INTERNATIONAL STANDARD

ISO 13628-8

First edition
2002-12-15

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

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

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

Reference number
ISO 13628-8:2002(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13628-8 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical 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 umbilicals*

— *Part 6: Subsea production control systems*

— *Part 7: Completion/workover 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 a revision, major amendment and expansion of Annex C of API[1)] 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 (ROTs), 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.

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

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

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;

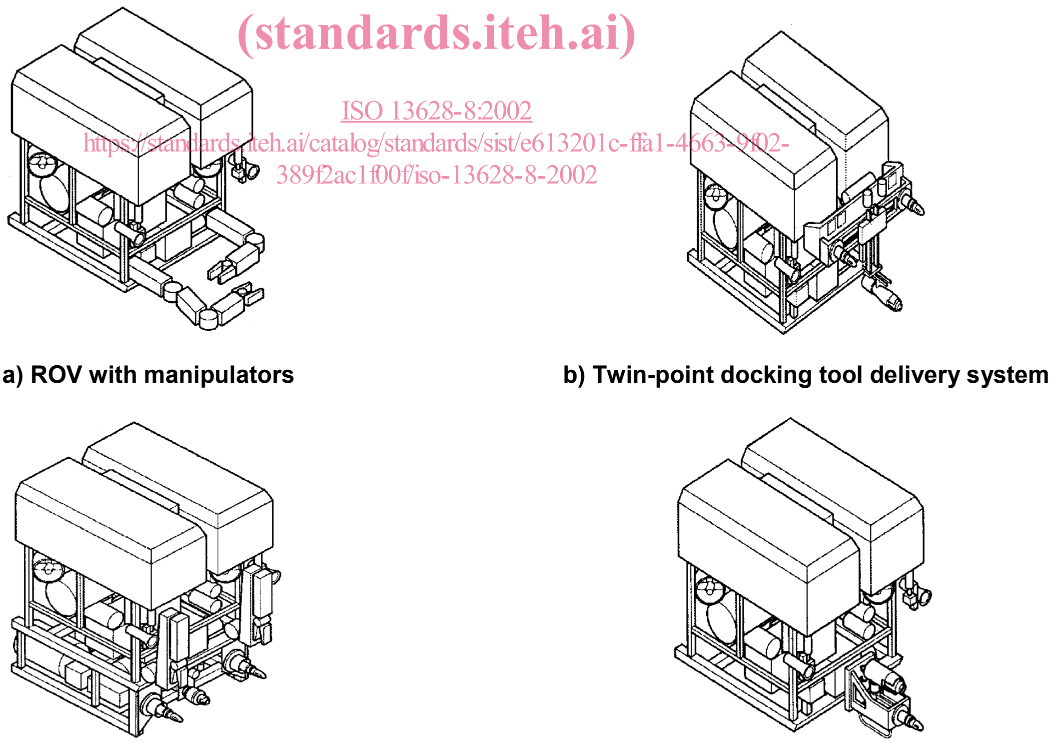
— with a manipulator-held tool;

— 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.

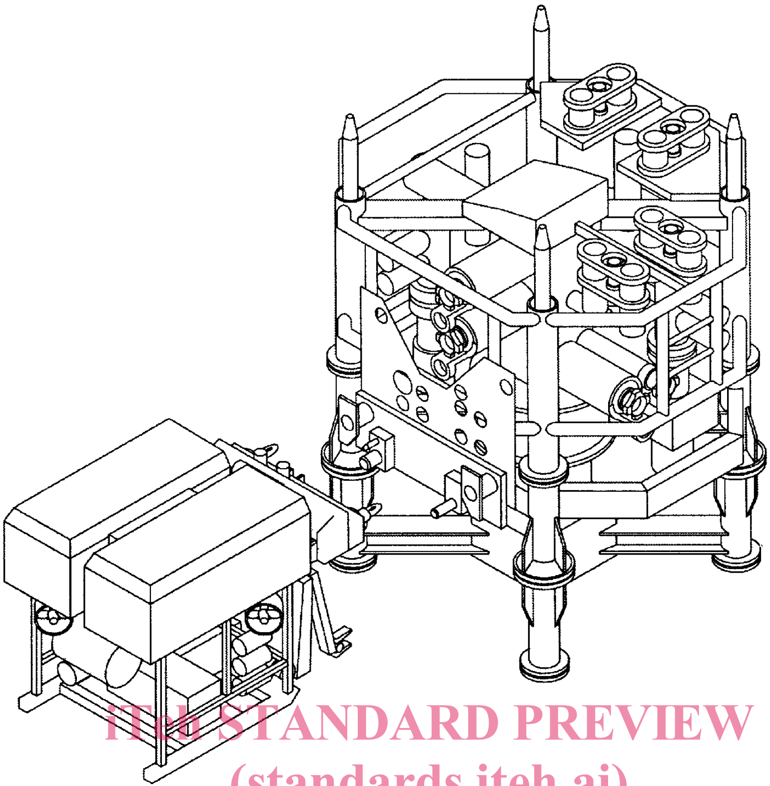


Figure 2 — Interfaces on typical tree

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.

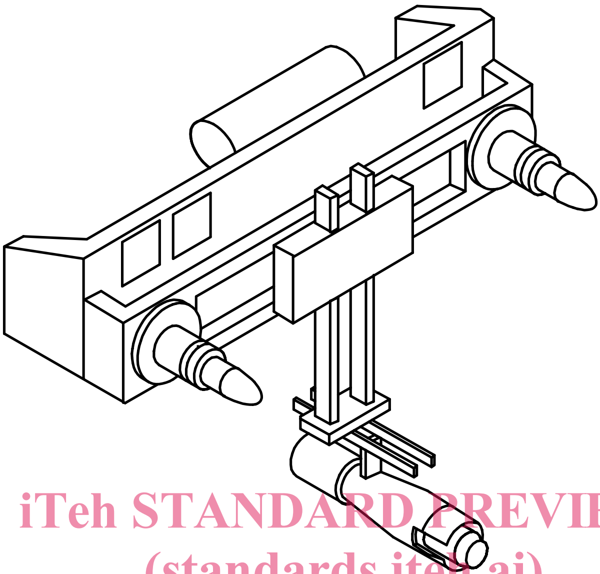


Figure 3 — Twin-point docking TDU

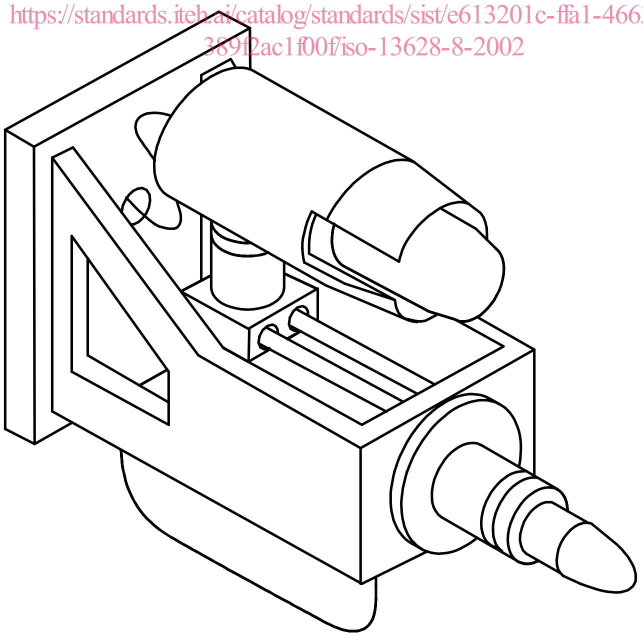


Figure 4 — Single-point docking TDU

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 ± 180° 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, ± 45°, 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,