BRITISH STANDARD

BS EN ISO 13628-9:2006

Incorporating amendment no. 1 (renumbers BS ISO 13628-9:2000 as BS EN ISO 13628-9:2006)

Petroleum and natural gas industries — Design and operation of subsea production systems —

Part 9: Remotely operated tool (ROT) intervention systems

The European Standard EN ISO 13628-9:2006 has the status of a British Standard

ICS 75.180.10

National foreword

This British Standard was published by BSI. It is the UK implementation of EN ISO 13628-9:2000. It is identical with ISO 13628-9:2006.

The UK participation in its preparation was entrusted to Technical Committee PSE/17, Materials and equipment for petroleum and natural gas industries.

A list of organizations represented on PSE/17 can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard, having been prepared under the direction of the Engineering Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 March 2001

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 13628-9

December 2006

ICS 75.180.10

English Version

Petroleum and natural gas industries - Design and operation of subsea production systems - Part 9: Remotely Operated Tool (ROT) intervention systems (ISO 13628-9:2000)

Industries du pétrole et du gaz naturel - Conception et exploitation des systèmes de production immergés - Partie 9: Systèmes d'intervention utilisant des dispositifs à commande à distance (ROT) (ISO 13628-9:2000)

Erdöl- und Erdgasindustrie - Auslegung und Betrieb von Unterwasser-Produktionssystemen - Teil 9: ROT-Systeme (ISO 13628-9:2000)

This European Standard was approved by CEN on 13 November 2006.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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Foreword

The text of ISO 13628-9:2000 has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum and natural gas industries" of the International Organization for Standardization (ISO) and has been taken over as EN ISO 13628-9:2006 by Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2007, and conflicting national standards shall be withdrawn at the latest by June 2007.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Endorsement notice

The text of ISO 13628-9:2000 has been approved by CEN as EN ISO 13628-9:2006 without any modifications.

INTERNATIONAL STANDARD

ISO 13628-9

First edition
2000-06-15

Petroleum and natural gas industries — Design and operation of subsea production systems —

Part 9: Remotely Operated Tool (ROT) intervention systems

Industries du pétrole et du gaz naturel — Conception et exploitation des systèmes de production immergés —

Partie 9: Systèmes d'intervention utilisant des dispositifs à commande à distance (ROT)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 13628 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 13628-9 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment*.

ISO 13628 consists of the following parts, under the general title *Petroleum and natural gas industries — Design and operation of subsea production systems*:

— *Part 1: General requirements and recommendations*

— *Part 2: Flexible pipe systems for subsea and marine applications*

— *Part 3: Through flowline (TFL) systems*

— *Part 4: Subsea wellhead and tree equipment*

— *Part 5: Subsea control umbilicals*

— *Part 6: Subsea production control systems*

— *Part 7: Workover/completion riser systems*

— *Part 8: Remotely Operated Vehicle (ROV) interfaces on subsea production systems*

— *Part 9: Remotely Operated Tool (ROT) intervention systems*

Introduction

This part of ISO 13628 is considered to be closely related to ISO 13628-1 and ISO 13628-8. ISO 13628-1 provides general requirements and overall recommendations for development of complete subsea production systems for the petroleum and natural gas industries, from design to decommissioning, and gives a description of how the ROT intervention systems relate to the total subsea production system.

The objective of subsea intervention systems, including vessel and deck handling equipment, is to facilitate safe and efficient intervention on subsea installations.

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Petroleum and natural gas industries — Design and operation of subsea production systems —

Part 9:
Remotely Operated Tool (ROT) intervention systems

1 Scope

This part of ISO 13628 provides functional requirements and recommendations for ROT intervention systems and interfacing equipment on subsea production systems for the petroleum and natural gas industries.

This part of ISO 13628 does not cover manned intervention and ROV-based intervention systems (e.g. for tie-in of sealines and module replacement). Vertical wellbore intervention, internal flowline inspection, tree running and tree running equipment are also excluded from this part of ISO 13628.

2 Terms, definitions and abbreviated terms

For the purposes of this part of ISO 13628, the following terms, definitions and abbreviated terms apply.

2.1 Terms and definitions

2.1.1
subsea intervention
all work carried out subsea

2.1.2
primary intervention
all work carried out during the scheduled intervention task

2.1.3
ROT system
dedicated, unmanned, subsea tools used for remote installation or module replacement tasks that require lift capacity beyond that of free-swimming ROV systems

NOTE The ROT system comprises wire-suspended tools with control system and support-handling system for performing dedicated subsea intervention tasks. They are usually deployed on liftwires or a combined liftwire/umbilical. Lateral guidance may be via guidewires, dedicated thrusters or ROV assistance.

2.1.4
deployment system
all equipment involved in the launch and recovery of the ROT system

2.1.5
heave-compensated system
system that limits the effect of vertical vessel motion on the deployed ROT system

2.1.6
skid system
storage, transportation, lifting and testing frames to facilitate movement of the ROT systems and the modules and components to be replaced or installed

NOTE Skids are used in combination with a skidding system.

2.1.7
sealines
all pipelines, flowlines, umbilicals and cables installed on the seabed

2.1.8
termination head
part of the PICS interfacing with the end of the sealine

2.1.9
pull-in head
part of the pull-in system acting as attachment point for the end of the pull-in wire

2.2 Abbreviated terms

CB	centre of buoyancy
CF	connection function
CG	centre of gravity
CT	connection tool
FAT	factory acceptance test
HPU	hydraulic power unit
ICS	intervention control system
ID	internal diameter
IP	ingress protection
LCC	life cycle cost
MQC	multi quick connector
NAS	National Aerospace Standard Institute
PGB	permanent guide base
PICS	pull-in and connection system
PIF	pull-in function
PIT	pull-in tool
ROT	remotely operated tool
ROV	remotely operated vehicle
SPS	subsea production system

SWL safe working load

WOCS workover control system

3 System selection

3.1 General

The design, configuration and operation of the ROT intervention system impacts directly on the LCC for the entire SPS. In order to obtain an SPS design providing safe and cost-effective intervention operations, it is important to obtain a closed loop between SPS design and intervention system design. See Figure 1.

An ROT intervention system typically comprises the following:

a) ROTs for dedicated intervention tasks,

b) deck handling equipment,

c) ICS,

d) deployment/landing equipment,

e) ROV spread interfaced with ROT systems.

An illustration of the main features of an ROT intervention system and associated equipment is shown in Figure 2.

The breakdown of the ROT intervention system into sub-elements and components as presented in this part of ISO 13628 should not pose limitations on the selection of new intervention concepts whose functionality and reliability can be documented.

Configurational options for the ROT intervention system and interfacing equipment, such as intervention vessel and ROV systems when used, are shown in Figure 3.

ROT intervention systems shall be evaluated for all phases of an intervention operation, which typically are:

— mobilization (specific issues at the location in question),

— deck handling and preparation,

— launch, descent and landing,

— intervention task,

— testing,

— complementary tasks,

— retrieval,

— demobilization,

— contingency.

During the evaluation, consideration shall be given to reasonably foreseeable misuse of the ROT intervention system.

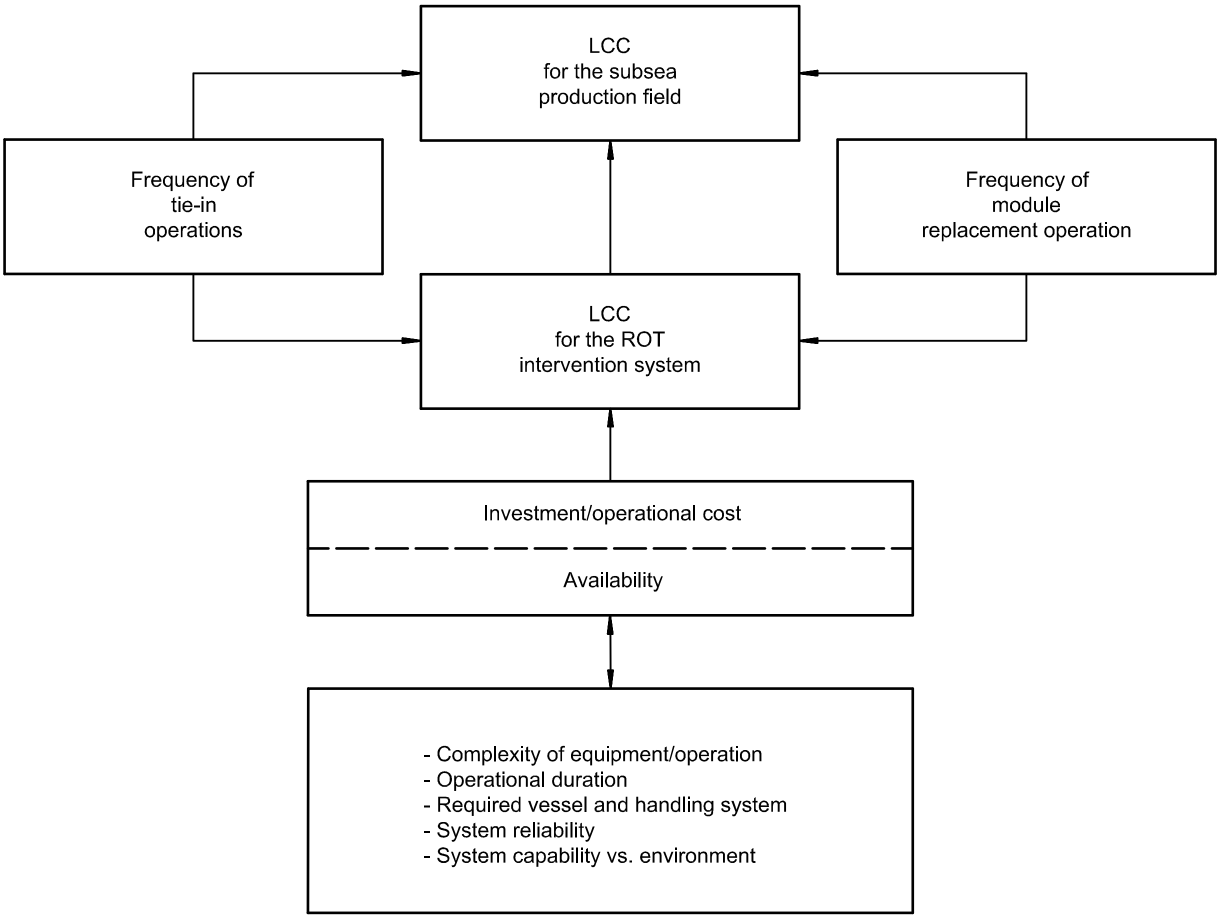

Figure 1 — Interaction of LCC

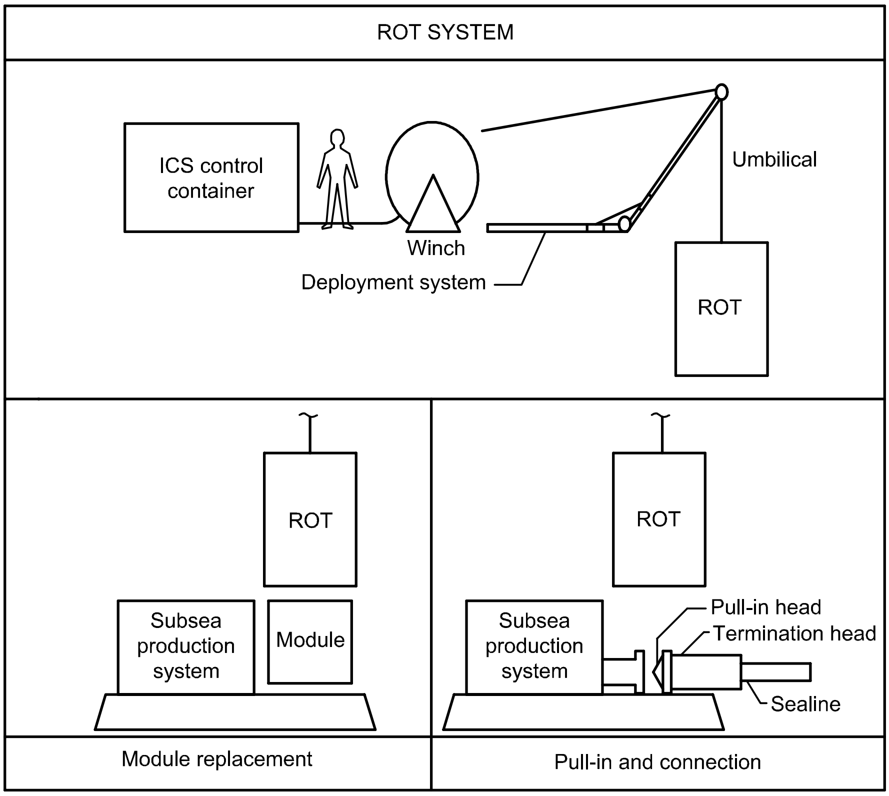

Figure 2 — Principal sketch of an ROT intervention system

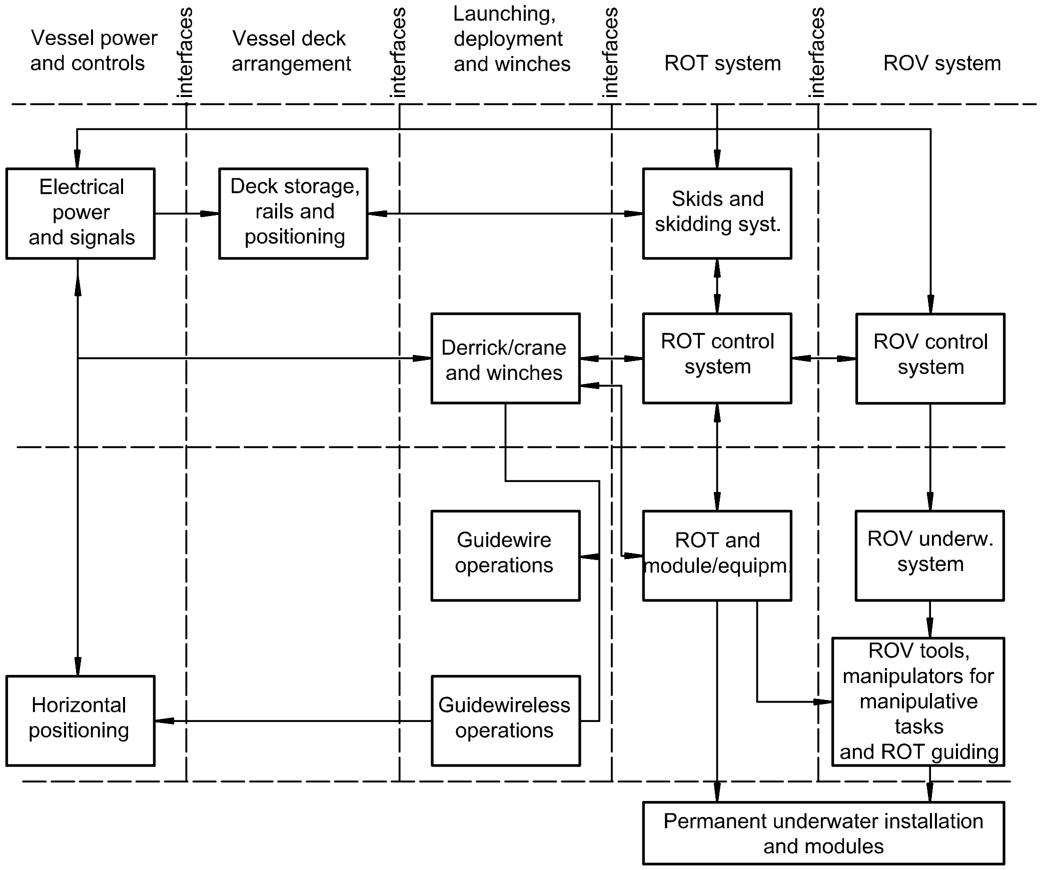

Figure 3 — Illustration of interfaces between the intervention vessel, the ROT system and, when used, the ROV system

3.2 Deck handling equipment

Deck handling equipment and launching techniques shall be selected to ensure that a wide range of vessels can be used. Flexibility shall be provided without compromising safety and reliability of the work, both on surface and subsea. Main issues are:

— means of moving intervention equipment on deck (skid systems vs. use of vessel cranes);

— means of deploying and landing ROT systems (winches and simple mobile A-frames vs. use of complex, purpose-made heave-compensated systems);

— means of installing on and removing from the intervention vessel.

The selection of equipment shall be dictated by the nature of the intervention task (e.g. tie-in operation, module replacement), environmental considerations affecting the operation and time available to carry out the required operation.

3.3 Intervention control system (ICS)

The ICS shall be designed for control and monitoring of

a) ROT function testing on deck,

b) ROT status during running, if required,

c) ROT functions during the intervention task.

These control functions may be provided either through

— ROT function testing on deck,

— a dedicated system for the ROT,

— an ROV control system, or

— a combined ROT/ROV system.

Main issues with respect to selection of the ICS configuration are

— complexity of the subsea work,

— cost and manning for a dedicated control system,

— level of modifications to a standard ROV control system,

— flexibility of the ROV during the subsea work,

— reliability and suitability of the subsystems within an ROV spread.

See Figure 4, which is meant to highlight the interrelationship between ROTs and ROVs and related interface requirements.

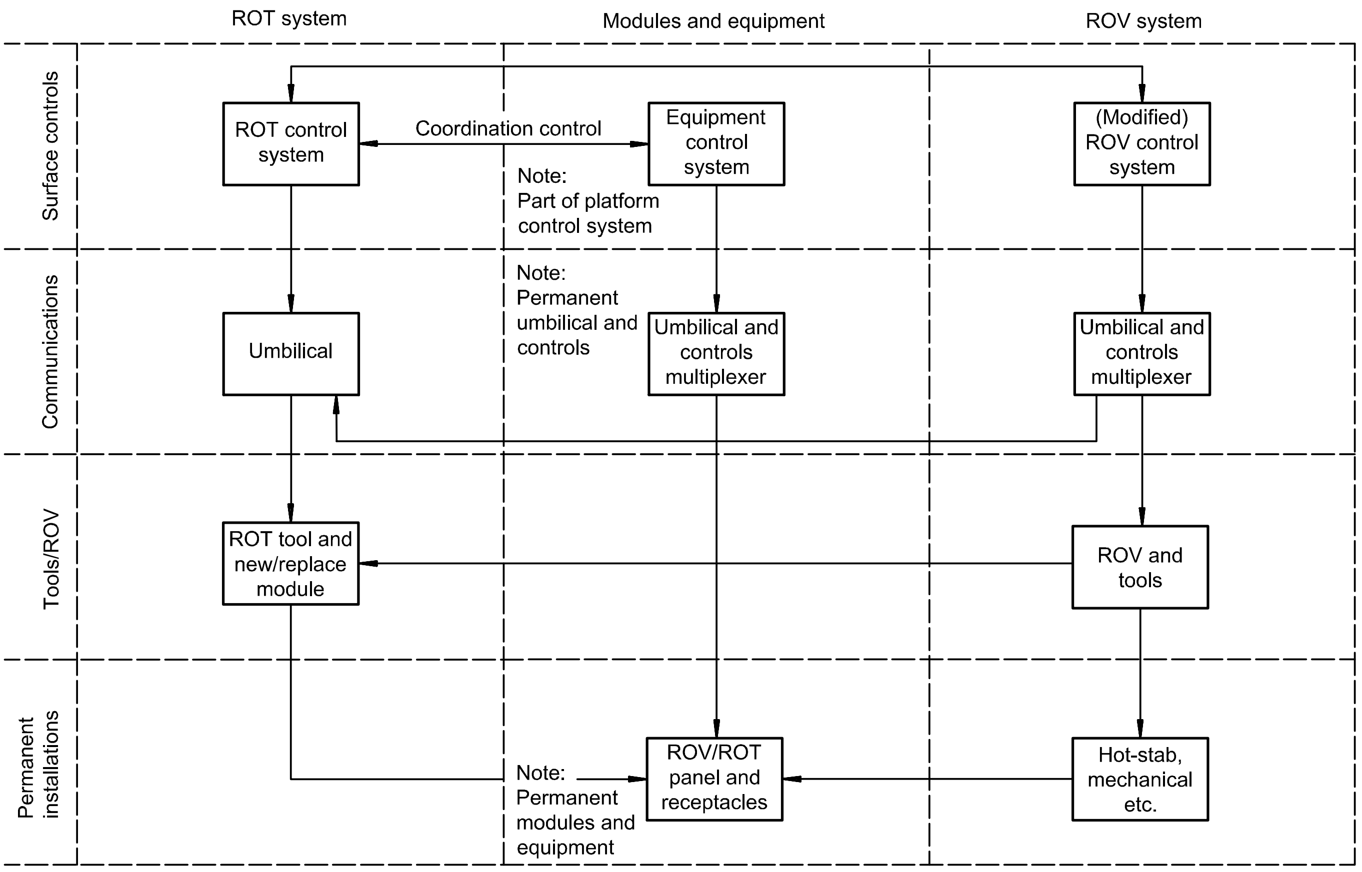

Figure 4 — Illustration of possible ICS options for ROT systems

3.4 Deployment/landing equipment

Selection of running philosophy is determined by

a) availability requirements (logistics and mobilization time for equipment),

b) field-specific parameters (water depth, wave, current and seabed conditions),

c) vessel requirements,

d) intervention task-specific parameters (planned vs. unplanned operation, complexity, frequency and subsea interface considerations),

Figure 5 shows two options available for horizontal positioning control.

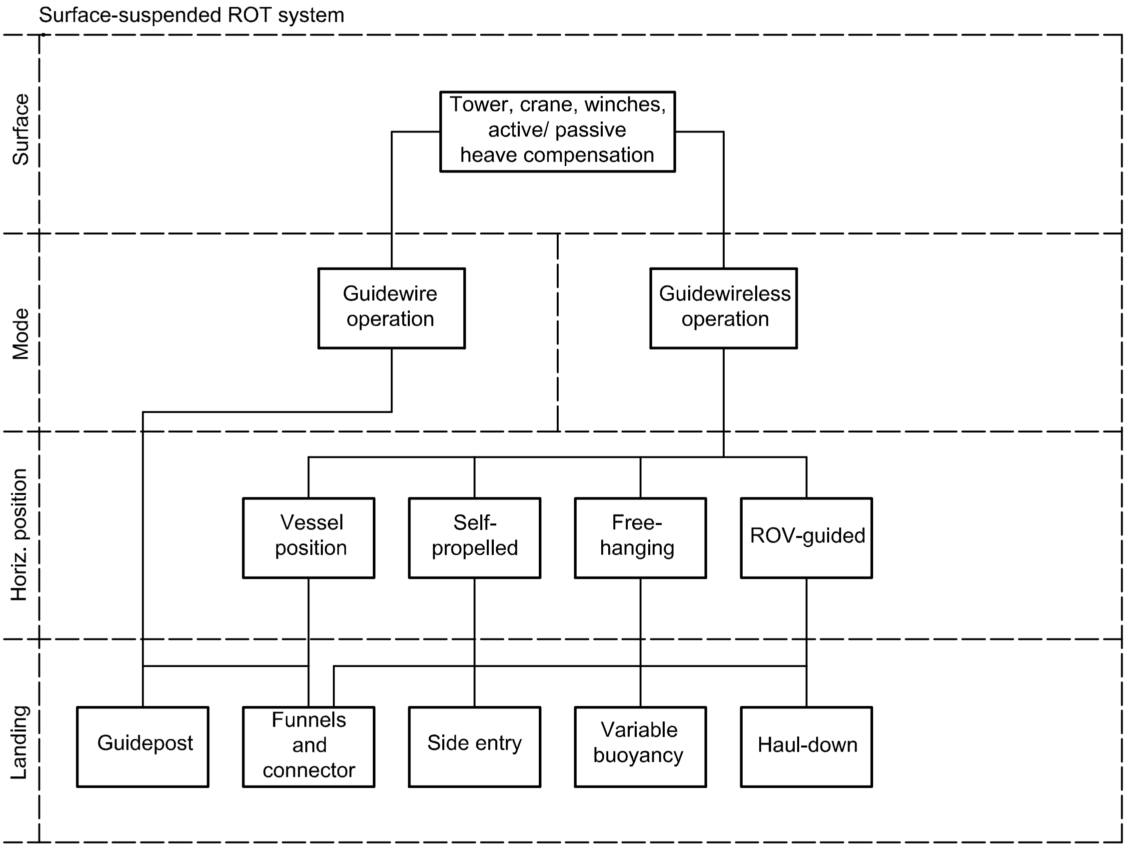

Figure 5 — Illustration of possible deployment and landing options for ROT systems

3.5 Tools for primary intervention tasks

a) The following considerations should be taken into account for tie-in operations:

— parameters related to the dedicated sealine;

— operational issues with respect to the vessel, e.g. simultaneous operations between subsea intervention and drilling or completion activities;

— environmental aspects, including e.g. water depths, current conditions and seabed conditions;

— limitations subjected to the alternative tie-in methods, e.g. winch capacity or length of pull-in rope;

— SPS field layout.

b) The following considerations should be taken into account for module replacement:

— operational issues with respect to the vessel, e.g. simultaneous operations between subsea intervention and drilling or completion activities;

— environmental aspects, including e.g. water depths, current conditions and seabed conditions;

— access at the subsea location;

— replacement in one or two tooling missions;

— mass and dimensions of module to be replaced.

4 Functional requirements and recommendations

4.1 General

This subclause contains general functional requirements and recommendations for the elements within the various options of ROT intervention systems and interfacing equipment.

a) The ROT intervention system shall be designed to be as small, simple, reliable and robust as possible, to ensure safety of personnel and to prevent damage to the intervention system, the SPS and/or the environment. No single failure should result in reduced safety for the involved personnel, or cause damage to involved equipment and/or the environment (consider redundancy in order to minimize the probability of failure).

b) The ROT functional requirements shall reflect its multiple use over the design life of the SPS.

c) The ROT intervention system shall be designed to allow for safe and easy operation, maintenance, repair and replacement of components.

d) Operations of all functions in the ROT intervention system shall be optimized with regard to duration.

e) Priority should be given to reduce the time required for mobilization/demobilization onboard the intervention vessel.

f) Functionality and operability of new ROT intervention concepts shall be documented in design and by testing under realistic conditions.

g) All intervention tasks shall be possible to suspend in a safe manner. It shall be possible to resume a task suspended due to equipment failure or adverse weather conditions.

h) All ROT operations should be fully reversible at any stage.

i) All tool functions, which upon failure may prevent retrieval of the ROT system to surface, shall have override features. These shall include release from both the permanently installed subsea systems as well as from sealines and replaceable components.

j) In case of a vessel drift-off, a weak-link or safe disconnection/release method shall be installed between the ROT system and the liftwire/umbilical. The ROT locking mechanism against the SPS should ensure that the ROT is not locked to the structure before the weak-link is established.

k) A weak-link or a fail-safe system should be included on all physical connections between ROT and ROV.

l) All elements in the ROT intervention system shall be certified for an SWL to suit the maximum expected load conditions during testing, transport and offshore operations. Mass of the module to be handled by the ROT should be included.

m) The ROT intervention system shall be designed for temperatures in the range 0 °C to 50 °C (32 °F to 122 °F). For operation and storage temperatures below 2 °C (35,6 °F), critical components shall be tested and documented for temperatures down to –18 °C (–0,4 °F).

n) The ROT system should be designed for long-term storage.

o) All equipment included in the ROT system shall be designed to withstand vibrations during transportation and operation in accordance with applicable regional regulations and actual conditions.

p) The ROT systems should allow operations from vessels such as mobile offshore drilling units simultaneously with drilling and completion activities. The following should be considered:

   1) relative offset between launch position and landing area;

   2) stack-up height, including height of the ROT system, the component/module to be installed and the umbilical sheave arrangement;

   3) mass of the ROT system, including the component/module, shall be minimized for handling purposes.

q) The ROT system should be designed to be run through a moonpool or over the side, both from a semi-submersible or from a monohull vessel.

r) The ROT intervention system should enable deployment of modules in any vessel heading relative to the subsea system.

s) ROT designs should give consideration to ROV operations during ROT use.

t) The ROT system shall be well balanced, with the resulting CG point directly below the handling cable attachment point prior to pick-up.

u) The ROT shall be designed for efficient launching on guidewires.

v) Cutting-loops, or similar solutions, shall be included for hydraulic functions with override possibilities in order to enable cutting of the loops with an ROV and hence prevent pressure lock in the respective hydraulic function.

w) Sensitive components or items which may be damaged during running, landing, operation, ROV involvement or interactions with wires, shall be protected against worst-case load condition.

x) Active hydraulic or electric components should not be left subsea in an activated mode.

y) Snagging points for guidewires, liftwires and umbilicals shall be avoided on the ROT system.

z) All tool functions should have visual subsea status and position indicators visible from ROV, clearly indicating the respective function status. Operations passing through several discrete steps, shall clearly identify the various stages of the operations.

aa) Provisions for emergency lifting should be included on all ROT systems.

4.2 Deployment and landing requirements and recommendations

This subclause contains functional requirements and recommendations for the ROT system during the deployment and landing phases of the intervention task.

a) ROT operations in which sensitive components, as part of the subsea system, are involved shall be carried out in a two-step sequence. The ROT shall be landed and sufficiently secured prior to manipulation of sensitive components, e.g. hydraulic lines.

b) The number of lines from the surface to the subsea work area should be minimized, to reduce the possibility of entanglement.

c) When an ROT system is deployed in a guidewireless operation, lateral and rotational control of the ROT system is required while entering into the subsea area in which sensitive components are exposed at the same level as the ROT.

d) If heave compensation on the ROT system liftwire is not specified, the ROT shall be designed for a vertical motion while on guidepost(s) and during landing. The design shall include a combination of crane-top motion amplitude, winch speed and the vessel period. Any potential amplification effects of crane-top motion down to the ROT shall be included.

e) The guidewire system on-surface should allow asymmetrical adjustment of the distance between the guidewires relative to the lifting point.

f) The guidewire winch(es) should be capable of installing replaceable guideposts.

g) The guidefunnels on the ROT shall enable simple and efficient entering and securing of the guidewires and eliminate trapping of the wires.

h) In order to achieve safe operation, the ROT and the transportation skid should enable entering on tensioned guidewires.

i) Sufficient running clearance between the ROT and the nearest obstructing element shall be ensured. Minimum 1,0 m (3,3 ft) clearance while on guidewires and 0,2 m (0,65 ft) while on guideposts should be provided. Cursor systems, guidecones and guideposts should be secured to avoid movements above the tolerance limits [1,0 m (3,3 ft) topside and 0,2 m (0,65 ft) subsea].

j) When guidewires are used, an emergency release system for the guidewires shall be included.

4.3 Surface equipment

4.3.1 General

The surface equipment system shall allow safe and efficient deck handling of the ROT system. Need for use of deck handling cranes should be minimized. The following general requirements and recommendations apply.

a) A skidding system should be used for transporting the ROT system and/or the components between working deck and launching position, to ensure safe handling. Functional requirements for tool skid systems are given in 6.3.2.

b) Where personnel are expected to climb onto a module or module stack-up for handling, inspection or maintenance, design considerations should be given to the placement of footrests, handholds, temporary gratings and attachment points for safety lines and fall-arrest systems.

c) Design and operation of all electrical systems on surface shall be in accordance with applicable regulations (equipment voltage and frequency shall be considered). Special attention should be given to equipment for use in explosion-hazard areas.

d) The lifting equipment shall be designed and documented in accordance with applicable regional regulations.

e) Design loads for lifting equipment shall include hydrodynamic loads where applicable:

f) Tools, components, modules, skids and trolleys shall have provisions for sea-fastening.

g) Dedicated sea-fastening attachment points shall be clearly marked "For sea-fastening only".

h) The jumper umbilicals/cables for use during deck operations should be of sufficient length to enable flexibility with respect to the surface equipment layout.

i) The jumper umbilicals/cables shall be adequately protected against damage during use and storage.

j) The jumper umbilicals/cables should be provided with hand-operated reeling mechanisms on the storage reels.

4.3.2 Tool skid systems

The following requirements and recommendations apply.

a) Skids for the various ROTs and the involved modules shall provide safe and efficient transportation and deck operations.

b) Each ROT, including the tool skids, shall be supplied with handling devices (e.g. lifting slings) certified for the maximum expected dry handling mass. This shall, where applicable, include the dry mass of the module to be handled by the ROT.

c) On the surface, replacement of components and modules in the various ROTs should be performed by skidding when required for safe operation due to vessel movement.

d) When required, tool skids should include all facilities (piping, valves and gauges, etc.) for function testing of the various ROTs.

e) The tool skids shall be balanced for safe lifting and handling with the dedicated ROT and, when applicable, with the replaceable module installed.

4.3.3 Common requirements and recommendations for umbilical and liftwire winch systems

The following requirements and recommendations apply.

a) The design of the winch systems shall enable safe and simple replacement of the umbilical/wire.

b) The handling and routing arrangement for umbilical/wire shall enable easy and efficient installation and operation.

c) It shall be verified that all sheaves suit the diameter and minimum bending radius of the umbilical/wire.

d) Winches shall provide efficient running, operation and storage of the complete umbilical/wire.

e) All winches shall be fitted with a mechanical brake system (fail-safe system).

f) The umbilical/wire should be evenly spooled onto the drum during wind-in. A level wind arrangement should be considered.

g) Winches should be operated from the ROT control console. It is recommended that in addition the winches be equipped with a mobile remote-operation control, as well as local control at the reels.

h) Winch load calculations shall be in accordance with the relevant standards and regulations in which appropriate considerations have been made for the dynamic loads.

i) The lifting winch or deployment system should include a facility for depth-display during operations. A metre-counter, acoustic link or equivalent should be considered.

j) Constant-tension winches shall allow for instant and direct switchover from normal operation to constant tension.

4.3.4 Umbilical winch system

The following requirements and recommendations apply.

a) Umbilical winches used for combined lifting and control functions shall have ample lift and brake capacities to handle the complete weight of the ROT system in air and in water. The capacity evaluation weight shall include mass of the ROT, the module to be installed if any, and the full length of the umbilical including hydrodynamic effects.

b) Umbilical winches should include an adjustable constant-tension mode, with the capacity to operate with the umbilical in tension during maximum design operation condition.

c) Umbilicals should have a system for easy attachment to the lift wire, when applicable.

d) Umbilical winches not used for ROT lifting shall have sufficient lift and brake capacities to handle the full length of the umbilical, including dynamic amplification.

4.3.5 Wire winch system

The following requirements and recommendations apply.

a) Lifting winches used in conjunction with non-lifting umbilicals shall have sufficient lift and brake capacity to handle the complete weight of the ROT system in air and in water. The complete weight shall include mass of the ROT, the module to be installed if any, and the full length of the umbilical including hydrodynamic effects.

b) Wires should be of a low-grease and torque-balanced design. Alternatively, a fibre rope or a ball-bearing swivel can be evaluated.

c) Wire winches should include an adjustable constant-tension mode with capacity to operate with the umbilical in tension during maximum design operation conditions.

4.4 Control system requirements and recommendations

4.4.1 General

The main components of the control function in an intervention system are:

— surface control system,

— surface/subsea communication,

— subsea control system.

This subclause contains general requirements and recommendations for the ICS.

a) Hydraulic control components should meet standardized pressure classes.

b) The capacities of the electrical and hydraulic systems in the ICS should provide for some increase in the number of functions.

c) The hydraulic system should be designed to maintain specific cleanliness and water content requirements. A typical cleanliness level is NAS Class 8 (see NAS 1638 [1]) or ISO 17/14 (see ISO 4406 [2]). Mechanisms for obtaining the required cleanliness level should be maintained throughout the whole process, including fabrication and assembly.

d) When selecting the type of hydraulic fluid, the interfacing equipment, i.e. ROV systems and workover systems, should be taken into consideration.

e) Separate purifier drain and fill connections should be fitted to all hydraulic reservoirs.

f) Electrical equipment exposed to harsh environments shall be water-ingress-protected, with a minimum IP rating.

g) The equipment shall be supplied complete with all necessary interface piping, instrumentation, cabling and hose jumpers in order to avoid on-site installation, except for connecting the units.

h) All control cables, piping, umbilical terminations, connectors, hoses and associated equipment shall be supported and protected adequately to prevent damage or contamination during storage, testing, equipment handling and operation.

i) All lines, cables, fittings and connectors shall be clearly marked to enable easy identification and connection. Multiconnectors should be evaluated to reduce hook-up time.

j) The same type of fitting should be used for the same pressure classes.

k) The number of different types of fitting should be minimized throughout the system.

4.4.2 Surface control system

The following requirements and recommendations are relevant for a purpose-built surface control container for the subsea intervention system.

a) The surface control equipment shall provide for safe, effective and reliable control and monitoring of all ROT functions, including testing.

b) The surface control system should include audio/visual contact between the ROT surface control unit and the ROV surface control unit.

c) The surface control system should provide facilities for monitoring applicable surface activities and for communication to crane/winch.

d) The surface control system should include facilities for computerized storage and printout of relevant feedback data from the various operations.

e) The surface control system should provide facilities for video recording of ROT system operations, including ROV operations for complementary work.

f) The total number of monitors should reflect the maximum number of functions to be monitored simultaneously.

g) The layout of the surface control unit should allow easy access to all components for maintenance and repair.

h) The surface control unit should enable deck-positioning flexibility, e.g. location of doors, safety exits, control panels, cable inlets/outlets, etc.

i) The surface control unit should have an operator-friendly design. Control panels shall be easily readable with logical and understandable markings.

j) The surface control unit shall have proper lighting, ventilation, temperature control and noise protection.

4.4.3 Surface/subsea communication

The following requirements and recommendations apply to an ROT intervention system with a dedicated umbilical. The umbilical can either be clamped to a lift wire or armoured to provide lifting capability as an integrated solution.

a) The umbilical shall contain necessary power cables, fibre optic lines, twisted pair signal cables and coaxial cables for power and signal transmission. Minimum one each spare power, fibre, coax and twisted pair shall be included.

b) The umbilical design shall be suitable for the application required, particularly in respect to torque balance, tensile strength, elongation, fatigue bending and rough handling, all in combination with good flexibility and low mass to ensure ease of handling and operation.

c) A combined umbilical/lifting wire should be considered. Breaking strength and fatigue resistance shall be documented.

d) The umbilical shall be designed able to operate under full load with all the umbilical on the winch drum, accounting for heat production in the umbilical.

e) In umbilicals containing hydraulic lines, the hydraulic return line should always have a pressure higher than ambient in order to prevent seawater ingress. Alternatively, other suitable seawater ingress-prevention facilities may be considered.

f) The umbilical terminations should be of lightweight design to enable handling and connection/disconnection by a maximum of two operators.

g) The umbilical shall be fitted with a ground wire of necessary size to prevent electrical potential differences between the ROT system and the surface equipment. To prevent black-out, sufficient high voltage isolation between the ROT system and the vessel's electrical system shall be provided.

h) The umbilical subsea termination shall include an umbilical bend restrictor.

i) The umbilical MQC plates shall be easy to operate. Guidance, alignment and orientation features shall be provided to ensure correct coupler alignment and prevent coupler damage during connection and disconnection.

j) The MQC plate should be the weak link for the umbilical.

k) The umbilical and liftwire attachments shall include a feature for safe disconnection of the umbilical and the liftwire from the ROT in case of vessel drift-off.

4.4.4 Subsea control system

The following requirements and recommendations apply.

a) The ROT system may be operated by use of a subsea HPU, either ROT-mounted or via an ROV.

b) The HPU installed should be mounted on a subframe isolated from the lifting frame by shock-absorbing elements (e.g. elastomer mounts).

c) All hydraulic components in the ROT system should be compatible with the hydraulic fluid used in the surface control system.

d) The ROT system shall have provision for flushing of the hydraulic system.

e) All hydraulic lines and components shall be sufficiently protected from overpressure, e.g. by adequate use of pressure-reducing or -relief valves.

f) Subsea electrical and electronic units shall be properly protected. Atmospheric containers and/or oilfilled pressure-compensated compartments should be used where applicable.

g) Alarm shall be provided upon critical low pressure and reservoir levels in the hydraulic system.

When an ROV is used in an override or contingency function transfer, e.g. power and/or control through a hot-stab connection, the following requirements and recommendations apply. Reference may also be made to recognized industry standards.

— The transfer of fluid between the two systems shall be based on fluid compatibility. Alternatively, a hydraulic motor/pump unit placed in the ROV skid should be considered to avoid interference of hydraulic fluid between the ROV system and the ROT system.

— When an ROV is docked on the ROT, the ROV should still be able to perform complementary work and monitoring tasks on accessible and viewable areas.

4.5 Tie-in operations

4.5.1 General

This subclause states functional requirements and recommendations to the PIF and the CF.

The PICS includes in general the following main equipment:

a) tools for pull-in and connection, either as separate tools or a combined tool;

b) connectors and seal assemblies;

c) hubs, caps and terminations;

d) pull-in porches/alignment structures.

The subsea electrical connection system shall be covered by a recognized industry standard.

4.5.2 Pull-in tool (PIT)

The following requirements and recommendations apply.

a) The PIT shall perform the complete pull-in operation in a single run and secure the sealine in a safe and defined position.

b) The PIT shall be mechanically locked to the subsea structure or the inboard hub during pull-in operations.

c) A subsea winch should be used for final pull-in sequence. Alternatively, a surface pull-in winch/take-up reel may be used.

d) All PIT elements shall be designed for the maximum sealine pull-in force.

e) The PIT should be capable of performing pull-in without back-tension in the sealine.

f) Skew load on the PIT shall be included based on the maximum entry angle of the wire.

g) If direct ROV pick-up of the pull-in wire is not possible, a wire delivery mechanism shall be included.

h) The ROV shall establish the connection between the pull-in wire and the termination head/pull-in head.

i) The PIT or the ROV shall be able to release the pull-in wire.

j) If a pull-in head is mounted on the outboard hub, this shall be removed either by the PIT at completion of pull-in, by ROV, or by the CT prior to commencement of hub stroke-in.

4.5.3 Connection function

The following requirements and recommendations apply.

a) The CT should be able to perform the complete connection or disconnection operation in a single run.

b) Safe storage positions for the outboard hub should be available both before a connection and after a disconnection.

c) The CT shall be designed to meet the maximum connection force required for mating or demating of the fixed and the stroking hub.

d) The CT shall be mechanically locked to subsea structure or the fixed hub during connection operations.

e) Loads from the sealine shall not cause any leakage in the connection.

f) The stroking force generated by the CT shall take into account all forces transmitted to the connection system.

g) The CT shall have the capability to enter, catch and align the hubs at a defined worst-misalignment condition.

h) It shall be possible to replace the seal assembly either by the CT or by an ROV. If a spool-piece connector is used, the seals shall be a part of the connector assembly (rather than the hubs), in which case it shall be possible to retrieve the complete connector, in order to replace the seals at the surface.

i) If clamp connectors are used, the CT, or where applicable an ROV, shall incorporate facilities to ensure that the make-up and break-out torque applied is kept within the specified torque range. In addition, turn-counting of jack-screw revolutions should be considered for enhanced operation feedback and operator information.

j) The CT should include means of testing the seal integrity after a connection is made up.

k) The CT should be capable of connecting a single subsea pig-launcher to the inboard hub of a single-bore sealine.

4.5.4 Connector and seal assembly

The following requirements and recommendations apply.

a) Any preload shall be maintained mechanically without use of hydraulic pressure.

b) The connection shall withstand cyclic loads caused by pressure, temperature and external loads.

c) For secondary seals and back-up seals, elastomer materials with verified service performance may be used.

d) The connectors for the sealines shall permit repeatable connections and disconnection, preferably without the need for replacement of the seals.

e) Connectors should be of a standard size/rating to facilitate beneficial interfacing with the CT design. Emphasis should also be put on standardizing the interface between the connector and the CT.

f) The clamp connector should be replaceable remotely without retrieval of either hub to surface.

g) Pigging requirements shall be taken into consideration when selecting seal ID.

h) The connector should allow for external pressure testing of the connection. If so, the annular area between the primary metal seal and the environmental seal shall be vented to avoid pressure build-up in case a leak develops in the metal-to-metal seal.

i) Multibore connections shall have a system for orienting the seal assembly relative to the hubs.

j) Connectors shall be designed for uniform force distribution around the hub circumference.

k) Connectors shall incorporate features that prevent unintentional release due to impact from tools, ROV, falling objects, tool failures or due to any other operational loads.

l) The load capacity of the connections shall ensure seal integrity for all operational loads.

m) Both sealine and header shall have sufficient load capacity to withstand pull-in, stroke-in and alignment loads. In addition, residual preload for final alignment of the hubs shall be taken into consideration. Adequate assisting marine operations to protect sealine from overstressing should be considered.

n) The distance between fixed and stroking hubs shall enable installation/retrieval of applicable equipment, such as pull-in head, caps, seals and connectors. Required back-stroke shall consider interfacing equipment.

o) It shall be possible to perform seal-seat inspection and cleaning prior to final connection.

p) The resulting face-to-face angular gap after engaging the hubs shall allow the clamp to enter the hubs with proper margin and provide final alignment and make-up of the connection.

4.5.5 Hubs, caps and termination heads

The following requirements and recommendations apply.

a) The fixed hub shall meet the PICS flexibility (stroke and alignment) requirements.

b) Hydraulic lines should include check valves to prevent loss of hydraulic fluid or ingress of water and dirt when disconnected. In case of risk for clogging of check valves, the hydraulic lines should be fitted with protection caps when disconnected.

c) All surplus bores in standard multibore hubs shall be permanently plugged.

d) In case of defect lines in the umbilical, it shall be possible for multibore seal plates to utilize the spare lines in the umbilical by means of by-pass solutions.

e) Hubs should not represent a flow restriction.

f) Hubs in piggable lines should have inside diameters flush with the line.

g) The hub seal preparations shall, in case of damage, accommodate a contingency seal surface by installation of modified seal rings.

h) Required pressure caps/blind hubs should be installed/retrieved by use of the ROT. Alternatively, the caps can be installed/retrieved by an ROV tool. The pressure caps shall be connected by means of a connector and shall have the same rating as the hub/bores it blinds off.

i) The long-term protection cap shall include means of protecting the seal area. The long-term protection cap shall be installed on surface and retrieved by the ROV or alternatively by the ROT.

j) The long-term protection caps shall prevent intrusion of salt water to the hub sealing areas and should not be pressure-containing. If required, a pressure-equalization device should be included.

k) The short-term protection cap shall protect against dirt and seawater circulation and be installed/retrieved by ROV.

l) The inboard protection and pressure caps shall include means of venting the manifold piping.

m) The inboard protection and pressure caps should include means of filling of manifold preservation fluid, to facilitate a complete filling of the manifold piping.

n) There shall be provision for installation of dirt protection plugs on any vital part.

o) The termination head shall be optimized with regards to mass, dimensions and interface with the sealine.

p) The termination head shall withstand all loads from the sealines and transmit them into the subsea structure.

q) The termination head shall have wire-attachment points for laydown purposes or in case a pull-out of the sealine is required.

r) The termination head/pull-in head and corresponding clamp shall prevent accidental release during all phases of the installation and pull-in operations.

s) The pull-in head shall enable connection of an ROV-installed hotstab for flushing and pressure-testing purposes. The possibility of using the hotstab for pigging purposes shall be evaluated.

t) The termination head/pull-in head shall enable bleed-off of internal pressure.

u) The pull-in head should be retrievable to surface.

v) The umbilical termination head shall have a marking system for rotation identification.

w) The umbilical termination head may have provision for installation of electrical coupler receptacles.

x) The umbilical termination head should have provisions for installation of removable plugs and covers, protecting the electrical coupler receptacles.

4.5.6 Pull-in porches/alignment structures

The following requirements apply.

a) The pull-in porches shall be designed to withstand or to be protected from snag loads, e.g. from lift wires and guidewires.

b) Maximum entry angles of the termination head shall be defined as it enters the alignment funnel.

4.6 Module replacement

This subclause contains functional requirements and recommendations for the installation or replacement of modules.

The following general requirements and recommendations apply.

a) The ROT system shall provide a safe locking of the replaceable module during handling, deployment/retrieval and operation.

b) Replacement of modules should be based on vertical retrieval and re-entry to the landing receptacle.

c) If power failure occurs or is switched off during running, the replaceable module shall remain locked to the ROT.

d) The module to be installed should be landed in a two-step sequence:

   1) landing the dedicated ROT system on the subsea landing structure;

   2) final landing and alignment of the module onto the subsea interface;

e) When a module is to be retrieved, the ROT system shall be designed with sufficient flexibility to self-align and freely enter the module mating point.

f) Modules interfacing pressurized equipment (e.g. valve insert, clamp connection) shall have provisions for verifying that internal pressure is bled off. It should also be possible to verify the seal integrity on connection points.

5 Test requirements and recommendations

The following requirements and recommendations apply.

a) If the ROT system design undergoes any changes in fit, form, function or material, the manufacturer shall document the impact of such changes on the performance of the system. A system design that undergoes a substantial change becomes a new design, requiring requalification.

b) New designs shall be evaluated with respect to requirement for qualification and wet testing.

c) The ROT system shall undergo a FAT prior to delivery of the system.

d) All functions in the ROT system, including contingency functions, shall be verified.

e) The ROT system shall have provisions for surface testing prior to deployment.

f) The ROT system should have its interfaces tested and verified on all working location(s) on the SPS.

g) ROT systems and modules should be drop-tested to demonstrate the system's ability to withstand dynamic shocks as specified. All functions shall be tested and verified before and after the drop test.

h) All structural, mechanical and control (electrical and hydraulic) internal interfaces within the ROT system shall be verified.

i) All structural, mechanical and control (electrical and hydraulic) external interfaces between the ROT system and interfacing systems and components shall be verified.

j) All dimensions and masses for the ROT system shall be verified.

k) The ROT system stability (CG/CB in air and water) shall be verified. Regarding ROTs for module replacement, the stability shall be verified with and without the replaceable module.

l) Entry and landing of the ROT system at maximum entry angle shall be verified.

m) All capacities such as torque output, stroking forces, override forces/torques shall be verified.

n) Proper calibration of all relevant equipment such as sensors, switches, gauges, etc. shall be verified.

o) ROV access for monitoring, inspection and operation of relevant ROT functions (including back-up) shall be verified.

6 Interfaces

The various detailed internal and external interfaces shall be identified and sorted out on a project to project basis.

The interfaces identified below are included as a guideline for establishing an interface register.

a) Vessels and rigs

Consider features such as:

1) handling, skidding and deployment/cursor system;

2) electric and electromagnetic compatibility;

3) provision of pneumatic and hydraulic power;

4) deck facilities and interferences, such as moonpool size;

5) effect on vessel fire-fighting and life safety;

6) dimensions and mass limitations of ROT and modules;

7) control container/room facility, including communication and monitoring system;

8) vessel stationkeeping;

9) motion characteristics and scheduling of simultaneous operations.

b) Subsea structures (templates, manifolds and riser bases)

Consider features such as:

1) layout and dimensions of landing area;

2) guideposts;

3) locking mechanisms and the pull-in funnel/alignment structure;

4) process piping /manifold system;

5) sealine snag loads;

6) others.

c) Subsea tree systems (including WOCS)

Consider features such as:

1) layout and dimensions of PGB landing area;

2) guideposts, locking mechanisms and the pull-in funnel/alignment structure;

3) process piping, wellhead load capacities, tolerances, sealines snag loads;

4) others.

d) Production control systems

Consider features such as:

1) number of lines;

2) sizes;

3) pressures;

4) fluids;

5) electrical connections;

6) others.

e) Flowlines

Consider features such as:

1) size;
2) rating;
3) stiffness;
4) termination;
5) material;
6) expansion forces;
7) pull-in forces;
8) rotational forces;
9) snagloads;
10) backstroke limitations;
11) others.

f) Umbilicals

Consider features such as:

1) size;
2) rating;
3) stiffness;
4) umbilical termination;
5) material;
6) expansion forces;
7) pull-in forces;
8) rotational forces;
9) snagloads;
10) backstroke limitations;
11) electrical connections;
12) others.

g) Risers

Consider features such as:

1) size;
2) rating;
3) stiffness;

4) termination;

5) material;

6) forces;

7) others.

h) Testing

Consider features such as:

1) test facility location;

2) test equipment;

3) others.

i) Transportation

Consider features such as:

1) site location;

2) method of transport;

3) mass and size limitations;

4) sea-fastening;

5) others.

j) Installation of structures

Consider features such as:

1) levelling requirements;

2) positioning tolerances;

3) installations;

4) mass limitations;

5) others.

k) Installation of sealines

Consider features such as:

1) survey;

2) pipelaying and umbilical installation;

3) sequences;

4) trenching;

5) mattresses and rockdumping;

6) others.

l) ROV systems

Consider features such as:

1) access for observation and inspection;

2) operation of ROV tools;

3) handling of pull-in wire;

4) operation of lockdown mechanisms and mechanical overrides;

5) cleaning of hubs;

6) others.

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