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	CLIENT: PETROBRAS					SHEET: 1 of 39																							
	JOB: E&P - PRODUCTION					-																							
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1. INTRODUCTION

1.1. OBJECTIVE

- 1.1.1. The purpose of this document is to define the minimum technical requirements for design, manufacturing, testing, delivery and decommissioning conditions for PLETs, PLEMs and In-Line Structures (ILT, ILY, ILV and ESDV), which will be part of the flowlines for production, injection and/or exportation of PETROBRAS subsea system developed by means of an EPCI Contract celebrated between PETROBRAS and CONTRACTOR.
- 1.1.2. This TECHNICAL SPECIFICATION is based on requirements and guidelines of the international standard ISO 13628-15 / API 17P (ref. [51]) and establishes additional and/or complementary requirements, exceptions, modifications and clarifications, in order to standardize the understanding among PETROBRAS, CONTRACTOR and its suppliers.

1.2. SCOPE OF THE DOCUMENT

- 1.2.1. This technical document is only applicable for the subsea PLETs, PLEMs and In-Line Structures, which will be designed and installed as part of the flowlines for the subsea system. Other types of subsea manifolds (except PLEMs), as well as Wet Xmas Trees are not part of the scope of this document.
- 1.2.2. The components, which are within the scope of work of this specification, are listed below:
- Structure;
 - Foundation;
 - Piping;
 - Padeyes and Lifting Points;
 - Subsea Valve (if applicable);
 - DRS connector modules, HCM and VCM, including the caps and their tools (if applicable);
 - Swivel (if applicable);
 - Coating, Thermal Insulation and Cathodic Protection System;
 - Panel for intervention with ROV and other interfaces;
 - Fasteners.
- 1.2.3. Any other item not included in the list above, but necessary to achieve the complete scope of supply of the subsea equipment ready to be installed and operated, shall be included in the technical proposal. The supply shall be understood as a complete project, where CONTRACTOR shall have overall responsibility for the delivery and warranty of the subsea equipment.

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2. TERMS AND DEFINITIONS

2.1. VERBAL TENSES

2.1.1. The following definitions apply to the use of the content within this document:

- a. “Shall” - is used to indicate that a provision is mandatory;
- b. “Should” - is used to indicate that a provision is not mandatory but is recommended as good practice;
- c. “May” - is used to indicate that the adoption of a provision is based on the discretion of the user of this Technical Specification;
- d. “Shall not” - Forbidden action or requirement.

2.2. DEFINITIONS

2.2.1. Block Cap

Component of the subsea connector system that substitutes the connector and, when latched onto the subsea equipment's hub, intends to contain its internal piping pressure, isolating it from the external environment and turning it able to operate the pipeline for an indefinite time in this condition.

2.2.2. Certification


Third-party issue of a statement, based on a decision following review, that fulfillment of specified requirements has been demonstrated related to the products, processes or systems. Review shall, in this context, mean verification of the suitability, adequacy and effectiveness of selection and determination activities, and the results of these activities, with regard to fulfillment of specified requirements by an object of conformity assessment (based on ref. [63]).

2.2.3. CONTRACTOR

Company directly awarded by PETROBRAS to supply components, structures, and/or part or whole subsea system. CONTRACTOR may award sub-suppliers to deliver part of the scope of work.

2.2.4. Low Pressure Cap

Component of the subsea connection system used during the rigid spool installation to avoid the spill and loss of its internal filling fluid during the subsea installation.

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2.2.5. **MATERIAL REQUISITION**

Project document intended for the procurement of materials that establishes all technical requirements and complementary instructions necessary for this objective. It lists all attachments that composes the scope of supply, such as Technical Specifications, Project Description, Technical Standards, Drawings, Data Sheets, etc.

2.2.6. **PIG**

Component or device that passes through a pipeline intended to clean or inspect it.

2.2.7. **Protection Cap**

Component of the subsea connection system that it is not pressure containing. It intends to protect the hub against accidental damage on the sealing areas, drop of objects inside the hub and prevent calcareous deposits when latched on subsea equipment's hub.

2.2.8. **Prototype**

Component or equipment individually manufactured and intended to be used in the performance verification / qualification tests for its design validation. In general, the prototype has dimensions representing the worst operating conditions (either minimum or maximum tolerances).

2.2.9. **Subsea Equipment / Subsea Structure**

System constituted by components (e.g. valves, chokes, connectors, pumps, instruments, etc.) for subsea application, interconnected to flowlines or interconnected among them by means of flowlines, umbilical and electrical cables. Its purpose is to fulfill specific function (e.g. safety barrier, collector, distributor, interconnection, chemicals injection, monitoring, flow control, etc.) during the design life of an oil & gas offshore field development. For purposes of this TECHNICAL SPECIFICATION, the terms subsea equipment and subsea structure are considered equivalent and can be used interchangeably to designate PLETs, PLEMs, In-Line Tees, Wyes, Valves and ESDVs.

2.2.10. **Swivel**


Intermediary component that connects a subsea structure and a pipeline (or two pipeline sections), allowing relative rotating movement between them.

2.2.11. **TECHNICAL SPECIFICATION**

Document that contains technical requirements that CONTRACTOR and its sub-suppliers shall fulfill.

2.2.12. **Test Cap**

Temporary component of the subsea connection system that is specified to be used during the hydro-test and (pre)commissioning of the pipeline.


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2.2.13. Third-Party Conformity Assessment Body

Body or person that is independent of the person or organization that provides the object, and or user interests in that object that performs conformity assessment services (see ref. [63]).

2.3. ABBREVIATIONS

1.	CAD	Computer Aided Design
2.	CoG	Center of Gravity
3.	CRM	Corrosion Resistant Material
4.	DPE	Double Piston Effect
5.	DRS	Diverless Rigid Spool
6.	EPCI	Engineering, Procurement, Construction and Installation
7.	ESDV	Emergency Shut Down Valve
8.	ET	Technical Specification (<i>Especificação Técnica</i>)
9.	FAI	Fail As Is
10.	FAT	Factory Acceptance Test
11.	FMECA	Failure Mode, Effects and Criticality Analysis
12.	FSC	Fail Safe Close
13.	FSO	Fail Safe Open
14.	HCM	Horizontal Connection Module
15.	ID	Internal Diameter
16.	IGES	Initial Graphics Exchange Specification
17.	ILT	In-Line Tee
18.	ILV	In-Line Valve
19.	ILY	In-Line Wye
20.	MDR	Master Document Register
21.	MEG	Mono Ethylene Glycol
22.	ND	Nominal Diameter
23.	NDT	Non Destructive Testing
24.	PLEM	Pipeline End Manifold
25.	PLET	Pipeline End Termination
26.	PSL	Product Specification Level
27.	PVT	Performance Verification Test
28.	RM	Material Requisition (<i>Requisição de Material</i>)
29.	ROV	Remotely Operated Vehicle
30.	RWP	Rated Working Pressure


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31.	SGO	PETROBRAS' Obstacles Management System
32.	SGSS	<i>Sistema de Gerenciamento da Segurança Operacional de Sistemas Submarinos</i>
33.	SIT	System Integration Test
34.	SMYS	Specified Minimum Yield Strength
35.	SPE	Single Piston Effect
36.	SSC	Sulfide Stress-Cracking
37.	STEP	Standard for the Exchange of Product Data
38.	SWL	Safe Working Load
39.	TPU	ThermoPlastic hose Umbilical
40.	UNS	Unified Numbering System
41.	UV	UltraViolet
42.	VCM	Vertical Connection Module
43.	WAG	Water Alternating Gas
44.	WCT	Wet Christmas Tree
45.	WD	Water Depth

3. REFERENCES

3.1. PRIORITY IN CASE OF REQUIREMENTS CONFLICT


- 3.1.1. The documents listed in sections 3.2 and 3.3 below are essential for the use of this TECHNICAL SPECIFICATION. The documents listed in section 3.4 are complementary.
- 3.1.2. For references listed with specific edition and/or publication year, only the mentioned version is applicable. For references listed without edition and without publication year, the last edition (including amendments) is the one applicable, valid at the signature date for the project contract.
- 3.1.3. Specifically, for API and ISO equivalent standards, CONTRACTOR shall consider the most updated edition between them.
- 3.1.4. In case of conflict between this TECHNICAL SPECIFICATION and any other document, the following precedence order prevails (decreasing order):
 - a. The Contract Terms celebrated between PETROBRAS and CONTRACTOR;
 - b. The MATERIAL REQUISITION from PETROBRAS, which makes reference for this Technical Specification;
 - c. This TECHNICAL SPECIFICATION;
 - d. PETROBRAS documents listed in section 3.2;
 - e. Codes and Standards listed in section 3.3;
 - f. Documents indicated in section 3.4.

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3.1.5. Any questions regarding the conflicts between the requirements shall be clarified and registered through the issue of a formal Technical Query to PETROBRAS.

3.2. ESSENTIAL TECHNICAL DOCUMENTS

Ref.	Designation	Title
[1]	N-133	<i>Soldagem</i>
[2]	NI-381	Execution of Drawing and other General Technical Documents
[3]	NI-1710	Coding of Technical Engineering Documents
[4]	N-1852	<i>Estruturas oceânicas</i>
[5]	N-2037	<i>Pintura de equipamentos submersos em água do mar</i>
[6]	N-2064	<i>Emissão e revisão de documentos de projeto</i>
[7]	I-ET-3000.00-1521-610-PAZ-001	Design of Interfaces for Operations via ROV
[8]	ET-3000.00-1521-610-PAZ-002	<i>Ferramentas para Operação por ROV</i>
[9]	ET-3000.00-1500-610-PEK-002	<i>Eslingas e skids para transporte de equipamentos submarinos</i>
[10]	ET-3000.00-1500-251-PEK-001	<i>Fixadores em Aço Baixa Liga de Alta Resistência para Aplicação Submarina</i>
[11]	ET-3000.00-1500-251-PEK-002	<i>Rastreabilidade de Fixadores de Alta Resistência para Utilização Submarina</i>
[12]	ET-3000.00-1500-29B-PMU-001	<i>Fixadores de ligas resistentes à corrosão para utilização em umbilicais submarinos</i>
[13]	I-ET-0000.00-0000-200-PSQ-001	Welding and NDT of Submarine Rigid Pipeline, Risers and Pipeline Components
[14]	I-ET-0000.00-0000-200-PSQ-002	Welding and NDT Requirements for Subsea Equipment Pressure-Containing Parts
[15]	I-ET-0000.00-0000-970-PSQ-001	Procedure and Personnel Qualification and Certification
[16]	I-ET-0000.00-0000-972-1AL-001	Quality of Materials General Requirements
[17]	I-ET-3000.00-1000-972-1AL-026	Complementary Quality Requirement for Subsea Equipment

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Ref.	Designation	Title
[18]	I-ET-0000.00-0000-972-P8L-001	General Requirement for Manufacturing Inspection
[19]	ET-3000.00-1000-972-P8L-026	<i>Requisito Padrão de Inspeção de Fabricação de Equipamentos de Completação e Produção de Petróleo</i>
[20]	ET-3000.00-1500-220-PEK-002	<i>Requisitos Gerais de Projeto e Testes de Válvulas de Bloqueio para Aplicação Submarina</i>
[21]	ET-3000.00-1500-224-PEK-001	<i>Requisitos Específicos de Projeto e Testes de Válvulas Esfera para Aplicação Submarina</i>
[22]	ET-3000.00-1500-220-PEK-001	<i>Sistema de Compensação de Válvulas Submarinas</i>
[23]	I-ET-3000.00-1500-24A-PEK-001	Subsea Connector Systems for Diverless Rigid Spool
[24]	I-ET-3000.00-1500-24A-PEK-002	Test requirements for Subsea Connector Systems for Diverless Rigid Spool
[25]	ET-3000.00-1514-270-PAZ-001	<i>Sistema de Conexão Vertical Direta com Pescoço de Ganso</i>
[26]	ET-3000.00-1514-270-PAZ-002	<i>Sistema de Conexão Horizontal Submarina de Dutos</i>
[27]	ET-3000.00-1514-270-PAZ-016	<i>Envelope de Cargas Combinadas Admissíveis de MCVs</i>
[28]	ET-3000.00-1500-600-PEK-004	<i>Documentação técnica para equipamentos submarinos</i>
[29]	I-ET-3000.00-1500-270-PEK-002	Subsea Swivel Requirements
[30]	I-ET-0000.00-0000-431-P9U-002	Wet Thermal Insulation for Subsea Equipment
[31]	ET-3000.00-1514-974-PEK-001	<i>Testes de Integração de Equipamentos Submarinos</i>
[32]	I-ET-0000.00-0000-219-P9U-003	Clad Bends Manufacturing Requirements
[33]	I-ET-0000.00-0000-211-P9U-002	Seamless (SMLS) Pipes Requirements
[34]	I-ET-0000.00-0000-219-P9U-004	CRA weld overlay clad pipe requirements
[35]	ET-3000.00-1000-972-P8L-062	<i>Requisito Padrão de Inspeção de Fabricação de Juntas Metálicas</i>
[36]	ET-3000.00-1521-610-PPC-001	<i>Simulação Computacional de Operações com ROV para Uso em Projetos de Equipamentos Submarinos</i>

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Ref.	Designation	Title
[37]	ET-3000.00-1500-940-PEK-001	<i>Projeto de proteção catódica para equipamentos submarinos</i>
[38]	I-ET-0000.00-0000-940-PIP-001	<i>Pipe-Soil and Equipment-Soil Interaction Analysis for Thermo-Mechanical Design of Subsea Pipelines</i>
[39]	ET-3000.00-1500-600-PEK-008	<i>Instalação de Equipamentos Submarinos</i>
[40]	N/A	<i>Manual de Sinalização para Ambientes Administrativos, industriais e Marítimos PETROBRAS</i>

3.3. ESSENTIAL CODES AND STANDARDS


Ref.	Designation	Title	Ed.	Year
[41]	ISO 10423 API 6A	Wellhead and Christmas Tree Equipment		
[42]	API RP 2A WSD	Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – Working Stress Design		
[43]	AWS D1.1/D1.1M	Structural Welding Code – Steel		
[44]	DNVGL-RP-B401	Cathodic Protection Design		
[45]	DNVGL-ST-F101	Submarine Pipeline Systems		
[46]	DNVGL-RP-N101	Risk Management in Marine and Subsea Operations		
[47]	DNVGL-RP-O501	Managing Sand Production and Erosion		
[48]	DNV-RP-D102	Failure Mode and Effect Analysis (FMEA) of Redundant Systems		
[49]	ISO 13628-4 API 17D	Subsea Wellhead and Tree Equipment		
[50]	API RP 17TR12	Consideration of External Pressure in the Design and Pressure Rating of Subsea Equipment		

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Ref.	Designation	Title	Ed.	Year
[51]	ISO 13628-15 API 17P	Subsea Structures and Manifolds		
[52]	SAE J514	Hydraulic Tube Fittings		
[53]	API RP 2GEO	Geotechnical and Foundation Design Considerations		
[54]	ASME B31.8	Gas Transmission and Distribution Piping Systems		
[55]	ISO 19901-4	Petroleum and Natural Gas Industries — Specific Requirements for Offshore Structures — Part 4: Geotechnical and Foundation Design Considerations		
[56]	ISO 19901-5	Petroleum and Natural Gas Industries — Specific Requirements for Offshore Structures — Part 5: Weight Control During Engineering and Construction		
[57]	API RP 14E	Recommended Practice for Design and Installation of Offshore Production Platform Piping Systems		
[58]	ISO 23936-2	Petroleum, Petrochemical and Natural Gas Industries — Non-Metallic Materials in Contact with Media Related to Oil and Gas Production — Part 2: Elastomers		
[59]	ISO 4406	Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles		
[60]	ABNT NBR 16381 EN	Onshore and Offshore Pipelines - Pig-Trap		
[61]	RESOLUÇÃO ANP Nº 41	<i>Regulamento Técnico do Sistema de Gerenciamento da Segurança Operacional de Sistemas Submarinos (SGSS)</i>		2015

3.4. COMPLEMENTARY REFERENCES

Ref.	Designation	Title	Ed.	Year
[62]	ISO 13628-1 API 17A	Design and operation of subsea production systems – General requirements and recommendations		
[63]	ISO 17000	Conformity assessment – Vocabulary and general principles		

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Ref.	Designation	Title	Ed.	Year
[64]	ISO 10303 series	Automation systems and integration — Product data representation and exchange		
[65]	ISO 15156-2	Petroleum and natural gas industries – Materials for use in H ₂ S-containing environments in oil and gas production – Part 2: Cracking-resistant carbon and low-alloy steels, and the use of cast irons		

4. PROJECT REQUIREMENTS

4.1. SERVICE CONDITIONS


- 4.1.1. This document establishes technical requirements for the subsea structures that will be installed with the flowlines of the PETROBRAS subsea system as defined in the MATERIAL REQUISITION, which makes reference for this TECHNICAL SPECIFICATION.
- 4.1.2. This TECHNICAL SPECIFICATION considers that the subsea structures (and tools, accessories and associated spare items) will be designed, manufactured and installed within the scope of work that involves the design, construction and installation of the pipelines, for which they will be connected. Thus, it is CONTRACTOR responsibility to fulfill, in the design of the subsea structures, all considerations in the subjects related to the pipeline (including, for example, but not limited to: installation method, pipe-laying vessel limitations and thermomechanical loads from the pipeline and spool).
- 4.1.3. Other specific service conditions for the subsea equipment will be also informed in the MATERIAL REQUISITION.

4.2. PRODUCT SPECIFICATION LEVEL

- 4.2.1. Unless otherwise specified in the MATERIAL REQUISITION, the Product Specification Level, as defined in ref. [41], for the structures and components shall be PSL 3G.

4.3. CERTIFICATION REQUIREMENTS

- 4.3.1. Subsea structures and components under the scope of the MATERIAL REQUISITION, which makes reference for this TECHNICAL SPECIFICATION shall have the same level of certification/verification as the one specified for the riser / flowline to which they are going to be attached, unless otherwise mentioned in the MATERIAL REQUISITION.


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4.4. CONFORMITY WITH SGSS

- 4.4.1. CONTRACTOR is responsible to present the conformity of the scope defined in the MATERIAL REQUISITION with the SGSS in accordance with ref. [61]. Items 20 and 21 of SGSS are related to design and installation of subsea systems, respectively.
- 4.4.2. CONTRACTOR shall demonstrate the correspondence between the documents to be issued with the requirements defined in this regulation at the beginning of the detailed project phase, consolidated with the MDR.
- 4.4.3. CONTRACTOR shall issue a document with this correspondence for PETROBRAS' assessment.
- 4.4.4. Within CONTRACTOR's scope of work the contents and requirements defined on items 20 and 21 of SGSS are to be fulfilled by studies and/or procedures to be issued by CONTRACTOR.

5. DESIGN REQUIREMENTS

- 5.1. The subsea equipment shall be designed in accordance with ref. [51], considering also the requirements defined in this TECHNICAL SPECIFICATION.
- 5.2. The subsea equipment design shall consider all service and operation conditions, as well as, the loads predicted in all design life cycle of the structure, including, at minimum: factory and integration tests, lifting and handling, transportation, preservation, deployment and DRS / HCM / VCM installation, pre-commissioning, commissioning, operation, retrieval (connection modules and/or whole structure) and decommissioning. Future installation of equipment supplied by CONTRACTOR, but outside its scope of installation shall also be considered in the design. This design shall be verified by means of engineering analysis captured in dedicated reports to be issued to PETROBRAS.
- 5.3. At least for the installation, (pre)commissioning, operation and retrieval phases, the actuating loads on the structure shall be based in a global analysis of the pipeline, which results shall be captured in reports that shall be referenced in the subsea equipment design report.
- 5.4. The structure, piping and its foundation, as well as the connection systems shall be designed to withstand the pipeline expansion predicted for its whole design life cycle.
- 5.5. An equipment retrieval study shall be presented by CONTRACTOR for the decommissioning phase. It shall detail all its necessary steps, lifting points, integrity evaluation, ROV accessibility study, the foreseen contingencies and the pertinent loadings. A detailed procedure for all the steps, with a list of all material required for the operation shall be presented.

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- 5.6. The computer files containing the 3D models of the structure, used to generate the drawings and the engineering analyses mentioned in item 5.2 shall be delivered to PETROBRAS.
- 5.7. CONTRACTOR shall supply three-dimensional CAD drawings of the subsea equipment and its components (connection systems / caps / tools / accessories). The CAD drawing shall contain the envelope of the respective equipment/component in real size, with nominal dimensions without tolerances, such that allows rotation, zoom and exploded view of assemblies. A 2D CAD version shall also be provided with the main orthographic views, in order to allow insertion of the as-built information into the SGO. The electronic file for the CAD drawings shall be issued in STEP (as per ref. [64]) or IGES (Initial Graphics Exchange) formats.
- 5.8. The loads imposed by the DRS, HCM and/or VCM, calculated for both short and long term settlement (end of subsea equipment design life), as well as the maximum expansion shall be considered in the subsea structure design.
- 5.9. The weight control for the subsea equipment shall be performed as per Class C as defined in ref. [56].


6. FUNCTIONAL REQUIREMENTS

6.1. GENERAL REQUIREMENTS

- 6.1.1. All special and ancillary tools necessary for testing, operation, installation and retrieval of the subsea equipment shall be included in its scope of work/supply.
- 6.1.2. All the hydraulic terminations of tools/components/accessories, such as: the termination for hydrotest of the test base, terminations of secondary unlocking tools and so on, shall be of JIC 6 type, as per ref. [52]. If another termination is used, an adaptor from this termination to JIC 6 shall be supplied together with the tool/component/accessory. All fittings shall be compatible with the equipment RWP.
- 6.1.3. The cleanliness level for all hydraulic control systems shall adhere, at minimum, to class 17/15/12 from ref. [59] (equivalent to class 6 from NAS 1638 Standard), unless otherwise informed in the MATERIAL REQUISITION.

6.2. INTERFACE LOADS

- 6.2.1. For the subsea structures supplied by CONTRACTOR, some of their hubs may be eligible to be tied in by DRS, HCM and/or VCM on a future project/development that are not part of the CONTRACTOR scope of work, as per MATERIAL REQUISITION. The foreseen loads (and/or the premises necessary to obtain these loads) imposed onto the hubs to be considered in the subsea structure design by this future tie in will be informed in the

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MATERIAL REQUISITION. CONTRACTOR shall take into account these future interface loads in the design of the subsea equipment and its connection system.


- 6.2.2. Similarly, for the subsea structures supplied by CONTRACTOR, some of their hubs may be eligible to be tied in with connector systems from DRS, HCM and/or VCM from previous projects/developments that are not part of CONTRACTOR scope of supply, but will be part of its scope of subsea installation work, as informed in the MATERIAL REQUISITION. CONTRACTOR shall consider in the design the loads imposed onto the subsea structure by these previous connection systems, as well as, evaluate if these systems are suitable to withstand the tie in loads foreseen in CONTRACTOR analysis. If applicable, requirements for the overhauling of the previous connection system will be also informed in the MATERIAL REQUISITION.
- 6.2.3. For the subsea structures which are not part of CONTRACTOR's scope of supply, but will be tied in by DRS, HCM and/or VCM under CONTRACTOR scope of installation, the load capability of the inboard hub onto the structure (out of scope of supply) will be informed in the MATERIAL REQUISITION.

6.3. PIPELINE INTERFACE

- 6.3.1. The PLET / In-Line interface with the pipeline may be performed by means of a welded joint or a flanged assembly as per ref. [49], unless otherwise mentioned in the MATERIAL REQUISITION.
- 6.3.2. In case CONTRACTOR adopts the use of flanges, these shall have ports for testing and they shall be tested through these ports on the vessel prior to PLET / In-Line installation and during their respective FAT / SIT, considering the nominal pressure of the pipeline.

6.4. INSTALLATION INTERFACE

- 6.4.1. The necessity of specific interface aids for the subsea equipment installation depends on the installation method chosen, which is under CONTRACTOR scope of work.
- 6.4.2. For equipment installed by cable (i.e. PLEM), installation slings shall have a shackle with a masterlink, or an adapter plate, for connecting the installation cable. The slings shall have a device for connection and disconnection (into the subsea equipment) by ROV.
- 6.4.3. In case the chosen method for PLET / In-Line installation requires a yoke for connection with a laying cable, this yoke shall be designed to minimize the loadings in the pipeline. In this case, an adequate method for the laying cable connection shall be proposed.
- 6.4.4. Similarly, depending on the installation method adopted, the PLET / In-Line design shall foresee interfaces to provide means for correction of the PLET / In-Line rotation along the pipeline axis, during its installation. As example of these interfaces can be listed: receptacles and/or padeyes for buoys, padeyes that allow (by using cables from vessel winch) the application of a counter torsion in relation to the structure rotation, etc. The

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application of swivels is also a possibility that should be evaluated, during the design phase, by CONTRACTOR. In case CONTRACTOR adopts the use of swivels, the ref. [29] shall be used.


- 6.4.5. In any case, the PLET / In-Line shall be designed to withstand all loads predicted by the use of these correction methods for contingency.

6.5. INSTALLATION REQUIREMENTS

- 6.5.1. CONTRACTOR shall be responsible to monitor the design of the subsea equipment and its components in order to assure that they can be laid using CONTRACTOR's vessel. Additionally, CONTRACTOR shall adhere to the minimum technical requirements, with regards to subsea equipment installation, as set forth in ref. [39].
- 6.5.2. The installation plan and the installation operation shall be in accordance to DnV Rules for planning and execution of Marine Operations (VMO Standard). Risk identification techniques and methods shall be used as applicable for the installation operation, and the identified risks shall be managed seeking zero accidents or losses (to personnel and equipment), according to ref. [46].
- 6.5.3. The subsea equipment shall be installed within the following tolerances:
- Center of the equipment within 5 m (radius) from the target position;
 - Orientation within +/- 5° from the target orientation;
 - Maximum vertical misalignment for the structures in installed condition of 2° (two degrees).
- 6.5.4. The position and orientation of the equipment shall be monitored via transponders and gyroscopic compass during the installation (during descent and deployment). The selected positioning devices shall have the appropriate accuracy to verify that the equipment is installed within the tolerances herein specified. The positioning services (including all required positioning equipment) are part of the CONTRACTOR scope. It is forbidden to install the subsea structures with the hub open, without any cap.
- 6.5.5. CONTRACTOR shall carry out a transportation, handling, overboarding, inboarding, retrieval and installation analysis for DRS connection system, HCMs and VCMs. It shall be clearly demonstrated the feasibility of the pivoting of the VCM (to put it on the vertical and to allow it to be connected to the flexible line for 1st and 2nd end connection) with no use of straps. The handling in all situations shall be possible only by using padeyes appropriately dimensioned.

6.6. METROLOGY INTERFACE

- 6.6.1. A transponder receptacle shall be foreseen at the top of the subsea structure, with a device for the transponder retrieval after the subsea equipment settlement onto the seabed.

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- 6.6.2. A drawing for the receptacle shall be provided, which shall include the recommended dimensions for the transponder body, as well as the exact position of the receptacle in relation with the other reference parts of the subsea equipment, specially, the hub.
- 6.6.3. In addition to the transponder interface in the subsea structure, it shall contain an interface for ROV docking, to be proposed by CONTRACTOR. This interface shall maintain the ROV positioned with enough precision to turn possible the metrology of the subsea equipment by an ROV.
- 6.6.4. A drawing for this interface shall also be provided, which shall include the recommended dimensions for the docking interface for the ROV side. The drawing shall contain also the exact position of this docking interface, in relation with the other reference parts of the subsea structure, specially, the hub. In addition, the as-built measurements shall be considered for this drawing to be submitted by CONTRACTOR.


6.7. ROV INTERFACE

- 6.7.1. All interfaces and tools for actuation via ROV shall comply with ref. [7] and [8], respectively.
- 6.7.2. For ROV interfaces shall be foreseen specific points for ROV landing and docking.
- 6.7.3. CONTRACTOR shall provide an accessibility study in accordance with ref. [36], for PETROBRAS evaluation, to demonstrate that all ROV interfaces are accessible for a workclass ROV, according to specified dimensions in ref. [7]. All possible assembly/connection configurations of modules, connection system, structure features, etc. shall be considered.
- 6.7.4. ROV interface panels shall be placed on the vertical or horizontal and never on the tilted position.
- 6.7.5. All receptacles for hot stab shall be supplied with an associated dummy stab. Hot stab parking places shall also be provided.


7. SPECIFIC REQUIREMENTS

7.1. STRUCTURE


- 7.1.1. The structure shall protect all components against impacts.
- 7.1.2. The subsea structure shall be designed in a way to prevent the loads from installation and operation phases to be transmitted to the valves (when applicable). In case the loads are transmitted to the valves, these valves shall be qualified for the loads that they will be exposed (see section 7.5.14).

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- 7.1.3. CONTRACTOR shall design the subsea equipment in a way to avoid the damage/rubbing on ROV cables at all sharp edges of the structure (mainly in the top surface of the structure).
- 7.1.4. When applicable, CONTRACTOR shall take into account the possibility of internal voids in the structural members of the subsea equipment and provide the proper means, during the design, to avoid the collapse of these elements under its subsea installation and service.
- 7.1.5. CONTRACTOR shall design the hydraulic systems (if applicable) of the subsea equipment and its components in a way to prevent the instrumentation and tubing / couplings to be in exposed areas of the structure, susceptible to damage.
- 7.1.6. The structural design requirements for subsea equipment shall be in accordance with the following standards: N-1852 (ref. [4]), ISO 13628-15/API 17P (ref.[51]), API RP 2A WSD (ref.[42]) and AWS D1.1 (ref. [43]).
- 7.1.7. Manufacturing and welding requirements shall adhere to ref. [4], with exception and modifications of the items below. In case of conflict, the items described in this technical specification shall prevail:
- Item 8.1.4.1 from ref. [4] can be disregarded in case the consumables fulfill the requirements from ref. [1] ;
 - Item 8.5 from ref. [4] can be disregarded if the welding procedures are qualified during the project execution, i.e., in case of the application of welding procedures previously qualified for previous projects, production tests shall be performed;
 - Partial joint penetrations according to ref. [43] are not allowed for joints classified as primary structural members, cyclically loaded or lifting padeyes;
 - Only the procedures described in sections 4.1, 4.3, 4.5, 4.7, 4.8, 4.9 and 4.11 from standard ref. [4] are necessary;
 - Note 1 of Table 5 from ref. [4] – The impact test requirements shall fulfill the section 7.1.10 of this TECHNICAL SPECIFICATION;
 - The additional requirements for welders qualification described in section 8.3.2 of ref. [4] are not necessary;
 - The welders that present a repair index greater than 2,5 % of the length inspected by ultrasonic testing in 3 m of weld or two reprovved films within 20 films in a period of 15 activity days shall be disqualified, trained and perform a new qualification;
 - Section 9.1.2 of ref. [4] – The NDT procedures shall be qualified in accordance with ref. [43] requirements by professional certified as per ref. [15] requirements.
- 7.1.8. Structure material selection shall be according to ref. [42] and requirements from ref. [51], with the following modifications defined in item 7.1.10 below. Other materials with equivalent properties may be proposed for PETROBRAS evaluation.

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- 7.1.9. The definition of group and class material for the structure elements shall be clearly identified in the design basis and in the drawings/calculation reports that shall be presented for PETROBRAS approval.
- 7.1.10. The ref. [51] requirements are applicable, considering the following modifications:
- Maximum mass fraction of sulfur (S) shall be 0,035 %.
 - For material thickness up to 50 mm: API RP 2A WSD Class B (minimum) shall be specified, with toughness requirements (Charpy V-notch). The material shall be tested at maximum temperature of 0 °C, and shall present impact energy values above 34 J for the average from three test specimens and above 27 J individually. The testing shall be performed in the transverse direction from the lamination.
 - For material thickness between 50 mm and 100 mm: API RP 2A WSD Class A shall be specified, with toughness requirements (Charpy V-notch). The material shall be tested at maximum temperature of -20 °C, and shall present impact energy values above 34 J for the average from three test specimens and above 27 J individually. The testing shall be performed in the transverse direction from the lamination.
 - For material thickness over 100 mm: API RP 2A WSD Class A shall be specified, with toughness requirements (Charpy V-notch). The material shall be tested at maximum temperature of -40 °C, and shall present impact energy values above 34 J for the average from three test specimens and above 27 J individually. The testing shall be performed in the transverse direction from the lamination.
 - For components subjected to highly concentrated cyclic stress and without redundancy: API RP 2A WSD Class A shall be specified, with toughness requirements (Charpy V-notch). The material shall be tested at maximum temperature of -20 °C, and shall present impact energy values above 34 J for the average from three test specimens and above 27 J individually, regardless the thickness up to 100 mm. The testing shall be performed in the transverse direction from the lamination.
 - For plates, padeyes and primary structural members subjected to loads on the thickness direction (Z), the requirements from section 5.4.1.3.b of ref. [51] (exception for the last paragraph) shall be totally fulfilled.
 - Components not classified as pad eyes or primary structural members: API RP 2A WSD Class C may be specified.
- 7.1.11. The minimum distance between welds shall be 50 mm. In case the nominal thickness equal or greater than 25 mm, CONTRACTOR shall demonstrate that, the NDT from ref. [43] and [4] is feasible. Otherwise, the minimum distance between welds shall be two times the nominal thickness.
- 7.1.12. The extent of the NDT shall follow the specified requirements for deck components on Table 6 of ref. [4].

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- 7.1.13. The inspection level shall fulfill the following selection criteria. In case, the adequate criteria for the component cannot be found below, CONTRACTOR shall request the proposed inspection level for PETROBRAS approval.
- a. Inspection Level I:
 - i. Primary components;
 - ii. Lifting padeyes, including the ones for accessories;
 - iii. Joints with thickness over 50 mm;
 - b. Inspection Level II:
 - i. Sliding beams;
 - ii. Sea-fastening;
 - c. Inspection Level III:
 - i. Pile guides;
 - ii. Floor framework, foot bridges and stairs;
 - iii. Stoppers;
 - iv. Anodes.
- 7.1.14. All welds shall be visually inspected with a 100 % extent.
- 7.1.15. For joints among components from different inspection categories, the most stringent inspection level shall prevail.
- 7.1.16. For welds that are assigned an inspection percentage, this percentage shall be applied at each welded joint (not for a percentage of joints from a batch). For the joints, which this inspection percentage reveals a defect, the totality of these remaining joints shall be inspected.
- 7.1.17. For weld inspection between base metals manufactured by the Thermo-Mechanically Controlled Processing (TMCP), the calibration blocks shall be manufactured with the same material specification, considering the same lamination direction concerning the foreseen directions for the ultrasound scanning.
- 7.1.18. A system to record the defect occurrence rate shall be implemented. This system shall be updated once every two weeks for each site where the welding and inspection activities are being performed.
- 7.1.19. In case this fortnight record points out a repeated occurrence of defects with a rate equal or greater than 10 % for the inspected welds, the inspection level shall be raised to 100 % ultrasound testing plus 100 % magnetic particle testing for all site welds performed during the period which the rate was determined. This inspection level shall be maintained until the cause for the defects occurrence have been determined, and that the fortnight record indicates the rate have been reduced to a value equal or lower than 2,5 %.


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7.2. PADEYES AND LIFTING POINTS

- 7.2.1. The handling of all structures/components/accessories/tools shall be feasible by padeyes with no necessity of straps.
- 7.2.2. The structure shall have, at minimum, four (04) padeyes on the top of the structure for handling during the transportation, installation and retrieval, as applicable. CONTRACTOR shall also consider, in the structure design, padeyes for sea fastening purposes.
- 7.2.3. Padeyes shall be designed in accordance with ref. [49].

7.3. FOUNDATION


- 7.3.1. The design of the subsea equipment shall include the proper means to prevent it to be buried in the seabed, at the beginning of its embedment, when installed at the first end (as applicable). Additionally, equipment-soil interaction analysis shall fulfill the requirements from ref. [38].
- 7.3.2. The foundation shall be designed as per ref. [53] or [55], considering the soil conditions and including declivity, as informed in the MATERIAL REQUISITION by PETROBRAS. It shall be also designed to, after its embedment and stabilization, not exceed the maximum vertical misalignment angle, which is also defined in the MATERIAL REQUISITION.
- 7.3.3. The foundation shall be designed in order to install and keep the structure leveled and stable within the limit that turns possible the DRS, HCM and/or VCM connection (requirements related to structure leveling are informed in the MATERIAL REQUISITION, if applicable). In case this condition cannot be met, CONTRACTOR shall propose, during the design phase, solutions to correct the leveling angle, such as: structure base modifications, soil jetting, inclusion of mechanism that can change the subsea equipment leveling after its embedment, etc. The use of mattress for soil correction is not allowed.
- 7.3.4. In the analysis for the structure's retrieval from the seabed, the suction loads that may arise from the interaction with the soil shall be evaluated. The calculations for such loads shall be detailed in this analysis and facilities can be foreseen in the foundation design with purposes of minimizing these loads.
- 7.3.5. The foundation load capacity calculation shall meet ref. [53] or ref. [55] requirements. Nonetheless, in the design basis document, it may be proposed a more detailed numeric model for PETROBRAS evaluation.
- 7.3.6. The foundation shall be verified considering all the connection loads from other structures/components.
- 7.3.7. Regarding the soil influence at the subsea structure and DRS / HCM / VCM designs, long term and short term embedment shall be considered.

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- 7.3.8. Conditions and/or requirements for subsea structure anchoring will be informed in the MATERIAL REQUISITION. CONTRACTOR shall include in the subsea equipment design solutions to fulfill the conditions and requirements set forth in this TECHNICAL SPECIFICATION.

7.4. PIPING

- 7.4.1. The piping shall be designed to meet the requirements from ref. [51].
- 7.4.2. The minimum internal diameters for the piping, connection systems and valves are informed in the MATERIAL REQUISITION.
- 7.4.3. Piping, valves, connectors systems, swivels, etc., shall be designed for the following conditions:
- Maximum internal pressure with no external pressure: according to ref. [49]. Consideration of the external pressure on the design for bursting may be adopted following the requirements of ref. [50].
 - External pressure relative to the water depth without the internal pressure: condition for all components.
- 7.4.4. Welding and NDT requirements for pressurized piping of subsea equipment are described in ref. [14], and they are only applicable to pressurized piping girth welds located at positions where external loads are absorbed by the structure (i.e., if the pressurized parts are internal to the structure). Internal welding overlay and buttering are also included in this technical specification.
- 7.4.5. Welds located in places where external loads are NOT absorbed by the structure frame shall be in accordance to ref. [13] (or by the alternative method described in ref. [14]).
- 7.4.6. For pipes made of materials other than carbon steel, the support elements welded to the pipe shall have the same material as the pipe, to avoid dissimilar weld. Other support components (not welded to the piping) may be of carbon steel.
- 7.4.7. For pipes of materials that need heat treatment, the support elements should have no elements welded to the pipe, preferably being fixed by means of bolted clamp or another adequate means. In case this is not possible, a component welded to the pipe shall be provided, prior to heat treatment.
- 7.4.8. The material for the parts in contact with the process fluid shall be compatible with the fluid specified as to chemical composition, flow rate, pressure, temperature, etc. Test reports or technical literature shall be submitted by CONTRACTOR for PETROBRAS evaluation to confirm the fluid compatibility.
- 7.4.9. For the assembly of structural members with pressurized components, the clause 834.5 from ref. [54] is applicable.
- 7.4.10. Girth welds shall not be covered by doubler plates, clamps or other elements.


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- 7.4.11. When applicable, cladded bends shall adhere to ref. [32] requirements.
- 7.4.12. Ref. [33] shall be considered for seamless pipes.
- 7.4.13. Requirement F of ref. [45] is mandatory. Requirement D is not mandatory however it is CONTRACTOR's responsibility to assure the correct weld alignment and meet the aimed hi-lo requirements.
- 7.4.14. Piping where PIGs will be used (as specified in the MATERIAL REQUISITION) shall fulfill the following criteria:
- Minimum bending radius and straight section between two consecutive connections (curve, Tee, reduction, etc.) for the piping shall be in accordance with the informed in the MATERIAL REQUISITION.
 - The curvature radius is referenced to the center of the bent pipe. The internal diameter of pipe bends shall be at least equal to the internal diameter of the straight pipe and maximum internal diameter shall be limited by the straight pipe's fabrication tolerance;
 - When applicable, piping derivations shall have guided bars for PIGs in accordance with ref. [60];
 - Structure shall have inner diameters equal to adjacent pipelines and/or ends of inlet or outlet spools, to allow passage of cleaning and instrumented PIGs.
 - Diameters should be kept constant. However, if changes are authorized by PETROBRAS in the internal diameter for the piping and its components (valves, hubs, fittings, connectors, pipe, etc.) the transition profile shall vary in the ratio of 1:5 in radius. CONTRACTOR shall report any change in pipeline inner diameters during project execution and certify the same change in the equipment.
 - CONTRACTOR shall inform to PETROBRAS, during the mechanical design and construction, the structure's final inner dimensions in order to optimize the PIG's design.
- 7.4.15. When required as per MATERIAL REQUISITION, CONTRACTOR shall consider in the equipment piping and applicable tools / accessories the effects of erosion as per ref. [47]. The service conditions data required for erosion calculation are presented in the MATERIAL REQUISITION. Erosional velocity shall be calculated as per ref. [57] and the erosion rate calculated as per ref. [47]. A detailed calculation report shall be issued by CONTRACTOR for PETROBRAS evaluation, describing the effects of erosion in the subsea structures and informing (at minimum): their critical points, erosion rates, geometry factors, thickness & IDs and material properties.
- 7.4.16. When cladded subsea equipment is specified in the MATERIAL REQUISITION, all structure piping and DRS system connectors, HMCs / VCMs and hubs shall be internally cladded with a minimum of 3 mm of Inconel® 625 (UNS N06625), unless otherwise informed there.

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7.5. VALVES

- 7.5.1. If applicable, valves shall be as specified in the MATERIAL REQUISITION.
- 7.5.2. Valves and actuators design shall comply with requirements defined on ref. [20] and [21]. Unless otherwise mentioned in the MATERIAL REQUISITION, the valve for subsea equipment application shall be from the ball valve type. If other type of valve is defined in the MATERIAL REQUISITION, the applicable TECHNICAL SPECIFICATION for such valve will be there defined.
- 7.5.3. Valve, actuator and their assembly qualification and factory acceptance tests shall comply with international standards from ref. [41], [49] and the sequence and requirements described on ref. [20] and [21].
- 7.5.4. Previously qualified valve design may be presented for PETROBRAS' approval since the following requirements are accomplished:
 - a. Qualification tests were performed in accordance with International Standards above defined, no matter which operator, or, in accordance with any PETROBRAS' previous project, since the requirements were similar to the ones defined on this document.
 - b. Qualification tests were performed for the same operational condition defined on the MATERIAL REQUISITION, or more critical conditions (working pressure, temperature, fluid content).
 - c. CONTRACTOR provides all documentation, signed by Third Party Conformity Assessment Body or PETROBRAS representative, as necessary, which means: qualification procedures and test reports and disassembling and inspection reports.
- 7.5.5. Valves shall be partial cladded or full cladded as specified in the MATERIAL REQUISITION.
- 7.5.6. Subsea valves shall be API flanged or welded as per contractors / manufacturers decisions.
- 7.5.7. Valve sealing type (MetalxMetal / Soft) and seat configuration (DPE x SPE) are defined in the MATERIAL REQUISITION.
- 7.5.8. The valves shall be designed to withstand the hydrostatic test pressure of the pipeline.
- 7.5.9. Qualification by "scaling" is NOT acceptable.
- 7.5.10. Valves for ESDV application shall have a maximum closing time of 120 s, unless otherwise informed in the MATERIAL REQUISITION.
- 7.5.11. Valve inner diameters shall be equal to adjacent pipelines ends to allow passage of cleaning and instrumented PIGs, as defined on the scope of supply.
- 7.5.12. It shall be included an ROV interface for a subsea fulfillment of the valve compensation system (hot stab plus isolation valve) for hydraulically actuated valves. Additionally, the compensation system shall fulfill the requirements from ref. [22].
- 7.5.13. A single prototype shall be used to qualify the ball valve design. The prototype may be

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refurbished after PVT for use as product to be delivered. Refurbishing requirements are defined on ref. [20] and [21].


- 7.5.14. The valve capacity to withstand, at minimum, the same loading level foreseen in installation analysis shall be verified through engineering analyses and load tests. Both methods shall demonstrate that the functionality of the valve in terms of sealing and actuation performance is not affected by the evaluated loading.

7.6. SWIVEL

- 7.6.1. As an option to avoid the structure rotation and the torsion in the pipeline, the connection between the PLET/In-Line structure and the pipeline can be made through a swivel device. It also allows the verticality of the hub structure, keeping the vertical angular misalignment within the allowable range for vertical connection purposes. In this case, the swivel shall fulfill the requirements listed below:
- 7.6.2. The swivel design and qualification shall fulfill the requirements from ref. [29]. Additional requirements for swivels for VCM application are captured in ref. [25].
- 7.6.3. If applicable, the flange used for connection between the swivel and the pipeline shall be the API 17D / ISO 13628-4 (ref. [49]) swivel flange type. The flanges shall have a metallic protection for their mating face.
- 7.6.4. If applicable, the swivels shall possess means to prevent the rim of the swivel flange to displace when this flanged connection is undone by using a stopper or any other means so that no risk is envisaged to the operator during this disconnection.
- 7.6.5. In case the swivels are post-energized, during the qualification, the energization shall be carried out under loads. The loads shall be representative of the installation and operational loads. Swivels shall be load tested for all the load conditions of their design life and FEA shall also be conducted for all load conditions.

7.7. HORIZONTAL / VERTICAL CONNECTOR SYSTEM


- 7.7.1. The design of the connector system shall fulfill the requirements from ref. [23] for DRS connection, ref. [26] for HCM connection and ref. [25] for VCM connection.
- 7.7.2. Clearance and tolerance studies for the interface among the components of the horizontal / vertical connector system and among these components and the subsea equipment shall be presented.
- 7.7.3. All DRS, HCM and VCM connectors shall be provided with their respective installation ring gaskets.
- 7.7.4. The DRS, HCM and VCM connectors shall be verified against dynamic (installation and operational) loads in both latched and unlatched conditions.

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- 7.7.5. Unless informed otherwise in the MATERIAL REQUISITION, CONTRACTOR shall issue for PETROBRAS evaluation a load envelope for VCMs in accordance with ref. [27].
- 7.7.6. Besides the padeyes required by ref. [25], the VCM shall possess at least one padeye between the CoG and the swivel and another between the CoG and the center of the connector. These padeyes shall withstand the VCM installation/removal.
- 7.7.7. The maximum dimensional envelope for the VCMs, as defined in the MATERIAL REQUISITION shall include the shackle of the main padeye in the vertical position and any additional accessories, which is considered as part of the VCM during offshore installation.
- 7.7.8. All test bases shall be representative not only of the hub, but also of the structure of the equipment where each connector will be connected in order to assess possible structural interferences. Additionally, the test bases shall possess means to test the connection system under the maximum specified vertical misalignment.
- 7.7.9. The connector system design shall have visual indicators to verify, by ROV, whether the connector is ready to be soft landed. Visual indicators to verify whether the connector is latched or unlatched, as well as, softland retraction and extension shall be also included.

7.8. CONNECTOR SYSTEM CAPS


- 7.8.1. The block caps are suitable for permanent application, shall be compatible with the operational/injection fluid specified in the MATERIAL REQUISITION and shall have a bi-directional metal to metal sealing system.
- 7.8.2. The test caps are suitable for temporary use (five years at minimum) and its sealing system can be from the elastomeric type.
- 7.8.3. The block and test caps can be mechanically or hydraulically actuated and shall allow the latching and unlatching via ROV, by means of PETROBRAS standard interface, as per ref. [7].
- 7.8.4. The block and test caps shall have a secondary mechanical unlocking device, as contingency, by means of a tool that can be held, handled and operated by ROV.
- 7.8.5. Both block and test caps shall be designed to withstand the pressure test for the subsea equipment and to avoid the entrance of seawater at the installation depth. They shall be also designed to withstand an external pressure differential related to the water depth of the subsea equipment.
- 7.8.6. The block and test caps shall have a back seal test function, with PETROBRAS standard interface for pressurization, through hot stab via ROV, as per ref. [7].
- 7.8.7. The caps shall possess a centralized interface by which they can be retrieved directly by the hook of the winch vessel, in order to not rely on the installation of slings at more than one lift point of the caps.
- 7.8.8. The block and test caps shall have a guidance system with the hub.

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- 7.8.9. Both block and test caps shall be provided with their respective installation ring gaskets.
- 7.8.10. The block and test caps shall be designed with two (02) ports (one for injection and the other for relief), with at least one block valve (operated by ROV) at each port, for pressure equalization (external and internal) and for MEG circulation (when applicable), through specific hot stabs. In order to avoid the injected MEG in one port to exit immediately in the other port, the MEG outlet at the injection port shall be positioned at a lower height than the relief access port. Requirements for valves, ports and respective hot stabs will be presented in the MATERIAL REQUISITION.
- 7.8.11. The protection cap shall cover both hub's sealing and locking areas and protect them against impacts loads.
- 7.8.12. The protection cap shall guarantee electrical contact with the hub.
- 7.8.13. The protection cap shall have a locking system, actuated by ROV. This locking system shall be designed in such way that the transportation and installation of the subsea equipment can be performed with this cap latched in the hub, in order to prevent its self-release.
- 7.8.14. The low pressure cap shall have a locking system, operated by ROV, and a primary sealing system to prevent the loss of the internal fluid filled in the rigid spool during its installation.
- 7.8.15. The low pressure cap shall possess a pressure equalization system, operated by ROV, to prevent that a hydraulic lock, created by the differential pressure, obstructs the cap removal by ROV after the rigid spool has started its installation.
- 7.8.16. The scope of supply for the caps to meet the project specific needs will be presented in the MATERIAL REQUISITION.

7.9. SEALING SYSTEM


- 7.9.1. The primary sealing areas shall be made in Inconel® 625 (UNS N06625). The use of any other CRM, qualified for subsea service, may be proposed for PETROBRAS analysis. Proper care shall be taken to avoid the galling effect between the metallic gasket and its sealing area. In case of damage of the sealing area, it shall be able to provide a contingency sealing system by means of a modified metallic ring gasket.
- 7.9.2. The ring gaskets shall be made from AISI 316L SS, Incoloy® or Inconel®. The use of any other CRM, qualified for subsea service, may be proposed for PETROBRAS analysis.
- 7.9.3. The ring gaskets shall comply with ref. [35].
- 7.9.4. Additional ring gaskets, from the resilient type, shall be predicted to check that the sealing systems used in the design are effective, throughout the FAT, including the sealing systems that prevent seawater ingress in the production bore. Qualification requirements for non-metallic seals are described in section 8.8.

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- 7.9.5. All flanged connections to be used in the subsea equipment and its components shall have a “test port”, in order to allow the execution of a gas (N₂) back seal test. This port shall be plugged after the back seal test, with an appropriate plug which is qualified for the flange pressure and temperature rating and the operating fluid of the flange. All flanges shall be tested at the yard and at the installation vessel. Flanges of equipment to be delivered to PETROBRAS (for example, swivel flanges) shall be tested by CONTRACTOR before the delivery.
- 7.9.6. The primary sealing systems shall be suitable for testing via hydraulic circuits, without relying on internal bore pressure tests.
- 7.9.7. The design for seal testing system to be performed subsea shall be able to eliminate “false negatives” during the execution of the seal tests after installation. Its design and qualification tests shall fulfill the conditions of the installation scenario.

7.10. COATING, THERMAL INSULATION AND CATHODIC PROTECTION

- 7.10.1. The subsea equipment shall contain a cathodic protection system, which shall be designed to meet the design life specified in the MATERIAL REQUISITION.
- 7.10.2. Each module or component that is not part of the resident structure of the subsea equipment shall contain its own cathodic protection system, designed to meet the design life specified in the MATERIAL REQUISITION.
- 7.10.3. The cathodic protection system shall fulfill the requirements of ref. [37] and [44].
- 7.10.4. The cathodic protection shall use aluminum anodes.
- 7.10.5. Inspection points for cathodic protection measurement shall be included in the structure, by means of plates made from the material AISI 316L SS, or other CRM, qualified for subsea service, on locations to be defined during the cathodic protection design phase.
- 7.10.6. Surfaces with relative movement shall be electrically connected by means of stranded cables, in accordance with ref. [44].
- 7.10.7. The design of components with coatings based on fluoropolymers shall consider the exposure to UV radiation.
- 7.10.8. The subsea equipment and its components such as, valves, connector modules, piping and structure shall be painted according to item 4.3 of ref. [5] (alternative C). Additional and modified painting requirements (coating assessment) may be presented in the MATERIAL REQUISITION and shall also be considered by CONTRACTOR. The sealing areas and/or surfaces with relative movement shall not be painted.
- 7.10.9. Unless otherwise informed in the MATERIAL REQUISITION, the following colors shall be used on structure: white for fixed parts, red or orange for structure padeyes and yellow for removable parts (connectors, etc.). Where colors were not specified, annex B orientations from ref. [62] shall be adopted.

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- 7.10.10. When required, thermal insulation for the subsea equipment and its components shall be supplied in accordance with ref. [30]. The thermal insulation shall cover the piping of the subsea structure and its respective connection system (DRS, HCM or VCM) at both the subsea equipment and flowline sides).

7.11. FASTENERS

- 7.11.1. The high strength low alloy steel fasteners (SMYS greater or equal to 105 ksi) shall be specified in accordance with ref.[10] and their respective traceability in accordance with ref. [11].
- 7.11.2. In case of the application of fasteners made from Inconel® 718 (UNS N07718), they shall be specified according to ref. [12].
- 7.11.3. Mounting report shall register the part numbers, lubricant specification and applied torque for each stud/bolt in order to fulfill traceability requirements.
- 7.11.4. All flange bolts shall be tightened using tensioners.


8. PERFORMANCE VERIFICATION TESTS (QUALIFICATION) FOR DESIGN

- 8.1. The design of the following components shall be qualified through performance verification tests:
- Bends;
 - Coatings;
 - Connector System (DRS, HCM and VCM), including caps and tools;
 - Fasteners;
 - Metallic Seals;
 - Non Metallic Seals;
 - Swivel;
 - Valve.
- 8.2. The design qualification for these components shall be performed by the manufacturer of each component. However, the fulfillment of the technical requirements and the contractual schedule is total responsibility of the CONTRACTOR.
- 8.3. Unless otherwise specified in the MATERIAL REQUISITION, CONTRACTOR shall mobilize, without any additional cost impacts for PETROBRAS, a Third-Party Conformity Assessment Body (recognized by PETROBRAS) to witness / approve all qualifications within the CONTRACTOR's scope of supply, independently of PETROBRAS witnessing on the qualifications.

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- 8.4. All qualifications shall be carried out for a specific temperature class from ref. [41] which comprehends the minimum and maximum design temperature specified in the MATERIAL REQUISITION.
- 8.5. The design for the valves shall be qualified in accordance with the guidelines set forth in the MATERIAL REQUISITION and section 7.5.
- 8.6. The design for the connector systems (DRS, HCM and VCM application), as well as, the associate caps and tools shall be qualified in accordance with the guidelines set forth in the MATERIAL REQUISITION, section 7.7 and ref. [23], [24], [25] and [26].
- 8.7. The swivel shall fulfill the requirements of ref. [29]. The curve “necessary torque for turning the swivel” x “tension and bending moment caused by the pipeline” shall be obtained by testing. Verification of the effect of high and/or low temperatures on the torque value can be made through tests or engineering analyses.
- 8.8. Qualification of non-metallic seal designs shall be according to ref. [41], ref. [49] and ref. [58].
- 8.9. The procedures for the Performance Verification Tests (PVT's) of the components mentioned in item 8.1 shall comply with the requirements of the PETROBRAS Technical Specifications and ref. [41] and [49].
- 8.10. In case CONTRACTOR proposes the use of previously qualified components approved for other projects application, the documentation (i.e. design, test procedure, qualification report, acceptance criteria, etc.) for that process shall be presented for PETROBRAS evaluation. It is mandatory that all tests have been witnessed/approved for, at least, one Third-Party Conformity Assessment Body representative recognized by PETROBRAS (or PETROBRAS itself), and it shall have the evidences of signatures and stamps throughout the tests records, which shall be part of the design qualification report/dossier.
- 8.11. Additionally, CONTRACTOR shall present, through a dedicate report, a comparison among the input data (pressures, temperatures, loads, etc.) considered for the previous project and for the intended project, thereby asserting that the previous qualification meets or exceeds the qualification requirements for this project.
- 8.12. The list of suppliers of all components not previously qualified shall be submitted to PETROBRAS evaluation. PETROBRAS reserves itself the right to not accept suppliers, which do not meet the following requirements:
- Track record of supplying the component for equal or higher water depth for the project.
 - Minimum 30 installations of the component.
 - Minimum five years of operation of the supplied component with no history of operational problems.

The evidence for the three requirements above mentioned shall be a letter issued by an oil & gas company (operator), signed by at least two employees with their respective updated contact information (e-mail, phone number and position) and describing the

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oil/gas fields where the components were installed, date, water depth, size and quantity of the components, at minimum.


9. QUALITY CONTROL REQUIREMENTS

9.1. ORGANIZATION

- 9.1.1. Quality guidelines for the design, manufacture and test of the structures and components which make part of the scope of supply of this document shall follow the requirements found in ref.[16] and [17], unless defined otherwise in the MATERIAL REQUISITION.
- 9.1.2. CONTRACTOR shall present a timetable with all supplying phases: engineering, manufacturing, assembly, qualification (PVT), testing (FAT and SIT) and delivery of the subsea structures and their components.
- 9.1.3. CONTRACTOR shall report weekly the physical progress of project, describing the following minimum information: work progress status, list of issued documents, non-conformity control (submitted and its current situation) and the forecast for the next two weeks of activities. CONTRACTOR shall also send the complete schedule with physical progress of the project to PETROBRAS.


9.2. INSPECTION

- 9.2.1. Inspection shall be in accordance with references [18] and [19]. It shall also be of the "Type C" as per the "*ABC da Inspeção da Fabricação*" (in portuguese) available at the vendor channel on PETROBRAS' website.
- 9.2.2. All non-conformities of design, manufacturing, qualification, assembly, testing, and installation shall be immediately notified to PETROBRAS.
- 9.2.3. All inspectors who follow the manufacture of the subsea structures and their components shall be in accordance with ref. [15], [18], [19] and with item 7.11.3.2 of ref. [51].
- 9.2.4. All critical items for the subsea equipment supply, such as, forgings, valves, connector systems, etc. shall be clearly identified by CONTRACTOR during the initial design of the subsea structures so that PETROBRAS can appropriately plan their inspection philosophy.

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9.3. FAT AND SIT REQUIREMENTS


- 9.3.1. Factory Acceptance Tests shall be carried out in order to verify the functionality and integrity of the subsea structures to be supplied as per MATERIAL REQUISITION and if the main components are assembled and operating as per the results of the PVTs.
- 9.3.2. Each subsea structure, after its complete assembly and with the test or block cap latched, shall undergo a hydrostatic test in accordance with the standard used for the design and manufacturing of subsea structure piping, to verify the structural integrity and all sealing points, including the valve sealing.
- 9.3.3. The water to be used for filling the piping in the phases of integrity tests, seal tests, PIG passage tests, etc., shall be treated with corrosion inhibitor, which shall be priorly informed by CONTRACTOR for PETROBRAS approval. The water quality report shall be also submitted for PETROBRAS evaluation.
- 9.3.4. Gas tests (N₂) are mandatory only for isolated components such as, valves, connector systems, swivels and flanges, in accordance to ref. [41], during respective PVTs and FATs. These tests shall be performed by their manufacturers, respectively.
- 9.3.5. When applicable, the interfaces between the anchoring system and the subsea equipment shall undergo functional testing. These tests shall simulate, at minimum, the maximum misalignment angles for the coupling of the equipment with the anchoring system and assess any possible geometrical interference. The performance of the locking mechanisms for coupling the equipment with the anchoring system shall also be evaluated.
- 9.3.6. The FAT for the subsea equipment, after its total assembly, shall include:
 - a. Torque measurement of the required torque to rotate the swivel, in non-energized condition, after its integration on the subsea equipment (if applicable).
 - b. Torque measurement for valves actuation, via ROV interface (if applicable).
 - c. Hydraulic pressure measurement for the actuation of the valves' hydraulic actuator (if applicable).
 - d. Sealing test for the valves' seats after integration into the structure at low and high pressure conditions (if applicable);
 - e. All torques, pressures, temperatures and other relevant testing parameters shall be registered electronically or in charts for all tests.
- 9.3.7. The manufacturer shall elaborate specific procedures for each test, in checklist format, with necessary resources and consumables, as well as acceptance criteria. Each procedure shall be approved by PETROBRAS before the beginning of its respective test.
- 9.3.8. SIT activities shall be in accordance with ref [31].
- 9.3.9. All facilities necessary for the FAT and SIT of the components are total responsibility of the CONTRACTOR.

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- 9.3.10. CONTRACTOR shall mobilize a Third-Party Conformity Assessment Body representative, recognized by PETROBRAS, to witness the FAT and SIT activities, unless otherwise informed in the MATERIAL REQUISITION.
- 9.3.11. For components where check valves are applied, the set pressure to crack open these check valves and their reseal pressure shall be verified during the FAT and SIT and adjusted, if necessary. A new verification shall be carried out on vessel prior to its installation (component or structure) to turn it possible to verify if the set point and reseal pressure of the check valve have changed. In case the installation of this component/structure is out of the scope of work of CONTRACTOR, it shall be clearly stated in the structure/component manual the methods required to verify and correct, if necessary, the set point and reseal pressure for the check valves.

9.4. INTEGRITY MANAGEMENT

- 9.4.1. Same integrity management requirements established for the risers/flowlines, are also applicable for the subsea structures and their components for which they are tied in, as per the scope of supply defined in the MATERIAL REQUISITION.
- 9.4.2. CONTRACTOR shall implement a FMECA in order to identify failure modes' mechanisms and causes and determine critical components, considering all phases of the project (manufacturing, maintenance, installation, operation, etc.). This FMECA study shall be in accordance with the same level of requirements defined for the riser / flowline associated with the subsea structure and shall be carried out in accordance with ref. [48] and orientations given in section 5.5.4 of ref. [62].
- 9.4.3. CONTRACTOR shall propose a plan for both subsea inspection and preservation / maintenance inspection (for storage items), comprising the subsea structures and all components of the scope of supply defined in the MATERIAL REQUISITION, which shall include, at least:
- The suggested inspection frequency based on the FMECA results. This proposed inspection frequency shall be previously approved by PETROBRAS.
 - Equipment necessary for inspection plan execution.
 - The acceptance criteria for the recommended inspections.
 - The complete list of components, which shall be replaced at each maintenance event, for all tools that need to go through maintenance and preservation.

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10. MARKING, TRANSPORTATION, STORAGE AND PRESERVATION

10.1. MARKING AND IDENTIFICATION

- 10.1.1. The identification plates for the subsea equipment, its functions and its components shall be of engraved type. Symbols and characters shall be painted in black color, anti-fouling, with a yellow or white background. The identification plates shall be welded into the structure.
- 10.1.2. Unless otherwise defined in the MATERIAL REQUISITION, the subsea equipment and their documentation shall be tagged according to the following rule XXX(X)-YYY(Y).ZZ, where:
- XXXX shall be substituted by the type of subsea equipment as follows: PLET, PLEM, ILT, ILY, ILV and ESDV.
 - YYYY shall be substituted by the code of the project / oil & gas field for which the subsea equipment will be part, as per MATERIAL REQUISITION.
 - ZZ shall be substituted by a sequential number.
- Example: ILT-BUZ5.05 stands for the fifth In-Line Tee for Búzios 5 field.
- 10.1.3. The connector modules, the valves and their documentation shall also receive a short tag, which differentiates them from each other.
- 10.1.4. For marking and identification, requirements from ref. [40] shall be fulfilled.
- 10.1.5. Padeyes and lifting points shall have their respective SWL identification painted.

10.2. TRANSPORTATION SKID AND SLINGS

- 10.2.1. All modules for the subsea equipment scope of supply, such as: connectors, caps, tools, etc., shall be delivered in transportation skids. These skids shall comply with the requirements from ref. [9]. This reference (ref. [9]) is applicable only for onshore transportation of subsea equipment but the slings and skids used for offshore transportation shall be dimensioned for this application.
- 10.2.2. Slings for offshore use shall be designed for both installation and recovery of subsea equipment.
- 10.2.3. Skids for both equipment and tools shall allow onshore and offshore transportation and the suitable storage of these items for the design life of the component. All skids that will be delivered to PETROBRAS shall be painted and shall be designed for the same design life than the respective equipment.
- 10.2.4. The VCM transportation skid shall be pivotable in order to allow the upright of the VCM in case the VCM is transported in the horizontal position onto its skid.

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- 10.2.5. The handling of all equipment/components/accessories/tools shall be feasible by padeyes with no necessity of straps. The VCM shall possess at least three padeyes with shackles to be connected to tag lines during the VCM overboarding / inboarding / tilting with appropriate SWL, especially for the case of inboarding (minimum SWL of 10 ton per padeye). CONTRACTOR shall detail the use of the tag lines at these padeyes during overboarding/inboarding and for the tilting before 1st or 2nd end connection.
- 10.2.6. All slings for the subsea equipment scope of supply shall meet the requirements from ref. [9]. The sling's quality certificate shall be delivered with the invoice of the equipment.
- 10.2.7. The painting requirements from section 7.10 are also applicable for the skids.

10.3. DELIVERY CONDITIONS

- 10.3.1. Only new items will be accepted for final delivery to PETROBRAS.
- 10.3.2. The subsea equipment and all its modules, tools and accessories shall be delivered clean, drained and dry. Hydraulic system and compensation chambers, when applicable, shall be delivered fulfilled with the proper fluid specified by their manufacturers.
- 10.3.3. The sealing areas shall be protected against impacts.
- 10.3.4. The calibration certificates for the tools and accessories included in the scope of supply of CONTRACTOR shall be delivered within a valid period of six months, at minimum, to the expiration date, in order to avoid re-certification by PETROBRAS just after the delivery.
- 10.3.5. All subsea structures / tools / accessories shall be properly conditioned and preserved for installation, pre-commissioning or delivery to PETROBRAS.
- 10.3.6. Prior to delivery to PETROBRAS, all items shall be prepared for long-term storage.
- 10.3.7. Unless otherwise informed in the MATERIAL REQUISITION, CONTRACTOR shall consider a minimum storage period of 18 months for the components, tools and accessories, which shall be delivered by CONTRACTOR to PETROBRAS. Guidance and information on how to extend the preservation of the materials shall be included in the manuals.

10.4. WARRANTY

- 10.4.1. The warranty for the subsea equipment shall comply with PETROBRAS' Materials Supply Conditions at the vendor channel on PETROBRAS's website, unless informed otherwise in the MATERIAL REQUISITION.

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11. DOCUMENTATION

11.1. INFORMATION TO BE PROVIDED IN THE MATERIAL REQUISITION

- 11.1.1. The table below presents the required information for the application of this Technical Specification and that shall be included in the MATERIAL REQUISITION.
- 11.1.2. Loading and service conditions related to the connection systems (DRS, HCM or VCM) to be installed on the subsea equipment will be informed in the MATERIAL REQUISITION.
- 11.1.3. Conditions or requirements for subsea structure anchoring system will be informed in the MATERIAL REQUISITION.
- 11.1.4. Other specific service conditions for the subsea equipment will be also informed in the MATERIAL REQUISITION.

Table 1: Summary of the information to be provided in the MATERIAL REQUISITION

Seq	Description
1.	Internal diameter for the piping and pigging requirements
2.	Fluid properties for erosion considerations (if applicable)
3.	Service conditions (pressure, temperature, SSC region as per ref. [65], chemical composition, pressure / temperature cycles, etc.)
4.	Minimum bend radius for the piping and pigging requirements
5.	Equipment (PLET/ In-Line) x pipeline interface specification (welded or flanged)
6.	Swivel specification
7.	Subsea valve specification, including actuation (mechanical x hydraulic), fail mode (FSC, FSO, FAI), sealing type (Metal x Metal / soft) and seat configuration (DPE x SPE)
8.	Bullseye specification
9.	Necessity for ancillary tools
10.	Soil and metocean data
11.	Project specific coating assessment requirements
12.	Maximum dimension for VCM / HCM (envelope)
13.	Anchoring system requirements
14.	Control system specifications (hydraulic fluid type, closing time, cleanliness level, etc.)
15.	Design life
16.	Subsea equipment vertical/horizontal misalignment limitations for DRS / VCM / HCM connection systems, including, as applicable, vertical/horizontal tolerances for hub connection during the whole system design life
17.	Scope of supply for the caps of the connector system
18.	Specification for valves, ports and hot stabs for the caps

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11.2. DOCUMENTS TO BE PROVIDED BY CONTRACTOR


- 11.2.1. The documentation to be provided by CONTRACTOR for PETROBRAS shall follow the guidelines set forth in ref. [28].
- 11.2.2. The documents shall be codified in accordance with ref. [3], revised as per ref. [6] and formatted in accordance with ref. [2].

11.3. DATA SHEET

- 11.3.1. Table 2 present the minimum data to be provided in the Data Sheet for the subsea equipment. This table can be used as a model for the mentioned Data Sheet.

Table 2: Minimum data to be informed in the subsea equipment Data Sheet

Seq	Description	Value	Unity	Observations
1.	Project			
2.	TAG			
3.	Name			
4.	Manufacturer			
5.	Main Dimensions (L x W x H)		m	
6.	Dry and submerged weight		kg	
7.	Nominal Diameter		in	
8.	Minimum Internal Diameter		in	
9.	Clad specification and thickness		mm	
10.	Thermal insulation specification and thickness		mm	
11.	Coating specification			
12.	Main Materials specifications			
13.	Main fluid specified			
14.	Design pressure		MPa	
15.	Design temperature (min and max)		°C	
16.	Design life		years	
17.	Water depth		m	
18.	Connection system type			
19.	Interface loads capacity (VCM, HCM, DRS, etc.)		kN / kNm	
20.	Valve type and actuation (torque and hydraulic actuation pressures)		Nm / bar	
21.	Material Requisition for the subsea equipment			
22.	MDR for the project			
23.	Operation Manual			
24.	Manufacturing Databook			
25.	Installation Date			

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Seq	Description	Value	Unity	Observations
26.	List of all scope of supply with Part Number, NM and Serial Number of all delivered items			