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**Erdöl- und Erdgasindustrie –
Auslegung und Betrieb von Unterwasser-Produktionssystemen –
Teil 8: Schnittstellen mit ferngelenkten Transporteinheiten (ROV) auf
Unterwasser-Produktionssystemen (ISO 13628-8:2002);
Englische Fassung EN ISO 13628-8:2006**

Petroleum and natural gas industries –
Design and operation of subsea production systems –
Part 8: Remotely Operated Vehicle (ROV) interfaces on subsea production systems
(ISO 13628-8:2002);
English version EN ISO 13628-8:2006

Industries du pétrole et du gaz naturel –
Conception et exploitation des systèmes de production immergés –
Partie 8: Véhicules commandés à distance pour l'interface avec les matériels immergés
(ISO 13628-8:2002);
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Nationales Vorwort

Der Text von ISO 13628-8:2002 wurde vom Technischen Komitee ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“ erarbeitet und als EN ISO 13628-8:2006 durch das Technische Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“, dessen Sekretariat von AFNOR (Frankreich) gehalten wird, übernommen.

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— in Bild D.1 ist „Dimensions in millimetres (inches)“ durch „Dimensions in inches“ zu ersetzen.

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$$1\text{ ft} = 0,304\text{ 8 m}$$

$$1\text{ in (inch)} = 25,4\text{ mm}$$

$$1\text{ kip/in}^2 = 1\text{ ksi} = 6,894\text{ 757 N/mm}^2 = 6,894\text{ 757 MPa}$$

$$1\text{ lbf} = 4,448\text{ 222 N}$$

$$1\text{ t} = 1\text{ 000 kg}$$

English Version

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Design and operation of subsea production systems —
Part 8: Remotely Operated Vehicle (ROV) interfaces
on subsea production systems
(ISO 13628-8:2002)

Industries du pétrole et du gaz naturel —
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Auslegung und Betrieb von Unterwasser-
Produktionssystemen —
Teil 8: Schnittstellen mit ferngelenkten Transporteinheiten
(ROV) auf Unterwasser-Produktionssystemen
(ISO 13628-8:2002)

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

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Foreword

The text of ISO 13628-8:2002 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 13628-8:2006 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 13628-8:2002 has been approved by CEN as EN ISO 13628-8:2006 without any modifications.

Introduction

This part of ISO 13628 is a revision, major amendment and expansion of Annex C of API¹⁾ 17D^[1].

The recommended practices for the selection and use of ROV interfaces have generally selected one interface for a specific application. The inclusion of a particular approach or recommendation does not imply that it is the only approach or the only interface to be used for that application.

In determining the suitability of standardization of ROV intervention interfaces for installation, maintenance or inspection tasks on subsea equipment, it is necessary to adopt a general philosophy regarding subsea intervention. This intervention philosophy is more fully described within this part of ISO 13628, as are the associated evaluation criteria used in selecting the interfaces incorporated into these recommendations.

This part of ISO 13628 is not intended to obviate the need for sound engineering judgement as to when and where its provisions are to be utilized, and users need to be aware that additional or differing details may be required to meet a particular service or local legislation.

With this part of ISO 13628, it is not wished to deter the development of new technology. The intention is to facilitate and complement the decision processes, and the responsible engineer is encouraged to review standard interfaces and re-use intervention tooling in the interests of minimizing life-cycle costs and increasing the use of proven interfaces.

This part of ISO 13628 does not cover intervention by remote operated tools (ROT), which are dedicated tools deployed on drill pipe or guidelines. Instead, it focuses upon defining the requirements of ROV interfaces with subsea production systems, with further reference to ROT interfaces only being made where deemed appropriate. The interfaces on the subsea production system can apply equally to ROTs and ROVs.

1) American Petroleum Institute, 1220 L Street NW, Washington D.C. 20005, USA.

1 Scope

This part of ISO 13628 gives functional requirements and guidelines for ROV interfaces on subsea production systems for the petroleum and natural gas industries. It is applicable to both the selection and use of ROV interfaces on subsea production equipment, and provides guidance on design as well as the operational requirements for maximising the potential of standard equipment and design principles. The auditable information for subsea systems it offers will allow interfacing and actuation by ROV-operated systems, while the issues it identifies are those that have to be considered when designing interfaces on subsea production systems. The framework and detailed specifications set out will enable the user to select the correct interface for a specific application.

2 Normative references

The following referenced document is indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10423, *Petroleum and natural gas industries — Drilling and production equipment — Wellhead and christmas tree equipment*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms, definitions and abbreviated terms apply.

3.1 Terms and definitions

3.1.1

functional requirement

minimum criterion which shall be satisfied in order to meet a stated objective or objectives

NOTE Functional requirements are performance oriented and are applicable to a wide range of development concepts.

3.1.2

guideline

recommendation of recognized practice to be considered in conjunction with applicable statutory requirements, industry standards, standard practices and philosophies

3.1.3

manufacturer

company responsible for the manufacture of the interface

3.1.4

operator

company which physically operates the ROV (delivery system)

3.1.5

remotely operated tool

ROT

dedicated tool that is normally deployed on lift wires or drill string

NOTE Lateral guidance can be by guide wires, dedicated thrusters or ROV assistance.

3.1.6

remotely operated vehicle

ROV

free-swimming submersible craft used to perform tasks such as valve operations, hydraulic functions and other general tasks

NOTE ROVs can also carry tooling packages for undertaking specific tasks such as pull-in and connection of flexible flowlines and umbilicals, and component replacement.

3.2 Abbreviated terms

CCO	Component change-out
FAT	Factory acceptance test
FMECA	Failure mode effect and criticality analysis
HIPPS	High integrity pipeline protection system
MQC	Multi quick connect
MTBF	Mean time between failures
ROV	Remotely operated vehicle
ROT	Remotely operated tool
SCM	Satellite control module
TDU	Tool deployment unit

4 Intervention philosophy and functional requirements

4.1 General

When designing interfaces for use on subsea production systems an intervention philosophy needs to be established. The intervention philosophy should address the activities to be carried out, the method of intervention for each task, the type of tool, the method of stabilization of the ROV by docking or positioning for the effective performance of its intervention tasks, and access requirements. The intervention philosophy should take into account the various intervention tasks, rationalizing them so that a consistent method is adopted, as a number of tasks may be performed consecutively.

Once the tasks to be carried out have been identified the ROV intervention method should be established.

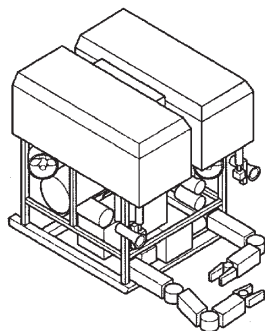
Figures 1 to 34 show a variety of ROV systems and interfaces.

4.2 Intervention by ROV

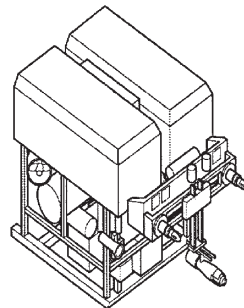
ROVs are free-swimming submersible craft that can be used to perform tasks such as valve operations, hydraulic functions, and other general tasks. ROVs can also carry tooling packages in order to undertake specific tasks such as tie-in and connection functions for flowlines, umbilicals and rigid pipeline spools, and component replacement. ROVs are essentially configured for carrying out intervention tasks in five ways:

- with manipulators for direct operation of the interface;
- with a manipulator-held tool;
- with TDUs;
- dual down line method (with ROTs);
- with tool skids or frames.

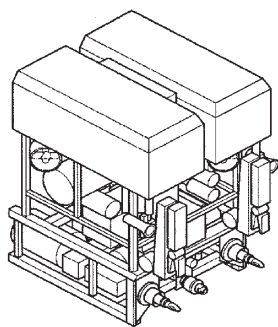
Interface tooling, so far as possible, should be designed to operate with a range of ROVs and not be limited in application to one design only, thus allowing the use of ROVs and intervention vessels of opportunity. Figure 1 shows typical ROVs.



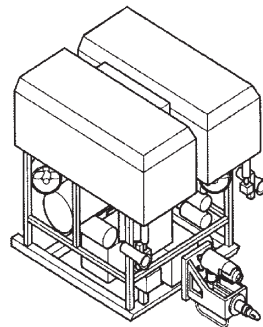
a) ROV with manipulators



b) Twin-point docking tool delivery system



c) Underslung tool skid



d) Single-point docking tool delivery system

Figure 1 — Typical work class ROV operationally configured

Figure 2 shows ROV and interfaces on a typical tree.

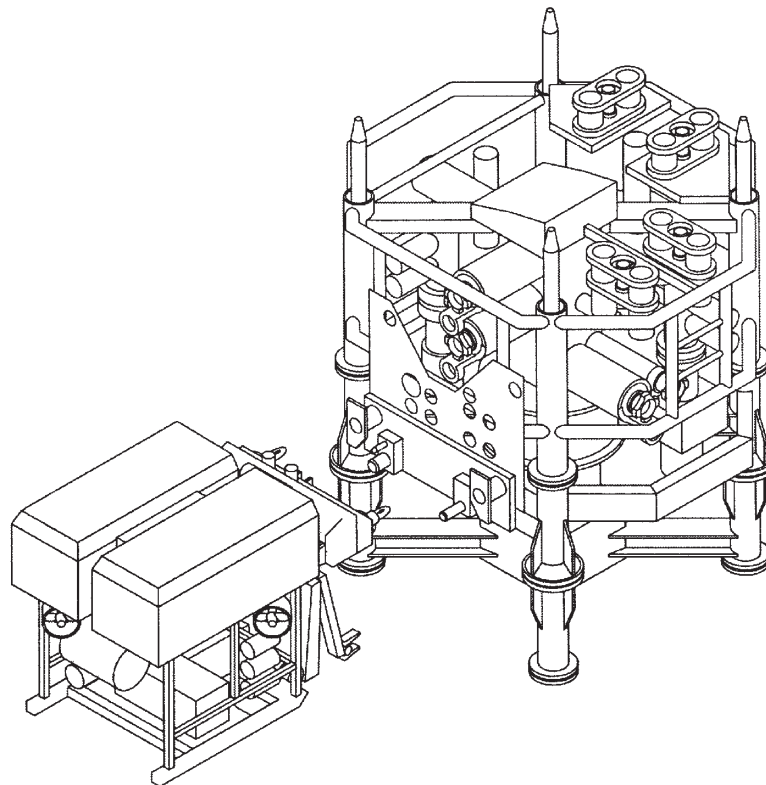


Figure 2 — Interfaces on typical tree

4.3 ROV intervention task configurations

4.3.1 ROV intervention with manipulators

A manipulator is a mechanical arm complete with joints allowing degrees of freedom (see Figure 1). The arm or arms are connected to the ROV vehicle frame. The more joints that the arm has, the more degrees of freedom and consequently the more versatile the arm.

At the end of the arm there is a gripper, usually consisting of two or three fingers that allow handles, objects and structural members to be grasped for the purpose of carrying out an activity or to stabilize the ROV.

Where a ROV is engaged in performing tasks, it can have two manipulator arms, one used for stabilising the ROV itself and the second for carrying out the function or task.

Manipulator systems operated by ROV vary considerably in their functionality and controllability. For tasks to be performed on a subsea production system using ROV manipulators or manipulator-held tooling, the following number of issues require special consideration:

- location of the interface such that it is within the manipulator capability in terms of reach, i.e. the working envelope (see Annex C for details of typical manipulator envelopes);
- pliancy between the tool body and the handle by which the manipulator holds the tool, to provide dexterity during insertion or pull-out of the tool, such that the manipulator's wrist angle does not have to move precisely in tandem with the insertion or pull movement of the rest of the arm (see Figure 19 for an example of design pliancy in the wire rope extension between a hot stab body and the manipulator handle);

- weight of any removable components such that they are within the manipulator capability in terms of the arm's lift and handling capacity;
- precision, accuracy and repeatability in determining the difficulty of the task;
- sufficient access and space to allow tools to be inserted into the interface and allowable clearance away from adjacent operations such as hot stabs, etc.;
- ability of the subsea equipment and component to resist the loads and torque reactions applied by the manipulator, tool and/or ROV;
- protection for equipment against impact from the ROV.

Consideration of environmental conditions, which may affect successful intervention and the completion of specific tasks identified above, will lead to the selection of one of the following stabilization methods:

- a flat horizontal platform area for the ROV to park, thrusting against the platform, adjacent to the interface, allowing vertical or horizontal access;
- a horizontal or vertical bar, to allow the ROV grabber (limited degree of freedom manipulator arm) to take hold (see Figure 6);
- ROV docking/receiver points (see Figures 7, 15, 16, 18 and 22);
- relatively flat, smooth surfaces for attaching suction cups.

Docking and interface points should be a minimum of 1,5 m (4,92 ft) above the clear local seabed level for unhindered operations.

ROV platforms should be avoided where they need to be removed, opened or closed in order that other intervention tasks can be performed.

The designer should take into account the various intervention tasks and rationalize these to adopt a consistent means of ROV docking on the subsea facility, as the ROV could be required to perform a number of tasks during the same dive.

In certain geographic locations, care needs to be taken in establishing the seabed level owing to soft mud and the effect of ROV thruster wash on the seabed.

See Figure 8 for specific details related to local tool loads.

4.3.2 ROV intervention with a tool deployment unit (TDU)

4.3.2.1 General

A TDU is a specifically designed work package that is attached to the front or rear of the ROV frame to accurately orient and position the tool by use of a Cartesian carriage arrangement (see Figure 3). The number of degrees of freedom are one, two or three axis, depending upon the complexity of the task and the position of the TDU's docking position relative to the tooling interface. The TDU can replace or be complementary to the manipulator arm or arms.

4.3.2.2 Twin-point docking system

The TDU is used in combination with two docking probes that latch onto and attach the Cartesian carriage and ROV to the subsea production equipment. The twin docked carriage system can access one or more intervention interfaces from the same docked position and is particularly suitable when grouping interface missions into panels. Figure 3 shows a typical twin-point TDU.

4.3.2.3 Single-point docking system

The single-point system is similar to the twin-point docking system, but with some operating differences. The single-point TDU is also a ROV-mounted work package, providing a similar means to accurately orient and position interface tooling, in a y - z Cartesian configuration. The single-point docking system docks and attaches much in the same way as two docking probes but has more flexibility to move freely around the subsea equipment. It is recommended for interfaces which are situated singly (or in isolated pairs) or where there is a limited amount of adjacent structure. Figure 4 shows a typical single-point TDU.

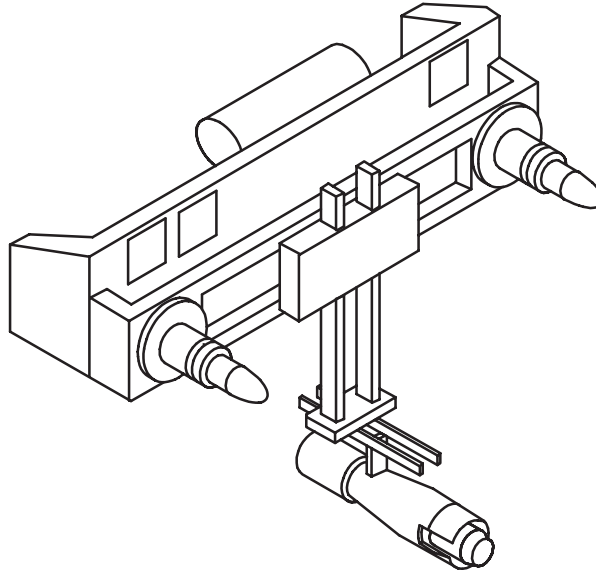


Figure 3 — Twin-point docking TDU

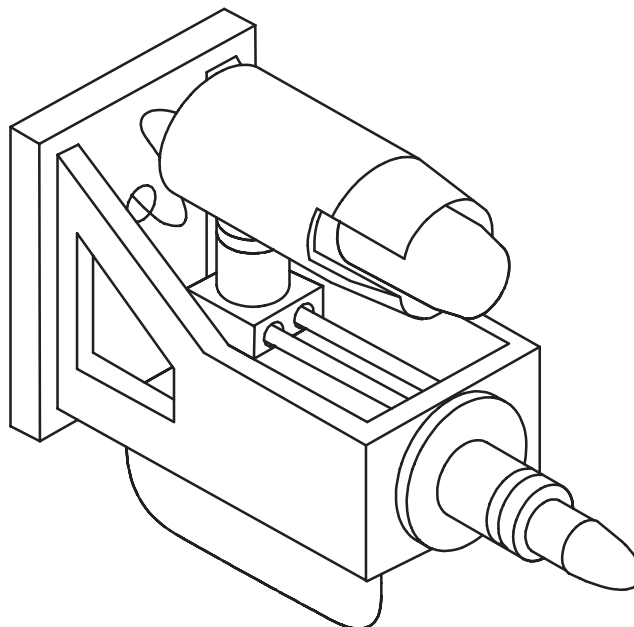


Figure 4 — Single-point docking TDU

4.3.2.4 General considerations for docking and TDU operation

In general, a single-point TDU has a maximum of two intervention interfaces that can be addressed from the single docking point. Ideally, the interface or interfaces are vertically aligned directly above the docking point (see Figure 10).

Interfaces for use with a twin-point docking TDU have to be located in an envelope governed by operational limits of the Cartesian carriage system and its relationship to the tooling interface points (see Figure 9).

Other considerations include the following:

- a single-point TDU generally requires lighter interface tool loading conditions than a twin-point TDU;
- a single-point TDU can impose more dynamic and static loading from the ROV into the docking structure on the subsea equipment and interface tooling than a twin-point TDU;
- a twin-point TDU requires more access space to accommodate the Cartesian carriage from several aspects — the ROV vehicle frame, the ROV deployment system (winch and surface handling equipment), its tether maintenance system (or garage), and the subsea equipment — especially where the interfaces are not externally located;
- the TDU frame needs to be designed for resisting loads and reaction torque generated by the environment, the ROV, the TDU docking probes and the interface tooling;
- a twin-point TDU is normally mounted on the upper half of the ROV, which dictates the elevation of the tooling interface points on the Cartesian carriage below (interface points should be a minimum of 1,5 m (4,92 ft) above the clear seabed level for unhindered operation);
- a single-point TDU is normally mounted near the base of the ROV, which dictates the elevation of tooling interface points above (the docking point should be a minimum of 1,5 m (4,92 ft) above the clear local seabed for unhindered operation).

In certain geographic locations, care needs to be taken in establishing the seabed level owing to soft mud and the effect of ROV thruster wash on the seabed.

Specific details related to local tool reaction loads are shown in Figure 8.

4.3.3 Dual downline intervention

4.3.3.1 General

The replacement of subsea components, such as control pods and chokes can be carried out by the use of a lifting and handling frame, more commonly called a CCO tool (see Figure 23). Generally, a CCO tool is used for component installation or recovery tasks that require surface lift capacity beyond that of a free-swimming ROV. The CCO tool is deployed from an intervention vessel via a lift line or drill pipe, the first down line, which is designed to support the weight and dynamic loads of the CCO tool and the component being replaced. The second down line is the ROV's umbilical/tether maintenance system. It is recommended that these two down lines be deployed from separate areas of the intervention vessel to avoid entanglement.

4.3.3.2 General considerations for dual downline operation

Lateral and rotational guidance of the CCO tool may be by guidelines/guideposts (at least two), a guidelineless re-entry funnel, thruster assistance or the ROV nudging the tool into place. If guidelines are used, additional care should be taken to ensure that these lines are heave-compensated and to avoid entanglement with the lift line or ROV umbilical. For guidelineless re-entry, the funnel should have a built-in helix that interfaces with an alignment key on the CCO tool to orient the CCO tool as it is landed in the re-entry funnel.

Other considerations include the following:

- the lift line or drill pipe should be heave-compensated, especially from small heave-prone intervention vessels, so that the CCO is not raised or lowered too quickly during a heave cycle (means to accomplish heave compensation include an active heave-compensated crane or configuration of the lift wire in a lazy S, located mid depth, using buoyancy cells to isolate heave motions from CCO tool movement below);

- dynamic motions and loads caused by stretch and a snap in the line caused by intervention vessel heave versus added mass sluggish movement of the CCO tool (and replacement component) need to be quantified and necessary strength built into the lift line and CCO tool;
- the CCO tool should have either a soft landing damper or a hard stand-off feature so that final landing and alignment with sensitive interfaces, such as hydraulic or electric couplers, is done in a controlled and low-impact manner, independent of intervention vessel heave or initial landing of the CCO tool on the subsea equipment;
- the helix for guidelineless re-entry typically accommodates $\pm 180^\circ$ of orientation allowance in order to spin the CCO tool into proper orientation (the ROV can help reduce the orientation angle by pre-orienting the CCO tool in a rough orientation, for example, $\pm 45^\circ$, as the CCO tool is nudged over the re-entry funnel, thereby reducing the size and complexity of the re-entry funnel);
- guidepost and CCO tool frame funnels should be examined with respect to funnel post clearance and the angular tilt that could occur from that clearance (tilt angle of a CCO tool and the replacement component could swing into adjacent equipment if access clearance is too close);
- CCO tool access is typically vertical from above, but horizontal access is also acceptable (vertical access guidance framework needs to be open bottomed to allow settling debris to pass through);
- CCO tool landing points on the subsea equipment should be a minimum of 1,5 m (4,92 ft) above the clear local seabed for unhindered operation.

In certain geographic locations, care needs to be taken in establishing the seabed level owing to soft mud and the effect of ROV thrusters wash on the seabed.

An example of a guideline-deployed CCO tool interface is shown in Figures 24 to 28.

4.3.4 Tool skid intervention

4.3.4.1 General

The replacement of subsea components, such as control pods and chokes, can also be carried out by a ROV-mounted lifting and handling CCO tool. Generally, a tool-skid CCO tool is used for component installation or recovery tasks that demand isolated and controlled seabed operation without interference from intervention vessel motions. Often the component requires a lift capacity beyond that of a free-swimming ROV. Therefore the tool skid provides added buoyancy ballast or trim adjustment, or both, to that already on the ROV so that detrimental effects from load transfer do not upset the hydrodynamic characteristics of the ROV.

Another use for tool skid intervention is to provide added power (hydraulic, electric-augmented pressure, flow, volume capacity, etc.) that is beyond the standard complement on the ROV alone, for various intervention tasks such as hydraulic hot stab functioning of connectors, pressure testing, pressure wash cleaning, debris vacuuming, etc.

4.3.4.2 General considerations for tool skid operation

A tool skid is designed to attach to the front, rear or bottom of the ROV frame (see Figure 1). Alternatively, the tool skid may be attached to the tether maintenance system (garage) or deployed separately and integrated into the ROV at the seabed. The ROV then manoeuvres the tool skid around in free-swimming mode at the seabed. The mounting location of the tool skid should not impede the flow or bollard thrust of the ROV thrusters (horizontal and vertical).

Other considerations include the following:

- component replacement using a CCO tool skid requires that the tool skid feature some form of variable buoyancy system or fixed buoyancy and weight exchange system to maintain proper trim when the CCO tool skid is empty or holding the subsea component;
- a CCO tool skid frame needs to be designed to resist CCO tool pick-up loads, weight transfer loads, ROV and environmental loads, especially when there is added drag caused by the addition of the tool skid to the ROV's hydrodynamic profile;
- a CCO tool skid should accommodate the ROV vehicle frame, the ROV deployment system (winch and surface handling equipment), its tether maintenance system (or garage) and access to the component and access around the subsea equipment;
- CCO tool skid access is either vertical from above or horizontal from the side (vertical access guidance framework needs to be open bottomed to allow settling debris to pass through);
- CCO tool skid interface points on the subsea equipment should be a minimum of 1,5 m (4,92 ft) above the clear local seabed for unhindered operation [higher when the tool skid is bottom-mounted so that the tool skid is a minimum of 1,5 m (4,92 ft) above the clear local seabed level].

In certain geographic locations, care needs to be taken in establishing the seabed level owing to soft mud and the effect of ROV thrusters wash on the seabed.

4.3.5 Other component interventions

4.3.5.1 General

In addition to control modules and chokes, other components that may be considered for installation and replacement using a CCO tool include

- insert valves (manifold/pigging),
- valve actuator assemblies,
- pig launchers,
- hydraulic accumulator assemblies,
- insert multiphase meters,
- insert multiphase pumps,
- chemical injection modules/manifolds,
- debris covers and pressure caps, and
- tree or manifold sensors (pressure, temperature, sand, etc.).

Key considerations in determining suitable components for replacement are

- equipment location,
- water depth,
- frequency of replacement,

- component size,
- component weight.

4.3.5.2 Flowline and pipeline connection

Flowline, pipeline and jumper connections using ROV-deployed systems are becoming a more frequent occurrence. As yet, no common interface for flowline connection has been established.

The design of connection systems that can be operated by ROVs for subsea production equipment requires not only local modifications to the equipment but can impact upon fundamental areas such as field layout of components. Further reference to basic requirements for connection systems is addressed in Annex E.

4.3.5.3 Control jumper connection

A number of control system umbilical jumper (flying lead) connection systems exist that are deployed by ROVs. These systems are manipulator deployed, or deployed by a TDU or a CCO tool skid. The support plates for the electrical or hydraulic connections may vary, depending on the application and the number of individual couplers inside the interface. As yet, these connections are not regarded as readily developed as standards. However, the relationships and type of interfaces for deployment and connection of the jumper can be developed into a form that can be deployed by intervention tools of flowline connection tools, reducing the need to develop specific tools (see Figure 32 and Figure 33).

4.4 Subsea facilities system design

4.4.1 General

The primary consideration that impacts on the system design is access to the interface for the ROV and tooling. Depending on the intervention method and interface location, access requirements can vary significantly and therefore should be addressed early in the design and clearly recorded in the intervention philosophy. Other, secondary, system design considerations are covered in Clause 6, while the recommended process is shown in Figure 5.

The interfaces on the subsea production equipment described and set out in this part of ISO 13628 should be capable of being accessed by a ROV or an ROT in either manipulator or TDU mode. Specific differences to this general rule have been highlighted within this part of ISO 13628.

4.4.2 General design philosophy

ROV intervention should be accomplished in a reliable manner which minimizes potential damage to the subsea equipment, the intervention tooling, the ROV, operating personnel and the environment. It requires that the equipment be designed for effective execution of the intended purpose under the environmental operating conditions in which it is to work.

4.4.3 Fail free

Interfaces and their associated operating equipment shall be designed such that, in the event of a power failure to the ROV or intervention equipment, all devices which could attach the ROV to the subsea equipment are released in a reliable and effective manner, allowing the ROV to be retrieved to the surface.

4.4.4 Minimizing damage potential

The interface should be designed such that the potential for damage is minimized during the positioning, docking and operation of intervention equipment. The retrievable portion of the intervention interfaces, the part attached to the ROV, shall be designed to yield before damage occurs to the portion fixed to the subsea equipment.

4.4.5 Load reaction

The loads imposed on the interface by the intervention equipment shall be considered in the design. Generally, interfaces where the loads are reacted directly into the structure are preferred to designs where complex load paths through the equipment/structure are required.

4.4.6 Minimizing interference

Interfaces shall be designed to minimize potential entanglement with umbilicals or equipment lowering lines and with the intervention equipment.

4.4.7 Positioning control

In performing tasks on subsea equipment a positive means of stabilization shall be provided, obviating the need for the ROV or intervention tooling thrusters to be used for positioning control while physically in contact with the equipment. This does not preclude the use of a constant horizontal or vertical thrust to ensure interfaces remain in contact throughout the intervention operation.

4.4.8 Access requirements

4.4.8.1 General

There are three locations where interfaces can be positioned on subsea production equipment for ROV intervention tasks:

- externally located interfaces;
- external boundary penetration;
- internally located interfaces.

The required amount of access for manoeuvring the ROV to the interface depends on the location of the interface. Access required should be based on the height and width of the ROV plus the “elbow space” requirements of the multifunction manipulators and space for manoeuvres. The height and width of any ROV tooling packages or payload shall be taken into account in the design process. It is necessary to ensure a minimum clearance all around the vehicle to allow “flying” room. In areas where significant currents exist more space should be allowed. Additionally, the type and capabilities of the planned ROVs for intervention should be considered. Consideration shall be given to ensuring the safe recovery of a vehicle suffering power failure.

4.4.8.2 Externally located interfaces

Mounting the interfaces on the exterior boundary of the subsea production equipment minimizes ROV operations, access space requirements and the potential for damage to the equipment: it is the preferred location, and can be achieved by locating the equipment at the external boundary of the equipment or by use of extension rods to provide operation from the boundary position. However, this is not always achievable, owing to other requirements imposed by equipment arrangement or protection considerations, and it could be necessary for the ROV to manoeuvre inside the external face.

4.4.8.3 External boundary penetration

Penetration of the exterior face of the structure with the ROV tooling system to access the interface, while the ROV itself remains outside of the enclosed space, requires greater consideration of space requirements but may remove the need for extension rods for interface operation and additional mechanical protection for the ROV interface. This solution is practical where the penetration depths of the ROV tool are less than 1 m (3,28 ft). For penetration depths greater than 1 m, access requirements become more complex and may lead to design implications for the ROV, the associated tooling package or both. The ability to observe operations with the TV camera shall also be considered in the design.

4.4.8.4 Internally located interfaces

4.4.8.4.1 General

Generally, operating interfaces are located within 0,5 m (1,64 ft) of the protection face or external edge of the equipment. Where the interface is located deeper than 1,0 m (3,28 ft) inside a protection frame, or the external face of the equipment, access will be required to allow mating and operation of the ROV and tooling. With this approach the interface is generally located directly on the equipment, reducing the need for valve stem extensions or other remote mechanisms.

Internal operations are generally required where large protective structures are placed around and above a piece of subsea equipment. Generally, these protective structures limit access to equipment, but, by careful planning during the design phase, the impact on accessibility can be minimized. Items to be considered when providing internal access are discussed in 4.4.8.4.2 to 4.4.8.4.4.

4.4.8.4.2 Width of access

The width of any access to the interior of the subsea structure will be determined by the responses to the following four questions/factors.

- a) Will there be vertical access to the work site?
- b) If the ROV has to penetrate a horizontal distance greater than its length, the width should be large enough to allow the ROV to turn round, including adequate space for ROV umbilical.
- c) Will ROV selection be limited to ROVs which have reversible controls?
- d) It is essential that the access path allow the ROV and its tooling to be retrieved should power to the ROV be lost.

The minimum width of the corridor will either be the width for the largest ROV selected or based on the turning radius for the ROV or ROV/payload combination.

4.4.8.4.3 Height of access

The height of any access tunnel will be determined by

- a) the height of the vehicle,
- b) the minimum bending radius of the tether/umbilical and the resultant clearance required above the vehicle,
- c) the height of any payload/work package, and
- d) the essentiality of the access path allowing the ROV and its tooling to be retrieved should power to the ROV be lost.

A minimum clearance of 0,5 m (1,64 ft) should be left both above and below the total calculated height for "flying" clearance. This clearance should be increased for long tunnels.

There should be at least 1,0 m (3,28 ft) clearance behind the ROV to allow the pilot some freedom in performing the docking and alignment manoeuvres and to account for differing manipulator characteristics (see also Annex B).

An additional factor to be considered is the height of the docking location with respect to the minimum flying height, whereby, if the docking arrangement requires the ROV to be above the 0,5 m (1,64 ft) clearance over the bottom of the access route, the height of the access (at least locally) shall be increased accordingly.

4.4.8.4.4 Vertical access

Worksites with a vertical entry require additional ROV access space, dependent upon the depth to the site.

The vertical distance from the lowest point of the ROV frame to the site of the intervention (inspection, cleaning, tool interface, etc.) should not exceed 0,3 m (0,98 ft).

Recommended space requirements/vertical depth into structure are given in Table 1.

Table 1 — Recommended space requirements/vertical depth into structure

Vertical depth into structure m (ft)	ROV size + allowance
$\leq 1,0$ (3,28)	5 %
$\leq 2,0$ (6,56)	10 %
$\geq 3,0$ (9,84)	20 %

5 Design performance

5.1 General

Interface designs should meet the requirements of the subsea facilities of which they form an integral part. Suitable verification should be undertaken that ensures the interface is capable of operations throughout the design life.

5.2 Materials

Interface designs shall be capable of functioning with appropriate materials in accordance with Clause 10.

Choosing materials is the ultimate responsibility of the operator-user, however the operator-user may specify the service conditions, leaving the supplier free to recommend a fit-for-purpose solution.

5.3 Load capability

Interfaces shall be capable of withstanding design loads without deformation or inhibiting of safe operation for field life. Suitable verification should be undertaken to ensure the interface is capable of operations throughout the design life.

5.4 Operating force or torque

Interfaces shall be designed to operate within the equipment manufacturer's force and torque specification or as specified in this part of ISO 13628.

5.5 Lifting devices

Lifting devices shall meet local legislation where applicable or documented industry practice.

5.6 Quality control

5.6.1 General

The quality control requirements for equipment specified in this part of ISO 13628 shall conform to ISO 10423 as appropriate.

For components not covered in ISO 10423 specific quality control requirements shall comply with the manufacturer's written specifications.

5.6.2 Structural components

Quality control and testing of welds on structural components shall be as specified for "non-pressure containing" welds in accordance with ISO 10423.

5.7 Temperature ratings

Subsea equipment covered by this part of ISO 13628 shall be designed and rated to operate throughout a temperature range of $-15\text{ }^{\circ}\text{C}$ to $45\text{ }^{\circ}\text{C}$ ($5\text{ }^{\circ}\text{F}$ to $113\text{ }^{\circ}\text{F}$), designated as such to suit surface testing of equipment.

5.8 Colours and marking

Underwater visibility is a prime consideration when selecting colours and marking systems. See ISO 13628-1.

6 Design considerations

6.1 General

Given that the established intervention philosophy is simplicity and reliability of the interface on the subsea production equipment, the following guidance outlines those features of the system which should be considered at the design stage.

6.2 Conceptual design

6.2.1 Assessment of requirements

Prior to finalizing the subsea production equipment design, all the operational tasks required for installing, operating, inspecting, maintaining, repairing and recovering elements of the subsea production system should be identified and assessed.

This activity typically takes the following factors into consideration:

- a) the need for ROV operation/task, and if it can be avoided;
- b) the frequency of the operation/task (e.g. an installation aid versus an operating valve);
- c) the sensitivity of the operation (e.g. critical/highly desirable/helpful);
- d) abandonment;
- e) ROV access requirements;
- f) the expected field life of the overall subsea system.

6.2.2 Failure mode effect and criticality analysis (FMECA)

It is recommended that an FMECA of the system installation be carried out. The FMECA should consider all phases of the system's lifetime, including installation and recovery. It should also determine the relative criticality of the subsystems/components, based on the effect of a failure and the expected MTBF.

6.2.3 Method of intervention

Examine the method of solving the identified tasks using ROV-based systems, ROT systems, a combination of both, or all these. By classifying the subsea intervention requirements/applications, the alternative means of conducting the intervention can be evaluated and the most appropriate method selected for simplification and ease of execution.

6.2.4 Frequent intervention

Frequent intervention will depend upon many factors but is driven by the need to replace components due to their reliability or performance and frequency of adjustment or actuation.

If a case is made for frequent intervention, the selection of interfaces should be based on simplicity, with due consideration for reusability.

6.2.5 Standard tooling

Where there are large numbers of items for which intervention could be conducted by a similar method, a standard tool should be considered, thus avoiding frequent tool change-outs.

6.2.6 Loading

6.2.6.1 General

The design considerations shall address the various loading conditions that ROV operations impart during subsea operations. These loads may act individually or concurrently and need to be considered during the design phase.

Loads are applied to the ROV and equipment interface by

- a) tooling engagement and reaction,
- b) environmental forces (current and, in exceptional circumstances, waves),
- c) umbilical loadings due to wave and current action,
- d) umbilical loadings due to surface vessel drift-off or incorrect umbilical winch operations, and
- e) impact due to collision between ROV and subsea facilities.

6.2.6.2 Design for loading

The following various approaches to interface loading design are available:

- a) design of the interface to accommodate all the loads imposed by the above load conditions;
- b) limiting of the forces that can be applied to the interface (e.g. allowing the ROV umbilical winch to pay out under load or limiting maximum ROV thruster forces);
- c) accepting that damage will occur under certain load regimes.

The combination of loads shall be considered and the maximum combined load shall be assessed; it might not be necessary to design the interfaces to accommodate the maximum sum of all loads.

6.2.6.3 Tooling forces

ROV tooling forces shall be limited so that under normal operation they cannot damage the equipment tool interface being operated. Where provision is provided on the tool to permit "overload" forces to be applied, there shall be a mechanism other than operational procedures to prevent this (e.g. simple cover over operating switches, function interlocks or software control).

6.2.6.4 Currents

Currents act on both the umbilical and the vehicle, and their potential impact, which includes the following, should be considered:

- a) drag force on umbilicals, thus affecting ROV manoeuvrability in the areas of intervention;
- b) drag forces on ROVs carrying equipment or equipped with TDU or tooling packages;
- c) drag forces on ROVs when assisting in ROT manipulations or positioning operations;
- d) current affecting visibility during near-seabed operations.

Adequate clearance in the areas of intervention should be provided, keeping in mind the type of umbilical deployment system, to prevent the umbilical from snagging on the subsea structures or equipment.

6.2.6.5 Collision

Unprotected subsea facilities and components which may be hit by a free-swimming ROV should be designed to resist collision damage when the vehicle (typically a vehicle with associated entrained water) is travelling at 1,5 m/s (3,64 ft/s). However, this impact velocity may be reduced if the ROV is manoeuvring within a structure or is about to dock.

6.3 Detailed design

Following the assessment of the requirements for ROV intervention (see 6.2.1), an intervention philosophy for the subsea system should be established in order to reduce the number of different ROV techniques and interfaces required. The basic steps in the design process are as follows:

- a) definition of tasks;
- b) compilation of specification for interfaces, generally in association with the relevant ROV contractor and subsea equipment supplier;
- c) choice of docking and tool deployment or manipulator philosophies;
- d) definition of intervention interfaces (at this point the intervention interfaces should be identified, addressed and specified at system, sub-system and component level and, once specified, their use and incorporation in the design rigorously monitored throughout the construction and installation phases);
- e) definition of the host subsea facility detail design for ROV interfaces for tool operation;
- f) definition of the ROV tools, interfaces, power supply and controls;
- g) documentation (design, maintenance and operating philosophies);
- h) final design stage with periodic reviews of the design for compliance with the recommendations and guidelines contained herein;