

	<b>TECHNICAL SPECIFICATION</b>		Nr: <b>I-ET-3010.1Y-5139-390-P4X-004</b>
	CLIENT: <b>BÚZIOS</b>		SHEET: <b>1</b> of <b>37</b>
	JOB : <b>HIGH CAPACITY FPSO</b>		
	AREA: <b>BÚZIOS</b>		
<b>SRGE</b>	TITLE: <b>MOORING SYSTEM</b>		<b>INTERNAL</b>
			<b>ESUP</b>

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### INDEX OF REVISIONS

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0	ORIGINAL ISSUE
A	REVISED WHERE INDICATED

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DATE	JAN/08/21	APR/07/21							
PROJECT	ENG	ENG							
EXECUTION	CXZ0	CXZ0							
CHECK	CXW3	CXW3							
APPROVAL	CYEL	CYEL							

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THIS FORM IS PART OF PETROBRAS N-381 REV.J ANNEX A – FIGURE A.1.

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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 High Capacity FPSO 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.

MOORING SYSTEM the package name.

OWNER: PETROBRAS.

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

### 1.3. ABBREVIATIONS

CCR Central Control Room

CS Classification Society

FAT Factory Acceptance Tests

FPSO Floating Production Storage and Offloading Unit

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

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

- ANSI American National Standards Institute
- API American Petroleum Institute

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- ASME American Society Of Mechanical Engineers
- BGV German Safety Regulations
- DIN German National Standard Code
- EN European Standards
- ISO International Standard Organization
- VDE / IEC German National Electric Standard Codes / International Electric Codes
- IEC 61892, INMETRO Resolution 179, May 18th 2010 and INMETRO resolution 89, February 23rd 2012
- Classification Society defined for the Hull scope.
- SOLAS II-1, Regulation 3-5, and MSC.1/Circ. 1379
- 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-01 – Normas da Autoridade Marítima para Embarcações Empregadas na Navegação em Mar Aberto;

## 2.3. CLASS APPROVAL AND CERTIFICATION

The 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

REF DOC NUMBER	REF DOC NAME
<b>GENERAL</b>	
I-DE-3010.1Y-1200-942-P4X-001	GENERAL ARRANGEMENT



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I-DE-3010.1Y-5400-94A-P4X-001	AREA CLASSIFICATION – 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
I-ET-3010.00-1200-940-P4X-002	GENERAL TECHNICAL TERMS
I-RL-3010.1Y-1200-940-P4X-001	GENERAL SPECIFICATION FOR AVAILABLE UTILITIES
I-ET-3A36.00-1000-941-PPC-001	METOCEAN DATA
<b>CONSTRUCTION</b>	
I-DE-3010.1Y-1357-140-P4X-001	MOORING BALCONIES AND FAIRLEADS STRUCTURE (AFT)
I-DE-3010.1Y-1357-140-P4X-002	MOORING BALCONIES AND FAIRLEADS STRUCTURE (FWD)
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
<b>HULL SYSTEMS</b>	
I-DE-3010.1Y-5139-944-P4X-004	MOORING HYDRAULIC SYSTEM
I-MD-3010.1Y-1200-940-P4X-027	DESCRIPTIVE MEMORANDUM - HULL SYSTEMS
<b>NAVAL</b>	
I-DE-3010.1Y-1350-960-P4X-002	CAPACITIES PLAN
I-DE-3010.1Y-1350-962-P4X-001	MOORING LINES ARRANGEMENT



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I-DE-3010.1Y-1350-964-P4X-001	TOWING ARRANGEMENT
I-ET-3010.1Y-1350-960-P4X-002	DESIGN REQUIREMENTS - NAVAL ARCHITECTURE
I-RL-3010.1Y-1350-960-P4X-009	MOTION ANALYSIS
<b>MECHANICAL</b>	
I-ET-3010.00-1200-300-P4X-001	NOISE AND VIBRATION CONTROL REQUIREMENTS
<b>PAINTING</b>	
I-ET-3010.00-1200-956-P4X-002	GENERAL PAINTING
DR-ENGP-I-1.15	COLOR CODING
<b>SAFETY</b>	
I-ET-3010.00-5400-947-P4X-002	SAFETY SIGNALING
DR-ENGP-M-I-1.3	SAFETY ENGINEERING GUIDELINE
<b>PIPING</b>	
I-ET-3010.1Y-1200-200-P4X-002	PIPING SPECIFICATION FOR HULL
I-ET-3010.00-1200-251-P4X-001	REQUIREMENTS FOR BOLTING MATERIALS
<b>ELECTRICAL</b>	
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-3010.00-5140-712-P4X-001	LOW-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS

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INSTRUMENTATION AND AUTOMATION	
I-ET-3010.00-1200-800-P4X-002	AUTOMATION, CONTROL AND INSTRUMENTATION ON PACKAGE UNITS
I-ET-3010.1Y-1200-800-P4X-014	AUTOMATION INTERFACE OF PACKAGE UNITS
I-ET-3010.00-1200-800-P4X-013	GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS
I-ET-3010.00-5520-888-P4X-001	AUTOMATION PANELS
COMMISSIONING	
I-MD-3010.1Y-1200-970-P4X-001	COMMISSIONING DESCRIPTIVE MEMORANDUM

Table 1 – Reference Documents

Note: Reference Documents latest revision shall be considered.

#### 4. DESIGN REQUIREMENTS

##### 4.1. DESIGN CONDITIONS

- 4.1.1. PACKAGE Equipment shall be designed for a 30-year life in a corrosive offshore environment without the need for replacement of 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 with the compliance of the normative and design requirements as stated in this specification and complying with the technical parameters stated on the above item 3 with the High Capacity FPSO design reference documents.
- 4.1.4. All elements of the PACKAGE shall be of proven design and well within the manufacturer's actual experience.

##### 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 where risk of personnel injury exist.

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<p>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.</p> <p>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”.</p> <p>4.2.5. Safety signaling shall be in full compliance with I-ET-3010.00-5400-947-P4X-002 – SAFETY SIGNALING.</p> <p>4.2.6. Double block &amp; bleed arrangements are required for isolation of equipment in piping classes of 300# and above.</p> <p><b>4.3. NOISE AND VIBRATIONS</b></p> <p>4.3.1. Noise and vibrations limits shall be in conformance with I-ET-3010.00-1200-300-P4X-001 – NOISE AND VIBRATION CONTROL REQUIREMENTS.</p> <p><b>4.4. MOTIONS AND ACCELERATION</b></p> <p>4.4.1. All equipment shall be able to withstand with the UNIT subjected to 100-year return period environmental conditions.</p> <p>4.4.2. All equipment shall be able to operate with the UNIT subjected to 1-year return period environmental conditions.</p> <p>4.4.3. All environmental conditions are defined in I-ET-3A36.00-1000-941-PPC-001 – METOCEAN DATA, at any draft from fully loaded to the minimum loaded / ballasted condition.</p> <p>4.4.4. For the Hull loading conditions details and the maximum designed operational trim and heel inclinations refer to I-ET-3010.1Y-1350-960-P4X-002 – DESIGN REQUIREMENTS - NAVAL ARCHITECTURE.</p> <p>4.4.5. For the design data and information regarding motion requirements refer to I-RL-3010.1Y-1350-960-P4X-009 – MOTION ANALYSIS.</p> <p>4.4.6. PACKAGE is also to withstand inertial forces during transportation from construction site to the final offshore location.</p> <p><b>5. PACKAGE SPECIFICATION AND TECHNICAL REQUIREMENTS</b></p> <p><b>5.1. SCOPE OF SUPPLY:</b></p> <p>5.1.1. Mooring System components and accessories are listed on <i>Table 1</i>. A schematic drawing (illustrative only) is presented in <i>Figure 1</i>.</p>			



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Equipment	item # in Figure 1	TAG	Quantity
Chain Jack	1	Z-Z-5139501A/D-01	4
Moorig Fairlead (FWD Portside)	3	Z-1357501A/G	7
Moorig Fairlead (AFT Portside)	3	Z-1357502A/G	7
Moorig Fairlead (AFT Starboard)	3	Z-1357503A/G	7
Moorig Fairlead (FWD Starboard)	3	Z-1357504A/G	7
Motorized Turndown Sheave	9	Z-Z-5139501A/D-02	4
Chain Locker	8	-	4
Chain Stopper FWD Portside	2	Z-5139505A/G	7
Chain Stopper FWD Starboard		Z-5139504A/G	7
Chain Stopper AFT Portside		Z-5139502A/G	7
Chain Stopper AFT Starboard		Z-5139503A/G	7
Chain Stopper FWD Portside Control Panel	-	PN-Z-5139505A/G	1
Chain Stopper FWD Starboard Control Panel	-	PN-Z-5139504A/G	1
Chain Stopper AFT Portside Control Panel	-	PN-Z-5139502A/G	1
Chain Stopper AFT Starboard Control Panel	-	PN-Z-5139503A/G	1
Hydraulic Power Unit for Mooring system (FWD)	-	UH-5139505B	1
Hydraulic Power Unit for Mooring system (AFT)	-	UH-5139505A	1

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Hydraulic Power Unit for Mooring system (AFT/FWD) Control Panel	-	PN-UH-5139505A	1
Hydraulic Power Unit for Mooring system (AFT/FWD) Control Panel	-	PN-UH-5139505B	1
Tugger (Auxiliary) Winch	10	GN-Z-5139501A/D	4
Skidding System – Gantry Brake	-	GC-Z-5139501A/D	4
Drip Pan	7	-	4
Lighting	12	-	Note (1)
Drag Chains <sup>(2)</sup>	-	-	4
Local Controls	-	-	4
Installation Chain	14	-	4
Messenger Chain	15	-	28
Messenger Wire Rope	16	-	28
LLLC Link	17	-	6
Connecting Shackle	21	-	64
Tail Chain	22	-	28
HMPE Cable	23	-	28
Heaving Line	-	-	28

Table 1 – Scope of Supply – Mooring Equipment and Accessories

Notes:

(1) Adequate lighting per bundle

(2) Drag Chains for guiding the hydraulic flexible hoses that connect hydraulic headers tie-in points to the movable parts of Mooring System.

(3) The MOORING SYSTEM and related accessories shall be designed to receive up to 7 mooring lines per bundle.

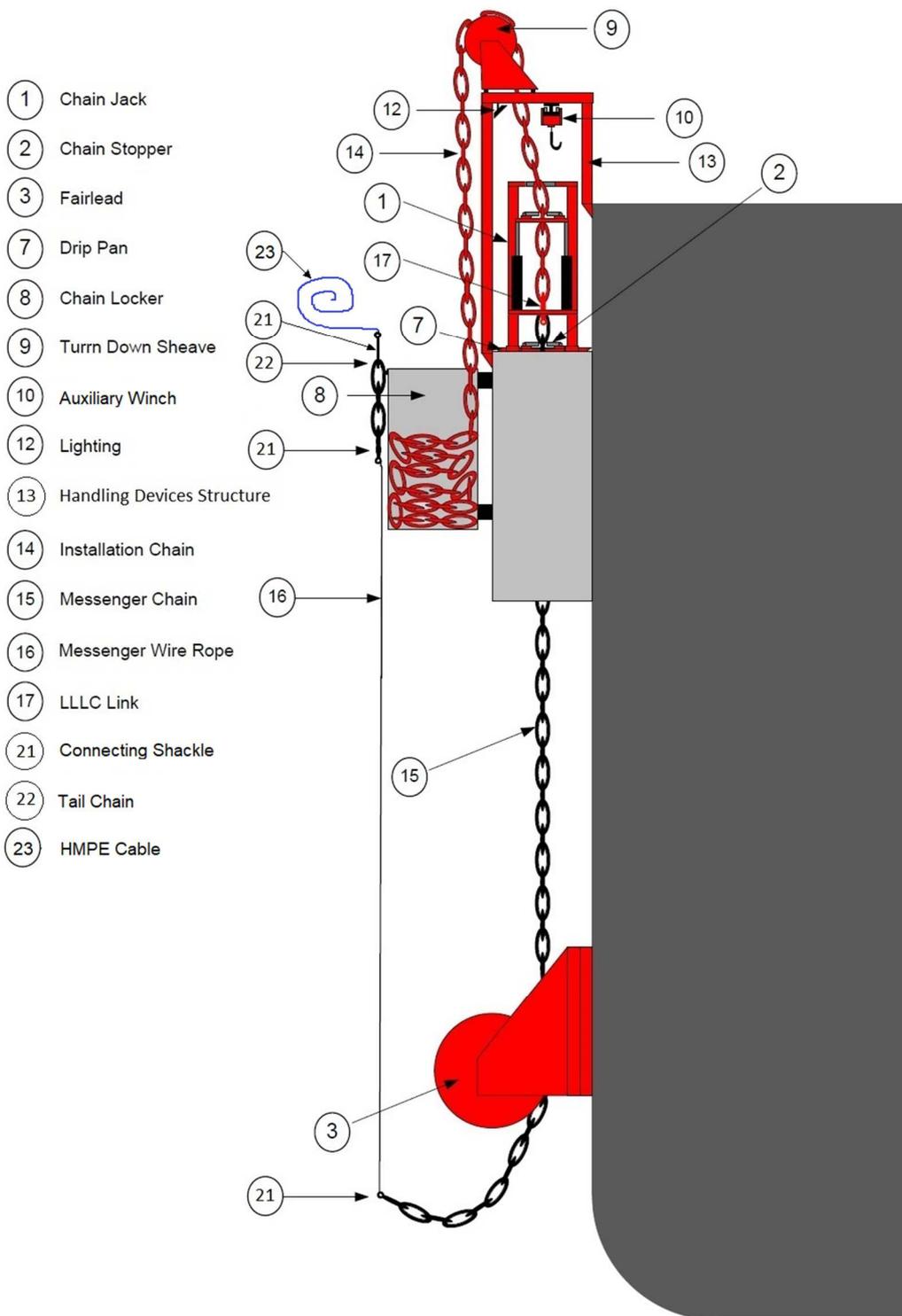


Figure 1 – Schematic arrangement of mooring system and components to be supplied

5.1.2. It is also included in this PACKAGE four (4) Towing Retrieval Winches listed on *Table 2* below.

Equipment	TAG	Quantity
Towing Retrieval Winch (AFT)	GN-1350501A/B	2 x 100%
Towing Retrieval Winch (FWD)	GN-1350502A/B	2 x 100%

Table 2 – Scope of Supply –Towing Retrieval Winches

- Note: Document I-DE-3010.1Y-1350-964-P4X-001 – TOWING ARRANGEMENT shall be consulted for other towing equipment and accessories that shall be supplied by HULL SUPPLIER but that are not included in this Technical Specification.

5.1.3. 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 and all equipment to allow all necessary operations of the MOORING SYSTEM.

5.1.4. 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 in the FPSO side shell, near main deck elevation, 2 (two) in the forward (PS/SB) and 2 (two) in the stern (PS/SB). Document I-DE-3010.1Y-1200-942-P4X-001 – GENERAL ARRANGEMENT shall be consulted for more details.

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

5.2.3. MOORING SYSTEM hazardous area requirements shall comply with I-DE-3010.1Y-5400-94A-P4X-001 – AREA CLASSIFICATION – GENERAL.

## 6. TECHNICAL SPECIFICATION:

### 6.1. GENERAL

6.1.1. The mooring lines pattern is shown on I-DE-3010.1Y-1350-962-P4X-001 - MOORING LINES ARRANGEMENT. The FPSO heading is 190 degrees from true north. Mooring lines are numbered from fore-portside cluster counterclockwise (top view). Anchor depths varies from 2,036m to 2,081m.

6.1.2. Estimated mooring lines top tensions and top angles, with FPSO at target position, ballast condition (draft = 10.8m), with all risers connected and no external forces, are given in table below:

Line #	Top Tension (kN)	Top Angle (deg) <sup>(1)</sup>
1	1,998	53.3
2	1,961	53.7
3	1,920	54.2
4	1,882	54.7
5	1,846	55.1
6	1,794	55.9
7	1,783	56.1
8	1,692	58.8
9	1,709	58.2
10	1,687	58.1
11	1,694	57.6
12	1,729	57.0
13	1,768	56.3
14	1,790	55.8
15	1,849	53.2
16	1,765	54.2
17	1,764	54.2
18	1,720	55.1
19	1,742	54.9
20	1,694	55.7
21	1,857	54.7
22	1,908	54.0
23	1,906	54.0
24	1,986	53.1
25	1,982	53.1
26	2,075	52.2

Table 3 – Mooring Lines pre tensions at target position.

(1) Top angle is measured from horizontal plane.

6.1.3. Estimated maximum dynamic tensions, at fairlead, for ballast condition (draft – 10.8m), are shown on table below:

Line #	Dynamic Tension at Fairlead (kN)
1	5.701
2	5.670
3	5.592
4	5.520
5	5.454
6	5.275
7	5.350

8	5.367
9	5.420
10	5.220
11	5.192
12	5.305
13	5.432
14	5.445
15	5.758
16	5.551
17	5.831
18	5.781
19	6.183
20	6.105
21	6.506
22	6.561
23	6.266
24	6.392
25	6.091
26	6.200

**Table 4 – Mooring Lines estimated maximum dynamic tensions.**

6.1.4. 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 with installation chain or messenger chain with installation chain.

6.1.5. Mooring line top chain segment will be a per below:

- Studless chain R4S Grade, standard IACS W22;
- Diameter: 120 mm;
- Weight in Air: 2.85 kN/m;
- Weight in Water: 2.48 kN/m
- Axial Stiffness – EA: 986,000 kN
- MBS (as new): 1,5059 kN

6.1.6. LLLC link is described on item 6.19 of this specification.

**6.1.7. The information regarding mooring lines pre-tensions, maximum dynamic tensions at fairlead and top chain segment characteristics shall be confirmed by OWNER on the detailed engineering phase according to**

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**specific Mooring Analysis Report (this report is not part of the document list).**

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

## 6.2. 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 hull 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 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 messenger 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, that are devices for guiding and organizing the hydraulic flexible hoses connected to the movable part, while it dislocates. 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 dislocate 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 discard all mooring lines stored on chain locker to an anchor handling tug supply vessel (AHTS) and to pull-in a new installation or messenger chain from AHTS to chain locker. There shall be a discard hole on the deck of each mooring balcony, properly designed for such operations.

6.2.8. The mooring balconies shall be arranged in accordance with documents I-DE-3010.1Y-1200-942-P4X-001 – General Arrangement.

6.2.9. The fairleads, chain stoppers and chain jack assemblies shall be arranged in a

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way to avoid unnecessary wear on the chain links.

6.2.10. 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. The necessary parameters for the system operations, as described in item 6.8, shall be available locally on each balcony.

6.2.11. Auxiliary handling devices shall be provided for each bundle to assist on mooring operations.

### 6.3. FAIRLEAD

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

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

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

6.3.4. 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 approval.

6.3.5. 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.

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

6.3.7. 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).

6.3.8. For the FPSO towing to site location, the fairleads shall be accommodated in such a way that the hook-up can be initiated by any mooring line of the bundle (one fairlead shouldn't obstruct the operation of another). In case it is necessary to lock fairleads for the towing (to prevent rotation on azimuth angle), they shall be sea fastened using fusible wire cables, positioning them with the azimuth angles defined by I-DE-3010.1Y-1350-962-P4X-001 – MOORING LINES ARRANGEMENT. Other procedures may be proposed subject to OWNER's approval.

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

6.3.10. Fairlead maximum operational azimuth angle shall be compatible with mooring lines pattern given by I-DE-3010.1Y-1350-962-P4X-001 – MOORING LINES ARRANGEMENT.

#### 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).

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. 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. 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.

6.5.3. Tension measurement system shall be calibrated, after installed on FPSO, against a recognized standard by the PACKAGER, as part of MOORING SYSTEM commissioning.

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<p>6.5.4. 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. That is, without the need to reduce mooring line tension or to pay-out the 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 approval.</p> <p>6.5.5. The load pins or cells shall be designed, as a minimum, for the same load bearing capacity than the chain stopper.</p> <p>6.5.6. Accuracy of the system shall be within 5% in the range between 50% and 200% of the mean design pretension of the lines. Outside this range larger tolerances can be accepted but should be discussed with OWNER.</p> <p>6.5.7. The tension monitoring system shall have alarms in case of mooring line failure.</p> <p><b>6.6. CHAIN JACK ASSEMBLY</b></p> <p>6.6.1. There shall be 1 (one) chain jack assembly for each mooring line bundle, in a total of 4 assemblies per FPSO.</p> <p>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.</p> <p>6.6.3. The chain jack assembly shall be hydraulically operated, and auxiliary functions shall be hydraulically controlled.</p> <p>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 tension of the mooring line. Also, the chain jack shall be able to pay-out mooring chain from the chain-locker to AHTS vessel.</p> <p>6.6.5. A motorized turn-down sheave shall be located on top of the jacking mechanism, with means to guide the retrieved chain safely to the deck for cutting or to the appropriate chain locker for storage.</p> <p>6.6.6. The mooring chain shall be guided safely in and out of the chain locker without the need of human interference.</p> <p>6.6.7. 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.</p> <p>6.6.8. The motorized turn-down sheave, jacking mechanism 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 movement of the stoppers. In manual mode, the following controls</p>			

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<p>shall be available:</p> <ul style="list-style-type: none"> <li>• Chain Jack extend and retract.</li> <li>• Upper and lower stoppers opening independently.</li> <li>• Both stoppers open (lockable function).</li> </ul> <p>6.6.9. 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).</p> <p>6.6.10. 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.</p> <p>6.6.11. The chain jack assembly structural strength is to be designed for the rated braking capacity and the stress levels shall not exceed the Classification Society requirements.</p> <p>6.6.12. The chain jack assembly shall be designed with a cross shaped hole enabling the retrieved chain to be properly aligned from any angle of twist, when entering the stopper.</p> <p>6.6.13. 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.</p> <p>6.6.14. 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.</p> <p>6.6.15. In case of unexpected HPU shut down, the chain jack shall safely hold the tensioned chain.</p> <p>6.6.16. Chain grabber latches and turn down sheave surfaces in contact with the chain shall be approximately 5% softer than the chain itself.</p> <p>6.6.17. 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.</p> <p>6.6.18. Turn-down sheaves pockets shall fit the LLLC chain link.</p> <p>6.6.19. 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 (chain without tension). Both operations shall be executed in automatic mode.</p> <p>6.6.20. The chain jack pull capacity shall be defined according to the pre-tension levels defined in Table 3 of item 6.1.2 and also taking into account 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</p>			

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pretension, when the FPSO is at minimum draft. That is:

Chain jack pull capacity = 2,075 kN x 1.75 = 3,631kN.

The pre-tension values (and chain jack pull capacity) shall be confirmed by Petrobras during detailing engineering phase.

## 6.7. HYDRAULIC POWER UNIT (HPU)

- 6.7.1. Two (2) Hydraulic Power Units (HPUs) shall be supplied and installed in suitable locations near the mooring clusters (UH-5139505A – Engine Room / UH-5139505B – Forecastle), each of them shall feed respective PS/SB clusters.
- 6.7.2. It shall be possible to operate both HPUs independently. There should be no hydraulic communication between bow and stern units.
- 6.7.3. The HPUs shall be dimensioned to supply enough power to operate one of the respective cluster chain jack assembly at full power and, simultaneously, all necessary auxiliary equipment as defined in the operational procedures. A minimum of 2 x 100% or 3 x 50% hydraulic pumps shall be provided for redundancy.
- 6.7.4. The HPU electric motors tension shall be 480V.
- 6.7.5. The HPUs shall be suitable for operating in a marine environment and adapted to tropical weather.
- 6.7.6. 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).
- 6.7.7. 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 tank due to gravitational oil return from mooring equipment, hoses and piping.
- 6.7.8. HPU shall have a clear indication of its maximum and minimum allowed oil level.
- 6.7.9. Document I-DE-3010.1Y-5139-944-P4X-004 – MOORING HYDRAULIC SYSTEM shall be revised on detailed design phase according to PACKAGER requirements and herein specifications.
- 6.7.10. HPU shall be provided with alarm and automatic shutdown of in case of low level or high temperature of hydraulic oil in hydraulic tank.
- 6.7.11. MOORING SYSTEM shall have means of protection against high pressure on hydraulic oil.
- 6.7.12. The HPUs heat exchangers shall have higher hydraulic oil pressure than cooling

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water pressure in all scenarios.

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

6.7.14. HPU shall be designed according to its **MANUFACTURER** standards.

**6.8. LOCAL CONTROLS**

6.8.1. 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.

6.8.2. 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.

6.8.3. The communication of portable controls with the system may be cabled or wireless. 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 suitable 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 approval.

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

6.8.5. 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.

6.8.6. 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:

- Haul in, pay out, stopper controls and mode indications;
- 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:

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<ul style="list-style-type: none"> <li>○ Static, in the stopper structure through load pins or cells;</li> <li>○ Dynamic, using hydraulic pressure as parameter;</li> <li>● Chain length measurement: <ul style="list-style-type: none"> <li>○ Chain outside fairlead;</li> <li>○ Chain in locker, from chain jack winch;</li> </ul> </li> <li>● Emergency stop;</li> <li>● HPU Pumps start and stop;</li> <li>● HPU emergency shut down switch independent of other functions;</li> <li>● LCC power switch; and</li> <li>● Alarms: <ul style="list-style-type: none"> <li>○ High tension in the line (static or dynamic);</li> <li>○ Low tension in the line (static or dynamic);</li> <li>○ High oil temperature;</li> <li>○ Low oil level;</li> <li>○ Automatic stop of pay-out (bitter end near turn down sheave);</li> <li>○ Max chain out (5 m before automatic stop)</li> <li>○ Min chain out (10 m before outer end of chain reaches fairlead);</li> <li>○ Chain stopper load cell error.</li> </ul> </li> </ul> <p>6.8.7. After the end of guarantee period PACKAGER shall disclose to OWNER the password to access the PLC.</p> <p>6.8.8. The MOORING SYSTEM local controls, panels, PLC and accessories shall be designed with suitable protection for the marine environment for requested design lifetime.</p> <p><b>6.9. CHAIN LOCKER</b></p> <p>6.9.1. At least four (4) fixed or movable chain lockers shall be provided, one for each mooring line bundle.</p> <p>6.9.2. 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-3010.1Y-5400-94A-P4X-001 – AREA CLASSIFICATION – GENERAL shall be verified.</p> <p>6.9.3. 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.</p> <p>6.9.4. 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.</p> <p>6.9.5. Chain locker shall have means for internal access by operators (to be used only in extraordinary situations).</p>			

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## 6.10. AUXILIARY HANDLING DEVICES

- 6.10.1. 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, installation, tensioning and de-installation of mooring lines, as required by procedures described on item 7.
- 6.10.2. One (1) Tugger (Auxiliary) Winch shall be provided with a minimum capacity of 10T to assist with these operations.
- 6.10.3. The handling devices (and chain jack assembly) shall be capable of 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).
- 6.10.4. The final scope of supply will depend on mooring equipment arrangement and procedures adopted. Loose equipment, such as manual hoists, tiorfor and slings, shall not be included.

## 6.11. MOORING BALCONY STRUCTURE, FACILITIES AND ARRANGEMENT

- 6.11.1. Mooring balcony shall have proper illumination through 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).
- 6.11.2. Each Mooring balcony shall have a discard hole to allow pay-out or pull-in mooring chains to an AHTS vessel. The discard hole shall be within reach of the chain jack assembly. The discard hole shall be provided with a dedicated sliding stopper plate, which is a chain stopper composed by a steel cover plate that slides over the discard hole. The plate has an opening designed to pass thru the first mooring link and hold the link above. Other discard arrangements may be proposed subject to OWNER's approval.
- 6.11.3. Means shall be provided (such as a guide) to allow connecting a cable on the discard chain end link (positioned above balcony deck), pass thru the discard hole, go underneath the balcony structure until the balcony guard rail, where it should be fastened. This cable will assist to transfer the discard chain to AHTS vessel (similar to messenger wire rope).
- 6.11.4. The discard hole shall have the necessary guiding devices so that chain can be pulled-in/pulled-out without interference with other structures or mooring lines.
- 6.11.5. 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 dislocating. The balcony deck shall have suitable draining means.
- 6.11.6. HULL SUPPLIER shall provide adequate cathodic protection for the

MOORING SYSTEM and balcony structure.

6.11.7. The balcony shall be designed with suitable holding points (such as a flat bar pointing outwards) for the Tail Chain (item 6.16), outside the guardrail, near respective chain stopper. Operators shall have access to fasten/unfasten the chain from the deck. The balcony deck shall have openings to allow intermediate fastening of the messenger wire, with access for its release from above the deck. A proposed arrangement is described in Figure 2. Other arrangements may be proposed by PACKAGER subject to OWNER's approval.

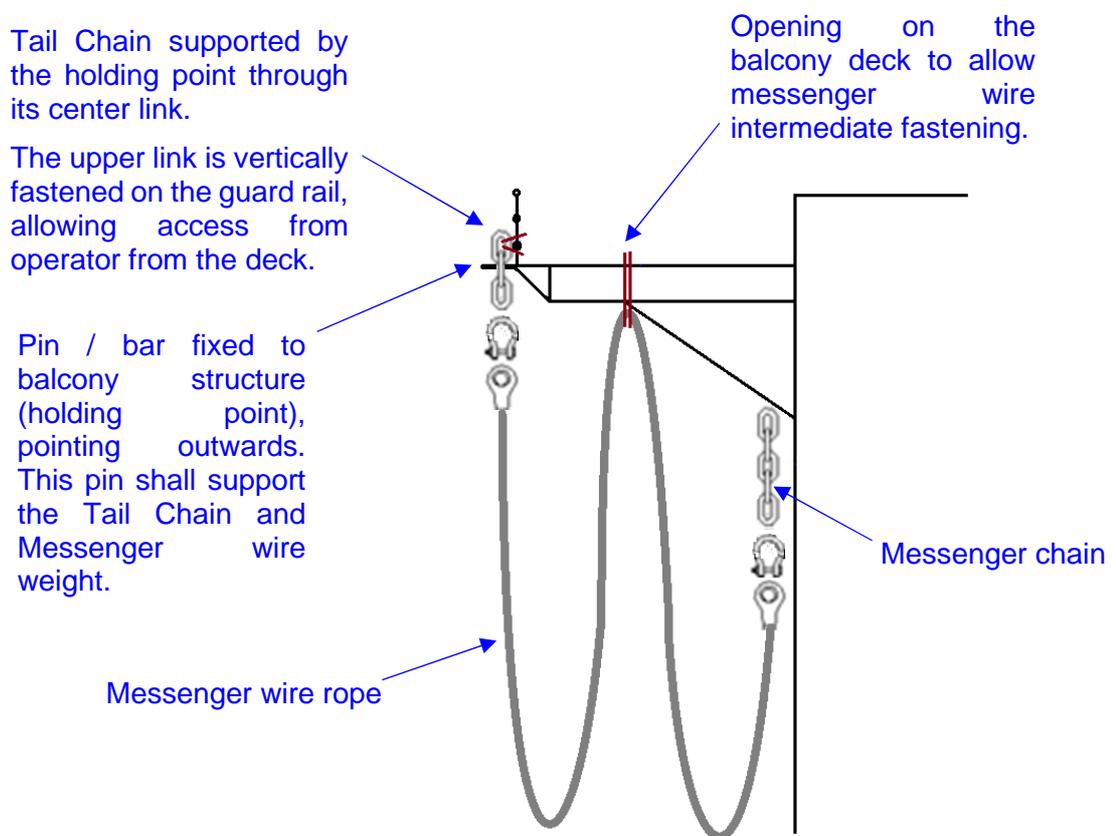


Figure 2 – Proposed holding points for Tail Chain and Messenger Wire Rope

## 6.12. MOORING INSTALLATION CHAINS AND ACCESSORIES

- 6.12.1. 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.
- 6.12.2. The quantities of each item are defined in Table 1.
- 6.12.3. All mooring chains shall be supplied according to IACS W22 standard.

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<p>6.12.4. The installation chain, messenger chain and tail chain shall have the same diameter as the mooring line top chain segment of 120mm. <b>This diameter shall be confirmed by OWNER on the detailed engineering phase according to specific Mooring Analysis Report.</b></p> <p><b>6.13. INSTALLATION CHAIN</b></p> <p>6.13.1. Specification:</p> <ul style="list-style-type: none"> <li>• Studless chain, R3 grade, diameter 120mm, length 150m, with common link on both ends;</li> </ul> <p>6.13.2. 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.</p> <p><b>6.14. MESSENGER CHAIN</b></p> <p>6.14.1. Specification:</p> <ul style="list-style-type: none"> <li>• Studless chain, R3 grade, diameter 120mm, with common link on both ends;</li> <li>• Length: Distance between Chain Stopper flapper and fairlead sheave pin centerline plus 4 m.</li> </ul> <p>6.14.2. Each Messenger Chain shall be delivered pre-installed, passing through each Chain Stopper and Fairlead without twisting. The end of messenger chain shall be connected to the corresponding messenger wire rope (or pendant wire).</p> <p><b>6.15. MESSENGER WIRE ROPE (OR PENDANT WIRE)</b></p> <p>6.15.1. Specification:</p> <ul style="list-style-type: none"> <li>• Six strand steel core wire rope, length 60m, with closed spelter socket on both ends.</li> <li>• Minimum Break Load (MBL): 150T</li> <li>• Maximum diameter: 52mm</li> </ul> <p>6.15.2. The messenger wire rope shall be delivered with one end connected to the messenger chain and the other end connected to the tail chain. The connecting shackle is described in item 6.18 (same for both ends).</p> <p><b>6.16. TAIL CHAIN</b></p> <p>6.16.1. Specification:</p> <ul style="list-style-type: none"> <li>• Studless chain, R3 grade, diameter 120mm, with common link on both ends.</li> </ul>			

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<ul style="list-style-type: none"> <li>Length: 3 links</li> </ul> <p>6.16.2. The Tail Chain shall be delivered supported by balcony structure as described in item 6.11.</p> <p>6.16.3. The Tail Chain is used to allow holding the messenger wire rope by AHTS shark jaw.</p> <p><b>6.17. HMPE CABLE</b></p> <p>6.17.1. Specification:</p> <ul style="list-style-type: none"> <li>HMPE cable, diameter 1”, length 70m, with eye type termination on both ends.</li> </ul> <p>6.17.2. The HMPE cable will be connected to the tail chain (using a connecting shackle) to assist to pay-out the messenger chain to AHTS vessel on hook-up operation.</p> <p><b>6.18. CONNECTING SHACKLE</b></p> <p>6.18.1. Specification:</p> <ul style="list-style-type: none"> <li>A standard chain-connecting shackle, in which an external nut and nut-locking device restrains the pin, shall be used. Other types of connectors (Kenter links, Baldt links, etc.) are not acceptable.</li> <li>The shackle shall be suitable for assembly on messenger chain link, on the tail chain and on the closed spelter socket of messenger wire rope.</li> </ul> <p>6.18.2. The connecting shackles will be used to connect messenger chain and messenger wire rope; messenger wire rope and tail chain; and tail chain and HMPE cable.</p> <p><b>6.19. LLLC LINK</b></p> <p>6.19.1. Specification:</p> <ul style="list-style-type: none"> <li>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.</li> <li>LLLC links shall be suitable for assembly on mooring line top chain segment.</li> <li>LLLC links shall have a minimum breaking load (MBL) of at least 50% of MBL of the mooring line top chain segment.</li> </ul> <p>6.19.2. 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 messenger chain.</p>			

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## 6.20. HEAVING LINE

### 6.20.1. Specification:

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

6.20.2. The Heaving Line will be connected to HMPE cable and will be thrown from FPSO to the AHTS deck.

## 6.21. TOWING RETRIEVAL WINCH (FWD/AFT)

6.21.1. In spite of 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 forecandle towing rooms (PS/SB), while the other two (2) shall be located in the AFT main deck (PS/SB). Drawing I-DE-3010.1Y-1350-964-P4X-001 - TOWING ARRANGEMENT shall be consulted for reference.

6.21.2. Towing Retrieval Winches shall be capable to recover the chafe chain and the rest of main bridle line from tug boat until the smit bracket in the FPSO deck, with the FPSO on its minimum draft.

### 6.21.3. Specification:

- Minimum pull capacity: 12T
- Minimum pull speed at maximum capacity: 4m/min
- Steel wire cable: compatible with winch capacity with minimum length of 200m, termination 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, the following operations shall be described:

- Mooring lines hook-up and adjustment to required tension, including but not limited to:
  - Procedure to transfer the messenger wire rope from platform to AHTS vessel;
  - Procedure for mooring lines hook-up and final tensioning.

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<p>- Procedure to discard the top chain excess to AHTS vessel (these chains shall not remain in the chain locker after concluding the hook-up operation);</p> <ul style="list-style-type: none"> <li>• Procedure to pull-out the entire installation chain from chain locker to AHTS vessel and pull-in a new one.</li> <li>• De-installation of the mooring lines.</li> <li>• Calibrating chain stopper load-cell or load-pin, with mooring line installed.</li> <li>• Replacing chain stopper load-cell or load-pin, with mooring line installed.</li> </ul> <p>7.1.2. These procedures shall be submitted for OWNER's approval and shall be part of the MOORING SYSTEM final documentation.</p> <p>7.1.3. PACKAGER shall supply all temporary accessories, materials and components (with valid certificates) required by the hook-up procedures that are not included in Table 1.</p> <p><b>7.2. SPARE PARTS</b></p> <p>7.2.1. Spare parts requirements to be verified on item <b>Erro! Fonte de referência não encontrada.</b> 10.2 – <b>Erro! Fonte de referência não encontrada..</b></p> <p><b>8. GENERAL REQUIREMENTS</b></p> <p><b>8.1. ELECTRICAL REQUIREMENTS</b></p> <p>8.1.1. All electrical equipment installed in hazardous areas (see Area Classification documentation) or installed outdoors and kept on during emergency condition (ESD) shall be certified according to IEC 61892, INMETRO Resolution 179, May 18th 2010 and INMETRO resolution 89, February 23rd 2012.</p> <p>8.1.2. All electrical signal connections for external interconnection with the panel shall be clustered in junction boxes with at least IP-56 level of protection, located inside the panel and grouped according to the different types of signals involved.</p> <p>8.1.3. Electrical equipment and material shall comply with requirements of I-ET-3010.00-5140-700-P4X-002 – SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.</p> <p>8.1.4. Electrical induction motors shall comply with requirements of I-ET-3010.00-5140-712-P4X-001 – LOW-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS or I-ET-3010.00-5140-712-P4X-002 – MEDIUM-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS.</p> <p>8.1.5. Concerning electrical system voltages and quantity of feeders for motors, panels and auxiliaries, centrifugal pumps shall be fed according to definitions of I-ET-3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.</p>			

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<p>8.1.6. Power lighting and grounding installations inside the package shall comply with requirements of I-ET-3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.</p> <p>8.1.7. Grounding installations shall comply with I-ET-3010.00-5140-700-P4X-001 – SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS and I-DE-3010.00-5140-700-P4X-003 – GROUNDING INSTALLATION TYPICAL DETAILS.</p> <p><b>8.2. INSTRUMENTATION AND AUTOMATION REQUIREMENTS</b></p> <p>8.2.1. PACKAGE shall be protected with all necessary instruments to operate safely, adequately and without interruption in a tropical marine environment.</p> <p>8.2.2. The instrumentation and control design shall fulfill the requirements of the following technical specifications:</p> <ul style="list-style-type: none"> <li>i. I-ET-3010.00-1200-800-P4X-002 – AUTOMATION, CONTROL AND INSTRUMENTATION ON PACKAGE UNITS.</li> <li>ii. I-ET-3010.00-1200-800-P4X-013 – GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.</li> </ul> <p>8.2.3. The minimum requirements for the adequate interfacing of the PACKAGE Automation and Instrumentation System with the UNIT are described on I-ET-3010.1Y-1200-800-P4X-014 – AUTOMATION INTERFACE OF PACKAGE UNITS.</p> <p>8.2.4. For the control and automation panels design requirements I-ET-3010.00-5520-888-P4X-001 – AUTOMATION PANELS shall be considered.</p> <p><b>8.3. PAINTING REQUIREMENTS</b></p> <p>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.</p> <p>8.3.2. All components shall be delivered fully painted/coated, except the chain links and any other otherwise indicated on this specification.</p> <p>8.3.3. The performed pre-treatment and complete coating shall be in accordance with the paint manufacturer's data sheets.</p> <p><b>8.4. SKIDS LAYOUT AND FOUNDATION REQUIREMENTS</b></p> <p>8.4.1. PACKAGE components which are supplied assembled on skids shall follow the below minimum requirements.</p> <p>8.4.2. PACKAGE skid structure shall be designed to withstand the design conditions mentioned on item 4.4 and also to ensure the lifting conditions on manufacturing site and shipyard. Lifting lugs shall be provided according to PACKAGER lifting procedure.</p>			

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<p>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.</p> <p>8.4.4. Skid structure shall be designed to be welded to the supporting structure unless otherwise specified.</p> <p>8.4.5. 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 alves shall be installed on a suitable height to allow safe access for monitoring, operation, and maintenance.</p> <p>8.4.6. All necessary maintenance davits, monorails, padeyes or trolleys shall be provided to ensure the safe and easy maintenance conditions.</p> <p>8.4.7. Access ladders, platforms, gratings and any other access device shall be metallic type and designed according to PACKAGER / MANUFACTURER standard and to the industrial recognized international codes.</p> <p>8.4.8. 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.</p> <p>8.4.9. PACKAGE Equipment and components shall be located entirely within the skids / equipment base perimeter, including all equipment, piping, valves, electrical, instrumentation and controls.</p> <p><b>8.5. AVAILABLE ON BOARD</b></p> <p>8.5.1. For other utilities available onboard refer to I-RL-3010.1Y-1200-940-P4X-001 – GENERAL SPECIFICATION FOR AVAILABLE UTILITIES.</p> <p><b>8.6. NAMEPLATES AND TAG NUMBERING</b></p> <p>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.</p> <p>8.6.2. Tagging of all instruments, electrical, mechanical and piping items, including valves, shall be carried out.</p> <p>8.6.3. Tags shall be supplied with the number and description in the Brazilian Portuguese Language, unless otherwise stated in the technical data sheets.</p> <p>8.6.4. For TAG numbering refer to I-ET-3000.00-1200-940-P4X-001 – TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN</p> <p>8.6.5. For Instrumentation tagging the ISA –5.1 and N-1710 shall be followed.</p>			

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## 9. PACKAGE MANUFACTURING

### 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: Systems and equipment shall demonstrate satisfactory operation at least in 3 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. QUALITY ASSURANCE AND CONTROL SYSTEM

- 9.2.1. PACKAGER shall submit his Quality Assurance / Quality Control handbook to HULL SUPPLIER for information.
- 9.2.2. Engineering, fabrication and manufacturing shall conform to good manufacturing practices. Quality system according to ISO 9001 in relevant extent shall be in place and implemented.

### 9.3. WELDING AND NDT

- 9.3.1. All equipment, structures and piping welds shall be performed according to the requirements described in the latest revision of I-ET-3010.00-1200-955-P4X-001 – WELDING.
- 9.3.2. Welding shall be carried out with procedures and welders qualified in accordance with ASME Section IX. Welding shall not be performed before qualified welding procedures have been approved.
- 9.3.3. Intermittent fillet welds are not acceptable.
- 9.3.4. Welding inspection and NDTs shall be performed according to the requirements described in the latest revision of
- I-ET-3010.00-1000-970-P4X-002 – REQUIREMENTS FOR NDT and
  - I-ET-3010.00-1200-955-P4X-002 – REQUIREMENTS FOR WELDING INSPECTION.
- 9.3.5. Qualification and Certification for procedures and personnel shall be in accordance with I-ET-3010.00-0000-970-P4X-001 – REQUIREMENTS FOR

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9.3.6. Final NDTs, for acceptance purposes shall be carried out after completion of any post weld heat treatment (when applicable) and before the applications of painting, hydrostatic testing, etc.

### 9.4. INSPECTION AND TESTS

9.4.1. PACKAGER / MANUFACTURER shall develop and implement an Inspection and Test Plan (ITP) containing hold points, review and witness points following the schedule of the PACKAGE inspections, tests and events accordingly.

9.4.2. PACKAGE inspection, tests and events shall be attended by the MANUFACTURER, PACKAGER, HULL SUPPLIER, CS and OWNER inspection team whenever necessary.

9.4.3. PACKAGE shall be tested according to the design codes, applicable industry standards, CS Rules and any other one requirement stated on this technical specification.

9.4.4. Unless waive by OWNER, the following PACKAGE inspections and checks shall be witnessed by OWNER inspector:

- i. verification of equipment construction materials (vessels, heat exchangers, pumps, etc.) for conformity with the specification requirements;
- ii. verification of piping, fittings and valves conform to specification of materials and fabrication;
- iii. reports for all NDT performed on the pressure retaining parts (radiographic, dye penetrant, magnetic particles and ultrasonic inspection);
- iv. approval of the relief valve settings and witness of their testing after setting;
- v. review of Inspection and Test Records;
- vi. visual check.
- vii. Electrical tests as:
  - a MEGGER test for cables and electric motors;
  - all tests stated in the respective motors and power / control panel respective specifications.

### 9.5. FACTORY ACCEPTANCE TEST (FAT)

9.5.1. FAT is a set of functional and performance tests to be executed in any equipment,

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electrical, instrumentation and telecom panels or any other commissionable item carried out on the PACKAGER / MANUFACTURER factory or in specialized test facilities, in order to demonstrate its compliance with the project specifications and allow its release to shipyard.

9.5.2. For Factory Acceptance Test (FAT) minimum scope requirements:

- i. Pressure test (usually hydrostatic) test of all vessels, heat exchangers, tanks, pumps, pipes and valves.
  - o Note: All piping systems and equipment shall be drained and dried after hydrostatic testing.
- ii. Performance test, NPSH test and Mechanical running test of all pumps.
- iii. Electrical continuity checks on all wiring and earthing.
- iv. Functional checks on all instruments and valves.
- v. Alarms and Equipment Protection Tests.
- vi. All other equipment tests and factory checking to be carried out according to the FAT procedure approved by parts.

9.5.3. For Factory Acceptance Test (FAT) event invitation e reports:

- i. OWNER, CS and HULL SUPPLIER shall be communicated about the FAT event following ITP and the fabrication schedule. FAT invitation schedule shall be negotiated during PACKAGE kick-off meeting on the detail design phase.
- ii. PACKAGER shall issue the FAT procedure for all parts involved as OWNER, HULL SUPPLIER and CS, where applicable, and submit to them for approval.
- iii. PACKAGER shall issue the FAT report with all test results and duly signed or stamped by all parts that witnessed the FAT and with the test reference documentation attached.
- iv. Acceptance of FAT will not be considered as the final acceptance test of the PACKAGE.

## 9.6. PRE-COMMISSIONING AND COMMISSIONING

9.6.1. PACKAGER / MANUFACTURER shall be required to provide any necessary support for installation, assembly, pre-commissioning and commissioning of the PACKAGE either at a shore based fabrication yard or onboard the FPSO.

9.6.2. PACKAGER / MANUFACTURER is responsible for assembly supervision of the PACKAGE equipment, including the assembly of components to be delivered loose (for example, some components of the pumps, like stuffing box, etc.).

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9.6.3. Final acceptance will be on satisfactory completion of commissioning tests as specified by OWNER.

## 10. PACKAGE DELIVERY REQUIREMENTS

### 10.1. PRESERVATION, PACKING AND TRANSPORTATION

- 10.1.1. PACKAGER / MANUFACTURER shall ensure all the conditions and practices of preservation, packing and transportation are fulfilled and following the PACKAGE / Equipment specific and technical characteristics recommendations.
- 10.1.2. PACKAGER / MANUFACTURER shall submit to HULL SUPPLIER the PACKAGE preservation requirements and recommendations with all necessary considerations for the PACKAGE Equipment preservation during the UNIT whole design life.
- 10.1.3. Preservation and packing shall be proper for transportation and storage in a marine environment and protected against moisture and damage during transport, handling and lifting.
- 10.1.4. In any case, suitable preservation and protective measures shall be provided to prevent equipment deterioration prior to entering into service.
- 10.1.5. All packing shall be clearly marked for shipping, including lifting points, gross weight, dimensions and center of gravity.
- 10.1.6. All sea fastening and temporary supports used on the equipment for shipment shall be clearly identified.
- 10.1.7. PACKAGER / MANUFACTURER shall ensure that all loose valves, tubes and instruments are supplied with plastic caps.
- 10.1.8. PACKAGER / MANUFACTURER shall also ensure that all electric panels and motors will be supplied with Volatile Corrosion Inhibitor (VCI) impregnated plastic protection or similar, and external plug for space heater connection.
- 10.1.9. PACKAGER / MANUFACTURER shall provide clear and comprehensive instructions on the exterior of all packages advising the necessary warning notices for unpacking, handling and installing the equipment on arrival at destination.
- 10.1.10. The equipment shall be thoroughly cleaned internally and be free of all loose foreign materials.
- i. The preparation shall make the equipment suitable for outdoor storage in a coastal tropical climate from the time of Shipment.
  - ii. If there is a risk of damage to valves and other appurtenances during transportation, they shall be disconnected and tagged. All components shall then be securely packed as above.

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- iii. Spare parts and tools to be packed separately and clearly marked “Spare Parts” and “Tools” respectively.

## 10.2. SPARE PARTS, CONSUMABLES AND TOOLS

- 10.2.1. All equipment / material consumable and spare parts recommended by PACKAGER / MANUFACTURER for the construction, testing, commissioning, pre-operation, start-up and hook-up phases.
- 10.2.2. For the hook-up operation, 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.
- 10.2.3. A set of load-cells (or load-pins) for mooring line monitoring system, for three (3) 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).
- 10.2.4. All spare parts recommended or required by the CS, such spare parts will be delivered together with the relevant equipment;
- 10.2.5. All special tools required for construction, pre-commissioning, commissioning and all levels of maintenance and operation.
- 10.2.6. Spare parts list recommended by PACKAGER / MANUFACTURER for two years of operation.

## 10.3. DOCUMENTATION

### 10.3.1. Drawings and Weight Control

For Engineering Documentation minimum requirements:

- i. PACKAGER / MANUFACTURER design drawings shall show all necessary dimensions and details required for interface information and installation.
- ii. Clearances for maintenance shall be shown on the drawings.
- iii. Drawings and documents shall be clear and completely legible with all text in the English language.
- iv. Instruction manuals for operation and maintenance of the PACKAGE equipment shall be provided in Portuguese language.
- v. Drawings are only accepted when signed by PACKAGER as checked and approved. All revised editions of drawings or documents shall show the revisions clearly marked up, the issue date and PACKAGER’s checked and approved signatures.

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<p>vi. PACKAGER / MANUFACTURER shall produce a weight / center of gravity data sheet considering each PACKAGE component with the respective assembly dry and operational weight and CoG.</p> <ul style="list-style-type: none"> <li>o Note: Operational weight means the component dry weight added to the respective component fluid weight on operational condition.</li> </ul> <p>vii. PACKAGER shall send in advance all recommendations for PACKAGE installation, maintenance and commissioning.</p> <p>10.3.2. Data Book</p> <p>PACKAGER shall issue a PACKAGE / Equipment Data Book to be delivered to HULL SUPPLIER for approval. Data Book minimum content shall be as the following:</p> <ul style="list-style-type: none"> <li>i. Certified drawings, data sheets, technical specifications, performance curves and calculation memorandum.</li> <li>ii. Construction, maintenance and operating manuals, instructions for preservation and commissioning, and all catalogs, including of the sub-suppliers.</li> <li>iii. All certificates of materials and equipment, certificates of electrical cables and equipment to hazardous areas, all tests, destructive and non-destructive examinations, test reports (including FAT), certificates and reports of classification society, procedures for welding qualifications and welding processes.</li> <li>iv. The documentation requested by Brazilian law NR-13, subdivided for equipment (if applicable).</li> <li>v. The documentation requested by Brazilian law NR-10, subdivided for equipment (if applicable).</li> </ul> <p>Data Book delivery standard and conditions including number of parts and sections, number of printed and electronic copies will be further defined by OWNER on detail design phase.</p> <p><b>10.4. TRAINING</b></p> <p>10.4.1. PACKAGER shall provide training to qualify OWNER technicians for operation and maintenance (install, dismantle, replace parts, make adjustment, etc.) of each equipment.</p>			