GUIDANCE NOTES

GD06-2016

China Classification Society

GUIDELINES
FOR CERTIFICATION OF SUBSEA PRODUCTION SYSTEM

2016

Contents

Chapter 1 General

Section 1 General provision

1.1.1 Objective

1.1.1.1 *Guidelines for Certification of Subsea Production System* (hereinafter referred to as the "Guidelines") are formulated to provide acceptable standards for the design, manufacturing, installation and inspection of the subsea production system/equipment, so as to design and manufacture qualified subsea production equipment and minimize the risk of safety production accident and marine pollution caused by leakage of hydrocarbon and harmful chemical substances due to such causes as design defect, system/equipment failure or maloperation.

1.1.1.2 It also provides the China Classification Society (hereinafter referred to as the "CCS") with technical standard when conducting design approval, certificate issuing or identification for the subsea production system/equipment.

1.1.2 Scope

1.1.2.1 The Guidelines specify the inspection and certification requirement on the subsea production system and subsea equipment (including only the subsea wellhead, subsea Christmas tree, subsea manifold, pipeline components, subsea connector, jumper pipe, foundation and structure, subsea control system and umbilicals at present). Those subsea production equipment not covered in the Guidelines shall be designed, manufactured and tested according to the standards recognized internationally.

1.1.2.2 The Guidelines apply to the process to produce hydrocarbon in one or more subsea wellheads and then transport it to specific offshore (fixed, floated or subsea) or ashore production process facilities, or subsea production system and its equipment consisting of multiple subsystems necessary for injecting water/gas via the subsea wellhead.

1.1.2.3 The requirements of the Guidelines on subsea production system/equipment cover and are higher than relevant statutory requirements of the Chinese Government. If the subsea production systems/equipment in foreign waters are required to be inspected according the Guidelines, special statutory requirements from the coastal states shall also be met.

Section 2 Definitions and abbreviations

1.2.1 Definitions

For the purpose of the Guidelines, the following definitions apply:

1.2.1.1 Subsea production system

The generic term of the hydrocarbon production system consisting of subsea equipment used for subsea oil and gas production, colleting and transportation, distribution, separation, boosting, subsea pipeline connection (pipeline component), jumping between subsea equipment (jumper pipe and subsea connector) and subsea injection (water, gas or chemical agent injection), as well as their control system and equipment, protection system and equipments, and bracing structure (excluding the subsea pipeline) between the subsea wellhead and the first boarding shut-down valve on the production and/or process facilities and between the external transportation shut-down valve of the production and/or process facilities and the subsea pipeline boarding shut-down valve.

1.2.1.2 Production and/or Process facilities

The offshore fixed, mobile, floating, man-made island, and the subsea or ashore oil and gas production

and/or process facilities.

1.2.1.3 Boarding shut-down valve

A safety barrier concept used to isolate the subsea production system from the persons and equipments on the production and/or process facilities that has the same function with the surface safety valve (SSV) of the dry-type Christmas tree system, and locates usually at the position close to the riser or the boarding end of the subsea pipeline.

1.2.1.4 Engineering environment test

The process and operation simulating offshore engineering construction under water. In the Guidelines, the main difference between the engineering environment test and sea test is that the former is not carried out at sea but with actual engineering ship. The common ground is that such subsea operations as subsea installation, taking places, operation and recycling, and the function and performance test required shall be completed without direct human interference, that is, to complete the operations and tests in complete accordance to the actual engineering.

1.2.1.5 Sea test

The engineering environment test conducted at sea.

1.2.1.6 Subsea connection system

The generic term of the subsea connector and subsea running tool.

1.2.1.7 Subsea connector

The quick attachment joint that can form a pressure airtight flow system and is used usually independently or with the jumper pipe for connecting the subsea pipeline and the subsea pipeline components, subsea pipeline and subsea equipment, and subsea equipment. There are three types of connectors, namely, the collet connector, clamp connector and bolt-flange connector.

1.2.1.8 Running Tool or Pull-in Tool

The generic term that involves generally the running tool for subsea connector, seal ring replacement kit and other maintenance tool, which can be used for installing, uninstalling and maintaining the subsea connector without any instruction or assistance.

1.2.1.9 Hub

The flange with external angle ledge and sealing mechanism on the butt joint part of the subsea connector, which come usually in pair.

1.2.1.10 Clamp

The equipment with internal chamfer ledge used for tightening the supporting hub.

1.2.1.11 Collet segments

The parts with internal chamfer ledge that are distributed uniformly to form symmetric components and used for tightening the supporting hub.

1.2.1.12 Actuation ring

The primary locking mechanism of the collet connector that slides usually from the root of the collet segments to the other end to locking the hub via the collet segment.

1.2.1.13 Receiver structure

The foundation support of the subsea connector supporting hub that has sufficient strength and guide function generally.

1.2.1.14 Secondary Locking mechanism

The mechanical lock device used to prevent the attachment joint from occasional unlocking due to such reasons as vibration. The secondary lock is realized generally by fixing the actuation ring onto the upper surface of its supporting structure by tightening the screw.

1.2.1.15 High-load-bearing

The loading status of a load applied to a part that generates an equivalent loading stress of more than 50% of the min. yield strength of the basis material.

1.2.1.16 Objective evidence

The documented field experience, test data, technical periodical, finite element analysis or calculation result used for verifying the applicable performance requirement.

1.2.1.17 Shall

It is used to express the requirement specified in the Guidelines that shall have no disputation and be followed strictly, unless it is accepted by all relevant parties.

1.2.1.18 Shall

It is used to recommend the suitable practice out of several possible methods without mentioning or excluding other practices, which indicates the a practice/method has the priority but it is not necessary.

1.2.1.19 May

It is used to express that a practice is permitted in the range specified by the standard.

1.2.1.20 Other definitions used in chapters of the Guidelines will be specified in such chapters respectively.

1.2.2 Abbreviations

1.2.2.1 The abbreviations used in the Guidelines are expressed as follows:

S/N	Abbreviations	Full names
1	API	American Petroleum Institute
2	AWS	American Welding Society
3	BOP	Blowout preventer
4	CRA	Corrosion-resisting alloy
5	EDP	Emergency detaching parts
6	ESD	Emergency shut-down
7	FAT	Factory acceptance test
8	HAZOP	Hazard and Operability Analysis
9	HIPPS	High Integrity Pipeline Protection System
10	ITP	Inspection and test plan
11	MEG	Mono Ethylene Glycol
12	NACE	National Association Of Corrosion Engineers
13	PCS	Production control system
14	PIV	Production isolating valve
15	PLEM	Pipeline End Manifold
16	PLET	Pipeline End Terminal

17	PMV	Production main valve
18	PSD	Production shut-down
19	PSL	Product specification level
20	pWPS	Preliminary welding procedure specification
21	PVT	Performance verification test
22	ROT	Remote operation tool
23	ROV	Remotely-operated vehicle
24	SAT	Site acceptance test
25	SCM	Subsea control module
26	SCSSV	Surface Controlled Subsurface Safety Valve
27	SEM	Subsea electronic module
28	SIL	Safety Integrity Level
29	SIT	System Integrity Test
30	SSIV	Subsea Isolating Valve
31	TGB	Temporary Guide Base
32	WPQR	Welding Procedure Qualification Record
33	WPS	Welding Procedure Specification

1.2.2.2 Abbreviations in the chapters of the Guidelines will be specified in such chapters.

Section 3 Recognized standard

1.3.1 General requirements

1.3.1.1 In addition to meeting the requirement of the Guidelines, the CCS recognizes the applicable parts of the international standard, foreign advanced standard, national standard and industrial standard in respect of the design, manufacturing, installation, inspection and test of subsea production system/equipment.

1.3.1.2 Any standard to be used to substitute the one recognized by the Guidelines shall be proved that it has the same safety level with that of the recognized standard, and evaluated and approved by the CCS first before being used.

1.3.1.3 Different standards shall not be applied to the same equipment or system.

1.3.1.4 Any inconsistence with the design standard, and exempt and modification of the design standard shall be noted clearly in the design document, and approved by the owner and the CCS.

1.3.1.5 The latest standard at the time when the design contract takes effect shall be adopted. Otherwise, it shall be specified clearly in the contract.

1.3.2 Recognized standard

1.3.2.1 In addition to the subsea production system designed according to the Guidelines, the CCS accepts the subsea production system and equipment designed according to the following standards or the equivalence.

1	ANSI/API RP 17A	Design and Operation of Subsea Production SystemsGeneral Requirements and Recommendations.
2	API RP 17B	Recommended Practice for Flexible Pipe.
3	API RP 17C	Recommended Practice on TFLThrough Flowline Systems.
4	ANSI/API RP 17D	Design and Operation of Subsea Production SystemsSubsea Wellhead and Tree Equipment.
5	API RP 17E	Specification for Subsea Umbilicals.
6	ANSI/API RP 17F	Specification for Subsea Production Control Systems.
7	ANSI/API RP 17G	Specification for Subsea Production Control Systems.
8	ANSI/API RP 17H	Remotely Operated Vehicle (ROV) Interfaces on Subsea Production Systems.
9	API RP 17I	Installation Guidelines for Subsea Umbilicals.
10	ANSI/API RP 17J	Specification for Unbonded Flexible Pipe.
11	ANSI/API RP 17K	Specification for Bonded Flexible Pipe
12	ANSI/APIP 17M	Petroleum and natural gas industriesDesign and operation of subsea production systems Part 9: Remotely Operated Tool (ROT) intervention systems.
13	ANSI/API RP 17N	Subsea Production System Reliability, Technical Risk & Integrity Management.
14	ANSI/APISpec.6A	Specification for Wellhead and Christmas Tree Equipment.
15	API 17 O	Recommended Practice for Subsea High Integrity Pressure Protection Systems (HIPPS).
16	ASME B31.3	Process Piping.
17	ASME B31.8	Gas Transmission and Distribution Piping Systems.
18	AWS D1.1/D1.1M	Structural welding code Steel
19	GB/T 21412.1	Design and Operation of the Subsea Production System in the Petroleum and Natural Gas Industry, Part 1: General Requirement and Recommended Practices.
21	GB/T 21412.2	Design and Operation of the Subsea Production System in the Petroleum and Natural Gas Industry, Part 2: Flexible Pipe System Used Subsea or at Sea.

22	GB/T 21412.3	Design and Operation of the Subsea Production System in the Petroleum and Natural Gas Industry, Part 3: Through-the-flow-line (TFL) System.
23	GB/T21412.4	Design and Operation of the Subsea Production System in the Petroleum and Natural Gas Industry, Part 4: Subsea Wellhead Device and Christmas Tree Equipment.
24	GB/T 21412.5	Design and Operation of the Subsea Production System in the Petroleum and Natural Gas Industry, Part 5: Subsea Umbilicals.
25	GB/T 21412.6	Design and Operation of the Subsea Production System in the Petroleum and Natural Gas Industry, Part 6: Production Control System.
26	GB/T 21412.7	Design and Operation of the Subsea Production System in the Petroleum and Natural Gas Industry, Part 7: Well Completion and Repair Riser System.
27	GB/T 21412.8	Design and Operation of the Subsea Production System in the Petroleum and Natural Gas Industry, Part 8: Interface for the Remote Operated Vehicle of the Subsea Production System.
28	GB/T 21412.9	Design and Operation of the Subsea Production System in the Petroleum and Natural Gas Industry, Part 9: Maintenance System of the Remote Operated Tool.
29	GB/T 20174-2006	Boring and Oil Extraction Equipment and Drilling-through Equipment in the Petroleum and Natural Gas Industry.
30	GB/T20972.1-2007	Materials Used in the Hydrogen Sulfide Environment During Oil and Gas Exploitation in the Petroleum and Natural Gas Industry, Part 1: General Principle for Selecting Crack-resistance Materials.
31	GB/T20972.2-2008	Materials Used in the Hydrogen Sulfide Environment During Oil and Gas Exploitation in the Petroleum and Natural Gas Industry, Part 2: Crack-resistance Carbon Steel, Low Alloy Steel and Cast Iron.
32	GB/T20972.3-2008	Materials Used in the Hydrogen Sulfide Environment During Oil and Gas Exploitation in the Petroleum and Natural Gas Industry, Part 3: Crack-Resistance and Anti-corrosion Alloy and Other Alloy.
33	GB/T 22513-2008	Wellhead Device and Christmas Tree of the Boring and Oil Extraction Equipment.
34	IEC 60885	Electrical test methods for electrical cables
35	IEC 60811	Common test method for insulating and sheeting materials of electric and optical cables.
36	IEC 60794	Optical fibre cables.
37	ISO13628-1	Petroleum and natural gas industries Design and operation of subsea production systems Part 1: General requirements and

		recommendations.
38	ISO13628-2	Petroleum and natural gas industries Design and operation of subsea production systems Part 2: Flexible pipe systems for subsea and marine applications.
39	ISO13628-3	Petroleum and natural gas industries Design and operation of subsea production systems Part 3: Through Flow Line TFL systems.
40	ISO13628-4	Petroleum and natural gas industries Design and operation of subsea production systems Part 4: Subsea wellhead and tree equipment.
41	ISO13628-5	Petroleum and natural gas industries - Design and operation of subsea production systems Part 5: Subsea control umbilicals.
42	ISO13628-6	Petroleum and natural gas industries - Design and operation of subsea production systems Part 6: Subsea production controls.
43	ISO13628-7	Petroleum and natural gas industries Design and operation of subsea production systems Part 7: Completion/workover riser systems.
44	ISO13628-8	Design and Operation of Subsea Production Systems - Part 8: Remotely Operated Vehicle ROV Interfaces on Subsea Production Systems.
45	ISO13628-9	Petroleum and natural gas industries Design and operation of subsea production systems Part 9: Remotely Operated Tool ROT intervention systems.
46	ISO13628-15	Petroleum and natural gas industries Design and operation of subsea production systems Part 15: Subsea structures and manifolds.
47	ISO 14313	Petroleum and natural gas industries Pipeline transportation systems - Pipeline valves.

1.3.2.2 Risk assessment shall be carried out on subsea production system and equipment designed according to other standard or adopting new technologies, and the safety technology level shall not be lower than those of the Guidelines and recognized standards.

Chapter 2 Inspection and certification

Section 1 General provision

2.1.1 General requirements

2.1.1.1 The Guidelines are used by the CCS as the basis for design approval, certification inspection and identification inspection on the subsea production system/equipment, which can be used as the basis for statutory inspection after being recognized by competent authorities or quoted by statutory rules.

2.1.1.2 In case of any major change to the subsea production systems, key equipment, and their arrangements and materials that have been inspected as per the Guidelines, the applicant shall inform the CCS in time and obtain relevant approval.

2.1.1.3 To guarantee the smooth and timely inspection on the subsea production system/equipment, the applicant shall provide proper inspection conditions, including the transportation to the inspection site and other convenience.

2.1.2 Certificate issuing

2.1.2.1 The subsea production system conformity certificate can be issued only after the subsea production system/equipment is applied for certification by the owner or its agent, subjected to design review, inspection, and test, and then confirmed to comply with relevant provisions of the Guidelines.

2.1.3 Certificate validity period

2.1.3.1 The certificate validity period is 5 years, unless otherwise specified. Application for certificate renewal inspection shall be made 3 months ahead of the expiration date of the current certificate, and an extended period of no more than 1 month is allowed by the CCS if the inspection cannot be completed in time due to objective cause. The validity period of the new certificate starts from the expiration of the old certificate. The annual inspection shall be conducted within 3 months before/after the anniversary date the inspection certificate is issued for the first time or renewed most recently.

2.1.4 Certificate validity condition

2.1.4.1 The certificate gets invalid automatically in case of any of the following circumstances:

(1) No application for inspection or test is made within the inspection interval specified in the Guidelines;

(2) No application for inspection is made after the system and key equipment are subject to environmental disruption and accidental damage;

(3) Reconstruction and repair affecting the safety have been made on the system and key equipment without approval;

(4) Defects affecting the safety remain on the system and key equipment;

(5) The subsea production system is subject to serious damage caused by the responsible party due to failure of observing the operation rules on such system in the specific range.

(6) The responsible party of the subsea production system fails to report to the CCS of or conduct necessary repair on the serious defects found on the system that violate the requirement of the Guidelines, applicable regulations or standards;

(7) No application for the CCS's inspection and approval on any damage, reconstruction, repair or major replacement on the subsea production system, transmission medium change, or major transmission condition change.

2.1.4.2 The certificate can be valid again after the items equivalent to expiration inspection are completed within half a year after the certificate is invalid; the certificate cannot be valid again until an inspection equivalent to that in the certificate change range is completed if the certificate has been invalid for more than half a year.

Section 2 Subsea equipment inspection classification

2.2.1 General requirements

2.2.1.1 The subsea production equipment shall be subject to inspection to make sure it meets the requirement of the Guidelines or the client.

2.2.1.2 For products involved in the Guidelines, if no technical requirement is specified, they can be designed, manufactured, inspected and tested as per the standards recognized by the CCS.

2.2.1.3 For products specified in the Guidelines, relevant standards can be accepted for substitution. However, they shall be subject to design evaluation, in-phase inspection and test as well as function test, so as to confirm they are equivalent to the provisions of the Guidelines.

2.2.1.4 After the subsea equipment is inspected to be qualified, relevant certificate and / or other inspection certification documents will be issued to the applicant.

2.2.2 List of subsea production equipment certification classifications

2.2.2.1 The products are inspected as per the following three types, namely, A, B, and C.

The subsea production equipment is inspected for certification as per the following three types, namely, A, B, and C (see Table 2.2.2.1). The principle is that equipment of Types A and B shall obtain the certificated issued by the CCS and be marked with category at a conspicuous position on the certificate; for equipment of Type C, only factory certificate is required. Table 2.2.2.1 shows a minimum requirement of equipment certification classification, which can be adjusted by the responsible party and the CCS according to the the specific production requirement and the contract/agreement signed by both parties. CA indicates the product inspection certificate issued by the CCS, and W indicates the certificate issued by the manufacturer.

(1) Type-A equipment certification requirement

① The design document shall be reviewed and approved by the CCS;

② Relevant construction document shall be reviewed and approved by the CCS first before commencement;

③ The responsible party and the CCS will send representatives to participate in the commencement meeting;

④ Inspection shall be applied according to the quality assurance plan during manufacturing;

⑤ The performance and function test, pressure test and loading test shall be applied for inspection;

⑥ The CCS shall review the equipment manufacturing record.

(2) Type-B equipment certification requirement

① Safety-related design data shall be reviewed and approved by the CCS;

② The performance and function test, pressure test and loading test shall be applied for inspection;

③ the CCS shall review the equipment manufacturing record.

For type-A and type-B equipment, the CCS shall review the manufacturer's quality

management system and quality assurance/quality control (QA/QC) as well as quality plan before commencement, and specify the quality control point and inspection activity category.

(3) Factory certificate requirement on type-C equipment

If it is safety-related, the CCS accepts the equipment with product certificate provided by the manufacturer. The factory shall carry out the production according to recognized standards, regulations and manufacturing method. Otherwise, relevant document, calculation and analysis report must be subject to design review by the CCS.

(4) The skid-mounted equipment shall be subject to certification inspection, and the certification inspection category shall be determined according to the highest certification inspection category of such components as the container, equipment and material of the skid-mounted equipment. Such components shall also be subject to certification inspection as per the above-mentioned classification requirement, or be provided with relevant certificates.

Table 2.2.2.1 List of equipment inspection and certificate classification

No.	Equipment name	Inspection type			Certificate type	
		A	B	C	CA	W
1	**Subsea wellhead device**	**×**			**×**	
1.1	Subsea wellhead connector	×			×	
1.2	Subsea baseplate-type wellhead	×			×	
1.3	Wellhead head		×		×	
1.4	Conductor housing		×		×	
1.5	Casing head		×		×	
1.6	Tubing hanger		×		×	
1.7	Seal assembly		×		×	
1.8	Wellhead corrosion protection cap			×		×
1.9	Guiding device/guideline		×		×	
1.10	Wellhead protector and abrasion resistance bush			×		×
2	**Subsea Christmas tree and test tree**	**×**			**×**	
2.1	Christmas tree connector		×		×	
2.2	Actuator for the processing valve, group valve and valve		×		×	
2.3	Throttle valve and throttle valve actuator		×		×	
2.4	Christmas tree cap (internal cap)		×		×	
2.5	Christmas tree garbage cap			×		×
3	**Subsea manifold and pipeline end manifold**	**×**			**×**	
4	**Process pipeline component: Pipe tee (including Y type and T type) terminal, subsea safety isolating valve**	**×**			**×**	

No.	Equipment name	Inspection type			Certificate type	
		A	B	C	CA	W
	device/assembly, and pipeline connecting system/component for other connection process.					
5	**Non-process pipeline component (such as the component for supporting)**		**×**		**×**	
6	**Well completion/repair riser system**	**×**			**×**	
6.1	Riser foundation	×			×	
6.2	Flexible riser buoyancy block		×		×	
6.3	Riser tension system		×		×	
6.4	Riser		×		×	
6.5	Riser joint		×		×	
6.6	Connector/joint		×		×	
6.7	Key control valve		×		×	
7	**Subsea separation system/device**	**×**			**×**	
7.1	Power equipment (driving motor)		×		×	
7.2	Oil-water interface monitoring system and device		×		×	
7.3	Equipment, container and system monitoring system and device		×		×	
8	**Subsea pressurization system / device /station**	**×**			**×**	
8.1	Power equipment (driving motor)		×		×	
8.2	System and equipment monitoring system and device		×		×	
9	**Jumper pipe**	**×**			**×**	
9.1	Subsea steel jumper pipe	×			×	
9.2	Subsea flexible jumper pipe		×			×
10	**Subsea connection system/device**	**×**			**×**	
10.1	Connecting hub		×		×	
10.2	Locking mechanism (primary and secondary)		×		×	
10.3	Pressure cap			×		×
10.4	Garbage cap			×		×
11	**Subsea flowmeter and inspection**		**×**		**×**	

No.	Equipment name	Inspection type			Certificate type	
		A	B	C	CA	W
	device (for example, the sand detector					
11.1	External electricity and signal connector, cable and signal line		×		×	
11.2	Electricity and signal socket contacting the seawater		×		×	
11.3	Power supply and electric appliance components			×		×
12	**Control system of the subsea production system**					
12.1	Offshore hydraulic power unit		×		×	
12.2	Subsea control cabinet		×		×	
12.3	Subsea umbilical termination head assembly (distribution and control)	×			×	
12.4	Subsea distribution unit (electricity and liquid)	×			×	
12.5	Subsea umbilical termination head	×			×	
12.6	Umbilicals		×		×	
12.7	Flexible pipe system (including pipes and accessories)		×		×	
12.8	Electricity, liquid, signal fly line and joint		×		×	
12.9	Energy accumulator/device		×		×	
12.10	Hydro-power pump /circulating pump		×		×	
12.11	Control and monitoring instrument		×		×	
12.12	Control cabinet and control display		×		×	
12.13	Control computer and complex computer			×		×
13	**Subsea equipment control module**	**×**			**×**	
13.1	Subsea control module (SCM)		×		×	
13.2	Other control-related equipment			×		×
14	**Subsea driving system and equipment**		**×**		**×**	
14.1	Subsea driving pressure-containing member		×		×	
14.2	Driving-related equipment			×		×
15	**Subsea equipment processing pipe system**		**×**		**×**	
15.1	Nonstandard pipeline and pressure-containing structural material		×		×	

No.	Equipment name	Inspection type			Certificate type	
		A	B	C	CA	W
15.2	Composite material pipe fitting		×		×	
15.3	Composite material elbow		×		×	
16	**Equipment, component and material contacting directly with seawater**					
16.1	pressure-containing container	×		×		
16.2	Main functional pumping set (pump and driving motor)		×		×	
16.3	Valve group and valve		×		×	
16.4	Pipeline and pipe fitting (including the hose)		×		×	
16.5	Metering device		×		×	
16.6	Cable		×		×	
16.7	Connector (including liquid, electricity and signal)		×		×	
16.9	Heat reservation and corrosion-resisting materials		×		×	
17	**All casting/forging pieces used on subsea equipment**		**×**		**×**	
18	**Foundation and structure**					
18.1	Protective structure material of the subsea equipment		×		×	
18.2	Supporting structure material of the subsea equipment		×		×	
18.3	Suction anchor		×		×	
18.4	Suction anchor centering guide cylinder			×		×
18.5	Materials for suction anchor body and accessories		×		×	
19	**Cathode protection**		**×**		**×**	
19.1	Cathode protection material for subsea material		×		×	
19.2	Cathode protection material for tools			×		×
20	**Subsea tools**					
20.1	Custom tool (including running tool)		×		×	
20.2	Special tool (rather than custom type)			×		×
21	**Installation and well repair control system**		**×**		**×**	

No.	Equipment name	Inspection type			Certificate type	
		A	B	C	CA	W
21.1	Hydraulic power unit and well repair control panel		×		×	
21.2	Well repair roller		×		×	
21.3	Tubing hanger roller		×		×	
21.4	Emergency cut-off device		×		×	
21.5	Driving unit for the operation tool of the blowout preventer and Christmas tree		×		×	
21.6	ROV fly line of the BOP and Christmas tree		×		×	
21.7	Remote well repair control unit/portable electronic test equipment		×		×	

Section 3 Design review

2.3.1 General provision

2.3.1.1 Prior to commencement, the application unit shall submit the drawing data (including the debugging routine requirement on key equipment) specified in the section in triplicate to the CCS for review. If necessary, the CCS can extend the scope of the drawing data to be submitted for review.

2.3.1.2 The manufacturing and installation processes on the subsea production equipment shall be submitted to the unit of the CCS responsible for inspection for review.

2.3.1.3 For any principled modification or supplement to the approved drawing data, such modification or supplement shall be submitted by the applicant again for review.

2.3.1.4 Prior to construction and installation of any subsea production system/equipment, the applicant shall submit a written application to the headquarter of the CCS or its field inspection agency for construction inspection.

2.3.2 List of drawing data to be submitted

(1) General specification of the engineering project:

It shall at least include simple description on field location, environment condition, shut-in pressure, well flow property, production plan, oil and gas storage, and oil and gas transmission plan.

(2) Material and manufacturing specifications;

(3) Drawing and calculation report (including but not limited to):

① General layout diagram;

② Subsea production system/equipment flow chart;

③ Legend, symbol and description of the subsea production system/equipment diagram;

④ Pigging flow chart;

⑤ Process control flow chart;

⑥ Safety control flow chart;

⑦ Design-related calculation sheet, for example, the process calculation sheet.

(4) Bill of materials (BOM);

(5) Relevant design data sheet, for example, the list of mass and heat balance (balance sheet of materials).

2.3.2.2 Subsea wellhead

(1) Technical standard applied to the product;

(2) General product specifications (including the product design basis and product specifications);

(3) Product design drawing: Main component drawing, component and BOM;

(4) Design calculation sheet (including but not limited to the strength and corrosion prevention calculation sheet);

(5) Prototype and /or type test report (if any);

(6) Corrosion prevention layout diagram;

(7) Test procedure and acceptance criteria;

(8) Appearance mark and description;

(9) ROV operation interface and relevant document.

2.3.2.3 Subsea Christmas tree

(1) Technical standard applied to the product;

(2) General product specifications;

(3) Product design drawing, including component drawing, component and BOM;

(4) Design calculation sheet (including but not limited to the strength and corrosion prevention, flow assurance and lifting calculation sheets);

(5) Risk assessment /analysis report (applicable to new products);

(6) Prototype and /or type test report (if any);

(7) Main process drawing and document;

(8) Control logic diagram (including safety monitoring and control);

(9) Corrosion prevention layout diagram;

(10) Appearance mark and description;

(11) Test procedure and acceptance criteria;

(12) ROV operation interface and relevant document.

2.3.2.4 Subsea pipe fitting and pipeline component

(1) Technical standard applied to the product;

(2) General product specifications;

(3) Product design drawing, including component drawing, component and BOM;

(4) Design calculation sheet (including but not limited to the structure and pipeline strength calculation and analysis, corrosion prevention, flow assurance and lifting calculation sheets);

(5) Risk assessment /analysis report (applicable to new products);

(6) Main process drawing and document;

(7) Control logic diagram (including safety monitoring and control);

(8) Corrosion prevention layout diagram;

(9) Appearance mark and description;

(10) Test procedure and acceptance criteria (including FAT and SIT, and engineering environment test program for newly-developed products).

(11) ROV operation interface and relevant document.

2.3.2.5 Subsea connection system

The documents submitted by the applicant to the CCS for review include but not limited to the following:

Basic design condition (including at least the brief description of the equipment, such as the application, basic function, environment condition, and operating conditions, such as pressure, well flow property and temperature);

(1) Technical specification;

(2) Bill of materials;

(3) Relative design data sheet;

(4) Material and manufacturing specifications;

(5) General layout diagram, corrosion prevention and nondestructive test layout plans,, and relevant information;

(6) Equipment control flow chart and relevant data;

(7) Relevant data such as the equipment structure strength (including various design conditions, installation and design) calculation sheet and finite element analysis on each component of the connector;

(8) Corrosion prevention calculation sheet;

(9) ROV operation interface and relevant document;

(10) Risk analysis data (if any);

(11) Test procedure and acceptance criteria (including FAT and SIT, and engineering environment test program for newly-developed products).

(12) Operation instructions.

2.3.2.6 Jumper pipe

(1) Technical standard applied to the product;

(2) General product specifications;

(3) Product design drawing, including BOM;

(4) Design calculation sheet (including but not limited to the stress analysis, vibration, corrosion prevention, and lifting analysis calculation sheets under extreme working condition);

(5) Main process drawing and document;

(6) Corrosion prevention layout diagram (if applicable);

(7) Appearance mark and description;

(8) Test procedure and acceptance criteria;

(9) ROV operation interface and relevant document (if applicable).

2.3.2.7 Subsea control system and umbilicals

(1) Technical standard applied to the product;

(2) General product specifications;

(3) Product design drawing, including BOM;

(4) Design calculation sheet (including but not limited to the power load, umbilicals, and lifting analysis calculation sheets);

(5) Control logic diagram;

(6) If the control system involves such subsea equipment as the subsea distribution assembly and umbilical termination head assembly, relevant facility drawings shall also be submitted as per Clause 2.3.2.4;

(7) Test procedure and acceptance criteria.

2.3.2.8 Foundation and structure

(1) Technical standard applied to the product;

(2) General product specifications;

(3) Product design drawing, including BOM;

(4) Design calculation sheet:

① Mud mat: Including but not limited to the bearing capacity, slippage, sedimentation, torsion and penetration capability, and lifting calculation reports;

② Suction anchor: Including but not limited to the compression bearing capacity calculation and lifting calculation sheet;

③ Driven pile: Including but not limited to the strength calculation and pile strength calculation report at lifting, piling and free-standing operating conditions.

(5) Pointing device layout diagram (If applicable);

(6) Corrosion prevention layout diagram;

(7) Appearance mark and description;

(8) Test procedure and acceptance criteria;

(9) ROV operation interface and relevant document.

2.3.2.9 the CCS will review the drawing data submitted to confirm that the design complies with the previsions of the Guidelines or standards accepted by the CCS. After the review, the CCS will issue drawing review approval notification to the applicant, mark the approval status on the submitted technical documents and send back the approved drawings.

Section 4 Manufacturing inspection

2.4.1 General provision

2.4.1.1 The subsea equipment shall be manufactured as per the quality system and drawing data approved by the CCS.

2.4.1.2 Single component and equipment shall meet relevant requirement of respective product, and pass the factory acceptance test and system integration test.

2.4.1.3 The acceptance test procedure shall be executed comprehensively at the manufacturing site so as to ensure the components are manufactured as per relevant requirement and meet the system performance requirement.

2.4.2 Preparation before inspection

2.4.2.1 For the manufacturer that manufactures the subsea production equipment for the first time, the Surveyor shall evaluate and confirm its production capacity, including the quality assurance systems of the production site, facilities and manufacturer, overall qualification of the constructors and subcontractors.

2.4.2.2 Before commencement, the Surveyor shall check and confirm the preparation related to the commencement, manufacturing and inspection, such as manufacturing preparation working plan, construction/welding process, welder/nondestructive test personnel's qualification, list of product permit requirements, list of welding specifications, nondestructive detection chart, list of inspection/test items, list of effective inspection equipment, manufacturing-related materials, manufacturing tolerance standard, subcontractor conditions (if applicable), and technical documents (such as the drawing document) necessary for the commencement.

2.4.2.3 The field Surveyor shall review the approved drawing data, test schedule (program) and drawing review comments, examine and approve the field construction drawings, construction process to confirm the construction drawing and process comply with the approved drawing data and relevant regulation requirement, and conduct the inspection as per the approved drawing data and test schedule (program).

2.4.3 Manufacturing inspection requirement

2.4.3.1 In addition to conducting specific product inspection according to the product drawing approved in Section 3 of the chapter, the Surveyor shall understand the operating principle of the whole subsea production system / equipment, the function of the product inspected in the system, and the specific requirement of the equipment specifications.

2.2.4.2 The Surveyor shall conduct product inspection according to the approved drawing and equipment specifications.

2.4.3.3 The manufacturing inspection involves the inspection during manufacturing and pre-delivery inspection and test.

2.4.3.4 The manufacturing inspection includes but not limited to the following items:

(1) Confirm the inspection and test plan;

(2) Confirm or evaluate welder's qualification;

(3) Check welding procedure specification and relevant welding procedure evaluation record;

(4) Check the material certificate or document;

(5) Witness the nondestructive test of the welding , review the nondestructive test record of the welding, and pay attention to the different requirements on the process pipeline and structural components;

(6) Check the postweld heat treatment, especially for the pressure line with acid medium, which shall meet the requirement of relevant standard;

(7) Check whether such key parameters as installation and size of the equipment, parts and components are consistent with those of the approved drawings and relevant standards;

(8) Check to confirm the corrosion prevention operation of the equipment meets the redetermined requirement, and pay attention to the different requirements on the process pipeline and structural components;

(9) Check to confirm the control, monitoring and instrument on the equipment are consistent with those in the drawing;

(10) Conduct the test and inspection according to the approved test schedule (procedure);

(11) Check the status of the list of items as per the inspection and test plan, and issue relevant release permit;

(12) Check other items agreed on by all parties in advance.

2.4.4 Welding and nondestructive test

2.4.4.1 pressurized pipeline and pressurized parts

(1) In addition to special requirement specified in other chapters of the Guidelines, the welding of pressurized pipeline and pressurized parts of the subsea structure shall meet the requirement of the standard applied generally;

(2) The welding of the upper pressurized parts of the subsea Christmas tree shall meet the welding requirement of ISO13628 Petroleum and natural gas industries - Design and operation of subsea production systems Part 4: Subsea wellhead and tree equipment 5.3.1;

(3) The welding of the corrosion-resisting alloy used for the subsea Christmas tree shall meet the welding requirement of ISO13628 Petroleum and natural gas industries -

Design and operation of subsea production systems Part 4:Subsea wellhead and tree equipment 5.3.3

Design and operation of subsea production systems Part 4: Subsea wellhead and tree equipment 5.3.3.

(4) The welding, welding process evaluation and nondestructive test technique requirement of the subsea manifolds and pipeline components shall meet the requirement of the technical specifications, but shall not be lower than the technical requirement of ISO13628 Petroleum and natural gas industries Design and operation of subsea production systems Part 15: Subsea structures and manifolds7.11.

2.4.4.2 Main structural components

(1) In addition to special requirement specified in other chapters of the Guidelines, the welding of main structural parts of the subsea structure shall meet the requirement of the standard applied generally; the welding of key parts shall be carried out as per the requirement pressurized parts;

(2) Generally, the welding of main structural parts of the subsea structure shall meet the requirement of ISO13628 Petroleum and natural gas industries - Design and operation of subsea production systems - Part 1: General requirements and Recommendations Annex K (normative) Requirements and recommendations for lifting devices and unpressurized structural components K.3 Welding of structural components, and the equivalent standard can also be accepted;

(3) The welding of the structural components of the subsea Christmas tree shall meet the welding requirement of ISO13628 Petroleum and natural gas industries - Design and operation of subsea production systems Part 4: Subsea wellhead and tree equipment 5.3.2.

2.4.4.3 CRA material welding

The overlaying, welding process evaluation, postweld treatment and acceptance of the CRA material shall meet relevant requirement of GB/T22513 Chapter 6 (or the equivalent standard ISO10423).

2.4.5 Heat treatment

2.4.5.1 The forging material used for the pressurized and highly-pressurized components shall be subject to heat treatment as per ISO13628-4 5.2.2 Material properties.

2.4.6 Nondestructive test

2.4.6.1 The pressurized structural components shall be subject to the following generally after welding:

(1) 100% visual inspection;

(2) 100% surface inspection;

(3) 100% ultrasonic and / or X-ray inspection.

2.4.6.2 Pressurized components of the manifold and pipeline component

(1) The nondestructive test on the pipe fitting of the manifold and pipeline component shall meet the requirement of ISO13628-15 7.7 Non-destructive inspection of components;

(2) The nondestructive test on the overlaying components of the manifold and pipeline component shall meet the technical requirement of 7.10 Overlay welding and buttering of components;

(3) The postweld nondestructive test requirement of pipeline of the manifold and pipeline component shall meet the requirement of 7.11 Welding and non-destructive testing of piping systems7.11.3 Inspection and non-destructive testing (NDT) of welds.

2.4.6.1 Main structural components

The nondestructive test on the structural component of the subsea structure and equipment shall meet the requirement of the approved technical specifications or the welding requirement on non-pressurized components specified in ISO10423 and GB/T 22513.

2.4.7 Purchased equipment inspection and confirmation

(1) Review the delivery documents and relevant certificate of the purchased equipment as per relevant requirement of Section 2;

(2) Check the consistence of the equipment nameplate and certificate.

2.4.8 Function and performance test

2.4.8.1 For the function and performance test on the subsea production system/equipment,generally all the subsea operating conditions shall be simulated as much as possible onshore, and specific test requirement of each equipment shall be in consistent with that of corresponding chapter and section. The test program of main subsea equipment shall be submitted to the drawing review department specified by the CCS for approval.

2.4.8.2 Overall inspection confirmation before test: To guarantee the manufacturing, construction and installation quality of each equipment and system before debugging, items in 2.4.8.3-2.4.8.10 shall be checked or confirmed as per inspection document approved before debugging.

2.4.8.3 Equipment appearance inspection

The equipment appearance inspection includes but not limited to the following items:

(1) Check the correctness of the equipment nameplate, sign or code;

(2) Check to confirm the equipment is assembled and installed as per the installation process and manufacturer's instruction;

(3) Check to confirm the rotating parts are provided with safety precautions;

(4) Check to confirm the equipment is connected firmly with the pedestal/main structure;

(5) Check to confirm the heat preservation and/or freeze-proofing and/or venting practice are in place;

(6) Check to confirm the operation, maintenance access and safety passageway are qualified (if applicable);

(7) Check to confirm the small operating platform, rail and ladder (if applicable) meet the requirement;

(8) Check to confirm there are no sundries and dangerous articles around the site.

2.4.7.4 Internal inspection confirmation of the equipment

The internal inspection confirmation of the equipment includes but not limited to the following:

(1) Check to confirm there are no foreign matters inside the equipment or container;

(2) Check to confirm the integrity of the internal coating

2.4.7.5 Pipeline appearance check

The pipeline appearance inspection includes but not limited to the following items:

(1) Check to confirm the pipeline is arranged orderly, so as to facilitate the inspection and maintenance;

(2) Check the inlet/outlet of the valve and the medium for correct flow direction;

(3) Check to confirm the valve rotation direction and open/close status display are correct;

(4) Check to confirm the size and installation of the inlet/outlet pile of the safety valve are correct.

2.4.7.6 Instrument control system inspection

The instrument control system inspection includes but not limited to the following:

(1) Check to confirm all the instruments installed in the system pass the inspection and calibration of specialized department;

(2) Check to confirm the instrument appearance is neat, the numeric characters are clear, and the instrument indicator returns to zero or is in the normal indication position;

(3) Check to confirm the cable is arranged reasonably, not subject to damage easily, and kept away from heat source and liquid leakage source;

(4) Check to confirm the cable is installed firmly and orderly, and convenient for line inspection;

(5) Check to confirm the conduction connection and earthing connection are effective and correct;

(6) Check to confirm the equipment control panel is in good condition, arranged rationally, and convenient for operation;

(7) Check to confirm the operation position for emergency shut-down meets the design requirement.

2.4.7.8 Purging and washing test

Check to confirm the purging and washing test is competed and meets the requirement if it is required according to actual equipment requirement.

2.4.7.9 Debugging special tool and special inspection instrument

(1) Check to confirm the special tool and instrument needed are ready;

(2) Check to confirm the inspection instrument required for debugging is calibrated by the statutory department.

Section 5 Subsea equipment installation and debugging

2.5.1 Inspection basis

The authentication test on offshore installation and debugging of the subsea equipment is conducted mainly based on the requirement of the approved inspection and test plan (ITP).

2.5.2 Main inspection contents

2.5.2.1 Installation process authentication

2.5.2.2 Verification test on installation correctness authentication

(1) Subsea equipment function test;

(2) Subsea equipment performance test, for example, tightness.

2.5.2.3 Debugging result authentication after installation:

(1) Authenticate whether the joint debugging result of the subsea production system meets the preset requirement;

(2) Authenticate whether the subsea system meets the preset requirement;

(3) Authenticate the normal operation function and emergency operation function of the subsea control system;

(4) Authenticate the redundancy control function of the subsea control system.

Section 6 Production period inspection on the subsea production system

2.6.1 General requirements

2.6.1.1 The periodic inspection during production (production period inspection) refers to the annual inspection, renewal inspection and temporary inspection on production facilities issued with work permit by the safety office during production.

2.6.1.2 The production period inspection shall be carried out as per the time specified generally. If experience or technical analysis indicate that different interval for inspection is more suitable, such interval can be adopted after being approved by the CCS.

2.6.1.3 No major changes shall be made to the inspected structure, equipment, device, arrangement or materials, except for the change to the equipment or device directly for the purpose of repair or maintenance, which shall be applied for relevant inspection by the CCS.

2.6.2 Annual inspection

2.6.2.1 Inspection deadline

The annual inspection shall be conducted within 3 months before/after the anniversary date the inspection certificate is issued for the first time or renewed most recently. The annual inspection can be replaced by the renewal inspection.

2.6.2.2 Inspection items

(1) The appearance integrity inspection on the platform-boarding valve and subsea equipment (including subsea control equipment and umbilicals);

(2) Test the automatic control and local control functions of the platform-boarding valve, or check the maintenance and repair record according to the plan if the test is not practical (circuit simulation test is accepted);

(3) Check the insulating property of the umbilicals, optical cable continuity, and corrosion monitoring record. In the maintenance period, each pipeline (1.0 time of the design working pressure for control pipeline, and 1.1 times that of of the design working pressure for chemical agent pipeline) shall be subject to hydraulic pressure test.

(4) Conduct control function test on the subsea Christmas tree, subsea manifold, and pipeline components with remote shut-down function for the subsea control system (simulation test can be accepted if the planned maintenance and repair record is available for the main subsea equipment);

(5) Subsea Christmas tree:

① Check the maintenance and repair record of the subsea Christmas tree;

② Conduct communication verification test on the subsea control module;

③ Conduct function test on the function valve (circuit simulation function test can be accepted if planned maintenance record is available);

④ The emergency shut-off test includes the platform emergency shut-off simulation and emergency shut-off signal test;

⑤ Check whether the cathodic protection meets the requirement.

(6) Subsea manifold:

① Test control system;

② Check the corrosion monitoring record (the corrosion thickness cannot exceed the corrosion allowance);

③ Test to see whether the function meets the requirement of normal operation and switching (circuit simulation test can be accepted if planned maintenance record is available);

④ Check whether the cathodic protection meets the requirement.

(7) Pipeline components:

① Conduct the inspection specified in (6) above;

② Check whether the geographic position of the pipeline component is within the specific range.

(8) Subsea control equipment (distribution unit)

① Conduct the inspection specified in (6) above;

② Conduct signal transmission validity test.

(9) Jumper pipe

① Check the corrosion monitoring record (the corrosion thickness cannot exceed the corrosion allowance);

② Check whether the cathodic protection meets the requirement;

③ Check the monitoring record to see whether the position and angle are within the allowable range.

(10) Other subsea equipment:

① Check the corrosion monitoring record (the corrosion thickness cannot exceed the corrosion allowance);

② Check whether the cathodic protection meets the requirement;

③ Check the monitoring record to see whether the position and angle are within the allowable range.

(11) Alternative measure

If the periodic routing inspection plan, monitoring and maintenance scheme of the responsible party on the subsea production system, equipment, and control system are accepted by the CCS, the annual inspection contents can be substituted by the routing inspection, monitoring and test record within 3 months.

(12) Other inspection items deemed necessary by CCS.

2.6.3 Renewal inspection

2.6.3.1 Inspection deadline

The certificate validity period is 5 years, and application for certificate renewal inspection shall be made 3 months ahead of the expiration date of the current certificate. An extended period of not more than 1 month is allowed by the CCS if the inspection cannot be completed in time due to objective cause. The

validity period of the new certificate starts from the expiration of the old certificate.

2.6.3.2 Inspection items

(1) All annual inspection contents;

(2) Pressure test on pressurized subsea equipment:

① Tightness of the subsea Christmas tree body as well as the main test function valve and safety valves when being closed (differential pressure test method used in the industry can be accepted);

② Other subsea equipment (if the upper limit of the working pressure can be controlled, the max. working pressure or working pressure can be accepted as the min. test pressure, whichever is bigger).

(3) Function test on the production main valve of the subsea Christmas tree, production flutter valve, main hohlraum valve, hohlraum flutter valve, shut-down valve of the subsea manifold, shut-down valve of the pipeline component, and control system;

(4) Function and tightness test on the subsea safety valve;

(5) Validity inspection on corrosion prevention measures of the subsea equipment;

(6) Appearance leakage inspection on all subsea equipment (routing inspection records within 3 months can be accepted);

(7) Other inspection items of the above-mentioned facilities deemed by the CCS or responsible party.

2.6.4 Temporary inspection

2.6.4.1 The subsea production system shall be subject to temporary inspection in the following conditions:

In case of any major change to the subsea production systems, key equipment, and their arrangements and materials that have been inspected as per the regulation, the responsible party of the subsea production system shall applied to the CCS for temporary inspection.

Chapter 3 General rule for system and equipment design

Section 1 General provision

3.1.1 Objective

3.1.1.1 Realize the designed functions for the subsea production system while guaranteeing safety and environment protection;

3.1.1.2 Guarantee the subsea equipment manufacturing meets the requirement of competent authority (if specified), specifications or relevant standards;

3.1.1.3 Reduce the operation risk of the subsea production system/equipment.

3.1.2 Functional requirement

To reach the above-mentioned objectives, the subsea production system/equipment shall have the following functions:

(1) Transmit safely the well flow to relevant equipment for processing safely;

(2) Transmit safely the needed fluid into the well safely;

(3) Effectively control the fluid outputted from/inputted in the well;

(4) Conduct systematic design on the failure safety.

3.1.3 Application

Unless otherwise specified, the chapter applies to all phases of the subsea production system/equipment items, including the overall design requirement on the subsea production system, operation interface requirement of the subsea production system and other relevant system, as well as verification on the subsea production system/equipment performance requirement via analysis and test.

ISO13628-1Petroleum and natural gas industries Design and operation of subsea production systems Part 1:General requirements and recommendations 1 Scope

The chapter also applies to the contents of ISO13628-1 Petroleum and natural gas industries - Design and operation of subsea production systems - Part 1: General requirements and recommendations, 1 Scope.

Section 2 System and equipment design

3.2.1 General provision

3.2.1.1 During specific oilfield development, the design basis shall be provided as soon as possible, which includes the following contents generally:

(1) Load (any load that may affect the subsea production system/equipment at each relevant phase such as manufacturing, storage, test, transmission, installation, well drilling/completion, operation and dismantling);

(2) Operation requirement;

(3) Technological process;

(3) Well flow composition;

(4) Injection requirement and medium;

(5) Operation requirement;

(6) Operation strategy;

(7) Test requirement;

(8) Status monitoring;

(9) Control system design data;

(10) Pipeline data;

(11) Heat expansion data;

(12) ROV torsion tool;

(13) Guide anchor and guide post locking mechanism.

3.2.1.2 Comprehensive considerations shall be taken to optimize the subsea production system design. The demand for oilfield development at each phase shall be taken into comprehensive consideration.

3.2.1.3 During primary design, the demand for expanded production shall be taken into consideration.

3.2.1.4 During subsea production system design, the requirement on the manufacturing, test, installation, operation, inspection, maintenance, repair and discarding of the subsea production system shall be taken into consideration systematically.

3.2.1.5 The requirement on the subsea installation, recycle and interference shall be taken into consideration systematically for the design of the subsea production system/equipment.

For the interference, the interference requirement at each relevant phase such as installation, recycling and maintenance shall be taken into consideration.

3.2.1.6 All pressurized equipment shall be selected and classified according to the system operation or max. test pressure. For pressurized equipment installed subsea, the design pressure can be the hydrostatic pressure after adjustment.

3.2.1.7 The system design shall facilitate the fault diagnosis without recycling the system /equipment.

3.2.1.8 In addition to the requirement of the clause, the general design requirement shall meet the requirement of ISO 13628-1 5.5.

3.2.2 Design load

3.2.2.1 Any load that may affect the subsea production system/equipment at each relevant phase such as manufacturing, storage, test, transmission, installation, well drilling/completion, operation and dismantling shall be specified in the design basis and treated as the design basis.

3.2.2.2 The specific accidental load of an item shall be specified via special risk analysis in actual application, and the accidental load can involve the falling object, pulling load (such as salvage, fishing gear and anchor), as well as unusual environmental load (for example, earthquake). ISO 13628-15.4 Design Loads can be referred for design.

3.2.2.3 Load caused by falling object or salvage (including fishing operation) on subsea production equipment: The impact load of the falling object shall be treated as the plastic limit condition. The actual impact force applied to the structure shall be treated as the initial design load. In addition, relevant requirement on falling object and trawlnet load in ISO 13628-1.

The min. pulling speed is not less than 3.0 m/s generally.

3.2.2.4 The selection of design loads for the unpressurized main structural components and hoisting equipment shall follow the requirement of ISO 13628-1, 5.4.2.

3.2.2.5 The guide base for boring shall involve the possibility of verification for top cement liquid level in

the pipeline (for example, the grouting funnel). The proper arrangement on the cement liquid level (for example, the cementing plug) shall be taken into consideration.

3.2.3 Ambient conditions

During subsea production system design, the installation position of the subsea production system, as well as the ambient condition data of the external transportation pipeline, gathering pipeline in the oilfield and tie-back shall be taken into consideration.

The environment conditions to be considered include the ocean data, meteorological data, oil pool and liquid data, well completion data, process and operation data, and relevant facility data. The consideration and selection of each environment condition shall follow the requirement of ISO13628 5.2.

3.2.4 Product specification level

The specification level of the subsea equipment shall not be less than the lowest PSL specified in Fig. 3.2.4.

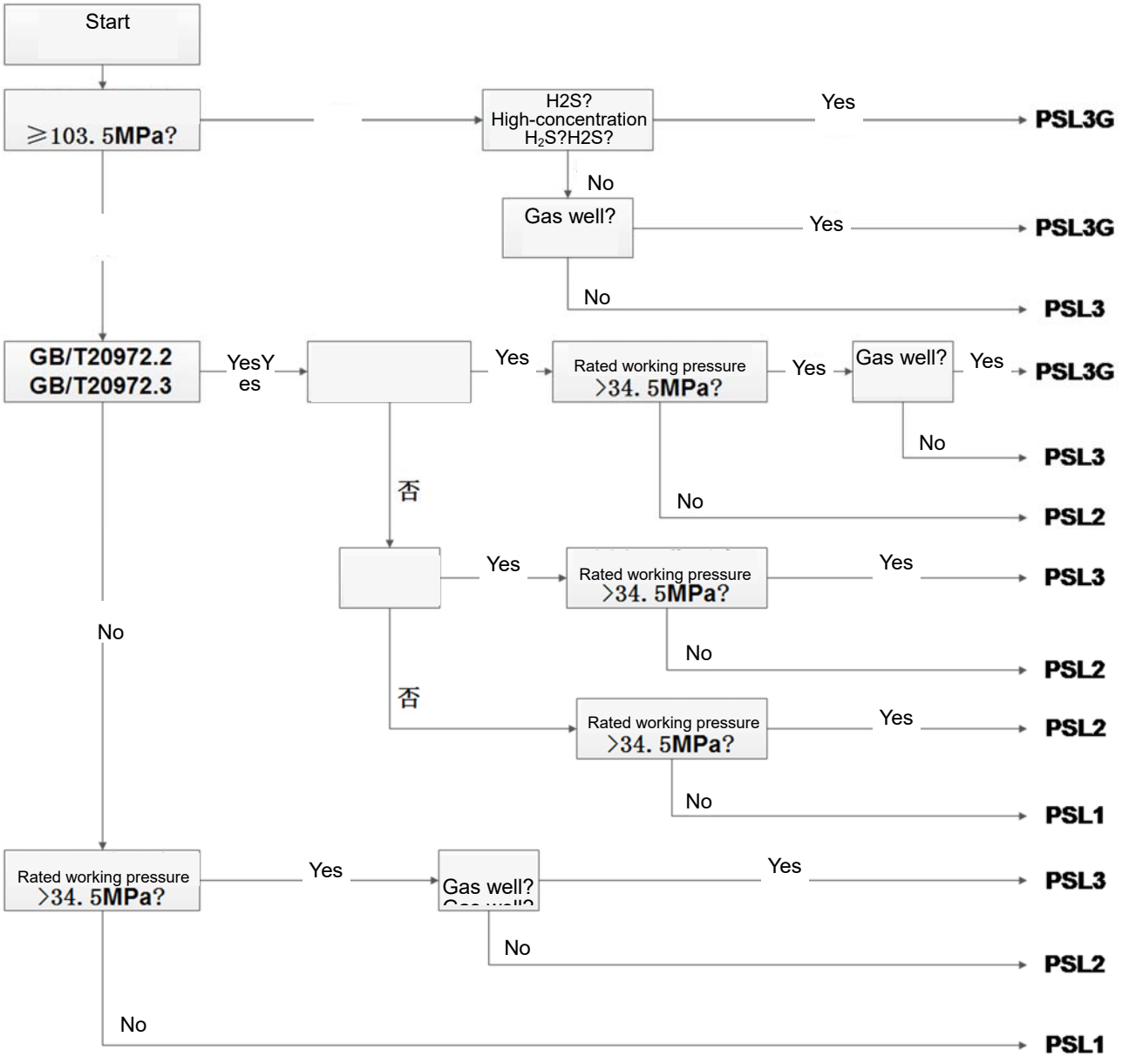

Fig. 3.2.4 Recommended lowest PSL

(1) PSL1 includes the operation condition recommended in the section, which is the practice widely applied in the petroleum industry.

(2) PSL2 includes all the requirements of PSL1 as well as the specific operation conditions recommended in the section;

(3) PSL3 includes all the requirements of PSL2 as well as the specific operation conditions recommended in the section;

(4) PSL3G includes all the requirements of PSL3 as well as the specific operation conditions recommended in the section. The PSL3G sign applies only to the terms and numerical tables that must be provided with additional air-tight seal test requirement for the device; the specified device can be used for air-tight seal test;

(5) PSL4 includes all the requirements of PSL3G and some additional requirement. PSL4 applies to the operation condition exceeding the range specified in Fig. 3.2.4, which used for main equipment generally.

3.2.5 Rated working pressure

3.2.5.1 The selection of the rated working pressure of the subsea production equipment shall meet the requirement of recognized standard, so as to match with the subsea production equipment and connecting system connecting with it. For example, the max. rated working pressures generally used for the Christmas tree are: 13.8 MPa (2,000 psi) , 20.7 MPa (3,000 psi) , 34.5 MPa (5,000 psi), 69.0 MPa (10,000 psi) , 103. 5 MPa (15,000 psi) and 138.0 MPa (20,000 psi) Current domestic pressure levels are 14 MPa, 21 MPa, 35 MPa, 70 MPa, 105 MPa and 140 MPa.

3.2.5.2 The rated working pressure selected for the subsea wellhead and Christmas tree shall be bigger than the shut-in pressure.

3.2.6 Max. and min. temperatures

3.2.6.1 Max. temperature

(1) If the max. operating temperature can be specified accurately, it can be treated as the max. design temperature. For example, the oil pool temperature can be treated as the max. design temperature of the subsea production system/equipment and components;

(2) If the max. operating temperature cannot be specified, the max. design temperature shall not be lower than the max. operating temperature plus 30C;

(3) The high temperature shut-down function specified according to ISO10418 or other recognized standard can be used to limit the max. operating temperature, and an margin shall be added when specifying the max. design temperature; when the max. design temperature affects the selection of material and pressure level, pay attention not to select the max. design temperature that is higher than the specified value.

3.2.6.2 Min. temperature

The min. design temperature determines the low temperature performance requirement of the material, which shall be the stringent one out of the following:

(1) Min. operating temperature (obtained at normal operation, startup, shut-down or disorder condition minus 5;

(2) Select a safety factor based on the min. environment temperature of the available meteorological data and the quality of the meteorological data;

(3) Min. temperature occurred during decompression minus 5.

3.2.7 Temperature level

The rated design temperature of the subsea production equipment shall be in consistent with that of

ISO10423 or GB/T 22513-2008, as shown in Table 3.2.7.

Table 3.2.7 Rated temperature

Temperature level	Operation range (℃)	
	Min. environment temperature bearable for the device	Max. fluid temperature that can be touched by the device
K	-60	82
L	-46	82
P	-29	82
R	Room temperature	
S	-18	66
T	-18	82
U	-18	121
V	2	121

3.2.8 Material

3.2.8.1 Scope

The section applies to the material application of subsea structure, manifold, pipeline and other component that are important for the safety and operation of the subsea production system.

3.2.8.2 The following factors shall be taken into consideration for material selection:

(1) Select materials with sound market supply, manufacturing and performance;

(2) Minimize the material types, and take the cost, interchangeability and usability of relevant spare parts into consideration;

(3) Design lifetime;

(4) Working environment;

(5) Experience in using the material and anticorrosive methods in the same corrosion environment;

(6) System usability requirement

(7) Maintenance and system redundancy concept

(8) Corrosion allowance

(9) Inspection and corrosion monitoring possibility

(10) External and internal environment, including the compatibility impact of different materials

(11) Evaluation on failure probability, failure mode, criticality and consequence, including any adverse effect on personal health, environment, safety, and material assets;

(12) Impact of corrosion inhibitor and other chemical treatment on the environment.

3.2.8.3 The material application shall generally:

(1) Be accompanied with relevant design specifications in the design specification requirement;

(2) Comply with recognized national and ISO standards;

(3) Be provided with past record of special applications, for example, components of the same type and size range.

3.2.8.4 The material shall be easy for welding (if applicable).

3.2.8.5 In addition to the requirement of the section, the application of metal material, non-metal material, subsea bolt material and materials shall meet relevant requirement of ISO13628-16 Materials and corrosion protection.

3.2.8.6 Material level

(1) The material level of the production equipment as well as different environment factor and such factors as production variability shall be listed in the specification or relevant technical documents submitted. The material level selected shall meet the requirement of 3.2.8.6;

3.2.8.6

Table 3.2.8.6 Material requirement

Material level a	Min. material requirement	
	Body, hub and outlet connection	Pressure control parts (such as the clamp and locking actuation ring, clamp and seal ring body)
AA - General application	Carbon steel or low alloy steel	Carbon steel or low alloy steel
BB - General application	Carbon steel or low alloy steel	Stainless steel
CC - General application	Stainless steel	Stainless steel
DD - Acid environment a	Carbon steel or low alloy steel b	Carbon steel or low alloy steel b
EE - Acid environment a	Carbon steel or low alloy steel b	Stainless steel b
FF - Acid environment a	Stainless steel b	Stainless steel b
HH - Acid environment a	Corrosion-resisting alloy bc	Corrosion-resisting alloy bc
a indicates relevant equivalent standard ISO15156 can also be accepted as per the GB/T20972.1 definition; b indicates it meets the requirement of GB/T20972.1, GB/T20972.2 and GB/T20972.3, and relevant equivalent standard ISO15156 can also be accepted; c CRA is required for the surface wetted with fluid; CRA lining made with low alloy steel or stainless steel is allowed.		

(2) If the mechanical property can be guaranteed, the arbon steel and low alloy steel can be replaced by stainless steel, and stainless steel can be replaced by corrosion-resisting alloy by.

(3) For the forgings materials of pressurized parts and high-loading components, the requirement on forging technology, process, heat treatment and test sample shall be in consistent with that of API RP 6HT. The test sample shall be subject to heat treatment together with the approved material body, but it is not necessary to eliminate the residue stress at the same time.

3.2.9 Corrosion prevention

3.2.9.1 External corrosion prevention

(1) Effective anti-corrosion measures shall be taken or anti-corrosion materials shall be adopted for the surface of the subsea production system/equipment exposed in the ocean environment;

(2) If the anti-corrosion coating is adopted for protection, the coating adopted shall be approved by the CCS. Otherwise, permission must be obtained by the CCS;

(3) The sacrificial anodes method is generally adopted for cathodic protection on the structure;

(4) If different metals are connected in the system, electrochemical corrosion prevention measure shall be taken;

(5) In addition to the requirement of the clause, the requirement of ISO13628-1 6 Materials and corrosion protection shall also be met.

3.2.9.2 Internal corrosion prevention

(1) The oil and gas production system is mainly subject to carbon dioxide (CO_2) corrosion, hydrogen sulfide (H_2S) corrosion, and chloridion corrosion. The design is mainly focused on the $CO_2$and H_2S corrosion under acidic condition. Generally, one or more of the following measures shall be taken to control the corrosion:

① Select corrosion-resisting materials, including the high alloy materials;

② Add corrosion allowance for carbon steel material during design;

③ Add corrosion inhibitor to the system;

④ Conduct dehydration;

⑤ Provide internal coating.

(2) For metal materials, corrosivity evaluation shall be conducted at least on the following items:

① CO_2 contents;

② H_2S contents;

③ Contents of oxygen and other oxidizing agent;

④ Operating temperature and pressure;

⑤ Acidity and pH value;

⑥ Halide concentration/chemical property of water;

⑦ Flow velocity limit.

(3) If the operation temperature of a part of the system is lower than the water dew point, such system is defined as the wet-type;

(4) The carbon dioxide corrosion evaluation shall be based on the recognized corrosion prediction model or application experience of similar oil and gas field;

(5) For corrosion-resisting materials used in the "acidity" environment, the requirement on drying or usage of corrosion inhibitor shall be followed strictly;

① The equipment and pipeline subject to H2S corrosion shall meet the requirement of the standard NACE MR 0175/ISO 15156 Petroleum and Natural Gas Industry - Materials Used in the H2S Environment During Oil and Gas Production;

② The acid environment risk shall be evaluated in the design lifetime, especially for the circumstance that water will be injected in the future;

(6) During design of the oil and gas pipeline, the corrosion inhibitor efficiency shall be 85%, including glycol and / or methyl alcohol injection, unless higher efficiency is proved to be

available:

① The actual corrosion inhibitor efficiency shall be recognized and proved via corrosion test, unless relevant valid industry or test data is available for demonstration.

② The preset operating environment shall be taken into full consideration for the corrosion inhibitor performance evaluation, such as the product component, corrosion and flow limitation;

(7) For pipeline system used to transporting hydrocarbon containing heavy water, the corrosion on the pipeline shall be reduced by adopting both the combination of the pH stabilizer and corrosion inhibitor or the corrosion inhibitor alone; the joint effect of the combination of the pH stabilizer and corrosion inhibitor shall be recognized or proved via corrosion test, unless relevant valid industry or test data is available for demonstration;

(8) The water injection system shall be subject to corrosion evaluation:

① The water injection involves the injection of degassed seawater, untreated seawater and production water, including the underground water;

② The corrosion evaluation on the degassed seawater injected during the regular degassing process, the max. operating temperature and oxygen equivalent level suitable for the injection area can be applied;

③ For carbon steel injection pipeline used at seabed in the low corrosion environment, the min. corrosion allowance shall not be less than 3 mm generally. If the design corrosion allowance is bigger than 3 mm-4 mm, corrosion-resisting alloy or composite pipeline shall be adopted;

④ If degassed seawater, production water and/or gas will pass through the injection system alternately, special consideration shall be given for material selection. In case of any possibility of backflow, all the components that may contact the injected water shall be subject to oil resistance processing and corrosion processing by injecting chemical agent and production-increasing chemical agent. For carbon steel pipeline, the max. flow velocity shall be determined after evaluation, and the corrosion and corrosion ability of the flow velocity to the system shall also be taken into consideration during the evaluation.

3.2.9.3 Evaluation after contingency

If seawater(Cl-) -sensitive materials (such as the CRA material) are adopted for the subsea production equipment, the equipment shall be subject to comprehensive safety evaluation during installation and debugging, after long-term seawater contacting, and before being put into operation.

3.2.10 Manifold and pipeline component process pipeline

3.2.10.1 In principle, the pipeline and supporting structure shall not be welded directly.

3.2.10.2 Pipeline system capable of pigging:

(1) The min. Radius of the elbow on the pigging pipeline shall be 3 times of the radius of the pipeline;

(2) The continuous bend, valve, branch pipe and their combination shall be separated with straight leg with a min. length of 3 times of the internal diameter of the pipeline;

(3) Pigging sundries shall not be piled up on the branch pipe of the pigging pipeline. The branch pipe shall locate transversely right above the central axis of the header pipe;

(4) The design and manufacturing of the tee joint and components on the pigging pipeline shall meet the requirement of pigging operation; the tee joint with bars is generally used to reduce the possibility of damaging the pigging device (aluminum) plate during pigging operation;

(5) Continuous inner diameter shall be provided on the whole pigging pipeline.

3.2.11 Flow valve design

3.2.11.1 ISO 13628-4ISO 10423 ISO 14313 万波

3.2.11.1 The design of the process flow valve shall meet the requirement of ISO 13628-4, ISO 10423 and ISO 14313.

3.2.11.2 The valve performance shall not be affected at the max. combination of the external load (for example, the pipeline connected) and the operating load. The valve supplier shall specify the load limit. The valve performance shall be proved via analytic demonstration and / or test.

3.2.11.3 Any penetration on the valve body and bonnet shall be avoid as much as possible. Any port used for test shall be sealed and welded after the test.

3.2.11.4 For the valve on the pipeline capable of pigging operation, the pipe cleaner shall be specified by the final user/owner. The value design shall apply to all specified pipe cleaner without limit or block in any direction. There shall no sundries or loose debris that may damage the pipe cleaner in the valve. For the valve on the pipeline capable of pigging operation, method of verifying whether the valve is in the fully-opened position before pigging operation shall be available.

3.2.12 Subsea equipment structure

In addition to the following requirement, the subsea structure shall meet the requirement of the normative standard applied:

3.2.12.1 The subsea structure shall be capable of aligning the physical connection interfaces between relevant equipment, such as the interfaces between wellhead device/production guide foundation, subsea Christmas tree/manifold and piping, manifold/subsea pipeline terminal and auxiliary installation equipment, as well as protective structure (if any) and other relevant port.

3.2.12.2 The subsea structure can be fixed/locked onto the subsea wellhead system, or independent (not be fixed directly onto the wellhead device). For the independent type, relevant structural piping shall be capable of being connected flexibly onto the wellhead module or manifold module.

3.2.12.3 The size of the subsea structure shall match with the maintenance method (such as the remotely-operated vehicle, remote operation tool or diver).

3.2.12.4 The anti-trawl structure shall be capable of preventing the device protected from being pulled or towed during trawl operation. Such capability shall be verified via model test or geometric evaluation by combining the module test data. The test procedure and verification standard shall be recognized by local fishery authority or fishery/trawl specialist with rich experience in specific area.

3.2.12.5 Pressure balance measure shall be taken to prevent hollow structure from being crushed. The internal protection requirement on the hollow structure shall be evaluated.

3.2.12.6 During falling object protection design, the design/operation procedure of the protection structure shall guarantee that the subsea equipment will not be damaged by falling object, fishing tool and other accidental load. The structure design shall also guarantee that the remotely-operated vehicle, umbilicals and guide rope are not hooked with each other.

3.2.12.7 Hinge joint or movable panel can be used to provide protection for each wellbay and key devices.

3.2.12.8 The bottom edge of the structure/protection structure shall be embedded into the seabed, so as to reduce the risk of being hooked.

3.2.12.9 The following factors shall be taken into consideration for the load transmitting between the wellhead system and the guide frame/bottom frame:

(1) Soil condition and axial stiffness of the wellhead system;

(2) Anti-deformation structure design in the vertical direction and stiffness of the bottom structure;

(3) Interface design and flexibility tolerance (if any) of the subsea structure/wellhead;

(4) Sleeve thermal expansion.

3.2.12.10 The guide structure/bottom structure shall be capable of transmitting the design load on the interface system and equipment to the foundation. The thermal expansion effect of the drill conductor / wellhead head shall be taken into consideration for the design of the wellhead supporting structure/production guide foundation.

3.2.12.11 The oil well supporting structure shall provide the drill conductor with guide, positioning and locking capability, as well as sufficient space for putting in place and operating the subsea wellhead blowout preventor, and for the adjacent Christmas tree.

3.2.12.12 The onshore assembly and test demand on the supporting device shall be taken into consideration during the design of the wellhead supporting structure.

3.2.12.13 The use of drillings treatment system shall be taken into consideration during wellhead system design, that is, the accumulation of drillings in the structure shall not interfere with the preset operation.

3.2.12.14 To guarantee efficient repair, maintenance, and installation of the subsea operations the design of on the subsea basement, supporting structure and its equipment shall follow the principles below:

(1) If there are no other safety measures available, all recyclable modules and structures shall be locked with proper locking mechanism, and such mechanism shall be operated via preset loading and unloading scheme;

(2) The hinged protection structure shall be designed to be replaceable;

(3) The positioning area and the surrounding area shall be designed in a way that they can bear the load applied by such subsea operation equipment as various repair, maintenance and installation equipment during the positioning and operation process. The max lowering speed of the tool controlled with guide wire shall be 1.6 m/s. The max lowering speed of the tool controlled with drill stern shall be 0.8 m/s;

(4) Proper observation position shall be provided during the positioning,connection and operation of the tool, module and equipment ;

(5) Proper positioning area and/or fixing point shall be provided at the control operation position;

(6) Protection measure shall be taken at sensitive parts/positions on the subsea structure that are easy to be damaged by the subsea repair, maintenance and installation equipment;

(7) A funnel shall be provided to facilitate the replacement of the acoustics transponder, and capable of avoiding acoustics shield and possible hooking;

(8) All locking and lifting mechanisms on the protective cap shall be operated as per such subsea operation schemes as the preset repair, maintenance and installation;

(9) The locking mechanism that can be operated via the preset operating equipment shall be adopted for the replaceable guide post;

(10) For permanently-installed guide post with guide line, the design that allows new guide line to be installed on the broken line or fixator shall be adopted;

(11) If torque or knocking is required during the process of installing equipment on the subsea structure, a special tool or interface shall be provided;

(12) The design (such as the position of the anodes block and details of other structures) shall be capable of preventing the preset subsea repair, maintenance and installation equipment from being hindered or hooked.

(13) The positioning speed and soft boarding system demand shall be evaluated;

(14) The operation requirement on the subsea repair, maintenance and installation equipment when being lowered from the ship shall be met, necessary guide line offset angle shall not limit the operation path of the ROT, and the lowering gap or possibility of affecting the operation safety

shall be reduced;

(15) Sign shall be provided to facilitate the diver and / or remotely-operated vehicle's recognition on the equipment;

(16) Sufficient gaps shall be maintained between tools, blowout preventers, modules and any part of the recyclable equipment and structures, as well as adjacent modules and equipment, so as to avoid any accidental collision or impact during installation and recycling operation. Physical contact between the module and adjacent structure is not allowed, even with the worst accumulated tolerance;

(17) For operation without guide line, physical limiting measures (such as the guide funnel or bumper beams) shall be provided, so as to avoid any collision between adjacent equipment.

3.2.13 Sealing

3.2.13.1 The sealing between components/parts of the subsea equipment shall meet the special requirement on each equipment specified in relevant chapters, and the sealing material shall be selected as per recognized standards.

3.2.13.2 Sealing between metals shall meet the requirement of ISO13628-1 6.2.3.3, recognized standard/standard accepted by the CCS.

3.2.13.3 Sealing between non-metallic materials shall meet the requirement of ISO13628-1 6.3 Non-metallic materials, recognized standard/standard accepted by the CCS.

3.2.13.4 All the sealing (including the secondary sealing material and sealing area) shall resist all specific fluids that may be contacted during the test, debugging and operation process.

3.2.13.5 The sealing material selected shall be capable of scratch resistance.

3.2.13.6 Generally, the sealing material shall be superior to the body material. Corrosion-resisting alloy material shall be adopted for sealing surface exposed directly to the seawater without any cathodic protection.

3.2.13.7 Corrosion-resisting material shall be used as the elastic material used on the valve seat and sealing.

3.2.13.8 Materials made via forging, rolling or hot isostatic pressing shall be adopted for the valve body and bonnet of the subsea valve, unless otherwise specified.

3.2.14 Test

3.2.14.1 The interface matching between single components, assembly parts, equipment, as well as equipment and tools shall meet the requirement specified, and verified via the factory acceptance test (FAT) and system integrity test (SIT).

3.2.14.2 For the test on subsea equipment on the water surface, all working conditions that may be encountered underwater shall be simulated generally, and the test result shall meet the preset requirement.

3.2.14.3 For general test requirement and test procedure requirement, see the requirement of relevant chapters. For those not specified, the requirement of ISO13628-1 7 Manufacturing and testing shall be met.

3.2.14.4 For the factory acceptance test (FAT) and system integrity test (SIT), relevant record chart shall be kept.

3.2.15 Transportation and lifting

3.2.15.1 For subsea equipment and main components of the subsea production system:

(1) They can be hoisted with drill stern (if applicable);

(2) Special transportation devices shall be minimized;

(3) The unique number, dry weight and hoisting point shall be marked.

3.2.15.2 The hoisting capacity of the working ship shall be taken into consideration if offshore hoisting is required for the equipment. Special lifting sling shall be used for hoisting work.

3.2.16 Work and operation

3.2.16.1 Work requirement

Work shall meet relevant requirement specified in ISO13628-18 Operations.

3.2.16.2 Operation requirement

(1) The operation, maintenance and repair procedures of the subsea production system/equipment as well as the equipment instructions provided by the manufacturer shall be available;

(2) The repair, maintenance and inspection record on the subsea production system/equipment shall be available;

(3) The operator shall conduct the hazard and operability analysis on the subsea production system/equipment, find out problems that may occur under normal and abnormal circumstance, causes, possible subsequence, as well as measures to be taken;

(4) In addition to the requirement of the section, relevant requirement in ISO13628-19 Documentation shall also be met.

3.2.17 Anti-pollution

3.2.17.1 The subsea production system and equipment shall be designed and arranged in a way that the risk of hydrocarbons pollution to the marine environment due to accident, leakage or maloperation can be minimized.

3.2.17.2 Any equipment containing hydrocarbons shall be designed in a way that it will not pollute the marine environment when being removed, displaced or cleaned. The cleaning liquid shall be recycled, so as to avoid any marine environment pollution.

3.2.17.3 The setting and operation of the pigging operation equipment shall not cause the dirt to pollute the marine environment.

Section 3 Safety system

3.3.1 Scope

3.3.1.1 The safety system specified in the chapter includes the safety protection measures taken to avoid any accident caused by the subsea production system/equipment and the shut-down measures taken after any accident.

3.3.1.2 It applies to the overall safety system design on the subsea production system ranging from the subsea wellhead to the boarding shut-down valve.

3.3.2 Standard accepted

(1) SY/T 10033 Recommendations for the Design, Installation and Test for the Safety System of the Basic Upper Facilities of the Offshore Production Platform.

(2) API RP 14C Recommendations for the Analysis, Design, Installation and Test for the Basic Safety System of the Offshore Production Platform.

(3) IEC 61511 Safety Instrument System Standard

3.3.3 Safety system design

3.3.3.1 The conditions of both the subsea and platform shall be taken into consideration and analyzed comprehensively during the safety system design, so as to minimize the risk.

3.3.3.2 During safety system design, each process unit shall be subject to safety analysis, so as to identify the possible accident, analyze its cause and consequence, find out detectable abnormal situation, and take relevant safety protection measure.

3.3.3.3 Two-level protection shall be provided for the safety system (level 1 and level 2), so as to minimize the impact caused by equipment failure. Generally, safety devices with different function types shall be adopted for such 2-level protection. Otherwise, identical disadvantages will exit.

3.3.3.4 If a processing unit is connected to an upstream or downstream unit, they are not isolated during operation, and the safety devices of the upstream and downstream units can protect it, the safety device required for such processing unit can be ignored.

3.3.3.5 When the safety device detects any accident, acoustic-optic alarm shall be sent out in the manned control station.

3.3.3.6

3.3.3.6 The safety analysis function table shall be used to list the safety devices required for each process unit and the safety functions executed by each safety device (for example, shut-down), so as to verify comprehensively whether the design logic of the safety production system is reasonable.

Section 4 High integration pressure protection system

3.4.1 General provision

3.4.1.1 The subsea high integrity pressure protection system (HIPPS) shall meet the requirement of the section. For the definition, composition, typical configuration, general technology (such as control) as well as maintenance and test, operation and training, and document saving requirement, see relevant contents in Section 3, Chapter 4 of the *Regulations on Offshore Oil and Gas processing System* issued by the CCS.

3.4.1.2 In addition to following the provisions of the section, the standard API RP 17 O issued by American Petroleum Institute can be referred to for the design of the HIPPS of the subsea production system.

3.4.2 HIPPS application condition

3.4.2.1 When being used, the usability and reliability of the HIPPS shall not be lower than those of the single mechanical pressure unit replaced.

3.4.2.2 HARZOP analysis shall be conducted on HIPPS and the protected system when HIPPS is used for system protection.

3.4.3 Technical requirements

3.4.3.1 HIPPS shall be independent of the flow control system, flow shut-down and emergency shut-down system, and be capable of completing pressure safety protection alone.

3.4.3.2 The safety integration level of the HIPPS shall reach SIL3.

3.4.3.3 To avoid unnecessary production halts or any risk caused by restarting after such halt, the possibility of potential false shut-down shall be minimized when configuring the HIPPS system.

3.4.3.4 The HIPPS shall be designed as per the failure safety principle.

3.4.3.5 HIPPS shall have the function of hardware and software diagnosis and test.

3.4.3.6 HIPPS shall have the self-locking function in case of skipping (shut-down), and the skipping can only be relieved via resetting by the operator. The skipping resetting can be carried out only when the pressure of the sensor is lower than the skipping pressure.

3.4.3.7 The actuator shall be provided with at least 2 shut-down valves:

(1) The shut-down valve shall not be used for other purpose at the same time;

(2) The shut-down valve shall be made with corrosion-resistant materials;

(3) The valve shall be provided with fully-closed indication device.

3.4.3.8 During HIPPS design, the impact of the water hammer due to quick valve shut-down on the design pressure of the upstream unit shall be taken into consideration.

3.4.3.9 The potential impact of the ablation, hydras formation, fluid viscosity change, and wax content change on the HIPPS shall be considered especially during the design.

Section 5 Shut-down system

3.5.1 General provision

3.5.1.1 The shut-down system of the subsea production system/equipment shall be designed integrally with those of other systems on the production and/or process facilities.

3.5.1.2 The shut-down consists of process shut-down (PSD) and emergency shut-down (ESD). Process shut-down means the shut-down pushed automatically when the instrument detects any abnormality, whereas emergency shut-down means the shut-down pushed manually.

3.5.1.3 The shut-down system shall be designed as per the failure safety principle.

3.5.1.4 In addition to the provision of the section, the shut-down system shall meet relevant provision in Section 4 of Chapter 4 of the *Regulations on Offshore Oil and Gas Processing System* issued by the CCS.

3.5.2 Shut-down

3.5.1.1 If the control system/equipment is preset with operation limit, any operation can be stopped, and the safety status of the well shall be guaranteed.

3.5.1.2 The shut-down system shall have the function of automatic failure detection.

3.5.1.3 The shut-down system shall be tested without interfering with other system.

3.5.1.4 The shut-down system shall adopt the UPS, and the power source used by the system shall have redundancy.

3.5.1.5 The shut-down shall be carried out as per the preset logic, and the kinetic energy of the fluid shall be considered for the shut-down duration, so as to avoid any damage to the system caused by quick shut-down.

3.5.1.6 The liquidity safety guarantee of the overall subsea production system shall be taken into consideration for the shut-down.

3.5.3 Boarding shut-down valve

3.5.3.1

3.5.3.1 General requirements

(1) To cut off dangerous source in time in case of any failure to the production and/or process facilities, boarding shut-down valve shall be provided between the subsea production system and production processing facility;

(2) The design pressure of the boarding shutoff valve shall not be lower than the max. allowable working pressure of the approved subsea pipeline.

(3) Two control modes, namely, remote and local, shall be provided for the valve;

(4) Generally, the valve shall have the shut-down function in case of failure;

(5) The boarding shut-down valve shall meet the requirement of API Spec 6A and API Spec 6AV1, and the fire resistance rating shall meet the requirement of 30 min.

3.5.3.2 Boarding shut-down valve arrangement

(1) The boarding shut-down valve shall be arranged at a position within 3 m away from the first point of the boarding riser, for example:

If the boarding shut-down valve is installed horizontally: A position within 3 m away from the edge of the production processing facility where the riser boarding point locates;

3 m

If the boarding shut-down valve is installed vertically: A position within 3 m above the first accessible working deck that is above the splash zone (except for the berthing deck).

(2) A fusible-plug-type temperature sensing detector shall be installed at a position within 1.5 m away from the boarding shut-down valve; the temperature sensing detector shall be installed in a way to facilitate the fire detection;

(3) The status (open/close) indication device shall be provided for the valve.

3.5.4 Subsea isolating valve at the root of the riser

3.5.4.1 Generally, subsea isolating valve shall be provided at the boarding riser root on the subsea production system, so as to facilitate process shut-down and emergency shut-down.

3.5.4.2 The pressure of the subsea isolating valve shall not be lower than the max. allowable working pressure of the approved subsea pipeline.

3.5.4.3 The subsea isolating valve shall be of two-way pressure bearing type.

3.5.4.4 In addition to the remote control from the production processing facility or automatic control of the HIPPS system, the subsea isolating valve shall also be controlled by the diver or ROV locally.

3.5.4.5 The closing duration of the subsea isolating valve shall be determined via risk analysis, and the water hammer impact, process requirement and safety impact shall also be considered comprehensively.

3.5.4.6 ISO13628-4Petroleum and natural gas industries Design and operation of subsea production systems Part 4:Subsea wellhead and tree equipment

3.5.4.6 The design, manufacturing, test of the subsea isolating valve shall meet relevant requirement of ISO13628-4Petroleum and natural gas industries - Design and operation of subsea production systems Part 4: Subsea wellhead and tree equipment.

3.5.4.7 The status (open/close) indication device shall be provided for the valve.

Section 6 Diameter measurement

3.6.1 General requirements

3.6.1.1 The pigging operation requirement shall be considered for the design of the subsea production system. The pressure of the temporary pigging loop shall not be lower than the max. allowable operation pressure of the processing pipeline.

3.6.1.2 The design of the subsea production equipment on the pigging loop shall also meet the pigging operation requirement.

3.6.2 Diameter measurement

3.6.2.1 The purpose of the diameter measurement is to check whether the subsea equipment pipeline fabricated meets the design requirement, such as the size and roundness, and provide the pigging operation with data basis.

3.6.2.2 The diameter measurement is generally carried out via ball passing. Ball passing shall meet the requirement of the technical specifications, but not lower than that on the subsea pipelines connected.

Chapter 4 Subsea wellhead

Section 1 General provision

4.1.1 Scope

4.1.1.1 In addition to the provision of the chapter, the subsea wellhead shall meet relevant requirement of ISO13628-4 on the subsea wellhead.

4.1.1.2 The application of the subsea wellhead mentioned in the chapter is consistent with that in ISO13628-4, 8, which generally refers to the subsea wellhead system tripped in from the floating drilling vessel, excluding the system without guide rope. It mainly includes the following basic components:

(1) Temporary guide base;

(2) Permanent guide base;

(3) Conductor housing;

(4) Wellhead head system;

(5) Sleeve hanger;

(6) Annular seal assembly;

(7) Hole protection device and anti-abrasive sleeve;

(8) Anti-corrosion cap;

(9) Feeding, recycling and test tool.

4.1.2 Objective

4.1.2.1 Provide reference standard for the design of such basic elements as the function, strength, interface, sealing and test of the subsea wellhead.

4.1.2.2 Provide technical basis for CCS and third party's inspection on the subsea wellhead.

4.1.3 Functional requirement

4.1.3.1 The strength of the subsea wellhead shall meet the requirement of the most unfavorable combination operating conditions, for example, supporting;

4.1.3.2 The subsea wellhead shall meet such basic function requirements as guiding, supporting, sealing, and providing surface and subsurface access;

4.1.3.3 Effective interface shall be provided for the subsea wellhead, so as to facilitate ()the connection of other subsea equipment;

4.1.3.4 Effective anti-corrosion and anti-abrasion measures shall be taken for the subsea wellhead.

Section 2 Technical requirement

4.2.1 General requirements

4.2.1.1 All pressure-bearing equipment and pressure control units in the subsea wellhead shall meet the requirement of ISO15156 (all contents), including:

(1) Wellhead head;

(2) Sleeve hanger bodyshoulder;

(3) Annular seal assembly;

The requirements of ISO 15156 do not apply to the following components and devices:

(1) Stopper ring;

(2) Load ring;

(3) load-bearing ledge;

(4) Suspension equipment;

(5) Hole protection device and anti-abrasive sleeve.

4.2.2.2 Adverse factors (parameters) in the life cycle of the well shall be considered for the design, such as operations on the well during boring, test, well completion and production. The specification used to control the wellhead system structure strength can guarantee short-term reliability, but not the integration of long-term production application.

As a result, the following issues must be evaluated further:

(1) External circulation load;

(2) Internal pressure circulation load and displacement;

(3) Thermal load and gradient;

(4) General corrosion;

(5) Stress corrosion cracking (caused by hydrogen, H2S or chloride).

The above-mentioned issues may need to be evaluated via fatigue analysis, evaluation of fracture mechanics, structure evaluation involving Thermal load, or structure evaluation due to corrosion allowance reduction. The cathodic protection system is generally used for production well protection to reduce corrosion, which causes free hydrogen release, resulting in possibility of increasing stress corrosion cracking.

Chapter 5 Subsea Christmas tree

Section 1 General provision

5.1.1 Scope

5.1.1.1 The chapter specifies the min. requirement on the subsea Christmas tree, including the traditional and horizontal Christmas tree. In addition to the requirement of the chapter, it shall meet relevant requirement of the ISO13628-4 on the subsea Christmas tree.

5.1.1.2 Relevant performance verification test shall be carried out on newly-developed subsea Christmas tree as per ANSI/API Spec.6A and ISO10423, or equivalent standard.

5.1.2 Definitions and Abbreviations

5.1.2.1 Main definitions and abbreviations of the chapter are equivalent to those in ISO 13628-4 3.1 and 3.2.

Section 2 Technical requirement

5.2.1 General requirements

5.2.1.1 The Christmas tree shall have necessary barrier function valve, including at least a fail-closed production master valvePMV and a fail-closed annulus master valve (AMV). Other valves can be added according to the requirement of the production and workover process.

5.2.1.2 Each penetration on the Christmas tree shall be provided at least with a remotely-controlled and fail-safety master valve and relevant trickle valve. In addition, a closing device shall be provided above the side outlet on each penetration.

5.2.1.3 Other side outlet for example, the injection pipeline shall be located on the lowest remotely-controlled PMV and(the injection bore shall be) close to the remotely-controlled and fail-safety control valve and check valve. If there is a valve under the injection bore, the injection bore of the hydrate inhibitors can be located at a place under the fail-safety production master valve.

5.2.1.4 All the valves on the vertical penetration of the Christmas tree shall be opened and remain opened via the external operation device independent of the original actuator.

5.2.1.5 Key valves connected with the emergency shut-down device (such as the main valve and trickle valve) shall be provided with local valve position indicating device.

5.2.2 Design

5.2.2.1 As an integral device, the subsea Christmas tree shall provide safety test channel between the oil reservoir and external environment together with the wellhead system.

5.2.2.2 Non-stop vertical channel shall be provided between the production channel and annular channel for the vertical Christmas tree.

5.2.2.3 The system shall have the fail-safety function, and any single failure will not fail the whole system.

5.2.2.4 If the Christmas tree is subject to the accidental load mentioned in 5.2.6 of the chapter, the necessary shielding unit (wellhead connector and production master valve) shall be kept integrit.

5.2.2.5 The leakage path of the system shall be minimized.

5.2.2.6 The main components (such as the valve and connector) shall be reliable enough to meet the design lifetime requirement.

5.2.2.7 All modules and equipment shall be designed with such devices as the onshore and offshore transportation lug. Damping device or transport framework shall be adopted for all equipment to guarantee transport safety.

5.2.2.8 Necessary test board/brace/transport mat and connector protection shall be provided for all the equipment, so as to meet the requirement on all onshore and offshore activities.

5.2.2.9 Interfaces on the Christmas tree system shall be available for installing/recycling well completion riser (vertical tree) or drill pipe.

5.2.2.10 The Christmas tree system shall include a cathodic protection system.

5.2.2.11 ROV interface shall be provided to facilitate mechanical operation or overriding operation. All installation/recycling operations shall be completed via remote control toolkit.

5.2.2.12 Safe and effective connection shall be designed for field assembling of all equipment for rolling and pitching of 1.5 degrees.

5.2.2.13 All the equipment shall be balanced, and the weight and use of the counterweight shall be minimized.

5.2.2.14 The components and subcomponents of the subsea Christmas tree shall be interchangeable, provided the configuration function demand is met, which generally involves the wellhead connector, valve bank, valve and actuator, tree cap, operation tool, block, and control unit.

5.2.2.15 All the equipment shall be provided with ladder, platform and proper protection where the personnel need to climb for module or module group inspection, maintenance or other purpose. For places with components stacked, such as XMT / LWRP EDP, the ladder shall be arranged in a way that personnel can go from one component to another easily.

5.2.2.16 All connectors shall be provided with position indication that can be read clearly by the ROV.

5.2.2.17 The Christmas tree system module shall be designed in a way that it will not interfere with the guide line and ROV umbilicals.

5.2.2.18 All interfaces used repeatedly shall be provided with protection cap that can be recycled by lightweight ROV. The protection cap is used to protect all sealing surface temporarily.

5.2.2.19 Min. sealing protection shall be provided during subsea installation, operation and maintenance. The sealing surface cannot be left unprotected for certain period.

5.2.2.20 The Christmas tree shall be provided with pressure monitoring point for shutting down the system and pressure test valve.

5.2.2.21 The Christmas tree shall be designed to facilitate the work and inspection of ROV.

5.2.2.22 The ROV grab bar shall facilitate the preset operation, and provide ROV with stable working condition.

5.2.2.23 In case of main system failure, all connectors can be released mechanically by ROV/ROT.

5.2.2.24 All connectors shall be designed to avoid any accidental unlocking when they are subject to shock load, vibration, thermal load and other load, so as to prevent them from affecting the locking mechanism.

5.2.3 Wellhead connector

5.2.3.1 For traditional Christmas tree, metal sealing and elastic sealing shall be adopted as primary sealing and secondary sealing respectively for the contact surface of the tubing hanger.

5.2.3.2 Sound certificated sealing shall be available on the connection interface of the wellhead connector, so as to facilitate the test sealing after the Christmas tree is installed to the wellhead.

5.2.3.3 If the connector is operated via hydraulic pressure, its function must be available in the well workover mode.

5.2.3.4 The mechanical locking device shall be prevented it from being released accidentally, and provided with visual switch status indicator.

5.2.4 Outlet tube connector

5.2.4.1 The design, manufacturing and test of the outlet tube connector shall meet the requirement of Chapter 7 of the Guidelines.

5.2.4.2 The mechanical locking device shall be provided to avoid accidental release, and visual switch status indicator shall be available to indicate whether it is closed.

5.2.5 Valve, valve bank and actuator

5.2.5.1 All the Christmas tree gate valves shall be sealed in both way, and the cavity pressure shall facilitate the close of the valve.

5.2.5.2 Mechanical overriding operation device shall be provided for PMV and AMV of the Christmas tree, so as to facilitate the direct operation of ROV.

5.2.5.3 To facilitate the ROV observation, the position indicator shall involve all valve and actuator functions, and displays clearly the function status (end position and all travels). The position indicator shall display clearly all function operation positions for ROV overriding.

5.2.5.4 The ROV control function safety pin cannot be used on the permanently-installed valve.

5.2.5.5 The hydraulic valve shall be closed in case of hydraulic system failure.

5.2.6 Guide structure

5.2.6.1 Any area with a diameter of 100 mm on the protection cover plate of the permanent guide structure, valve activator and other vulnerable equipment shall bear an impact load of 10 kJ.

5.2.6.2 The load can be transmitted to the wellhead connector/wellhead.

5.2.6.3 It can allow ROV to conduct visual inspection on the Christmas, including the actuator, connector and other component.

5.2.6.4 It can bear the impact load of the down-pass tool and ROV.

5.2.6.5 All ROV tool operating interfaces shall be arranged on a panel installed vertically to the Christmas, so as to provide the ROV with a horizontal access channel.

5.2.7 Permanent guide base

5.2.7.1 Permanent guide base

The guide post shall be replaced via a ROV locking device.

5.2.7.2 Optimal design shall be made for the guide post locking device, so as to avoid any unlocking due to wire and cable dragging.

5.2.7.3 The guide post shall be provided with through bore to the seabed, so as to allow the guide cable anchor to pass through.

5.2.7.4 The permanent guide base shall be designed in a way to facilitate ROV's inspection and cleaning of all required areas, such as the connecting hub and connecting plate.

5.2.8 Hydraulic control interface

5.2.8.1 Metal sealing shall be adopted for hydraulic coupling.

5.2.8.2 All hydraulic systems (including pipelines) shall be supported and protected thoroughly, so as to

minimize the probability of damage during test, handling, installation/recycling and normal operation.

5.2.8.3 Seamless pipes shall be used for all hydraulic system pipelines.

5.2.8.4 All the hydraulic pipelines shall be cleaned and washed thoroughly first before assembling, so as to meet the applicable cleaning requirement.

5.2.8.5 The NPTF screwed pipe shall be used at the hydraulic pipeline terminal of the hydraulic valve actuator, hydraulic connector and/or other terminals.

5.2.8.6 Multiple-terminal hydraulic interface board

(1) Sufficient strength and stiffness shall be guaranteed to facilitate the insertion of multiple metal seal fittings;

(2) Aligning system shall be provided for multi-port hydraulic interface, so as to facilitate accurate alignment of the insertion plate on the other side.

5.2.8.7 All hydraulic pipelines shall be welded to minimize the leakage.

5.2.9 Special requirement on vertical Christmas tree

5.2.9.1 Upper connection of the vertical Christmas tree

(1) The tree cap can be non-pressure or pressure typeaccording to the specific requirement of the project;

(2) The Christmas tree cap shall be lowered and locked on the Christmas tree hub, and can protect the sealing area of the running equipment and the hydraulic bolt;

(3) The Christmas tree cap can provide hydraulic connection between the control unit and tree function module;

(4) For pressure-type cap, the hydraulic connector of the tree cap shall match with the feeding tool, with the following functions at least:

① The tree cap joint can be locked/unlocked via hydraulic drive;

② Tree cap sealing test;

③ Pressure washing;

④ Release capability assisted by ROV or ROT.

5.2.9.2 Tree cap running tool

(1) The tool can be associated with the emergency cutoff package (EDP);

(2) It includes a hub used to connect the hydraulic operation connector to the top of the Christmas tree;

(3) The connector shall be designed to be independent of the main system and can be released via the assistance of ROV.

5.2.9.3 tubing hanger system

(1) The production and annular bore of the tubing hanger shall be provided with jack, so as to match with the running tool and bolt of the Christmas tree;

(2) Installation and test on small parts used for production can be carried out before shipping. The control line and tubing thread of the surface controlled subsurface safety valve (SCSSV) shall be arranged completely;

(3) The hydraulic thrust plate of the tubing hanger shall avoid any seawater entrance at the operating depth, and be free of any depression, so as to avoid any sundry accumulation;

(4) A integrated or plug-in plug capture device shall be provided for the annular ring of the tubing

hanger.

5.2.10 Special requirement on the subsea horizontal Christmas tree

5.2.10.1 The Christmas tree valve can be used to close the production well flow, allow the connection between the annular bore and the production, workover barge/platform or drill pipe, as well as the connection between the production and annular bore, and facilitate the injection of various inhibitors.

5.2.10.2 The internal tree cap is generally installed on the upper part of the tubing hanger inside the Christmas tree.

5.2.10.3 The internal tree cap shall be lowered, sealed and locked on the upper part of the tubing hanger inside the Christmas tree. The running and recycling of the BOP and riser shall be considered during the design.

5.2.10.4 Tubing hanger

(1) The tubing hanger shall be lowered, guided, positioned and locked on the Christmas tree within one stroke;

(2) When the tubing hanger is positioned, the metal sealing and elastic back-pressure sealing of the production outlet and the production annular bore shall be established;

(3) After the tubing hanger is installed, the sealing integration shall be verified. The test pressure shall be suitable for the well flow direction;

(4) An internal distance sleeve shall be provided for the tubing hanger, so as to facilitate the flow of the output liquid during running and recycling.

Section 3 Test

5.3.1 General requirements

5.3.1.1 The materials used for the Christmas tree shall meet the requirement of GB/T21412.4, ISO13628-4, API 17D and API 6A, and the environment for material test shall be similar with that for material application as much as possible.

5.3.1.2 The subsea Christmas tree test mainly involves the function test, component pressure test, subsea control module (SCM) communication verification test and ROV operating interface test, so as to check whether the designed, manufactured and purchased subsea Christmas tree meets the requirement of the Guidelines and technical specifications.

5.3.2 Factory acceptance test

5.3.2.1 Factory acceptance test range

During the subsea Christmas tree manufacturing, the factory acceptance test on function and performance shall be carried out after the following (but not limited to) components are assembled as per the requirement of the technical specifications:

(1) Christmas tree assembling;

(2) Pipeline;

(3) Garbage cap;

(4) Isolation protection;

(5) Tubing hanger;

(6) Block;

(7) Isolation sleeve of the block;

(8) Distance sleeve of the block;

(9) Chemical injection metering valve;

(10) Chemical injection metering valve;

(11) Christmas tree internal cap;

(12) Control system and subsea control module

5.3.2.2 After being assembled, the following (but not limited to) components shall be subject to pressure test as per the technical specifications:

(1) Hydraulic pipeline test;

(2) Hydraulic test on well bore;

(3) Air pressure test on well bore;

(4) Hydraulic test on the tester of the wellhead protector;

(5) Pressure test on the control pipeline.

5.3.2.3 After being assembled, the following (but not limited to) components shall be subject to function test as per the technical specifications:

(1) Hydraulic function test on the hydraulic valve;

(2) Hydraulic function test on the throttle valve;

(3) Replacement function test on the attachment joint and seal ring;

(4) Test on the internal cap of the recycle tree and tubing hanger;

(5) Test on the protective jacket of the internal cap of the installation tree;

(6) Test on the internal cap of the recycle tree of the well bore and tubing hanger;

(7) Opening and locking of the protective cap of the Christmas tree;

(8) Installation and assembling of well workover control system.

5.3.3 Extended factory acceptance test (EFAT)

5.3.3.1 The extended factory acceptance test is mainly used to verify the mechanical, hydraulic and electrical (interaction instrument) interfaces and operation correctness after the Christmas tree is assembled.

5.3.3.2 The following (but not limited to) components shall be subject to intervention test as per the technical specifications:

(1) ROV operation and manual operation valve function test;

(2) Interface test on the running and installation tool module;

(3) Interface test on the internal cap of the tree and tubing hanger;

(4) Garbage cap test;

(5) Interface test on the well bore protector and test device;

(6) Running tool test on other additional equipment.Test on the running tool for other additional equipment.

5.3.4 System Integrity Test

5.3.4.1 System Integrity Test is mainly used to test the compatibility of the Christmas tree and other function modules (such as interface test on the supporting running/ installation tool as well as the tool used during late installation, and the installation/positioning simulation test of the Christmas tree itself).

5.3.4.2 The system integration test shall be carried out as per the technical specifications, including mainly but not limited to the following:

(1) Test on the interface of the ROV and ROV operating panel of the Christmas tree and whether the valve position indicator works normally;

(2) Running test on the transceiver of the Christmas tree;

(3) Lifting test on the Christmas tree;

(4) Interface test on the running and installation tool;

(5) Unfolding and folding of the Christmas tree protection structure;

(6) SCM communication verification test: involves mainly the SCM valve control function test, emergency shut-down test and system redundancy test.

Chapter 6 Subsea manifolds and pipeline components

Section 1 General provision

6.1.1 Scope

6.1.1.1 This chapter applies to the structural components of the subsea production system, including production and injection manifolds, modular and integrated single satellite wells and multi-well templates, subsea treatment units, and subsea booster stations.

6.1.1.2 This chapter applies to the structural components of the flowline system, including flowline riser bases and export riser bases (FRB ERB), pipeline end manifolds (PLEM), pipeline end termination (PLET), subsea isolating valve (SSIV), other structures (T-type and Y-type connection structures, subsea connection points), and protective structures.

6.1.1.3 This chapter does not apply to the valves connectors , throttle valves, and control systems of flowline and manifold.

6.1.1.4 In addition to the technical requirements of this chapter, the subsea manifold and pipeline component shall meet corresponding requirements of *ISO13628 Petroleum and natural gas industries Design and operation of subsea production systems Part 15: Subsea structures and manifolds* in terms of design, manufacturing and test.

6.1.2 Functional requirements

6.1.2.1 Functional requirements of the subsea manifolds

(1) The manifold system is designed to perform the following functions :

① Collect the produced fluid from several production wells (or distribute gas or water to several gas or water injection wells);

② Lead fluid or liquid through the manifold header;

③ Include one or more manifolds;

④ Be able to isolate the header from slots of each well;

⑤ Conduct process connections on the manifold and appropriate pipeline and/or test pipeline;

⑥ Be able to ensure continuity of cleaning of the flowline.

(2) The pipeline components shall be capable of achieving the preset functions and purposes.

6.1.2.2 The final users shall determine or approve the following performance and structure requirements, including:

(1) The max. dimension and desired weight

(2) Ratings of pressure and temperature (rated pressure and temperature)

(3) Equipment interface (operating interface)

(4) Process and instrument diagram (P&IDs)

(5) Material requirement

(6) Water depth

(7) Design life

(8) Data of geotechnical engineering and geophysics

(9) Marine meteorological data

(10) Dropped objects protection requirement11

(11) Trawl prevention requirement

6.1.2.3 The manifolds and pipeline components shall be designed such that the requirements of the technical specifications and all regulations are met, the ratings of pressure and temperature reached, the loading/unloading capabilities of the ship taken into consideration (dimension and mass), and the preset functionality and adaptability achieved in the specified operational environments.

6.1.3 Load

6.1.3.1 The following loads shall be considered at least during design of the product:

(1) Operating and environmental loads;

(2) Installation loads: the loads mainly produced in hoisting, transport and installation;

(3) Hydraulic test load;

(4) Installation and impact load (dead weight, speed of 0.6 m/s);

(5) ROV (if applicable) impact load;

(6) Drag load of fishing equipment

It is unnecessary to be considered if the water depth reaches 750 m or more, with evidences of low risk of fishing equipment drag.

(7) Thermal load.

Section 2 Design

6.2.1 Arrangement

The manifold shall be arranged with its function and arrangement of the subsea production system, together with accessibility of ROV taken into full consideration.

6.2.2 Design of pipeline

The process pipelines of the manifold shall subject to the stress analysis in order to ensure its safety factor is higher than the subsea pipeline connected to them.

6.2.3 Selection of materials

The materials selected for each component, including those sealing materials, shall meet requirements of ISO13628-1 and ISO13628-15. For the materials used in the areas filled with production liquid, injection fluid and completion fluid, and the areas exposed to chemical injection and application, the requirements of materials are equivalent to those of the sealing materials.

Section 3 Key points of inspection

6.3.1 Key points of design review

6.3.1.1 The design review of the manifold system and components shall be in accordance with the design specification.

6.3.1.2 The design review shall cover but is not limited to the following points:

(1) Review of design input

(2) Design outputs

(3) Selection of materials

(4) review of conformance to customer requirements5

(5) Interior interface

(6) External interface

(7) Intervention analysis, including ROV accessibility

(8) Corrosion prevention layout

(9) Safety concerns

(10) ease of maintenance and operation

(11) Installation and calculation analysis

(12) Retrieval issues

(13) Review of reports on stress analysis, strength calculation and corrosion-resistant calculation.

6.3.2 Manufacturing

6.3.2.1 The complete field acceptance tests shall be performed in the workshop. Any defective shall be repaired and then analyzed to find the causes and/or judged to be acceptable or not according to the system dependability calculated. There are several modes for the factory acceptance test, ranging from inspection of individual component, inspection of part of the system (e.g. control system), interface inspection, to inspection of the complete system. The modifications and changes in the test and manufacturing shall be documented.

6.3.2.2 The test shall simulate the actual environment conditions of all phases and operations from installation to maintenance. The special tests may be necessary to the delivery and transport, dynamic load and backup system. The function test may be usable, providing data on the response time measurement, working pressure, flow, and failure-finding and operation of the shutdown system.

6.3.2.3 It is recommended that independent parts of the manifold and template system, e.g. valves, drives, parts and control system parts, are validated separately. The specified operating conditions/limits of the manifold and template system shall be tested and recorded.

6.3.2.4 It shall be ensured that the valve is half-open during test to ensure no pressure difference in the valve cores or between the channel and cavity.

6.3.2.5 Key points of quality control

(1) The raw materials shall be tested and proved to be consistent with drawing requirements in terms of materials, size and the like. Meanwhile, the materials shall be stored as required, especially corrosion-resistant to pipelines, elbows and valves, as well as end cover on the pipe outlet to prevent entry of dust or foreign matters.

(2) Using,, keeping and handling of welding materials shall comply with requirements of WPS and relevant regulations.

(3) The product shall be manufactured and installed according to the approved process documents, without adjustment of assembling order prior to getting approval.

(4) All pipes except valves shall be pre-cleaned before installation into the pipeline system of the subsea structures.

(5) The process pipelines cannot be welded with the structural parts directly, subject to arc striking on them, or welded with temporary parts such as hoisting equipment usually.

(6) The pipelines shall be welded or repaired according to the approved welding procedure specifications. In general, the procedures shall not be inferior to the technical requirements stated in Chapter 10 *Welding of Subsea Pipeline Systems*, Part Three of CCS *Rules for Materials and Welding.*

(7) Nondestructive test

① The nondestructive test is conducted to ensure that all weld seams are free from any defects and all of them are qualified..

② The nondestructive test shall be conducted either in the manufacturing or each phase.

③ The nondestructive test is applicable to welding of all structures and pipelines of the subsea equipment.

(8) Dimensional inspection

① The visual and dimensional inspection is conducted to ensure that the product dimensions, relevant marks, anodes installations, and assemblies shall comply with drawings, with the weld seams being qualified in the appearances.

② The visual inspection is required for each phase of the manufacturing.

(9) The two circumferential weld seams on the pipeline shall be separated by at least 1.5 times pipe diameter or 500 mm, whichever is the greater.

(10) The corrosion-resistant processes (including paint application and wrapping of thermal contraction wraparound sleeve) shall subject to process certification before formal performance. The operators in charge of key processes shall be qualified with certificates.

(11) The product shall be fitted with end covers at the end before delivery, so as to avoid entry of dust or other foreign matters.

(12) The product shall be filled with suitable fluids or oil. It shall be cleaned, protected and packaged based on its specialization, with other special requirements being achieved as well.

(13) Other special requirements.

6.6.3 Factory acceptance test

6.6.3.1 A typical foemat for subsea equipment testing procedure colud include the following:

(1) Objective

(2) Scope

(3) Requirements for fixtures/set-up,facilities,equipment,environment and personnel;

(4) Performance data, i.e.acceptance criteria

(5) References information

6.6.3.2 The factory acceptance test tipically covers the following items:

(1) Individual component testing;

(2) Assembly fit and function testing using actual subsea equipment and tools where possible;3

(3) Interface checks using actual subsea equipment and tools where possible

(4) Interchangeability testing

(5) Hydrostalic testing

① Include the valve seal checks at operating pressure

② verifies piping code requirements

③ duration accoding to design code or 1 h (recommended) if not specified

④ Includes seal testing of end closures.

6.3.4 Extended factory acceptance test (EFAT)

6.3.4.1 The test covers installation and recall of pressure caps, as well as tests of integrity of installation, locking and recall.

6.3.4.2 The mudmat, if any, shall be tested with regard to arm locking function.

6.6.5 System integration test

6.6.5.1 The test is conducted to simulate all possible marine operations on the land and validate, to a certain extent, relevant equipment/systems installed in the subsea permanently.The purpose of the test is to simulate all operations which could be done offshore, to the extent pratical, and to verify all equipment/systems related to the permanent seabead installations.

6.6.5.2 The system integrity test tipically comprises the following activities:

(1) Documented integrated function test of components and subsystems

(2) Final documented function tests including bore testing and leak testing

(3) Final documented function test of all the electrical and hydraulic control interfaces

(4) Documented orientation and guidance fits tests of all interfacing components and modules;

(5) Simulated installations, interventions and production mode operations as practical in order to verify and optimize relevant procedures and specifications

(6) Operations under specified conditions, including extreme tolerance conditions, as practical, in order to reveal any deficiencies in system, tools and procedures.

(7) Operations under relevant real conditions as practical, to obtain system data such as response times for shutdown actions;

(8) Testing to demonstrate that equipment can be assembled as planned (wet conditions as necessary) and satisfactorily perorm its functions as an integrated system;9

(9) Filling with correct fluids and lubrication, cleaning, preservation and packing as specified.

(10) Connection test 0f relevant subsea structures

① Functional integrity testing on the connection, locking and disassembling of subsea connectors using the ROV systems and tooling

② Replacemen of seal rings and cleaning of hubstesting

(12) Function test of the manifold/template using workover control system

(13) Runing and retriecing of control pods;

(14) Pull-in and connection of umbilical (hydraulic/chemical lines and electrical connections) and flowlines;

(15) Tolerance check of manifold system after reinstallation;

(16) Pigging operations.

6.6.6 Key points of quality control for the test

6.6.6.1 Disassembling and locking test of the converter

This test is conducted to verify that the converter can be installed, taken down and relocked with no obstacle.

6.6.6.2 Stop and accessibility test of ROV

(1) This test can be simulated using a model with the same dimension as the ROV, which is conducted to verify that the ROV can be fixed with the equipment successfully under the water.

(2) All beams to be fastened with ROVs shall subject to this test.

(3) The test cannot be performed unless the mudmat has been applied with paint and installed.

6.6.6.3 Lifting lug test

The lifting lug to be tested meets the dimension requirements and is validated via pre-installed of the shackle or connector to be used on the sea.

6.6.6.4 Free rotation test of YOKE (if applicable)

(1) Except the normal friction on the hinging position, YOKE is able to rotate from the lay-down position to the other side smoothly, with no conflict with any equipment or structure pre-installed on the manifold or pipeline components (PLET/ILTA).

(2) The test cannot be carried out before the manifold or pipeline components (PLET/ILTA) have been applied with paint, the YOKE, mudmat, temporary converter and all pressure/overflow caps have been installed, and the foldable mudmat is folded.

6.6.6.5 Opening and locking test of the mudmat (if applicable)

(1) The mudmat tested shall be opened or folded with the help of its own weight or a crane respectively. It shall also be locked or unlocked smoothly by the locking mechanism. The manifold or pipeline components (PLET/ILTA) fitted with the level mudmat shall subject to this test.

(2) This test shall be performed only when the folded plate and locking mechanism have been applied with paint. Before it, the foldable plate shall be in a horizontal position.

6.6.6.6 Assembling test of skid shoe

(1) This test is conducted to confirm that the skid shoe can be connected or disconnected with the manifold or pipeline components (PLET/ILTA) smoothly, with smooth insertion of the pin during the connection.

(2) This test shall not be done unless the paint application of the manifold or pipeline components (PLET/ILTA) has been completed.

6.6.6.7 Actuation test of valves

(1) This test is conducted to confirm that the ROV torque spanner can be operated smoothly.

(2) During the test, a model of the torque spanner is inserted into the tool port of the valve to confirm its smooth insertion or extraction.

6.6.6.8 Electric continuity test

(1) This test is conducted to verify that components of the manifold or pipeline components (PLET/ILTA) are interconnected with ground wires, with a connection resistance of 0.100 or less between these components and that of less than 0.010 between the anodes and structural protected position.

(2) All manifolds or pipeline components (PLET/ILTA) shall subject to the electric connection inspection. This inspection shall not be done unless the manifold or pipeline components (PLET/ILTA) have been assembled (except the pressure cap).

6.6.6.9 Protection of openings

(1) Protection of openings is conducted before the welding or processing, namely, cover the openings if a pipe is out of service for a long time.

(2) All pipelines shall subject to this protection. Always confirm that the pipe is clean inside and the cover is intact before covering.

6.6.6.10 Weighing

(1) It is conducted to confirm that the actual weight and design weight of the manifold or pipeline components (PLET/ILTA) differ within the acceptable range. Meanwhile, it is also to verify that the position of gravity meets the requirement.

(2) All manifolds or pipeline components (PLET/ILTA) shall subject to the inspection.

6.6.6.11 Paint test

(1) It is conducted to confirm the acceptable paint application of the manifolds or pipeline components (PLET/ILTA).

(2) All manifolds or pipeline components (PLET/ILTA) shall subject to this inspection.

6.6.6.12 Inspection of correct installations of equipment and instruments

(1) It is conducted to confirm the correct installations of the equipment and instruments.

(2) All manifolds or pipeline components (PLET/ILTA) shall subject to the inspection.

(3) This inspection shall not be done unless the manifold or pipeline components (PLET/ILTA) have been assembled (except the pressure cap).

6.6.6.13 Purging, cleaning and measuring of process pipelines

(1) This test is conducted to confirm that the manifolds or pipeline components (PLET/ILTA) have been cleaned inside.

(2) Always confirm that the pipeline has passed the NDT and appearance and dimension inspections before implementations of the ball-passing, purging and the like. The high-pressure water flushing, cleaning via pipeline cleaner and the like are provided.

(3) All manifolds or pipeline components (PLET/ILTA) shall subject to this test.

6.6.6.14 Ball-passing test

It is conducted to measure continuity and roundness of the pipeline drift diameter, whose results shall be recorded. The following items shall be noted during the ball-passing test:

(1) Verify that inner diameter of the tested pipeline meets the requirements. The aluminum plate for the test has a diameter inconsistent with the technical specification that is usually 97% of the min. inner diameter.

(2) If the corrosion-resisting composite multi-layered pipe is provided, the aluminum plate shall be applied with polyethylene externally to avoid contamination of composite materials inside the pipe.

(3) The diameters of the two measuring plates for the ball-passing test shall be measured before the test.

(4) After the test, the measuring plates shall be free from damage; otherwise, they shall be retested until being acceptable.

(5) The record on the ball-passing test shall be attached with photos of the measuring plates.

6.6.6.15 Hydraulic test

(1) It is conducted to confirm that the process pipelines meet the design requirements in terms of sealing. It aims to simulate all process stages such as installation, in-service, shutdown and reproduction. It cannot be done unless the process pipelines have been installed and the relevant nondestructive test and the purging, cleaning and measuring of pipelines completed successfully. The medium used in the hydraulic test shall be filled with preservative and colorant. After the test, the remaining liquid inside the pipeline shall be removed and the

pipeline dried.

(2) The hydraulic test shall be done under the pressure of 1.25P or P+7MPa, whichever is smaller (P is the design pressure). The pressurization equipment used in the pipeline hydraulic test shall be capable of controlled continuous pressurization. Installation position, range, accuracy and dial diameter of the pressure gauge shall be consistent with relevant national standards.

6.6.6.16 The tightness test of the back of connector shall be done by reference to relevant requirements in Chapter 7 of these Guidelines.

6.6.6.17 Valve

(1) Test the valve operations (open, half open, close), verify that the valve indicator makes correction indication, and record the torque or number of turns.

(2) Perform the tightness test on both sides of the valve (if applicable).

6.6.6.18 Filling and seepage tests of MEG

It is conducted to confirm that the ILTA is filled with MEG with no seepage and provide protections for connections in the future.

Chapter 7 Subsea connection system

Section 1 General provision

7.1.1 Scope

7.1.1.1 This chapter sets the min. requirement of the subsea connection system.

7.1.1.2 It covers technical provisions on the design, manufacturing, installation, operation, storage and maintenance of the subsea connection system.

7.1.1.3 The corrosion-resisting alloy given in this chapter means the non-ferrous metal alloy, namely, the total quantity of one or more alloy elements among the following exceeds 50%: titanium, nickel, cobalt, chromium and molybdenum. It does not mean the anti-cracking corrosion-resisting alloy given in ISO15156 all sections.

7.1.2 Focuses of this chapter

(1) Overall performance and function requirements of the subsea connection system

(2) Requirements of design, material and corrosion prevention of the subsea connector with regard to strength and tightness, ensuring achievement of its basic performances

(3) Functional requirements of the running tools of the subsea connector, including the requirements on the ROV operating interface

(4) Quality control of key points of the manufacturing

(5) Test requirements of marine environments, namely, sea test requirements.

7.1.3 Construction of subsea connection system/device

7.1.3.1 Collet connector

The collet connector usually consists of:

(1) Connector body

(2) Male hub structure, commonly known as male connector

(3) Male hub receiver structure

(4) Alignment structure (the male hub receiver structure is also an align structure)

(5) Female connector

(6) Sealing assembly

(7) Collet segments

(8) Primary locking mechanism

(9) Secondary locking mechanism

7.1.3.2 Clamp connector

The clamp connector usually consists of:

(1) Connector body (supporting structure)

(2) A couple of flanges

(3) Primary locking mechanism: clamp and collet segment

(4) Secondary locking mechanism: usually square head bolt

(5) Guide rings of the guide mechanism, main guide mechanism and main flange face

7.1.3.3 Bolt-flange

(1) A couple of flanges

(2) Sealing gasket

(3) Connecting bolt

Section 2 Design

7.2.1 General requirements of design

7.2.1.1 The subsea connection system shall be designed with full consideration given to convenience of operation, maintenance and recall of the equipment.

7.2.1.2 The requirements and feasibilities of all stages, e.g. manufacturing, storage, installation and maintenance, shall be considered during the design.

7.2.1.3 Categories and materials of the connector joints shall be in line with the acceptable relevant standards and regulations.

7.2.1.4 During the design, the effect of heat expansion encountered by the equipment in service that is caused by the temperature variation and gradient shall be considered; besides, the resonance shall also be avoided as well.

7.2.1.5 In addition to these principles, the bolt-flange connector shall be designed, manufactured and tested according to API Specification 16A.

7.2.1.6 The connecting system applied to the Christmas tree nipple shall have a lower rated temperature.

7.2.1.7 The subsea connector shall have the specification level and temperature class not lower than those of the subsea equipment connected.

7.2.1.8 The working pressure rating shall match that of the subsea equipment connected.

7.2.2 Arrangement

7.2.2.1 The running tools of the connector shall be arranged appropriately. The vulnerable parts and pipes shall be located with protections or equipped with protection structures.

7.2.2.2 They shall have the applicable ROV operating interface meeting the requirements of accessibility and maneuverability of the ROV.

7.2.2.3 The pipelines of the running tools shall be fixed, with full considerations given to impacts of waves with regard to selections of fixing methods and fixtures.

7.2.3 Functional requirements

7.2.3.1 The subsea connector shall meet the following at least:

(1) The preset functions and performances such as connection and sealing shall be achieved. The pressure bearing capability shall not be lower than the rated working pressure of the subsea equipment connected.

(2) It shall include the mechanic locking device to avoid accidental release, and be able to prevent unexpected unlocking caused by impact load, vibration, hot load and other loads.

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(3) The connector shall pass the tightness test such as the back pressure test after the subsea installation and replacement of seal rings.

7.2.3.2 Functional requirements of the subsea running tools

(1) The running tools shall be capable of installation, locking, removal and replacement of seal rings.

(2) The hydraulically-driven subsea connection system shall be fitted with a second operating mode (hydraulically or mechanically operated) to operate it when the running tools are invalid.

(3) The tools shall be considered to match the necessary operating load, external pressure caused by water depth, and ROV impact load.

(4) Other functions and performances stated in the specifications or contracts.

7.2.4 Material class

7.2.4.1 The material classes shall be selected according to rules in 3.2.8.

7.2.4.2 The material requirements for the hub shall not be lower than those of the devices connected to it.

7.2.4.3 The material requirements for the PSL1 pressure-containing members (e.g. hub) shall not be lower than those of the devices connected to it.

7.2.4.4 Material performance requirements of pressure-containing members of PSL2 or higher

(1) These members shall be made by the specified standard or nonstandard materials. The nonstandard design means achievement of the design requirements given in 7.2.6.5.

(2) The pressure-containing members of the subsea connectors operating at the rated pressures of 13.8 MPa 20.7 MPa, 34.5 MPa and 69 MPa shall meet the standard mechanical properties.

① 0.2% yield strength≥414 MPa

② Tensile strength≥586 MPa

③ 50 mm elongation≥18%

④ Section constriction ≥35%。

(3) The pressure-containing members of the subsea connectors operating at the rated pressures of 103.5 MPa and 138.0 MPa shall meet the standard mechanical properties.

① 0.2% yield strength≥517 MPa

② Tensile strength≥655 MPa

③ 50 mm elongation≥17%

④ Section constriction ≥35%。

(4) The nonstandard materials shall meet written regulations of the manufacturer. The regulations shall cover the min. requirements of tensile-strength, yield strength, elongation, section constriction rate, toughness and stiffness for the specified alloy. All the nonstandard materials shall have the min. yield strength of more than 75K, the elongation of not less than 15%, and the section constriction rate of not less than 20%.

(5) Requirements of material impact toughness for the pressure-containing members

①The impact toughness shall reach the values in table 7.2.4.4 (1).

Table 7.2.4.4 (1) Impact requirements of Charpy V-notch (10 mm10 mm)

Temp. class	Test Temp./ ℃	Min. average impact work (transverse)/J		
		PSL1	PSL2	PSL3 and PSL4
K	-60	20	20	20
L	-46			
P	-29			
R	-18			
S				
T				
U				
V				

② When a small sample is used, the impact toughness value of the Charpy V-notch shall equal to that of the 10 mmX10 mm sample times the corresponding correction factor listed in table 7.2.4.4 (2).

Table 7.2.4.4 (2) Correction factor of small impact sample (PSL1-PSL3)

Dimension of sample /(mm × mm)	Correction factor
10 7.5	0.833
10 5.0	0.667
10 2.5	0.333

③ PSL4 shall not apply to the small sample.

7.2.5 Strength requirements

7.2.5.1 The subsea connector shall be designed with the strength not lower than that of the subsea equipment pipeline. As far as the subsea connector is concerned solely, the rules in the design specification shall be met. The material requirements for the hub shall not be lower than those of the devices connected to it, but higher than those of the body, cover, end and outlet connection of PSL2 (GB/T 22513 5.4).

7.2.5.2 The design loads of the subsea connector usually include the installation load, load under operation conditions, load in case of manufacturing misalignment (connector/hub and tool) and installation misalignment, load caused by lowering of tools, and load generated by ROV.

7.2.5.3 Loads generated by the applicable working conditions of the subsea connector during operation: bending stress transferred to the connector from expansion and constriction of subsea steel jumper pipe, shaking generated by the vortex-induced vibration of the jumper pipe, twist produced by displacement of the subsea structure, and stretch stress as a result of dead weight of the jumper pipe, effect of flows and displacement of subsea structures, as well as the stress produced under the most unfavorable combination of the above working conditions.

7.2.5.4 The ROV parking station of the running tools of the subsea connector shall be designed to meet the preset strength requirements of the ROV tools, with consideration given to the impact load of ROV collision.

7.2.5.5 The subsea connector and running tools shall be able to bear the wave impact loads during installation.

7.2.5.6 Under all the corresponding phases and conditions, the limit statuses shall meet requirements of 7.2.6. The typical design conditions include installation, removal, system pressure test, operation and shutdown.

7.2.6.7 In addition to strength requirements, the hub and its connections shall reach the stiffness requirements.

7.2.6 Design methods

7.2.6.1 The hub and its connections shall be in accordance with one or more design methods given in this section or the acceptance criteria.

7.2.6.2 ASME design methods

The design methods are referred to in the annex 4, division 2, volume 8 of *ASME Boil and Pressure Vessel Code*. The acceptable design stress is limited according to the rules below:

$S_t \leq 0.9S_y$ and $S_m \leq (2/3)S_y$

Where:

S_m——Design stress intensity under the rated working pressure

S_t——Total maximum allowable stress intensity of main diaphragm under the testing pressure for hydrostatic test

S_y——Specified min. yield strength of materials

7.2.6.3 Theory of strain energy

This design method of basic wall thickness can be defined according to the three-dimensional composite stress under the test pressure of static water pressure test for strength and limited based on the rules below:

$S_e = S_y$

Where:

S_e——Maximum allowable equivalent stress calculated based on the theory of strain energy

S_y——Specified min. yield strength of materials

7.2.6.4 Analysis of test stress

The applications of the analysis of test stress are referred to in the annex 6, division 2, volume 8 of *ASME Boil and Pressure Vessel Code*.

7.2.6.5 Design requirements of nonstandard materials

The design methods in the annex 4, division 2, volume 8 of ASME are applied to design and calculation of the pressure bearing devices made from nonstandard materials. The acceptable design stress is limited according to the rules below:

$S_T = 5/6S_y$ or $2/3R_{m\cdot min}$, whichever is the smaller

$S_m = 2/3S_y$ or $1/2R_{m\cdot min}$, whichever is the smaller

$S_s = 2S_y$ or $R_{m\cdot min}$, whichever is the smaller

Where:

S_T——Total maximum allowable stress intensity of one-off diaphragm under the testing pressure for hydrostatic test

S_y——Specified min. yield strength of materials

$R_{m\cdot min}$——Specified min. tensile strength of materials

S_m——Design stress intensity under the rated working pressure

S_s——Max. composite strength of the primary stress plus the secondary stress

7.2.6.6 Clamp connector

(1) For the clamp connector, stress analysis shall be conducted on the clamp, hub (or a pair of flanges), and connection between the hub and pipe. The results shall be within the preset scope, with sufficient safety margins left.

(2) The locking mechanismclamp of the clamp connector shall be designed according to the design method in 7.2.6 of this section or other acceptance criteria. Each clamp shall be designed according to the max. load caused during its assembling with any hub. The stresses during assembling, operation and test shall be calculated.

(3) The clamp shall provide sufficient gripping force to make the hub end faces keep contact and prevent those at the outside diameter from separation under the rated working pressure.

7.2.6.7 Collet connector

(1) For the collet connector, stress analysis shall be conducted on the collet segment, actuation ring (primary locking ring), hub (or a pair of flanges), and connection between the hub and pipe. The results shall be within the preset scope, with sufficient safety margins left.

(2) The hub and its connection of the collet connector shall be designed to meet the requirements in 7.2.6 of this rule. If they are designed based on other standards, sufficient evidences shall be provided.

7.2.6.8 Bolt-flange connector

(1) For the bolt-flange connector, stress analysis shall be done on the flange and its connection with the pipeline. The results shall be within the preset scope, with sufficient safety margins left.

(2) For the nonstandard flange, strength of the connection between it and the pipeline shall reach the requirements in 7.2.6. For the standard flange, its applicability shall be validated according to application environments, working conditions and the like.

7.2.6.9 Major structural members

(1) The major structural members mean those that are kept undersea after proper location of the subsea connector to provide support and guidance, as well as those requiring to be used during operating maintenance, e.g. guide structure.

(2) They shall be designed with considerations given to strength requirements under working conditions as well as strength and function requirements within the design lifetime. The design safety factor shall not be less than 1.5 usually, based on the min. yield strength of materials, or in accordance with the approved industrial regulation. The finite-element analysis (FEA) can be used to prove that the applied load does not cause deformation affecting other performances. Alternatively, the validation test of 1.5 times design load can replace the design analysis. The components shall subject to the test load with no deformation affecting the performance and test documents being kept.

7.2.6.10 Hoisting members

The hoisting members include the members for temporary and permanent hoisting. It is advisable that the hoisting members are designed by reference to ISO13628-4 Annex H (informative) Design and testing of subsea wellhead running retrieving and testing tools and Annex K (informative) Design and testing of pad eyes for lifting.

7.2.7 Seal ring and fixed pin

7.2.7.1 Seal ring

(1) The sealing between components/parts of the subsea connector shall be done in accordance with the operating environment conditions and requirements. The seals used for production

shall be made from metal, but those for temporary purpose or testing made from that other than metal.

(2) The materials and sealing areas for all seals, including the secondary seals, shall be able to withstand all specific fluids that may be accessible to during test, commissioning and operation.

(3) The sealing materials shall be superior to materials of the body usually. It is recommended that the corrosion-resisting alloy is applied or corresponding corrosion preventions taken for the sealing faces with no cathodic protection and being exposed to seawater directly.

(4) For safety reasons, the secondary seals are advisable.

(5) When the joint is locked to the male hub receiver structure via the seal ring, if the seal ring has been locked into the joint, the ring cannot be reused once the joint is unlocked. However, the ring for tests can be reused as long as this is permitted by the procedure document.

7.2.7.2 Fixed pin

(1) The seal ring is fitted with fixing devices/pins to facilitate the operations below sea level.

(2) As long as the seal ring fixing pin is required, it shall be made from materials resistant to seawater.

7.2.8 Hub and its receiver

7.2.8.1 Hub

(1) The hub shall have sufficient strength and surface stiffness to meet the demand of connecting the seals.

(2) The hub and pipeline shall be connected such that it is convenient to conduct the strength and tightness test during delivery, as well as the welding procedure qualification test during manufacturing.

7.2.8.2 Male hub receiver structure

(1) The male hub receiver structure shall meet the strength requirements for support first;

(2) It shall be designed to provide guidance;

(3) It is advisable to install the angle dial or indicator on the male hub receiver structure to facilitate installations and operations;

(4) It is advisable to separate the male hub receiver structure from the hub to facilitate installations and operations.

7.2.9 Locking mechanism

7.2.9.1 The locking mechanism of the collet segment subsea connector is comprised by two stages usually, namely, the hydraulic actuation ring as the first stage and the mechanic (bolted) locking device as the second stage. The secondary lock pin shall be inserted into the male/female connectors until its bottom touches the actuation ring of connector.

7.2.9.2 The collet segment vertical connector shall be fitted with a secondary locking mechanism to provide additional protection for the accidental connection release caused by vibration. This mechanism usually consists of two helical locking rods.

(1) Integral collet connector - the hydraulic actuation system, a permanent component of the connector, is maintained at the bottom of sea.

(2) Non-integral collet connector - the hydraulic actuation system is a part of the running tools. After the tools have been used, the collet connector at the bottom of sea has no hydraulic component any more.

7.2.9.3 The clamp connector is the main locking device of the connector. A typical one has three

clamping sections that are surrounded on two drum stands to work via a rotating screw. The double helical screws or two clamping sections can be applied as well.

7.2.9.4 All bolted locking mechanisms shall be designed with considerations given to the actual demand of preventing the reverse rotation.

7.2.10 Pressure cap

The pressure cap, if any, shall meet the strength and tightness requirements same as those of the subsea connector.

7.2.11 Corrosion-resistant

7.2.11.1 The external corrosion control is achieved by selecting suitable materials, coating system and cathodic protection. The corrosion control plan shall be formed during design and integrated into the system design.

7.2.11.2 The corrosion control shall meet the requirements of *ISO13628 Petroleum and natural gas industries Design and operation of subsea production systems Part 15: Subsea structures and manifolds 8 Fabrication and manufacturing considerations 8.1 External corrosion protection.* Based on these Guidelines, calculation of the sacrificial anodes shall meet DNV-RP-B401.

7.2.11.3 The coatings shall be designed or selected according to requirements of design temperature and marine environments of the connector.

7.2.12 Thermal insulation requirement

The thermal insulation of the joint is performed, if possible, by pre-wrapping the thermal insulating materials around the connector. If it is impossible, the doghouse can be located around the joint with water acting as the heat storage source.

7.2.13 Installation and removal

7.2.13.1 Landing mode during connection of the collet connector

For connection of the collet connector, the soft and hard landing modes are provided. The following shall be considered during design of the connecting system:

(1) The soft landing is completed with the support of tools such as the hydraulic cylinder

(2) The hard landing only applies to installation of the jumper pipe, with the ROV being applied for observation and providing guidance.

7.2.13.2 Permissible deviation

The subsea connector can be installed with the acceptable max. deviation angle that is not less than the specification requirement. Under the normal conditions:

(1) When the collet connector is installed with a deviation of not less than 2 in the vertical direction, the running tools can be used for installation for the subsea connector.

(2) The clamp connector can enable successful installation of the hub with an inclination of 2 in any direction.

(3) The flange connector shall meet the requirement not less than the technical specification.

7.2.14 Function requirements of running tools

7.2.14.1 The running tools shall be capable of installing, removing or maintaining the subsea connector.

7.2.14.2 As far as the running tool design and the pipeline arrangement are concerned, full considerations shall be given to accidents (e.g. impact of ROV) during installations below the sea level, as well as convenience of the ROV operations.

7.2.14.3 The ROV interface of the running tools shall be enough clear to be identified and operated easily by the ROV. The interface and its marking shall meet the requirements in annex B of ISO 13628-1.

7.2.14.4 Requirements of guide mechanism

(1) The guide mechanism shall be designed in such a reasonable manner to facilitate applications in installation, removal and maintenance.

(2) For the rounded cone type guide cylinder, the diameter of the circle at large end of the cone shall not be less than 1.5 times the diameter of member to be captured by it. The pyramid shall have an angle of declination of not less than 40 in the horizontal direction, with a typical cone angle of 45. As the member is to be captured by the cylinder, the cone (S) and inner cylinder shall be designed such that they allow the equipment, even if being deviated from the vertical by 3, to enter in an direction and assist them in keeping upright.

7.2.15 Colors and marking

The colors and marking system shall have the following functions:

(1) Definite structure and orientation

(2) Make clear the equipment to be installed on the structure and operating interface

(3) Define position of a member relevant to the whole structure

(4) Identify operating status of the equipment, e.g. locking/unlocking of connector and ON/OFF of valves

(5) For the recyclable equipment, the marking system shall be able to verify that it has arrived at the preset installation position and/or locked position, e.g. from guide column to locking fixture.

(6) It should be designed to satisfy requirements of ISO13628-1 Annex B (normative) Colors and marking, ISO13628-15 12 Equipment marking and ISO 13628-8.

7.2.16 Requirements of storage, maintenance and repair

The designer shall issue the storage, maintenance and repair requirements and instructions according to characteristics of the subsea connector.

Section 3 Manufacturing

7.3.1 General requirements

7.3.1.1 During manufacturing of the subsea connector, the welding of the pressurized parts shall subject to the process certification.

7.3.1.2 Preliminary welding procedure specification (pWPS)

The pWPS is prepared by the manufacturer before the welding process approval test. It is used to provide guidance in preparation of the technical documents of the test. It shall include all technical parameters in the welding procedure specification. During the approval test, relevant technical parameters can be modified or improved according the test results.

The pWPS to be submitted for approval shall include:

(1) Grade, class, thickness and delivery status of base metal;

(2) Model, class and specification of welding materials (welding rod/wire/flux, protective gas)

(3) Model and main performance parameters of welding equipment

(4) Design, processing requirement and linear materials (if any) of the groove

(5) Weld bead arrangement and welding sequence

(6) Welding position (flat, vertical, horizontal, overhead welding)

(7) Welding variables (power supply polarity, welding current, arc voltage, welding speed, and flow rate of protective gas)

(8) Preheating prior to welding, interpass temperature, heat treatment after welding, and actions to eliminate stress after welding

(9) Welding environment: on the site or in the workshop

(10) Other relevant special requirements.

7.3.1.3 Welding Procedure Qualification Record (WPQR)

(1) WPQR is a technical document correctly describing and recording the technical parameters in detail that are applied or obtained during the welding process approval test. It works as the basis for the approval of welding procedure specification. All results in the record, including the retest results, shall be assessed.

(2) During the tests, the parameters and results shall be filled into the WPQR with signature of the Surveyor.

(3) Welding of the test piece and test of the sample shall be witnessed by the Surveyor.

7.3.1.4 Welding Procedure Specification (WPS)

The WPS is a technical document that originates from the pWPS modified and improved by the factory according to the acceptable WPQR, with the formal approval from the CCS. It is used to guide the product welding. The factory shall, based on the test results, prepare the complete welding procedure specifications and submit them to the CCS for approval together with the test record.

7.3.2 Material performance verification

7.3.2.1 In general, that main pressurized parts or key parts subject to the material review and performance verification according to the actual conditions is advisable. The material performance verification shall meet the requirements in GB/T 22513-2008 *Drilling and production equipment - Wellhead and Christmas tree equipment*, 5.3.5 Material Verification Test - PSL2-PSL4, as well as 7 Performance Verification of Materials of Corresponding Class During the Quality Control. Its equivalent standard ISO 10423 (API 6A) applies as well.

7.3.2.2 DD, EE, FF, and HH class materials

The pressurized parts or pressure control parts for operating environments exposed to sulfured hydrogen shall suffer the stiffness test one by one, so as to verify that they reach the specified values given in GB/T 20972. 2 and GB/T 20972. 3.

7.3.2.3 Acceptance criteria

The verification and acceptance of material performance shall be conducted to prove that the values not lower than those specified in the specification or required by the design, as well as those given in the regulation, are reached.

7.3.3 Manufacturing process inspection

7.3.3.1 The ITP and test program shall be submitted and the field audits of the Surveyor performed.

7.3.3.2 The manufacturing process shall subject to the inspection according to the items required by ITP, with the results consistent with the approved drawings and documents or relevant regulations.

7.3.3.3 The pairing and welding of key structures as well as nondestructive test results shall subject to inspection of the CCS Surveyor.

7.3.3.4 The control of key dimensions shall subject to inspection and approval of the CCS Surveyor after the welding.

7.3.3.5 Welding

(1) Pressurized structural

① The pressurized structural shall be welded and tested according to GB/T 22513-2008 Drilling and production equipment - Wellhead and Christmas tree equipment, as well as the rules in 6.3 of 6 Welding - General Requirements. Its equivalent standard ISO 10423 (API 6A) applies as well.

② The end and outlet connection shall be components of the body, or connected via welding consistent with the requirements given in chapter 6 of GB/T22513. The PSL4 devices shall not be designed to subject to group welding.

③ The corrosion-resisting alloy interior linings shall be welded and tested according to GB/T 22513-2008 Drilling and production equipment - Wellhead and Christmas tree equipment, as well as the rules in 6.3 of 6 Welding - General Requirements. Its equivalent standard ISO 10423 (API 6A) applies as well.

(2) Main non-Pressurized structural

The main non-pressurized structural are deemed as non-pressurized members usually. The welding shall meet the requirements in GB/T 22513 Drilling and production equipment - Wellhead and Christmas tree equipment, as well as those for the non-pressurized members given in 6 Welding - General Requirements, or those for the welding of non-pressurized members given in the equivalent standard ISO10423, or the structure welding regulations such as AWS D1.1.

(3) Welding of anodes blocks

① The anodes blocks shall be welded in the manner of full penetration welding.

②They shall, after being welded, subject to appearance inspections according to the welding processes and technical specifications.

(4) Dimension inspection

The dimension inspections on the following items shall be done according to the technical specifications:

① Parallelism, perpendicularity, inside diameter, and coaxiality of inner cone surface of the connection of the upper flanges

② Parallelism, perpendicularity, inside diameter, and coaxiality of inner cone surface of the connection of the lower flanges

③ Angle of inner bevel of the clamp claw, roughness of the bevel

④ Position error of connecting hole of the pin shaft at the clamp flap

⑤ Inner diameter, spherical radius, roundness and height of the seal ring

⑥ Uniformity of arrangement of the collet segment

Section 4 Factory acceptance test

7.4.1 Hydrostatic test

7.4.1.1 The hydrostatic test shall be done at the pressure of 1.5 times the rated working pressure.

7.4.1.2 The number of cycles shall be in accordance with the technical specifications, which is usually not less than the technical requirements in 8.1.1.3.

7.4.1.3 Test procedure and acceptance criteria

(1) Pressurize it to 5%-10% of the test pressure and keep the pressure for 3 min with no leakage;

(2) Pressurize it to the rated test pressure and keep the pressure for 3 min with no leakage;

(3) Depressurize it to the rated working pressure and keep the pressure for 15 min with no leakage;

(4) Depressurize it to 5%-10% of the test pressure and keep the pressure for 3 min with no leakage;

(5) In case of no leakage, pressurize it to the rated working pressure in turn and depressurize it, which is deemed as one cycle. This cycle shall be done for 200 times, with no visual seepage or leakage and the pressure maintaining period not required.

(6) Repeat the steps (1) and (4).

7.4.1.4 Acceptable standard of the test pressure

(1) The drop or rise of the original pressure caused by temperature difference between the test liquid and equipment pipeline is acceptable, provided that the pressure variation can be stabilized finally. Otherwise, check and repair the seepages. After the stability is rebuilt, readjust the pressure to the test pressure value. During the pressure stabilization phase of the test, the pressurization equipment shall be isolated.

(2) Any visual liquid seepage or leakage is unacceptable. The max. pressure drop shall not exceed 5% of the test pressure or 3.45 MPa, whichever is the smaller.

7.4.2 Interchangeability test

7.4.2.1 If the interchangeable tools or components are available, the relevant interchangeability test shall be performed, e.g. interchangeability test of the hydraulic ballhead.

7.4.2.2 Basic requirements of the interchangeability test:

(1) Smoothness

(2) Be able to achieve the function and performance requirements

(3) The pressurized parts, after having subjected to the interchangeability test, shall suffer the hydrostatic test according to the rules in ①-③ of 8.1.1.3

(4) It is advisable to carry out (but not limited to) the interchangeability test items

① Interchangeability of seal rings and their tools

② Interchangeability of hydraulic and electric ballheads

③ Interchangeability of actuation tools

④ Interchangeability of running tools

7.4.3 Installation and removal test

7.4.3.1 The function tests during installation such as guidance, alignment, tightening and locking shall be performed.

7.4.3.2 After completion of the subsea connector connection and the corresponding tests, relevant tools shall be used for removal of the connector, including unlocking and breakout.

7.4.3.3 After the installation, the hydrostatic test shall be performed according to the rules in 7.4.1.3 (1) - (4) so as to validate the effective installation.

7.4.3.4 During installation and removal, such key data as operating torque shall be recorded for reference in the field installation.

(1) Collet connector

The alignment test of the collet connector shall be completed with no support of staffs, smooth guidance from the guide structure, and no unacceptable wearing on the guide cylinder.

The connector shall be locked smoothly with no abnormal sound. After unlocking of the connector, the actuation ring and collet segment shall be free from unacceptable wearing.

(2) Clamp connector

During the alignment, the acceptable max. deflection angle shall be validated and recorded.

The alignment test of the clamp connector shall be completed with no support of staffs, smooth guidance from the guide structure, and no unacceptable wearing on the guide cylinder.

The connector shall be locked smoothly with no abnormal sound.

The guide rail and pin shall be free from unacceptable wearing.

(3) Bolt-flange connector

During the alignment, the acceptable max. deflection angle shall be validated and recorded.

7.4.4 Requirements on installation and replacement of the seal ring as well as the tightness effectiveness test

7.4.4.1 The weight and dimensions of the seal ring tool shall apply to the ROV robot arm.

7.4.4.2 The operating tests of the tools used for replacing the seal ring, namely, taking down or properly placing it, shall be conducted.

7.4.4.3 When the joint is locked to the male hub receiver structure via the seal ring, if the seal ring has been locked into the joint, the ring cannot be reused once the joint is unlocked. However, the metal ring for tests can be reused as long as this is permitted by the procedure document.

7.4.4.4 Test of tightness effectiveness (back pressure test)

(1) After installation and replacement of the seal ring, the tightness effectiveness test of the connector shall be performed.

(2) The test pressure shall be defined with reference to the technical specification, but not lower than 1.2 times the working pressure.

(3) Test procedure and acceptance criteria.

① Apply and keep the test pressure not less than 1h, with no leakage during the specified hold period.;

② In case of pressure drop, the max. value shall not exceed 5% of the test pressure or 3.45 MPa, whichever is the smaller.

7.4.5 Corrosion-resistant

7.4.5.1 Coating inspection

(1) The coating processes shall match the requirements of Subsea corrosion-resistant;

(2) The coating processes and construction records of the parts whose connectors are kept in the sea for a long term shall be reviewed according to the technical specification.

(3) Appearance, thickness, adhesion force and the like of the coating shall be tested and validated.

7.4.5.2 Protective current test (if applicable)

The protective current shall be measured according to the corrosion-resisting process calculation sheet.

7.4.6 Electric continuity test (if applicable)

The electric continuity of the connector shall be tested according to the approved drawings and technical specifications. If the resistance acts as the test index, the max. resistivity shall be less than 0.10 . Any other applicable index, after having been conversed, shall not be less than this standard.

7.4.7 Relevant tests of the hydraulic ballhead

7.4.7.1 Operation performance test

(1) The appearance inspection shall be performed to verify that there is no obvious scratch or damage and the relevant certificates match the products.

(2) The insertion and extraction test shall be performed to confirm its smoothness.

7.4.7.2 It is advisable to carry out the strength and tightness performance tests in the steps below:

(1) Apply the 1.1 times that of rated working pressure to the hydraulic ballhead set and its pipeline and keep it for not less than 3 min. with no leakage;

(2) Pressurize it to the 1.5 times rated working pressure and keep it for not less than 3 min. with no leakage;

(3) Depressurize it to the rated working pressure and keep the pressure for not less than 3 min. with no leakage, and then release all the left pressure;

(4) Pressurize it to the rated working pressure and keep the pressure for not less than 3 min. with no leakage, and then release all the left pressure;

(5) Repeat the step (4) for two times.

7.4.7.3 Strength and tightness performance tests as well as acceptance criteria for pressure maintaining

Any visual liquid seepage or leakage is unacceptable. The max. pressure drop shall not exceed 5% of the test pressure or 3.45 MPa, whichever is the smaller.

7.4.8 Trial fit-up test of electric ballhead

(1) The appearance inspection shall be performed to verify that there is no obvious scratch or damage and the relevant certificates match the products.

(2) The insertion and extraction test shall be performed to confirm its smoothness.

(3) The basic performance tests such as conductivity shall be conducted according to the technical specification.

7.4.9 Test of the hydraulic actuator of running tool

7.4.9.1 The running tools shall subject to the factory approval test in accordance with the technical specification.

7.4.9.2 It is advisable to test and accept the hydraulic actuator of the running tool according to ISO13628-4 7.10 Valves, valve blocks and actuators 7.10.4.2 Factory acceptance testing, or GB21412.4 7.9 Valves, valve blocks and actuators 7.9.4 Test.

7.4.10 Measuring the drift diameter

The subsea connector shall meet the ball-passing requirement of the subsea structure connected to it. Before the subsea connector leaves the factory, the drift diameter shall be measured and recorded.

7.4.11 Weighing

7.4.11.1 General requirements

The weights of the subsea connector and its running tools, including those in the air or water, shall be

measured and recorded.

7.4.11.2 Collet connector

(1) During delivery of the running tools of the subsea connection system, verify that the centers of gravity are in line with the design drawings;

(2) During delivery of the running tools of the subsea connector, after connection of the female joint, verify that the centers of gravity are in line with the design drawings.

7.4.11.3 Clamp connector

During delivery of the clamp connectors, measure and verify that the centers of gravity are in line with the design drawings.

7.4.12 Pressure cap test (if applicable)

7.4.12.1 The pressure cap shall subject to the hydrostatic test and back pressure test before use, so as to validate its structural strength and sealing capacity.

7.4.12.2 General requirements

(1) The liquid used for each test shall be marked clearly in the test record sheets.

(2) The approved test record sheets shall be used to record all test results.

(3) The readouts of the pressure tests shall be recorded on the pressure record paper.

(4) The pressure recording shall begin once the test pressure is reached and kept stable. Meanwhile, it shall be ensured that the test instrument and pressure monitoring equipment are isolated from the pressure sources.

(5) The pressure test shall be done according to the equipment safety operation procedures and HSE rules.

(6) Before the tests, all parts of the pressure cap shall be cleaned completely to ensure that there are no metal filings and sanding materials inside the bolt hole, seal ring groove and internal port. Before or after the pressure test equipment is assembled, always check and confirm that all parts are free from operative damages.

(7) In case of any violation against or conflict with the test procedures, apply to the owners, manufacturers and issuing authorities for approval.

(8) It shall be specially noted that if the test pressure of the male hub receiver structure is lower than that of the pressure cap, regardless of the receiver used for test or production, it cannot be used.

(9) The pressure monitoring equipment (such as pressure sensor, pressure gauge and pressure recorder) shall be indicated in the pressure record sheets.

(10) The rated pressures displayed on the pressure control equipment (e.g. valve, pipe, tubing and hose) shall be higher than the test pressures.

7.4.13 Acceptance inspection of the outsourced parts

Unless specified otherwise, the outsourced parts of the subsea connectors shall subject to the following factory acceptance tests according to the technical specialization:

(1) Appearance inspection

(2) Inspection of conformity between the certificates and the products

(3) Tests of main functions and performances

(4) Relevant certificates and documents of the outsourced parts have been registered and maintained properly.

Section 5 System integrity test

7.5.1 General requirements

7.5.1.1 The system integrity test aims for verifying reasonableness of the interface between the subsea connection system and other associated systems (e.g. ROV), and covers the function and performance tests.

7.5.1.2 This test shall have detailed test procedures and acceptance criterias and be approved by CCS.

7.5.2 Tightness test of the system

7.5.2.1 Subsea connector

(1) The subsea connector, after having been installed, shall conduct the system tightness test.

(2) The test pressure is 1.1 times that of the rated working pressure and shall be maintained for 15 min. with no leakage.

7.5.2.2 Running tools of the subsea connector

(1) The hydraulic operating parts of the subsea connection running tools (e.g. hydraulic ballhead), after having been connected, shall conduct to the system tightness tests to confirm the integrity of the system tightness..

(2) The test pressure is 1.1 times that of the rated working pressure and shall be maintained for 3 min. with no leakage.

7.5.3 Installation test

7.5.3.1 Installation test requirement

The running tools shall be able to simulate connection and locking of the subsea connector successfully in the test site. Then, the tightness test shall be performed according to 9.2.1.

7.5.3.2 Details of field validation:

(1) There shall be no dirt around the primary locking mechanisms (collet segment, clamp, flange) and the hub;

(2) Validate that the guide module of the joint be installed and aligned correctly by referencing to the approved assembling drawings;

(3) Validate that the actuation ring and secondary lock pin of the joint have arrived at the specified location;

(4) After the tests, confirm that there is no evidence of clear scratch or extrusion on the locking mechanism and hub;

(5) Install the garbage cap to the hub (if any) and confirm there is no risk of impact with the surrounding structures.

7.5.4 Recall test

7.5.4.1 Based on the requirements of the test procedures, use the ROV operating arm to simulate removal of the subsea connector step by step on the land.

7.5.4.2 After the recalls, verify that the primary and secondary locking mechanisms (if any) and the hubs have no unacceptable scratch or bruise.

7.5.5 Interface test of ROV and running tools

7.5.5.1 Impact test of ROV

All ROV tools shall be tested on the running tools of the subsea connector. ROV and its mechanic arm

shall be protected against impact with adjacent structures of the tools as well as the pipelines.

7.5.5.2 Interface test of ROV tools

(1) The ROV operating arm shall match the ROV operating interface of the subsea connection system;

(2) The ROV operating arm shall match the operating handle of the cleaning tools of the subsea connector;

(3) The ROV operating arm shall match the operating handle of the seal ring replacement tool.

7.5.6 Replacement of seal ring

7.5.6.1 Requirements for replacement

(1) Check the ROV's capability of using the replacement tools to take down the seal ring after it has stopped at the parking station;

(2) Check the ROV's capacity of using the cleaning tools to clean the hub;

(3) Check the ROV's capability of using tools to install the new seal rings.

7.5.6.2 Tightness effectiveness test after replacement of seal ring

After the installation, the tightness effectiveness test shall be conducted (via the back pressure test method usually). The back pressure test is conducted with reference to the rules in 7.4.4, but with a pressure-holding time of not less than 15 min.

Section 6 Design approval of new products

7.6.1 Basic requirements for the design approval

(1) These Guidelines set the min. technical requirements for the design approval of the subsea connection system in terms of safety and achievement of main functions;

(2) The product prototype that have subjected to design approval shall be checked and marked by the Surveyor, so as to ensure that it is manufactured according to the approved drawings, meets the validation principle, and matches the preset purpose.

(3) The manufacturer shall arrange the required tests in the laboratories approved by China National Accreditation Board for Laboratories, other laboratories accepted by the CCS, or the test sites meeting the test conditions. Meanwhile, the CCS Surveyor shall verify the test conditions and witness the test processes.

(4) The prototype test shall be done with witness of the Surveyor. The prototype test shall involve the product performance, NDT, destructiveness, environment and other tests within the scope of the requirements raised by the validation principles and the test outline shall be approved by related parties in advance..

(5) The design approval and inspection of this connecting system are mainly based on *Principle of Design Approval of the Subsea connection system* (prepared by the CCS and reviewed by the committee of experts).

(6) For the problems on new technologies, both parties shall cooperate to organize experts to review and solve them.

(7) If the accepted regulations are not in line with this principle, the later will govern.

7.6.2 Scope

This principle makes corresponding provisions for the design approval procedures and technical

requirements of the collet segment type, clamp and general bolt-flange subsea connection system/device. It mainly covers the technical requirements on the design, manufacturing, test, installation and operation.

For the running tools of the subsea connector, these Guidelines only raise requirements for their functions.

7.6.3 Procedures and contents of the design approval

7.6.3.1 Documents submitted by the applicant

(1) The applicant shall submit the application of design approval and the technical specification (or technical contract or written requirements);

(2) The applicant shall submit the design drawings, calculation sheets, technical specifications and the like to the CCS for approval:

Before commencement, the applicant shall submit the drawings and documents specified in 2.3.2.5 of these Guidelines (including the equipment commissioning program) to the CCS for review.

(3) Inspection and test plan (ITP) and quality control plan (if any). Among them, the performance test plan shall be prepared by reference to API Spec.17D 307 Performance Verification Testing and GB/T 22513-2008 Drilling and production equipment - Wellhead and Christmas tree equipment.

7.6.4 Procedures and contents of the design review

7.6.4.1 Design documents

(1) The CCS shall review and register the application of design approval and the technical specification (or technical contract or written requirements) submitted by the applicant;

(2) The CCS shall conduct the drawing reviews, field inspections and the like on the engineering samples.

7.6.4.2 Approval of documents on manufacturing

The following test procedures shall be reviewed and approved:

(1) The procedures of performance verification test (PVT);

(2) Process approval procedures (usually include the welding procedure specification (WPS), heat treatment process, corrosion prevention process, nondestructive test process, etc.);

(3) Procedures of function test (e.g. FAT, SIT, SAT).

7.6.5 Procedures and contents of the field inspection

7.6.5.1 Reviews of relevant test procedures and documents

The test program shall be approved according the ITP. It usually involves the FAT, SIT, sea test, and so on.

7.6.5.2 Witness of inspection and test

It usually covers:

(1) Tracking and inspecting the raw materials and components;

(2) Manufacturing process inspection, especially controls on the key points on the basis of ITP requirements;

(3) Signing the release pass (where necessary) for the critical product manufacturing phases (e.g. before the hydraulic test) according to the ITP requirements;

(4) Witnessing the tests according to the approved test programs.

7.6.5.3 Reviewing the delivery documents and signing the certificates

(1) Reviewing the delivery documents

The delivery documents shall be reviewed to be qualified. They include but is not limited to the certificates of main raw materials, welding material certificates, welding processes, welder certificates, pressure vessel manufacturing certificates, welding inspection records and NDT reports, and inspection records of appearances and dimensions (if applicable),

Certificates of main outsourced equipment (valves, hydraulic actuator and so on), certificates and explosion protection certificates of the electric control cabinets (if applicable).

(2) Signing the release pass of the product according to the contract and/or ITP requirements (if applicable);

(3) Signing corresponding certificates.

7.6.6 General requirements of performance verification and test

7.6.6.1 Unless specified otherwise, this chapter applies to three kinds of connectors. Among them, those whose classes are not defined (namely, PR1 or PR2) apply to the common requirements of the two classes.

7.6.6.2 The performance verification is usually performed to prove that the subsea connection system, if being subjected to the rated pressure/temperature and the test fluid conditions matching the class of material, meets the design performance requirements as well as the applicable regulations and standards. It covers tests of the carrying capacity, period, operating force or torque as well. There are two performance requirement classes, namely, PR1 and PR2.

7.6.6.3 The performance verification tests shall be performed on the trial products or prototype (if applicable) so as to verify that such specified performance requirements as the forced circuiation , temperature cycle, loading cycle, mechanical circulation and standard test fluid conform to the product designs.

7.6.6.4 The design verification procedures and the performance verification results of the designs shall be documented by the manufacturer.

7.6.6.5 The test products before accepting the performance verification tests shall subject to the hydrostatic tests on the basis of the PSLI requirements.

7.6.6.6 Any product subjecting to the hydrostatic test shall be free from paint or other coatings that may hinder the leakage detection and/or observation.

7.6.6.7 All the measuring equipment shall be calibrated by the national measuring authorities and awarded certificates. The pressure measuring instrument shall reach the accuracy of 0.5% of the dial range at least.

7.6.6.8 Cleaning and washing

Before all tests, the inner cavities of the connector shall be cleaned/washed and processed (e.g. aeration-drying) until they are ready for tests. For those materials or pipelines with special requirements, suitable liquids (e.g. oil) shall be used for cleaning.

7.6.6.9 Inspections before tests

(1) Before the tests, always verify that the key test equipment (e.g. instruments and devices for tests) and the instrument calibration certificates and the like conform to the field test equipment and instruments.

(2) Verify that the field test conditions conform to the approved test programs.

(3) Appearance inspection

The tested equipment shall subject to the appearance inspection to verify that there is no visual defect.

7.6.6.10 After test

(1) Appearance inspection

The appearance inspection is required after the test. It may be required to disassemble or open the equipment for inspection as the case may be, so as to verify that no visual deformation occurs to the tested equipment or it is within the acceptable test range (if any). It is advisable to take photos of relevant items for archiving.

For the collet segment or clamp connectors, during inspections of the key components after the installation and removal tests, note whether any damage or scratch occurs to the lower/upper flanges and any injury occurs to the seal rings; if yes, measure the ring and verify that its abrasion loss is within the acceptable range.

(2) Equipment maintenance

After the hydrostatic test and the tightness test are performed to test the strength and performance with the help of liquids, the equipment maintenances shall be done, e.g. aeration-drying or application of corrosion-resisting medium.

7.6.6.11 Appropriate considerations shall be given to safety of the personnel and equipment.

7.6.7 Procedures of performance verification test

7.6.7.1 The procedures apply to the product designs (including the design changes).

7.6.7.2 Alternative procedures

Other procedures consistent with or superior to the test requirements of this principle can be used.

7.6.8 Changes to the product validity

7.6.8.1 Design change

The performance evaluation is required for the designs that subject to substantial changes. The substantial design changes (including changes to mating, type, function or material) affect the performances of products in the original operating conditions and thus shall be confirmed by the manufacturer.

Note: The mating, if being defined as the geometrical relationship between two components, shall cover the tolerance rules used in the designs of the components and their mating parts. However, if being defined as the adjusted or formed status, it shall cover the tolerance rules used in the designs of the seals and their mating parts.

7.6.8.2 Metal materials

In case of changes to the metal materials, if the adaptability of new metal materials can be certified by other methods, it is unnecessary to perform new performance evaluations.

7.6.8.3 Nonmetallic seals

In case of changes to the nonmetallic materials, if the adaptability of new nonmetallic materials can be certified by other methods, it is unnecessary to perform new performance evaluations. In case of substantial changes to structures of the newly designed nonmetallic seals, the performance evaluation tests shall be carried out according to the corresponding requirements.

7.6.9 Performance test

7.6.9.1 Integrity of structure

(1) The tested products shall be free from the permanent deformation inconsistent with the requirements.

(2) The collet segment/clamp connector hub, male hub receiver structure, locking mechanism, guide mechanism of the clamp connector, ROV operating mechanism, and ROV parking station (collet segment) shall be free from any plastic deformation inconsistent with the requirements during all the tests.

(3) The flange faces and locking bolts of the flange connector shall be free from any plastic deformation inconsistent with the requirements during all the tests.

7.6.9.2 Fluid compatibility of the nonmetallic seals

(1) If the connectors are fitted with the nonmetallic seals, corresponding tests shall be performed according to E.1.6.4 Fluid compatibility of the nonmetallic seals and E.1.13 Test of nonmetallic seals, annex E (informative) Performance evaluation procedures of GB/T22513.

(2) When the nonmetallic seals of the connectors are only used for sealing from the sea water and there is an evidence that they conform with the design requirements (including those of design lifetime) in the sea water, the liquid compatibility test is unnecessary. Otherwise, the test shall be conducted according to the requirements in the above (1).

(3) The samples shall be maintained in the standard test liquids, temperatures and pressures below so as to compare the physical and mechanic performances before and after the immersion. This test involves those other than the full-range pressure and temperature tests given in 7.2 of these Guidelines.

7.6.9.3 Pressure-holding period

(1) Start of the pressure-holding period

The pressure-holding period begins when the pressure and temperature have gotten stabilized and the tested device with the pressure monitoring unit has been separated from the pressure source. The specified period shall be the min. pressure-holding time.

(2) Stability of pressure

The pressure is considered to be stable when the test pressure fluctuates within 5% or 3.45 MPa per hour, whichever is the smaller. Through the pressure-holding period, the pressure change shall be controlled within 5% or 3.45 MPa, whichever is the smaller.

(3) Stability of temperature

The temperature is considered to be stable when the temperature variation per minute is less than 0.5. Through the stabilization phase, the temperature shall be maintained at or exceed the limit value, but not exceed it by more than 11.

7.6.9.4 Hydrostatic test at the room temperature

(1) Test medium

The test medium shall be a fluid matching the test temperature and being maintained in the form of liquid or gas through the tests. The mixture of water, gas, hydraulic liquid or other liquid, regardless of additives, can be used as the test medium.

(2) Replacement of gas

If the hydrostatic test is specified, the manufacturer can replace liquids with gases and apply the test methods and acceptance rules that rely on the gases.

(3) Test pressure and holding time

The min. pressure shall be 1.5 times the rated working pressure and the holding time of each phase not less than 1h. These Guidelines do not necessitate the cyclic pressure test, unless specified in the specification.

(4) Acceptance criteria

During the hydrostatic test under the room temperature, if there is no visual leakage through the

specified pressure-holding period, the acceptance shall be approved. The pressure variation displayed on the pressure measuring device during the pressure-holding period shall be less than 5% of the test pressure or 3.45 MPa, whichever is the smaller.

If the pressure monitoring gages or forms are used for recording, the pressure drop per hour shall not exceed 3% of the test pressure. Meanwhile, through the pressure-holding period, the pressure shall not be less than the test pressure stated in (3) of this article and the original pressure not exceed 5% of it.

(5) Requirements of stress measuring

① For the collet connector, it is advisable to measure the stress distribution at the collet segment, actuation ring (primary locking ring), and the connection between the hub and pipe.

② For the clamp connector, it is advisable to measure the stress distribution at the clamp and the connection between the hub and pipe, so as to verify the methods and results of computing and analysis.

③ For the bolt-flange connector, it is advisable to measure the stress distribution at the connection between the flange and pipe, so as to verify the results of computing and analysis.

7.6.9.5 Air pressure tests at the room temperature

(1) Test medium

The air, nitrogen, methane, other gas or mixture can be used.

(2) Test conditions

① Apply the non-flammable and non-explosive gases as far as possible;

② It is advisable to conduct the tests in the water all the time;

(3) Requirements of leakage detection

The air pressure tests performed at the room temperature shall be fitted with methods to detect the leakage. The whole product or the sealing area to be checked of the product can be immersed in the liquid to facilitate detection of possible leakage. Alternatively, the connector of the cover encompassing all the potential leakage paths of the verified parts of the product can be connected to one end of the pipe, and the other end of it shall be immersed in the liquid or connected to the measuring equipment. Other approved accuracy measuring methods can also be acceptable.

(4) Test pressure and holding time

The min. pressure shall be 1 times that of the rated working pressure and the pressure-holding time is not less than 15 min. In case of phased pressurization, the holding time of each phase shall not be less than 15 min. as well.

(5) Acceptance criteria

During the air pressure test at the room temperature, if there is no visual continuous bubbles, the acceptance shall be approved. In case of visual leakage, the quantity of leakage measured in the atmospheric pressure shall be less than 20 ml/h in the specified pressure-holding period.

If the pressure monitoring gages or forms are used for recording, the pressure drop per 15 min. shall not exceed 3% of the test pressure or 2 MPa (300 psi), whichever is the smaller. Meanwhile, through the pressure-holding period, the pressure drop shall not be less than the test pressure stated in 7.2.5.3 and the original pressure not exceed 5% of the test pressure stated in (4) of this article.

7.6.9.6 Tests at the min./max. temperatures

During the hydrostatic pressure or air pressure tests at the high/low temperatures, if the pressure variation displayed on the pressure measuring dial is less than 5% of the test pressure or 3.45 MPa, whichever is the smaller, the acceptance shall be approved.

7.6.9.7 Pressure-temperature cyclic test

(1) The test pressure shall adapt the rated working pressure rating;

(2) Measuring position of temperatures.

The temperature measuring equipment shall be located in a 13 mm through-hole of the tested device, and contact the device, and if possible, distance itself from the sealed fluid wetting surface by 13 mm or less on other devices.

As one choice to measure the max. temperature, the temperature of the heating fluid can be measured directly provided it is not cooled manually and the environmental condition, namely, room temperature, is maintained.

(3) Heating during the test at the max. temperature

For the test at the max. temperature, heating shall be performed inside or outside the through-hole. It shall not be stopped until the temperature of the whole through-hole or corresponding wetting surface, or that of the heating fluid inside the test piece reaches or exceeds the max. value.

(4) Cooling during the test at the min. temperature

For the test at the min. temperature, the whole external surface of the device shall be cooled.

(5) Procedures of the pressure-temperature cyclic test

The pressure shall be monitored and controlled during the change of temperature. Meanwhile, the following procedures whose letter codes are seen in 7.6.9.7 shall be observed: During the pressure-holding period, the acceptable max. pressure drop shall be 5% of the test pressure or 3.45 MPa, whichever is the smaller.

a) Increase the temperature to the max. value under the operational seawater temperature and the atmospheric pressure;

b) Apply the test pressure, maintain it for at least 1 h, and then release it;

c) Decrease the temperature to the lowest value;

d) Apply the test pressure, maintain it for at least 1 h, and then release it;

e) Heating the temperature to the operational seawater temperature;

f) During applying the test pressure under the operational seawater temperature and heating the temperature to the max. value, maintain the pressure at 50%-100% of the test pressure;

g) Maintain the test pressure for at least 1 h;

h) Lower the temperature to the min. value while maintaining the pressure at 50%-100% of the test pressure;

i) Maintain the test pressure for at least 1 h;

j) Heating the temperature to the operational seawater temperature, during which the pressure shall be maintained at 50%-100% of the test pressure;

k) Release the pressure and then heat the temperature to the max. value;

i) Apply the test pressure, maintain it for at least 1 h, and then release it;

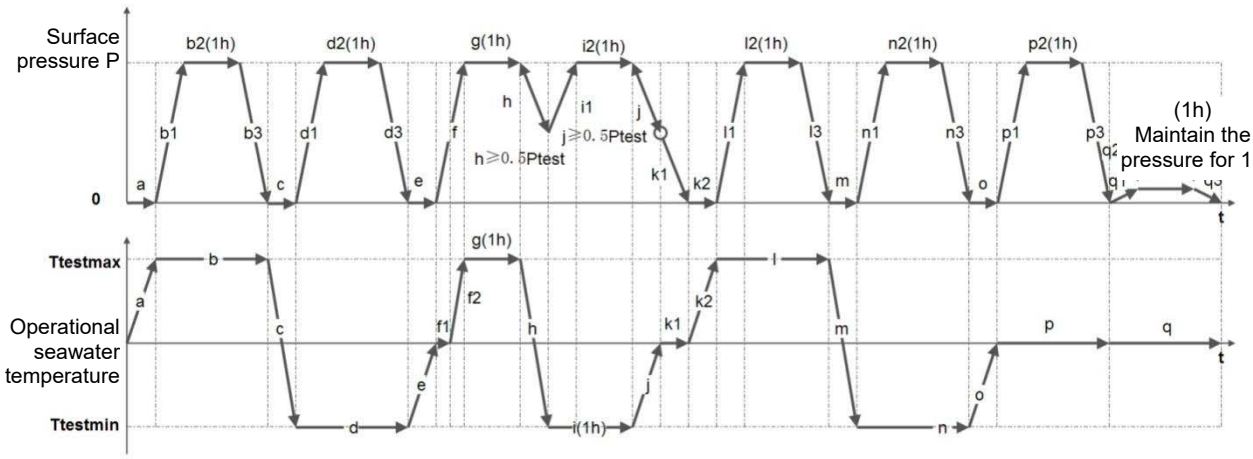
m) Decrease the temperature to the lowest value;

n) Apply the test pressure, maintain it for at least 1 h, and then release it;

o) Raise the temperature to the operational seawater temperature;

p) Apply the test pressure, maintain it for at least 1 h, and then release it;

q) Apply the 5%-10% of the test pressure, maintain it for at least 1 h, and then release it;



f250%-100%

Note: Duringheating the temperature to the max. value, maintain the pressure at 50%-100% of the test pressure

Figure 7.6.9.7 Procedures of the pressure-temperature cyclic test

(6) PR1 class

It is allowable to perform the temperature-pressure cyclic test with no regard to the rules in 7.6.9.7, provided that sufficient objective evidences are presented.

(7) PR2 class

It is necessary to perform the temperature-forced circuiation test according to the rules in 7.6.9.7.

7.6.9.8 Loading-unloading cycle

(1) Test requirement

The loading/unloading cyclic tests at the rated loads are specified by the manufacturer. Each time when the connecting device is assembled, it shall conduct to the pressure-holding test for 5 min. at the rated working pressure.

(2) PR1 class

It is allowable to perform the test with no regard to the rules in 7.6.9.8(1), provided that sufficient objective evidences are presented.

(3) PR2 class

It is necessary to perform the test according to the rules in 7.6.9.8(1).

7.6.9.9 Bending moment

(1) Test requirement

It shall, under the status of the specified max. stress, subject to the primary cycling test at the rated load as specified by the manufacturer. The connecting device shall be applied with the rated load specified by the manufacturer to generate the max. stress during the primary cycle.

(2) PR1 class

It is allowable to perform the bending moment test with no regard to the rules in 7.6.9.9(1), provided that sufficient objective evidences are presented. However, the hydrostatic test is still required.

(3) PR2 class

It is necessary to perform the bending moment test according to the rules in 7.6.9.9(1).

7.6.9.10 Vibration test

(1) Verify that the pipe connector has no leakage and its body does not suffer fatigue conditions under the rated working pressure (hydraulic pressure) and the possible vibration frequency. After the test, check the connector for damage and carry out the hydrostatic test again to confirm the excellent tightness.

(2) The vibration test frequency and excitation density shall be determined with considerations given to the vibration frequency and energy of the connected pipelines, the vortex-induced oscillation frequency and energy of the jumper pipe, and the vibration frequency and energy caused by the flowing of the internal fluids at least.

(3) The test time is defined by the technical specification, which is usually not less than 5h.

7.6.9.11 Durability cyclic test

(1) The durability cyclic test of the subsea connection system shall be done as required by the technical specification of the manufacturer;

(2) It includes but is not limited to the pressure/temperature/load cyclic tests and the installation/removal tests.

7.6.9.12 Test of the nonmetallic seals

The nonstandard, nonmetallic seals shall not serve for the oil and gas medium. If they serve for the seawater, the tests shall be done according to the principles of GB/T22513 E.1.13 *Test of the nonmetallic seals* to confirm their temperatures, pressures, corrosion-resisting performances and lifetimes.

For the nonmetallic seals made of standard materials, the model selection shall conform to the recognized standards.

7.6.9.13 Operation performance test

(1) The subsea connection system shall be capable of working under the torque force specified in the manufacturer's specification. The operating toques of the connector shall be validated and recorded accordingly.

(2) Operation performance test of the locking mechanism

The subsea connection system, after having been manufactured, shall subject to the operation performance test of the locking mechanism, with the steps being implemented by reference to the principles below:

a) Properly fix the hub end of the connector (flange connector, one of the ends being fixed);

b) Apply the max. locking pressure given in the specification to lock the connector;

c) Measure the torque force required for using the primary locking system to unlock the connector and record it;

d) Repeat the steps b) and c) using the 67% of the locking pressure recommended by the manufacturer (excluding the flange connector);

e) Repeat the steps b) and c) using the 33% of the locking pressure recommended by the manufacturer (excluding the flange connector);

f) Repeat the steps b)-e) twice at least;

g) Only the secondary unlocking system (overriding system), if being installed on the connector, is required for repetition of the steps b)-f) (excluding the flange connector).

h) Record all the locking torque forces and corresponding opening pressures;

i) Check and record the wearing of the locking mechanism.

(3) Test of tightness devices

① The subsea connection system, after having been manufactured, shall subject to the

operation performance test of the tightness mechanism, with the steps being implemented by reference to the principles below:

a) Properly fix the hub end of the connector (flange connector, one of the ends being fixed);

b) Apply the locking pressures/torque forces recommended by the manufacturer to lock the connector to the other end of the connection. Apply the 5%-10% of the rated working pressure, keep it for 3 min. at least, and then release all the pressure and unlock it. Repeat this step for five times;

② After 5 cycles and unlocking, lift the connector (clamp, female joint of the collet connector, the other end of the flange connector) and then go back to the hub end of the connector;

③ Apply the 1.1 times that of rated working pressure until the connector seals fail or 24 times forced circuiations are finished;

④ Record the required load for removing the connection from the hub end (one of the ends of the flange connector) of the connector.

7.6.9.14 Test of applying the back pressure test to verify the effective tightness

(1) Have sufficient objective evidences and perform the tests stated in 7.2.16.2;

(2) Perform the following tests after replacement of seal rings:

① The back pressure test succeeds; and

② Meet the requirements of the pressure-temperature cyclic test given in 7.6.9.7;

7.6.9.15 Test of bearing external pressures

(1) Test procedure and acceptance criteria;

① After successful connection, place the connector into the pressure chamber of designed water depth in order to conduct the test of bearing external pressure. It shall be free from deformation. After that, disassemble it to check for internal seepage or leakage.

② The test pressure is usually 1.2 times the pressure of corresponding to the design water depth.

③ The test time is usually not less than 1 h.

(2) Exemption

This test can be exempted only when there are sufficient objective evidences, enough design margins and approval of the orderer.

7.6.10 Engineering environment test

7.6.10.1 General requirements

(1) The engineering environment test usually aims at the functionality (e.g. mechanic connection test) and tightness tests. If having been installed onto the subsea equipment, it shall, together with the equipment, subject to the function test and meet the requirement of the overall tightness test;

(2) Engineering environment test outline and procedures shall be exhaustive and clear in steps and consider all technical details. If considerations include marine environments (e.g. wind wave) and capabilities of the ROV, the control range of running speed of the subsea connector shall be listed;

(3) The sea test can replace engineering environment test.

7.6.10.2 Documents to be submitted for review

(1) Test procedures (programs);

(2) Relevant calculation reports;

7.6.10.3 Test requirement

(1) Preparations before tests

① Before the tests, all items of the engineering environment test shall be completed on the land, tested to be qualified, and be granted with the release permit from the CCS Surveyor;

② Before the tests, the sea test emergency plans shall be prepared well.

(2) Function test

① Installation of the subsea connector

② Locking of the subsea connector (including the secondary locking in terms of the collet connector);

③ Removal of the subsea connector

④ Test of replacement of seal ring

⑤ Back pressure test.

(3) Performance test

① Conduct the performance test of the subsea connector according to the preset test program;

② Conduct the effectiveness test of tightness after installation of the subsea connector;

a) If conditions permit, the hydrostatic test shall be performed according to the rules in 7.4.1.3 (1) - (4) so as to validate the effective installation.

b) If the test in 7.6.9.12 is passed, the back pressure test can be done according to the requirements in 7.5.6.2 so as to validate the effective tightness.

Chapter 8 Jumper

Section 1 General provision

8.1.1 Scope

8.1.1.1 In addition to the technical requirements specified in this chapter, flexible jumpers shall also meet the corresponding requirements in Part 2 in ISO13628.

8.1.1.2 Technical requirements in terms of design, manufacturing, test, and delivery for covering subsea spools

8.1.2 Definitions, terms, and abbreviations

8.1.2.1 For main definitions and abbreviations in this chapter, see ISO 13628-2 3.1 and ISO 13628-2 3.2.

8.1.2.2 Terms in this chapter

(1) Jumpers, including rigid jumper pipes and hose jumper pipes, are usually used to bear the joint between two subsea facilities which have a great displacement effect.

(2). Spools, on the other hand, are usually used to bear the joint between two subsea facilities which have a small displacement effect.

Section 2 Technical requirements

8.2.1 Design requirements

8.2.1.1 For general design requirements, see ISO 13628-2 5.3.

8.2.1.2 For system design requirements, including load and load effect, pipeline design methods, pipeline structure design, and system design requirements, see ISO 13628-2 6.

8.2.1.3 The following parameters shall be considered during model selection:

(1) Whether the jumper pipes can be easily put into the auxiliary ship during transportation and installation;

(2) Whether the subsea jumper pipes will be affected by trawling;

(3) Jumper pipes with a long span may appear according to the design requirements;

(4) External design pressure and installation time of jumper pipes;

(5) The weight of jumper pipes, especially that a ship with a larger tonnage and a greater hoisting capacity may be required in a deep water project due to the great weight of jumper pipes;

(6) The internal design pressure of tubes;

(7) Design temperature;

(8) Selection of produced fluids based on the material;

(9) Thermal insulation requirements;

(10) Surface temperature.

8.2.1.4 A spool shall be designed to consider such factors as the elasticity, elastic deformation, thermal deformation, and the bending moment that the connector can bear systematically.

8.2.2 Requirements for anticorrosion

8.2.2.1 In addition to the requirements specified in this document, the anti-corrosion technologies shall also meet the requirements in ISO 13628-2 5.6.

8.2.2.2 Requirements of polyethylene thermal contraction sleeve joints for anti-corrosion technologies:

(1) Surface treatment

Clear the welding joints of the pipeline by remove the welding slags, burrs, and dust from the surface of the steel tubes, and removing the greasy dirt, couplant and any other pollutants from the surface by means of gasoline or degreaser.

(2) Construction with epoxy primer

① Do not heat polyethylene (PE) with naked flame;

② Epoxy primer shall be covered with three layers of polyethylene (3LPE). Exposed epoxy layer, however, shall not be covered with PE.

(3) Inspection and acceptance

After the construction of thermal contraction sleeves, check such four items as the appearance, leak points, cohesion, and thickness visually.

① Appearance inspection

The thermal contraction sleeves shall be completely integrated with the surface of the tube substrate and the finished surface shall be smooth and glossy. The thermal contraction sleeves shall not crack. There shall be at least an overlapping of 50 mm between the thermal contraction sleeve and both sides of the original coating.

② Inspection of leak points

Conduct the inspection of leak points by using an electric spark leak detector. If any pinhole is found, mend it and check leak points again.

The holiday inspection shall be conducted until there is no leak point on the mended coating or repaired coating.

③ Cohesion between the thermal contraction sleeve and primer

After the mending, the cohesion between the thermal contraction sleeve and primer shall be accepted according to the methods specified in the technical specification. Usually, when the temperature of the tube body is 23℃±2℃, the peel strength shall not be smaller than 15 N/cm.

④ Thickness inspection

A mounted thermal contraction sleeve shall be measured with a calibrated thickness gauge and its thickness shall not be smaller than the minimum thickness specified for this process.

Section 3 Manufacturing and test

8.3.1 Welding and nondestructive test

The welding procedure qualification used shall meet the requirements specified in the technical specification and the specifications used.

8.3.2 General requirements for factory test

8.3.2.1 The factory test for spools shall include the following items:

(1) Anticorrosion inspection and test for joints;

(2) Test of ROV operation interface;

(3) Inspection of floating block mounting;

(4) Test of electroconductive continuity for mounted zinc spelters;

(5) Identification inspection;

(6) Internal cleaning;

(7) Simulating the installation test, removal, and maintenance test.

8.3.2.2 preflush

(1) After the construction phase, jumper pipe elements shall be rinsed with high-pressure water until clean and impurity-free water flow from the tube element end;

(2) After the rinse, the pipeline shall also be dried by an air compressor; the pipe end shall be mounted with a protective cap (garbage cap) to prevent external garbage or other structure from entering the internal pipe line. For corrosion-resistant pipelines, it is recommended to put some desiccant into them to lower the humidity inside after rinsing and drying them;

(3) For M-shaped jumper pipes, it is recommended to pre-install a spherical pig which meets the design requirements before welding the pipe end and the joint to clean the inside of the pipe, caliper, drain off water, and make it easy to conduct subsequent back pressure test and hydrostatic test. Otherwise, the problem that the air gathering at the elbow is difficult to be exhausted due to the great curvature of the elbow may be caused.

8.3.2.3 Sphere pigging

During the test, it shall be ensure that the spherical pig can pass the whole jumper pipeline without any resistance. After the test, slight scratch or abrasion on the surface of the metal caliper board is acceptable. Obvious deformation or depression and breakage of edges of the caliper board, however, are not acceptable.

8.3.2.4 Hydrostatic test

(1) Before the hydrostatic test, ensure that the test object has been cleaned and calipered, both ends of the jumper pipe and the test hub have been correctly connected, and preservatives and colorant have been added to the test liquid;

(2) The minimum hydrostatic test pressure shall be 1.3 times that of the design pressure of the jumper pipe, the test time shall be 15 min., and no leakage is allowed;

(3) During the test, do not use the valve on the pipeline as a seal in the pressure test, unless it is designed to be used in a pressure test;

(4) During the test, the weld seam of the jumper pipe shall not be coated or covered. Precoating a thin part with primer in approved cases, however, is acceptable.

8.3.2.5 Simulation installation test, removal, and maintenance test

(1) Verify the design of the sling and rigging as well as the correctness of the lifting option;

(2) Place the spool between the hubs of the two connectors on the manufacturing platform to simulate the worst working condition where the mounting angle is seriously deflective, thus checking whether the jumper pipe is suitable;

(3) Conduct the test by replacing the seal rings on both ends;

(4) Verify the functions of the secondary releasing tools;

(5) Verify the interface and function of the ROV tool.

Chapter 9 Subsea control system

Section 1 General provision

9.1.1 General requirements

9.1.1.1 In addition to the requirements specified in this chapter, the subsea control system and umbilicals shall also meet the corresponding requirements in ISO13628-5 and ISO13628-6.

9.1.1.2 The subsea control system shall adapt an integrated design. Its process control drawing, shutoff control drawing, system layout drawing, and system process drawing shall be designed and submitted for an approval together with those of the production facilities on which the subsea control system is based and those control and instruments drawing of related equipments.

Section 2 Subsea production and control system

9.2.1 General requirements for subsea production and control system

9.2.1.1 The subsea control system and the topside control system shall be designed integratedly.

9.2.1.2 The subsea control system shall be a fail-safe one, that is, its shutoff shall be controllable in case of the failure of some of its parts (such as the pilot control, multichannel signals or electro-hydraulic signals).

9.2.1.3 The response time of the whole system. For example, the time for finishing the required action) shall be specified. If possible, two levels of response time can be defined respectively for normal operation and fail-safe operation (for example, in case of failure of multi-circuit control).

9.2.1.4 The subsea control system shall be able to receive the input signals from the shutoff system, that is, the shutoff of the upper production system or the shutoff valve of the riser shall normally cause the shutoff of the wing valve or other barrier valves at the mouth of the well

9.2.1.5 A high-level emergency shutoff shall cause the shutoff of all subsea barrier valves.

9.2.1.6 Usually, it is not compulsory to separate the control system and the shutoff system of the subsea control system. These two systems can be combined with the operation control functions (such as the control and state of the throttle valve as well as the monitoring over the pressure and temperature).

9.2.1.7 The control fluid discharged by an open control system to sea shall cause no harm to the environment.

9.2.1.8 A hydraulic circuit that may be polluted by the well flow shall be separated from other systems. A detachable joint in this circuit shall be regarded as a category 2 emission source and be used to divide danger areas.

9.2.2 Special test requirements for the subsea production control system and its devices

9.2.2.1 For devices of the subsea control system, for example, the distributing manifolds of subsea distributing units (SDHs) and umbilical termination heads (UTHs), the performance test shall be conducted according to Chapter 6 "Performance and functions of subsea manifolds".

9.2.2.2 The continuity test and flushing test for small-bore pipes (Tubing pipes)

(1) Test the accessibility and patency of all instrument capillary tubes, and verify the patency of the pipeline loop;

(2) After the test, flush the pipes with the specified water-base hydraulic oil until the required

cleanliness level is reached.

9.2.2.3 Test for the distribution units for electric power, hydraulic pressure, and signals

(1) Test whether the interfaces of the distribution box and its base are proper and whether they can be mounted and recycled without any obstacle;

(2) Test whether the functions of the distribution units can be implemented;

(3) Test the signal return function of the distribution units.

9.2.2.4 Continuity test for hydraulic pressure, electric fly wire, and the corresponding distribution units

(1) Check whether the corresponding fly wire and distribution unit can be connected, disconnected, and placed in a temporary slot;

(2) Check whether collision, obstacle, and even winding occur when the corresponding fly wire and distribution unit are connected, disconnected, and placed in a temporary slot.

9.2.2.5 For the EFAT of the subsea control system, pay attention to the following tests:

(1) Analog communication test for the MCS and PCS systems;

(2) Simulated shutoff test for the MCS and ESD systems;

(3) Communication test for the umbilicals simulators between the MCS and SCM systems.

Chapter 10 Subsea umbilicals

Section 1 General provision

10.1.1 General requirements

10.1.1.1 In terms of design and manufacturing, subsea umbilicals shall meet the requirements in ISO13628 Petroleum and natural gas industries Design and operation of subsea production systems Part 5: Subsea umbilicals or its equivalent standards.

10.1.2 Function requirements

10.1.2.1 Subsea umbilicals and its parts shall have the following features:

(1) Be able to bear all design loads and combination of loads;

(2) Be able to be stored and operate at the specified temperature;

(3) The materials are suitable for the environment;

(4) The cables can transmit power and signals with the required characteristics;

(5) Optical fibers can transmit signals at the specified wavelength within the required range;

(6) The hoses and/or metal tubes used can transmit liquefied products with the specified flow, pressure, temperature, and cleanliness;

(7) Penetrant in the parts can be drained out in a controllable method;

(8) Be able to be recycled and re-installed.

10.1.2.2 For installation convenience, umbilicals shall be equipped with suitable temporary terminals, so that a loop can be formed for electric and hydraulic operation, and monitoring and test can be conducted easily.

10.1.3 Performance requirements

10.1.3.1 Optical cables shall be able to operate continuously and reliably even they are immersed by seawater.

10.1.3.2 Carriers for mechanical prevention and their encapsulants shall be able to prevent seawater from entering, thus avoiding direct contact of seawater and normal or fractured optical cables.

Section 2 Manufacturing

10.2.1 Factory acceptance test

10.2.1.1 Before delivery, umbilicals shall be conducted with the following tests usually:

(1) DC resistance test;

(2) During and after the mechanical test, insulation resistance test and optical signal test shall be conducted;

(3) Tensile test;

(4) Bending rigidity measurement;

(5) Flattening test;

(6) Fatigue test.

10.2.2 Cables

10.2.2.1 Tests during manufacturing (if applicable):

a) Appearance and dimension inspection;

b) Conductor resistance test;

c) Resistivity test for the shielding layer;

d) Resistivity test for the insulation layer;

e) High-voltage direct current test;

f) High-voltage alternating current test;

g) Breakdown voltage;

h) Partial discharge test;

i) Inductance characteristic test;

j) Capacitance characteristic test;

k) Attenuation characteristic test;

l) Characteristic impedance test.

10.2.2.2 Tests for parts in cables (if applicable):

a) Appearance and dimension inspection;

b) Sparking test, not for core wires with a semiconductor layer;

c) DC conductor resistance test;

d) Insulation resistance test;

e) High-voltage direct current test;

f) Inductance characteristic test;

g) Capacitance characteristic test;

h) Attenuation characteristic test;

i) Characteristic impedance test;

j) Interference test;

k) Time domain reflectometer (TDR) test.

10.2.3 Optical Cables

10.2.3.1 Optical cables

a) Transmission and optical characteristic test;

b) Mechanical performance test;

c) Environmental performance (including the performance of optical cables for seawater, hydrogen, and working medium;

d) External pressure test;

e) Optical cable splicing test.

10.2.3.2 Optical cable parts

a) Appearance and dimension inspection;

b) At the specified wavelength, each optical fiber in the optical cable shall be tested with an optical time domain reflectometer (OTDR) at both ends. The generated curve shall be able to describe all main points, such as the initial point, the terminal point and the continuity point (if any), and the attenuation value shall meet the requirements in the technical specification.

10.2.4 Hoses

10.2.4.1 Hoses

a) Appearance and dimension inspection;

b) Pressure and forced circuiation test;

c) Length variation test;

d) Leakage test;

e) Bursting test;

f) Impulse test;

g) Low temperature bending test;

h) Crush test;

i) Volume expansion test;

j) End connector anti-rotation test;

k) Medium compatibility test (immersion method);

l) Penetration test.

10.2.4.2 Hose parts

a) Appearance and dimension inspection;

b) Pressure and forced circuiation test;

c) Lining bursting test;

d) Length variation test;

e) Bursting test;

f) Pressure decay test.

10.2.5 Metal pipes and parts

10.2.5.1 A welding procedure qualification shall be conducted before the welding of metal pipes.

10.2.5.2 After the welding, conduct an appearance inspection and a nondestructive test for all metal pipes.

10.2.5.3 Tests that shall be conducted include:

a) Appearance and dimension inspection;

b) Pressure test. The minimum test pressure shall be 1.25 times that of the rated working pressure;

c) Tensile test;

d) Flattening test;

e) Hardness test;

f) Expansion test;

g) Chemical analysis;

h) Corrosion test;

i) Bursting test.

Section 3 Test

10.3.1 Factory acceptance tests for umbilicals

Before the equipment installation, a series of factory acceptance tests shall be conducted for umbilicals according to the requirements in the technical specification, mainly including:

10.3.1.1 Appearance and dimension inspection;

10.3.1.2 Cable tests:

(1) Conductor DC resistance test;

(2) Insulation resistance test;

(3) high-voltage direct current test;

(4) Test for characteristics of the transmission line, and the inductance, capacitance, and impedance shall also be measured if possible;

(5) Interference test.

10.3.1.3 Time domain reflection test for optical cables

10.3.1.4 Hoses shall be conducted with the following tests, and be cleaned after the tests:

(1) Hydrostatic test;

(2) Pressure decay test;

(3) Flow test;

(4) Dynamic loudness test.

10.3.1.5 Metal pipes shall be conducted with the following tests, and be cleaned after the tests:

(1) Hydrostatic test, with the pressure 1.25 times that of the design pressure;

(2) Flow test.

10.3.2 Pre-lading test

Umbilicals that have been transported to the installation site or have been stored for longer than 3 months shall be tested before lading:

10.3.2.1 Cables:

(1) Conductor DC resistance test;

(2) Insulation resistance test.

10.3.2.2 time domain reflection test for optical cables:;

10.3.2.3 hydrostatic test and pressure decay test for hoses and metal pipes:

10.3.3 Pre-installation test

10.3.3.1 Cables:

(1) Conductor DC resistance test;

(2) Insulation resistance test;

(3) Cables whose rated voltage is greater than 1 kv: high-voltage direct current test.

10.3.3.2 Time domain reflection test for optical cables:

10.3.3.3 Hydrostatic test and pressure decay test for hoses and metal pipes:

10.3.4 Monitoring during laying

10.3.4.1 Monitor the continuity of the cable conductors and abort the operation and conduct a DC resistance test for all cables in case of an interruption;

10.3.4.2 Conduct a time domain reflection monitoring for each optical fiber of the optical cable, and abort the operation and check the optical fibers in case of any obvious attenuation or continuity interruption.

10.3.4.3 Conduct a pressurized monitoring for hoses and metal pipes, and pause the operation and find out the reason in case of any unexplainable pressure loss or obviously different characteristics.

10.3.4.4 Appearance inspection. During the laying, check whether there are unacceptable deformation, kinking, surface damage, kinking of metal shielding or any unacceptable defect according to other technical specifications on the umbilicals.

10.3.5 Pre-connection test

If possible, conduct the tests specified in Section 10.3.3 for umbilicals whose temporary terminals have been dragged to the preset position before connection.

10.3.6 Tests after the laying

If possible, conduct the following tests for the connected umbilicals without damaging the control system:

10.3.6.1 Cables:

(1) Conductor DC resistance test;

(2) Insulation resistance test.

10.3.6.2 Time domain reflection test for optical cables:

10.3.6.3 Hoses and metal pipes: hydrostatic test and pressure decay test.

(1) The test pressure of the control pipeline shall be 1.0 time that of the rated working pressure;

(2) The test pressure of the chemical agent pipeline shall be 1.1 times that of that of the rated working pressure.

Chapter 11 Foundation and structure

Section 1 General provision

11.1.1 Objective

11.1.1.1 This chapter mainly specifies the design and construction requirements for foundations used by subsea equipment, and the subsea foundations involved includes mudmats, suction piles, and driven piles.

11.1.2 Functions

11.1.2.1 Foundations used by subsea equipment shall be strong enough, so that the structure of the foundations will not deform excessively when the load of the equipment is transferred from the foundations to the seabed.

11.1.2.2 Foundations used by subsea equipment shall have adequate vertical and horizontal bearing capacity, so that the position of the subsea equipment is within the allowed range under the design load conditions.

11.1.3 Recognized specification standards

Recognized specification standards for foundations used by subsea equipment include:

(1)	API RP 2A	Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms
(2)	ISO 13628-1	Petroleum and Natural Gas Industries - Design and Operation of Subsea Production Systems
(3)	China Classification Society	Rules and Regulations for the Construction and Survey of Fixed Offshore Platforms in Shallow Waters 2004

Section 2 Technical requirements

11.2.1 General requirements

11.2.1.1 In terms of type, foundations used by subsea equipment shall be selected based on the load nature, structural features, and the soil conditions and installation methods of the seabed.

11.2.1.2 To increase the bearing capacity and stability and decrease the dimensions of the mudmat, additional skirtboards can usually be considered.

11.2.1.3 When using a mudmat as the foundation of the subsea production equipment, you shall fully consider the effects brought by the geological conditions: too hard sail may cause the skirtboard to fail to be inserted while soft seabed soil may require a very large mudmat to provide the required loading capacity and thus cause difficulty to the installation.

11.2.1.4 Suction piles and driven piles are applicable to most geological conditions. Suction piles are applicable to very soft soil while driven piles are applicable to weak soils with sands and aggregates.

11.2.1.5 The following factors shall be considered when designing the foundation:

(1) The effect brought by uplift and external washing of the soil inside the foundation;

(2) Pulling resistance and sliding resistance shall be great enough to bear the vertical and horizontal loads generated by applied force;

(3) It is recommended to evaluate the loss of the foundation caused by soil liquefaction or the excessive displacement and/or slope failure caused by possible seabed seismic motion.

(4) It is recommended to avoid some concrete characteristics which may bring negative effects to the frictional resistance of the external or internal steel soil interface. For example, for corrosion prevention, no painting except for sacrificial anodes is recommended.

11.2.1.6 For the structure of the subsea equipment, at least the following working conditions shall be considered:

(1) Transportation conditions

The dead weight during the transportation, inertia force generated during the movement of the transport ship, and the acting force generated by securing;

(2) Installation conditions

Dead weight and a certain dynamic amplification factor in case of offshore hoisting; dead weight, acting force at the subsea pipeline connections, and lateral load generated by movement in case of subsea installation;

(3) Inplace conditions

Such environmental loads as the loads generated by the dead weight and operation, acting force at the subsea pipeline connections, and seawater pressure in case of inplace operation;

(4) Occasional conditions

Possible impact by dropped objects, fishing net trailer and seismic load in case of inplace

11.2.1.7 For a mud-mat foundation with a skirtboard, the penetration resistance of the skirtboard must be calculated to ensure that the skirtboard can reach the penetration depth below the design mud line. In the design drawing, the possible penetration of the suction pile caused by pressurization must be considered.

11.2.1.8 Waves and ocean current may cause washout and erosion around the subsea foundation. Sands have a higher possibility of washout than clays and this possibility usually increases with the decrease of the depth of water. For a foundation installed on sand layers, to prevent erosion, it may be required to conduct gravel classified pack around the foundation. Setting skirtboards around the foundation helps prevent the undersurface of the foundation from washout. In case of a suction pile, you may need to consider the possibility of washout if you design it to allow a certain washout depth.

11.2.2 Mudmat

11.2.2.1 Mud-mat foundations are usually in the following three structures:

(1) Integrated structure: For mud-mat foundations in this structure, the upper device (if small) can usually be manufactured and installed together with the supporting members and mud mat as a whole;

(2) Folding structure: For mud-mat foundations in this structure, we can fold the mud mat when running the foundation to decrease the area and unfold the mud mat when the foundation reaches the seafloor to increase the bearing area;

(3) Separated structure: For mud-mat foundations in this structure, the upper device and mud mat are usually manufactured and installed separately.

11.2.2.2 When installing mudmats, you shall consider their types. Usually, for an integrated or separated mudmat, you can install it by hoisting it to the side. However, for integrated mudmats you need only one hoisting to install the device and mudmat in place while for a separated mudmat, you need two hoistings,

that is, install the mudmat to the seafloor first and then install the upper device on the mudmat. Folding mudmats can be installed by conducting an s-type laying with stingers and pipelines to shorten the time required for butting the subsea equipment and pipelines.

11.2.2.3 A mudmat shall be designed to consider such factors as the stability, settlement, and interaction between adjacent structures based on the standards API RP 2A and ISO 13628-1. Obtain the related loads based on the environmental conditions, soil data, external load, and the self-weight of the structure to conduct the structure design. The dimension is mainly determined based on the characteristics of the subsea production equipment as well as the intensity index of the soil.

11.2.2.4 For a mudmat, its bearing capacity, slippage, settlement, torsion and penetration capability shall usually be calculated and analyzed.

(1) Bearing capacity

Check the bearing capacity of the soil based on the structural load obtained by analyzing the operation conditions. The calculation result shall meet the requirement in API RP 2A that the safety factor of the bearing capacity shall be two times that in failure mode. The maximum vertical load that the foundation can bear is :

$$Qu = (c \cdot N_c \cdot F_{cs} \cdot F_{cd} \cdot F_{ci} \cdot q \cdot N_q \cdot F_{qs} \cdot F_{qd} \cdot F_{qi} + 0.5 \cdot \gamma \cdot B_1 \cdot N_\gamma \cdot F_{\gamma s} \cdot F_{\gamma d} \cdot F_{\gamma i}) \cdot A_e$$

In the formula:

c——The effective cohesion intercept of Mohr's envelope

$$N_q = tan^2 \left(45^\circ + \frac{\emptyset}{2}\right) \cdot e^{\pi \cdot tan\emptyset}$$

$$N_c = \left(N_q - 1\right) \cdot cot\emptyset$$

$$N_q = 2 \left(N_q + 1\right) \cdot tan\emptyset$$

F_{cs}, F_{qs}, $F_{\gamma s}$ - Form coefficient

F_{cd}, F_{qd}, $F_{\gamma d}$ - Depth coefficient

F_{ci}, F_{qi}, $F_{\gamma i}$ - inclination coefficient

γ - Soil multiplicity

A_e - Basic effective area

ϕ——Effective friction angle

The analysis of the bearing capacity shall be made to consider the effect of the eccentric load, which decreases the ultimate vertical load that the mudmat can bear, that is, it is required to decrease the effective area of the foundation.

(2) Slippage

The slippage analysis shall be made to meet the requirement in API RP 2A that the safety factors in both horizontal directions shall be greater than 1.5.

$$F_{os} = \frac{F_{HF}}{F}$$

In the formula:

F_{HF}———Horizontal failure load

F---------External load in the structural horizontal direction

Horizontal failure load involves two cases: drained and undrained. In case of undrained,

$$F = cA$$

In case of drained,

$$F = c'A + Q_u \tan \phi$$

In the formula: *c* is the undrained shear strength of the soil, A is the area of the foundation, and is the effective cohesion.

(3) Settlement

Basic settlement consists of elastic settlement and consolidation settlement . Elastic settlement is the main part of basic settlement and it is a deformation where the soil is loaded but still keeps its original moisture content:

$$S_e = \frac{Q_o \cdot \alpha \cdot L \cdot (1 - v^2) \cdot F_{\gamma d} \cdot F_{\gamma s}}{2E_s}$$

In the formula:

Q_o——Contact pressure

α ——The number of angular points which affect settlement

v——Poisson's ratio of soil

E_s——Soil elastic-module

Consolidation settlement is caused by soil drainage. The foundation is composed of different soil layers, so the multi-layer method shall be used, that is, use the sum of settlement of each layer of soil as the total consolidation settlement:

$$S_g = \frac{C_c \cdot H_c}{1 + e_0} \cdot \lg\left(\frac{\sigma_0 + \Delta\sigma}{\sigma_0}\right)$$

In the formula:

C_c———Compression index

H_c———Thickness of soil layer

e_0———In situ void ratio of soil body

σ_0———Effective overlaying soil pressure

Δ_o———Average pressure increment

(4) Torsion

The basic torsional analysis shall be made in condition that the safety factors in both horizontal directions are greater than 2.0. See the formula below. The formula shows that the foundation (that is, the skirtboard) is strong enough to avoid the rotation of the structure. In addition, the torsion resistance is also an important factor to determine the driving depth of the skirtboard. In addition, the gradient of the seabed is also a main factor which affects the dimensions of the skirtboard.

$$F_{to} = \frac{p \cdot A_e \cdot (L_e + B_e)}{2 \cdot M}$$

In the formula:

p ———Passive earth pressure

A_e、 L_e、 B_e———Effective torsional area, length, and width

M ———Torsional moment

(5) Penetration depth of skirtboards

Calculate the penetration resistance of the skirtboard , to determine the penetration depth of the skirtboard.

$$Q_d = Q_f + Q_q = f \cdot A_s + q \cdot A_p$$

In the formula:

Q_d———Side friction

Q_f———End friction

f———Unit side friction

A_s———Lateral area of the skirtboard

q ———Unit friction at skirtboard end

A_p———End area of the skirtboard

In some cases, pressure difference can be used to increase the penetration capacity in the condition that the foundation will not be damaged.

11.2.3 Suction pile

11.2.3.1 Suction-pile foundations are usually in the following two structures:

(1) Single-pile structure. A suction-pile foundation in this structure is composed of a rigid cylindrical shell and a roof. It has a great diameter which is usually in range of 2.5-7.5 m;

(2) Multi-pile structure. A suction-pile foundation in this structure is composed of separate suction piles which are connected only on the top and bottom, with an opening on the top of each suction pile.

11.2.3.2 The draw ratio of a suction pile determines the bearing capacity and penetration capacity of a suction-pile foundation. Usually:

(1) A suction-pile foundation used in soft clay has a great draw ratio. A foundation that is in shape of slim tube and at the same weight, however, provides a greater penetration depth and can reach hard soil layer, thus providing a greater bearing capacity. In case of very soft clay, the draw ratio can be as great as 7.0;

(2) Comparatively, suction piles used in sands or hard clays usually have a smaller draw ratio (usually within 1.5). Due to great soil resistance, such a suction pile has a smaller penetration depth. In this case, a great diameter can be used to ensure that the tube of the suction pile will not lose its strength due to too large sinking suction in case of enough penetration depth.

11.2.3.3 Methods for calculating the compression bearing capacity usually include: limit equilibrium method/plastic limit method, semi-empirical beam-column analysis method, and finite element method:

(1) The limit equilibrium method/plastic limit method determines a reasonable failure mode for the suction-pile foundation based on experimental analysis, value simulation, and engineering experience. This method is the theoretical basis to calculate the bearing capacity of a suction foundation. Calculate its ultimate bearing capacity based on the static equilibrium and failure criteria;

(2) The semi-empirical beam-column analysis method expresses the soil resistance only based on a series of experience and rules. It does not determine the failure mechanism, but expresses the soil resistance with a series of nonlinear coupling and nonlinear soil spring (P-Y curve)

along the length of the pile. This method calculates the compression bearing capacity based on the experiment and analysis results, and is difficult to provide general results.

(3) The finite element method automatically finds the critical failure mechanism by using the finite element program. This method provides a high calculation precision and considers nonlinear factors. In addition, it can even simulate complex soil characteristics.

In actual design, we usually adopt the combination of theoretical analysis and numerical simulation and conduct a mutual verification to obtain a correct and reasonable bearing capacity result.

11.2.3.4 The vertical anti-lifting bearing capacity can be calculated by using the method in API RP 2A. The calculation of the vertical pulling resistance in clay involves three failure modes, that is, local shear, local tension, and wide-range shear. All these three failure modes may occur. During calculation, we shall take the minimum value. The pulling resistance considering the suction we get based on the calculation result is 1.5-2.0 times that not considering the suction. The pulling resistance of sands involves two cases: drained and partially drained. In case of partially drained, the permeability coefficient of sands and lasting duration of loads play an important role in generation of suction. Tests show that calculating the pulling resistance without considering the suction is a safe method.

11.2.4 Driven pile

Driven-pile foundations are the most common foundations in ocean engineering structures at present. For such a foundation, we mainly use displacement deformation curves of soil (that is, curves P-Y, T-Z, and Q-Z) to simulate the acting force of soil against the pile and to check the strength of the pile. In addition, the pile shall also meet the strength requirements in case of hoisting, pile, and stick-up in structure. Its bearing capacity can be calculated using the calculation method in API RP 2A.

11.2.5 Construction inspection

11.2.5.1 Drawings that shall be submitted for checking for foundations of all types include:

(1) Inspection, test, and process documents, such as welding process, welding specifications, nondestructive test drawing, test programs involving transportation, subsea inplace, pile technology, and electromechanical equipment;

(2) Environment and basic data

① Environmental condition data: including water depth, highest and lowest tide levels, maximum rising of sea level in case of no surge, speed and direction of ocean current, variation of flow rate with the water depth, as well as height, period and direction of waves (if applicable);

② Basic data: including general geological survey, geomorphologic survey (mud line drawing), geophysical survey, survey on the soil property and structure of the seabed, test on the mechanical performance of the soil, and calculation of soil mechanics.

(3) General arrangement drawing and anti-corrosion design drawing (such as the arrangement drawing and calculation report of the anodes block);

(4) Hoisting and installation programs and the analysis.

11.2.5.2 All drawings of the foundation shall be checked based on the general arrangement and related drawings of the facility which bears the foundation.

11.2.5.3 For driven-pile foundations, all applicable drawings in *Rules and Regulations for the Construction and Survey of Fixed Offshore Platforms in Shallow Waters 2004* involving the design, installation, and acceptance of driven piles shall also be submitted.

11.2.5.4 For a mudmat foundation, the following items shall also be submitted:

(1) General arrangement and details drawing of mudmat;

(2) Final assembly and details drawing of pre-assembled mudmat;

(3) Coating and marking drawing of pre-assembled mudmat;

(4) ROV interface drawing of pre-assembled mudmat;

(5) Calculation report on the bearing capacity, slippage, settlement, torsion and penetration capability of mudmats;

(6) Strength calculation report of mudmat;

(7) Design Basis Specifications;

(8) Structural Material Specifications;

(9) Other required drawings.

11.2.5.5 For a suction pile foundation, the following items shall also be submitted:

(1) Structural drawing of suction pile;

(2) Coating and marking drawing of suction pile;

(3) Calculation report on the bearing capacity, penetration capability and pulling resistance of the suction pile;

(4) Strength analysis (including buckling analysis) report of the suction pile

(5) Design Basis Specifications;

(6) Structural Material Specifications.

11.2.5.6 Base structures of all types shall meet the applicable construction requirements for the main structure in *Rules and Regulations for the Construction and Survey of Fixed Offshore Platforms in Shallow Waters 2004*.