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

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

The European Standard EN ISO 13628-8:2006 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 13628-8:2006. It is identical with ISO 13628-8:2002.

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A list of organizations represented on PSE/17/-/4 can be obtained on request to its secretary.

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 13628-8

December 2006

ICS 75.180.10

English Version

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)

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)

Erdöl- und Erdgasindustrie - Konstruktion und Betrieb von Unterwasser-Produktionssystemen - Teil 8: Schnittstellen ferngelenkter Fahrzeuge (ROV) mit 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of an identical text or by endorsement, at the latest by June 2007, and conflicting national standards shall be withdrawn at the latest by June 2007.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.

INTERNATIONAL STANDARD

ISO 13628-8

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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

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ISO 13628-8:2002(E)

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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.

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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 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 (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;

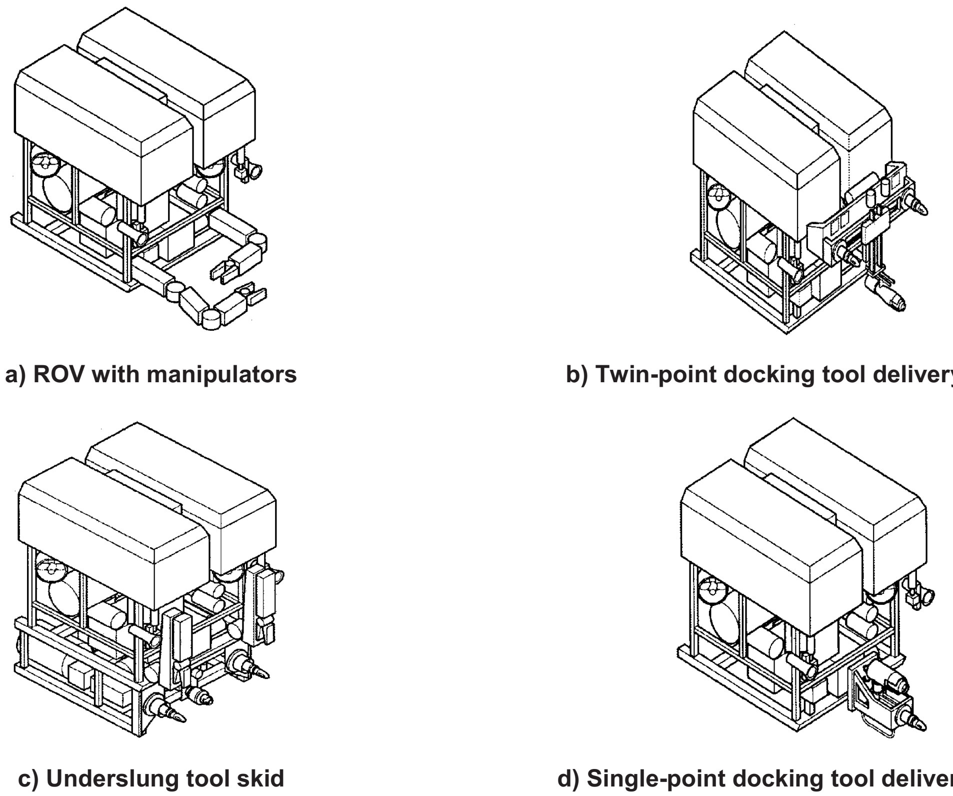
— with a manipulator-held tool;

— 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.

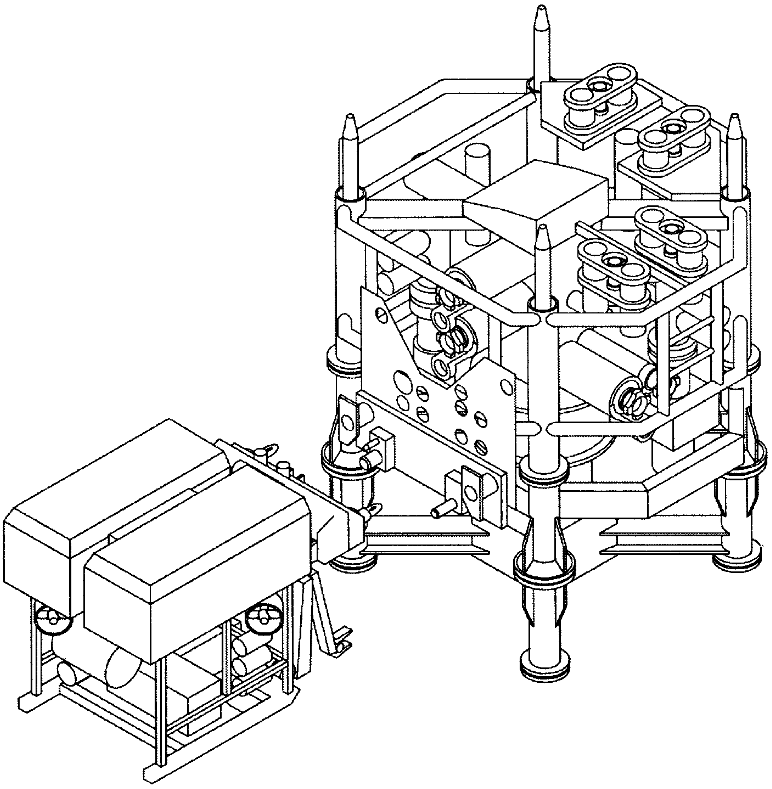


Figure 2 — Interfaces on typical tree

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.

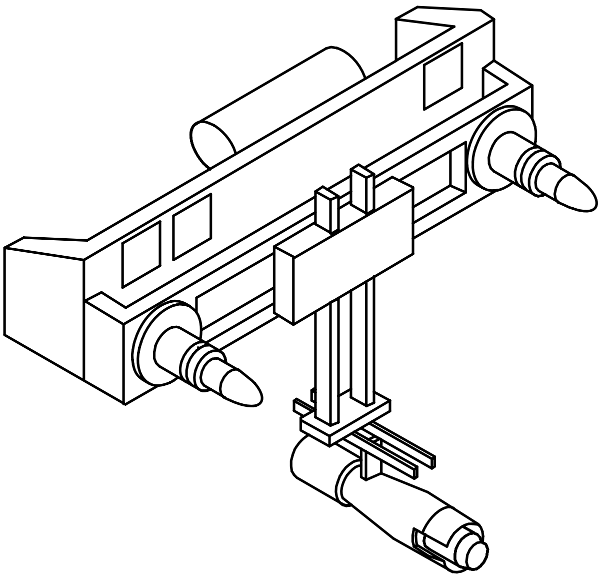


Figure 3 — Twin-point docking TDU

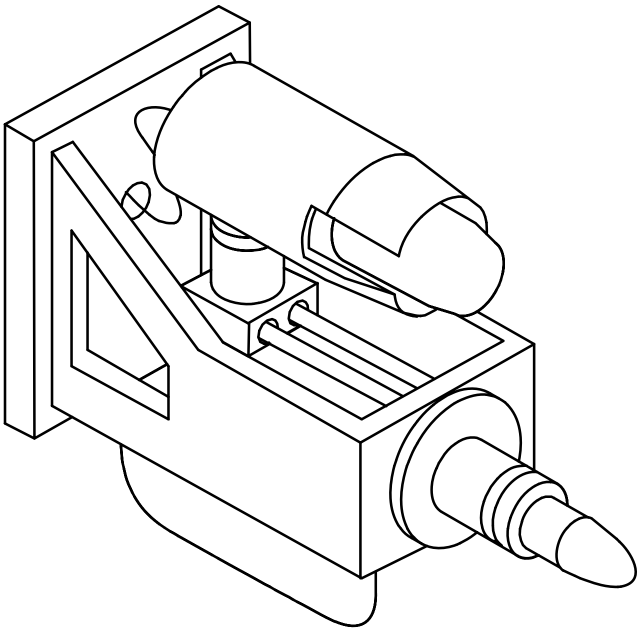


Figure 4 — Single-point docking TDU

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,

— 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 t) 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
⩽ 1,0 (3,28)	5 %
⩽ 2,0 (6,56)	10 %
⩾ 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 °C to 45 °C (5 °F to 113 °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;

i) ensuring sub-system suppliers are considering ROV operation and intervention in their design and that such operation/intervention requirements and techniques are in accordance with the overall design philosophy for the subsea installation and this part of ISO 13628.

Effort in the design phase will be required on those areas of the subsea system that are the most susceptible to failure. Those assemblies should be thoroughly examined and designed for simplicity, durability and redundancy or ease of replacement.

Within the range of normal manned diving operations the subsea production system operation using the ROV interfaces should be capable of being operated by divers, either manually or with tooling.

During the design phase of the subsea production equipment consideration should be given to the running and positioning of control lines/cables, particularly if these items are to be site run during the construction phase, in order to ensure avoidance of interference with ROV operations. The recommended practice is that flexible hoses/lines are not run. Rigid lines should be run and protected so as to prevent damage to the lines and avoid interference with ROV operations. Flying leads for control systems such as “fly-to-place” [see 7 h) 3)] jumpers, etc. are not included in this recommendation. Figure 5 shows a typical design process.

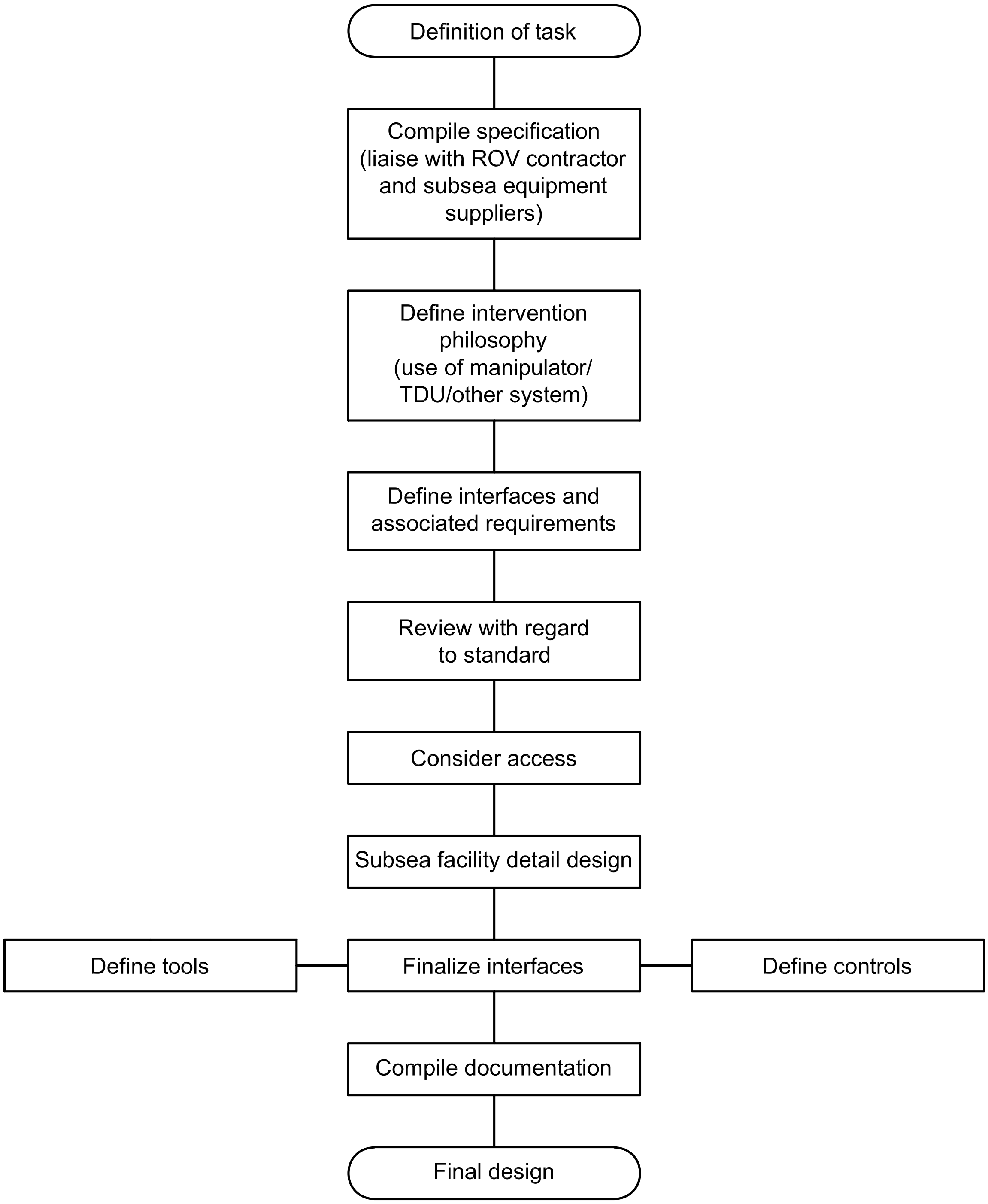


Figure 5 — General design process for ROV tooling interface

6.4 Desired design features

6.4.1 Visual aids

Visual aids are essential and should provide for the following:

a) the location (i.e. where on the structure the ROV currently is);

b) the angle of viewing (i.e. where possible, the aid should move across the field of vision, not forward/aft, but where not possible it is preferable to use an indicator which comes flush with a contrasting background at either end of its travel);

c) the status of the valve or equipment under observation or operation (for valves, for example, the status indicator should provide for clear, unambiguous indication of the number of turns or distance travelled as appropriate);

d) scale (i.e. visual aid should define open, closed and fractions thereof in respect of any component);

e) identification of component type.

Visual aids can be labels, painted signs or simple indicators of operational status.

See also ISO 13628-1.

6.4.2 Colour recommendation

See ISO 13628-1.

6.4.3 Anti-fouling recommendations

As any object placed in the sea will eventually become fouled with marine growth or sedimentation or both, it is the designer's responsibility to ensure that the visual aids are designed so that they remain readable during their specified lifetime (see ISO 13628-1).

Hydraulic connectors, ROV interfaces and other items with sensitive surfaces, and which may require operation at any time over the subsea installation's lifetime, should be equipped with anti-fouling covers in conjunction with the use of anti-fouling materials, paint or coatings. This is to inhibit marine growth or sedimentation from preventing connection or operation when the system is required.

Protection should be in the form of caps, plugs, etc. that do not incorporate a watertight seal. This is because such a seal placed at the interface on the surface, prior to the structure being installed, could form a pressure seal impossible to break when required. Where a watertight seal is required, an appropriate, incompressible fluid shall fill any “internal” void and a means of breaking the seal should be incorporated in the plug design. If plastic is to be used particular care should be taken over the dimensional stability of the material.

Interfaces requiring mechanical protection should have a storage position for the protection device adjacent to the interface, but not in a position to foul operations.

6.4.4 Parking locations

Where the ROV is to monitor a particular location for a long period of time it is desirable to have a docking position, grab bar or a platform on which the ROV can sit. This is to ensure a constant viewing position, and in the case of a platform it is easier for the ROV to maintain position by thrusting down against the platform than in free-flying mode.

6.4.5 Guidance

Where ROV tooling is to be deployed by manipulator, guide cones may be sited around the point where a tool or docking system is to be inserted. Guide cones that face upwards should be open-ended, allowing debris to fall through, or equipped with a suitable debris cap.

6.4.6 Guideposts

All guideposts on the structure should not excessively protrude above the running funnel of the finally installed item as they are an obstruction to ROV inspection as well as an object for umbilical entanglement. Subframes that are not recoverable and have guideposts should have removable guideposts.

6.4.7 Observation tasks

"Open frame" designs make observation tasks easier for ROV operations.

6.4.8 Structure orientation

The orientation of the subsea structure should consider all environmental parameters and the ease of subsequent ROV operations. There is no one optimal structure orientation for maximum ROV availability: any potential orientation requirements should be assessed on a case-by-case basis. Consideration should be given to

a) field layout requirements,

b) currents (see also 6.2.6.4), and

c) visibility.

6.4.9 Valve stem protection against excess torquing

Valve stem protection can be provided by

a) visual identification of maximum safe torque;

b) defining the relationship between breakout torque, running torque and damage torque;

c) prudent operational practice, such as

   1) appropriate hydraulic motor selection within the ROV,

   2) ROV hydraulic pressure release, to avoid potential of over-torque, and

   3) surface calibration of the ROV tooling torque prior to operation;

d) for ball valve operations, a positive mechanical stop (this should be provided), without the valve internals, and

e) using appropriate end-effecter shapes (see Annex D).

6.5 Undesirable design features

6.5.1 Snagging

Efforts should be made to avoid features that will snag ROV tether/umbilical, fishing equipment, installation or operational lines, etc.

EXAMPLE "Goal post" type anodes, transponder brackets, loose hoses/wires, mini guide posts, indicator rods or gaps within protection structures that may cause tether/umbilical traps.

Sharp edged items should be avoided. Any such items which are redundant should be removed prior to the installation of the structure.

EXAMPLE Unnecessary padeyes, scaffolding brackets or construction support frameworks.

6.5.2 Valves

A 12 mm (0,5 in) valve is the minimum size for safe, direct operation by most manipulators.

6.5.3 Levers

Generally designers should take into consideration the potential difficulties involved with sliding operational tasks (e.g. pushing a lever up, down or along). Because of the orientation of the mechanical linkage of the manipulators and their control systems it is at present difficult for ROVs to operate sliding lever handles where the operation is in a vertical (up/down) or horizontal (push/pull) orientation. Operation of the slide/lever type from the side (left/right) is possible, providing there is room for the manipulator to be inserted to the left or right of the handle.

It is acknowledged that as manipulator technology progresses the ability for “Cartesian” and “trajectory” operations could be included in the range of movements and designers should be aware of the potential.

6.5.4 Fittings

Avoid quick-connect fittings requiring the pulling back of the retaining ring at the same time as pushing the fitting onto the connector, the reason being that a single manipulator does not have the dexterity in its claw to perform both operations at the same time. However, there are several connectors that do not require the retaining ring to be pulled back to make the connection (i.e. push on).

6.5.5 Hidden indicators

Indicators shall be visible from the location where the work is to be performed.

6.5.6 Operating heights

Operations from the same location but requiring differing distances from the structure while being performed at different heights should be avoided.

Items required to be operated or inspected should not be placed near the mud-line: all such items should be at least 1,5 m (4,92 ft) above the mudline. This is to ensure vehicle access to the interface and the docking location. In cases where there is no discernible mudline the designer shall take into account access, visibility and the effect of the ROV thrusters on the bottom conditions when determining minimum heights for interfaces. The height of interface therefore should be 1,5 m (4,92 ft) above the effective local seabed, including build-up of drill cuttings.

See also Annex B.

7 ROV interfaces and subsea systems

The ROV interfaces with many of the elements of a subsea system. This clause lists the key elements that should therefore be considered during the design of the system.

Each of the following alphabetical list items should be read in conjunction with the appropriate standard.

Subsea equipment should be designed in accordance with this International Standard.

Specifically the design should take account of the following.

a) **Subsea trees:**

   IMPORTANT — The subsea tree should be interfaced with its appropriate tooling during an acceptance test, or similar, prior to being prepared for installation.

   1) access for the ROV, including nominated viewing positions if tree equipment is blocked by structure;

   2) selection of the correct intervention system;

   3) load constraints from ROV in operational mode;

4) tree design should minimize the potential for snagging;

5) clear and unique identification marking;

6) consider grouping of valving on a single face;

7) height of interfaces above mud-line;

8) establish if load reaction points are required for ROV operations and design as appropriate;

9) ROV overrides.

b) **Manifolds:**

1) access for the ROV including nominated viewing positions if equipment is blocked by structure;

2) selection of the correct intervention system;

3) load constraints from ROV in operational mode;

4) manifold design should minimize the potential for snagging;

5) clear and unique identification marking;

6) height of interfaces above mud-line;

7) establish if load reaction points are required for ROV operations and design as appropriate.

c) **Subsea valves for manifolds or trees:**

IMPORTANT — During valve integration and acceptance tests the ROV interface should also be formally verified by jig or tooling.

1) access for the ROV;

2) selection of the correct intervention system;

3) torque requirement, breakout and operating should be within one hydraulic motor range;

4) load constraints from ROV in operational mode;

5) visible and robust indication system;

6) manual ROV override capability;

7) seal test hot stab and associated valves location.

d) **Subsea chokes** (ROT techniques may also be considered for this application)**:**

1) potential for choke to be changed out;

2) practicability for change-out, which may influence the intervention system selected;

3) access for change-out tooling;

4) size and weight of module and the capacity of the change-out tooling;

5) angle that the choke sits for ease of recovery (normally vertical or horizontal);

6) manual handling on vessel/rig post recovery in a safe manner;

7) light ROV installed debris covers for choke receptacles during change-out operations;

8) seal test facilities require optimization if multiple seals are involved;

9) protection caps for exposed hubs.

e) **Control modules** (ROT techniques may also be considered for this application)**:**

1) potential for module to be changed out;
2) practicability for change-out, which may influence the intervention system selected;
3) access for change-out tooling;
4) size and weight of module and the capacity of the change-out tooling;
5) angle that the module sits for ease of recovery (normally vertical);
6) manual handling on vessel/rig post recovery in a safe manner;
7) connector point for ROV diagnostics check, or ROV observed status display;
8) camera access to all connectors;
9) identification of vent ports as appropriate;
10) ROV cleaning tool access;
11) coupler/connector protection during module change-out.

f) **Multiphase meters** (ROT techniques may also be considered for this application)**:**

1) potential for meter to be changed out;
2) practicability for change-out, which may influence the intervention system selected;
3) access for change-out tooling;
4) size and weight of meter module and the capacity of the change-out tooling;
5) angle that the module sits for ease of recovery (normally vertical);
6) manual handling on vessel/rig post recovery in a safe manner;
7) seal test facilities require optimisation if multiple seals are involved;
8) connection point for ROV diagnostics check or ROV observed status display;
9) protection caps for exposed hubs.

g) **HIPPS** (ROT techniques may also be considered for this application)**:**

1) potential for HIPPS modules to be changed out;
2) practicability for change-out, which may influence the intervention system selected;
3) access for change-out tooling;
4) size and weight of module and the capacity of the change-out tooling;
5) angle that the module sits for ease of recovery (normally vertical);
6) manual handling on vessel/rig post recovery in a safe manner;
7) seal test facilities require optimisation if multiple seals involved;
8) ROV override;
9) protection caps for exposed hubs.

h) **Umbilical jumpers:**

IMPORTANT — Umbilical jumpers are normally of relatively short lengths installed at the time of the major equipment installation tie-in, it is therefore important that the major equipment installation procedure and the umbilical tie-in procedure be in accord.

1) stiffness of jumpers;

2) bend radius of umbilicals, which may result in the umbilical being unable to be connected;

3) weight of jumper end and the capacity of the ROV to manoeuvre the jumper safely to point of installation, this jumper installation method is known as “fly-to-place”;

4) end of connections to be verified for correct installation;

5) in very stiff umbilicals it may be necessary to consider the need for single hoses to be installed (flying leads);

6) relative position of jumper tie-in point with respect to the mud-line as it is effected by the bend radius of the umbilical from tie-in point to seabed for ease of installation;

7) parking porches may be required;

8) electrical and hydraulic connectors should be accessible for cleaning and operability.

8 Operational considerations

When developing the design philosophy for the intervention interfaces, the designer should consider the type of tasks involved. In general, for component replacement or where lifting operations are required, vertical access should be provided. For valve operation, the making up of hot stabs or electrical connections and other types of light work, horizontal access is preferred where possible. Tools designed specifically for the operations involved should be used, where the ROV can dock onto the interface and be held firmly in place while the task is being performed. In designing the interface, care should be taken to avoid the necessity for rigid design requiring complicated tooling.

Any ROV manipulator or tooling operation that requires the pilot to actively control the ROV during performance of the task should be avoided. ROVs are often used to guide objects suspended from the surface, or the object is carried by the ROV or deployed to the seabed location for pick-up by the ROV.

9 Indicator systems

Remote interface operation often requires supplementation by a visual means to the ROV operator. This visual indication can be achieved by several means, but it the indication system should conform to the following.

All valve, connector elevation and position indicators on individual modules or components involving ROV interfaces should have visual indicators. The visual indicators should be designed such that they are

a) self-explanatory, giving the operator a clear indisputable indication of the equipment status,

b) sited to be observable during relevant operations,

c) easily read from different angles with standard ROV camera systems,

d) easily read from at least 0,5 m (1,64 ft) in normal visibility,

e) substantial and robust enough to last for the design life of the subsea component/equipment,

f) protected from mechanical damage, and,

g) where appropriate, capable of counting functions.

10 Material selection

10.1 General

The material of which the interface is manufactured shall be fully specified by the designer with responsibility for making the material selection. Generally, the ROV-related interfaces and tools should be designed with materials suitable for frequent use in water. The designer shall clearly differentiate between permanent subsea equipment and equipment used for a short time during intervention operations. Permanent subsea equipment shall be designed in accordance with the appropriate part of ISO 13628. Interfaces should cater for

a) yield stress,

b) ultimate tensile strength,

c) fatigue properties,

d) internal wear of the interface if it is to be frequently used,

e) corrosion, and

f) marine fouling.

10.2 Selection criteria

Key factors to be considered when selecting a material for construction of the interface assembly include the following:

— the interface mounted on the subsea production system should exhibit greater inherent strength than the interface carried by the ROV/ROT, such that in the event of a mishap during operations the interface cannot be damaged or made inoperable;

— the interface should be designed to operate correctly throughout the entire period of submersion, and should broadly equate to the design life of the equipment to which it is attached;

— corrosion-resistant materials, suitable coatings and cathodic protection systems to prevent corrosion should be used. Intervention equipment, used only a limited number of times throughout the life of the subsea production system may be designed to use materials suitable only for intermittent immersion in seawater;

— the method of mounting the interface assembly to the subsea structure should be given adequate consideration by the design engineer, to ensure that the interface remains secure during the interface operation.

11 Documentation

11.1 General

The implementation and maintenance of accurate records can prove an invaluable aid for future operational reference and system designs.

The areas where such records typically apply are

a) subsea equipment design phase (defines the interfaces and tooling),

b) testing phase (dry or tank testing of operation),

c) installation phase (determines design effectiveness), and

d) field lifetime maintenance (enables future requirements to be predicted more accurately).

11.2 Equipment design

It is important to record information pertaining to all relevant subsea intervention tasks, interface specification and tooling requirements at an early stage of project work. If an intervention philosophy is drafted at the project commencement and subsequently amended throughout the detailed design, significant risks of costly equipment modification or changes in specification can be avoided.

Intervention philosophies vary between developments but should be employed as the focus of reference for the ensuing interface, tooling and ROV capability definitions.

An outcome of the design process should also be to define the scope of

a) onshore testing, requirements, test equipment, jigs and procedures (and observations),

b) qualification tests where new tooling is necessary, and

c) the frequency of intervention.

11.3 Testing

Once interfaces have been selected and during the period of fabrication when interfaces are being incorporated onto the subsea equipment a set of simple trials or FATs should be carried out. In addition to demonstrating that the field equipment is fit for purpose, the records from the trials can be used to provide the foundations for determining the performance of the equipment once installed and then on through its working life. Whilst certain aspects of the information recorded will be intervention-specific, others (e.g. time of operation) allow comparisons to be made between different types of interface and tooling (e.g. manipulator/ROV tooling/diver) for future reference.

11.4 Information feedback

The information gained during installation provides the first details of the equipment performance in its operating environment. The information recorded during the operational life of the field can and should be fed back into the design process.

12 ROV interfaces

12.1 General

This clause considers individual interfaces and their respective function, identifies the key required attributes and provides the detail necessary to allow fabrication. When selecting an interface, reference should be made to the preceding clauses of this part of ISO 13628.

12.2 Stabilization

12.2.1 General

A ROV is required to be stable during the carrying out of tasks, whether those tasks are manipulator or dedicated tooling tasks. This stabilization is achieved in a number of ways, including

a) working platforms,

b) suction cups or feet,

c) grasping, and

d) docking.

12.2.2 Working platforms

12.2.2.1 Function

If the task to be performed requires vertical or both vertical and horizontal access the incorporation of a working platform into the subsea structure could be the best solution.

12.2.2.2 Application

Working platforms can be formed by utilizing part of the subsea structure, such as protection covers, or specifically as a purpose-built platform.

12.2.2.3 Design

Platforms can be constructed of grating or may be of bar construction of sufficient area to support the ROV. Platforms for ROV use should be flush and free from obstruction.

12.2.3 Suction cups or feet

12.2.3.1 Function

Suction cups or feet consist of an arm attached to the ROV with a suction cup on the end in contact with the structure that is activated by the ROV, in order for the vehicle to maintain its position relative to the interface.

12.2.3.2 Application

Suction cups or feet are normally used when carrying out manipulative operations, such as cleaning, inspection or operating individual valves.

12.2.3.3 Design

The interface requirement of the subsea structure is a flat surface broadly adjacent to the task area for the suction cup. Suction cups are provided as part of the ROV spread.

12.2.4 Grasping

12.2.4.1 Function

To provide a standard interface for an intervention system for station keeping during the execution of tasks. Grasping may be by ROV manipulator arm with parallel or pincer jaw or a TDU configured similarly.

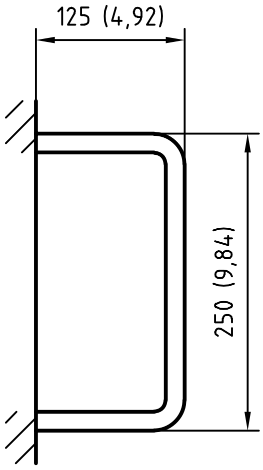
12.2.4.2 Application

An interface should be provided on all items of subsea production hardware (see also 12.2.4.4.) to allow ROV stabilization during operations based upon grasping.

12.2.4.3 Design

A grasping handle shall be as shown in Figure 6.

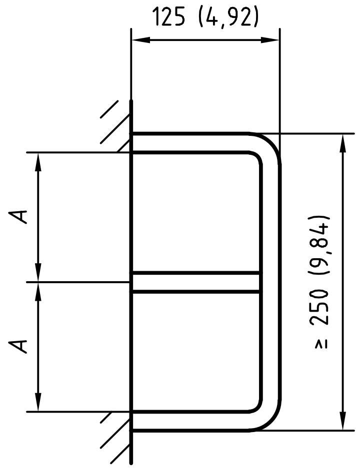
Dimensions in millimetres (inches)



Bar diameter = 20 mm (0,75 in)

Tensile strength = 450 N/mm^2 (65 kip/in^2)

a) Type A



Bar diameter = 51 mm (2 in) or 20 mm (0,75 in)

Tensile strength = 450 N/mm^2 (65 kip/in^2)

b) Type B

Figure 6 — Grasping handle for stabilization

Grasping intervention interfaces shall be designed to withstand a minimum force of 2,2 kN (500 lbf) applied from any direction and a gripping force of 2,2 kN (500 lbf) applied from any direction. The method of attachment is optional.

12.2.4.4 Operation

Grasping handles can be used in place of or, as normal, complementarily, to a docking interface. The handles can also be designed as bumper bars to provide protection to the interface panel.

12.2.5 Docking

12.2.5.1 Function

This standard interface provides an intervention system for station keeping and firmly attaches a ROV to an underwater structure in order to prevent ROV movement during the execution of tasks and provide a positive location for repeatability of tasks. The docking receptacle profile is shown in Figure 7.

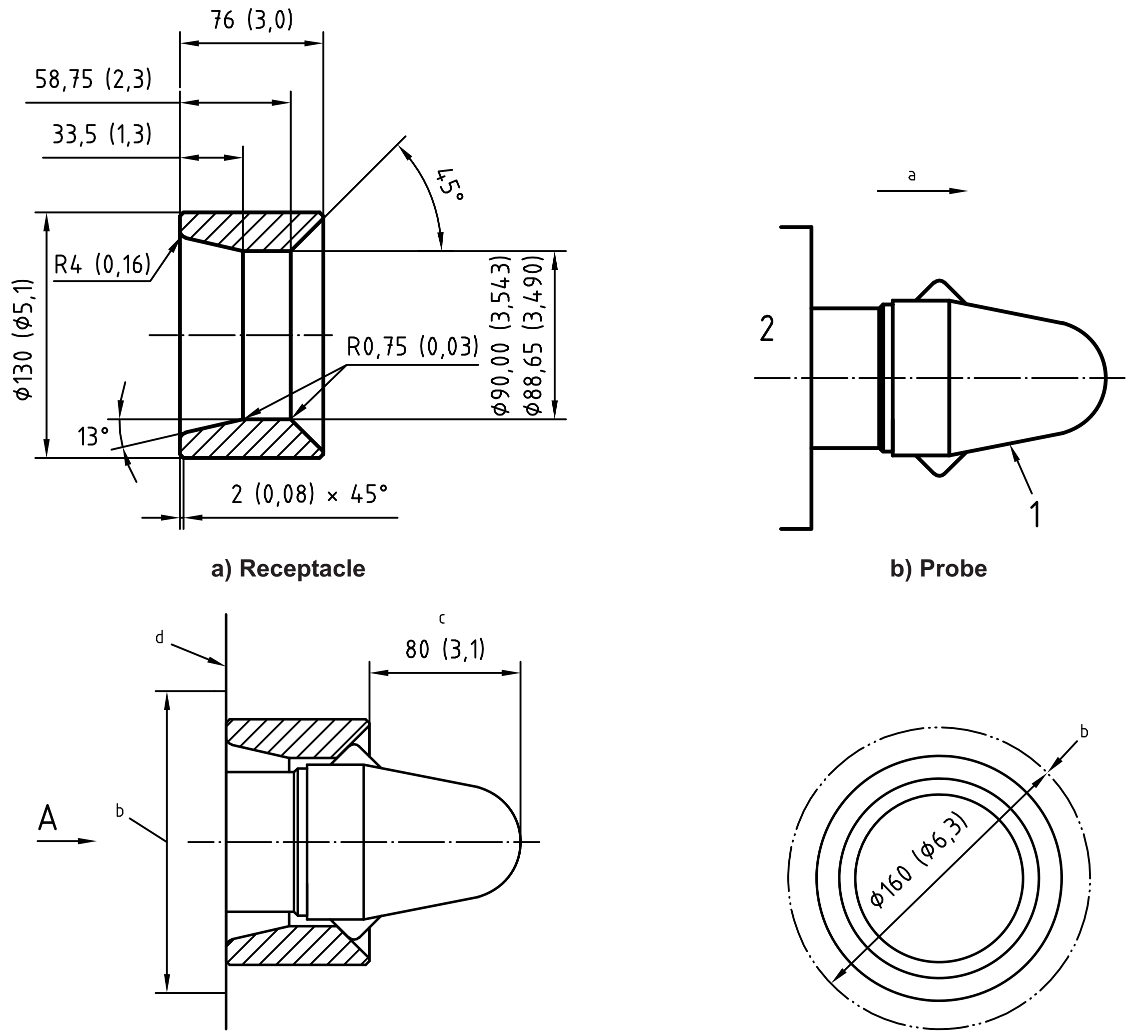
12.2.5.2 Application

Docking is to be used where the loading of the subsea equipment interface is not desirable, as in the case of the operation of needle valves or hot stabs, where heavier loads are being handled, as is the case of a jumper stab plate connection, or where many interfaces are close together, as in a panel.

Generally positive docking is used where the tooling configuration is to be operated by a single-or twin-docking TDU, but is also used to provide positive stabilization during manipulator operations. A docking receptacle is used in conjunction with a docking probe mounted on the ROV. The docking probe is typically a hydraulically operated device with fail-safe release and overload limitation features.

The docking receptacles are incorporated into the structure of the subsea equipment, and may be positioned with either a horizontal or vertical axis. The receptacle can be a separate bolted or weld-in unit, or can be incorporated as part of the subsea equipment.

Dimensions in millimetres (inches)



a) Receptacle **b) Probe**

c) Clearance **d) View on A arrow**

Key

1 docking probe

2 ROV tooling

a Direction of docking.

b Area to be free of obstruction.

c Clearance for probe.

d Docking face.

Figure 7 — Docking probe and receptacle

Docking receptacles may be used singly, in pairs or in other combinations, allowing the ROV to dock and deploy tooling in configurations to suit particular applications. Figure 9 shows a vertical face twin probe docking layout complete with recommended positional tolerances. This layout is representative of those used for valve operation or override on subsea trees. The tooling envelope shown illustrates a standard area into which tooling interfaces may be fitted, in order to be reached by the tooling system or manipulator arm.

12.2.5.3 Design

The docking receptacle shown in Figure 7 consists of a simple tubular with a front entry angle and rear locking profile.

When incorporating a docking receptacle into a subsea structure it is recommended that as a minimum the support structure be designed to withstand the forces and moments shown in Figure 8. These values are based upon a typical work class ROV docking and docked to the receptacle, using the parameters given in Table 2.

For any designed system the engineer should assess the specific requirements and adjust the values as necessary. Figure 7 shows minimum areas around the receptacles which are to be kept clear in order to allow docking probe access. In general, placing receptacles within a flat plate area rather than in an isolated position greatly aids ROV docking.

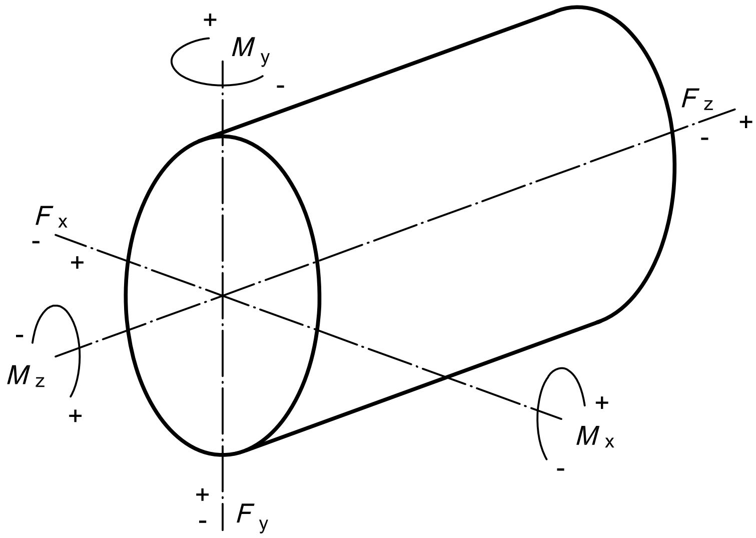
The docking receptacle should be manufactured from material with a minimum tensile strength of 450 MPa (65 300 psi) but the engineer is free to specify other materials where different load conditions exist.

Protection from marine growth and corrosion will be necessary in most environments, and consideration should be given to the use of corrosion-resistant materials or appropriate coatings.

The means of attaching the docking receptacle is optional.

Table 2 — Typical docking parameters

Docking velocity	0,25 m/s (0,82 ft/s)
Lateral current (whilst docked)	2,5 m/s (8,2 ft/s)
ROV thrust (whilst docked)	100 % full



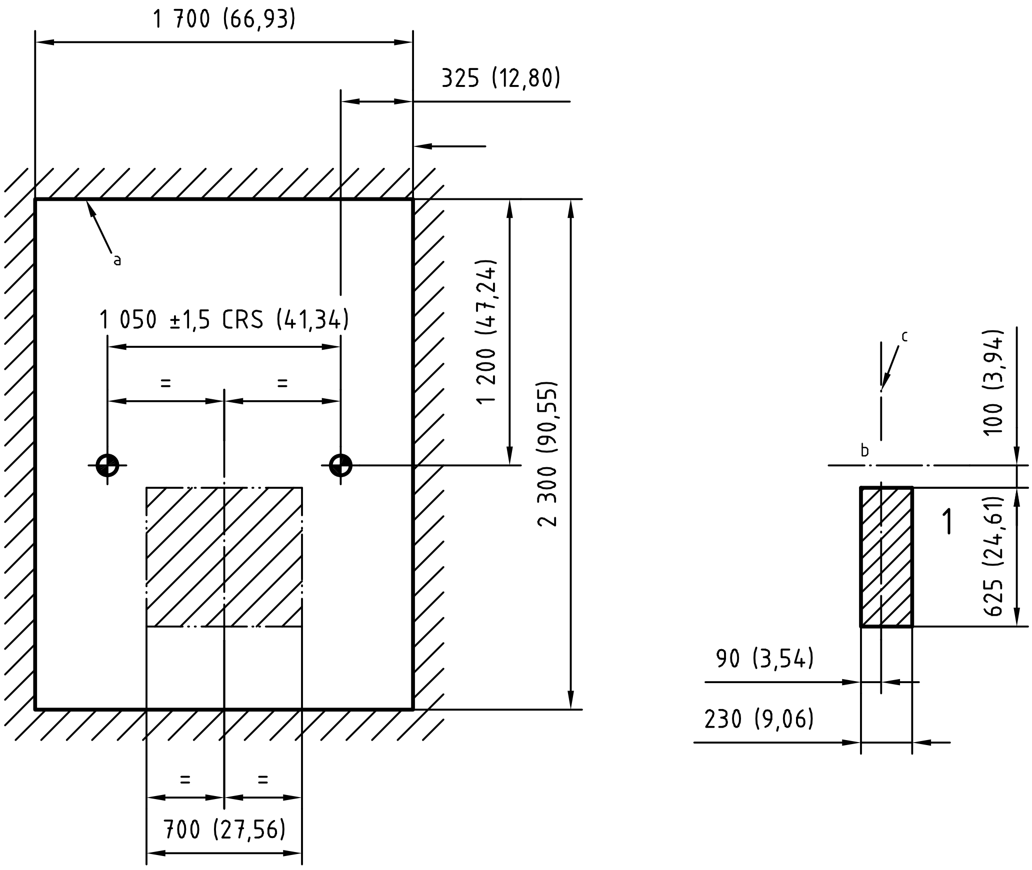
M_x	± 1 570 N·m (1 158 lbf)	F_x	± 3 800 N·m (854 lbf)
M_y	± 6 080 N·m (4 484 lbf)	F_y	± 980 N·m (220 lbf)
M_z	—	F_z	± 5 060 N·m (1 137 lbf)

Figure 8 — Docking receptacle loading

12.2.5.4 Operation

The ROV approaches the docking location and free-flies the docking probe or probes into the docking receptacle or receptacles. The probe is then actuated by the ROV, locking the dogs behind the rear profile pulling the probe flange against the docking face.

Dimensions in millimetres (inches)



Key

1 torque tool

[a] Recommended clearance area for access to and allowance for cameras, support brackets, etc.

[b] CL of docking probes.

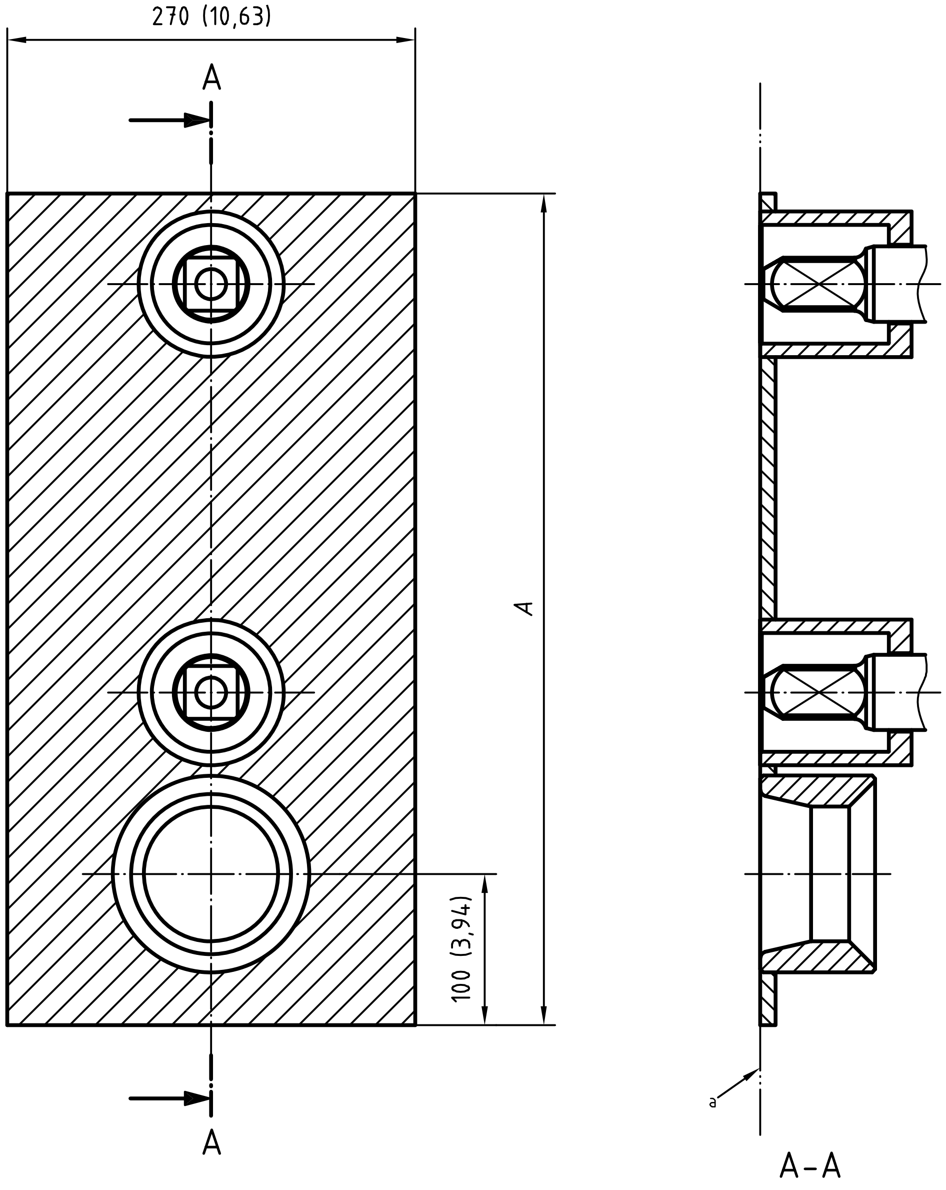
[c] Docking face.

NOTE 1 Penetration envelope into a structure is typically in the range of 140 mm (5,5 in). Specific tooling can be made for greater depths of penetration.

NOTE 2 MQC plate installation requires that this envelope be lowered relative to the docking points. See Figure 33.

Figure 9 — Typical tooling envelope for twin-docking TDU

Dimensions in millimetres (inches)



[a] docking face

NOTE 1 Area shown shaded to be kept flat and free from obstructions.

NOTE 2 Dimension A is normally in the range 350 mm (13,78 in) to 550 mm (21,65 in), depending on the tooling requirement.

Figure 10 — Typical tooling envelope for single-docking TDU

12.3 Handles for use with manipulators

12.3.1 Function

This standard interface provides for ROV operations involving subsea equipment requiring linear or rotary action or both.

12.3.2 Application

The handles are used in conjunction with a ROV manipulator or purpose-built tooling to allow direct operation of the interface by providing the required action.

12.3.3 Design

The interface consists of a T-bar or O-ring arrangement, attached to the equipment to be operated, which is grasped in the jaws of a manipulator or a purpose-designed tooling receptacle. See Figure 11.

Due consideration shall be given to the maximum forces that will be applied during operation.

For rotary applications, the stem should be capable of resisting the maximum torque which will be generated during its operation where the risk of damage to equipment may occur when using a manipulator. Wherever possible end stops should be built into the equipment to prevent over-stressing of the handle stem, which shall resist the maximum forces which are considered to be generated when operating the equipment in the worst conditions.

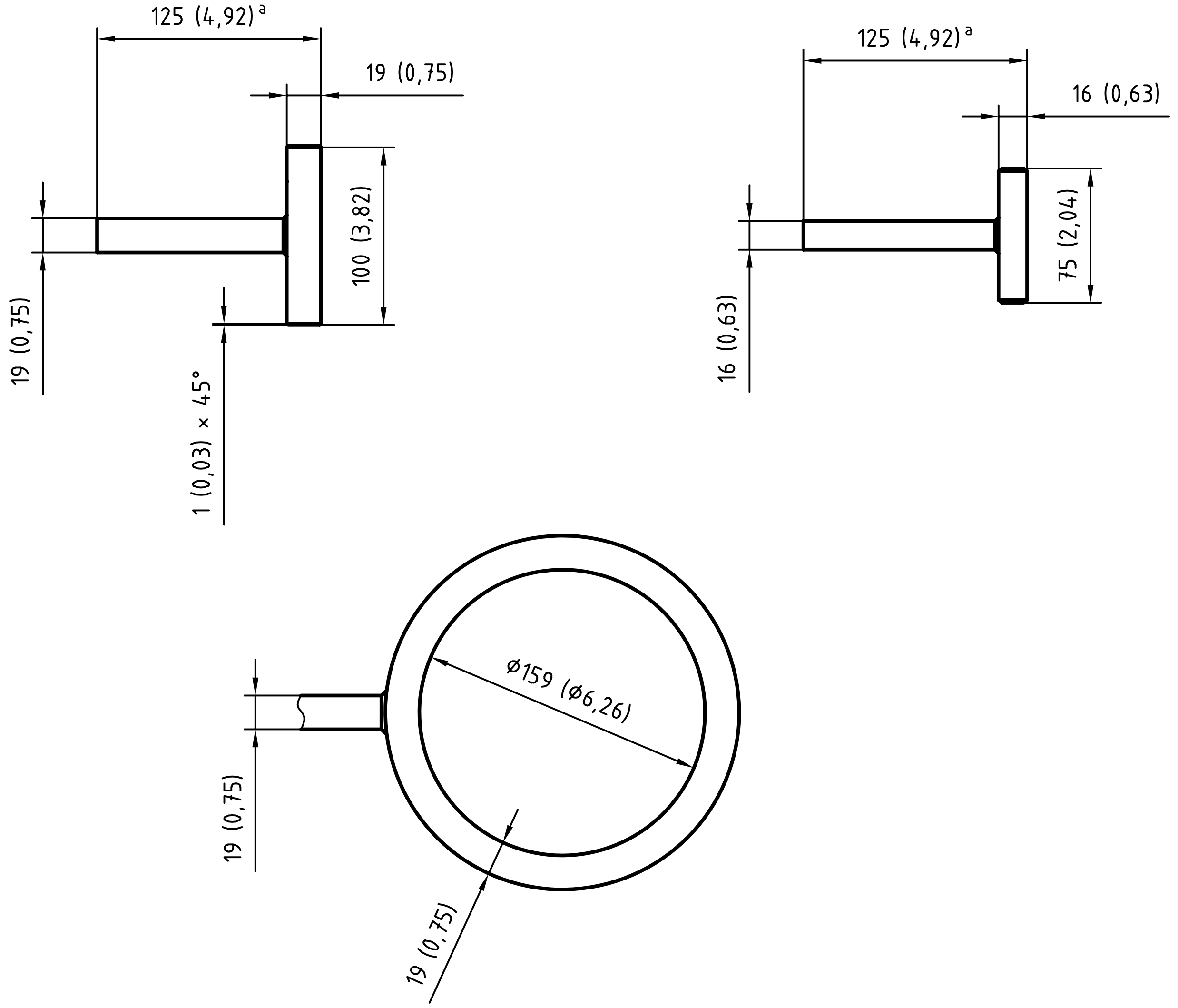
The inclusion of compliance between the handle and the attachment to the tool will allow for any out–of-line forces generated by the operator in linear applications.

12.3.4 Operation

The handles are operated by locating them directly in the jaws of a manipulator or by securing them in a purpose-built tooling receptacle such as a TDU fitted with a torque tool. See Figure 12.

Attention should be given to providing markings indicating the direction of travel in which a handle will move, in order to reduce the chance of attempted operation against the limit of travel and subsequent travel damage to the handle bar itself.

Dimensions in millimetres (inches)



Material strength = 450 N/mm² (65 kip/in²)

a Clear area for manipulator.

Figure 11 — Handles for use with manipulators

12.4 Handles for use with TDUs

12.4.1 Function

These handles are for holding subsea equipment.

12.4.2 Application

They are used in conjunction with twin- or single-docking tooling, allowing direct operation of the interface by providing the required action.

12.4.3 Design

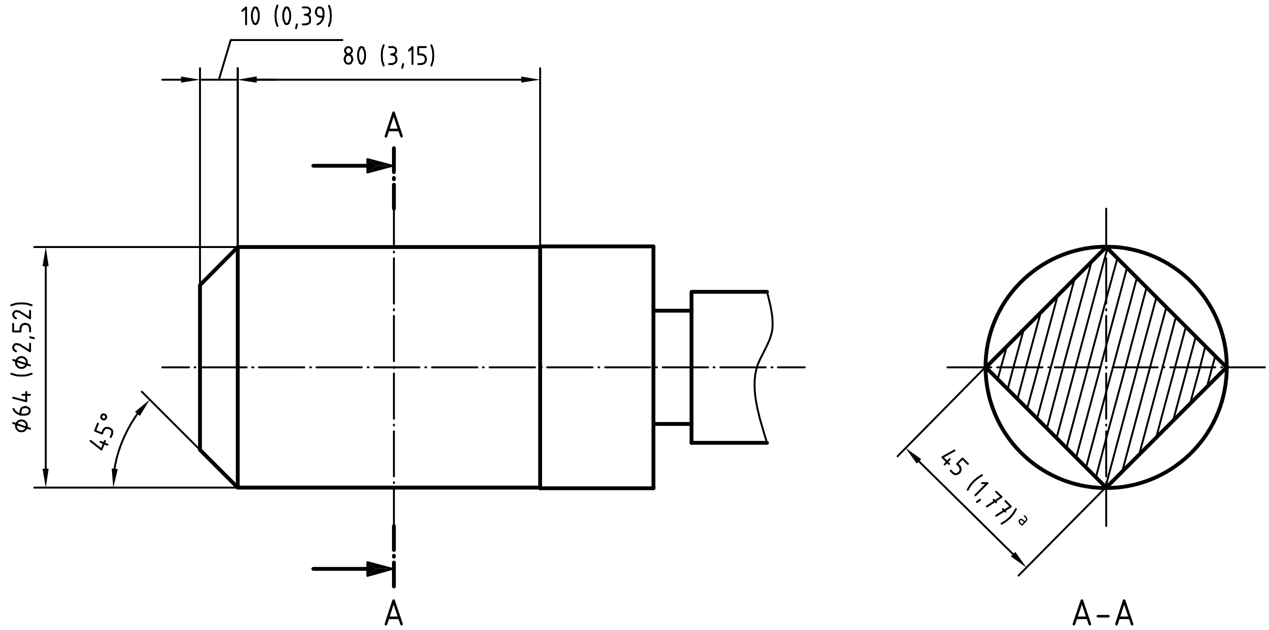
The interface consists of a square handle with flats at 45° to the vertical.

Due consideration shall be given to the maximum forces that will be applied during operation. Clearance space is required along the section where the manipulator or TDU gripper holds to allow proper location of the gripper. The section between the tool and handle, held by a manipulator gripper, should be designed with some degree of pliancy so as to forgive limits to dexterity during insertion or pull-out of the tool, so 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. An example of design pliancy is the wire rope extension between a hot stab body and the manipulator handle as shown in Figure 19.

12.4.4 Operation

The handle is operated by attachment of a manipulator or TDU gripper. The gripper prevents rotation by resisting load through the flat faces of the handle. The handle is moved to the desired location, all loads are transmitted through the handle and into the gripper.

Dimensions in millimetres (inches)



a Across flats.

Figure 12 — Handle for use with TDU

12.5 Rotary (low torque) interface

12.5.1 Function

This standard interface provides for the ROV operation of subsea equipment requiring a rotary action.

12.5.2 Application

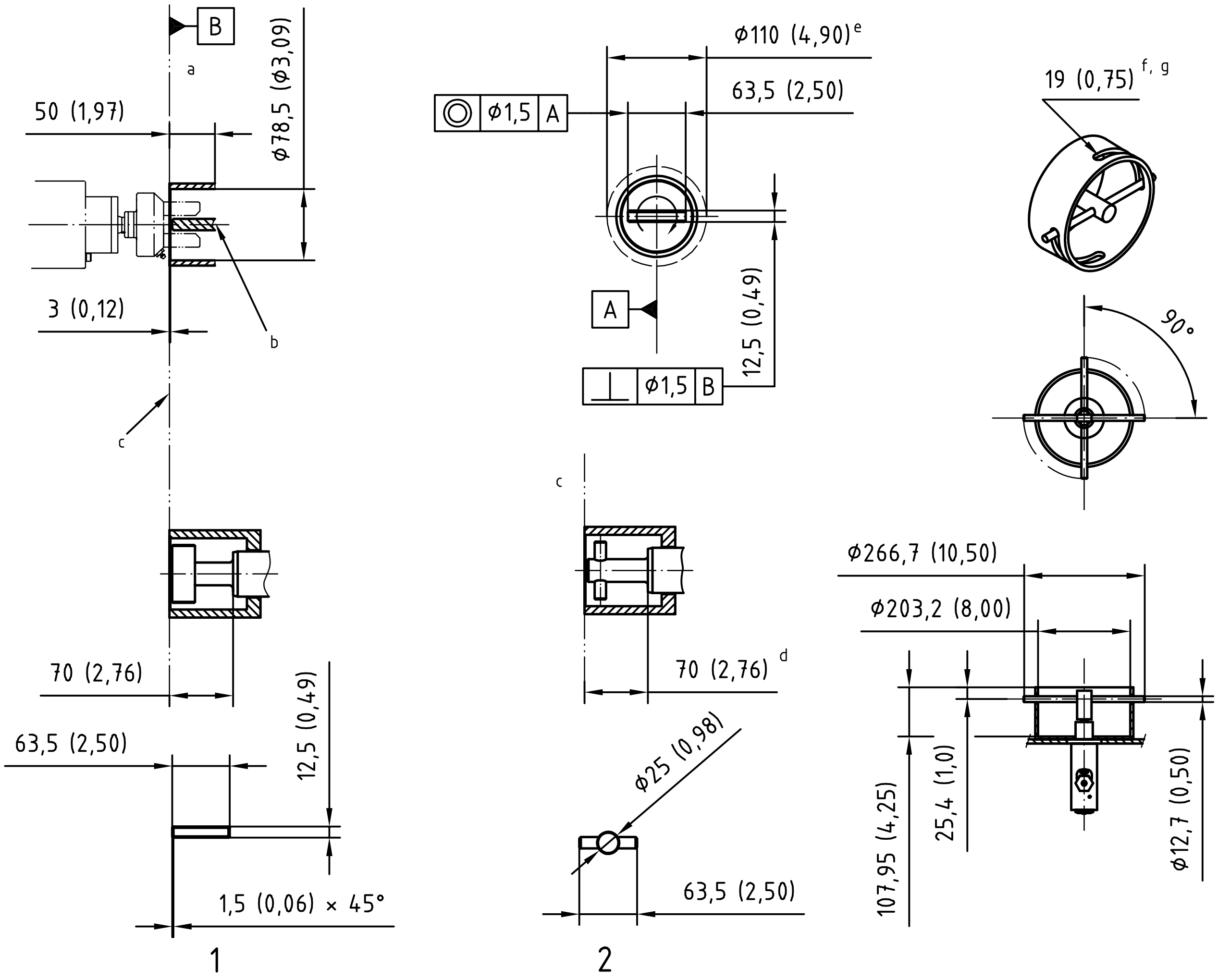
It is used in conjunction with a ROV-mounted torque tool for the operation of subsea tree needle valves and other low-torque functions.

12.5.3 Design

The interface (see Figure 13) consists of a T-bar or paddle enclosed in a tubular housing.

The interface is generally mounted with the drive stem horizontal, but may be mounted vertically if required. The interface receptacle can be incorporated into a panel by bolting or welding, or can be free-standing or made as part of the subsea equipment. In the case of panel mounting, the panel should be flush with the docking face.

Dimensions in millimetres (inches)



a) Type A **b) Type B** **c) Type C**

To avoid damage to the valve handle, it is important that the top operating end be maintained within the receptacle.
Max. torque rating = 75 N·m (663,8 lbf·in)

Key

1 flat paddle style (Type A)
2 T-bar handle (Type B)

a Depth for tool access.
b Rotary valve handle can be T-bar or flat paddle style.
c Docking face.
d Tooling receptacle with T-bar handle.
e Tool diameter.
f Full radial slot.
g 2 × 180° apart.

Figure 13 — Low-torque receptacle

The interface flange should be manufactured from material with a minimum tensile strength of 450 MPa (65 300 psi) in order to operate at the specified torques, but the engineer is free to specify other materials where different load conditions exist.

Protection from marine growth and corrosion will be necessary in most environments, and consideration should be given to the use of corrosion-resistant materials or appropriate coatings

The interface is approached by the ROV tool along the drive stem axis, and therefore access is required in this area.

12.5.4 Operation

The ROV-mounted torque tool is presented to the interface along its axis, orientated to engage the tool drive adapter on the T-bar or paddle. Once fully engaged the tool can provide continuous rotation in either direction with all torque reacted by the ROV deployment system. This interface has no built-in guidance for assisting engagement and therefore should be used in conjunction with a twin or single docking system that provides positive location of the tool head.

12.6 Rotary (high-torque) interface

12.6.1 Function

This standard interface provides for the ROV operation of subsea equipment requiring a rotary action.

12.6.2 Application

It is used in conjunction with a ROV-mounted torque tool for the override or operation of subsea tree valves, SCM lock downs, running tool operation, shackle release and other functions require the application of high torque.

12.6.3 Design

The interface (see Figure 14) consists of a square drive stem enclosed in a tubular housing with internal torque reaction lugs.

The interface is generally mounted with the drive stem horizontal but may be mounted vertically if required. The interface receptacle can be incorporated into a panel by bolting or welding, be free standing or be made as part of the subsea equipment. In the case of panel mounting, the panel should be flush with the docking face.

The interface should be manufactured from material with a minimum tensile strength of 450 MPa (65 300 psi) so that it can operate at the specified torques, but the engineer is free to specify other materials where different load conditions exist.

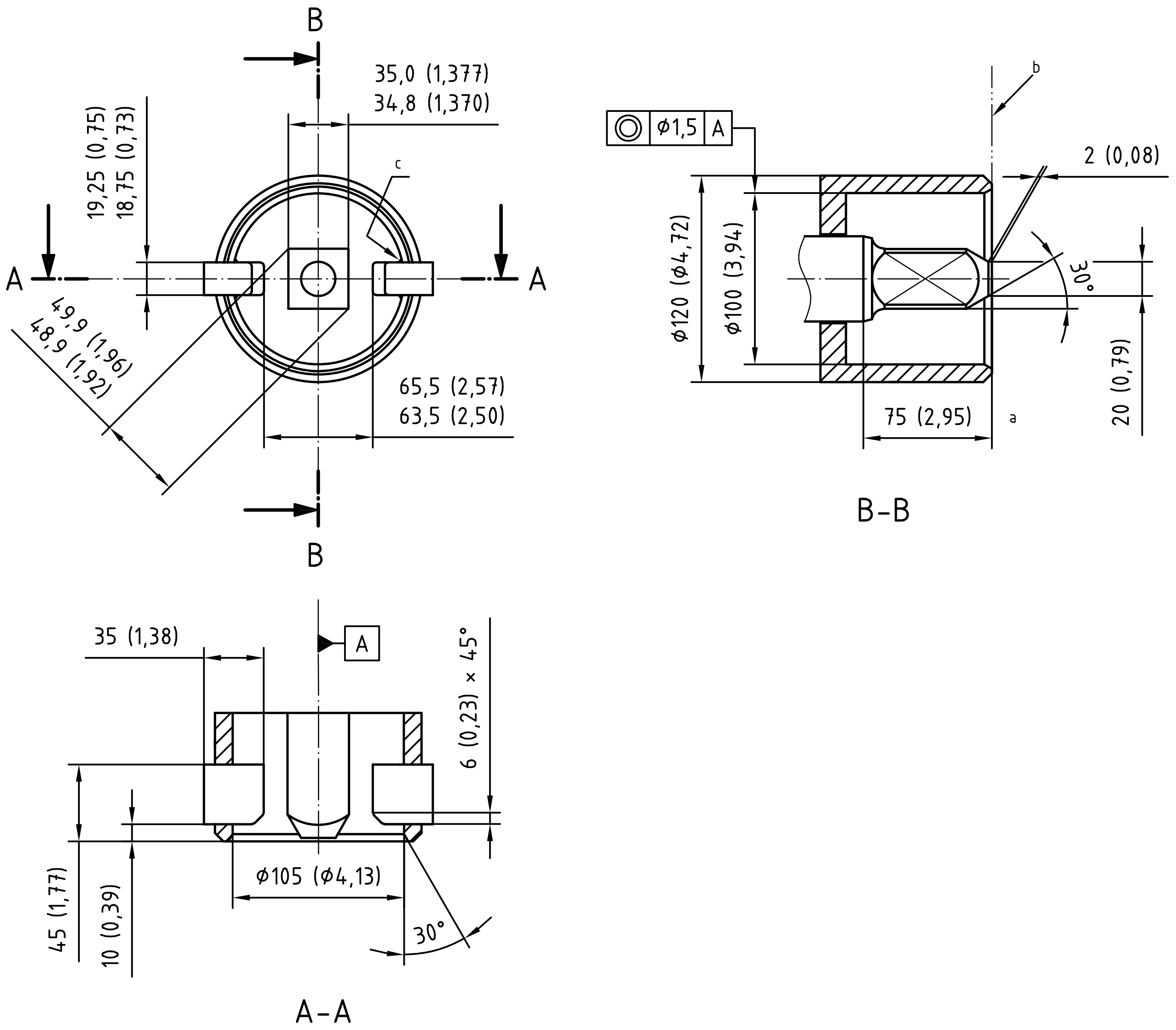
Protection from marine growth and corrosion will be necessary in most environments, and consideration should be given to the use of corrosion-resistant materials or appropriate coatings.

The interface is approached by the ROV tool along the drive stem axis; access is therefore required in this area.

12.6.4 Operation

The ROV-mounted torque tool is presented to the interface along its axis, orientated to engage the torque reaction lugs into slots in the tool. The tool drive socket is then slowly rotated, if necessary, and moved forward to engage the drive stem. Once fully engaged the tool can provide continuous rotation in either direction with all torque reacted within the tool and interface, not into the ROV deployment system. This interface has no built-in guidance for assisting engagement and therefore should be used in conjunction with a twin or single docking system that provides positive location of the tool head.

Dimensions in millimetres (inches)



Max. torque rating = 2 000 N·m (17,7 klbf·in)

a Min. depth for tool access.

b Docking face.

c Internal fillet weld shall not exceed 3 mm (0,12 in) leg length.

Figure 14 — High-torque receptacle

12.7 Linear (push) interface — Types A and C

12.7.1 Function

This standard interface provides for the ROV operation of subsea equipment requiring a push action.

12.7.2 Application

It is used in conjunction with a ROV-mounted tool, primarily for the override of hydraulic gate valves allowing ROV opening of the valve after fail-safe closure. In this application the interface is usually incorporated as part of the valve actuator and can be operated with the valve under pressure.

The interface may, of course, be incorporated into any piece of underwater hardware requiring a push action of this type and magnitude.

12.7.3 Design

The interface [see Figure 15 (type A) and Figure 16 (type C)], consists of an interrupted flange around a central stem. The flange allows a ROV-mounted tool to be engaged upon the interface using a “push and turn” action. The central stem can then be driven into the interface whilst the force produced is reacted at the flange.

The interface can be mounted in either the horizontal or vertical plane.

The maximum push force specified in Figure 15 is based upon that required to open gate valves at full differential pressure in most subsea applications.

The interface flange should be manufactured from material with a minimum tensile strength of 450 MPa (65 300 psi) in order to operate at the above loads, but the engineer is free to specify other materials where different load conditions exist.

Protection from marine growth and corrosion will be necessary in most environments, and consideration should be given to the use of corrosion-resistant materials or appropriate coatings.

The interface is approached by the ROV tool along the stem axis; access is therefore required in this area. In addition, a clear space around the interface is required, as shown for the tool diameter.

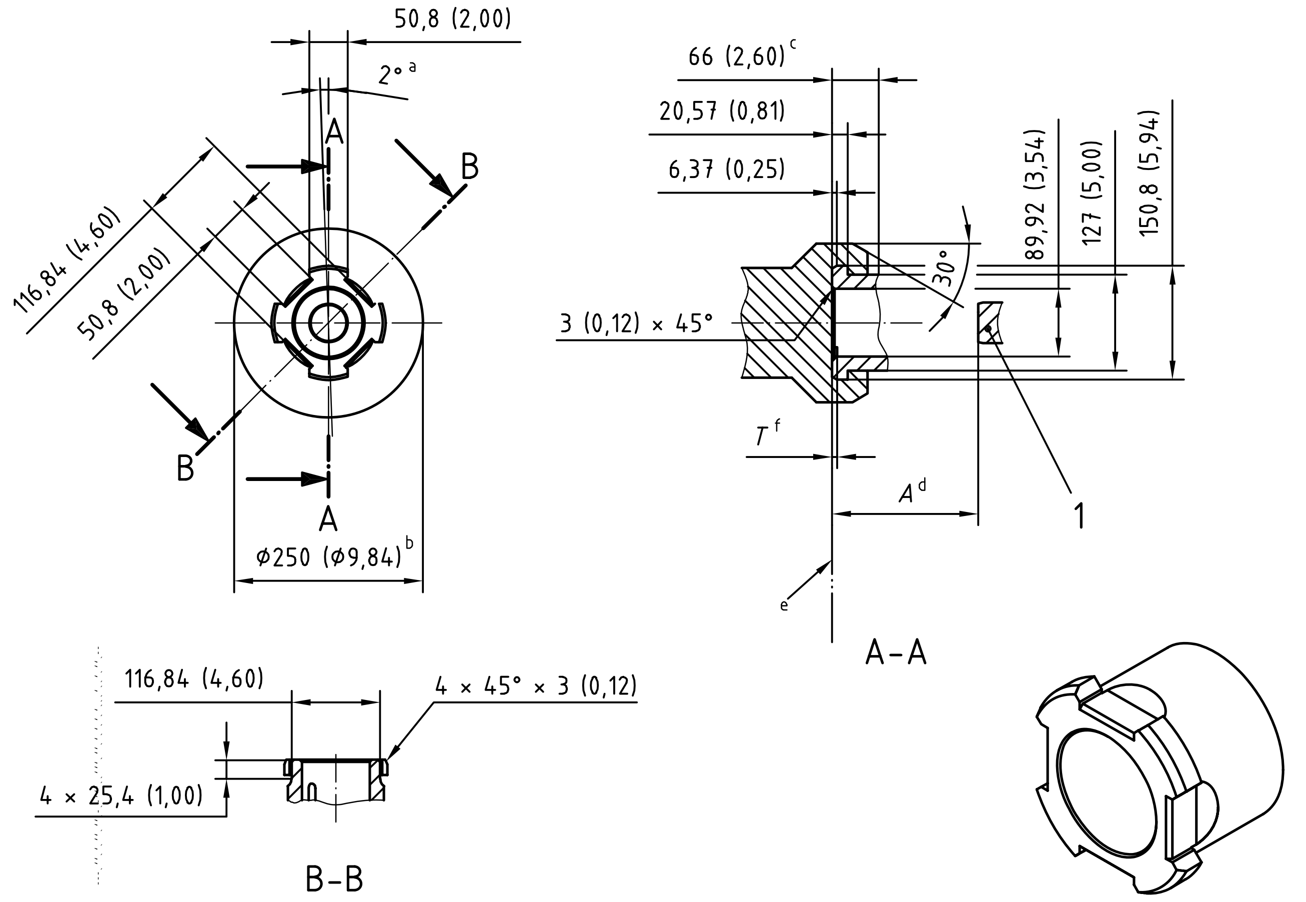
12.7.4 Operation

The ROV-mounted tool is presented to the interface along its axis in an orientation allowing it to engage in the slots of the flange. The tool is then rotated 45° clockwise to lock behind the flange. Once in this position the central stem is acted upon by the tool actuator. The tool may then be released by the ROV if required, leaving it engaged on the interface, holding the “pushed” position.

Release of the tool requires the release of the force within the tool holding the stem, followed by a 45° rotation anticlockwise allowing it to be withdrawn from the interface. In the case of hydraulic gate valve overrides, the internal fail-safe spring in the valve actuator returns the stem to the original position.

Linear push devices can be operated by manipulator or by TDU. It is important to check the stroke on the TDU to ensure sufficient clearance to fully make up the linear push device, and subsequently remove it.

Dimensions in millimetres (inches)



Max. linear force exerted by tool = 745 kN (167,5 klbf)

Key

1 valve stem

a Angular tolerance.

b Minimum clearance.

c Minimum clearance allowing tool engagement.

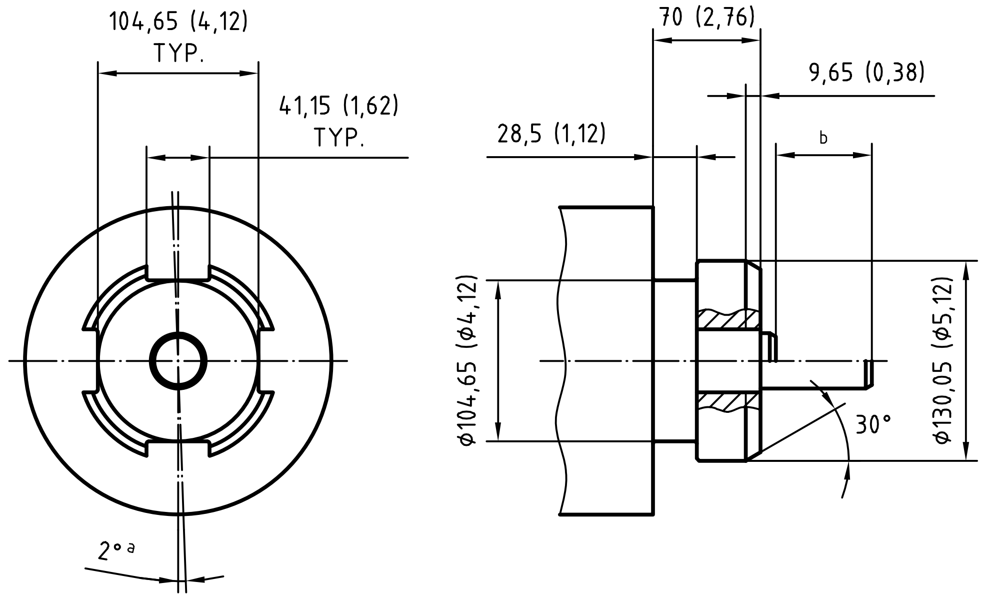
d Dimension A depends upon tool stroke.

e Docking face.

f Dimension $T = 5$ min.

Figure 15 — Linear push interface type A

Dimensions in millimetres (inches)



a Angular tolerance.

b Valve stroke.

Figure 16 — Linear push interface type C

12.8 Linear (push) interface type B

12.8.1 Function

This standard interface provides for the ROV operation of subsea equipment requiring a push action.

12.8.2 Application

It is used in conjunction with a ROV-mounted tool, primarily for the override of hydraulic gate valves allowing ROV opening of the valve after fail-safe closure. In this application the interface is usually incorporated as part of the valve actuator and can be operated with the valve under pressure.

The interface may, of course, be incorporated into any piece of underwater hardware requiring a push action of this type and magnitude.

12.8.3 Design

The interface (see Figure 17) consists of a flange around a central stem. The flange allows a ROV-mounted tool to be engaged upon the interface using a "hook-over" action. The central stem can then be driven into the interface whilst the force produced is reacted at the flange.

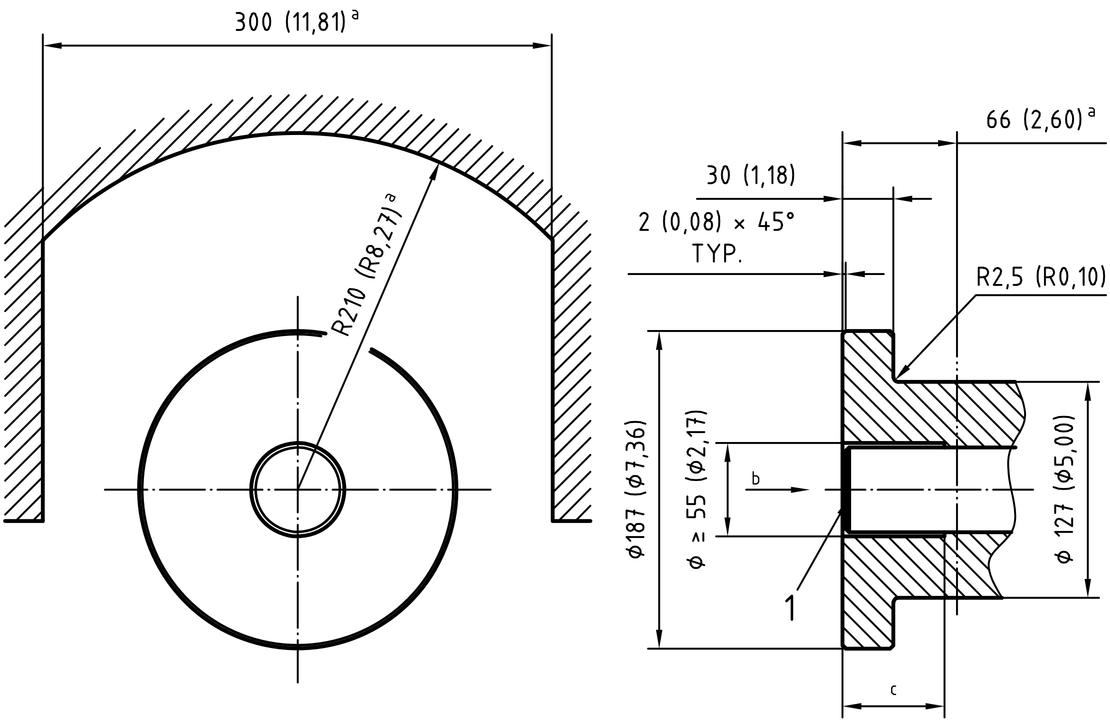
The interface can to be mounted in either the horizontal or vertical plane.

The interface flange should be manufactured from material with a minimum tensile strength of 450 MPa (65 300 psi) so that it can operate at the specified loads, but the engineer is free to specify other materials where different load conditions exist.

Protection from marine growth and corrosion will be necessary in most environments and consideration should be given to the use of corrosion-resistant materials or appropriate coatings.

The interface is approached by the ROV tool along the stem axis; access is therefore required in this area. In addition, a clear space around the interface is required, as shown in Figure 17, for the tool diameter and engagement.

Dimensions in millimetres (inches)



Key

1 valve override stem

[a] Minimum clearance required for tool engagement.

[b] Axial force.

[c] Valve stroke + 5 mm (0,2 in).

Figure 17 — Linear push interface type B

12.8.4 Operation

The ROV-mounted tool is presented to the interface by hooking it over the flange; clearance is therefore required above and in front of the interface as shown in Figure 17. Once in this position, the central stem is acted upon by the tool actuator stroking it forward and reacting the force at the flange. The tool may then be released by the ROV, if required, leaving it engaged on the interface and holding the “pushed” position.

Release of the tool requires firstly the release of the force within the tool holding the stem, allowing the internal fail-safe spring in the valve actuator to return the stem to the original position. The tool is then unhooked and removed.

Linear push devices can be operated by manipulator or by TDU. It is important to check the stroke on the TDU to ensure sufficient clearance to fully make up the linear push device, and subsequently remove it.

12.9 Rotary docking

12.9.1 Function

This provides docking, torque reaction, alignment and socket mating for ROV-deployed rotary tools.

12.9.2 Application

The receptacle is commonly fitted to valve panels on subsea equipment such as trees, manifolds, control modules and templates, and is suitable for any operation requiring a rotary override. See Table 3.

12.9.3 Design

The interface shown in Figure 18 consists of a tubular housing with a top mounting plate. The mounting plate contains two torque reaction slots located 180° apart. The base of the tubular housing is machined to accept a shaft bearing. The size of the machined hole and support bearing will vary according to the receptacle class (see Table 4) and, therefore, the shaft interface diameter.

12.9.4 Design requirements

The receptacle is generally mounted with the drive stem horizontal, but may be mounted vertically if required. If the tool is being deployed by a manipulator or a TDU it is possible to position the receptacle in any orientation to suit the range of the manipulator. The receptacle is mounted through a panel and bolted so that only the flange plate protrudes from the panel. The receptacles are normally manufactured from a low carbon steel with minimum yield stress 200 MPa (29 000 psi) and protected by an epoxy paint system. Where protection from debris and the long term build-up of hard marine growth is required, this should be by the use of receptacle covers.

12.9.5 Operation

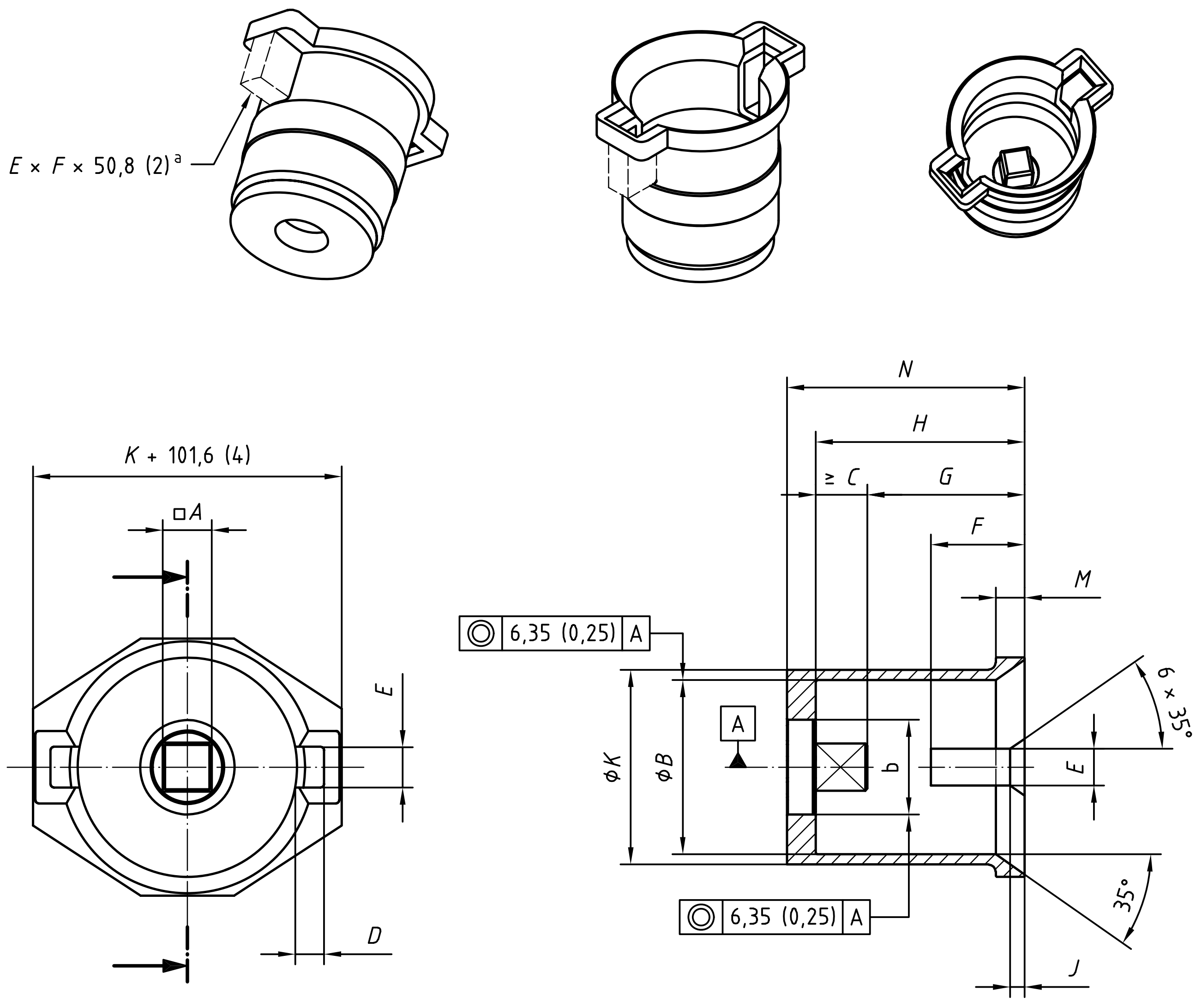
The torque tool will normally be centrally mounted on the lower front frame of the ROV (single-point docking). The ROV will present the tool to the receptacle interface and dock the tool and ROV to the receptacle. With the tool fully mated the drive stem can be operated as required by the torque tool. All generated torque is reacted within the tool and interface receptacle.

NOTE The receptacle design is also suitable for the manipulator deployment of tools. The choice of deployment method can be made as needed to suit the specific interface layout.

Table 3 — Rotary actuator intervention fixture classification

Class	Max. design torque N·m (lbf·ft)
1	67 (50)
2	271 (200)
3	1 355 (1 000)
4	2 711 (2 000)
5	6 779 (5 000)
6	13 558 (10 000)
7	33 895 (25 000)

Dimensions in millimetres (inches)



a Clearance both ends.

b See Note in Table 4.

Figure 18 — Rotary torque receptacle

Table 4 — Dimensions for receptacle classes 1 to 7 (see Figure 18)

Dimensions in millimetres (inches)

Dimension	Class						
	1	2	3	4	5	6	7
A square	17,50 (0,687)	17,50 (0,687)	28,60 (1,125)	38,10 (1,50)	50,80 (2,00)	66,67 (2,625)	88,90 (3,50)
B	154,0 (6,06)	154,0 (6,06)	154,0 (6,06)	154,0 (6,06)	190,5 (7,50)	243,0 (9,56)	243,0 (9,56)
C min.	41,0 (1,62)	41,0 (1,62)	41,0 (1,62)	41,0 (1,62)	63,5 (2,50)	89,0 (3,50)	89,0 (3,50)
D	38,0 (1,50)	38,0 (1,50)	38,0 (1,50)	38,0 (1,50)	57,0 (2,25)	82,25 (3,25)	82,25 (3,25)
E	32,0 (1,25)	32,0 (1,25)	32,0 (1,25)	32,0 (1,25)	38,0 (1,50)	44,5 (1,75)	44,5 (1,75)
F	82,5 (3,25)	82,5 (3,25)	82,5 (3,25)	82,5 (3,25)	127,0 (5,00)	178,0 (7,00)	178,0 (7,00)
G min.	140,0 (5,51)	140,0 (5,51)	140,0 (5,51)	140,0 (5,51)	140,0 (5,51)	222,0 (8,75)	435,0 (17,13)
G max.	146,0 (5,75)	146,0 (5,75)	146,0 (5,75)	146,0 (5,75)	146,0 (5,75)	228,0 (9,00)	441,0 (17,38)
H	181,0 (7,12)	181,0 (7,12)	181,0 (7,12)	181,0 (7,12)	206,0 (8,12)	—	—
J	12,7 (0,50)	12,7 (0,50)	12,7 (0,50)	12,7 (0,50)	—	—	—
K	168,5 (6,63)	168,5 (6,63)	168,5 (6,63)	168,5 (6,63)	—	—	—
M	25,4 (1,00)	25,4 (1,00)	25,4 (1,00)	25,4 (1,00)	—	—	—
N	194,0 (7,63)	194,0 (7,63)	194,0 (7,63)	194,0 (7,63)	—	—	—
As an alternative to dimension *A*, end effector shapes as found in Annex D for the appropriate torque range may be used.							

All dimension tolerances are as follows:

0,*x* ± 0,5 (0,020)

0,*xx* ± 0,25 (0,010)

C: $^{+1,27}_{\ 0}$ $\left(^{+0,05}_{\ 0}\right)$

NOTE 1 Chamfer on the end of the end effector profile is 45° × 1,65 (0,06) max.

NOTE 2 Clearance behind anti-rotation slots [*E* × *F* × 50,8 (2)] is to allow for locking feature option provided by some tools.

12.10 Hot stab hydraulic connection type A — 69,0 MPa (10 000 psi) working pressure

12.10.1 Function

The hot stab is a means of making a temporary supply of power (also occasionally gas) to a remote piece of subsea equipment using the ROV as the means of delivery and possibly the fluid reservoir.

12.10.2 Application

Hot stabs are normally used to

- over-ride existing systems,
- complement systems such as lower riser packages with locking and unlocking functions,
- hydraulically activate valves,
- test seals and connections,
- take fluid samples.

12.10.3 Design

The hot stab design is based upon a section of mandrel being inserted into a receptacle with matching ports, allowing pressurisation between the two isolated sections separated by seals.

12.10.4 Design requirements

The hot stab receptacle should be designed such that it does not fill with debris whilst not in use, for example, a passive blank may be provided, which is temporarily pushed out of the way by the insertion of the hot stab. Hot stab females can also be filled with blanking plugs to avoid debris ingress; where this is the case, a parking slot should be provided for the blank during use of the hot stab facility.

The hot stab should have a flexible joint in the handle or stab to ease connection and disconnection. See Figures 19 and 20.

12.10.5 Operations

Hot stabs can be operated by manipulator or by TDU. It is important to check the stroke on the TDU to ensure sufficient clearance to fully make up the hot stab, and subsequently remove it.

12.10.6 Materials in design

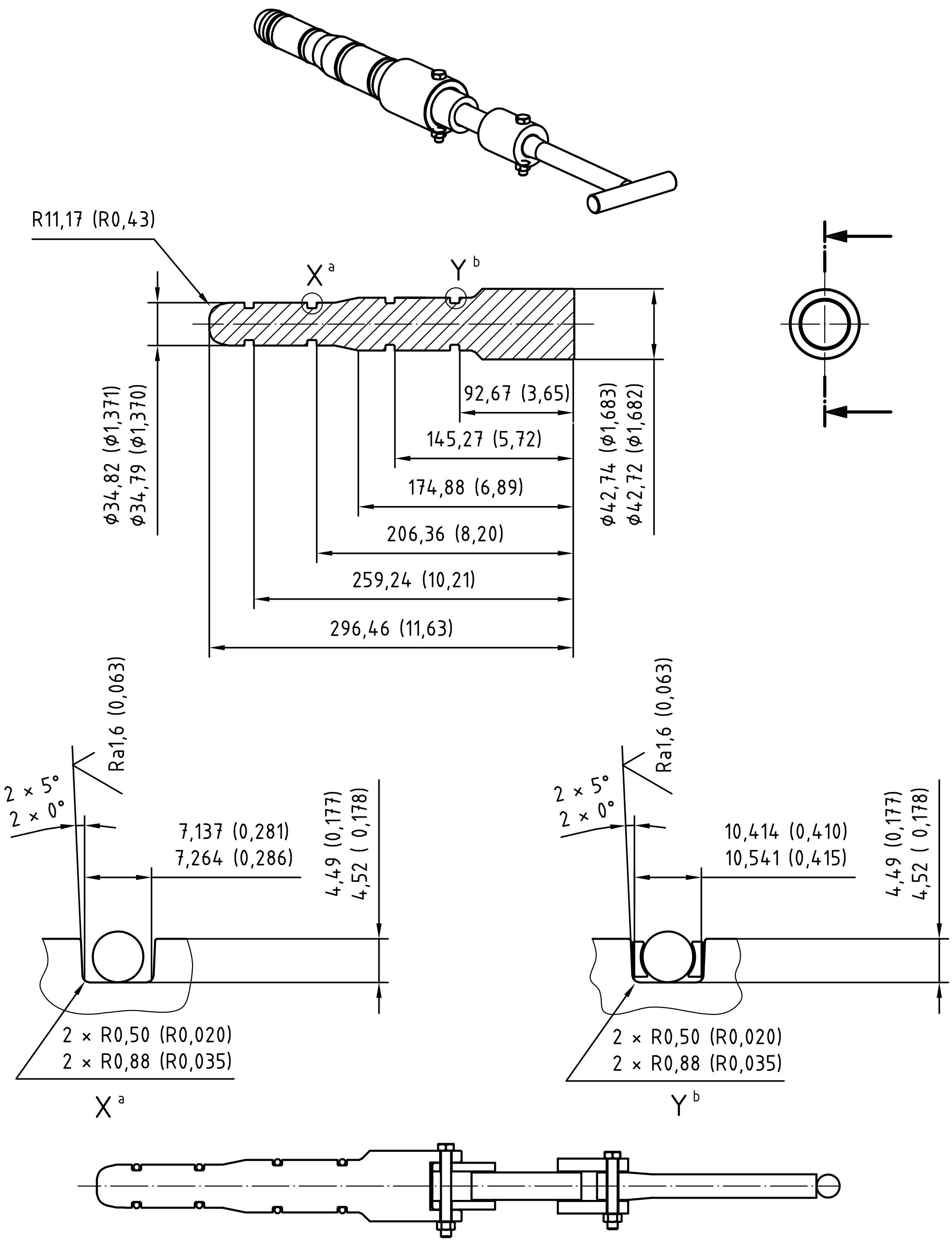
It is important that the design of the hot stab system ensure that the female part of the stab remains undamaged during the installation and continued use of the male stab. The material selection should also depend upon the intended use of the stab — a once or twice in a lifetime usage of a stab system (e.g. during pile sleeve grouting) might require a lower specification than a frequently used intervention stab.

12.11 Hot stab hydraulic connection type B

This hot stab connection includes the features of type A and also includes the ability to allow entry from either end and to have multiple ports by repeating certain dimensions. All other aspects of design materials and operational requirements remain as for type A. See Figure 21.

Coupling shall have opening at back to allow for venting. All seal bore datums shall be toleranced from the face of the coupling to 0,3 mm (0,01 in). Porting into the bore shall not come within 2 mm (0,08 in) of the straight bore of the “C” dimension. Debur all sharp edges.

Dimensions in millimetres (inches)

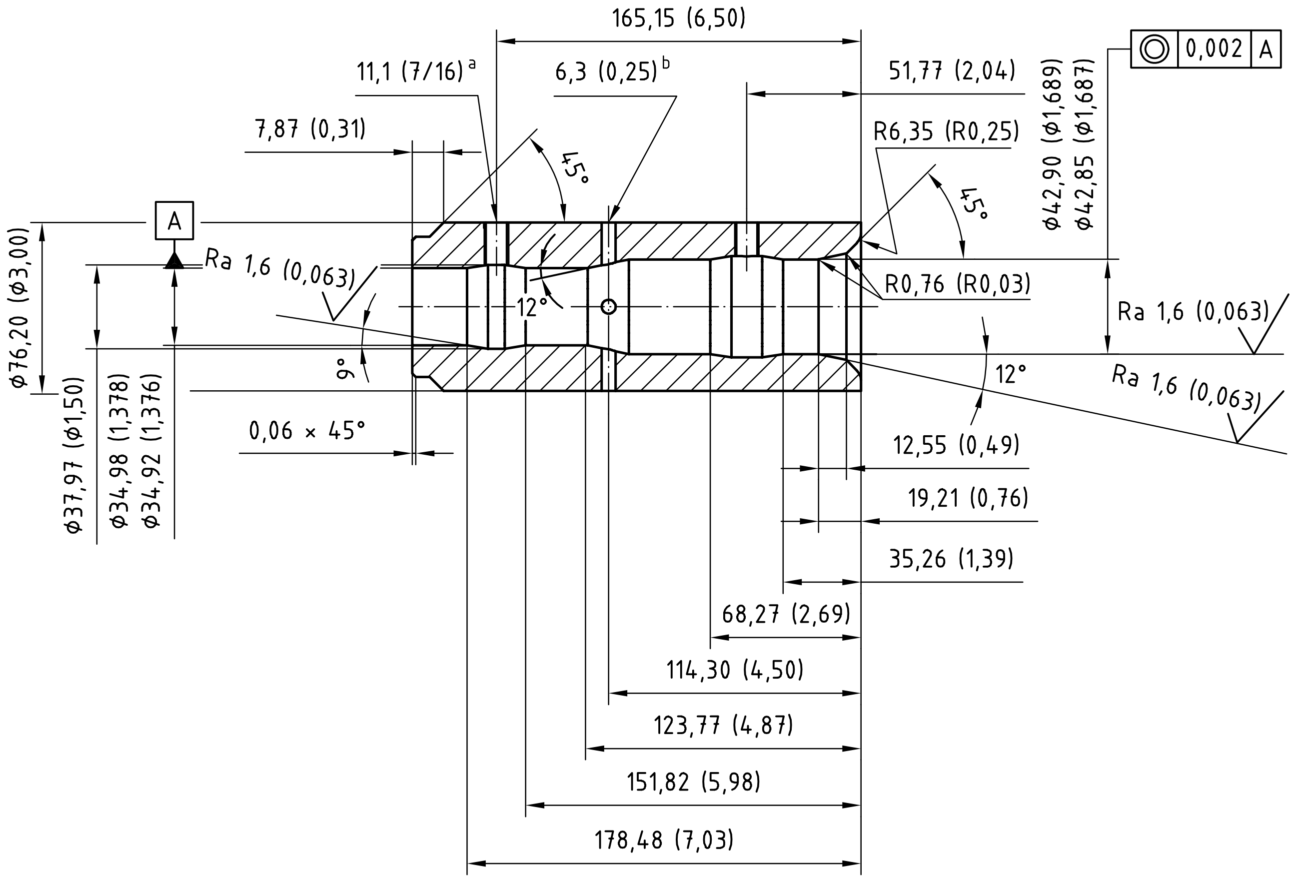


a 10 k detail.

b 15 k detail.

Figure 19 — Hot stab connection type A — General arrangement

Dimensions in millimetres (inches)

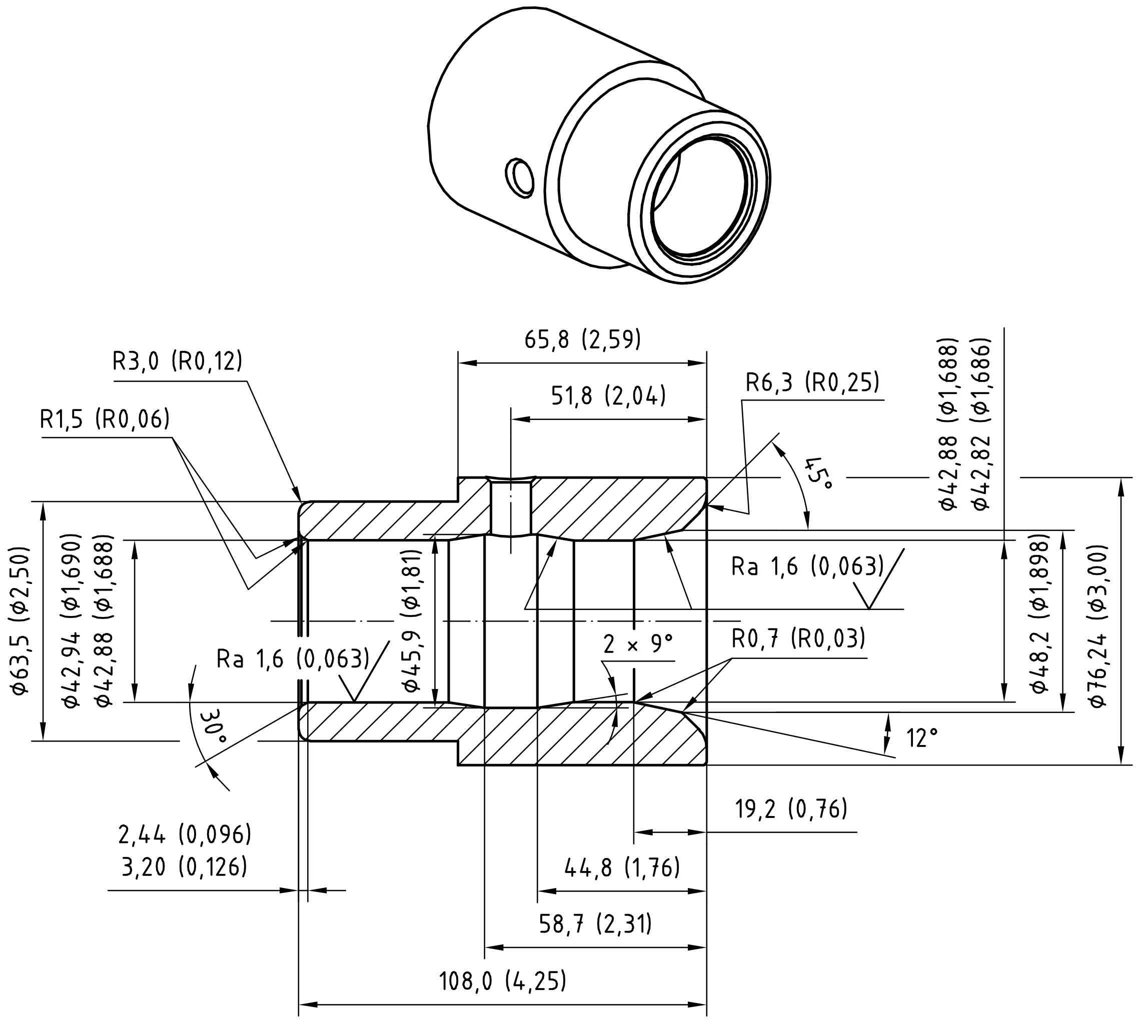


[a] Drill 11,1 (7/16) through tap 1/4 NPT two holes for 10 K application only. Use welded or proprietary high-pressure preps for 15 K.

[b] Drill four holes, 90° apart.

Figure 20 — Female receptacle — Type A

Dimensions in millimetres (inches)



Drill 11,1 (7/16) through tap 1/4 NPT one hole for 10 K application only. Use welded or proprietary high-pressure preps for 15 K.

Figure 21 — Hot stab connection — Type B

12.12 Rotary fluid coupling

12.12.1 Function

To provide multi-function hydraulic stabbing.

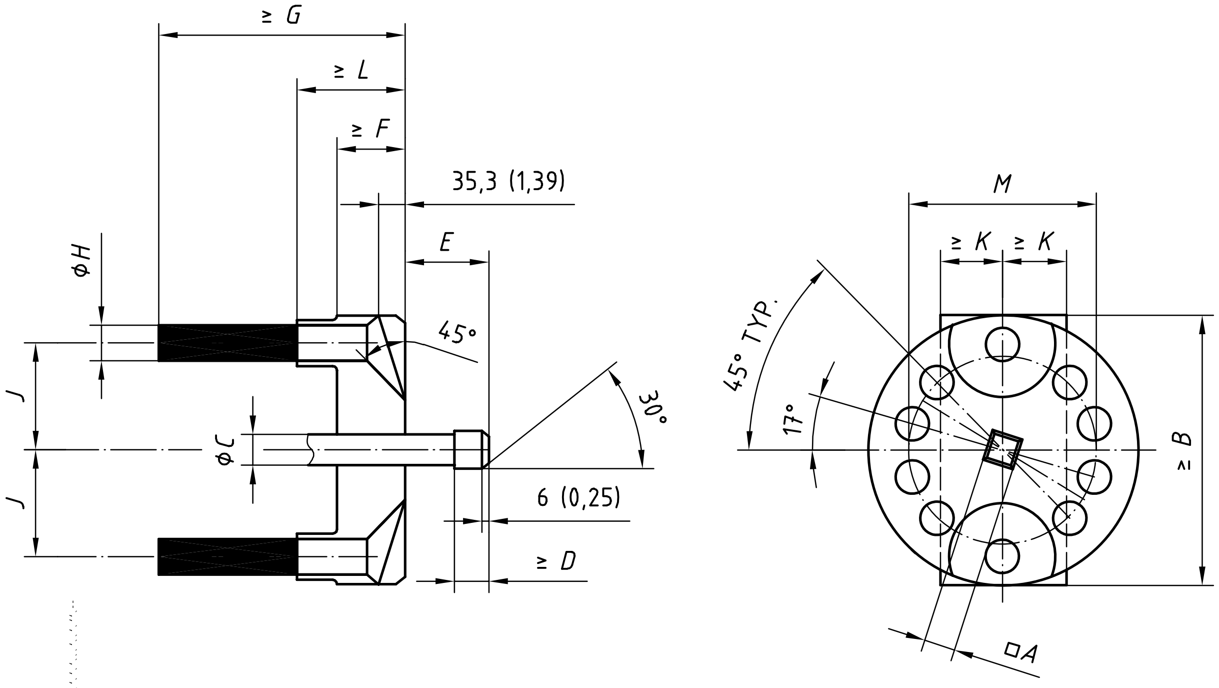
12.12.2 Application

Used for multi-function hydraulic stabs for pipeline repair systems and flowline connections.

12.12.3 Design

Basic design considerations of all hot stabs should be as described in 12.10. See Figure 22.

Dimensions in millimetres (inches)



Dimensions, mm (in)		
	Class	
	2	3
A	17,3/17,0 (0,680/0,670)	28,6/28,3 (1,125/1,115)
B	164,5 (6,47)	240,5 (9,47)
C	17,0 (0,670)	28,3 (1,115)
D	25,4 (1,000)	31,8 (1,250)
E	57/25,5 (2,25/1,00)	76/32 (3,00/1,25)
F	12,5 (1,50)	62 (2,45)
G	216 (8,50)	222 (8,75)
H	20,6 (0,812)	30,2 (1,187)
J	63,5 (2,500)	95,2 (3,750)
K	50 (1,97)	56 (2,20)
L	82,5 (3,25)	98,5 (3,87)
∅*M*	—	171,5 (6,750)

Fluid couplings are optional up to eight places as required. Use Figure 21 for coupling dimensions.

Tolerances are as follows:

three-place decimal: ± 0,2 mm (0,01 in)

two-place decimal: ± 0,5 mm (0,02 in)

fraction: ± 1 mm (0,04 in)

Figure 22 — Rotary fluid coupling

12.13 CCO interface

12.13.1 Function

This standard interface provides for landing and lockdown of ROV tooling systems for replacement of components on subsea facilities.

NOTE The interface can also be used with a ROT on a lift wire with ROV positioning or, positioned between API guideposts, the tool system could be on guide wires. As these two methods of deployment are not examined in further detail in this part of ISO 13628, reference can be made to ISO 13628-9.

12.13.2 Application

It is used for components where vertical installation and retrieval can be carried out by ROV tooling systems. Typical components which fall into this category are

— chokes,

— control modules,

— insert valves,

— multiphase meters,

— pig launchers,

— chemical injection modules,

— hydraulic accumulator modules,

— debris and pressure caps.

12.13.3 Design

The interface comprises two identical landing units (see Figures 23 to 27), each with one central lockdown receptacle and two weight receptacles. The weight receptacles may be used in combination with a subsea weight exchange system. Alternatively, cover plates may be positioned over the weight receptacles to enable soft landing dampers to react against.

The landing units shall be set at a centre pitch of 1 500 mm (59,06 in). This allows components of up to 1 100 mm × 1 100 mm (43,31 in × 43,31 in) plan area to be handled. A nominal height up to 1 700 mm (66,93 in) has been selected as this covers the majority of common components. It is recommended that the height of the interface be designed around the component. The top face of the landing units should be positioned flush with or above the component lifting mandrel. The landing units may be located at a high level, on the tree or manifold, or at a low level provided there is adequate access.

In the event that a component exceeds these sizes the next recommended pitch is 1 750 mm (68,90 in). Components longer than 1 700 mm (66,93 in) can be accommodated depending on tooling capabilities.

The component lifting mandrel design shall be designed in accordance with the lifting mandrel (see Figure 29).

The landing units may be structurally supported from either the structural framework or from the component base unit. The support arrangements shall take into account the clearance required for weight transfer units.

Design loads for the landing units are particular to the component and shall be evaluated on a case-by-case basis. The interface is designed around a vertical in-water mass of 1 200 kg (1,2 t) [3 000 kg (3 t) in air] that causes a shared maximum vertical load of 200 kN (45 klbf) and bending moment of 60 kN·m (44 klbf·ft). The interface should be manufactured from material with a minimum ultimate tensile strength of 450 MPa (65 300 psi) for these loads and the dimensions provided.

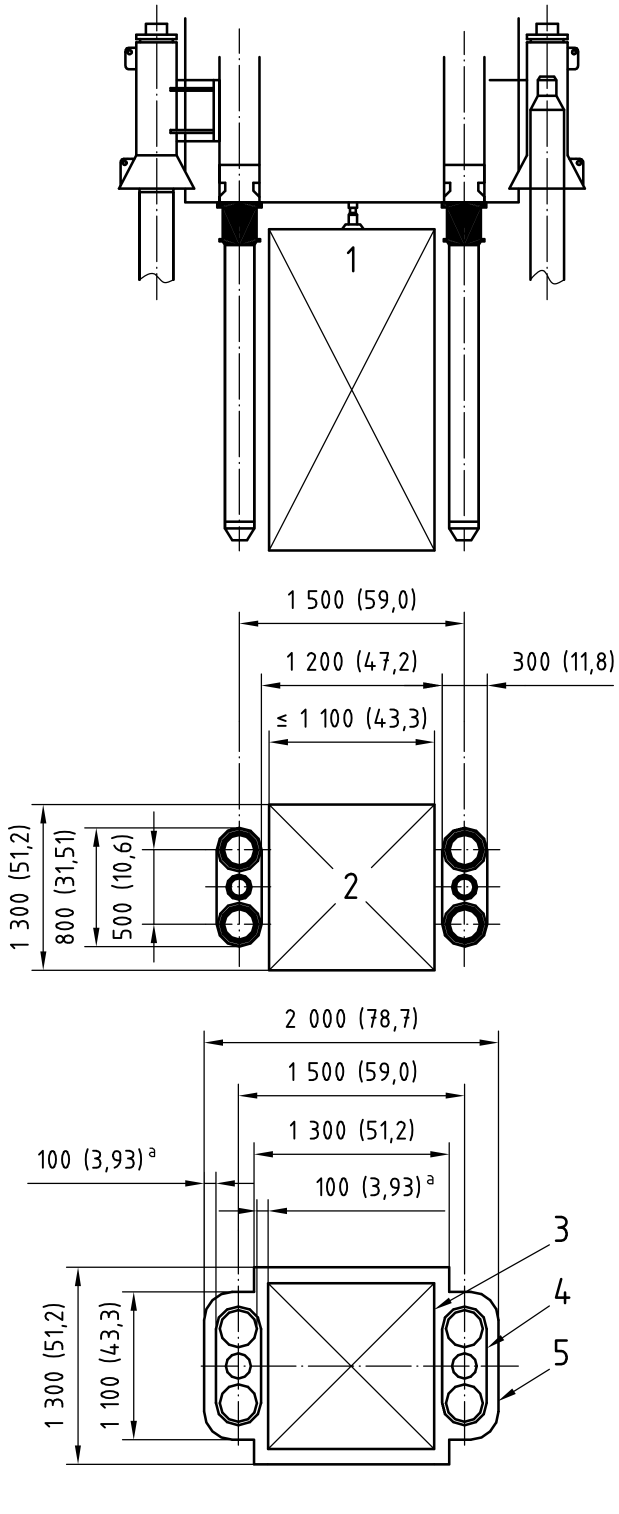
The lockdown receptacle is formed from a post with an internal profile in accordance with the docking probe receptacle profile, as shown in Figure 25. The lockdown post is attached to the bottom plate.

The two weight receptacles, which serve to transmit the weight of the landed object to the host structure, form part of the top plate and are attached to the bottom plate by spacer tubes.

12.13.4 Operation

The removal of a component typically consists of the ROV and tool system landing vertically on the interface and locking down, carrying out some form of weight exchange or buoyancy adjustment, followed by release of the component through the tooling system or operation of ROV torque interface and lifting of the component into the tooling system. The ROV and tooling system, with the component, then releases and manoeuvres away from the interface. Installation is a reverse procedure.

Dimensions in millimetres (inches)



Key

1 component

2 component maximum outline

3 maximum component (1 100 × 1 100)

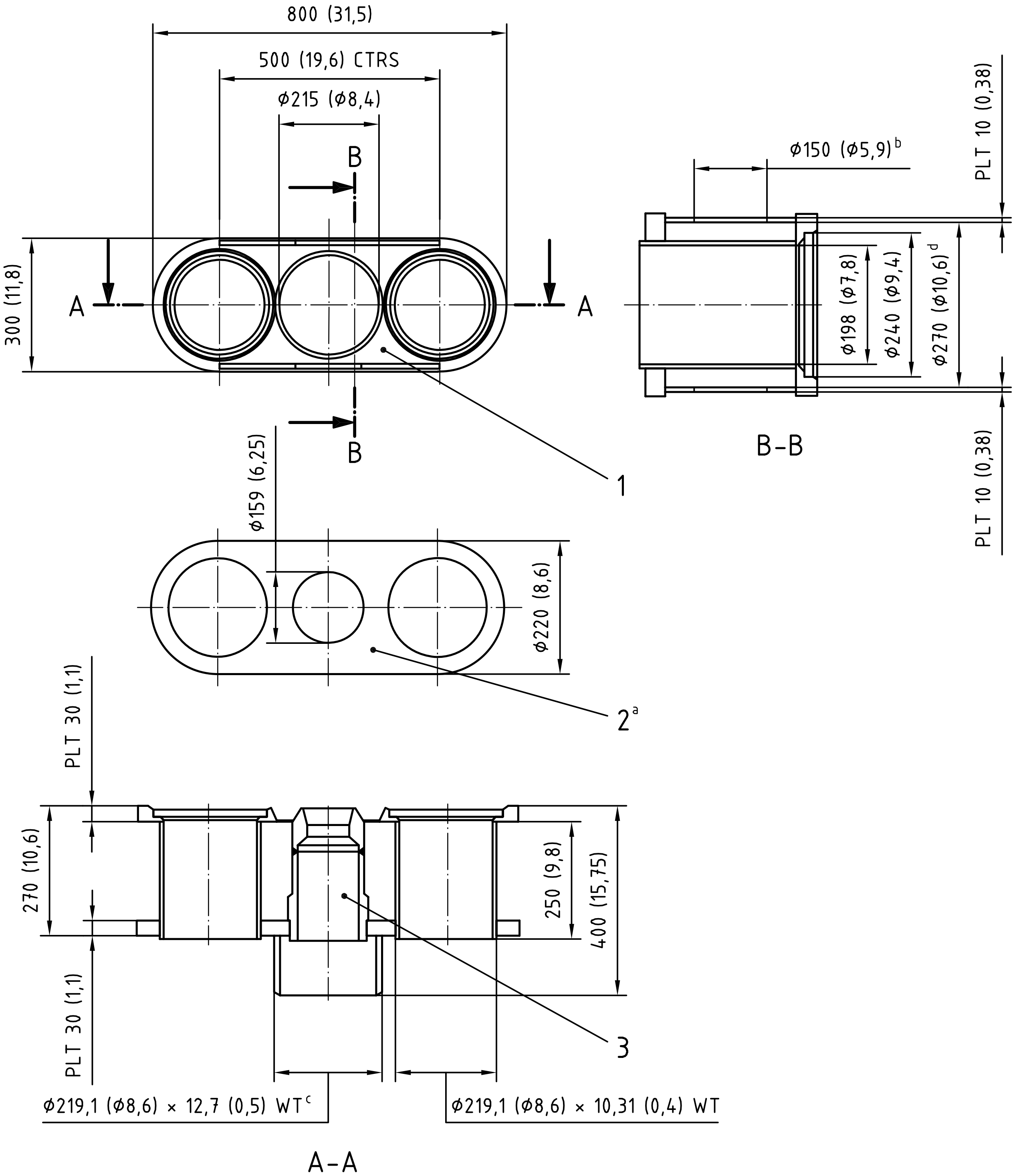
4 standard interface

5 minimum clear access outline

a Clear all round (typical).

Figure 23 — CCO (component change-out)

Dimensions in millimetres (inches)



Key

1 top plate

2 bottom plate

3 lockdown post (see Figure 25)

[a] Unspecified dimensions as per top plate.

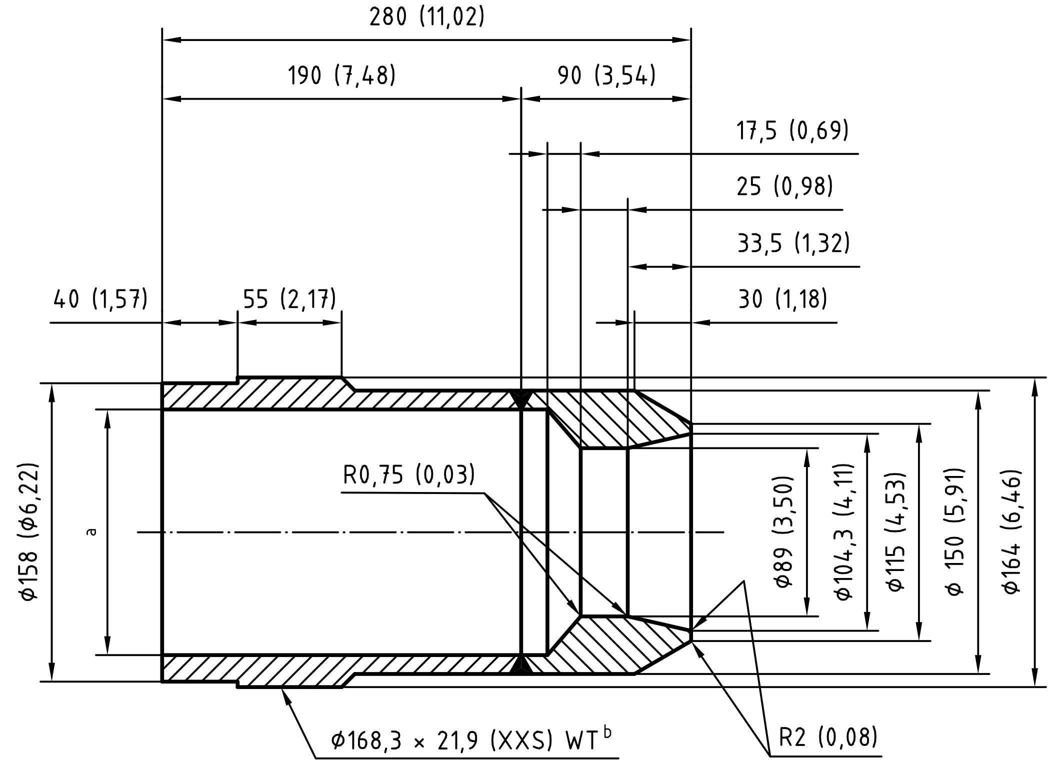
[b] New hole.

[c] API pipe.

[d] Between stiffs.

Figure 24 — CCO interface structure

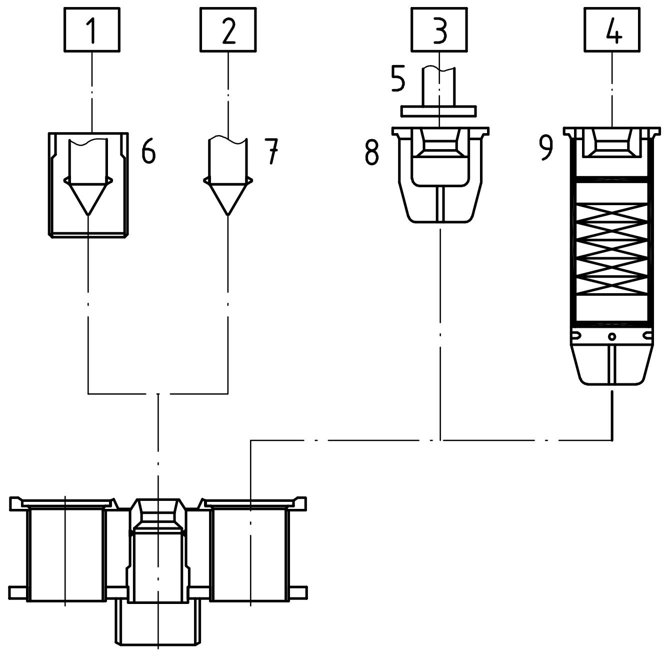
Dimensions in millimetres (inches)



[a] Nominal bore.

[b] API tube or bar stock.

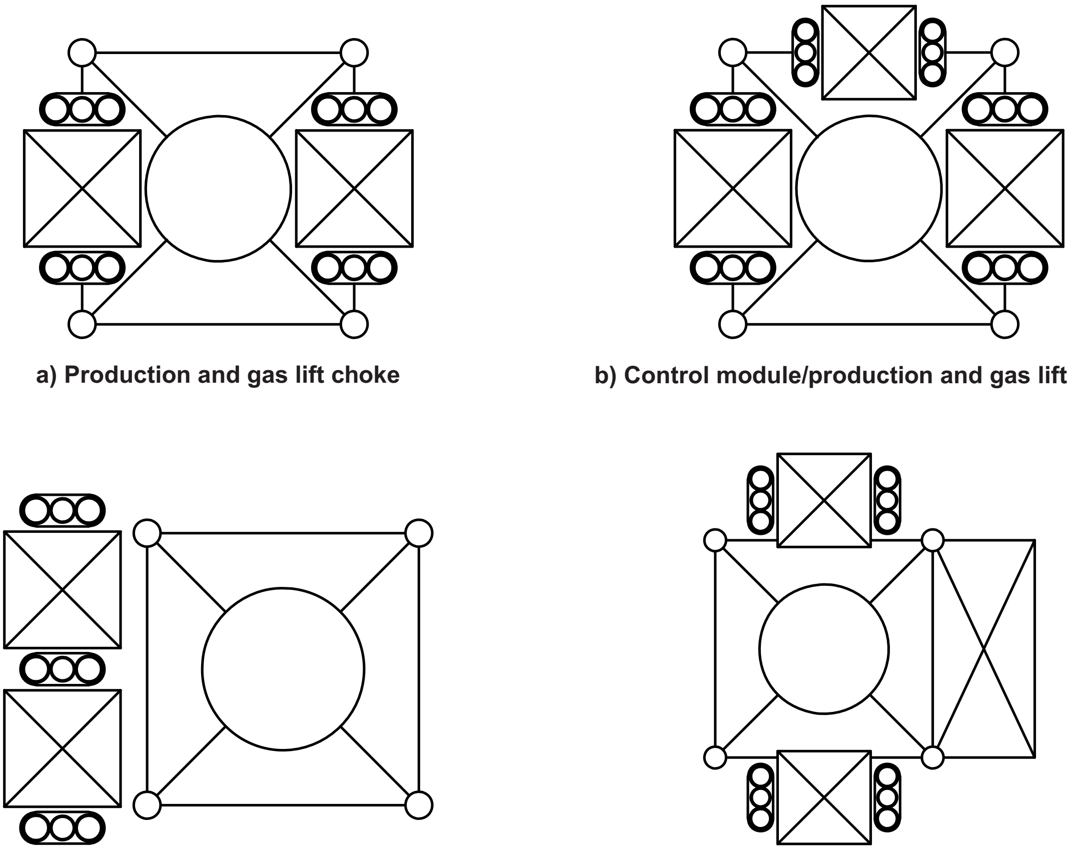
Figure 25 — CCO lockdown post detail



Key

1 high-capacity lockdown tool
2 lockdown tool
3 damped foot
4 weight exchange landing foot
5 landing damper
6 alignment panel
7 lockdown probe
8 cover plate
9 weight assembly

Figure 26 — CCO lockdown and weight system



a) Production and gas lift choke

b) Control module/production and gas lift choke

c) Shared interface

d) Horizontal tree

Figure 27 — CCO interface layout options

12.14 Lifting mandrels

The lifting mandrel designs presented have been developed for use with the component change-out tool interface. Two sizes provide for all current subsea replaceable payloads employed with the CCO interface. Typical examples of such applications are

— subsea control module,

— subsea choke insert,

— multi-phase flowmeter insert, and

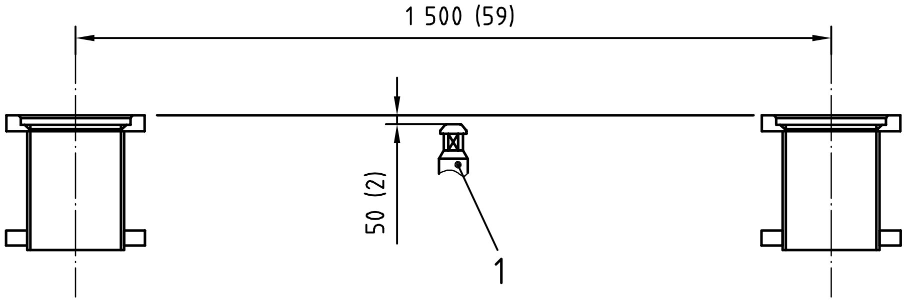
— valve insert.

With reference to Figure 29, the type A mandrel is employed for payloads up to 20 kN (4,5 klbf) gross weight (in air) and the type B mandrel for payloads greater than 20 kN (4,5 klbf) and up to 50 kN (11,2 klbf).

The mushroom-shaped top has been profiled to facilitate capture using a conical lead-in mechanism. The top of the mushroom is intended to be at the same elevation [or within 51 mm (2 in)] of the plane surface across the docking plates of the CCO interface. The machined flats are employed as an anti-rotational mechanism during payload transfer from the CCO tool into the subsea structure interface. These should be aligned such that the flats are transverse when the CCO interface is viewed as a front elevation (see Figure 28).

The connection interface for the mandrel to the payload is not defined. It can be implemented as a machined/bolted flange, weld socket connection or a threaded and pinned interface. The overall system will be subject to the recognized standard lifting certification testing prevailing within the geographical area of intended use or as specified by the end user.

Dimensions in millimetres (inches)

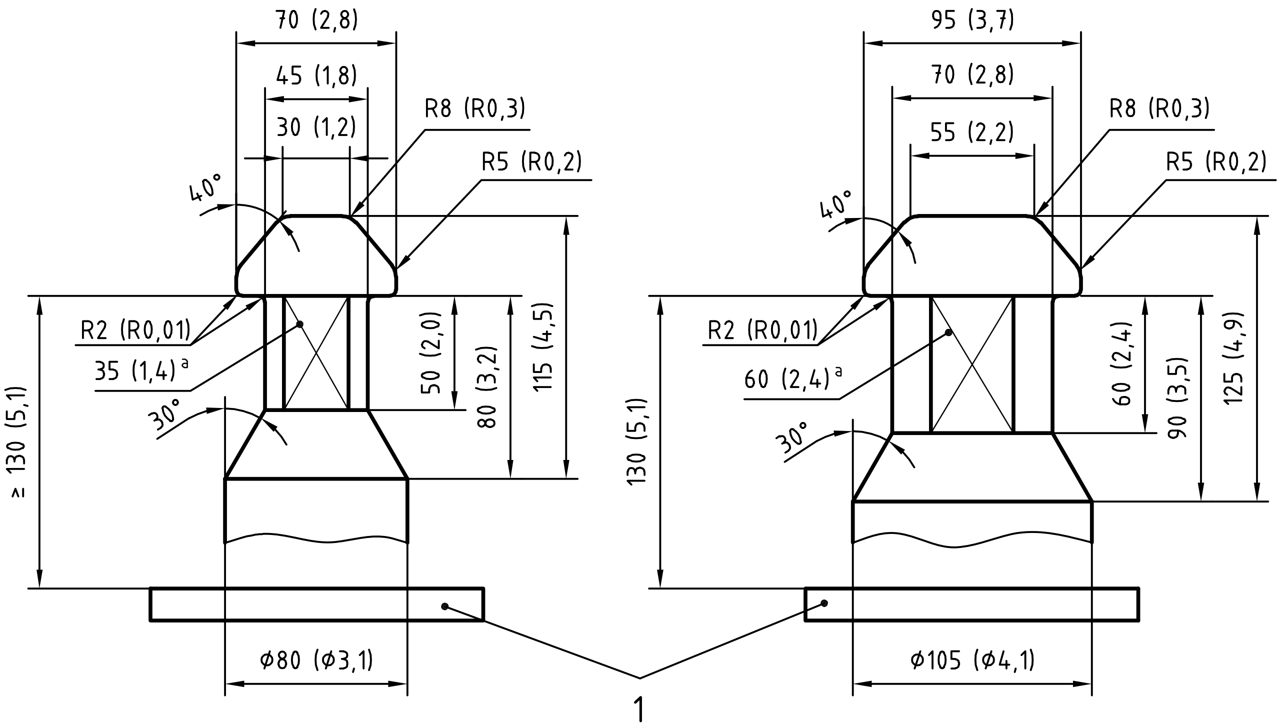


Key

1 orientation flat/lifting mandrel

Figure 28 — Lifting mandrel in relation to CCO interface

Dimensions in millimetres (inches)



a) Type A **a) Type B**

Key

1 attachment (design chosen to suit application)

[a] Across flat.

Figure 29 — Lifting mandrels

12.15 Electrical and hydraulic jumper handling

12.15.1 Function

This interface is for transferring, or installing, or both, electrical, hydraulic or combined electro-hydraulic jumpers associated with the interconnection of subsea production equipment.

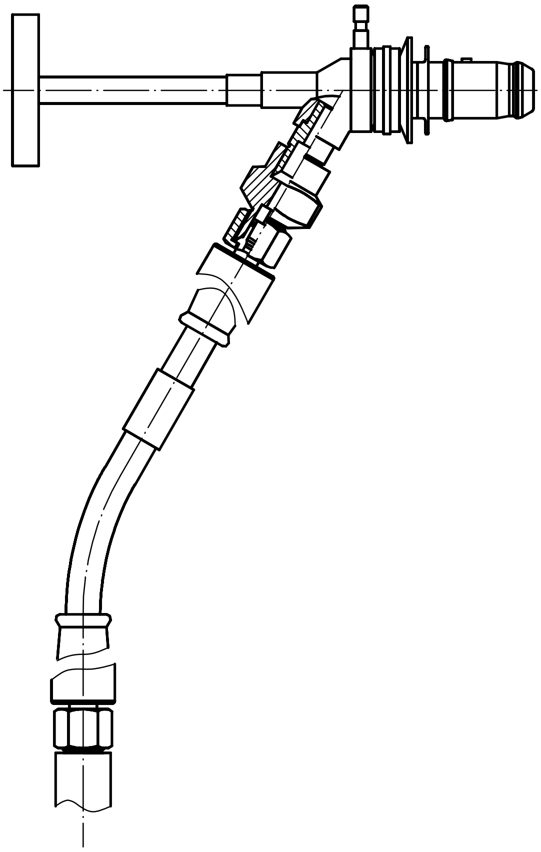
12.15.2 Application

It can be used for all “fly-to-place” connections/disconnections where the stab plate configuration and weight are within the capacity of the selected ROV.

12.15.3 Design

There are a significant number of subsea connection applications which require the transfer or installation of electrical, hydraulic or combined electro-hydraulic jumpers associated with the interconnection of subsea production equipment. The lengths of such jumpers range from a few metres to in excess of 100 m (328 ft). The jumpers are terminated either with a single electrical connector/hydraulic coupling or a number of connections assembled as a stab plate.

Figure 30 shows an electrical connector with an oil-filled hose conduit connection interface suitable for single connection jumpers.



NOTE Handle for use with manipulator (see Figure 11). Handle can also include compliant section (see Figure 19).

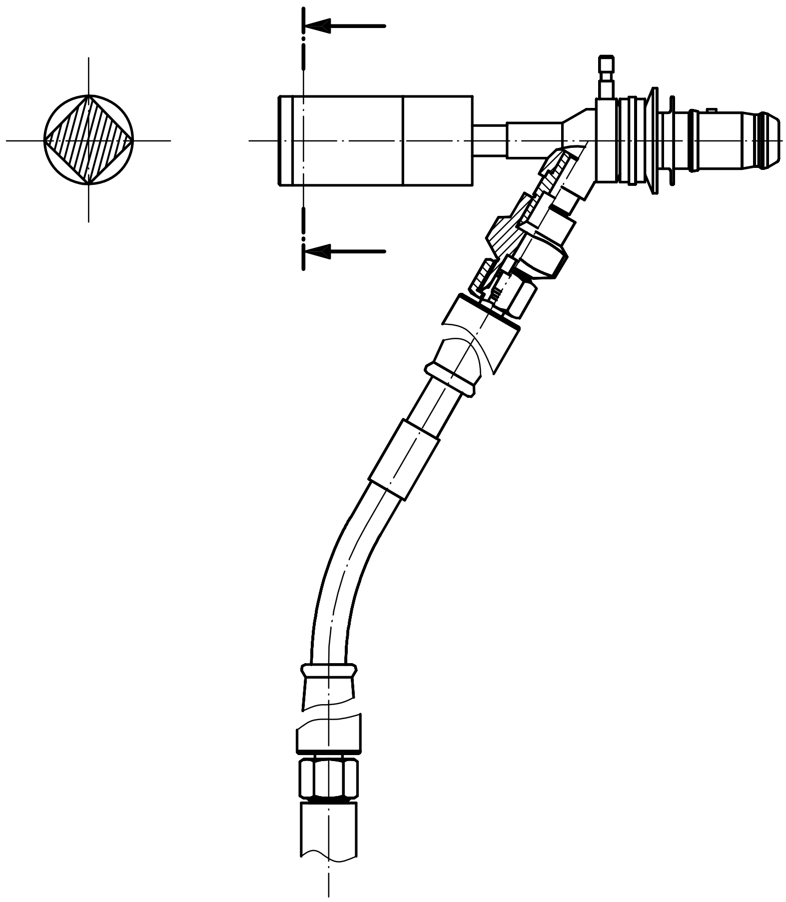
Figure 30 — Manipulator connection operations

Alternatively, a TDU gripper interface may be mounted to the rear of the connector, which provides an interface for the same connector for TDU operations (see Figure 31).

Whereas single-connection interfaces can be implemented for either manipulator or TDU operations, MQC stabplates are more easily handled by TDU equipment or a combination of manipulator and tool elevator (see 4.3.2). The locking system interface should be as shown in Figure 32 and Figure 33.

Where an application requires several connections to be made simultaneously, these are generally mounted onto a support plate, with proprietary subsea-mateable electrical or hydraulic connectors, or both, employed for individual interconnections. Such MQC stab plates may be required to provide a mating force against separating influences of mechanical insertion (self-sealing elements) and powered hydraulic supplies, and therefore a positive screw-locking mechanism is required which can generate sufficient force to make and break the connection. In addition to a combined central locating/locking pin a secondary alignment pin is recommended to provide controlled orientation of the stab plate for make-up. A clamping mechanism for position control and stress relief of the individual conduit hoses or cables or both is also necessary for tooling access and operations.

With reference to the relevant figures in this part of ISO 13628, all numerically dimensioned parameters are proposed as standard, non-defined dimensions and are optional or to suit the application.



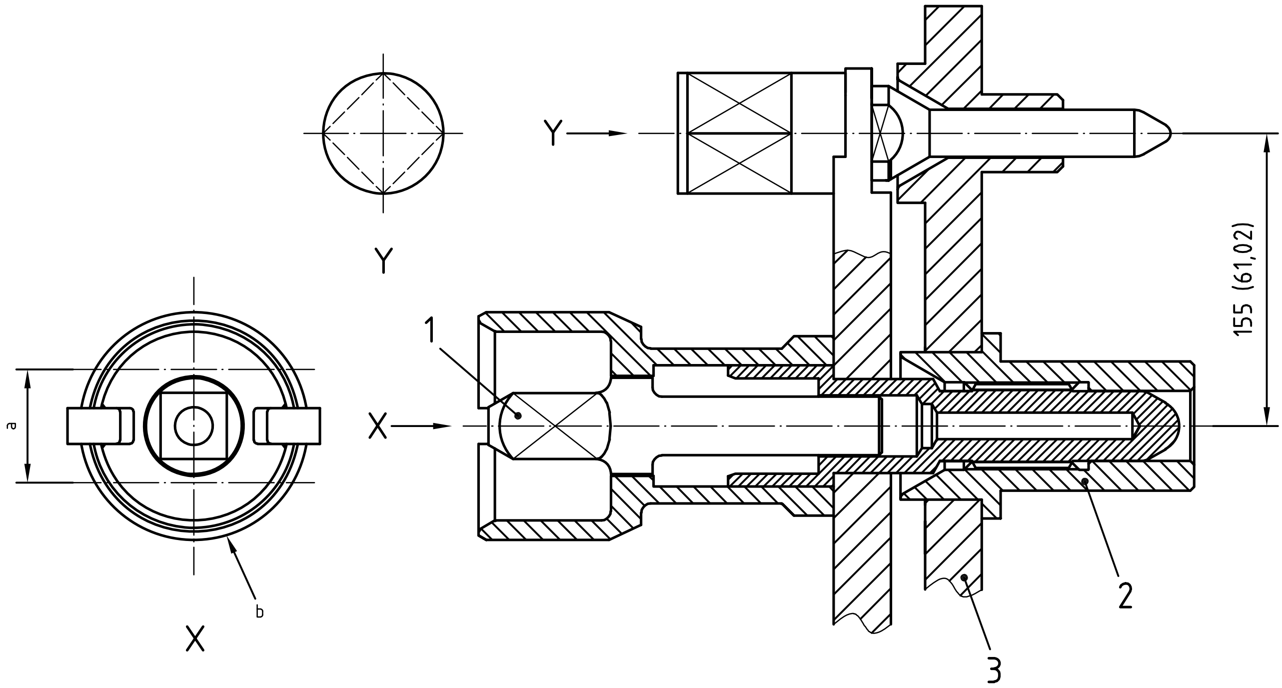
NOTE 1 Handle for use with TDU (see Figure 12).

NOTE 2 Gripper envelope (see Figure 34).

Figure 31 — TDU connection operations

Figure 32 shows a termination handling method and offset between the recommended handle and a central locking system. The material specification, plate shape and thickness are dependent upon the forces required; they are to be derived from individual application requirements and are outside the scope of this part of ISO 13628. The mechanism for locking is not defined; however, a good practice would be to incorporate a release mechanism for the inboard locking assembly in the event of stab plate jamming.

Dimensions in millimetres (inches)



Part section shows ROV interfaces only.

Key

1 stabplate drive screw

2 locking mechanism (inboard)

3 tree stabplate

[a] Receptacle may be truncated for minor weight-saving.

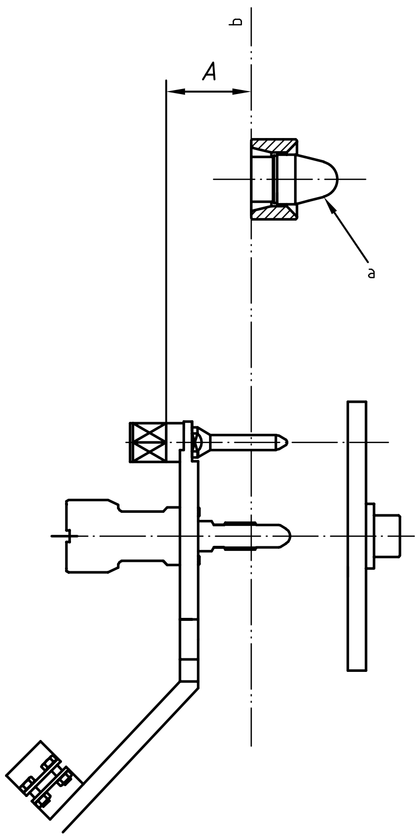
[b] See Figure 14.

Figure 32 — Multiple-connection jumper stabplate

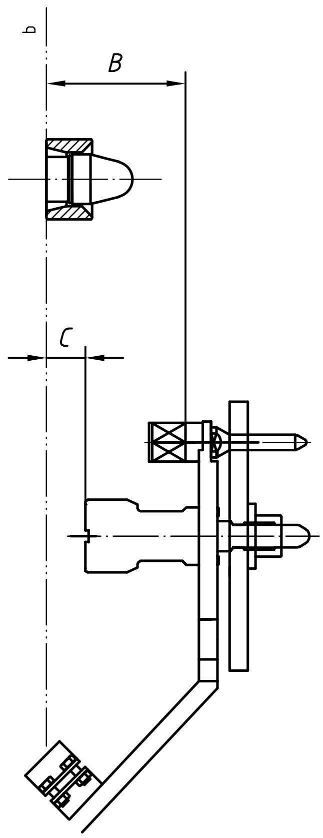
Figure 33 shows an MQC plate populated with hydraulic couplings. A similar arrangement could incorporate all electrical or a combination of electrical and hydraulic connections.

The recommended parameters are based upon use of the twin-TDU system operating envelope for the case of ROV transfer, which allows for two MQC plates to be designed within a single docking station. This will entail a total of five plates, two MCQs, two parking places and an intermediate park to temporarily place the protective cover plate during the operation. The same parameters will apply to the situation where the jumpers are diverless-installed, when the terminations are delivered by a special fly-in tool attached to the host vehicle.

Dimensions in millimetres (inches)



a) Disengaged position



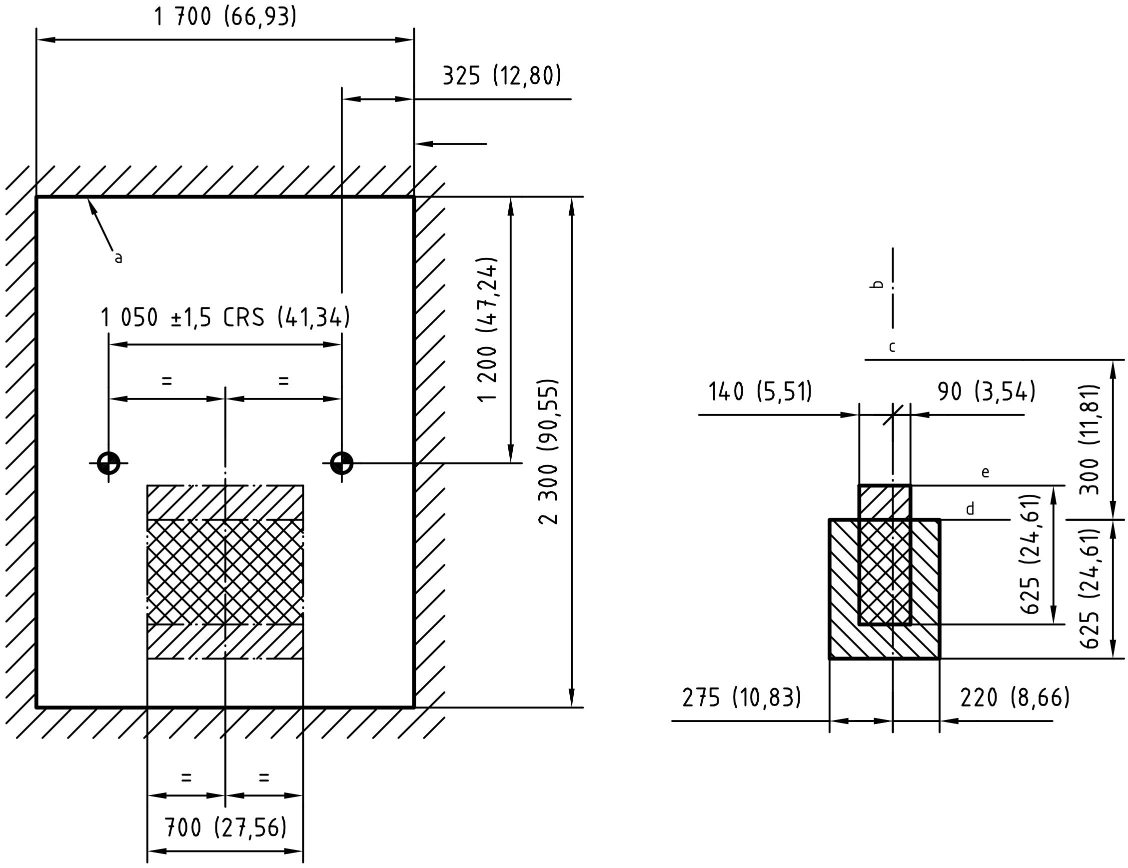
b) Fully engaged position

A	= 140 mm (5,5 in) max.
B	= 90 mm (3,5 in) max.
A + *B*	= 230 mm (9,0 in) max. = TDU “Z” stroke
C	= 270 mm (10,6 in) max.

[a] See Figure 7.
[b] Docking face.

Figure 33 — Typical jumper in disengaged/engaged positions

Dimensions in millimetres (inches)



a Recommended clearance area to permit access and allow for cameras, support brackets, etc.

b Docking face.

c Centre line of docking probes.

d Torque tool.

e Gripper.

Figure 34 — Combined gripper and torque tool envelopes for jumper handling

Annex A
(informative)

Summary of work class ROV specifications

Table A.1 describes a range of vehicles in operation at the time of publication[2)]. The dimensions and weights are provided as guidance only for use in the design of ROV interfaces.

Table A.1 — Range of ROVs

ROV	Length		Width		Height		Mass	
	mm	(in)	mm	(in)	mm	(in)	kg × 10^3	(klb)
Challenger	2 475	(97,44)	1 400	(55,12)	1 325	(52,17)	1,71	(3,76)
Hysub 60	2 510	(98,82)	1 420	(55,91)	1 480	(58,27)	1,77	(3,89)
Pioneer	1 620	(63,78)	1 620	(63,78)	1 620	(63,78)	1,34	(2,96)
Super Scorpio	2 500	(98,43)	1 500	(59,06)	1 700	(66,93)	2,25	(4,95)
Triton	2 440	(96,06)	1 420	(55,91)	1 320	(51,97)	2,27	(5,00)
Trojan	2 200	(86,61)	1 600	(62,99)	1 600	(62,99)	1,84	(4,05)
MRV	2 300	(90,55)	1 500	(59,06)	1 560	(61,42)	1,90	(4,18)
SCV	2 500	(98,43)	1 500	(59,06)	1 700	(66,93)	2,81	(6,18)
Examiner	2 000	(78,74)	1 950	(76,77)	1 800	(70,87)	1,73	(3,82)
Diablo	2 466	(97,09)	1 500	(59,06)	1 750	(68,90)	1,94	(4,27)
Triton XL	2 440	(96,06)	1 480	(58,27)	1 620	(63,78)	3,06	(6,74)
Hydra magnum	2 400	(94,49)	1 400	(55,12)	1 700	(66,93)	2,03	(4,47)
Hydra millennium	3 000	(118,11)	1 524	(60,00)	1 700	(66,93)	2,22	(4,90)
In order to take advantage of ROVs of opportunity, interfaces should be designed with a mass of 2 500 kg to 3 000 kg (5 510 lbs to 6 612 lbs). NOTE This list is not exclusive and is indicative of the different sizes of vehicle available.								

2) These are examples of products available commercially. This information is given for the convenience of users of this part of ISO 13628 and does not constitute an endorsement by ISO of these products.

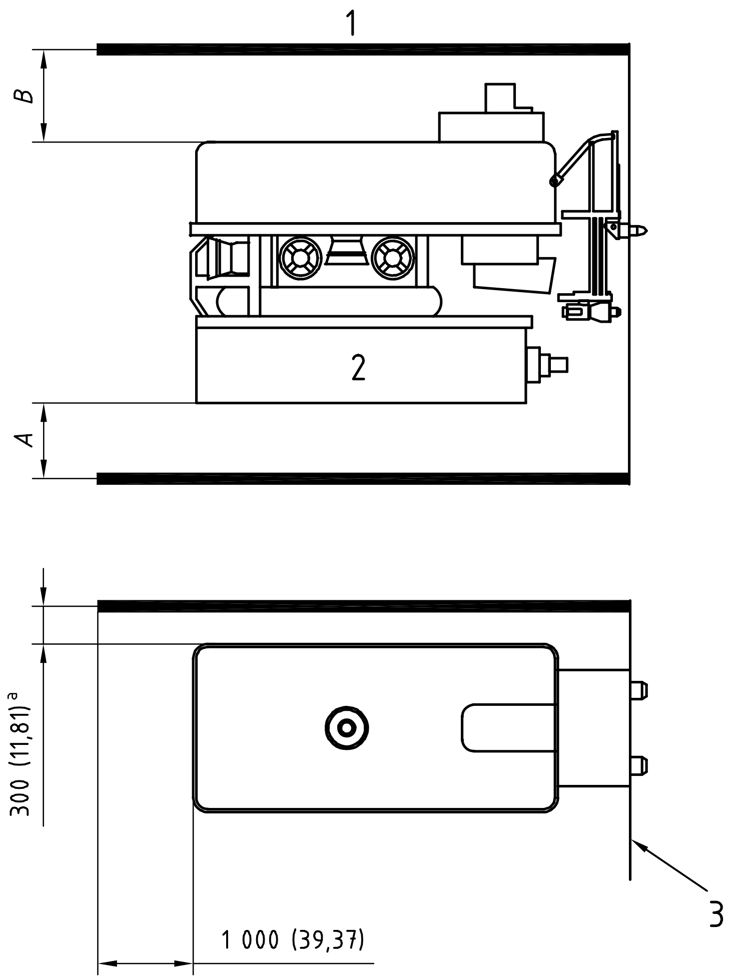
Annex B
(informative)

Access

Typical clearances required for vehicle operations are shown in Figure B.1.

Where the recommended clearances cannot be achieved, care shall be taken to ensure that the possibility of losing the ROV is avoided.

Dimensions in millimetres (inches)



A clear distance to the bottom of the ROV or underslung tooling package of 500 mm (19,68 in) min. is recommended. Clearance above the ROV should take account of the umbilical connection.

Key

1 structure

2 tooling package

3 face of structure

[a] Typical.

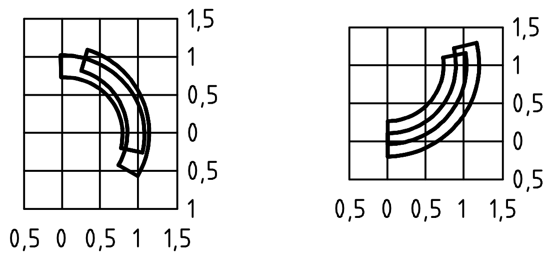
Figure B.1 — Clearances

Annex C
(informative)

Manipulator operating envelopes

The operating envelopes for a normal range of standard manipulators, are shown in Figures C.1 and C.2.

Scale in metres

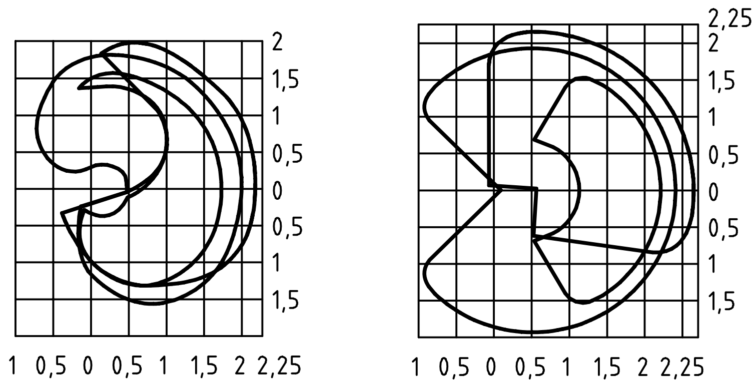


a) Side view

b) Plan view

Figure C.1 — Typical five-function grabber envelopes

Scale in metres



a) Side view

b) Plan view

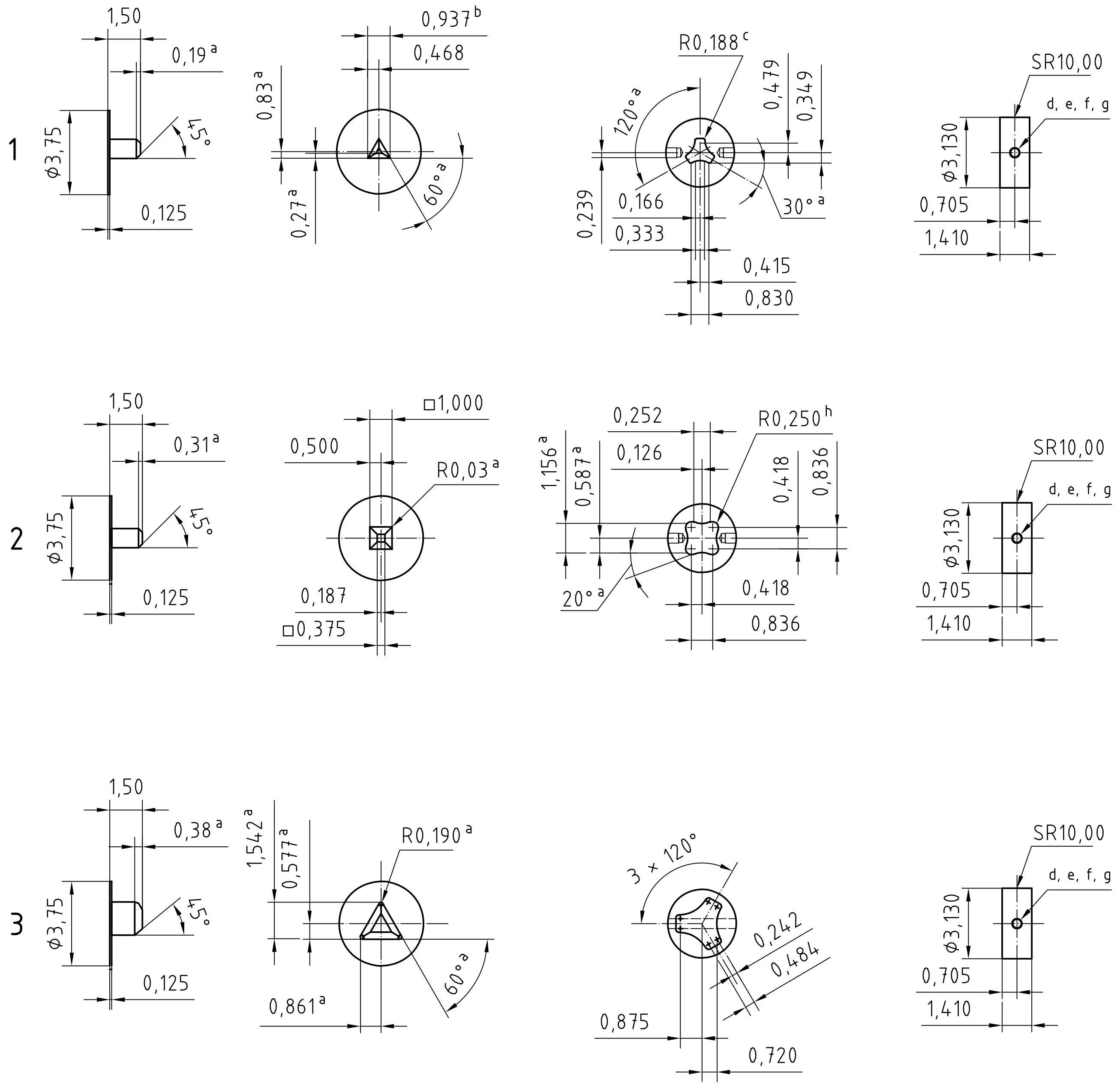
Figure C.2 — Typical seven-function manipulator envelopes

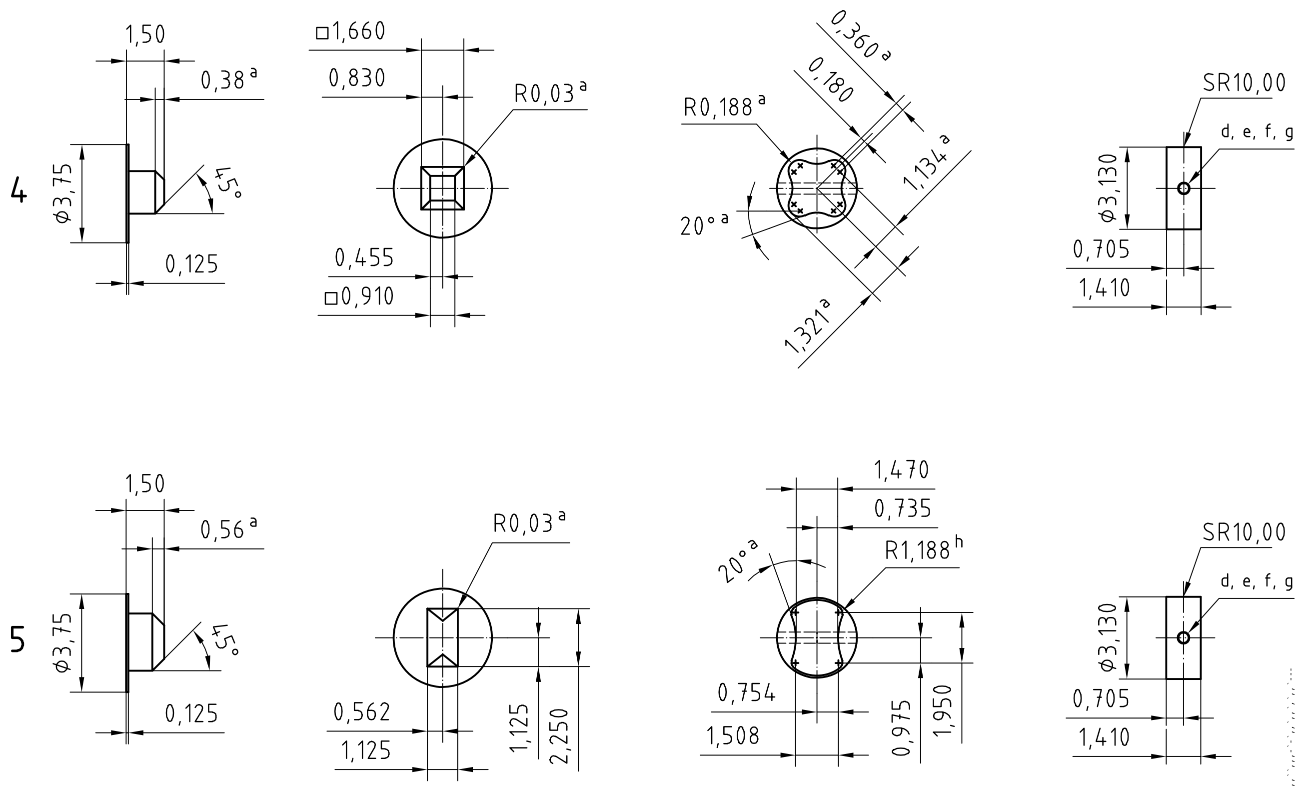
Annex D
(informative)

Alternative designs for end-effectors

There are cases where there might be a requirement to ensure, in a positive manner, that valves cannot be subject to over-torque. To achieve this a series of end-effectors have been developed, applicable to the full range of torque values from 0 kN·m to 2,71 kN·m (0 lbf·ft to 2 000 lbf·ft). Their designs are shown in Figure D.1.

Dimensions in inches





Key

1 15/16 in triangle to 50 lbf·ft

2 1 in square, 51 lbf·ft to 200 lbf·ft

3 2 in triangle, 201 lbf·ft to 500 lbf·ft

4 1,66 in square, 201 lbf·ft to 500 lbf·ft

5 (11/8 × 21/4) in rectangle 851 lbf·ft to 2 000 lbf·ft

[a] Typical.

[b] Before radius.

[c] Three places.

[d] 27/64 drill × 75 DP.

[e] 0,781 C bore × 0,10.

[f] 1/2-13 UNC-2B × 0,60 DP

[g] Two places, 180° apart.

[h] Four places.

Figure D.1 — Alternative profiles for end-effectors

Annex E
(informative)

Flowline tie-in systems

E.1 General

Flowline connection without the use of divers has been in use for a significant number of years. Connection and tie-in by diver-less systems of flexible or rigid flowlines, umbilicals or all these is a prerequisite for deepwater developments.

A typical connection system would consist of the inboard hub (mounted on the subsea tree or manifold), the outboard hub (connected to the end of the flowline), a seal plate, clamp and the connection tooling.

The inboard hub normally has minimal movement in the horizontal plane and the flowline (outboard) hub is normally pulled in towards the inboard hub, where it locates onto the seal plate. The system is typically finally connected by clamp using the ROV tooling, which activates one or two jackscrews or a collet connector.

E.2 Connection method

Pull-in of hubs can be in the horizontal plane, with or without buoyancy, or of a hinge and lockdown type assembly.

Hot stabbing for seal tests and also operation of jackscrews is normal.

A seal assembly and connection can also include hydraulic couplings.

The connector should

- achieve a reliable diver-less connection, that is capable of being tested for its integrity (sealing will be either metal-to-metal or a combination of metal and elastomeric sealing),
- achieve a short-stroke connection minimizing hub movement and residual stress, and
- allow seal replacement.

Bibliography

[1] API 17D, *Specification for subsea wellhead and christmas tree equipment*

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