PETROBRAS	**TECHNICAL SPECIFICATION**	**Nº**	I-ET-3010.00-1300-279-PEK-002
	CLIENT PETROBRAS	**SHEET**	1 of 14
	JOB DIVERLESS BELL MOUTH		
	AREA –		
SUB	**TITLE** **5K HYDRAULIC ACTUATOR FOR BSDL-SI**	NP-1	SUB/ES/EECE/ECE

REVISION INDEX

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	Original

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TABLE OF CONTENTS

1 SUBJECT

This document presents the Technical Specification of 5k Hydraulic Actuator for Diverless Bell Mouth – Standard Interface (BSDL-SI).

2 ABBREVIATION

BSDL-SI	Diverless Bell Mouth - Standard Interface (Portuguese acronym)
DL	Diverless
FAT	Factory Acceptance Test
FPU	Floating Production Unit
HPU	Hydraulic Power Unit

3 REFERENCE DOCUMMENTS, CODES AND STANDARDS

This section lists standards and documents applicable to the design of the monitoring system:

3.1 International Standards

[1] API 6A - Specification for Wellhead and Christmas Tree Equipment

[2] API 17E – Specification for Subsea Umbilicals

[3] API 17F - Standard for Subsea Production Control Systems

[4] API 17Q - Recommended Practice on Subsea Equipment Qualification

[5] ASME B16.5:2013 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service

[6] ASME B16.5:2013 - Pipe Flanges and Flanged Fittings

[7] DNVGL-RP-B401:2017 - Cathodic Protection Design

[8] ISO 13628-6:2006 - ISO 13628-6:2006

3.2 Petrobras documents

3.2.1 5K Hydraulic actuator documents

[9] I-DE-3010.00-1300-279-PEK-003 – 5K HYDRAULIC ACTUATOR ASSEMBLY FOR BSDL-SI

3.2.2 BSDL-SI documents

[10] I-LI-3010.00-1300-279-PPC-350 – BSDL-SI PART LIST

[11] I-ET-3010.00-1300-279-PPC-350 rev. B - DIVERLESS BELL MOUTH STANDARD INTERFACE SUPPLY SPECIFICATION

3.2.3 Subsea fasteners documents

[12] ET-3000.00-1500-251-PEK-001 – FIXADORES EM AÇO BAIXA LIGA DE ALTA RESISTÊNCIA PARA APLICAÇÃO SUBMARINA

[13] ET-3000.00-1500-251-PEK-002 - RASTREABILIDADE DE FIXADORES DE ALTA RESISTÊNCIA PARA UTILIZAÇÃO SUBMARINA

[14] ET-3000.00-1500-29B-PMU-001 - FIXADORES DE LIGAS RESISTENTES A CORROSÃO PARA UTILIZAÇÃO EM UMBILICAIS SUBMARINOS

3.2.4 Control and Monitoring System for Riser Supports

[15] I-ET-3010.00-1300-850-PEK-001 - CONTROL AND MONITORING SYSTEM FOR RISER SUPPORTS

[16] I-DE-3010.00-1300-850-PEK-001 - Riser Supports P&ID

4 DEFINITIONS

FPU CONTRACTOR	The company contracted by PETROBRAS to construct the FPU
DIVING TEAM	The party responsible for execution of diving-related tasks, to be defined during the bidding phase.
MAY	It is used when alternatives are equally acceptable
SHOULD	It is used when a provision is not mandatory, but is recommended as a good practice
SHALL	It is used when a provision is mandatory
SUBCONTRACTOR	Company contracted by FPSO CONTRACTOR, to supply hydraulic actuator system for BSDL.

5 INTRODUCTION

This technical specification gives criteria and guidance for detailed design, design validation, construction, and testing of hydraulic actuators and related modifications on handlers (see ref.[10]) to be installed on BSDL-SI as part of hydraulic system (see [15]) to provide diverless capability to pull-out operations.

6 TECHNICAL CARACTERISTICS

6.1 Design and fabrication

6.1.1 Selection of materials for all subsea structures shall be in accordance with DNVGL-RP-B401:2017 item 5.5, and be designed for the same design life as the riser.

6.2 Qualification

6.2.1 Hydraulic cylinder shall be designed according API 6A

6.2.2 All subsea equipment shall be qualified in accordance with API 17Q or ISO 13628-6:2006.

6.2.3 FPSO CONTRACTOR shall consider SUBCONTRACTORS with experience in subsea hydraulic actuators.

7 TECHNICAL REQUIREMENTS

7.1 System overview

7.1.1 BSDL-SI is illustrated without hydraulic actuator in Figure 1. BSDL-SI is a device

designed to support flexible line bend stiffener loads and allows diver less pull in operations. Pullout operation is diver operated by the use of handle to unlock latch bar. Three nominal sizes of BSDL-SI are considered: 32”, for umbilical lines, 46” and 48” for flexible production, service or gas/water injection lines.

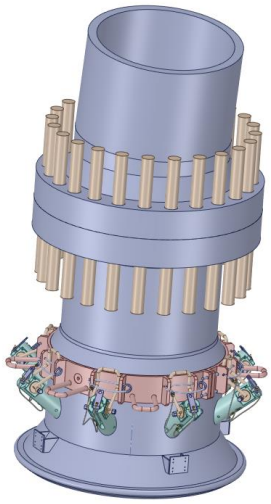

Figure 1 - BSDL

7.1.2 Hydraulic actuation system comprises simple action hydraulic actuators installed on BSDL-SI round blocks, tubings, umbilical and FPSO local panels as shown in ref. [15] that provide means for remote control to unlock BSDL-SI during diver less pull-out operation. The number of actuator for each BSDL-SI depends upon its nominal size as ref. [10].

7.1.3 General diagram of the hydraulic actuator system for BSDL-SI is presented in [16] and described with technical requirements in ref. [15].

7.1.4 The scope of this document cover only the hydraulic actuator assembly. The bell mouth itself it is not scope of this specification, however it is FPU CONTRACTOR scope as ref. [10] and [11].

7.2 5K Hydraulic actuator assembly for BSDL-SI

7.2.1 The hydraulic actuator is responsible primarily for diverless unlocking mechanism of the flexible line bend stiffener during pullout operation.

7.2.2 The scope hydraulic actuator assembly is separated from BSDL-SI as shown in Figure 2. The left figure presents the external view while the right one shows internal parts. The red parts represents the hydraulic actuator components and the blue parts are defined in BSDL-SI documentation as defined in ref. [10] and [11].

Note: The 5K hydraulic actuator assembly for BSDL-SI is different from previous versions (as that in I-ET-3010.00-1300-279-PEK-001 rev.B) by:

- Hydraulic pressure supply is 5000 psi (not anymore 3000 psi I-ET-3010.00-1300-279-PEK-001 rev.B);
- Hydraulic maximum force capacity limitation to prevent unintentional bend stiffener unlocking.

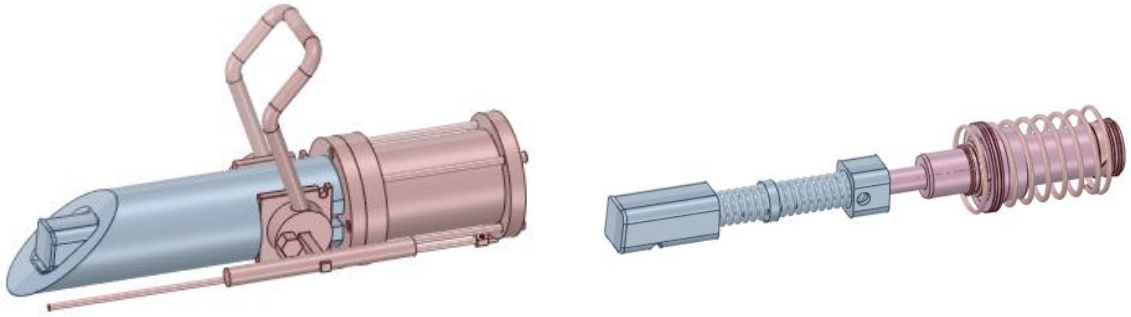

Figure 2 - Scope of BSDL-SI (blue) x scope of Hydraulic actuation System (red)

7.2.3 Drawing ref. [9] presents conceptual hydraulic actuator assembly and establishes detailed scope separation between BSDL-SI and hydraulic actuator.

7.2.4 Detailed design for actuators and tubing lines shall be submitted to Petrobras approval prior to start of hydraulics system components production; technical requirements described in following paragraphs shall be fulfilled as a minimum.

7.2.5 As a minimum design documentation shall comprise assembly and component drawings with dimensional and tolerances, stress analyses and material description.

7.2.6 Stress analysis shall be performed and allowable stress shall be considered according to API 6X.

7.2.7 Hydraulic actuator design shall be compatible with three modes of operation:

7.2.7.1 Mechanical automatic latching during pull-in operation

This is the primary mode of operation during pull-in activities and its latching/unlatching function is independent of hydraulic actuation. The BSDL-SI internal components provide all the necessary functionality for pull-in operation.

Handler remains at same position while latching bar moves towards inside by compressing de springs as shown in Figure 3. Driving force for the latch bar retraction is done by Cap DL (see ref. [10]) upwards movement during pull in operation.

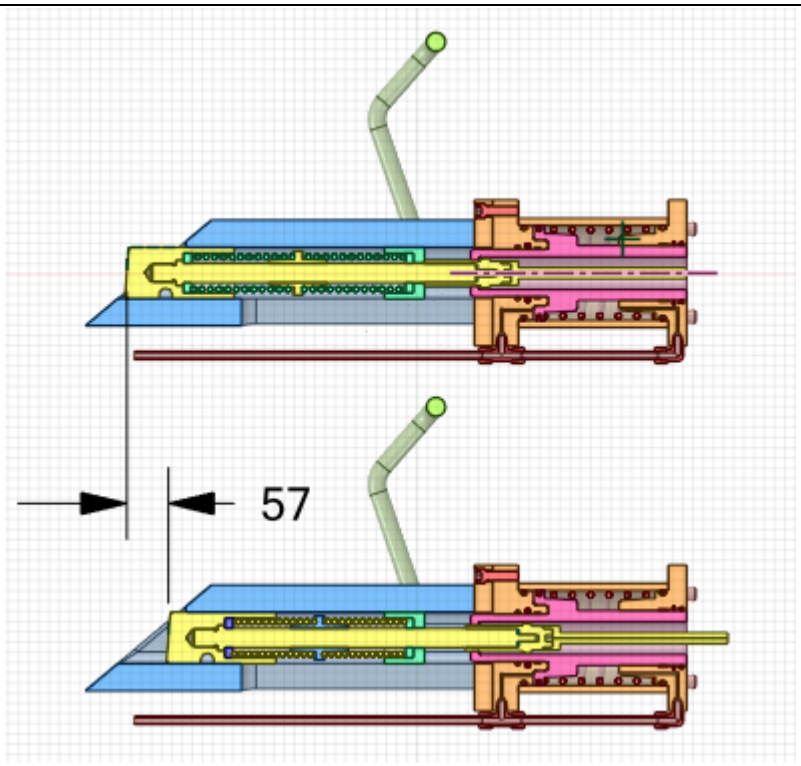

Figure 3 – Mechanical automatic latching during pullin

Return of latching bar is performed by spring force after Cap DL reaches a level with reduced section releasing space for latching.

Actuator design shall have drilled rod in order to allow free movement of latch mechanism axis as shown in Figure 4 in yellow color.

7.2.7.2 Manual override mode diver operated for pull-out activitiy

Latch bar retraction may be performed by handler movement operated by diver for pull-out activities. During override the internal components highlighted in yellow color in Figure 4**Erro! Fonte de referência não encontrada.** through Figure 6 moves on right direction driven by eccentric/sliding plate mechanism.

Two type of handlers shall be designed to perform override operation:

- In plane detachable handler is used initiate rotation until 45.
- Lateral detachable handler is used to complete 180° rotation.

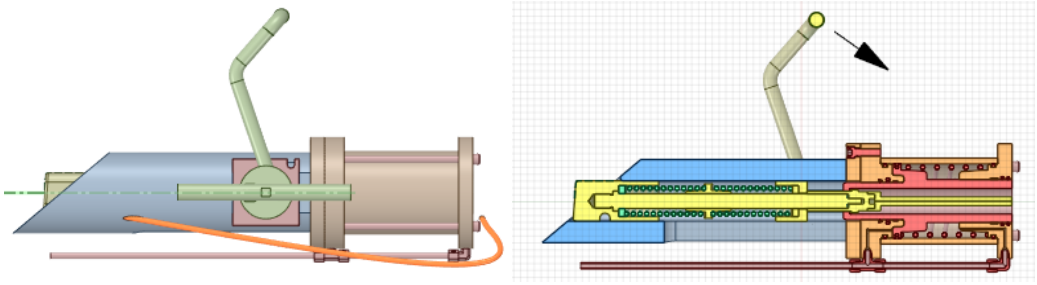

Figure 4 - Manual override diver operated for pull out activities

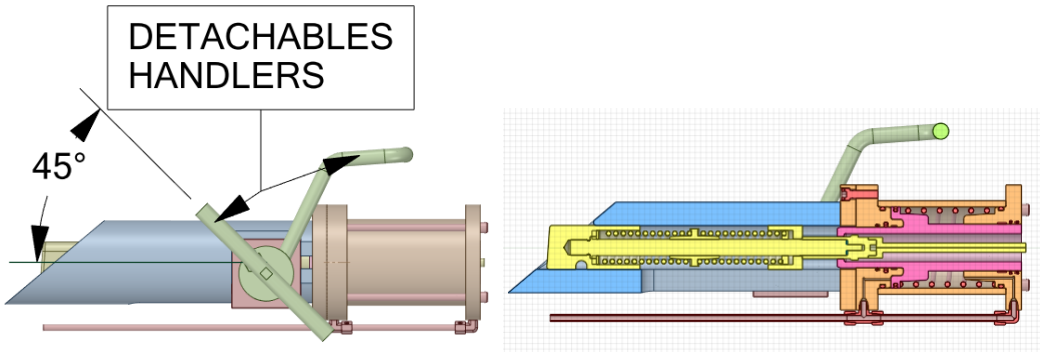

Figure 5 – Detachable in plane handler restricted rotation movement

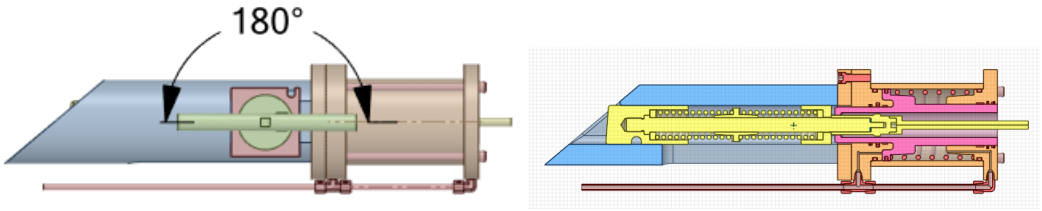

Figure 6 – 180° rotation performed by lateral detachable handler

Note that in override mode of operation none spring is compressed since whole assembly is moved as shown in figure above. Internal moving parts are highlighted in yellow color.

Hydraulic actuator piston rod and internal cap shall leave enough free space for BSDL-SI reaction block stroke, 57mm, during override operation. Reference [10] shall be consulted for BSDL-SI assembly dimensions to be considered in hydraulic actuator design.

7.2.7.3 Hydraulic remote control diverless operation

BSDLs single action hydraulic cylinders with spring return shall be designed for regenerative hydraulic circuit. Only one tubing line is used for all cylinders at each BSDL.

During pull-in operation the hydraulic actuator is aligned to HPU atmospheric pressure tanks the only remaining pressure acting over hydraulic actuator is due to 20m hydrostatic column and its FPSO dynamic effects from lower riser balcony to FPSO deck as shown in Figure 7.

Hydraulic actuator is pressurized by FPSO valves in order to retract latch bars during pull-out operation an allowing bend stiffener downwards movement (see Figure 8).

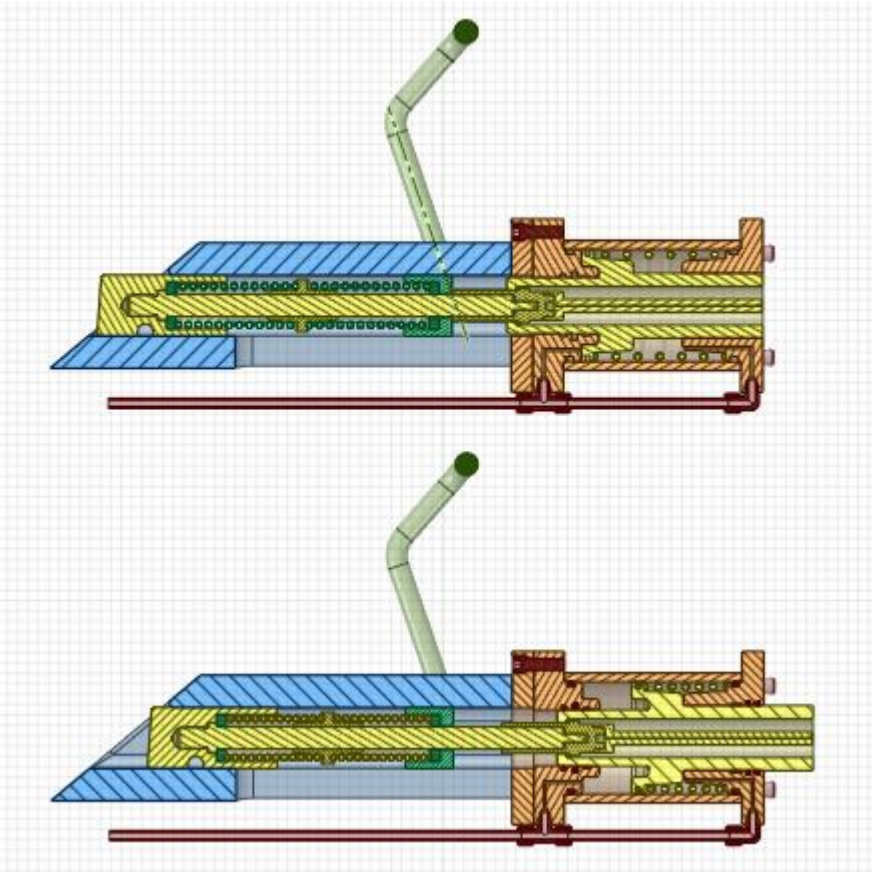

Figure 7 – Hydraulic actuation

7.2.8 BSDL/ACTUATOR interfaces and materials requirements

7.2.8.1 Bolting

Hydraulic actuator shall be hold to BSDL-SI round blocks by four 1/2 inch socket heads bolts. Wedge locking washers shall be used to prevent loosen bolts.

A mounting plate may be used to fix hydraulic actuator in BSDL-SI round block.

Bolt materials, INCLUDING TIE RODS, shall comply with references [12] and [13] if selected low alloy steel or reference [14] if selected corrosion resistant alloy 718.

7.2.8.2 Selection of materials (other than bolting) and cathodic protection; and Subsea hydraulic actuator and tubings shall be compatible with sea water environment and a combination of cathodic protection and use of corrosion resistance alloys are required as described in following paragraphs.

Three regions of round block and hydraulic actuator shall be considered for cathodic protection:

- Moving parts highlighted in yellow color in Figure 8 shall be protected cathodic protection connected to round block by copper cable shown in Figure 9. Handlers also shall be connected by another copper cable to round block.

- Hydraulic actuator piston rod shall be made as a single part of corrosion resistant alloy due to long during sea water exposure and need to keep sealing dimensions. Also calcareous deposit under cathodic protection in sea water environment needs to be prevented and its possible harmful effects in rod surface and possible sealing failure. So hydraulic actuator piston rod shall be insulated from cathodic protection by internal wear rings, insulating internal bush and gaps shown in ref. [9]. Additionally resistance to biofouling needs to be considered and copper alloys are required to combine sea water and biofouling resistance. Beryllium-copper, UNS 17200, shall be considered for hydraulic actuator rod.
- Stationary parts like actuator tube and caps are connected to round blocks and thus are subjected to cathodic protection. Hydraulic actuator tube and caps may use either CRA alloys or low alloy steels with external painting and internal hard coated in sliding surfaces provided that a numerical cathodic protection model (FEA type) using recognized software has been performed to show that regions like gaps between internal cap and rod will not be affected by calcareous deposit.

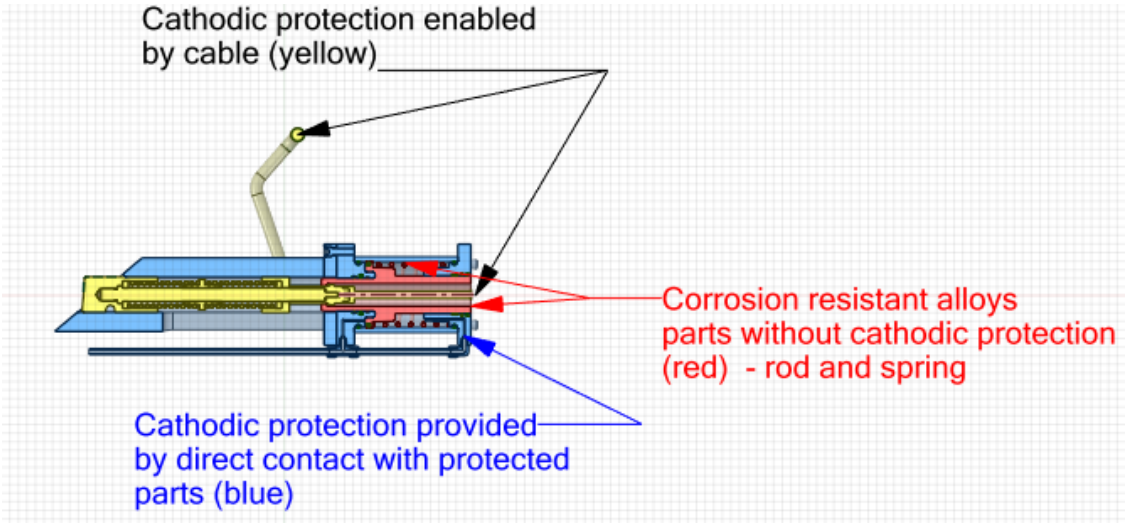

Figure 8 –Corrosion resistance and cathodic protection

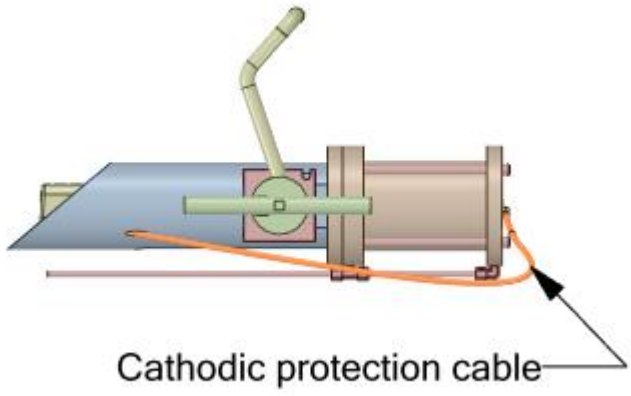

Figure 9 – Cathodic protection cable

7.2.8.3 Hydraulic actuator spring shall be made of alloy 718 with hardness limited to 35 HRC. Higher hardness than 35 HRC may be used if cathodic protection model reveals no susceptibility to hydrogen induced stress cracking effect inside cylinder tube chamber subjected to Petrobras approval.

7.2.8.4 Size restrictions

The hydraulic actuator length shall be limited to 300 mm or 357mm considering piston rod end of stroke.

7.2.8.5 Tubings and supports

Tubings and fittings shall be made of one of this options:

- Super austenitic stainless steel, shall comply with DNV RP B401.
- S32750 with hardness limited to 35 HRC and tubing design shall comply with DNVGL-RP-F112 (ed.2018).

Fitting sealings type shall comply with ISO 8434-2(JIC 37) standard.

Allowable working pressures shall be calculated according to ASME B31.3.

Tubing supports shall be provided at a maximum distance of 15 L/D (L – distance between supports and D – external tubing diameter).

7.2.8.6 Sealings

Sealings shall be selected considering, at least:

- Hydraulic fluid (see 7.2.14.9)
- Sea water
- Minimum and maximum temperatures defined in 7.2.14.6 and 7.2.14.7.
- Maximum test pressure defined in 7.2.14.1.
- Sealing components are expected to remain stationary for periods of up to 30yrs. It is recommended to consider PTFE-faced seals.

- As a minimum the sealing and wear rings configuration shall be considered as shown in [9].

7.2.9 Scope of supply include procurement, construction, assembly, FAT. Detailed description of components to be supplied is defined in I-DE-3010.00-1300-279-PEK-003 – .

7.2.10 Hydraulic actuator manufacturing, quality control, storing and shipping shall comply with [1] considering PSL 3.

7.2.11 Performance Requirements level PR2 shall be fulfilled.

7.2.12 Manufacturing and quality control data book shall be issued including full traceability of materials used. Each hydraulic actuator shall be low stress stamped with serial number linked with tests and material certificates.

7.2.13 Hydraulic lines cleanness shall be from 6B through 6F from SAEAS4059 or according to ISO 4406 class 17/15/12 (formerly NAS 1638 Class 6).

7.2.14 Design data shall be considered as follows:

7.2.14.1 Factory acceptance test pressure: 5000 psi

7.2.14.2 Maximum internal operating pressure at HPU: 3000 psi at FPU deck (20 m above BSDL-SI level);

7.2.14.3 Minimal Spring force: 2,5 x rod hydraulic force due to pressure produced as a result of hydrostatic column in umbilical considering 20m and fluid density.

7.2.14.4 Stroke: 57 mm

7.2.14.5 Minimum net rod force at 3000 psi internal pressure at initial stroke: 15kN. Net force is calculated considering hydraulic force minus the three spring forces as follows:

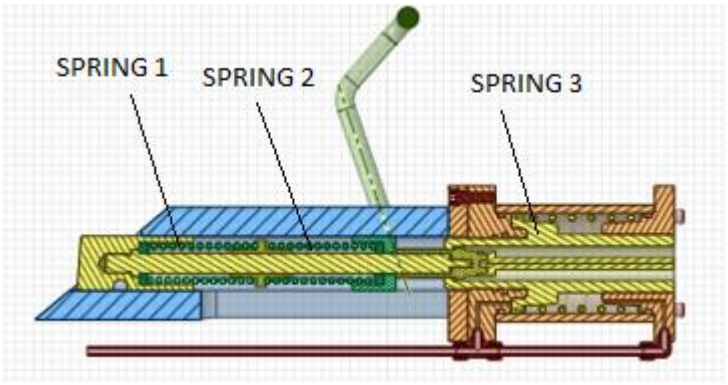

Figure 10

COMPRESSION SPRING

MATERIAL: INCONEL 718 (HARDNESS LESS THAN 35 HRC)				
LEFT HAND				
SQUARED AND GROUND END (*)				

I-TUBE		DN 48"/46"	DN 32"	
ACTIVE COILS	N	12	12	
TOTAL COILS	Nt	14	14	
WIRE DIAMETER	d	7,5	7,5	mm
OUTSIDE DIAMETER	De	57,5	52,5	mm
FREE LENGHT	L	167,6	156,2	mm
SOLID LENGHT	Ls	105,0	105,0	mm
TEST				
FORCE	F1	55,00	42,00	kgf
		539,6	412,0	N
LENGHT	L1	142,0	142,0	mm
FORCE	F2	119,5	130,5	kgf
		1172,6	1280,4	N
LENGHT	L2	112,0	112,0	mm

Figure 11 – Compression spring data

7.2.14.6 Minimum temperature: 20°C

7.2.14.7 Maximum temperature: 30°C

7.2.14.8 Maximum external pressure: 20m water column

7.2.14.9 Full compatibility with all of the water-glycol based hydraulic control fluids listed: MacDermid HW443, MacDermid HW525P or Castrol Transaque DW;

7.2.14.10 Design operational life: 30 years and 50 cycles.

7.2.14.11 Design Validation test shall be performed by subjecting a complete hydraulic cylinder assembly under sea water during at least 6 months to verify its functionality.

8 SCOPE OF SUPPLY

8.1 Hydraulic Actuator for BSDL

8.1.1 FPU CONTRACTOR shall provide all BSDLs to flexible risers and subsea umbilicals slots with a Hydraulic Actuator system for each.

9 SCOPE OF WORK

9.1 Executive Design

9.1.1 FPU CONTRACTOR shall design and detail a Hydraulic Actuator system for BSDLs locking/unlocking mechanism.

9.1.2 FPU CONTRACTOR shall design and detail a local panel system for BSDLs

locking/unlocking mechanism.

9.1.3 FPU CONTRACTOR shall design and detail umbilical line system including accessories for BSDLs locking/unlocking mechanism.

9.1.4 FPU CONTRACTOR shall design and detail the complete hydraulic system for BSDLs locking/unlocking mechanism.

9.2 Factory acceptance tests

9.2.1 FPU CONTRACTOR shall perform factory tests to confirm acceptance for all BSDLs with Hydraulic Actuator system.