between Auxiliary Lead Rope and balcony structures, as described on 6.16.2.
- Minimum Breaking Load (MBL): 15T.

Figure 3 – Picture of a Soft Shackle.

6.18. LLLC LINK

6.18.1. Specification:

- LLLC links shall have the compatible external dimensions/geometry as the mooring lines top chain segment, so that they can suitably pass through mooring components such as fairleads, chain stopper, chain jack and turn down sheave.
- LLLC links shall be suitable for assembly on mooring line top chain segment.
- LLLC links shall have a minimum breaking load (MBL) of at least 45% of MBL of the mooring line top chain segment.

Note: Mooring line top chain specification is defined in I-FD-MOORING SYSTEM AND PRE-TENSION.

6.18.2. The LLLC links will be used to connect the installation chain to the mooring line top chain segment (for hook-up final tensioning) and to connect installation

chain and support chain.

6.19. HEAVING LINE

6.19.1. Specification:

- Material: Polyester or Nylon,
- Diameter 1/4'', length 100m.

6.19.2. The Heaving Line will be connected to Messenger Cable and will be thrown from FPSO to the AHTS vessel.

6.20. TOWING RETRIEVAL WINCH (FWD/AFT)

6.20.1. Despite being within MOORING SYSTEM package, the Towing Retrieval Winches are independent equipment of the rest of the system. Two (2) winches (FWD) shall be located in the forecastle towing rooms (PS/SB), while the other two (2) shall be located on the AFT main deck (PS/SB). Drawing I-DE - TOWING ARRANGEMENT shall be consulted for reference.

6.20.2. Towing Retrieval Winches shall be capable to recover the chafe chain and the steel wire pendent from the tug boat to the FPSO smit bracket, with the FPSO on its minimum draft.

6.20.3. Specification:

- Minimum pull capacity: 12T
- Minimum pull speed at maximum capacity: 4m/min
- Steel wire cable: compatible with winch capacity, minimum length of 200m, terminated with closed spelter socket.
- Drive: Pneumatic
- Command: Local

7. MOORING SYSTEM PROCEDURES

7.1. GENERAL

7.1.1. PACKAGER shall deliver specific procedures describing activities inside the FPSO and the MOORING SYSTEM operation to demonstrate that all necessary equipment/accessories are properly provided and arranged. As a minimum, it shall be provided specific step-by-step procedures for the MOORING SYSTEM operations described on items 6.1.5 and 6.5.10.

7.1.2. OWNER general hook-up procedure outside FPSO and interface between FPSO and AHTS vessel is described on Annex 1. The MOORING SYSTEM shall be capable to comply with this procedure. Alternative solutions shall be submitted for

OWNER appraisal.

7.1.3. PACKAGER shall deliver a detailed procedure describing activities necessary for MOORING SYSTEM hibernation, which shall occur after the tensioning phase.

Note: Hibernation is a planned and adequate manner to shut-off the MOORING SYSTEM equipment, with the objective to increase its conservation, considering it is not expected to operate the MOORING SYSTEM for the following 5 years after the tensioning operation.

These procedures shall be submitted for OWNER verification and shall be part of the MOORING SYSTEM documentation.

8. GENERAL REQUIREMENTS

8.1. ELECTRICAL REQUIREMENTS

8.1.1. Electrical equipment, material, installations, tests and Documentation shall comply with Electrical documents listed in Table 1 and Table 2.

8.1.2. Attention shall be given to the starting current of HPU electric motors, that shall comply with requirements of I-ET-3010.00-5140-712-P4X-001 - LOW-VOLTAGE INDUTION MOTORS FOR OFFSHORE UNITS.

8.1.3. As required in I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS, soft-starters or VSD-FC (Variable Speed Drive - Frequency Converter) shall be included in PACKAGE scope of supply, to comply with maximum voltage drop during motor starting. See details in I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.

8.2. INSTRUMENTATION AND AUTOMATION REQUIREMENTS

8.2.1. PACKAGE instrumentation and control design shall fulfill the requirements of Instrumentation and Automation Documents listed in Table 1 and Table 2.

8.3. PAINTING REQUIREMENTS

8.3.1. Painting and coating in accordance with I-ET-3010.00-1200-956-P4X-002 – GENERAL PAINTING and DR-ENGP-I-1.15 COLOR CODING.

8.3.2. All components shall be delivered fully painted/coated, except the chain links and any other otherwise indicated on this specification.

8.3.3. The performed pre-treatment and complete coating shall be in accordance with the paint manufacturer’s data sheets.

8.4. SKIDS LAYOUT AND FOUNDATION REQUIREMENTS

8.4.1. PACKAGE components detailed on item 6 which are supplied assembled on skids shall follow the below minimum requirements.

8.4.2. PACKAGE skid structure shall be designed to withstand the design conditions mentioned on item 4.4 and to ensure the lifting conditions on manufacturing site and shipyard. Lifting lugs shall be provided according to PACKAGER lifting procedure.

8.4.3. The Skid main frame shall be all welded construction. Structural skid welds, including lifting facilities shall be continuous and shall comply with AWS D1.1 (structural welding code) and CS Rules. Skid structure shall be designed to be welded to the supporting structure unless otherwise specified.

8.4.4. PACKAGE skid layout and arrangement shall be designed to provide sufficient access to pumps, instruments, equipment, and control panels so as to ease the operability and maintenance with safe conditions. Instruments and valves shall be installed on a suitable height to allow safe access for monitoring, operation, and maintenance.

8.4.5. All necessary maintenance davits, monorails, padeyes or trolleys shall be provided to ensure the safe and easy maintenance conditions.

8.4.6. Access ladders, platforms, gratings and any other access device shall comply with I-ET-3010.00-1352-130-P4X-001 - FLOOR GRATINGS, TRAY SYSTEMS AND GUARDRAILS MADE OF COMPOSITE MATERIALS, where non-metallic material is used. Metallic material is also acceptable. For grating requirements (metallic and non-metallic), I-DE- HULL GENERAL NOTES AND TYPICAL DETAILS shall be followed.

8.4.7. PACKAGE skid shall have a drip pan to collect drained water from the equipment with drain flanges for the connection with the Hull draining system.

8.4.8. PACKAGE Equipment and components shall be located entirely within the skids / equipment base perimeter, including all equipment, piping, valves, electrical, instrumentation and controls.

8.5. AVAILABLE ON BOARD

8.5.1. For other utilities available onboard refer to I-RL–GENERAL SPECIFICATION FOR AVAILABLE UTILITIES.

Note: The fresh water cooling referenced on this document refers to Topsides cooling system. For Engine Room fresh water cooling system, refer to I-FD-ENGINE ROOM CENTRAL FRESH WATER COOLER (P-5120501A/B) and I-DE- ENGINE ROOM CENTRAL FRESH WATER COOLING SYSTEM.

8.6. NAMEPLATES AND TAG NUMBERING

8.6.1. PACKAGER / MANUFACTURER Equipment shall have nameplates in Brazilian Portuguese language, made of stainless steel AISI 316L, with 3 mm minimum thickness and fixed by stainless steel (AISI 316L) bolts or fasteners on visible and accessible location.

- Note 1: Additional nameplates shall be provided as per NR13 rules if applicable.

- Note 2: For further requirements refer to EXHIBIT V – DIRECTIVES FOR PROCUREMENT.

8.6.2. Tagging of all instruments, electrical, mechanical and piping items, including valves, shall be carried out as detailed on I-ET-3000.00-1200-940-P4X-001 – TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN.

9. PACKAGE MANUFACTURING AND DELIVERY REQUIREMENTS

9.1. GENERAL

9.1.1. All materials and equipment supplied by PACKAGER / MANUFACTURER shall be brand new (not overhauled), field proven, free from defects and accepted by Owner and the Classification Society.

9.1.2. Materials and equipment shall be manufactured according to internationally recognized standards for the offshore oil drilling and production industries and shall be in conformance with the Basic Design and Agreement specifications and requirements.

9.1.3. Field proven definition as EXHIBIT V – DIRECTIVES FOR PROCUREMENT: systems and equipment shall demonstrate satisfactory operation at least in 3 (three) floating offshore installation units, operating under process conditions (pressure, flow, capacity and similar fluids) for a minimum of 24,000 hours. For rotating equipment, they must demonstrate operation with fluid, flow and discharge pressure similar to the design. Unproven designs or prototypes (including components) without offshore service will not be accepted.

9.2. SPARE PARTS

9.2.1. For the commissioning, hook-up and tensioning operations, a set of spare parts shall be supplied considering the parts most susceptible to break or failure, according to MANUFACTURER's experience. Such parts shall include, for example, hydraulic hoses, hydraulic valves, key parts for motorized turn down sheave, load-cells/load-pins and so on. Such spare components shall prevent the need to exchange parts between equipment of different bundles. As a minimum, it shall be supplied:

- 1 Kit of Fuses
- 1 Hydraulic Filter cartridge
- 1 Kit Gaskets / seals, for Chain Jack Cylinders
- 1 Kit Gaskets / seals, for Fixed Chain Stopper Cylinders
- 1 Kit Gaskets / seals, for Sliding Chain Stopper Cylinders
- 1 Kit Gaskets / seals, for Skidding Cylinders
- 1 Converter

- 1 Transistor
- 1 Relay
- 1 Power contactor
- 1 Switch
- 1 Kit sensors

9.2.2. A set of load-cells (or load-pins) for mooring line monitoring system, for two (2) chain stoppers, including any special tool required for load-cell (or load-pins) replacement. The appropriate documentation such as certificates, calibration curves, etc. shall be delivered printed together with the load-cells (or load pins).

9.2.3. Backup cables for portable control, as per item 6.9.3.

9.2.4. For other PACKAGE spare parts, special tools and spare parts list recommended for two (2) years of operation refer to EXHIBIT V – DIRECTIVES FOR PROCUREMENT.

9.3. MANUFACTURING

9.3.1. PACKAGE equipment, structures and piping welding, welding inspection, non-destructive testing (NDT), bolted joints assembly and piping fabrication and commissioning activities shall be performed according to CONSTRUCTION and PIPING documents listed on Table 1 and Table 2.

9.4. DOCUMENTATION

9.4.1. For the PACKAGE documentation and data-book requirements refer to EXHIBIT III – DIRECTIVES FOR ENGINEERING and to EXHIBIT V – DIRECTIVES FOR PROCUREMENT.

9.5. INSPECTION AND TESTS

9.5.1. For PACKAGE inspection, tests, factory acceptance test (FAT) and inspection release certificate (IRC), refer to EXHIBIT V – DIRECTIVES FOR PROCUREMENT.

9.5.2. For PACKAGE inspection and test plan (ITP) requirements refer to EXHIBIT VII – DIRECTIVES FOR QUALITY ASSURANCE SYSTEM.

9.6. PRESERVATION, PACKING AND TRANSPORTATION

9.6.1. For PACKAGE preservation, packing and transportation requirements refer to EXHIBIT V – DIRECTIVES FOR PROCUREMENT.

ANNEX 1 – OWNER GENERAL HOOK-UP PROCEDURE OUTSIDE MOORING BALCONY

A. OBJECTIVE

The purpose of this Annex is to describe OWNER typical procedure (outside mooring balcony) for a mooring line hook-up operation. This description is intended for PACKAGER to understand the hook-up operation, the interface between FPSO and AHTS vessel, so that the MOORING SYSTEM can be designed accordingly.

B. DEFINITIONS

Workwire: AHTS main cable for anchor handling operations.

Sharkjaw: AHTS device to safe secure chains, located near the stern.

Quick release: a typical function of Sharjaws, in which it instantly liberates the chain.

C. PRE-OPERATION SCENARIO

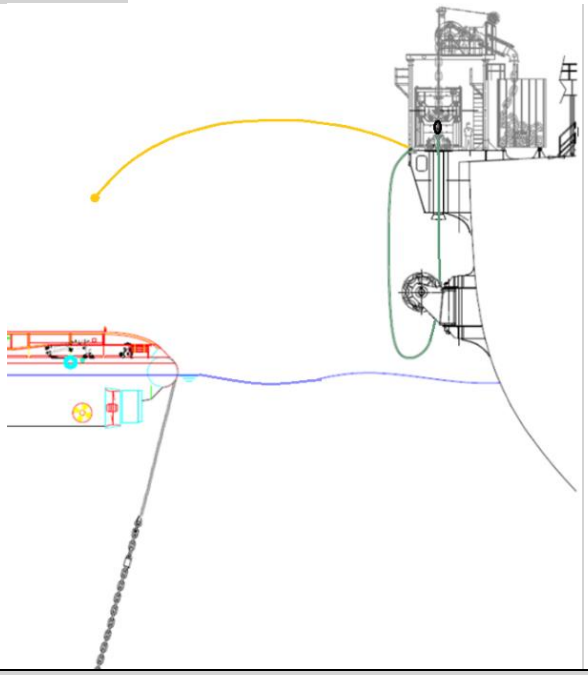
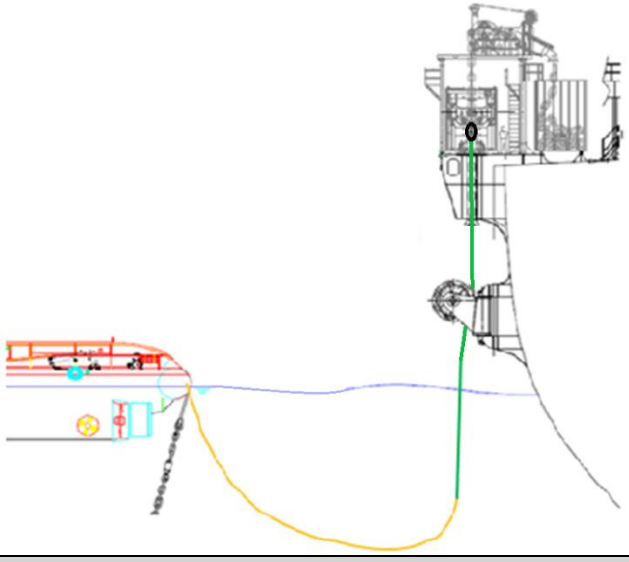
Previously to the arrival of the FPSO on it's designed location, all the torpedo piles are pre-installed, and all the polyester ropes and chains are connected to the torpedo piles, and laid down on the seabed, except for the top chains that are kept on the AHTS chain lockers.

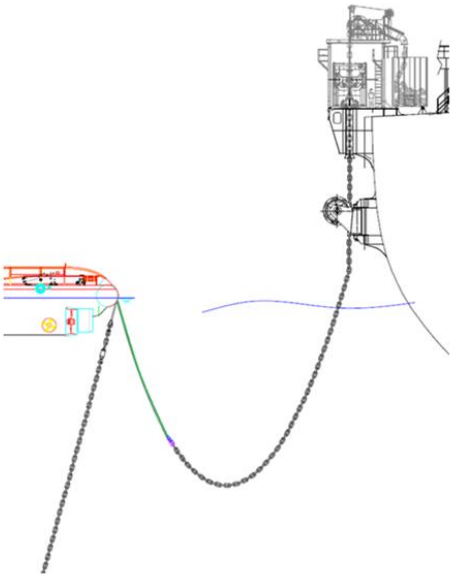
On the arrival of the FPSO on the design location, the tow tugs are disconnected from the FPSO and four positioning AHTS`s are connected. Once the positioning AHTS´s put the FPSO in the target position, the hook-up operation can be initiated.

D. HOOK-UP OF A MOORING LINE

Below is the step by step procedure typically performed by the AHTS and the FPSO for each mooring line:

Step	Job
1	AHTS pay out workwire and connect it to the pre laid mooring line.
2	AHTS heave in the workwire and secure the polyester rope chain tail in the sharkjaw.
3	AHTS move in direction of the FPSO. When the polyester rope gets some tension, the AHTS connect the top chain to the polyester rope chain tail and keep moving while paying out the top chain.
4	At the end of the top chain, the AHTS connect an extension wire, with predetermined length, pay it all out and secure the extension wire chain tail in the sharkjaw, to provide enough slack to approach the FPSO and, at the same time, keep the deck clear to operator's access.

5	On FPSO Balcony, one end of Messenger Cable shall be connected to the Installation Chain (using a LLLC link), over the fixed chain stopper, and the other end Messenger Cable is secured on balcony external guard rail, tied with the heaving line.
6	AHTS close in to the FPSO Balcony and receive the heaving line sent from the FPSO. At this moment the AHTS stern is approximately 20m to 30m away from the FPSO Balcony in horizontal distance. 
7	AHTS pull in the heaving line bringing the Messenger Cable. At this moment the AHTS stern is approximately 30m to 40m away from the FPSO Balcony in horizontal distance. 
8	After the Messenger Cable is secured by AHTS, the FPSO starts to pay out the installation chain. The installation chain goes out without tension (at the start, in dead vertical). It is not allowed the AHTS to apply tension on messenger line at this phase. The AHTS keeps roughly the same distance as in previous step (30m to 40m away from the FPSO).

	
9	After the FPSO has 70m of installation chain outside the fairlead, the AHTS heaves in the Messenger Cable and secure the Installation Chain on the sharkjaw. Only after this step, it is acceptable for AHTS vessel to tension the installation chain (load within MOORING SYSTEM and components admissible limits). The FPSO continues paying out until it reaches the maximum length safely possible of Installation Chain outside the fairlead (usually 110m).
10	AHTS heave in the extension wire and secure the top chain on the sharkjaw.
11	AHTS connect the installation chain to the top chain with a LLLC link.
12	If the open connection (KS Hook) between the bottom polyester rope and the torpedo pile is above seabed, the AHTS may move away from the FPSO, stretching the installation chain, in order to put the KS Hook on the seabed, as shown in the picture bellow. 
13	AHTS liberates the mooring line with quick release.
14	FPSO heave in the installation chain, until the top chain reaches the fixed chain stopper. In the beginning, the chain may be reaching the FPSO approximately in dead vertical.
15	Top chain is locked on fixed chain stopper. The chain jack assembly will be skidded to the next mooring line to be installed.

The Mooring Lines tensioning phase may occur after some or all mooring lines are connected to FPSO.