

Remotely Operated Tools and Interfaces on Subsea Production Systems

API RECOMMENDED PRACTICE 17H
FOURTH EDITION, XXXX 2023

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Foreword

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Introduction

This Recommended Practice provides general recommendations and overall guidance for the design and operation of remotely operated tools comprising ROT, ROV and AUV tooling, used on subsea production systems for the petroleum and natural gas industries worldwide.

The fourth edition of this document incorporates a design for docking of Autonomous Underwater Vehicles (AUV).

This RP provides guidance when designing for subsea operations to interact with (or near) subsea production systems. The framework and specifications set out will enable the user to design the appropriate interface for a specific application.

Specific recommendations are provided where a standard design or operating principles has been adopted and are accepted as standard industry practice. Requirements valid for certain geographic areas or environmental conditions are included where applicable.

The functional recommendations for the tooling systems and interfaces on the subsea production system allow alternative solutions to suit the field specific requirements. The intention is to facilitate and complement the decision process rather than replace individual engineering judgment and to provide positive guidance for the selection of an optimum solution.

Remotely Operated Tools and Interfaces on Subsea Production Systems

1 Scope

API Recommended Practice 17H provides recommendations for developing and designing remotely operated subsea tools and interfaces on subsea production systems to maximize the potential of standardizing equipment and design principles.

This document does not cover manned intervention, internal wellbore intervention, internal flowline inspection, tree installation, and tree running equipment. However, all the related subsea ROV/ROT/UUV/AUV interfaces are covered by this standard. The Recommended Practice applies to the selection, design, and operation of ROT, ROV, UUV, and AUV, including subsea vehicle tooling, hereafter defined as “subsea intervention systems”.

This Recommended Practice (RP) provides:

- a) functional requirements and guidelines for ROV/ROT/UUV/AUV interfaces
- b) guidance for the selection and use of ROV/ROT/UUV/AUV interfaces related to subsea production equipment
- c) guidance on design and operational requirements
- d) guidance for maximizing the potential of standardized equipment and design principles

The issues this RP identifies should be considered when designing for ROV/ROT/UUV/AUV operations to interact with (or near) subsea production systems. The framework and specifications set out will enable the user to design the appropriate interface for a specific application. These interfaces include subsea docking, recharging, data transfer, data harvesting, and mechanical intervention.

Resident ROVs/AUVs near the seabed can provide high value for oil and gas inspection, monitoring, and maintenance and repair activities. The benefits of employing resident ROVs/AUVs include reduced operating costs and improved safety.

The guidelines established in this RP will lead to efficient development and deployment of ROV/ROT/UUV/AUV systems, providing clarity for operators, contractors, and developers. Recommendations have been provided in a flexible manner to accommodate a wide variation of AUV styles and applications, while maintaining an appropriate level of interface commonality for specification.

This document defines four major categories of hot stabs and describes the geometry to maintain compatibility across all manufacturers. The categories were first introduced in Tech Report 17TR15, which described several common or previously used hydraulic hot-stab & receptacle configurations. The approach is to ensure backward compatibility of the hot stabs described in API Recommended Practice 17H, 2nd Edition and to align API RP 17H with API S53 and API 16D.

This Recommended Practice is not intended to replace sound engineering judgment as to when and where its provisions are to be utilized. Users need to be aware that additional or differing details may be required to meet a specific service or local legislation.

This document is not intended to deter the development of new technology. The intention is to facilitate and complement the decision making process. The responsible engineer is encouraged to review standard interfaces and re-use intervention tooling to minimize life-cycle costs and increase the use of proven interfaces.

2 Normative References

The following referenced documents are 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.

API Specification 6A, Specification for Wellhead and Tree Equipment

API Recommended Practice 17A: *Design and operation of subsea production systems – General requirements and recommendations*

API Specification 17D, *Specification for Subsea Wellhead and Tree Equipment*

API Specification 17F, Specification for Subsea Production Control Systems

API Standard 53, Blowout Prevention Equipment for Drilling Wells

API Specification Q1, *Specification for Quality Programs for the Petroleum, Petrochemical and Natural Gas Industry*

ISO 9001:2015, *Quality Management Systems - Requirements*

ASNT SNT-TC-1A, *Recommended Practice and ASNT Standard Topical Outlines for Qualification of Nondestructive Testing Personnel*

DNV 2.7, *Series*

API Specification 16D, Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment

EEMUA Publication 194, Guidelines for materials selection and corrosion control for subsea oil and gas production equipment

ANSI C84.1, For Electric Power Systems and Equipment—Voltage Ratings (60 Hertz) (2020)

IEEE 802.11 b/g/n (Wireless Local Area Networks)

IEEE STD C62.41, Recommended Practice Surge Voltages in Low Voltage AC Power Circuits (2005)

3 Terms, Definitions and Abbreviated Terms

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions:

3.1.1 **autonomous underwater vehicle** **AUV**

free-swimming submersible craft used to perform tasks such as inspection, data collection and transfer, and other general IMR tasks

3.1.2 **data harvesting**

methodology employed by an AUV and its associated equipment to capture and/or store data in a subsea environment.

3.1.3

data transfer

methodology employed by an AUV and the associated equipment to allocate or relocate data in a subsea environment.

3.1.4

deployment system

all equipment involved in the launch and recovery of the ROV and ROT system

3.1.5

design validation

confirmation that the operational requirements for a specific use or application have been fulfilled, through the provision of objective evidence

NOTE Typically validation is achieved by qualification testing and/or System Integration Testing.

3.1.6

design verification

confirmation that specified design requirements have been fulfilled, through the provision of objective evidence

NOTE Typically verification is achieved by calculations, design reviews, hydrostatic testing and Factory Acceptance Testing.

3.1.7

docking base

bottom-founded structure (either gravity-based or installed with a suction pile or similar technique) or a feature that is structurally integrated with the subsea facility that is cabled either back to the subsea facility or connected to shore

3.1.8

docking structure

replaceable feature that is fitted with guide cones to accept the guideposts on the docking base and connectors on cables to mate with those on the docking base

3.1.9

guideline

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

3.1.10

heave-compensated system

system that limits the effect of vertical intervention vessel motion on the deployed ROV and ROT system

3.1.11

hot stab

pressure balance coupling utilized for making temporary and permanent subsea fluid connections

3.1.12

independent sensor

any sensor which is not typically integrated into the rest of the subsea facility's customary sensing system and could include accelerometers, temperature sensors, strain gages, acoustic sensors, or others

3.1.13

manufacturer

company responsible for the manufacture of the equipment

3.1.14

operator

company which physically operates the subsea vehicle (delivery system)

3.1.15

payload

amount of additional tooling weight carried on the vehicle when it is trimmed neutrally buoyant in seawater

3.1.16

pull-in head

end of pipeline acting as attachment point for the pull-in wire

3.1.17

recharging

methodology employed by an AUV and its associated equipment to replenish its onboard power source(s)

3.1.18

remotely operated vehicle

ROV

free-swimming or tethered submersible craft used to perform tasks such as inspection, 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 rigid spools, flexible flowlines, umbilicals, and component replacement. Alternatively, modules or tools may be deployed by crane and mated with the ROV subsea.

ROVs are grouped within the following main categories:

OBSROV – (IMCA class I & II) These vehicles are small vehicles fitted with cameras/lights and may carry sensors or inspection equipment. They may also have a basic manipulative capability. They are mainly used for inspection and monitoring.

WROV – (IMCA class III) These vehicles are large ROVs normally equipped with a five-function grabber and a seven-function manipulators. These commonly have multiplexing controls capability that allows additional sensors and tools to be operated without the need for a dedicated umbilical system. WROV are split into two classes: medium WROV and large WROV depending on their defined work scope. WROVs can carry tooling packages to undertake specific tasks such as tie-in and connection function for flowlines, umbilicals and rigid pipeline spools, and component replacement.

RRV – (IMCA class I,II,III) These vehicles can be any size and have various capabilities. They are distinguished as an ROV/AUV which is parked subsea for extended periods of time.

3.1.19

ROT system

dedicated, unmanned, subsea tools used for installation and IMR tasks that require lift and/or handling capacity beyond that of free-swimming subsea vehicle systems

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

3.1.20

ROV toolskids

equipment skids or packages that can be attached onto the external surface of the subsea vehicle and are used to perform dedicated tasks

3.1.21

skid system

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

NOTE Skids are used in combination with a skidding system.

3.1.22

subsea vehicle

generic term which refers to an ROV, AUV, UUV, or ROT

3.1.23

termination head

part of the tie-in system interfacing with the end of the pipeline or flowline

3.1.24

tie-in system

integrated or separate pull-in and connection related equipment

3.1.25

underwater intervention drone

a hybrid vehicle capable of switching between ROV mode and AUV mode. UID's can perform tether-less intervention; either through teleoperation/piloting through wireless communication, fully autonomous intervention.

3.2 Abbreviated Terms

For the purposes of this document, the following abbreviated terms apply:

AC	Alternating Current
ANSI	American National Standards Institute
API	American Petroleum Institute
AUV	Autonomous Underwater Vehicle
BOP	blowout preventer
BSP	British Standard Pipe
CCO	component change-out
CoB	Center of Buoyancy
CoG	Center of Gravity
EEMUA	Engineering Equipment and Materials Users Association
EMI	electromagnetic interference
FAT	Factory Acceptance Test
FMECA	Failure Mode Effect and Criticality Analysis
HAZOP	hazardous operations
HIPPS	High Integrity Pressure Protection System
HPU	Hydraulic Power Unit
ICS	Intervention Control System
IEEE	Institute of Electrical and Electronics Engineers
IMCA	International Marine Contractors Association,
IMR	Inspection, Maintenance and Repair
ISO	International Organization for Standardization

LARS	Launch and Retrieval System
MILSPEC	Military Specification
MPFM	Multi-Phase Flow Meter
MQC	Multi Quick Connector
MTBF	Mean Time between Failures
NAS	National Aerospace Standard
NPT	National Pipe Thread
NPT	National Pipe Thread
Ø	diameter
OBSROV	Observation Class ROV
OEM	Original Equipment Manufacturer
PLEM	Pipeline End Manifold
PLET	Pipeline End Termination
ROT	Remotely Operated Tool
ROV	Remotely Operated Vehicle
RP	Recommended Practice
RROV	Resident ROV/AUV
SAE	Society of Automotive Engineers
SAFOP	safe operations
SDB	Subsea Docking Base
SDS	Subsea Docking Station
SPS	Subsea Production system
TDU	Tool Deployment Unit
TMS	Tether Management System
TR	Technical Report
USC	United States Customary (units)
UUV	Untethered Underwater Vehicle
UID	Underwater Intervention Drone
WROV	work class ROV

4 Subsea Facilities Design

4.1 Intervention Philosophy

This RP recommends taking a system wide approach to the design and implementation of subsea interventions. An intervention philosophy should be established when designing subsea vehicle interfaces for subsea systems. The interface philosophy should consider the various interface tasks, rationalizing them so that a consistent method is adopted and identifying which tasks can be performed consecutively.

The intervention philosophy should address:

- a) the activities to be carried out;
- b) the method of interfacing for each task;
- c) the type of tooling required;
- d) the method of stabilization of the vehicle (e.g., docking, station keeping, or positioning);
- e) access requirements.

The design, configuration, and operation of the subsea intervention system directly impacts the life cycle cost of the subsea production system. It is important to have alignment between subsea production system design and the subsea intervention system design to obtain a subsea production system design that provides safe and cost-effective intervention operations.

A system approach is required to develop an optimum subsea system and associated remotely operated tooling system design. The principal focus areas are standardization of interfaces, equipment, and intervention methods. Subsea intervention systems should be designed in parallel with subsea production systems to allow for intervention friendly solutions for the life of the field.

The design should focus on the safe and efficient handling, including deck handling, operation, and maintainability of the subsea tools and interfaces. A system for testing after mobilization should be provided.

The primary impact on the system design is access to the interface for subsea vehicles and applicable tooling or interfacing hardware. Intervention access requirements can vary significantly depending on the interface and intervention method and interface location. Intervention access should be addressed early in the design and documented in the intervention philosophy.

In determining the suitability of standardization of remotely operated tooling system interfaces for installation, maintenance, or inspection tasks on subsea equipment, it is necessary to adopt a general philosophy regarding subsea intervention. Details of the intervention philosophy is described within this Recommended Practice, as are the associated evaluation criteria used in selecting the interfaces incorporated into these recommendations.

4.2 Intervention Strategies

The development of an intervention strategy is of high importance for the overall field architecture. It should be determined based on a multidisciplinary systems approach at an early stage of systems engineering.

The intervention strategy may be based on use of a combination of tooling, including ROV, AUV, UUV, and ROT technologies.

The selection of equipment and intervention methods should be decided when establishing the intervention strategy.

Common recommendations for the subsea intervention systems should be used as far as practical. However, specific recommendations for ROV, AUV, UUV, and ROT systems and their subsystems are included in separate chapters where design or operational requirements are required.

Equipment should be designed for the effective execution of the intended purpose under the environmental operating conditions in which it is to work. Simplifying interfaces and reducing transit hazards (entanglement, collisions) reduces the required complexity, reduces cost, and increases reliability.

The following are aspects impacting the intervention strategy and should be addressed when developing an intervention strategy:

- a) field development plan;
- b) field architecture and infrastructure;
- c) environmental and metocean data;
- d) mobilization and demobilization of subsea intervention systems and associated modules;
- e) deck handling principles;
- f) standardization of tools and interfaces;
- g) quantity of tools (including back-up tools and tools needed onshore during fabrication and testing);
- h) guidance method of modules and tools;
- i) replacement in one or two tooling missions;
- j) multi-purpose tools versus dedicated tools;
- k) the selection of mechanically operated tools versus hydraulically or electrically operated tools;
- l) reuse of intervention systems;
- m) wet storage of tools;
- n) categorization of critical and non-critical operations;
- o) deck space requirement and deck layout;
- p) operational issues related to the IMR vessel, (e.g., simultaneous operations between subsea intervention and drilling or completion activities);
- q) environmental aspects, (e.g., water depths, current conditions, and seabed conditions);
- r) access at the subsea location;
- s) need for technology qualification;
- t) subsea worksite tool function verification equipment, (e.g., torque or pressure verification);
- u) need to develop a testing philosophy.

4.3 Intervention System Design

4.3.1 Subsea Intervention System Development

Subsea intervention systems should be designed for all phases of an intervention operation, which typically are:

- a) mobilization (specific issues at the location in question);
- b) deck handling and preparation;
- c) launch, descent and landing;
- d) planned & unplanned intervention and task;
- e) testing;
- f) retrieval;
- g) demobilization;
- h) contingency operations;
- i) emergency situations, (e.g., IMR vessel drift off);

The subsea intervention systems operating philosophy should be developed with the following design inputs:

- 1) availability requirements (logistics and mobilization time for equipment);
- 2) field-specific parameters (water depth, wave, current, seabed conditions and surface conditions);
- 3) intervention vessel requirements and interfaces (e.g., deck space requirement and deck layout);
- 4) vehicle requirements, including the number and class of the subsea vehicle required to perform the various intervention tasks;
- 5) Intervention task-specific parameters (planned versus unplanned operation, complexity, frequency and subsea interfaces).

4.3.2 Fail Free Interfaces

Interfaces for AUVs and their associated operating equipment should be designed such that in the event of a power failure, the devices are released from the subsea equipment. This will allow AUV to be retrieved to the surface.

4.3.3 Minimizing Damage Potential

Interfaces should be designed such that the potential for damage is minimized during the positioning, docking, and operation of interface and/or intervention equipment. Any retrievable portion of the interfacing, including the part(s) attached to the vehicle, should yield before damage occurs to the subsea equipment.

4.3.4 Load Reaction

Loads imposed on the interface by the interface and/or intervention equipment should be utilized 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.

4.3.5 Minimizing Interference

Interfaces should minimize potential entanglement and snagging with interface and intervention equipment.

4.3.6 Positioning Control

In performing tasks on subsea equipment, a positive means of stabilization should be provided (see section 6.3), minimizing the need for the subsea vehicle 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.

4.3.7 Temperature Requirements

Subsea equipment should be designed and rated to operate throughout a temperature range of 5°F to 113°F (-15°C to 45°C), designated as such to suit surface testing of equipment. For specific geographical areas where lower temperatures occur (e.g., arctic areas), these should be considered in the equipment's design.

4.4 Typical Components

A subsea intervention system typically includes the following components:

- f) tooling for dedicated intervention tasks;
- g) complimentary equipment (e.g., tool basket, guideposts);
- h) deck handling equipment;
- i) control system;
- j) deployment/landing equipment;
- k) guidance and entry equipment;
- l) subsea vehicle spread interface with equipment and tools.

4.5 Intervention Methods

There are several methods to ensure safe and efficient guidance of the subsea intervention system to the subsea work site. Typical methods include:

- a) surface guideline systems;
- b) guidelineless systems;
- c) subsea deployed guideline systems;
- d) thruster assisted systems;
- e) subsea vehicle assisted guidance.

4.5.1 Hot Stab Operations

Hot stabs may be operated by manipulator, TDU, deployment tool or diver. 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.

Grab bar positioning relative to stab interface can influence risk of seal damage. A linear action by the manipulator will reduce risk of seal damage.

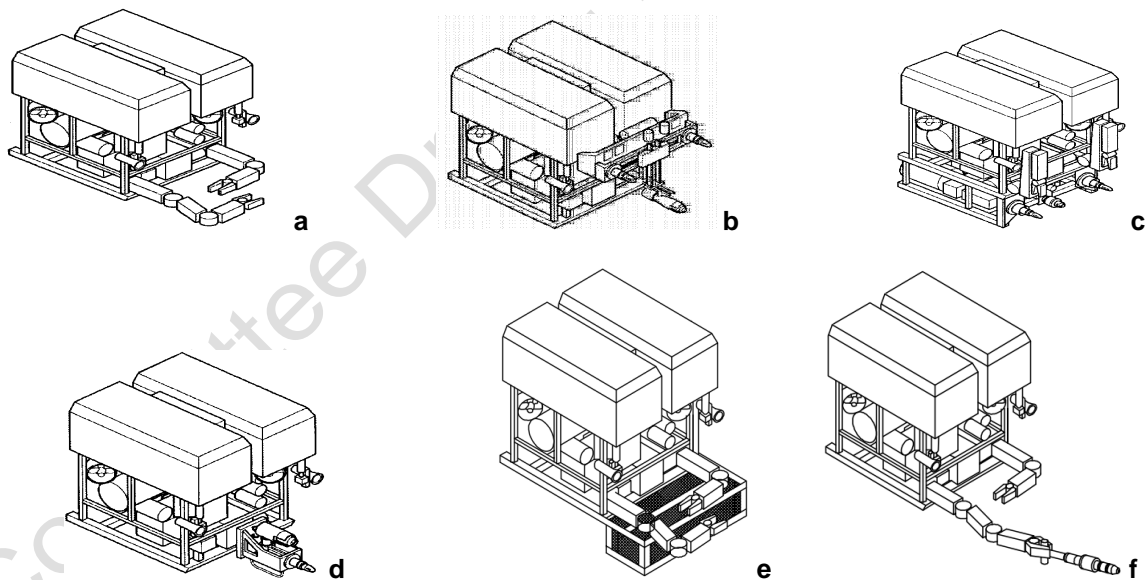
4.6 Typical Subsea Vehicle Configurations

Subsea vehicles are essentially configured for carrying out intervention tasks in six ways (see Figure 1):

- a) with manipulators for direct operation of the interface (Figure 1a);
- b) with TDUs (Figure 1b);
- c) with toolskids mounted on the external surface of the vehicle, either underslung, rear, front or side mounted (Figure 1c);
- d) with single point docking tool (Figure 1d);
- e) the operation may be supported by an external underslung basket which is used to store commonly utilized manipulator deployed tooling within easy access (Figure 1e);
- f) with a manipulator-held tool, including hydraulic or electric stabs for supply of hydraulic or electric power (Figure 1f).

WROVs normally have a base configuration consisting of a left hand 5-function grabber arm and right hand 7-function manipulator.

Interface tooling, so far as possible, should be designed to operate with a range of WROVs and not be limited in application to one design only, thus allowing the use of subsea vehicles and intervention vessels of opportunity. A dimensional envelope, representing most subsea vehicles in the market, is specified, see section 6.2.1. These dimensions may be used to design the access for safe and efficient intervention operations.



KEY

- a ROV/AUV/UUV with manipulators
- b ROV/AUV/UUV with twin point docking tool delivery system
- c under-slung toolskid and front mounted frame
- d single point docking tool delivery system
- e ROV/AUV/UUV with external basket
- f ROV/AUV/UUV with external handheld tooling

Figure 1—Typical Work Class ROV/AUV/UUV Operationally Configured

Figure 2 shows an ROV/AUV/UUV and typical interfaces on a subsea tree.

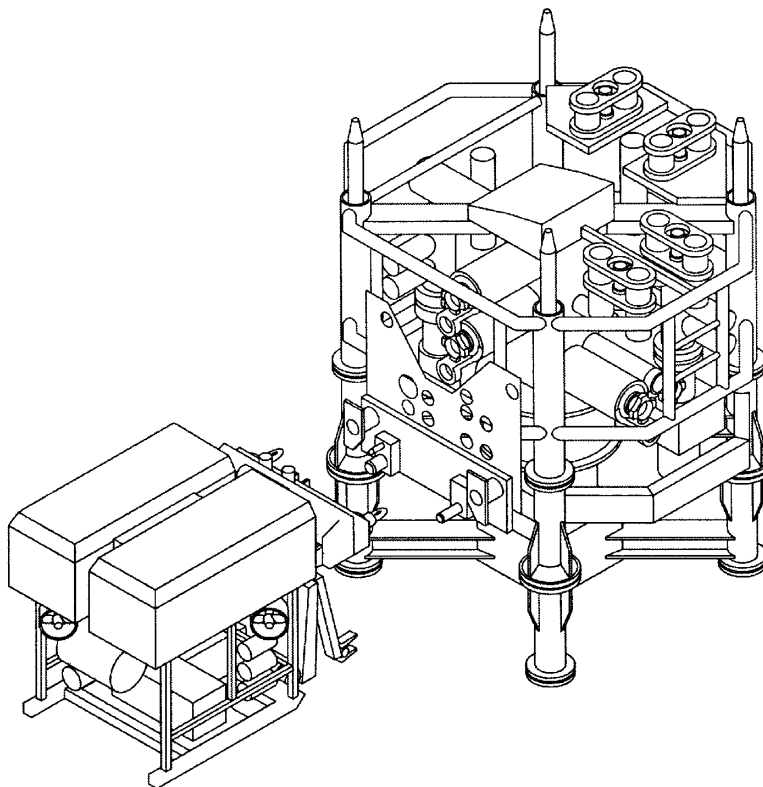


Figure 2—Typical interfaces on a Subsea Tree

4.7 Intervention Vessels

For various geographic regions and environmental conditions, different intervention vessels are used for the performance of installation and IMR activities.

In harsh environments, IMR vessels equipped with moon pools and dedicated handling systems, have been used extensively to allow for all year operations, while other areas less exposed to wind and sea have used standard supply vessels.

4.8 Component and Module Intervention

Installation and retrieval of subsea components and modules may be performed by use of AUVs, ROVs, UUVs, or ROTs or a combination of these.

The replacement of subsea components and modules that cannot be carried by a subsea vehicle, may be handled by a lift line or drill pipe designed to support the weight and dynamic loads of the tool and the component being replaced.

The operation may be supported with a second down line such as a separate control umbilical or via the ROVs umbilical/tether.

If multiple lines are used, it is recommended to select separate deployment areas of the intervention vessel to avoid entanglement.

NOTE ROTs includes tools which are initially deployed subsea by a crane or winch. The tool could then be used and manipulated by ROV/AUV and flown to the working location.

The tools can be controlled and operated by dedicated, self-contained control system, through the ROV/AUV control system or by mechanical actuation by use of manipulator or ROV/AUV tools.

An illustration of alternative subsea intervention systems for component or module intervention is shown in Figure 3a and Figure 3b.

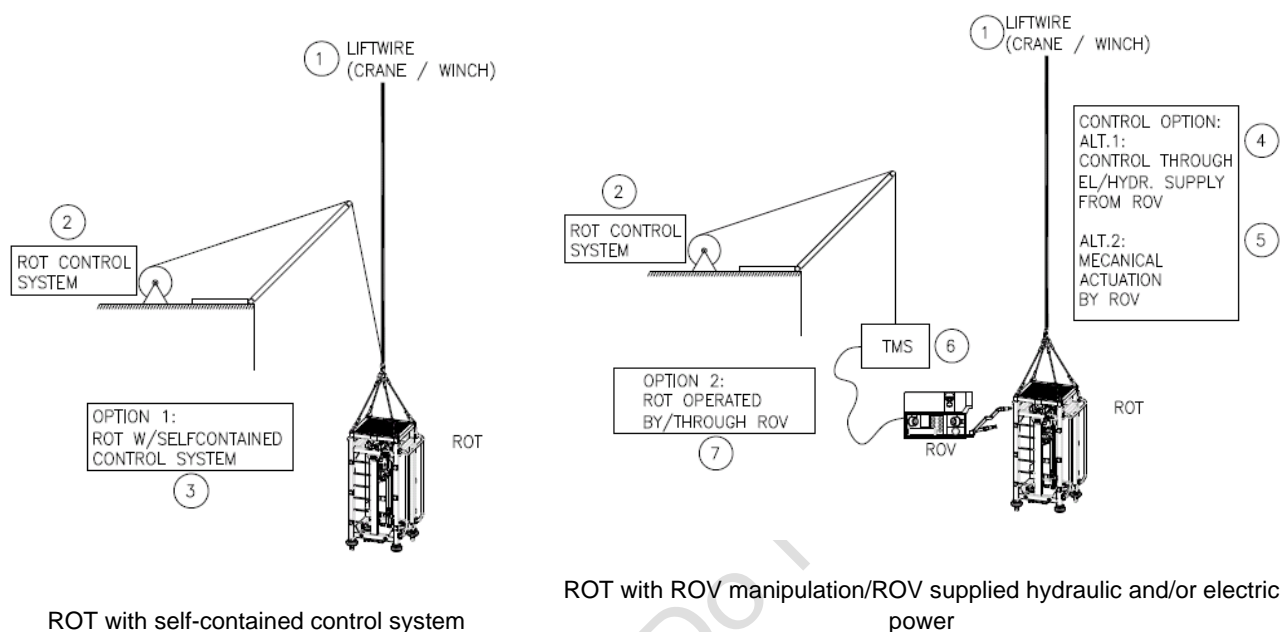


Figure 3—Typical ROT Configuration

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

4.9 Tie-in Systems

Diverless tie-in systems are used for connection of rigid flowlines, flexible flowlines, and umbilicals to subsea equipment. Tie-in systems may require the use of ROV/AUV/ROT or a combination of these to complete the connection and testing of the tie-in hardware. The tooling involved may range from a simple hydraulic hot stab or torque tool through to an integrated bolt/nut handling mechanism.

Typical operations that may need to be completed during tie-in include:

- Assistance with alignment
- Installation or replacement of a seal plate
- Actuation of a clamp or collet
- Actuation of connection/pull -in tooling
- Installation or removal of pull-in heads, pressure caps, debris caps
- Pressure/seal testing
- Actuation of locking mechanisms
- Inspection of connector status

4.10 System Interfaces

4.10.1 General

To ensure safe and efficient operations, the intervention vessel interface information should be communicated between the tool supplier and the tool operator.

4.10.2 Equipment

Intervention vessel interface information from the equipment manufacturer should include equipment datasheets for both ROV/AUV tools and ROT, and include the following information:

Equipment performance data:

- specific utility requirements (e.g., air, water, electricity, fluids);
- specific communications protocols with control system;
- video and data output capabilities;
- equipment dimensions; operational footprint (e.g., ROV/AUV panel docking);
- depth rating;
- Center of Gravity (CoG) and Center of Buoyancy (CoB);
- weight in water/in air.

Interface data:

- electrical and hydraulic connections (including electrical supply requirements);
- hydraulic requirements (e.g., fluid, flow, torque, number of turns, pressure, cleanliness);
- deployment and handling requirements.

Transport data:

- dimensions, footprint, inclusive transport container;
- seafastening and deck load distribution;
- utility requirements (e.g. air, water, electricity, fluids);
- subsea vehicle topside equipment interface requirements;
- system layout drawings/equipment drawings/pictures;
- contact information.

User documentation including necessary details for mobilization, operation, maintenance and preservation, storage and transportation of the specific equipment:

- handling and operation instruction incl. maintenance and preservation;
- technical description and component identification including pictorial representation (for spare part ordering);
- interface data;

- equipment performance data;
- lifting certificates;
- outline operation procedure;
- hydraulic schematics and electrical wiring diagrams;
- maintenance, preservation and storage program;
- drawings.

5 Design Recommendations

5.1 General

This clause provides functional recommendations for the design of remotely operated subsea intervention systems. Recommendations for ROV, UUV, AUV and ROT based tooling systems have as far as possible been merged into common sections. Equipment specific recommendations are specified where applicable.

5.1.1 Conceptual Design

5.1.1.1 Assessment of Requirements

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

The following issues should be addressed as a minimum:

- a) The need for deployment of a subsea vehicle services, and if the requirement can be met using non-interfacing means,
- b) The frequency of the operation/task
- c) The sensitivity of the operation (e.g. critical/highly desirable/helpful)
- d) Subsea facility abandonment
- e) Subsea vehicle access requirements
- f) The expected field life of the overall subsea system
- g) planned (primary) intervention task
- h) unplanned task (contingency)

5.1.1.2 Failure Mode Effect and Criticality Analysis (FMECA)

It is recommended that an FMECA of the system installation be carried out for operations contemplated to be performed by subsea vehicles. The FMECA should address all phases of the system's lifetime, ranging from installation to recovery. It should determine the relative criticality of the subsystems/components, based on the effect of a failure and the expected MTBF.

5.1.1.3 Method of Interfacing and/or Intervention

Examine the method of solving the identified tasks using a subsea vehicle-based system, and/or tooling systems. By classifying the subsea interfacing and/or intervention requirements/applications, the alternative means of conducting the interfacing and/or intervention can be evaluated, and the most appropriate method selected for simplification and ease of execution.

5.1.1.4 Frequency of Interfacing and/or Intervention

Frequent interfacing and/or intervention could depend on 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 interfacing and/or intervention, the selection of interfaces should be based on simplicity and reusability.

5.1.1.5 Standard Tooling

Where there are large numbers of items for which interfacing and/or intervention could be conducted by a similar method, a standard interface or tool should be utilized where possible, avoiding frequent tooling re-fitting.

5.1.1.6 Loading

5.1.1.6.1 General

The design shall address the various loading conditions that subsea vehicles impart during subsea operations. These loads may act individually or concurrently and should be included during the design phase.

Loads are applied to the subsea vehicle and equipment interface by:

- a) Tooling engagement and reaction
- b) Environmental forces (current and, in exceptional circumstances, waves)
- c) Installation/removal forces
- d) Interface/tooling forces
- e) Impact due to collision between a subsea vehicle and subsea equipment
- f) ROV/ROT tether (if required)

5.1.1.6.2 Design for Loading

The following approaches to interface loading design are available:

- a) Design of the interface to accommodate all loads described in 5.1.1.6.1,
- b) Limiting of the forces that can be applied to the interface (e.g. limiting maximum thruster forces),
- c) Accepting that damage will occur under certain load conditions.

The combination of loads should be analyzed, and the maximum combined load should be identified; it may not be necessary to design the interfaces to accommodate the maximum sum of all loads.

5.1.1.6.3 Tooling Forces

Subsea vehicle interface or tooling forces should be limited so that under normal operation they cannot damage the equipment tool interface being operated. Where provisions on the tool exist to permit “overload” forces to be applied, there should be a mechanism other than operational procedures to prevent this (e.g. simple cover over operating switches, function interlocks, or software control).

5.1.1.6.4 Currents

Currents inherently act on any subsea vehicle. The following loads should be addressed:

- a) Drag force on vehicle hull (or tethers) thus affecting vehicle maneuverability in the areas of interfacing and/or intervention.
- b) Drag forces on vehicles carrying equipment or equipped with tooling packages or payloads.
- c) Current affecting visibility and navigational instrumentation during near-seabed operations.

Adequate clearance in the areas of interfacing and/or intervention should be provided.

5.1.1.6.5 Collision

Unprotected subsea facilities and components which may be physically impacted by a free-swimming subsea vehicle should resist accidental collision damage when the vehicle is travelling, at 5 ft/s (1.5m/s).

NOTE: Typical impact energy used for accidental collision analysis is 4.5 kJ ($E=1/2 mv^2$), including associated entrained water – “added mass effect”.

However, impact energy may be lower when the subsea vehicle is maneuvering within a structure or is anticipating docking. Subsea vehicle velocities should not exceed 1 ft/s (0.3 m/s) when docking or operating near/inside infrastructure.

NOTE: Typical impact energy used for accidental collision analysis when internal to the structure is 180 J ($E=1/2 mv^2$).

An impact analysis is recommended when designing subsea structures.

5.1.2 Detailed Design

Following the assessment of the requirements for vehicle interfacing and/or intervention (see section 5.1.1.1), an interface and/or intervention philosophy for the subsea system should be established in order to reduce the number of different intervention techniques and interfaces required. Design inputs include the following:

- Definition of intervention tasks
- Compilation of specification(s) for interfaces, generally in association with the relevant subsea vehicle contractor and subsea equipment supplier
- Choice of docking and interface/tool deployment philosophies
- Definition of interfacing and/or intervention (at this point the 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)
- Definition of the host subsea facility detail design for subsea vehicle interfaces for tool operation
- Definition of the intervention tooling, interfaces, onboard power storage, and controls
- Documentation (design, maintenance, and operating philosophies)

- Ensuring sub-system suppliers are providing equipment which supports operation and interface and/or intervention requirements and techniques are in accordance with the overall design philosophy for the subsea installation.
- The effort in the design phase should be focused 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.
- During the design phase of the subsea production equipment, the location and running of control lines/cables should be planned to ensure avoidance of interference with subsea operation. This design input is particularly important when these items are to be site run during the construction phase.

5.2 Surface Equipment

5.2.1 General

Based on the selected intervention strategy, the remotely operated tools may require guidance during launch and recovery and landing and retrieval onto the subsea system. This sub-clause states recommendations for equipment used for handling of the tools on deck, and deployment/retrieval operations.

The following guidance outlines those features of the system which should be included at the design stage.

The recommendations given, apply in general for equipment needing a handling system due to weight, lifting height or accessibility.

5.2.2 Deck Handling Systems

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

Design functionality includes:

- a) means of moving subsea intervention equipment on deck (skid systems versus. use of intervention vessel cranes);
- b) means of deploying and landing subsea intervention systems (winches and simple mobile A-frames versus. use of complex purpose-made heave-compensated systems);
- c) means of installing on and removing from the intervention vessel (mob/demob);

The selection of equipment should be dictated by the nature of the intervention task (e.g., tie-in operation, module replacement), safety for personnel, environmental conditions affecting the operation and time available to carry out operations.

The following recommendations apply:

- a) skids and baskets for the various tools and the involved modules should provide safe and efficient transportation and deck operations;
- b) lifting points should be designed according to a recognized lifting standard (e.g., API 17D, BS 7121-2);
- c) each tool, including the tool skids, should be supplied with handling devices (e.g., lifting slings) certified for the maximum expected dry handling mass. This should, where applicable, include the dry mass of the module to be handled by the ROT;
- d) the tool skids and baskets should be balanced for safe lifting and handling with the dedicated tool and, when applicable, with the replaceable module installed;

- e) on the surface, replacement of components and modules in the various tools should be performed by skidding when required for safe operation due to intervention vessel movement;
- f) when required, tool skids should include all facilities (e.g., piping, valves and gauges) for function testing of the various tools.

5.2.3 Deployment Equipment

5.2.3.1 General

This subclause contains functional recommendations for the equipment and tools used during the deployment and landing phases during an intervention.

The following recommendations apply:

- a) operations in which sensitive components, as part of the subsea system, are involved should be carried out in a two-step sequence. The ROT should be landed and sufficiently secured prior to manipulation of sensitive components, e.g., hydraulic lines;
- b) guide-funnels on the equipment and tools should enable safe, simple and efficient entering and securing of the guidelines and eliminate trapping of the wires;
- c) the design of the deployment system should include emergency operations, for example intervention vessel drift-off;
- d) the number of lines from the surface to the subsea work area should be minimized, to reduce the possibility of entanglement;
- e) when a subsea intervention system is deployed in a guidelineless operation, means of lateral and rotational control is recommended while entering the subsea area in which sensitive components are exposed at the same level as the ROT;
- f) in order to achieve safe operation, the equipment, tools and the transportation skid should enable entering on tensioned guidelines;
- g) sufficient running clearance between the ROT and the nearest obstructing element should be ensured. Minimum 1.0 m clearance while on guidelines and 0.2 m while on guideposts should be provided. Cursor systems, guidecones and guideposts should be secured to avoid movements above the tolerance limits [1.0 m topside and 0.2 m subsea]. Running clearances for guidelineless systems needs to be defined. Protection of surrounding equipment by use of bumper bars may be utilized;
- h) for guideline-based operations, equipment and tools should be designed for operation without heave compensation and with a maximum landing speed of 6 ft/s (1.8 m/s). A soft-landing system is recommended for sensitive equipment;
- i) if a soft-landing system is utilized, it should be easy to activate and lock in retracted position for use with an active heave compensated system. The system can be of a passive design such as a water based soft landing system.

5.2.3.2 Lift Wire and Umbilical Winch Systems

5.2.3.2.1 General

The following recommendations apply:

- 1) winch load calculations shall be in accordance with the relevant standards and regulations such as DNVGL-ST-0377 and DNVGL-ST-0378;
- 2) constant-tension winches should allow for instant and direct switchover from normal operation to constant tension;

- 3) as well as local control, the winches should be equipped with a mobile remote operation to ensure a safe and well monitored operation;
- 4) the lifting winch or deployment system should include a facility for depth display during operations.
- 5) An overload protection system should be incorporated when selecting winches

5.2.3.2.2 Guideline Winch System

The following recommendations apply:

- 1) guideline winches should include an adjustable constant-tension mode, with the capacity to operate with the guideline in tension during maximum design operation condition
- 2) the guideline winches should have a defined operational tolerance (e.g. +15% to – 30% of set value);
- 3) guidelines should include an ROV operated guideline anchor for easy attachment and release. Guideline anchors should include an emergency release system (consider standardization across the project);
- 4) guideline anchors used for lifting (e.g., guideposts) should be certified for the applicable load.

5.2.3.2.3 Umbilical Winch System

The following recommendations apply:

- 1) umbilical winches used for combined lifting and control functions should have ample lift and brake capacities to handle the complete weight of the ROT system in air and in water. The capacity evaluation weight should include mass of the ROT, the module to be installed if any, and the full length of the umbilical including hydrodynamic effects. Loads to be defined based on field specific environmental data and intervention vessel characteristics;
- 2) umbilical winches should include an adjustable constant-tension mode, with the capacity to operate with the umbilical in tension during maximum design operation condition;
- 3) umbilicals should have a system for easy attachment to the lift wire, when applicable;
- 4) umbilical winches not used for ROT lifting should have sufficient lift and brake capacities to handle the full length of the umbilical, including dynamic amplification.

5.2.3.2.4 Lift Wire Winch System

The following recommendations apply:

- 1) lift wires should be of a low-grease and torque-balanced design;
- 2) a fiber rope or a ball-bearing swivel may be evaluated (alternative).

5.2.4 Tool and Equipment Deployment

A method for handling the tools and equipment on the intervention vessel and deployment subsea, should be developed with the following inputs:

- 1) safe handling of equipment in the work area;
- 2) intervention vessel facilities (a vessel typical for the geographic area should be used as a basis, if no specific intervention vessel has been selected);
- 3) intervention system design (e.g., size, weight and shape);

The following general recommendations apply:

- a) Manual handling of equipment should be limited to 53 lb (25kg). Heavier equipment should be prepared for handling by use of forklift and crane;
- b) For operations in harsh environments, the need for use of deck handling cranes should be minimized. A skidding system, or restraining system to avoid swinging loads, should be used for transporting the Subsea intervention system and/or the components between working deck and launching position, to ensure safe handling. Recommendations for tool skid systems are given in 5.2.2 and 5.2.3;
- c) access to the master link for lifting should be from deck level;
- d) during the design phase, the placement of access aids such as ladders, footrests, handholds, temporary gratings and attachment points for safety lines and fall-arrest systems shall be included in the design;
- e) design and operation of all electrical systems on surface should be in accordance with applicable standards and regulations. Equipment voltage and frequency should be addressed. Special attention should be given to equipment for use in explosion-hazard areas;
- f) the lifting equipment shall be designed and documented in accordance with applicable standards and regulations;
- g) design loads for lifting equipment should include hydrodynamic loads, where applicable;
- h) transport skids should have provisions for forklift interface;
- i) tools, components, modules, skids and trolleys should have provisions for sea-fastening;
- j) dedicated sea-fastening attachment points should be clearly marked "For sea-fastening only". Each seafastening point should be designed for 1G acceleration in any direction;
- k) the deck jumper (umbilical/cable) for use during deck operations should be of sufficient length to enable flexibility with respect to the surface equipment layout;
- l) the deck jumper (umbilical/cable) should be adequately protected against damage during use and storage;
- m) the deck jumper (umbilical/cable) should be provided with reeling mechanisms.

5.3 Intervention Tools

5.3.1 General

Specific design recommendations for subsea vehicle interface tooling can be found in clause 6 of this document.

Size, shape, CoG of intervention tools and equipment should allow for safe and efficient operations by use of a subsea vehicle.

The maximum submerged weight of subsea manipulator handled tools should not exceed 110 lb (50 kg).

NOTE If the weight limit must be exceeded, special handling procedures should be developed.

Subsea vehicle operated tools should have the ability to visually monitor their actions through the subsea vehicle in case of a control system malfunction (e.g., hot stab pressure gauge port, torque tool turns counter).

5.4 Module/Component Replacement Tools

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

The following general recommendations apply:

- a) the subsea intervention system should provide a safe locking (including double securing function) of the replaceable module during handling, deployment/retrieval and operation;
- b) replacement of modules should be based on vertical retrieval and re-entry to the landing receptacle;
- c) if power failure occurs or is switched off during running, the replaceable module should remain locked to the tool;
- d) the module to be installed should be landed in a two-step sequence, the two steps should not go automatically, but allow for a stop between steps for inspection;
 - 1) landing the dedicated subsea intervention system on the subsea landing structure.
 - 2) final alignment of the module onto the subsea interface.
- e) when a module is to be retrieved, the subsea intervention system should be designed with sufficient flexibility to self-align and freely enter the module mating point;
- f) modules interfacing pressurized equipment (e.g., valve insert, clamp connection) should have provisions for verifying that internal pressure is bled off. It should be possible to verify the seal integrity on connection points;
- g) all actuated functions that may prevent retrieval of the tool should have a local override or interface for a separate override tool, to recover the tool.

5.5 Subsea Intervention Tooling Control and Actuation

5.5.1 General

A variety of control systems and actuation principles for the tools have been established for ROT and tooling systems.

This section covers recommendations for control and actuation of ROT or subsea tooling within the following main categories:

- a) self-contained intervention control system;
- b) control systems controlled via the subsea vehicle control system;
- c) mechanical actuation;
- d) deck pack for testing, cleaning, removal of water and replacement hydraulic fluid.

5.5.2 Common Recommendations for Control Systems

The main purpose of the control system is to provide a safe and efficient means of operating the various tool functions, and to monitor essential tool operating parameters such as:

- a) pressure;
- b) flow;
- c) position indicators;
- d) self-diagnostics;
- e) interlocks;

- f) data logging;
- g) operating parameters as applicable (e.g., torque).

5.5.3 Self-Contained Intervention Control Systems

5.5.3.1 General

Self-contained Intervention Control Systems (ICS) may be used for the control and monitoring of ROTs. The independent control system configuration may include one or more of the following systems:

- a) surface control system;
- b) surface/subsea communication;
- c) subsea control system.

Functional requirements for the ICS should include:

- 1) hydraulic control components should meet standardized pressure classes;
- 2) the capacities of the electrical and hydraulic systems in the ICS should provide for some increase in the number of functions;
- 3) the hydraulic system should be designed to maintain specific cleanliness and water content requirements. A typical cleanliness level is SAE AS4059 Class 8B-F or ISO Class 17/14 (see ISO 4406[2]). Mechanisms for obtaining the required cleanliness level should be maintained throughout the whole process, including fabrication and assembly;
- 4) when selecting the hydraulic fluid, compatibility with interfacing equipment, i.e., subsea vehicle control systems and workover systems, shall be evaluated. If required qualification and compatibility verification should be conducted;
- 5) separate purifier drain and fill connections should be fitted to all hydraulic reservoirs;
- 6) all electrical equipment should be water-ingress-protected and have active electrical insulation monitoring. (For example, in accordance with "IMCA AODC 035 Guidelines for safe use of electricity underwater);
- 7) the equipment should be supplied complete with all necessary interface piping, instrumentation, cabling and deck jumpers in order to avoid on-site installation, except for connecting the units;
- 8) all control cables, piping, umbilical terminations, connectors, hoses, and associated equipment should be supported and protected adequately to prevent damage or contamination during storage, testing, equipment handling and operation;
- 9) all lines, cables, fittings and connectors should be clearly marked to enable easy identification and connection. The marking should include the pressure rating and test date;
- 10) multi-connectors should be evaluated to reduce hook-up time;
- 11) the same type of fitting should be used for the same pressure classes;
- 12) the number of different types of fitting should be minimized throughout the system.

5.5.3.2 Surface Control Systems

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

The surface control equipment should:

- a) provide for safe, effective and reliable control and monitoring of all subsea intervention system functions, including testing;
- b) include audio/visual contact between the subsea intervention system surface control unit and the ROV surface control unit;
- c) provide facilities for monitoring applicable surface activities and for communication to crane/winch;
- d) include facilities for computerized storage and printout of relevant feedback data from the various operations;
- e) provide facilities for video recording of the subsea intervention system operations, including subsea operations for complementary work;
- f) enable deck-positioning flexibility, e.g., location of doors, safety exits, control panels, cable inlets/outlets;
- g) have an operator-friendly design. Control panels should be easily readable with logical and understandable markings. The total number of monitors should reflect the maximum number of functions to be monitored simultaneously;
- h) have proper lighting, ventilation, temperature control and noise protection;
- i) allow easy access to all components for maintenance and repair;

5.5.3.3 Surface/Subsea Communication

The following recommendations apply to an ICS with a dedicated umbilical.

The umbilical may be clamped to or wrapped around a lift wire or designed with armoring to provide lifting capability without transmitting unwanted loads to individual internal umbilical tube/conductors or to the connections to the ICS.

Recommendations for communication should include:

- a) the umbilical should contain necessary power cables, fiber optic lines, twisted pair signal cables and coaxial cables for power and signal transmission. Minimum one each spare power, fiber, coax and twisted pair should be included;
- b) the umbilical design should be suitable for the application required, particularly in respect to torque balance, tensile strength, elongation, fatigue bending and rough handling, all in combination with good flexibility and low mass to ensure ease of handling and operation;
- c) a combined umbilical/liftwire can be utilized. The combined umbilical/lifting wire shall be certified according to an applicable standard such as DNVGL-ST-0377 and DNVGL-ST-0378.
- d) umbilicals should be designed able to operate under full load with all the umbilical on the winch drum, accounting for heat production in the umbilical;
- e) umbilicals containing hydraulic lines and which include a hydraulic return line, should always have a pressure higher than ambient pressure in the return line to prevent seawater ingress. Alternatively, other suitable seawater ingress-prevention facilities may be utilized;
- f) the umbilical terminations should be of lightweight design to enable handling and connection/disconnection by a maximum of two operators;
- g) the umbilical should be fitted with a ground wire of necessary size to prevent electrical potential differences between the subsea intervention system and the surface equipment. All systems should have active electrical insulation monitoring. (For example, in accordance with "IMCA AODC 035 Guidelines for safe use of electricity underwater);

- h) the umbilical termination should include an umbilical bend restrictor;
- i) the umbilical junction plates should be easy to operate. Guidance, alignment and orientation features should be provided to ensure correct coupler alignment and prevent coupler damage during connection and disconnection;
- j) the umbilical and lift wire attachments should include a feature for safe disconnection of the umbilical and the lift wire from the subsea vehicle/ROT in case of intervention vessel drift-off.

5.5.3.4 Subsea Control System

The following recommendations apply:

- a) the subsea intervention system may be operated by use of a subsea HPU, either subsea tool-mounted or via a subsea vehicle;
- b) the HPU installed should be mounted on a sub frame isolated from the lifting frame by shock-absorbing elements (e.g., elastomer mounts);
- c) all hydraulic components in the subsea intervention system should be compatible with the hydraulic fluid used in the surface control system;
- d) the subsea intervention system should have provision for flushing of the hydraulic system;
- e) all hydraulic lines and components should be sufficiently protected from overpressure, e.g., by adequate use of pressure-reducing or relief valves;
- f) subsea electrical and electronic units should be properly protected. Atmospheric containers and/or oil filled pressure-compensated compartments should be used, where applicable;
- g) alarm should be provided upon critical low pressure and reservoir levels in the hydraulic system.
- h) When interfacing with a subsea hydraulic control system, fluid compatibility should be addressed to prevent contamination. NOTE: It is best to use the same working fluid or a fluid which is compatible. Alternatively, a hydraulic motor/pump unit placed in the subsea vehicle skid can be utilized to avoid interference of hydraulic fluid between the subsea vehicle system and the subsea intervention system.

5.5.4 Vehicle Based Control Systems

Subsea vehicle control systems may be used for the control and monitoring of ROT. The vehicle-based control system is typically one of the following configurations:

- a) hydraulic power supply from dedicated umbilical from surface and control signals from a subsea vehicle;
- b) hydraulic power and control signals supply from a subsea vehicle.

5.6 Indicator Systems

Remote interface operation may require supplementary feedback by a video camera or other instrumentation on the subsea vehicle in order to verify proper operation. This indication can be achieved by various means, but the indication system should conform to the following guidelines.

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

- Self-explanatory, giving the subsea vehicle operator a clear indisputable indication of the equipment status
- Sited to be observable or receivable during relevant operations

- Easily read from different angles with standard subsea sensor systems
- Easily read from at least 2 ft (0.6m) in normal conditions.
- Substantial and robust enough to last for the design life of the subsea component/equipment
- Protected from mechanical damage, and
- Where appropriate, capable of counting functions
- Metal indicators should be compatible with cathodic protection systems.

6 Subsea Intervention Interfaces

6.1 General

This section describes subsea interfaces, their respective function and identifies the key required attributes.

Special attention should be given to the location of the interfaces relative to the subsea vehicle position during operation, and the need of space around the interface for easy access with the subsea vehicle manipulator or grabber.

It is recommended to verify all subsea intervention interfaces with the actual equipment or a gauge with verified tolerances to avoid future interface clashes.

Interfaces should be capable of withstanding design loads without acceptable deformation or inhibiting the safe operation for the life of the field.

Suitable verification should be undertaken to ensure the interface is capable of operations throughout the design life.

6.2 Subsea Vehicle Access

6.2.1 Subsea Vehicle Dimensions

The following typical dimensions can be assumed for the various ROV classes. These dimensions can be utilized for designing access requirements in the following sections.

- OBSROV: 2.0 m (length) 1.5 m (width)x 1.5 m (height)
- Medium WROV: 3.0 m (length) x 2.5 m (width) x 2.5 m (height)
- Large WROV: 4.0 m (length) x 2.9 m (width) x 3.0 m (height)

If additional skids/tools are mounted to the vehicle, the vehicle size should be increased accordingly.

6.2.2 Elevation of Subsea Intervention Interfaces

Subsea intervention interfaces should be elevated to a minimum level of 5 ft (1.5 m) above seabed to avoid interference due to seabed disturbance. Additional elevation may be required depending on seabed conditions and geographic regions.

6.2.3 General

There are three locations where interfaces can be positioned on subsea production equipment for subsea vehicle interfacing and/or intervention tasks:

- Externally located interfaces (tooling and vehicles remain outside the structure)
- External boundary penetration (tooling is internal, but vehicles remain outside the structure)
- Internally located interfaces (both tooling and vehicle are internal to the structure)

The required amount of access for maneuvering the subsea vehicle to the interface depends on the location of the interface. Access requirements should be based on the height and width of the vehicle plus an allowance for maneuvering. Specific guidance is given in the sections that follow. 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.

6.2.4 Externally Located Interfaces

Mounting of interfaces on the exterior boundary of the subsea production equipment minimizes ROV/AUV/UUV operations, access space requirements, and the potential for damage to the equipment. This is the preferred location and can be achieved by locating the equipment at the external boundary of the equipment or by the use of extension rods to provide operation from the boundary position. However, this is not always achievable, due to other requirements imposed by equipment arrangement or equipment protection design.

6.2.5 External Boundary Penetration

In some applications, penetration of the space frame is required to interface with an intervention tooling interface, while the subsea vehicle itself remains outside of the structure. Typical interface locations for these applications are interfaces less than 3 ft (0.9m) into the structure. For penetration depths greater than 3 ft (0.9m) access requirements become more complex and may lead to design implications for the subsea vehicle, and/or the associated interfacing/tooling package. The ability to observe operations with a camera or equivalent imaging system located on the subsea vehicle should be included in the design.

6.2.6 Internally Located Interfaces

6.2.6.1 General

Operating interfaces should be located within 2 ft (0.6m) of the protection face or external face of the equipment. Where the interface is located more than 2 ft (0.6m) inside a protection frame, or on the external face of the equipment, access should be required to allow mating and operation of the subsea vehicle and tooling.

The clearance guidelines established in this section should be met regardless of subsea vehicle size and design.

6.2.6.2 Width of Access

The width of any access to the interior of the subsea structure should be determined, by addressing the following four issues:

A) impact of vertical access to the work site

B) If the subsea vehicle is required to enter the structure a horizontal distance greater than the length the vehicle, the width should be large enough to allow the vehicle to turn around.

C) ability of the subsea vehicle to utilize reverse thrust to maneuver

D) provision of an access path allows the subsea vehicle and tooling to be retrieved should power to the vehicle be lost or become intermittent.

The minimum width of the corridor should either be the width for the largest subsea vehicle selected or based on the turning radius for the subsea vehicle (minimum 1.25 times the vehicles length) or vehicle/payload combination if reversible controls are not required.

6.2.6.3 Height of Access

The height of any access tunnel should be determined by:

- A) The height of the vehicle;
- B) The height of any payload/work package;
- C) The essentiality of the access path allowing the subsea vehicle and its tooling to be retrieved should power to the subsea vehicle be lost or become intermittent.

A minimum clearance of 1.5 ft (0.45m) 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 3 ft (0.9m) clearance behind the subsea vehicle to allow some freedom in performing the docking and alignment maneuvers and to account for different interface/tooling characteristics.

The height of the docking station location must be above the minimum flying height. If the docking arrangement requires the subsea vehicle to be above the 1.5 ft (0.45m) clearance over the bottom of the access route, the height of the access should be increased accordingly.

6.2.6.4 Vertical Access

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

The vertical distance from the lowest point of the vehicle to the site of the interfacing and/or intervention (i.e., inspection, cleaning, or tool interfaces) should not exceed 1 ft (0.3m).

Recommended space requirements/vertical depths into the structure are given by Table 1.

Table 1—Space Requirements for Vertical Access

Vertical Depth into Structure ft (m)	Vehicle Size + Allowance
≤ 3 (0.9m)	5%
≤ 6 (1.8m)	10%
≤ 9 (2.7m)	20%

6.3 Vehicle Stabilization

6.3.1 General

A subsea vehicle is required to be stable during the carrying out of tasks, whether those tasks are manipulator or dedicated tooling tasks. Stabilization can be achieved in several ways, including:

- a) working platforms;
- b) grabbing;
- c) docking;
- d) suction cups or feet

6.3.2 Working Platforms

6.3.2.1 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.

The working platform should be designed to accommodate loads from the subsea vehicle during landing and operation (thrust downloads + vehicle mass/weight).

6.3.2.2 Application

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

6.3.2.3 Design

Platforms can be constructed of grating or bar construction of sufficient area to support the subsea vehicle. Platforms for subsea vehicle use should be flush and free from obstruction. ROV platforms may be permanently installed, or subsea installable pending on application.

6.3.3 Grab Bars

6.3.3.1 Function

Grab bars provide a standard interface for an intervention system to accommodate station keeping during the execution of tasks. Grabbing may be by a manipulator arm with parallel or intermeshing jaw or a TDU configured similarly.

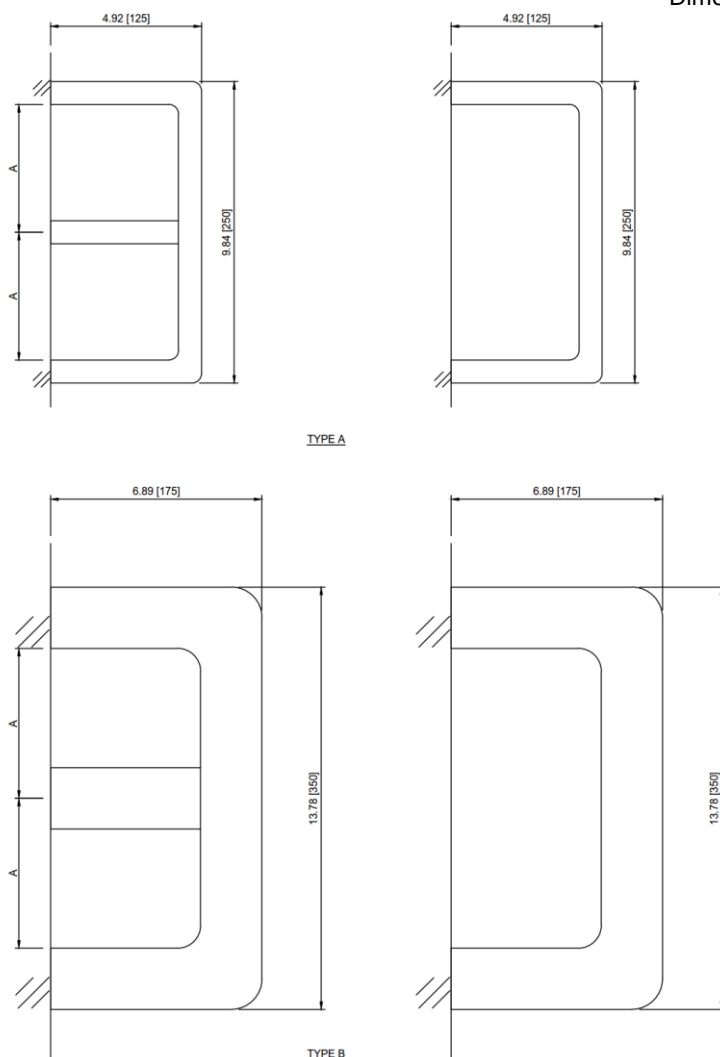
6.3.3.2 Application

An interface should be provided on all items of subsea production hardware to allow vehicle stabilization during operations.

6.3.3.3 Design

Details of a typical grab bar are shown in Figure 4. The grab bar should be designed to allow access to the entire working area at the specific equipment. The vertical section of the grab bar should include mechanical stops every 1.5 ft (0.5 m) to avoid unintentionally sliding of the subsea vehicle.

Dimensions in inches (millimeters)



KEY

- Type A Bar diameter = 0.75 in (19 mm)
- Type B Pipe diameter = approximately 2 in OD (51 mm OD)

Figure 4—Grab bar for stabilization

The grab bar should not be located close to sensitive equipment to avoid damage.

Grab bar intervention interfaces should be designed to withstand a minimum force of 500 lbf (2.2 kN) applied from any direction and a gripping force of 500 lbf (2.2 kN) applied from any direction.

6.3.3.4 Operation

Grab bar may be used as a docking interface or in conjunction with a docking interface. Grab bars may be designed as bumper bars to provide protection to the interface panel.

6.3.4 Docking

6.3.4.1 General

Docking receptacles can be used where the loading of the subsea equipment interface is not desirable, such as the operation of:

- Rotary low torque interface valves
- Hot stabs
- Flying lead stab plate connections
- Electrical connectors

Positive docking interfaces are used where the tooling configuration is to be operated by a single- or twin-docking TDU. The docking receptacles provide positive stabilization during manipulator operations. A docking receptacle is used in conjunction with a docking probe mounted on the subsea vehicle. 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 can be positioned with either a horizontal or vertical axis. Receptacles may be a separate bolted, welded or can be fabricated into the subsea structure.

6.3.4.2 Design

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. The values are based upon a typical work class ROV docking and docked to the receptacle, using the parameters given in Table 2.

Figure 5 shows a vertical face twin probe docking layout complete with recommended positional tolerances. Figure 6 shows a vertical face single probe docking layout complete with recommended positional tolerances. The 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, to be reached by the tooling system or manipulator arm.

For any designed system, the engineer should assess the specific requirements and adjust the values if necessary. Figure 5 and Figure 6 show the recommended minimum areas around the receptacles which are to be kept clean to allow docking probe access. In general, placing receptacles within a flat plate area rather than in an isolated position greatly aids vehicle docking.

The docking receptacle should be manufactured from a material with a minimum tensile strength of 65,300 psi (450 Mpa), however other materials can be specified where different load conditions exist.

Protection from marine growth and corrosion will be necessary in most environments. Corrosion resistant materials and appropriate coatings should be evaluated and selected based on the local conditions.

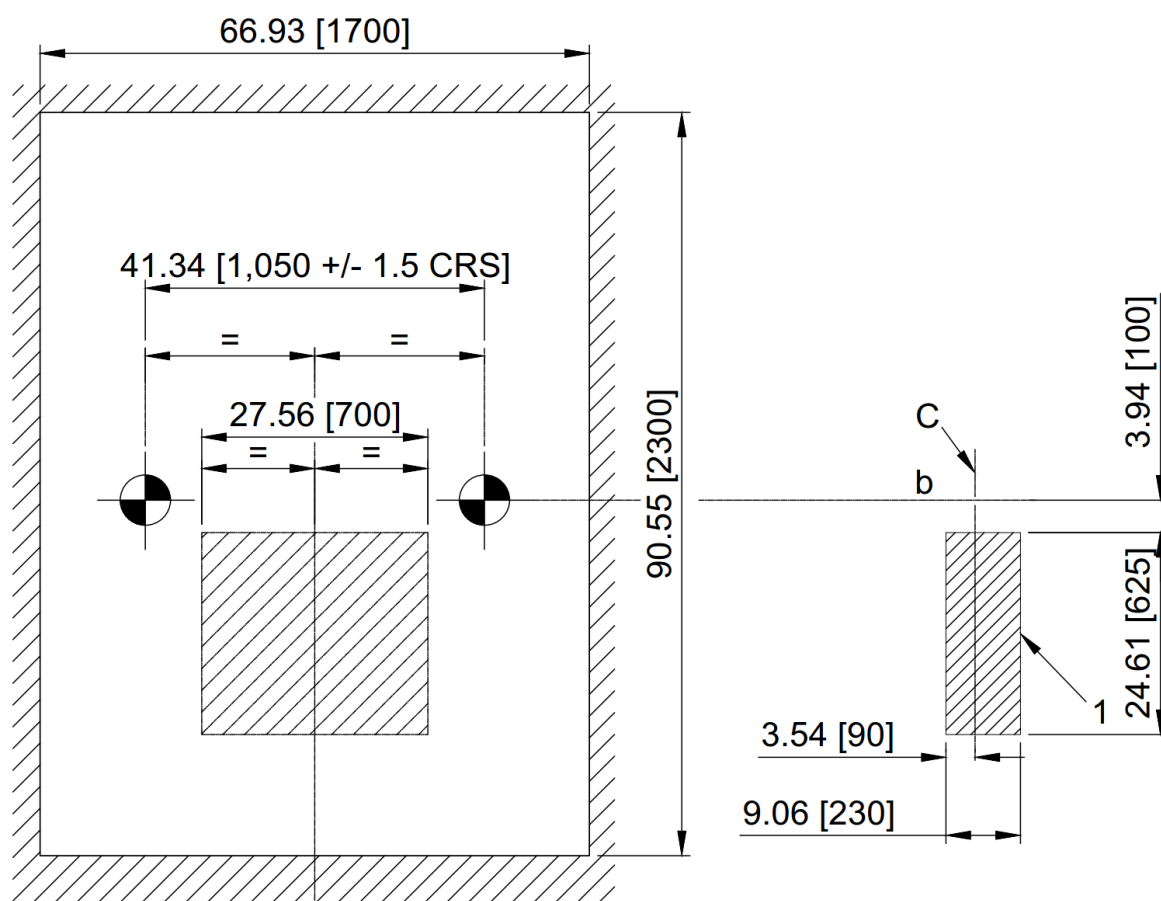
The means of attaching the docking receptacle is optional.

Table 2—Typical docking parameters

Docking velocity	1 ft/s (0.3 m/s)
Lateral current (whilst docked)	8.2 ft/s (2.5 m/s)
ROV thrust (when docked)	100 % full

NOTE Typical impact energy used for analysis is 180 J ($E=1/2 mv^2$).

Dimensions in inches (millimeters)



Key

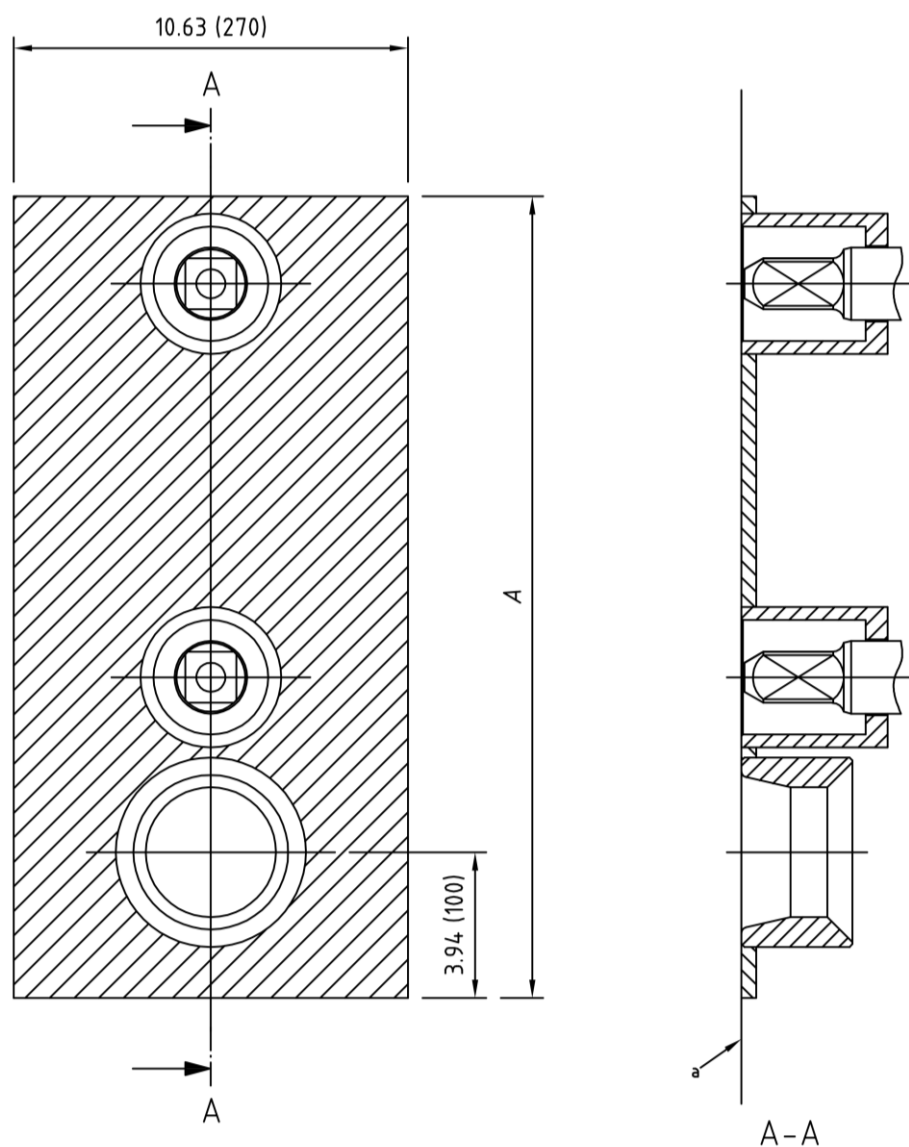
- 1 torque tool
- a Recommended clearance area for access to and allowance for cameras, support brackets
- b Centerline of docking probes
- c Docking face

NOTE Penetration envelope into a structure is typically in the range of 5.5 in (140 mm). Specific tooling can be made for greater depths of penetration.

NOTE for Type A Interface – Docking Probe

Figure 5—Typical tooling envelope for twin-docking TDU

Dimensions in inches (millimeters)



KEY

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 13.75 in (350 mm) to 21.50 in (550 mm), depending on the tooling requirement.

NOTE 3 features shown in the figure other than receptacle location and envelope are for reference only

NOTE 4 For Type A Interface – Docking Probe

Figure 6—Typical tooling envelope for single-docking TDU

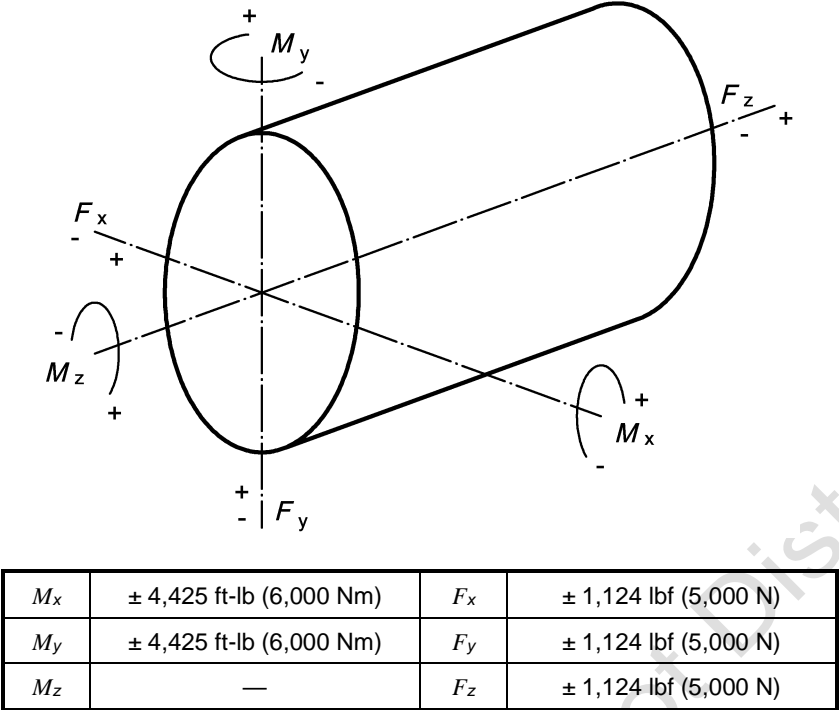


Figure 7—Docking Receptacle Loading

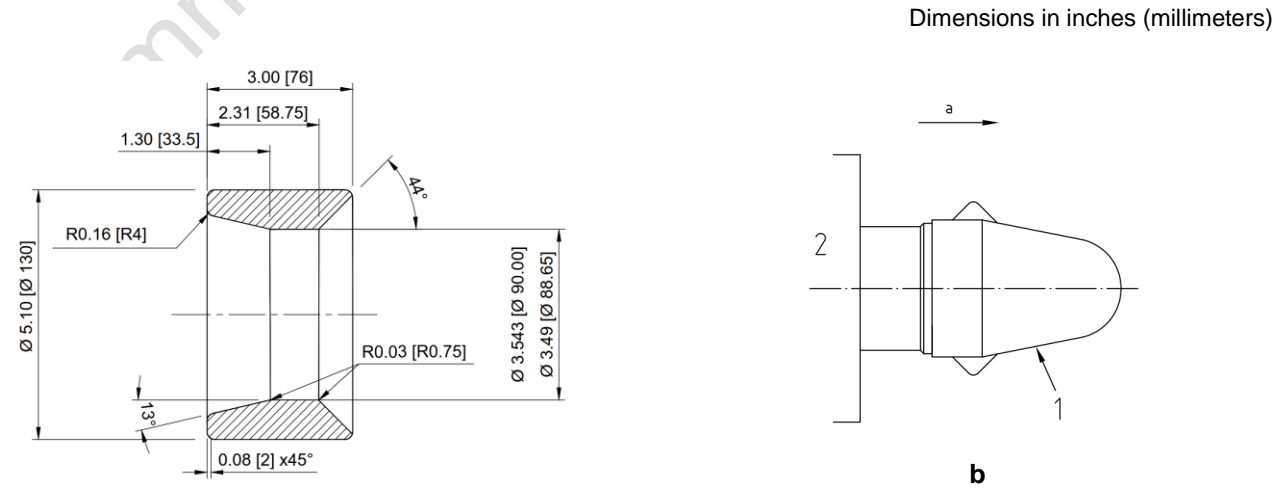
6.3.4.3 Operation

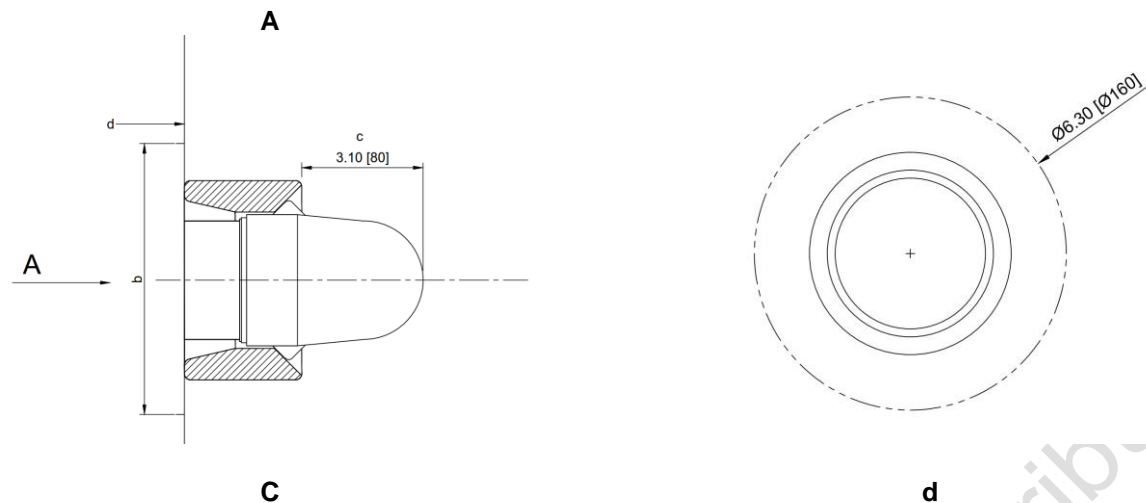
The subsea vehicle approaches the docking location and free flies the docking probe(s) into the docking receptacle(s). The probe is then actuated by the subsea vehicle, locking the dogs behind the rear profile pulling the probe flange against the docking face.

6.3.4.4 Docking Probe and Receptacle

This interface provides station keeping for intervention systems. The interface allows a subsea vehicle to firmly attach to an underwater structure to prevent vehicle movement during the execution of tasks and provide a positive location for repeatability of tasks. The docking receptacle profile is shown in Figure 8.

It is important that the design of the docking probe interface ensures that the fixed portion remains undamaged during the installation and continued use. Material selection should be decided by the equipment manufacturer. Material selection should follow the guidelines and principles in the EEMUA Publication 194.





Key

- 1 docking probe
- 2 tooling
- a Direction of docking
- b Area to be free of obstruction
- c Clearance for probe
- d Docking face

Figure 8 — Docking Probe and Receptacle

Failsafe mode for the docking probes should be defined in accordance with the application.

6.3.5 Suction Cups or Feet

6.3.5.1 Function

Suction cups or feet consist of an arm attached to the subsea vehicle with a suction cup on the end. The suction cups are activated by the vehicle when in contact with the structure to assist the subsea vehicle in maintaining position relative to the interface.

6.3.5.2 Application

Suction cups or feet may be used when carrying out unplanned manipulative operations.

6.3.5.3 Design

The interface requirement of the subsea structure is a flat surface adjacent to the task area for the suction cup and within the grabber arm range.

6.4 Manipulator Interface Handles

6.4.1 Function

This interface provides means for subsea operations involving subsea equipment requiring linear and/or rotary action. The handle interfaces should be designed to withstand a minimum torque 221 ft-lbs (300Nm) torque and minimum force of 500 lbf (2.2 kN) applied from any direction. The minimum tensile strength for manipulator interface handle material shall be 65 ksi (450 Pa).

6.4.2 Application

The handles are used in conjunction with a manipulator, or purpose-built tooling, to allow direct operation of the interface or device.

6.4.3 Design

The interface consists of a T-bar, D-ring or X-bar (fishtail) arrangement, attached to the equipment to be operated. The handle is grasped in the jaws of a manipulator or a purpose-designed tooling receptacle, see Figure 9. A T-bar configuration should not be used where the risk for snagging is significant.

To reduce or avoid load transfer from the subsea vehicle to the equipment, it is recommended to have a compliant section mounted between the handle and the tool.

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. The end stops should be designed to resist the maximum forces which are generated when operating the equipment in the worst conditions.

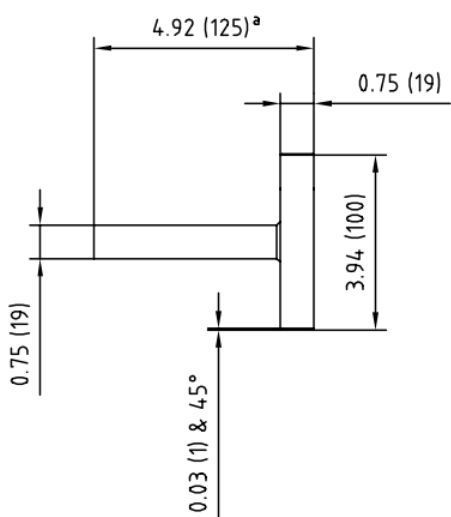
The type of handle should be standardized for the entire subsea system, and compatible with the same manipulator end effector.

6.4.4 Operation

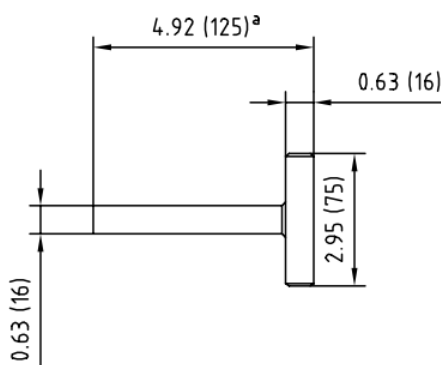
The handles are operated by locating them directly in the jaws of a manipulator, see Figure 9, or by securing them in a purpose-built tooling receptacle such as a TDU fitted with a torque tool, see Figure 10.

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

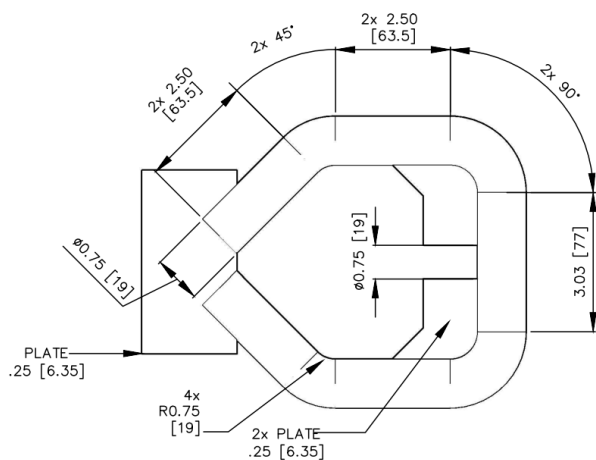
Dimensions in inches (millimeters)



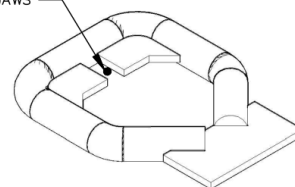
Type 1 - Large "Tee" handle



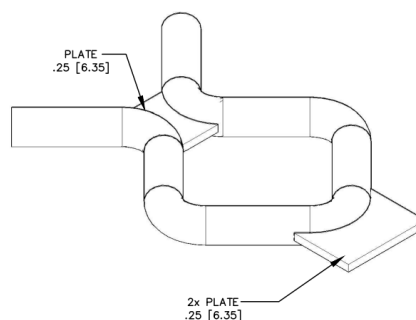
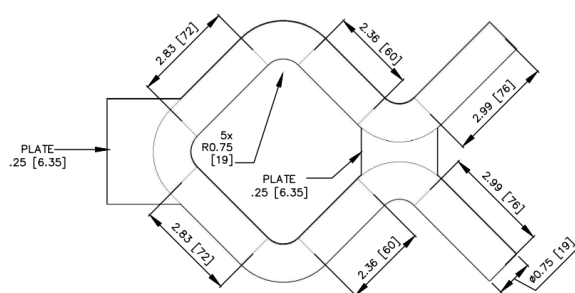
Type 2 - Small "Tee" handle



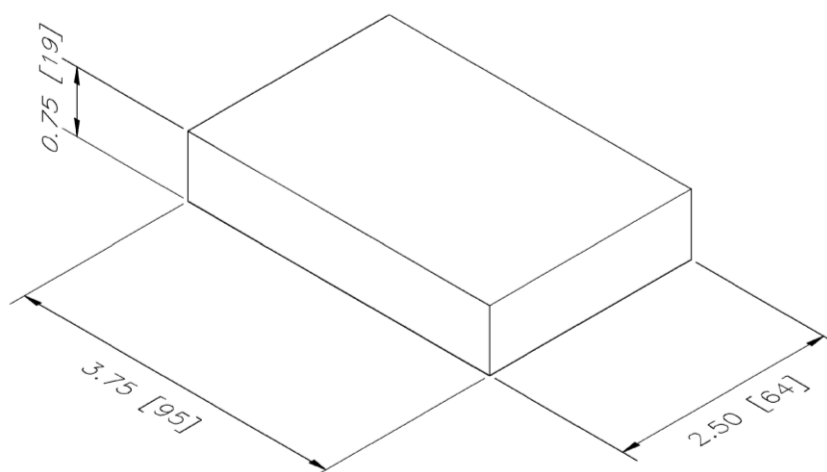
OPTIONAL FEATURE
FOR PA JAWS



Type 3 - "D" Ring Handle



Type 4 - "X" Bar (fishtail) Handle



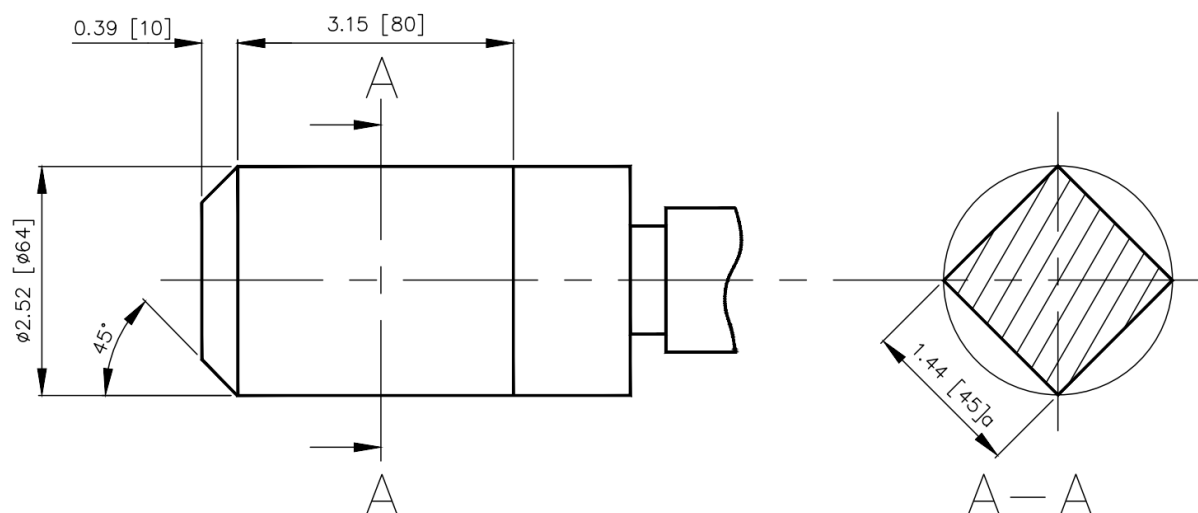
Type 5 - Typical Handle for Electrical/Optical Connectors

KEY

- a Clear area for manipulator.

Figure 9—Handles for Use with Manipulators

Dimensions in inches (millimeters)



KEY

a Across flats

Figure 10—Handle for Use with TDU

6.5 Rotary Low-Torque Interface

6.5.1 Function

The rotary low-torque interface provides for the remote operation of subsea equipment requiring rotary action.

6.5.2 Application

The rotary low-torque interface is typically operated by a subsea vehicle mounted torque tool or manipulator for operation of subsea small bore valves and other low torque functions. Special precautions should be taken to prevent over torque (i.e., torque control) of the low-torque interfaces.

6.5.3 Design

The rotary low-torque interface, see Figure 11, consists of a bar or paddle enclosed in a tubular housing.

The rotary low-torque interface should be designed to avoid accumulation of debris and silt. Design should be suitable for water jetting to remove any debris.

The interface is generally mounted with the drive stem horizontally but may be mounted vertically.

The interface receptacle may be incorporated into a panel by bolting or welding, or free-standing, or an integral part of the subsea equipment.

A compliant section mounted between the handle and the tool is recommended to reduce the load transferred from a subsea vehicle to the equipment. The maximum forces that can be applied to the interface shall not exceed the low torque interface rating.

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.

The low-torque interface and associated parts in the drive train (e.g., valves, connectors) shall have structural design for a max torque input of 151 lbf-ft (205 Nm) without any plastic deformation. This is the max torque a new manipulator can apply. NOTE: ROVs do not typically have torque control.

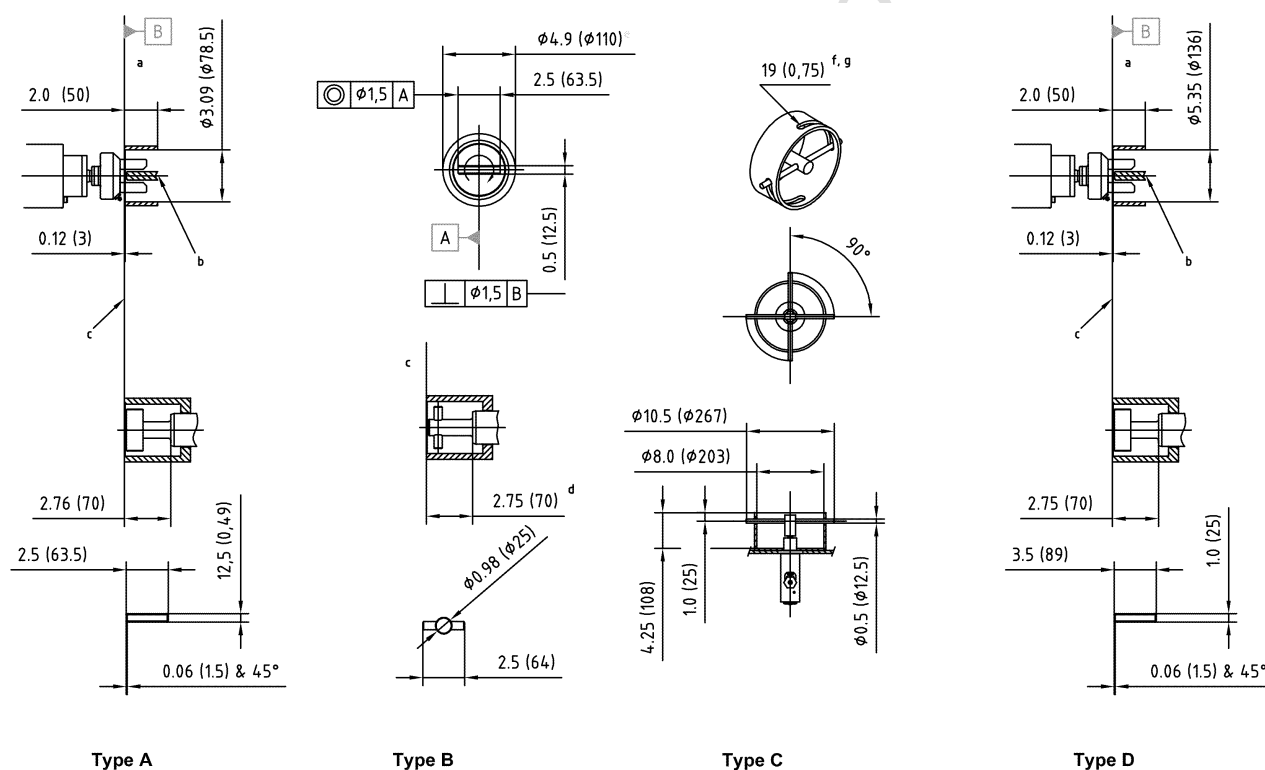
Valves, connectors, or other devices constructed for direct ROV operation through a low torque interface shall be geared to not exceed the following torque demand.

Standard torque rating = 55 lbf-ft (75 Nm)

Extended torque rating = 96 lbf-ft (130 Nm)

For use of extended torque rating, the paddle interface, valve stem, valve parts and end stop shall be designed for this torque without any permanent damage to the affected parts. Extended torque rating may be required to break open a valve which has been set to normal torque rating.

Dimensions in inches (millimeters)



To avoid damage to the interface handle/paddle, it is important that the handle/paddle remain within the envelope of the receptacle.

Maximum torque rating = 663.8 lbf-in (75 Nm)

Key

- 1 Flat paddle style (Type A)
- 2 T-bar handle (Type B)
- 3 Flat paddle style (Type D)
- 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 X180° apart

Figure 11—Low-torque Receptacle

The interface flange should be designed to withstand 258 ft-lb (350 Nm) torque, bending force of 738 ft-lb (1000 Nm) and an axial force of 450 lbf (2000 N), to operate at the specified torques.

Protection from marine growth and corrosion is required. Corrosion resistant materials or appropriate coatings are recommended.

The interface is approached by the remotely operated 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.

6.5.4 Operation

Type A and B are typically operated by use of a torque tool or by a manipulator held adapter. Type C and D can be operated directly from a WROV standard manipulator. To operate the low-torque receptacle, a subsea torque tool is aligned with the receptacle axis and inserted into the receptacle to engage the T-bar or paddle. Once fully engaged, the tool can provide continuous rotation in either direction. The torque required to operate the interface is provided by the subsea vehicle or deployment system. These interfaces have no built-in guidance for assisting alignment or engagement.

6.6 Low-torque Reaction Flange

6.6.1 Function

This flange interface is used in conjunction with a Type D low-torque interface. The flange can be utilized to mount a subsea actuator on the low-torque interface or to mount a tool to actuate the Type D low-torque interface. The interface flange provides a torque reaction point and the possibility to lock an actuator onto the interface.

6.6.2 Application

The interface flange is used in conjunction with subsea vehicle manipulators or a mounted torque tool for the operation of subsea valves and other low-torque functions. The rotary low-torque interface is used for the control of subsea valves by use of smaller subsea vehicles, AUV's or retrofitted actuators. The interface includes locking slots for actuators and torque reaction points. The reaction points should be inline with the low torque Receptacle paddle.

6.6.3 Design

The low-torque reaction flange (see Figure 12) consists of a circular tapered flange with reaction tabs. The low-torque reaction flange interface may be incorporated into a panel by bolting, welding, or made as part of the subsea equipment.

Dimensions in inches (millimeters)

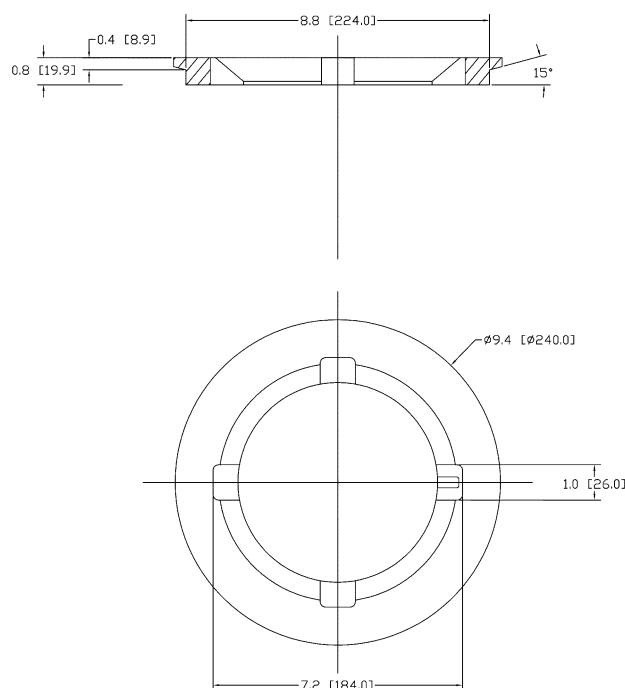


Figure 12—Low Torque Interface Flange

The maximum forces that can be applied to the interface shall not exceed the low torque interface rating.

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

6.6.4 Operation

The subsea vehicle mounted torque tool is presented to the interface along its axis, orientated to engage the tool drive adapter on the paddle. Once fully engaged, the tool can provide continuous rotation in either direction with all torque reacted by the subsea deployment system. This interface has no built-in guidance for assisting engagement.

6.7 Rotary High-torque Interface

6.7.1 Function

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

6.7.2 Application

The receptacle is commonly fitted to valve panels on subsea equipment (e.g., trees, manifolds, control modules and templates), and is suitable for any operation requiring a rotary override.

6.7.3 Design

The interface shown in Figure 13 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 3 for maximum design torques and Table 4 for interface dimensions.

Table 3—Rotary Actuator Intervention Fixture Classification

Class	Maximum. design torque lbf·ft (N·m)
1	50 (68)
2	200 (271)
3	1,000 (1,356)
4	2,000 (2,711)
5	5,000 (6,779)
6	10,000 (13,558)
7	25,000 (33,895)

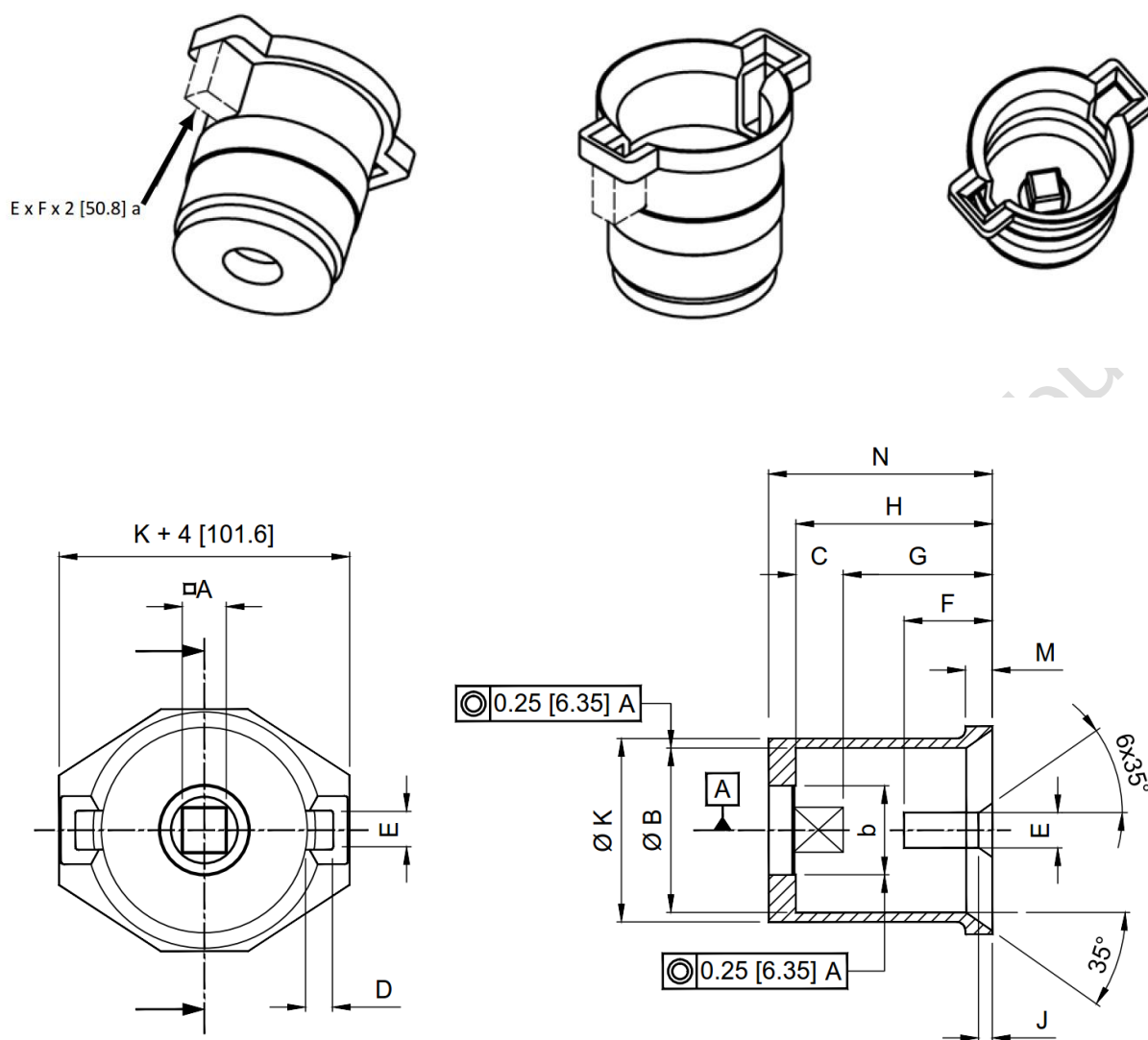
6.7.4 Design Recommendations

The receptacle is generally mounted with the drive stem horizontally, 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 receptacles are normally manufactured from low carbon steel with minimum yield stress of 36 ksi (250 MPa) 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 with the use of receptacle covers.

If higher torque values can be applied on the selected class interface (needed, planned or accidental), an FEA analysis can be performed for the receptacle to evaluate the input drive adapters and evaluation for the attached gear/valve drive train.

Dimensions in inches (millimeters)



Key

- a Clearance both ends
- b See NOTE 1 in Table 4

Figure 13—Rotary Torque Receptacle

Table 4—Dimensions for Receptacle Classes 1 to 7 (see Figure 13)

Dimensions in inches (millimeters)

Dimension	1	2	3	Class 4	5	6	7 (Short)	7 (Long)
A square	0.687 (17.45)	0.687 (17.45)	1.125 (28.59)	1.50 (38.1)	2.00 (50.8)	2.625 (66.68)	3.50 (88.89)	3.50 (88.89)
B	6.06 (153.9)	6.06 (153.9)	6.06 (153.9)	6.06 (153.9)	7.50 (190.5)	9.56 (242.8)	9.56 (242.8)	9.56 (242.8)
C min.	1.62 (41.1)	1.62 (41.1)	1.62 (41.1)	1.62 (41.1)	2.50 (63.5)	3.50 (88.9)	3.50 (88.9)	3.50 (88.9)
C max.	1.67 (42.4)	1.67 (42.4)	1.67 (42.4)	1.67 (42.4)	2.55 (64.8)	3.55 (90.2)	3.55 (90.2)	3.55 (90.2)
D	1.5 (38)	1.5 (38)	1.5 (38)	1.5 (38)	2.25 (57.0)	3.25 (82.25)	3.25 (82.25)	3.25 (82.25)
E	1.25 (32.0)	1.25 (32.0)	1.25 (32.0)	1.25 (32.0)	1.50 (38.0)	1.75 (44.5)	1.75 (44.5)	1.75 (44.5)
F	3.25 (82.5)	3.25 (82.5)	3.25 (82.5)	3.25 (82.5)	5.00 (127.0)	7.00 (178.0)	7.00 (178.0)	7.00 (178.0)
G min.	5.51 (140.0)	5.51 (140.0)	5.51 (140.0)	5.51 (140.0)	5.51 (140.0)	8.75 (222.0)	8.75 (222.0)	17.13 (435.0)
G max.	5.75 (146.0)	5.75 (146.0)	5.75 (146.0)	5.75 (146.0)	5.75 (146.0)	9.00 (228.0)	9.00 (228.0)	17.38 (441.0)
H	7.12 (181.0)	7.12 (181.0)	7.12 (181.0)	7.12 (181.0)	8.12 (206.0)	12.38 (314.5)	12.38 (314.5)	20.75 (527.0)
J	0.50 (12.7)	0.50 (12.7)	0.50 (12.7)	0.50 (12.7)	0.50 (12.7)	1.00 (25.4)	1.00 (25.4)	1.00 (25.4)
K min	6.63 (168.5)	6.63 (168.5)	6.63 (168.5)	6.63 (168.5)	10.00 (254.0)	11.00 (279.4)	11.00 (279.4)	11.00 (279.4)
M	1.00 (25.4)	1.00 (25.4)	1.00 (25.4)	1.00 (25.4)	1.00 (25.4)	1.50 (38.1)	1.50 (38.1)	1.50 (38.1)
N (Ref)	7.63 (194.0)	7.63 (194.0)	7.63 (194.0)	7.63 (194.0)	8.88 (225.6)	13.38 (339.9)	13.38 (339.9)	22.25 (565.2)
As an alternative to dimension A, end effector shapes as found in Annex C for the appropriate torque range may be used								
<p>All dimension tolerances are as follows:</p> <p>X.X in. +/- 0.020.; (Y mm +/- 0.5)</p> <p>X.XX in. +/- 0.010; (Y.Y mm +/- 0.25)</p> <p>X.XXX in. +/- 0.005; (Y.YY mm +/- 0.12)</p> <p>NOTE 1 Chamfer on the end of the end effector profile is 45° x 0.06 (1.65) maximum.</p> <p>NOTE 2 Clearance behind anti-rotation slots [E x F x 2.0 (50.8)] is to allow for locking feature option provided by some tools.</p> <p>NOTE 3 All dimensions to be "As built/Installed" dimensions, including actual coating.</p> <p>NOTE 4 Dimension M is both flange thickness and chamfer lead-in</p>								

6.7.5 Operation

The torque tool is normally centrally mounted on the lower front frame of the subsea vehicle (single point docking).

The subsea vehicle will present the tool to the receptacle interface. 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 receptacle.

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

6.8 Linear (push) Interfaces, Type A & Type C

6.8.1 Function

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

6.8.2 Application

It is used in conjunction with a subsea vehicle mounted tool, primarily for the override of hydraulic gate valves allowing remote 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.

6.8.3 Design

The interface [see Figure 14 (type A) and Figure 15 (type C)] consists of an interrupted flange around a central stem. The flange allows a subsea vehicle mounted tool to be engaged upon the interface using a “push and turn” action. The central stem can then be driven into the interface while 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 for type A and type C is based upon the force 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 65 ksi (450 MPa) 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 is required. Corrosion resistant materials or appropriate coatings are recommended.

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

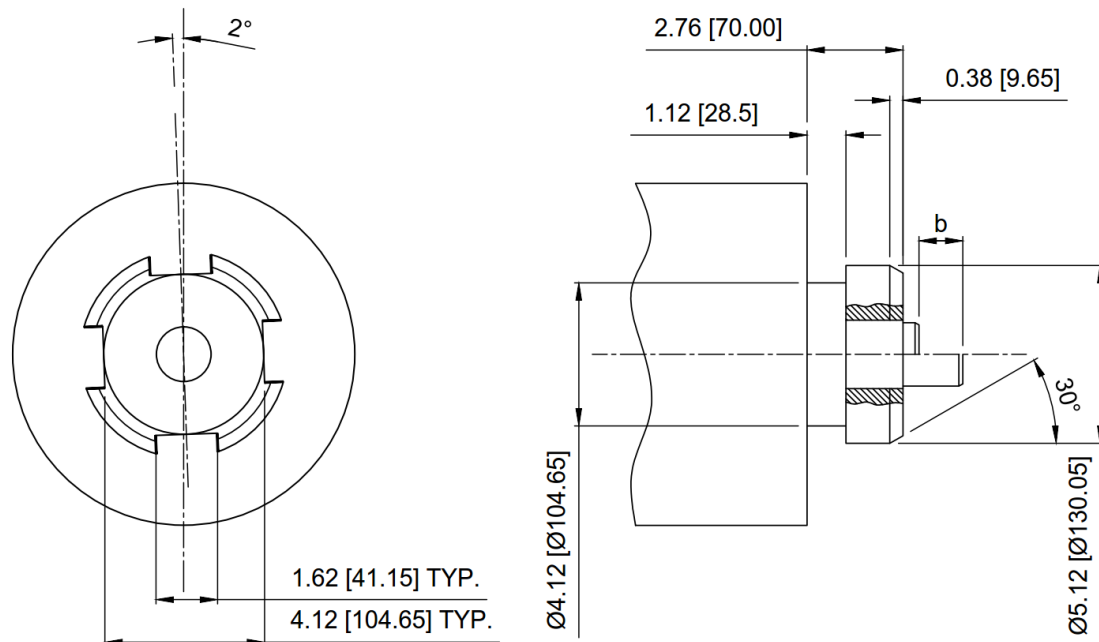
6.8.4 Operation

The subsea vehicle 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 subsea vehicle, 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. The top of the interface should be located not more than 1 in (25 mm) below the panel face.

Dimensions in inches (millimeters)



Maximum linear force exerted by tool = 167.5 klbf (745 kN)

Key

- a Angular tolerance
- b Valve stroke

Figure 15—Linear Push Interface Type C

6.9 Linear (push) Interface, Type B

6.9.1 Function

This standard interface provides for the remote operation of subsea equipment using push action.

6.9.2 Application

It is used in conjunction with a subsea vehicle mounted tool, primarily for the override of hydraulic gate valves allowing remote 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.

6.9.3 Design

The interface (see Figure 16) consists of a flange around a central stem. The flange allows a subsea vehicle mounted tool to be engaged on the interface using a “hook-over” action. The central stem can be driven into the interface while the force is reacted at the flange.

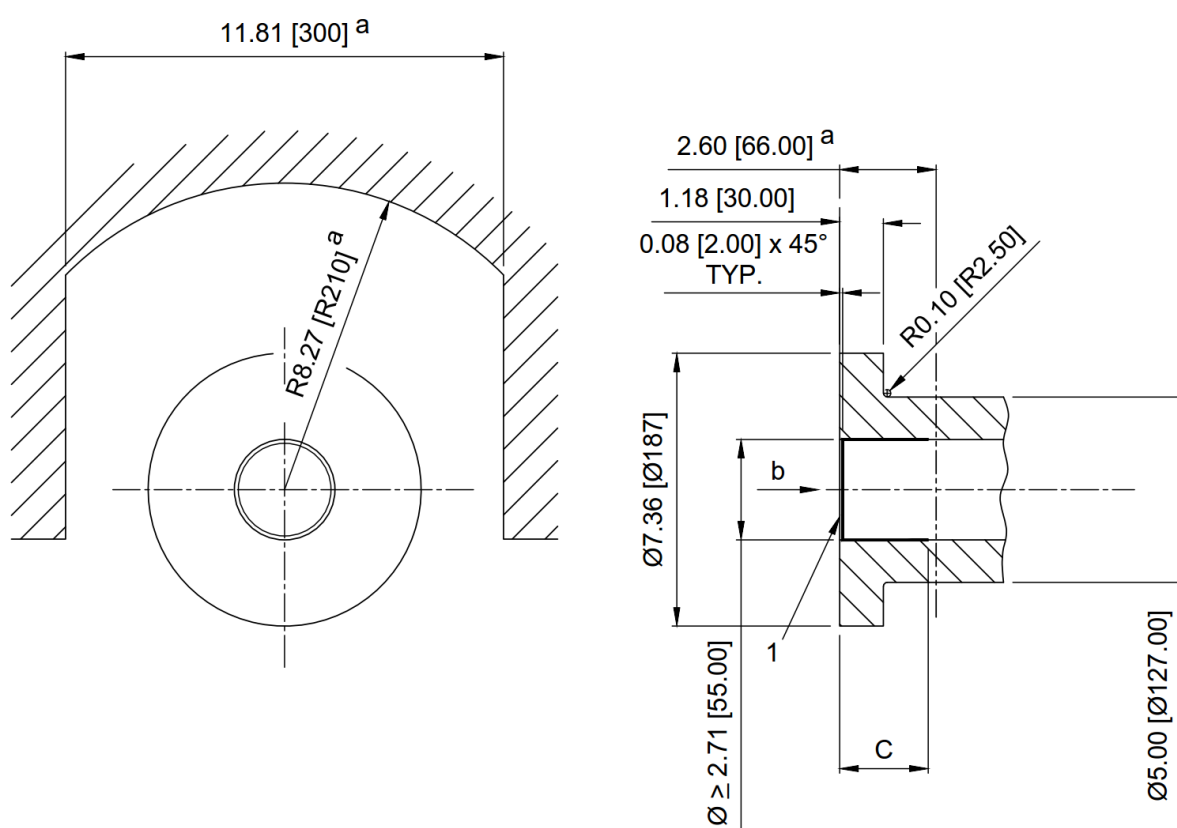
The interface can be mounted in either the horizontal or vertical plane.

The interface flange should be manufactured from material with a minimum tensile strength of 65 ksi (450 MPa) 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 is required. Corrosion resistant materials or appropriate coatings are recommended.

The interface is approached by the subsea vehicle mounted tool along the stem axis. Tooling access is required in this area. In addition, a clear space around the interface, and adjacent interfaces requiring locking tools in place in both positions, is required, as shown in Figure 16, for the tool diameter and engagement.

Dimensions in inches (millimeters)



Maximum linear force exerted by tool = 167.5 klbf (745 kN)

Key

- 1 Valve override stem
- a Minimum clearance required for tool engagement
- b Axial force
- c Valve stroke = 0.2 in (5 mm)

Figure 16—Linear Push Interface Type B

6.9.4 Operation

The subsea vehicle mounted tool is engaged with the interface by slipping it over the flange. Clearance is required above and in front of the interface as shown in Figure 18. When the subsea vehicle is in position, the central stem is acted on by the tool actuator stroking it forward, reacting against the flange. When fully stroked, the tool can be released by the subsea vehicle, leaving it engaged on the interface and holding the “actuated” position.

Release of the tool first requires 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 failsafe position. The tool is then unlatched 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 to remove it. The top of the interface should be located within 1 in. (25 mm) below the panel face.

6.10 Hot Stab Connections

6.10.1 Function

The hot stab is a device designed to make fluid connections to subsea equipment. Often a subsea vehicle is used to supply fluid through the connection. A hot stab is characteristically a pressure balanced connection, where system pressure does not introduce disengagement forces into the connection. However, the male stab can be hydraulically locked into the female receptacle or cause a hydraulic lock under certain conditions in subsea equipment. Separation forces can be introduced into the system, for example; seal failure, vehicle driveoff or when utilizing unsecured hoses with high flow or high-pressure applications. The hot stab can include multiple separate hydraulic ports depending on type and size.

6.10.2 Application

Hot stab receptacles can be used to perform any of the following tasks or functions:

- a) hydraulic or mechanical override of existing systems
- b) interface with systems (e.g. lower riser packages) with locking and unlocking functions
- c) hydraulically activate valves and tools
- d) hydro test and operate pigging functions
- e) test seals and connections
- f) displace water enclosed spaces
- g) flush of subsea components
- h) BOP intervention
- i) deliver hydraulic supply for interchangeable intervention tooling
- j) installation of umbilical's or flying leads
- k) chemical injection

A subsea vehicle Intervention is required as a secondary control system for subsea BOPs by API 53 and API 16D (see bullet h above). Both API documents require single-port docking receptacles designed in accordance with API 17H for critical functions on the BOP and provide a standard interface for intervention.

The applications for the hot stab are not limited to those listed in this document. Other applications may arise based on field or operator specific needs.

6.10.3 Types of Hot Stabs

This document defines four categories of hot stabs. Each category is defined by profile (single bore or dual bore) and diameter size. The described categories are intended for all future standard designs. These types supersede the type A, B, C and D described in the second edition of API 17H.

Type 1: Single Bore Multiport (non-taper design)

Type 2: Dual Bore Multiport (taper design)

Type 3: Single Port High Flow

Type 4: Dual Entry High Flow

Type 1 & Type 2 hot stabs are typically used to make a temporary hydraulic (or gas) connection to a remote piece of subsea equipment where high pressure / low flow applications are required.

Type 3 hot stabs utilize large bore connections intended for applications which require larger flow rates such as actuation of a subsea blow-out preventer (BOP) ram or annular preventer, flushing operations, pipeline flooding, pipeline dewatering and other high flow circulation, cleaning, or remediation operations.

Type 4 hot stabs utilize large bore connections intended for applications which require larger flow rates such as actuation of a subsea blow-out preventer (BOP) ram or annular preventer, flushing operations, pipeline flooding, pipeline dewatering and other high flow circulation, cleaning, or remediation operations. Type 4 hot stabs utilize connections with only one seal diameter and are designed to accommodate stabbing from both sides (dual entry). The dual entry design is utilized when the directionality of the hot stab receptacle cannot be predicted or when it is advantageous to enter the receptacle from either side.

6.10.4 Design Recommendations

The geometry of the internal profile of the female receptacle is defined in this document. Design of the male stab is left open to interpretation to allow for variation in the selection of seal types, material, and fabrication tolerances.

All dimensions are interface dimensions and assume no coatings have been applied. If coatings are utilized the interface dimensions given shall be measured after coating is applied.

Isolation valves (e.g. needle valve or ball valve or dual check) may be used on hydraulic ports to reduce water ingress/contamination into fluid and to reduce leakage/spill to environment

Test port applications commonly use isolation valves to provide a hydraulic lock on the hydraulic circuit and prevent seawater ingress.

The hot stab should feature a flexible or compliant section between the handle and the stab body to assist manipulator access during insertion or retrieval.

The hot stab should be equipped with a guide nose to ensure first stage alignment of stab into receptacle during connection.

The hydraulic interface between the receptacle and subsea piping/tubing shall be an industry standard such as threaded Medium Pressure (MP)/High Pressure (HP)/BSP/SAE/NPT, API 17SS or 6BX flange.

Locking male hot stabs should fit into all locking and non-locking female receptacles to ensure backward compatibility.

Correct and full mating between male stab and female receptacle should be clearly visible using a standard ROV mounted subsea camera. The interface between the male stab and female receptacle should use contrasting colors as an aid.

Seal areas in receptacles have been specified such that the male hot stabs can be produced with a variety of seal designs and pressure ratings.

The length of the male stab should be limited to the envelope recommended in this document. If plastic components are selected for use on the male hot stab, the designer shall allow for the short- and longer-term effects of seawater exposure, including potential dimensional changes and swelling of plastics caused by absorption of seawater that may prevent the hot stab from being extracted from the receptacle.

The required stab force should be kept as low as possible. The required stab force should be verified and documented by the hot stab manufacturer.

Hot stab applications utilizing unsecured hoses can introduce separation forces into the system. In these applications, it is recommended to include a mechanical locking feature that will retain the male hot stab and prevent separation from the female receptacle.

When multiple hot stab receptacles with similar functions are placed on a structure, the function of the port should remain consistent across all receptacles where possible. (e.g. all port "A" should be the same function).

6.10.5 Mounting Recommendations

Sufficient space shall be provided around the female receptacle to ensure full engagement of the male stab and for the removal of any debris from the receptacle. Recommended envelopes are shown in figures 20, 23, 26 and 29.

The hot stab female receptacle should be mounted in the horizontal plane where possible.

A pressure-retaining blanking (or dummy) male stab is recommended to be inserted into the female receptacle subsea when the hot stab is not being utilized, unless using a pressure-retaining blanking (or dummy) male stab will be detrimental to equipment or application. The blanking (or dummy) male stab provides seal surface protection from calcification, debris, and marine growth, as well as acting as a secondary barrier to the hydraulic system. A non-pressure-retaining blanking (or dummy) male stab can be used but will not act as a secondary barrier to the hydraulic system.

Where blanking (or dummy) male stabs are used, a parking slot can be provided for parking the blanking (or dummy) hot stab. Lanyards can be used to attach blanking (or dummy) hot stabs to subsea equipment to prevent loss when removed. It is important that lanyards are sufficient length that they do not inhibit manipulator operation.

When installing the hot stab receptacles onto ROV/AUV interface panels, the face of the female receptacle shall be protruding above the outer surface of the panel. If the receptacle is mounted to the inner surface of the subsea vehicle interface panel, the panel should be no greater than 0.75 in. (20 mm) thick with a free access area large enough to accommodate the male hot stab including the associated hydraulic fittings. If the mounting flange on the receptacle utilizes a split flange design, then it should utilize an anti-rotation feature to prevent the receptacle from rotating.

When mating rear mounted receptacles, potential interference between locking pin and hydraulic fittings on the male hot stab and ROV panels should be checked prior to deployment. The clearance behind the receptacle should be checked to ensure the nose of the male hot stab has enough room when fully engaged with the receptacle. Figure 17 shows a typical hot stab with locking mechanism engaged with receptacle. Recommended envelopes can be found in figures 20, 23, 26 and 29.

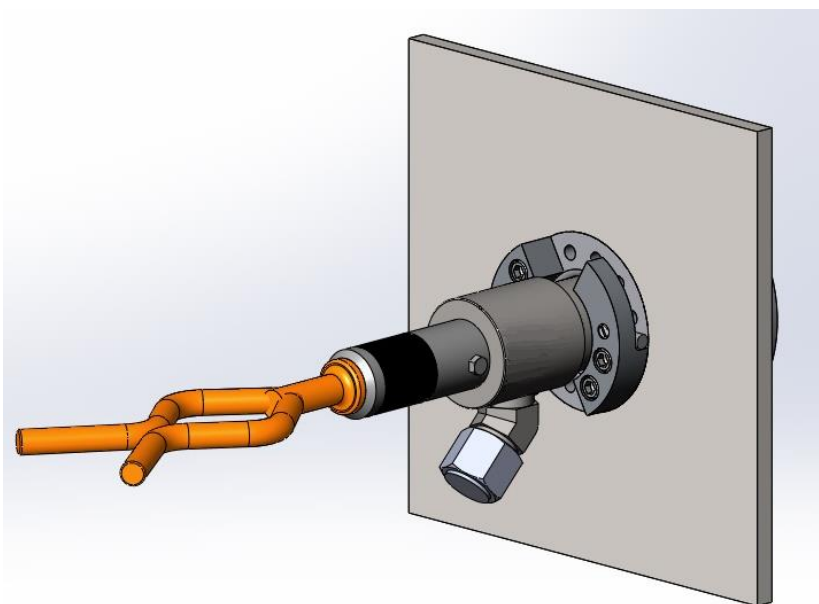


Figure 17—Typical Hot Stab with Locking Arrangement and Hydraulic Connection

6.10.6 Hot Stab Materials

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 be based on the intended use of the stab. A once or twice in a lifetime usage of the stab system (e.g., during pile sleeve grouting) might require a lower specification than a frequently used intervention stab.

Material selection should be decided by the equipment manufacturer. Material selection should follow the guidelines and principles in the EEMUA Publication 194 in conjunction with the following:

- a) Materials should be seawater corrosion resistant alloys and/or protected by a cathodic protection system for the design life. The cathodic protection must be assessed during material selection.
- b) Galling between mating parts should be carefully assessed and mitigating actions taken. Mitigating action includes selection of non-galling materials or dissimilar metal used for mating parts. Receptacles should be produced in a harder material than the stabs to be used.
- c) Able to withstand typical ROV impact loads as per section 5.1.1.6.5.

NOTE: typical materials for subsea hot stab applications are (XM-19) (UNS S20910), (Alloy 218) (UNS S21800), ANSI SS 316 (UNS S31600), Aluminum Bronze (UNS C62300), UNS N06625 (UNS N066250), duplex (UNS S32205/S31803) and super duplex (UNS S32750/S32760)

6.10.7 Hot Stab Connection, Type 1

The Type 1 hot stab is a multi-port design with single stab seal diameter. Different seal diameters and number of ports can be produced. Internal bore and hydraulic ports can be optimized for each design based on design pressure, interface requirements and number of ports. The Type 1 hot stabs typically utilize 1 to 6 individual ports. Figure 18 shows a typical example of a Type 1 Hot Stab. The internal interfaces dimensions of the Type 1, multiport hydraulic interface including seal surface areas are shown in Figure 19. Specific interface dimensions for each bore size can be found in Table 5.



Figure 18—Typical Type 1 Hot Stab

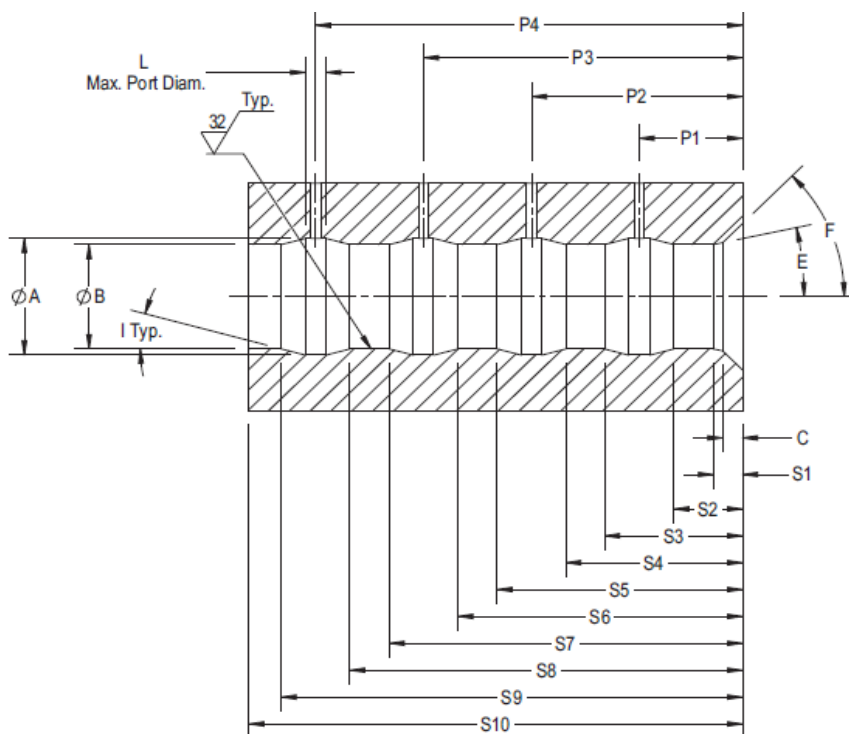


Figure 19—Single Bore Multiport Hot Stab Receptacle

Table 5—Principle Dimensions for Type 1 Receptacle

Nom. size in. (mm)	A	B	C	E	F	I
Ø 1 1/8 (28)	Ø 1.25 (32)	Ø 1.102/1.104 (28.00/28.05)	0.125 (3.18)	15 deg	45 deg	10 to 15 deg
**Ø 1 3/8 (35)	Ø 1.54 (39)	Ø 1.376/1.378 (34.95/35.00)	0.125 (3.18)	15 deg	45 deg	10 to 15 deg
**Ø 1 3/4 (43)	Ø 1.85 (47)	Ø 1.687/1.689 (42.85/42.90)	0.250 (6.35)	15 deg	45 deg	10 to 15 deg
**Ø 2 1/4 (55)	Ø 2.32 (59)	Ø 2.165/2.169 (55.00/55.10)	0.250 (6.35)	15 deg	45 deg	10 to 15 deg

Nom. size in. (mm)	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Ø 1 1/8 (28)	0.36 (9.1)	0.84 (21.3)	1.33 (33.7)	1.63 (41.3)	2.11 (53.7)	2.41 (61.3)	2.90 (73.7)	3.20 (81.3)	3.69 (93.7)	3.99 (101.3)

Ø 2 1/4 (55)	Ø9.5 (241)	Ø6.0 (150)	3.0 (75)	Ø2.5 (65)
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NOTES:

1. All dimensions are in USC units with SI units in brackets (mm)
2. X1; shall be interpreted as the maximum outer clearance diameter including locking mechanism
3. X2; shall be interpreted as the maximum inner diameter free space for a non-locking mechanism hot stab
4. X3 shall be interpreted as the minimum clearance allowance for different stab nose designs
5. X4 shall be interpreted as the maximum OD clearance distance for a stab for removal of potential debris and allowance for different stab nose designs.

6.10.8 Hot Stab Connection, Type 2

The Type 2 hot stab connection typically has two separate ports utilizing a tapered design where each of the ports is located on a different seal bore. However, there have been designs that use up to six individual ports located on two seal diameters, but these are not considered a standard design. Internal bore and hydraulic ports can be optimized within each size and design based on design pressure, interface requirements, and number of ports. Figure 21 shows a typical Type 2 hot stab design. The internal dimensions and seal surfaces for the Type 2 dual-bore, dual-port, tapered hot stab are shown in Figure 22. It is noted that vent port "O" is required to prevent a hydraulic lock during insertion and removal of male hot stabs. Specific interface dimensions for each bore size can be found in Table 7.



Figure 21—Typical Type 2 Hot Stab

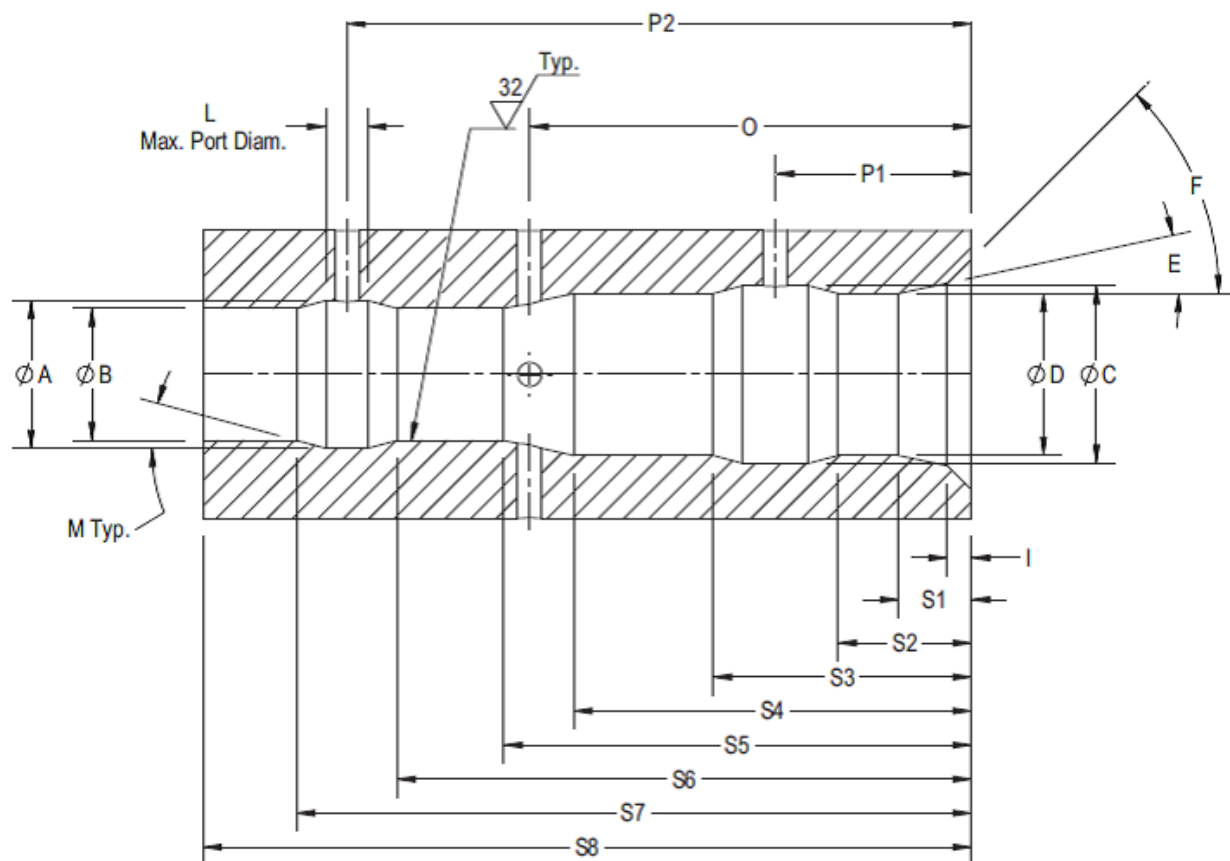
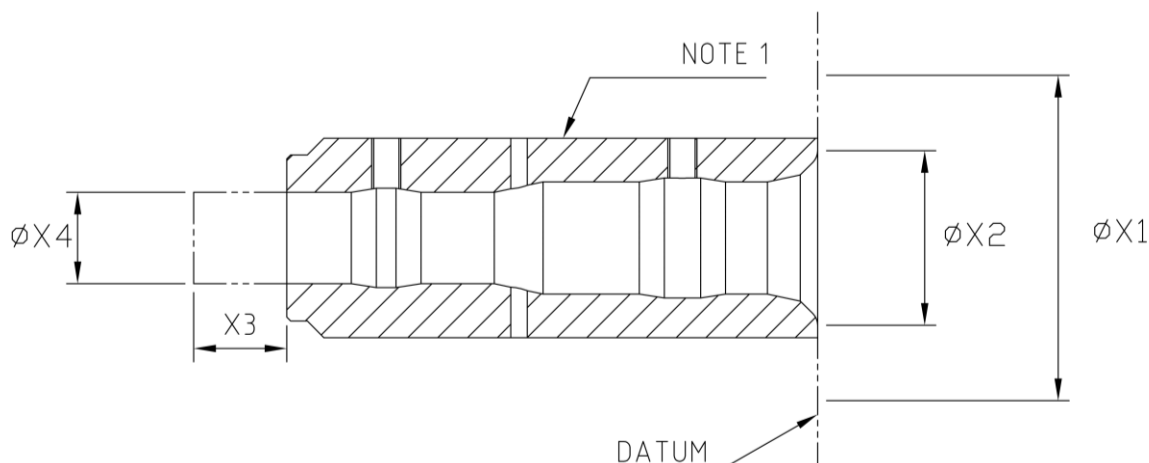


Figure 22—Dual Bore Dual Port Tapered Hot Stab Receptacle

Figure 23 shows the envelope which should be allocated around the hot stab receptacle for connection of hydraulic tubing/pipework, room for flushing of debris, stabber nose clearance, and lock interface on the Type 2 – Dual Bore Tapered Hot Stab. Recommended dimensions for the envelope can be found in Table 8. The end user should determine requirements for the envelope.



NOTE 1 – clearance to be provided for check valve/piping access near the hydraulic port

Figure 23—Type 2 Installation Envelope

Table 7—Principle Dimensions for Type 2 Receptacles

Nom. Size in. (mm)	A	B	C	D	E	F	I	M	O
Ø 1 1/8 X 1 3/8 (28/35) Dual	Ø 1.25 (32)	Ø 1.102/1.104 (28.00/28.05)	Ø 1.54 (39)	Ø 1.376/1.378 (34.95/35.00)	15 deg	45 deg	0.250 (6.35)	10 to 15 deg	2.7 (68.5)
**Ø 1 3/8 X 1 3/4 (35/43) Dual	Ø 1.54 (39)	Ø 1.375/1.377 (34.92/34.98)	Ø 1.85 (47)	Ø 1.687/1.689 (42.85/42.90)	15 deg	45 deg	0.250 (6.35)	10 to 15 deg	4.5 (114.3)

Nom. size in. (mm)	S1	S2	S3	S4	S5	S6	S7	S8
Ø 1 1/8 X 1 3/8 (28/35) Dual	0.57 (14.6)	1.63 (41.3)	2.11 (53.7)	2.41 (61.3)	2.90 (73.7)	3.31 (84.0)	3.53 (89.6)	3.85 (97.8)
**Ø 1 3/8 X 1 3/4 (35/43) Dual	0.76 (19.3)	1.39 (35.3)	2.69 (68.3)	4.14 (105.2)	4.87 (123.7)	5.98 (151.9)	7.03 (178.6)	8.00 (203)

NOTES:

1. Smaller diameters Male Hot Stabs (OD less than 1.25" (31.75 mm)) have historically been susceptible to bending during manipulation, and are not recommended
2. All dimensions are in USC units with SI units in brackets (mm)
3. All dimensions are given without coating
4. "P" dimensions and port details to be determined by manufacturer
5. Vent port "O" is required to allow venting during insertion and removal of male hot stab
6. Radius in intersections between seal surface and cavity angle recommended to avoid seal damage
7. ** these sizes are considered recommended standards
8. Surface roughness is given in micro-inches

Table 8 – Envelope Dimensions for Type 2 Receptacles

Nom size In. (mm)	X1	X2	X3	X4
Ø 1 1/8 X 1 3/8 (28/35) Dual	Ø6.0 (150)	Ø4.0 (100)	2.5 (65)	Ø2.0 (50)
Ø 1 3/8 X 1 3/4 (35/43) Dual	Ø6.5 (165)	Ø4.0 (100)	2.5 (65)	Ø2.0 (50)

NOTES

1. All dimensions are in USC units with SI units in brackets (mm)
2. X1; shall be interpreted as the maximum outer clearance diameter including locking mechanism
3. X2; shall be interpreted as the maximum inner diameter free space for a non-locking mechanism hot stab
4. X3 shall be interpreted as the minimum clearance allowance for different stab nose designs
5. X4 shall be interpreted as the maximum OD clearance for a stab for removal of potential debris and allowance for different stab nose designs.

6.10.9 Hot Stab Connection, Type 3

The Type 3 hot stab connection is a single port connection intended for applications which require high flow rates such as subsea BOP hydraulic control and flushing operations. Internal bore and hydraulic ports can be optimized within each size and design based on the design pressure, flow rates, and interface requirements.

The **Ø1.7 (43) nominal size receptacle is the standard interface for BOP, Capping Stack and Subsea Dispersant Delivery of high flow function. The male hot stab and female receptacle for this stab shall utilize a nominal 1 in (25mm) port.

All high flow hot stab assemblies shall include a locking feature a mechanical locking feature that will retain the male hot stab and prevent separation from the female receptacle.

For some applications, hydraulic porting connection type and dimensions are defined by port diameter, pressure rating, and user requirements. Figure 24 shows a typical Type 3 Hot Stab design. Internal dimensions and seal surfaces for the Type 3 - Single Bore High Flow Hot Stab are shown in Figure 25. Specific interface dimensions for each bore size can be found in Table 9.



Figure 24—Typical Type 3 Hot Stab

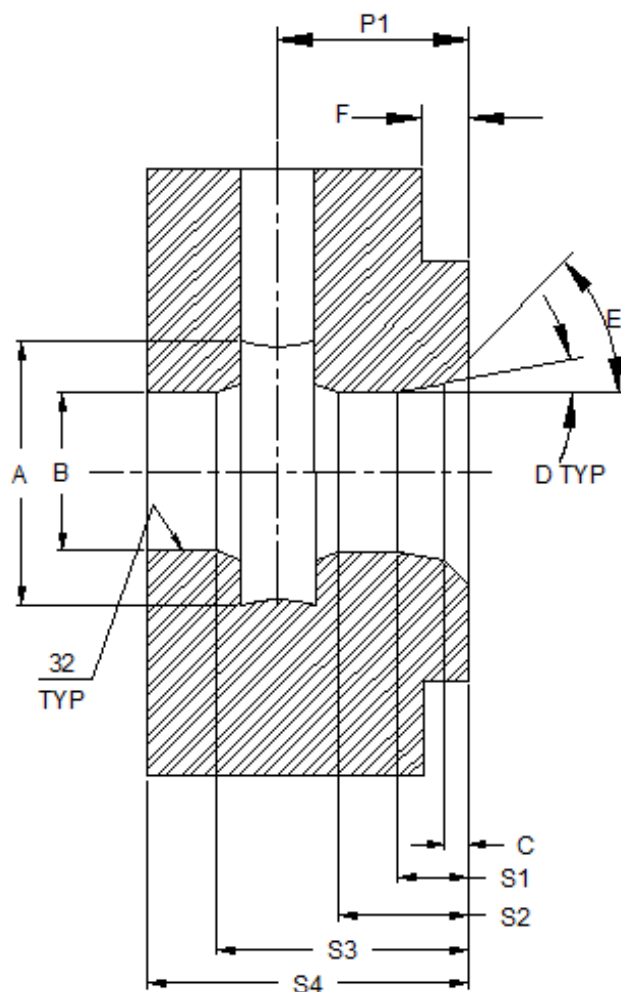


Figure 25—Single Port High Flow Hot Stab

Table 9—Principle Dimensions for Type 3 Receptacles

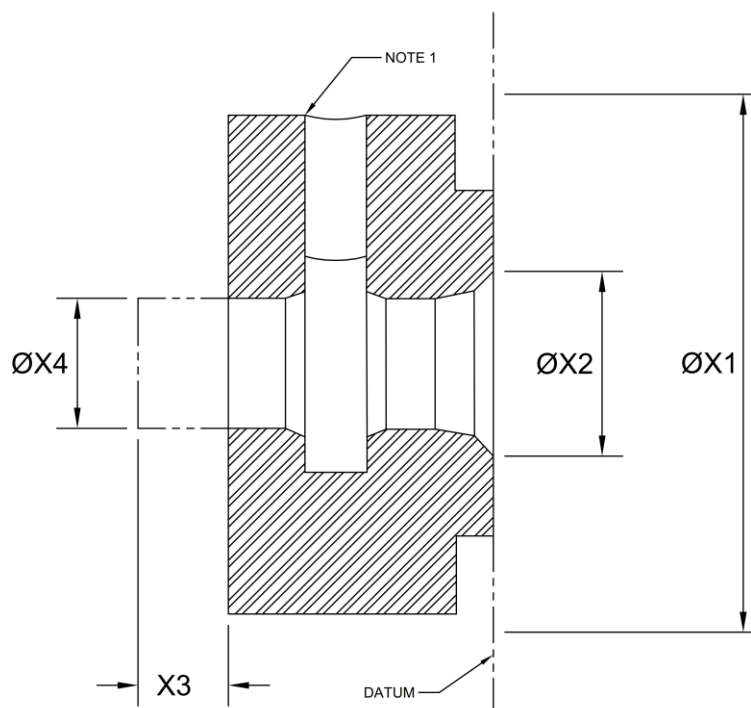
Nom size in. (mm)	A	B	C	D	E	F (min)
**Ø1.7 (43)	Ø2.8 (71)	Ø1.687/1.689 (42.85/42.90)	0.250 (6.35)	10 to 15 deg	45 deg	0.500 (12.7)
Ø2.0 (50)	Ø2.17 (55)	Ø1.968/1.970 (50.00/50.05)	0.250 (6.35)	10 to 15 deg	45 deg	0.500 (12.7)
Ø2.5 (65)	Ø2.76 (70)	Ø2.559/2.561 (65.00/65.05)	0.250 (6.35)	10 to 15 deg	45 deg	0.500 (12.7)
**Ø3.5 (89)	Ø4.12 (104.6)	Ø3.500/3.502 (88.90/88.95)	0.50 (12.70)	10 to 15 deg	45 deg	0.500 (12.7)
Ø4.0 (100)	Ø4.56 (116)	Ø3.937/3.939 (100.00/100.05)	0.250 (6.35)	10 to 15 deg	45 deg	0.500 (12.7)
**Ø5.0 (127)	Ø5.16 (131)	Ø5.005/5.000 (127.13/127.00)	0.50 (12.70)	10 to 15 deg	45 deg	0.500 (12.7)
Ø6.0 (152)	Ø6.50 (165)	Ø6.000/6.003 (152.40/152.47)	0.50 (12.70)	10 to 15 deg	45 deg	0.500 (12.7)

Nom. size in. mm)	S1	S2	S3	S4
**Ø1.7 (43)	0.76 (19.3)	1.39 (35.3)	2.69 (68.3)	3.44 (87.4)
Ø2.0 (50)	1.00 (25.4)	1.49 (37.9)	3.46 (87.9)	3.95 (100.4)
Ø2.5 (65)	1.00 (25.4)	1.64 (41.7)	4.20 (106.7)	4.84 (123.0)
**Ø3.5 (89)	1.38 (35.1)	2.00 (50.8)	5.00 (127.0)	5.63 (143.0)
Ø4.0 (100)	1.00 (25.4)	1.98 (50.4)	5.92 (150.4)	6.90 (175.4)
**Ø5.0 (127)	1.18 (29.7)	1.83 (46.5)	5.68 (144.3)	6.50 (165.1)
Ø6.0 (152)	1.18 (29.7)	1.83 (46.5)	6.42 (163.0)	7.07 (179.6)

NOTES:

1. All dimensions are in USC units with SI units in brackets (mm)
2. All dimensions are given without coating.
3. Body dimensions are symmetric about the center line, perpendicular to dimension "A"
4. "P" dimensions and port details to be determined by manufacturer
5. ** these sizes are considered recommended standards
6. surface roughness is given in micro-inches

Figure 26 shows the envelope which should be allocated around the hot stab receptacle for connection of hydraulic tubing/pipework, room for flushing of debris, stabber nose clearance, and lock interface on the Type 3 – Single Port High Flow Hot Stab. Recommended dimensions for the envelope can be found in Table 10. The end user should determine requirements for the envelope.



NOTE 1 – clearance to be provided for check valve/piping access near the hydraulic port

Figure 26—Type 3 Installation Envelope

Table 10—Envelope Dimensions for Type 3 Receptacles

Nom size in. (mm)	X1	X2	X3	X4
Ø1.7 (43)	Ø6.5 (165)	Ø4.0 (100)	2.5 (65)	Ø2.0 (50)
Ø2.0 (50)	Ø7.5 (190)	Ø4.0 (100)	3.0 (75)	Ø2.0 (55)
Ø2.5 (65)	Ø10 (250)	Ø5.90 (150)	4.0 (100)	Ø3.0 (75)
Ø3.5 (89)	Ø10 (250)	Ø5.90 (150)	5.0 (130)	Ø4.0 (100)
Ø4.0 (100)	Ø12 (305)	7.480 (190)	6.0 (150)	Ø4.0 (100)
Ø5.0 (127)	Ø12 (305)	7.480 (190)	7.5 (190)	Ø5.0 (130)
Ø6.0 (152)	Ø18 (455)	10.24 (260)	8.88 (225.5)	Ø6.06 (307.8)

NOTES:

1. All dimensions are in USC units with SI units in brackets (mm)
2. X1; shall be interpreted as the maximum outer clearance diameter including locking mechanism
3. X2; shall be interpreted as the maximum inner diameter free space for a non-locking mechanism hot stab
4. X3 shall be interpreted as the minimum clearance allowance for different stab nose designs
5. X4 shall be interpreted as the maximum OD clearance for a stab for removal of potential debris and allowance for different stab nose designs.

6.10.10 Hot Stab Connection, Type 4

The Type 4 hot stab connection is a single port connection intended for applications designed to accommodate entrance from both sides (dual entry). The dual entry design is utilized when the directionality of the hot stab receptacle cannot be predicted or when it is advantageous to enter the receptacle from either side.

All high flow hot stab assemblies shall include a locking feature a mechanical locking feature that will retain the male hot stab and prevent separation from the female receptacle.

For other applications, hydraulic porting connection type and dimensions are defined by port diameter, pressure rating, and user requirements. Figure 27 shows a typical Type 4 Hot Stab design. Internal dimensions and seal surfaces for the Type 4 – Dual Entry Flow Hot Stab are shown in Figure 28. Specific interface dimensions for each bore size can be found in Table 11.



Figure 27—Typical Type 4 Hot Stab

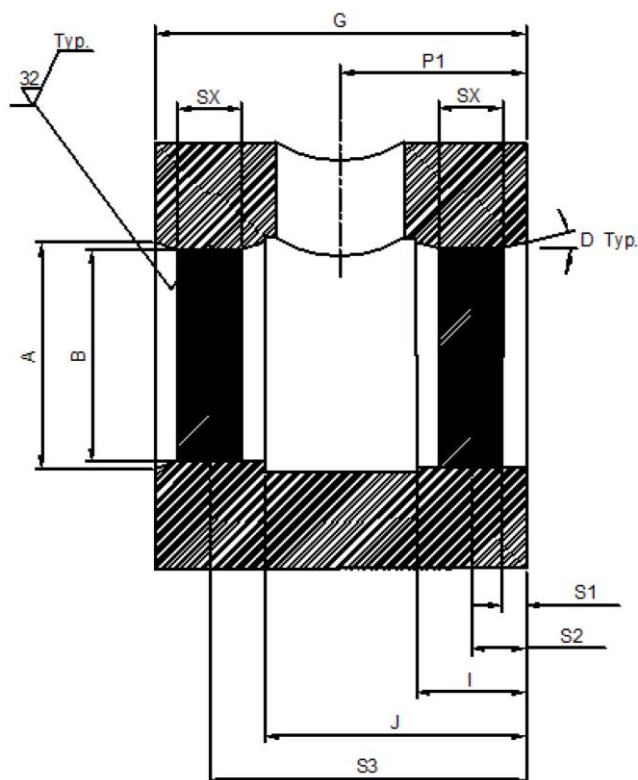


Figure 28—Dual Entry High Flow Hot Stab

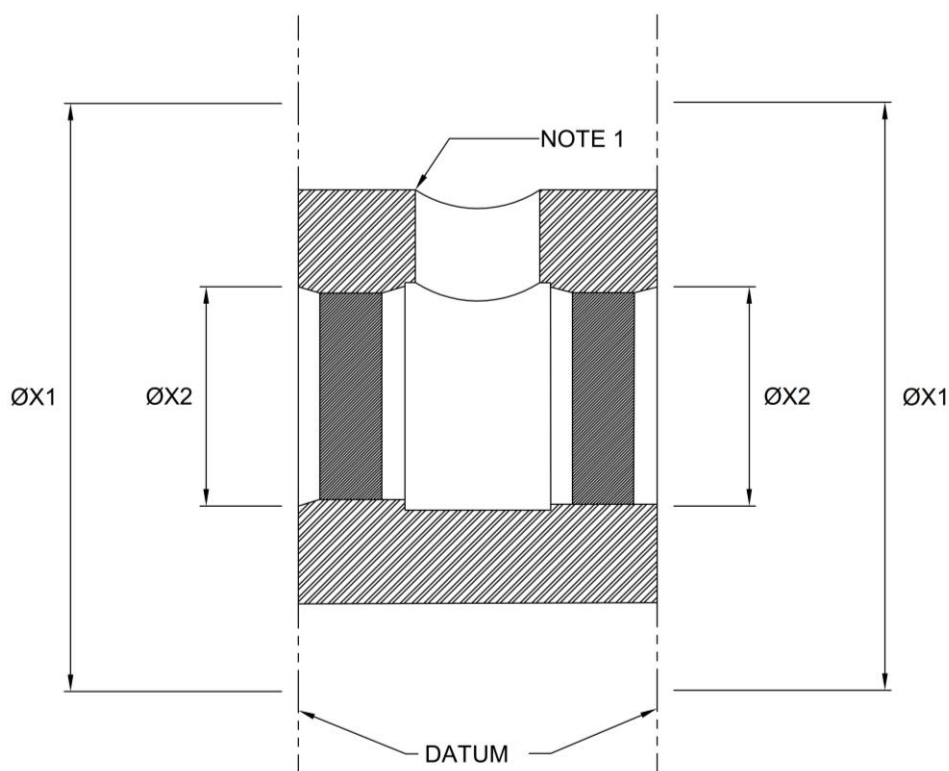
Table 11—Principle Dimensions for Type 4 Receptacles

Nom size in. (mm)	A	B	D	G	I	J
Ø2.2 (55)	Ø2.32 (59)	Ø2.165/2.167 (55.00/55.05)	15 deg	4.33 (110.0)	1.65 (42.0)	2.68 (68.0)
Ø3.1 (80)	Ø3.47 (88)	Ø3.150/3.152 (80.0/80.05)	15 deg	6.30 (160.0)	2.13 (54.0)	4.17 (106.0)
Ø4.0 (100)	Ø4.57 (116)	Ø3.937/3.939 (100.0/100.1)	15 deg	8.66 (220.0)	2.56 (70.0)	5.91 (150.0)
Ø5.9 (150)	Ø6.50 (165)	Ø5.906/5.908 (150.0/150.1)	15 deg	10.24 (260.0)	3.03 (77.0)	7.21 (183.0)
Ø8.0 (200)	Ø8.66 (220)	Ø7.874/7.878 (200.0/200.1)	15 deg	17.80 (452.0)	5.55 (141.0)	12.24 (141.0)
Nom. size in. (mm)	S1		S2	S3	SX	
Ø2.2 (55)	0.63 (16.0)		0.96 (24.3)	3.37 (85.7)	0.47 (12.0)	
Ø3.1 (80)	0.63 (16.0)		1.22 (31.0)	5.08 (129.0)	0.98 (25.0)	
Ø4.0 (100)	0.63 (16.0)		1.38 (35.0)	7.28 (185.0)	1.18 (30.0)	
Ø5.9 (150)	0.63 (16.0)		1.52 (38.5)	8.72 (221.5)	1.38 (35.0)	
Ø8.0 (200)	0.63 (16.0)		2.42 (61.5)	15.39 (391.0)	3.54 (90.0)	

NOTES:

1. All dimensions are in USC units with SI units in brackets (mm)
2. All dimensions are given without coating.
3. Body dimensions are symmetric about the center line, perpendicular to dimension "A"
4. "P" dimensions and port details to be determined by manufacturer
5. ** these sizes are considered recommended standards
6. surface roughness is given in micro-inches

Figure 29 shows the envelope which should be allocated around the hot stab receptacle for connection of hydraulic tubing/pipework, room for flushing of debris, stabber nose clearance, and lock interface on the Type 4 – Single Port High Flow Hot Stab. Recommended dimensions for the envelope can be found in Table 12. The end user should determine requirements for the envelope.



NOTE 1 – clearance to be provided for check valve/piping access near the hydraulic port

Figure 29–Type 4 Installation Envelope

Table 12–Envelope Dimensions for Type 4 Receptacles

Nom size in. (mm)	X1	X2
Ø2.2 (55)	Ø8.5 (215)	Ø5.90 (150)
Ø3.1 (80)	Ø10 (250)	Ø5.90 (150)
Ø4.0 (100)	Ø12 (305)	Ø7.50 (190)
Ø5.9 (150)	Ø18 (455)	Ø10.25 (260)
Ø8.0 (200)	Ø21.5 (550)	Ø12.8 (325)

NOTES:

1. All dimensions are in USC units with SI units in brackets (mm)
2. X1; shall be interpreted as the maximum outer clearance diameter including locking mechanism
3. X2; shall be interpreted as the maximum inner diameter free space for a non-locking mechanism hot stab

6.10.11 Hot stab locking mechanism

There are several locking mechanisms that have been utilized on hot stab connections. This subclause provides guidance to standardize “J” slot locking mechanisms as this is the most common design for locking mechanisms [see Figure 30]. Figure 31 shows the configuration of the “J” slot with respect to the receptacle face. Specific interface dimensions for the pin and the slot for each bore size are found in Table 13.

Other locking designs have been utilized and meet the requirements of this recommended practice. In general a locking mechanism provides two functions; a visual indication that the hot stab is fully engaged and the functionality to resist loads that may cause the hot stab to become disengaged from the receptacle.

The “J” slot locking design should include the following requirements:

- “J” slot locking mechanism, including pins and tabs, must fit within the envelope dimension X1 for the corresponding Hot stab hydraulic connections (Type 1, Type 2 Type 3 and Type 4).
- Installation of a J-lock interface onto the receptacle must not prevent the insertion of a stab without locking mechanism into the same receptacle fitted with a J-lock interface. See defined X2 dimension
- The weight and tension of the hydraulic hoses and fittings should not cause the hot stab to rotate from the fully locked position
- Materials shall meet the requirements of clause 8 of this document
- The design should contain 2 lock pins which shall be configured 180 degrees apart
- Rotation from insertion to the locked position must be at least 30 degrees
- At least 1 lock pin diameter engagement in the “J” slot
- A visual indication that the locking mechanism is fully engaged is required, the lock pin in the “J” slot may be used as a visual indicator
- the mechanism must be designed to resist loads from hydraulic hoses and external forces from installation
- The lock pin, when engaged shall not impede the functional sealing integrity of the stab and receptacle interface.

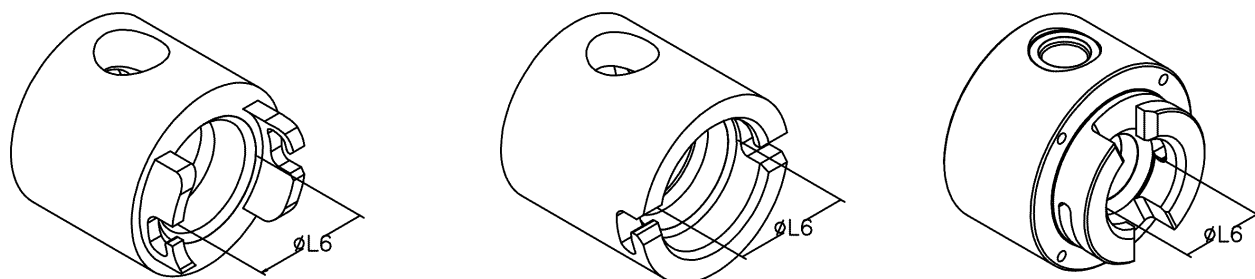
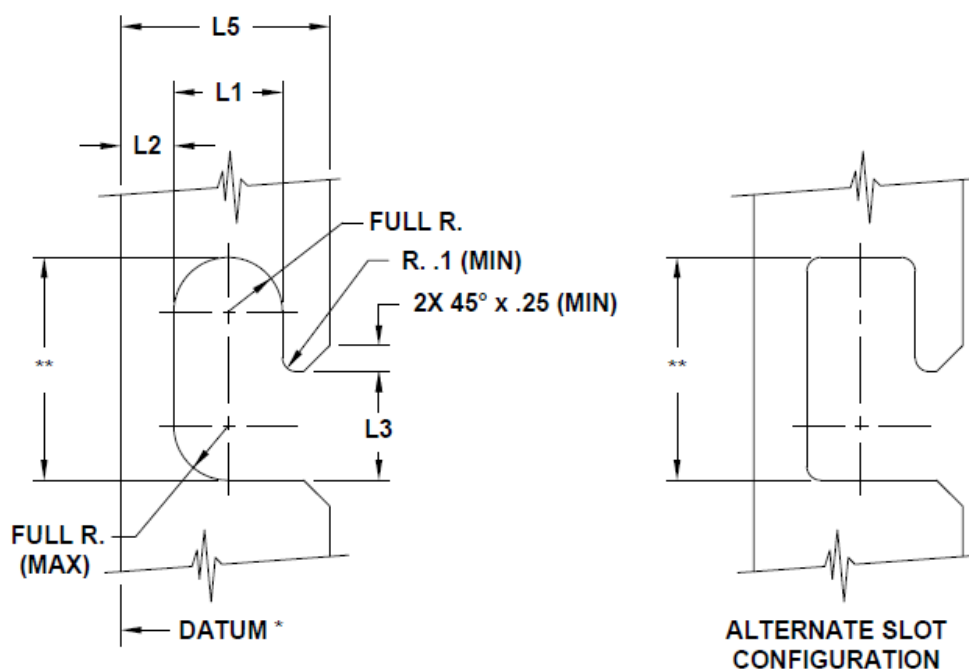


Figure 30—"J" Slot Lock



- * RECEPTACLE FACE, SEE SINGLE-PORT HIGH FLOW HOT STAB RECEPTACLE
 ** ROTATION FROM INSERTION TO THE LOCKED POSITION MUST BE AT LEAST 30 DEGREES AND ONE FULL ENGAGEMENT LENGTH OF L3.

Figure 31—"J" Slot Details

Table 13—"J" slot lock interface dimensions

Nom. size	Lock pin	L1	L2	L3 (MIN)	L5 (MAX)	L6
Ø1.7 (43)	Ø0.38 (9.6)	0.44 (11.2)	0.0 (0)	0.44 (11.2)	1.00 (25.4)	Ø4.0 (100)
Ø2.0 (50)	Ø0.38 (9.6)	0.44 (11.2)	0.0 (0)	0.44 (11.2)	1.00 (25.4)	Ø4.0 (100)
Ø2.2 (55)	Ø0.75 (19.0)	0.91 (23.0)	0.38 (9.6)	0.91 (23.0)	1.75 (44.5)	Ø5.90 (150)
Ø2.5 (65)	Ø0.75 (19.0)	0.91 (23.0)	0.38 (9.6)	0.91 (23.0)	1.75 (44.5)	Ø5.90 (150)
Ø3.1 (80)	Ø0.75 (19.0)	0.91 (23.0)	1.2 (31)	0.91 (23.0)	3.15 (80)	Ø5.90 (150)
Ø3.5 (89)	Ø0.75 (19.0)	0.91 (23.0)	0.38 (9.6)	0.91 (23.0)	1.75 (44.5)	Ø5.90 (150)
Ø4.0 (100)	Ø0.75 (19.0)	0.91 (23.0)	0.25 (6.4)	0.91 (23.0)	1.75 (44.5)	7.480 (190)
Ø5.0 (125)	Ø0.75 (19.0)	0.91 (23.0)	0.25 (6.4)	0.91 (23.0)	1.75 (44.5)	7.480 (190)
Ø5.9 (150)	Ø0.75 (19.0)	0.91 (23.0)	1.28 (32.5)	0.91 (23)	3.2 (81.5)	10.24 (260)
Ø6.0 (152)	Ø0.75 (19.0)	0.91 (23.0)	0.25 (6.4)	0.80 (6.3)	1.75 (44.5)	10.24 (260)
Ø8.0 (200)	Ø0.75 (19.0)	0.91 (23.0)	1.28 (32.5)	0.9 (23)	3.2 (81.5)	12.80 (325)

NOTES:

1. All dimensions are in USC units with SI units in brackets (mm)

6.11 Rotary fluid coupling

6.11.1 Function

To provide multi-function hydraulic stabbing.

6.11.2 Application

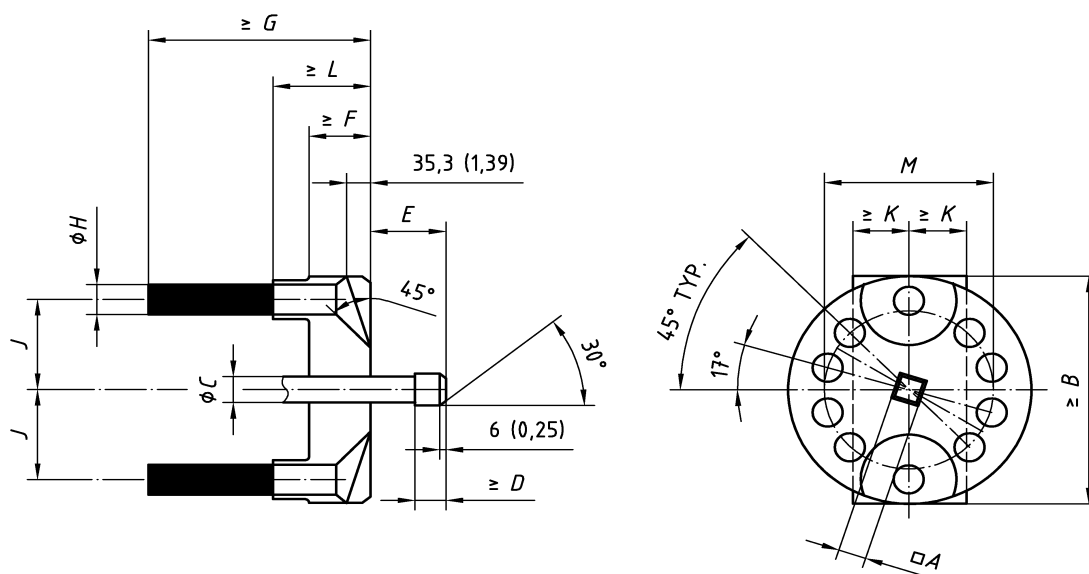
Used for multi-function hydraulic stabs for pipeline repair systems and flowline connections.

6.11.3 Design

A rotary fluid coupling, (also known as a swivel union or swivel joint), is a device used to make a hydraulic connection from a stationary inlet to a rotating outlet. The interface dimensions for the rotary fluid couplings are shown in Figure 32.

NOTE Fluid couplings are optional up to eight places as required.

Dimensions in millimeters (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)
ϕM	—	171,5 (6,750)
Tolerances are: three-place decimal: $\pm 0,2$ mm (0,01 in) two-place decimal: $\pm 0,5$ mm (0,02 in) fraction: ± 1 mm (0,04 in)		

Figure 32—Rotary Fluid Coupling

6.12 Component Change-out Interface

6.12.1 Function

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

6.12.2 Application

The change-out interface for components is used where vertical installation and retrieval can be carried out by subsea vehicle in conjunction with tooling systems. Typical components which fall into this category are:

- chokes;
- control modules;
- insert valves;
- multiphase meters;

- e) pig launchers;
- f) chemical injection modules;
- g) hydraulic accumulator modules;
- h) debris and pressure caps.

6.12.3 Design

The interface comprises two identical landing units [see Figure 33, Figure 34, Figure 35, Figure 36, and Figure 37], 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 should be set at a center pitch of 59.0 in (1,500 mm). This allows components of up to 43.3 in x 43.3 in (1,100 mm x 1,100 mm) plan area to be handled. A nominal height up to 66.9 in (1,700 mm) has been selected as this covers most 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.

If a component exceeds these sizes the next recommended pitch is 68.9 in (1,750 mm). Components longer than 66.9 in (1,700 mm) can be accommodated depending on tooling capabilities.

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

Design loads for the landing units are particular to the component and should be evaluated on a case-by-case basis. The interface is designed around a vertical in-water mass of 2,640 lbf (1,200 kg) [6,600 lbf in air] that causes a shared maximum vertical load of 45,000 lbf (200 kN) and bending moment of 44,000 lbf-ft (60 kN-m). The interface should be manufactured from material with a minimum ultimate tensile strength of 65,300 psi (450 MPa) 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 37. 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.

Dimensions in inches (millimeters)

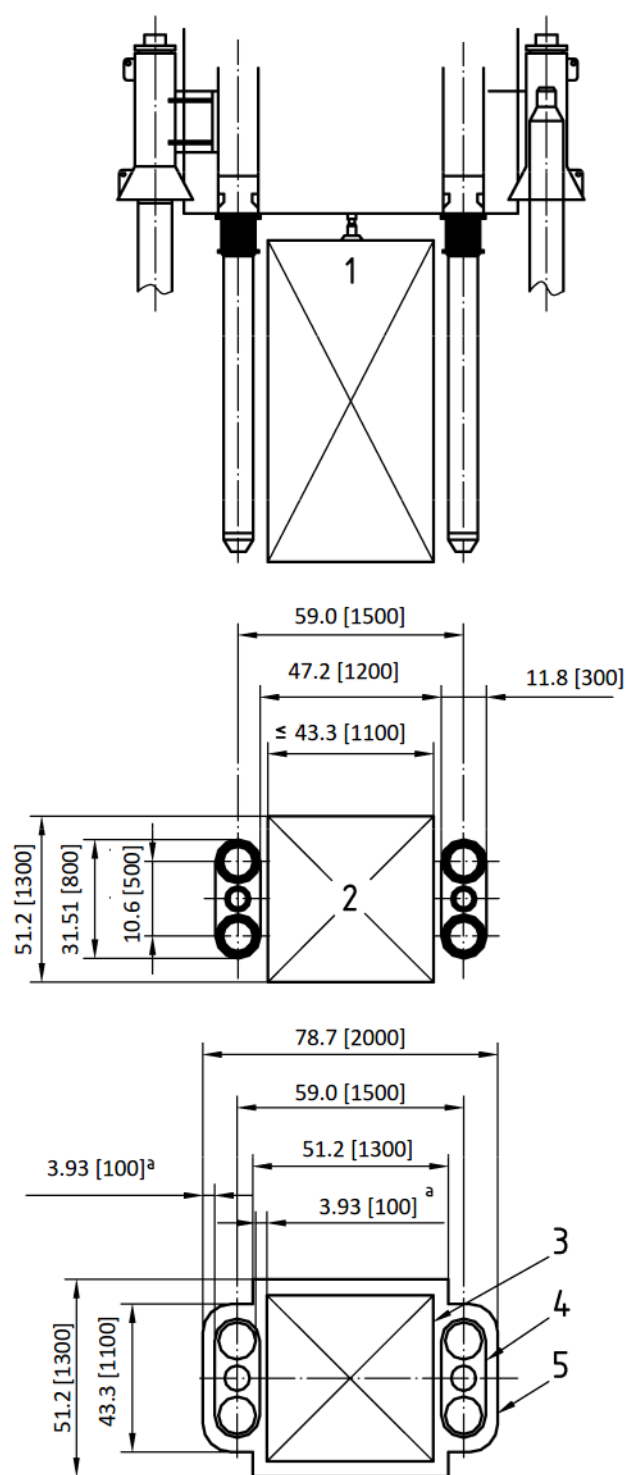
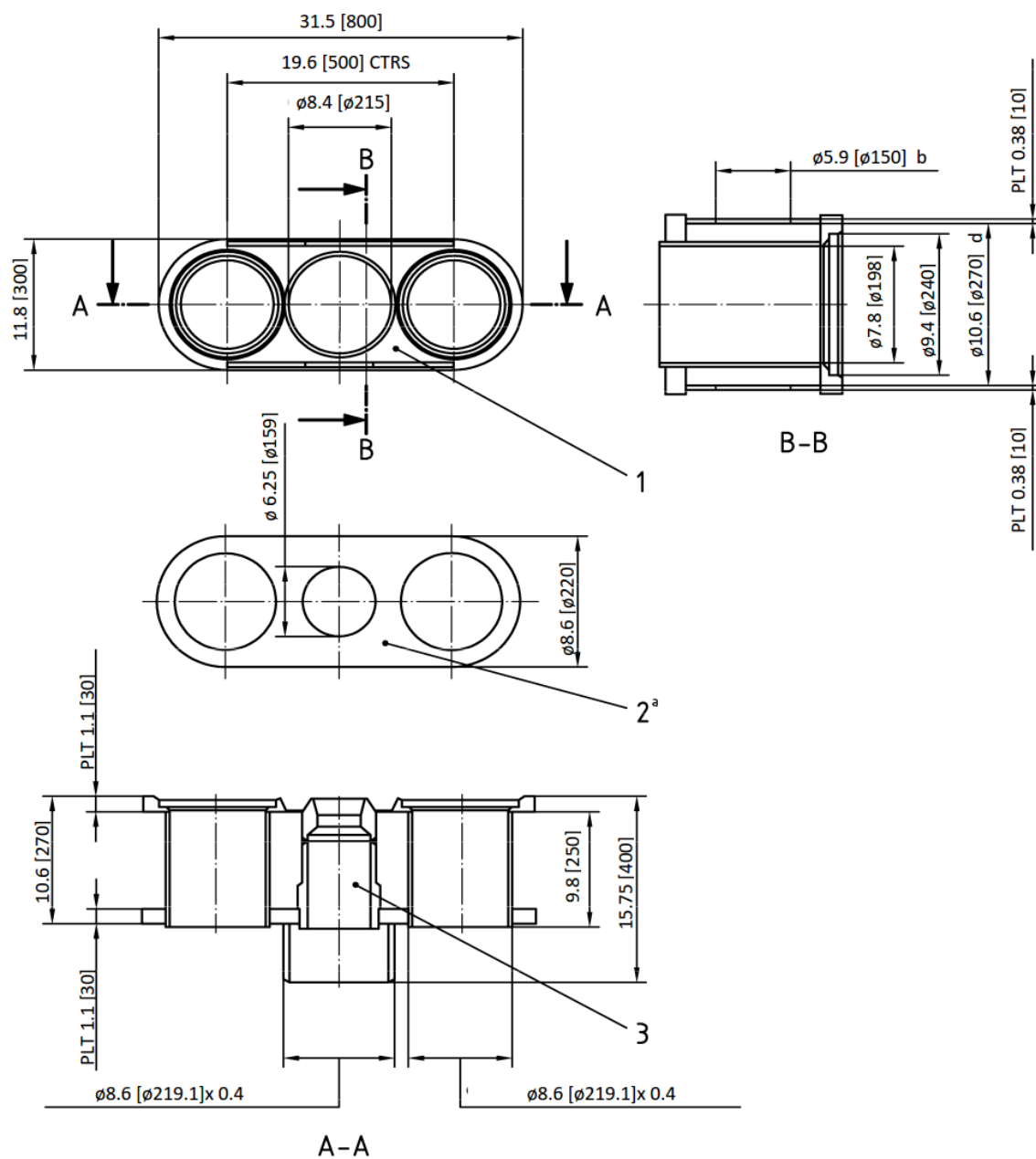


Figure 33—Component Change-out (CCO) Interface

Dimensions in inches (millimeters)



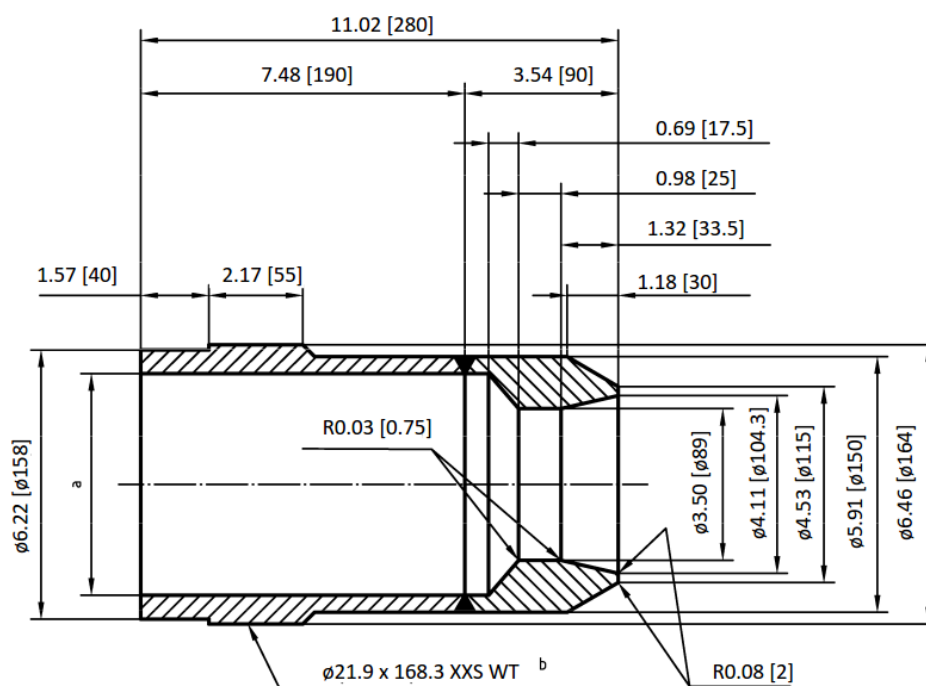
Key

- 1 top plate
- 2 bottom plate
- 3 lockdown post (see Figure 26)

- a Unspecified dimensions as per top plate
- b new hole
- c API pipe
- d between stiffers

Figure 34—Component Change-out (CCO) Interface Structure

Dimensions in inches (millimeters)



KEY

- a Nominal bore
- b API tube or bar stock XXS

Figure 35—Component Change-out (CCO) Lockdown Post Receptacle

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

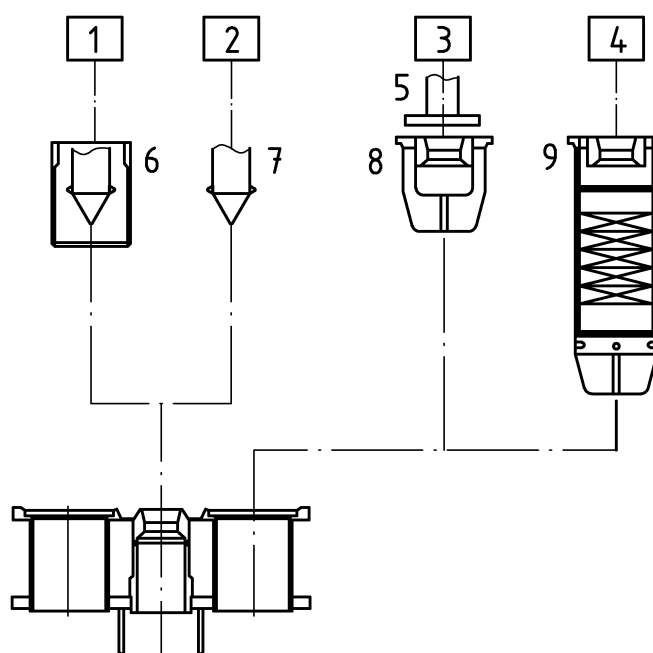
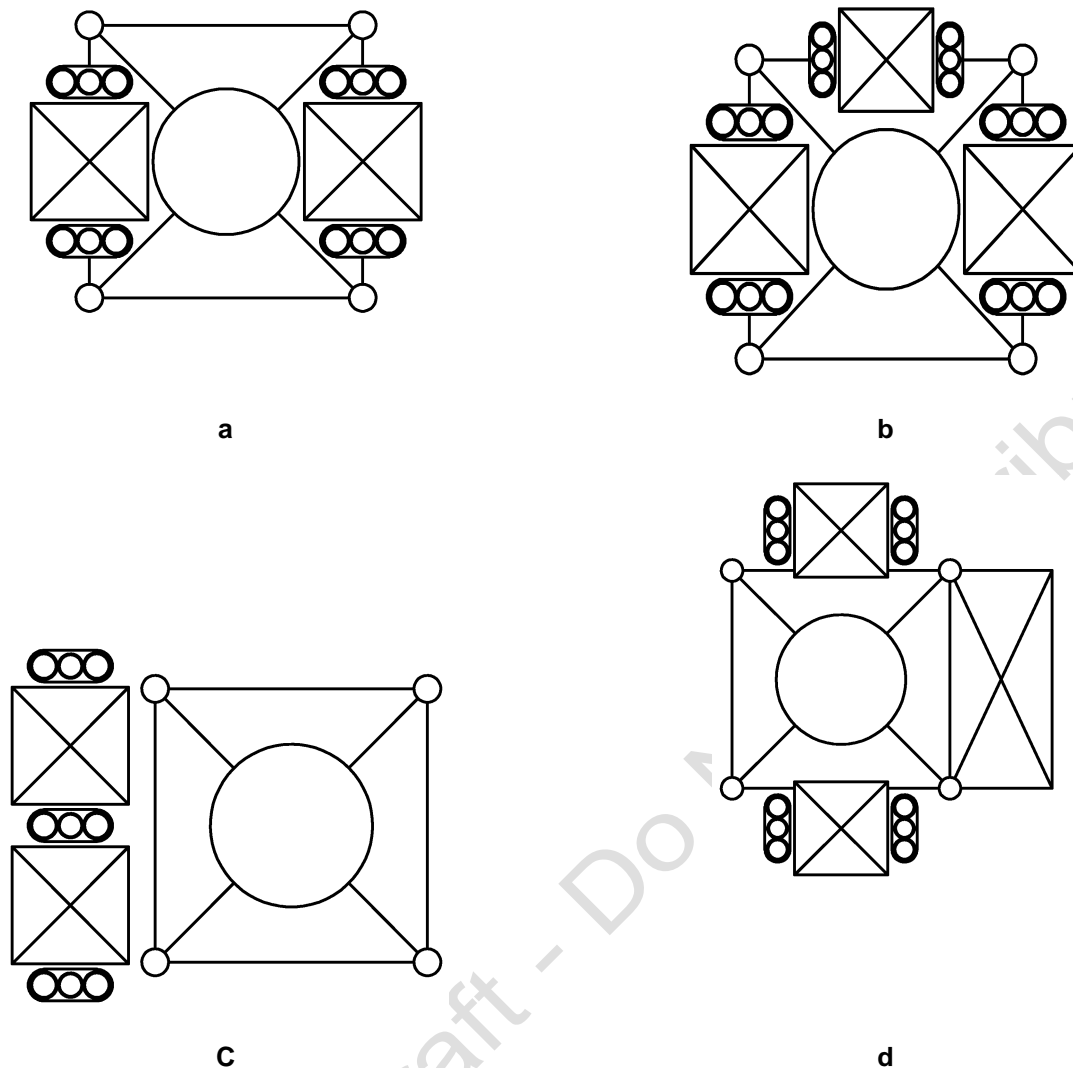


Figure 36—Component Change-out (CCO) Lockdown and Weight System



KEY

- a production and gas lift choke
- b control module/production and gas lift choke
- c shared interface
- d horizontal tree

Figure 37—Component Change-out (CCO) Interface Layout Options

6.12.4 Operation

The removal of a component typically consists of the following sequence:

- subsea vehicle and tool system landing vertically on the interface
- engaging a lockdown feature
- perform a weight exchange or buoyancy adjustment
- release the component, via the tooling system or operation of torque interface
- lifting of the component into the tooling system
- vehicle and tooling system with the component, releases lockdown feature

- vehicle and tooling system maneuvers away from the interface
- Installation is a reverse procedure

6.13 Lifting mandrels

The lifting mandrel designs presented have been developed for use with the CCO tool interface. Two sizes provide for all current subsea replaceable payloads employed with the CCO interface.

Typical examples of such applications are:

- a) subsea control module;
- b) subsea choke insert;
- c) multi-phase flowmeter insert;
- d) valve insert.

With reference to Figure 38, the Type A mandrel is employed for payloads up to 4,500 lbf (20 kN) gross weight in air and the Type B mandrel for payloads greater than 4,500 lbf (20 kN) and up to 11,200 lbf (50 kN).

Dimensions in inches (millimeters)

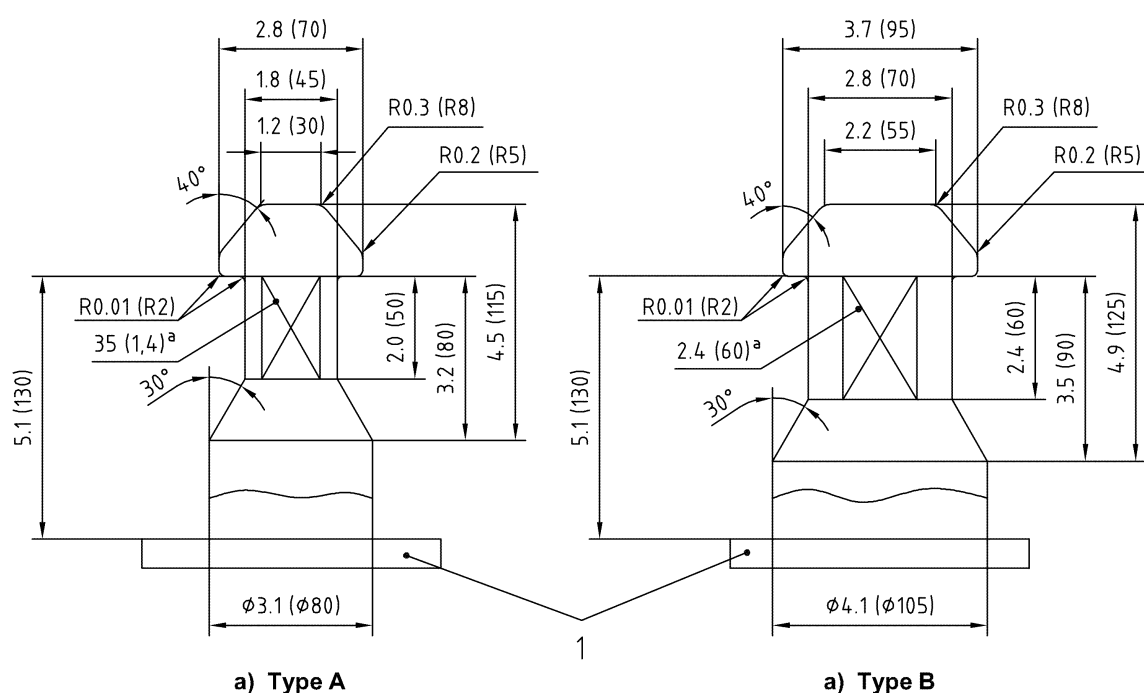


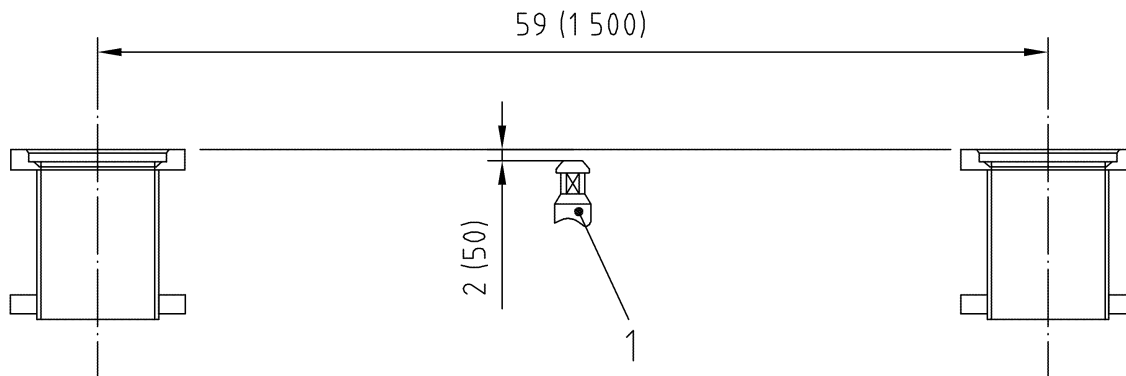
Figure 38—Lifting mandrels

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 2 in (51 mm)] 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 39.

The connection interface for the mandrel to the payload is not defined. It can be implemented as a machined/bolted flange, weld socket connection of 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 inches (millimeters)



Key

1 Orientation flat/lifting mandrel

Figure 39—Lifting mandrel in relation to component change-out interface

6.14 Electrical and hydraulic flying lead handling

6.14.1 Function

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

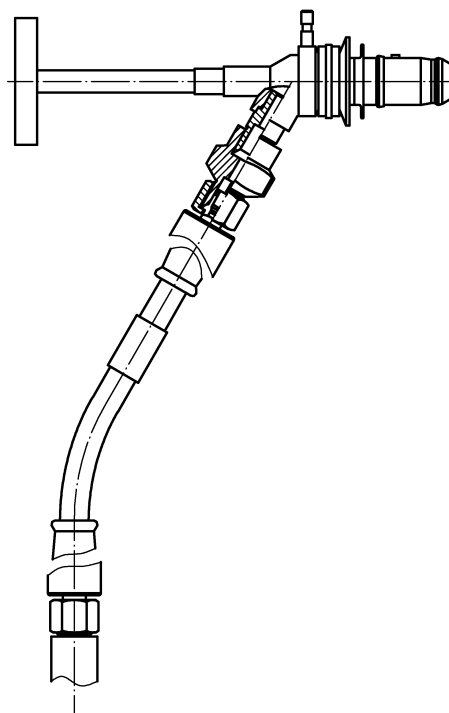
6.14.2 Application

This interface can be used for all "fly-to-place" connections/disconnections where the stab plate configuration and weight are within the capacity of the selected subsea vehicle.

6.14.3 Design

There are a significant number of subsea connection applications which require the transfer or installation of electrical, hydraulic, or combined electro-hydraulic flying leads associated with the interconnection of subsea production equipment. The length of such flying leads ranges from a few feet to lengths more than 300 ft. The flying leads are terminated either with a single electrical connector/hydraulic coupling or several connections assembled as a stab plate.

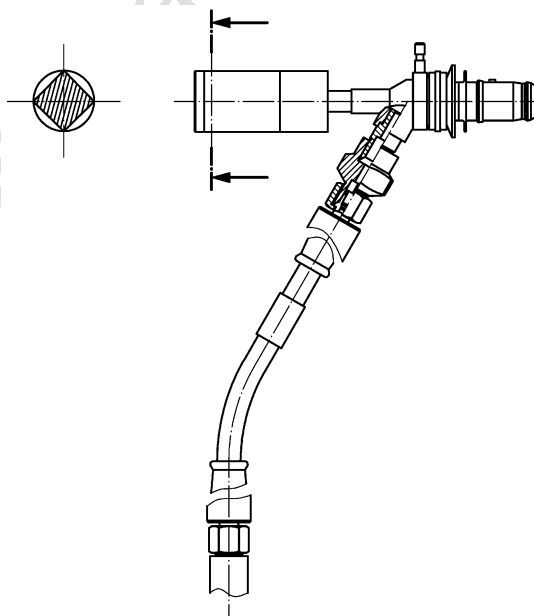
Figure 40 shows an electrical connector with an oil-filled hose conduit connection interface suitable for single connection flying leads.



NOTE Handle for use with manipulator, see Figure 9 (Handle can include compliant section).

Figure 40—Manipulator connection operations

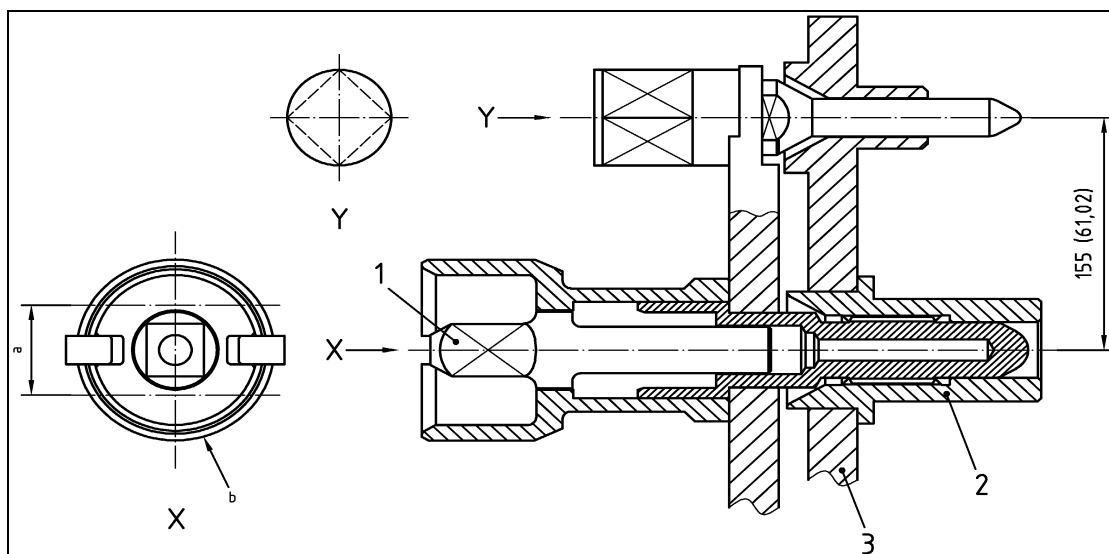
Alternatively, a TDU gripper interface may be mounted to the rear of the connector, which provides an interface for the same connector for TDU operations, see Figure 41.



NOTE 1 Handle for use with TDU, see Figure 10.

Figure 41 — Tool Deployment Unit (TDU) Connection Operations

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. The typical locking system interface are shown in Figure 42 and Figure 43.



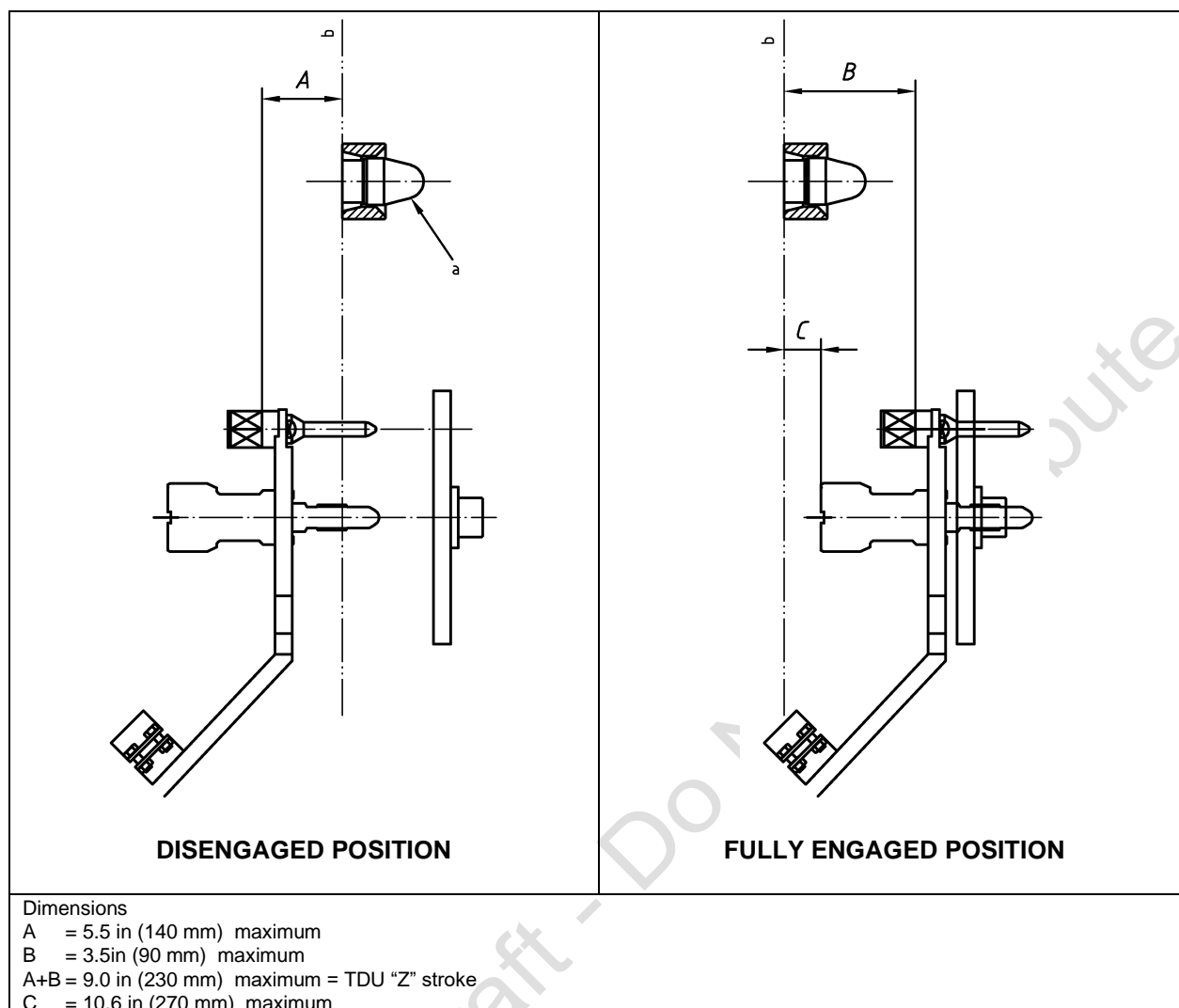
NOTE: Part section shows ROV interfaces only.

Key

- 1 Stabplate drive screw
- 2 Locking mechanism (inboard)
- 3 Tree stabplate
- a Receptacle may be truncated for minor weight-saving
- b See Figure 13

Figure 42—Multiple-Quick Connection (MQC)

Dimensions in inches (millimeters)



KEY

- a see Figure 5
- b docking face

Figure 43—Typical Flying Lead in Disengaged/engaged Positions

Where an application requires several connections to be made simultaneously, these are generally mounted onto a support an MQC stab-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.

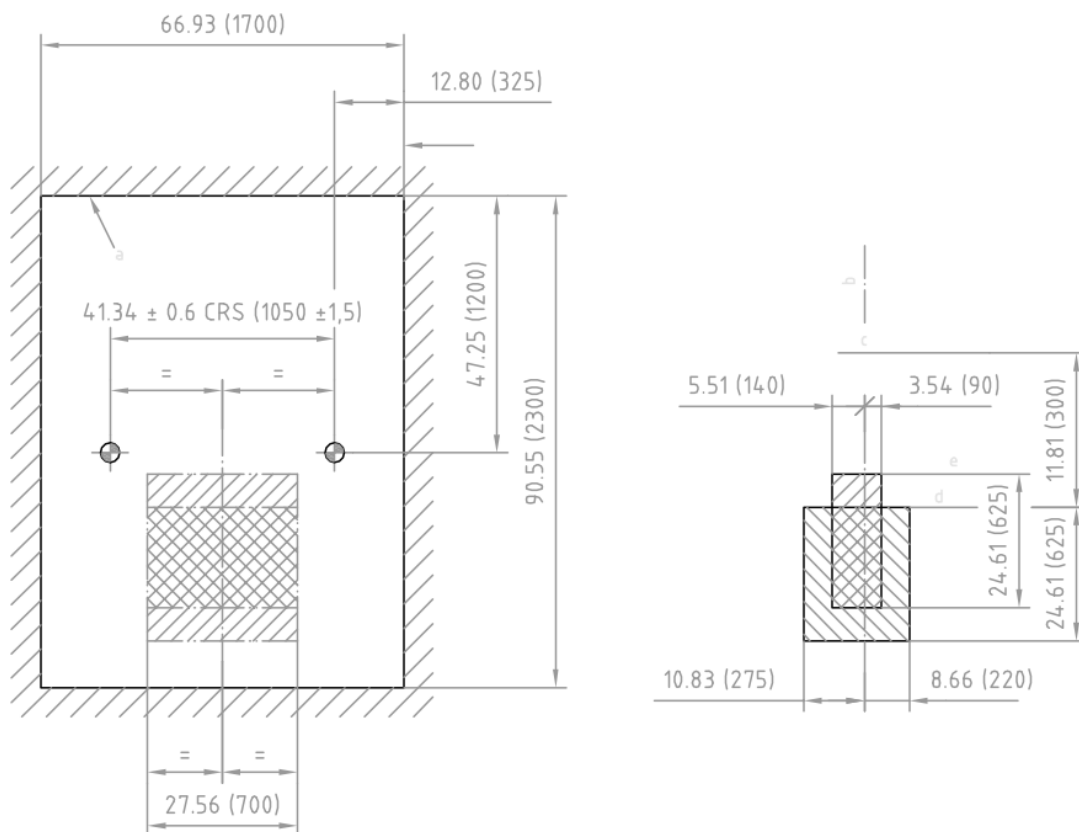
In addition to a combined central locating/locking pin a secondary alignment pin is recommended to provide controlled orientation of the stab plate for make-up. A clamping mechanism for position control and stress relief of the individual conduit hoses or cables or both is necessary for tooling access and operations.

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

Figure 44 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. These forces are to be derived from individual application requirements and are outside the scope of this Recommended Practice. The mechanism for locking is not defined. However, a good practice is to incorporate a release mechanism for the inboard locking assembly in the event of stab plant jamming.

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 normally entail a total of five plates, two junction plates, two parking places and an intermediate part to temporarily place the protective cover plate during the operation. The same parameters will apply to the situation where the flying leads are installed diverless, and when the terminations are delivered by a special fly-in tool attached to the host vehicle.

Dimensions in inches (millimeters)



KEY

- a recommended clearance area to permit access and allow for cameras, support brackets
- b docking face
- c center line of docking probes
- d torque tool
- e gripper

Figure 44—Combined Gripper and Torque Tool Envelopes for Flying Lead Handling

6.15 Subsea Vehicle Mounted Skid Interface

6.15.1 Function

Subsea vehicle mounted skids can be used to attach additional equipment to the ROV to expand its functionality for a wide variety of applications. Skids typically consist of supplemental tooling or sensors housed inside a structural frame that can be attached below the ROV.

6.15.2 Application

Skids can be configured with a wide variety of tooling including dredge equipment, survey and inspection tools, retractable tooling storage drawers, BOP systems, workover intervention tooling, fluid reservoirs, flowline connection tools, additional ROV buoyancy, pipeline repair equipment.

6.15.3 Design Recommendations

The height, width and overall length of the tool skid package and the mounting position on the vehicle should be designed for any space restrictions in the launch and recovery system, particularly for moon pool or hanger deployed systems.

Recommended size for an under-slung tool skid is less than 20 in (0.5 m) in height and length and width in accordance with the subsea vehicle envelope.

Weights of the skids should be checked versus through frame lift capacity of the selected vehicle.

Skids should be designed to be capable of being neutrally buoyant in any configuration.

The center of buoyancy and center of gravity should allow the skid to maintain operational orientation without requiring correction, such as ballast or thrust from the ROV.

The design and layout of the skid should take into account access to skid components for service and maintenance.

The skid should be designed to support the total weight of the subsea vehicle if landed on the deck without support. The skid design for this load case should consider loading of the ROV frame structure to avoid damaging the vehicle.

The global weight of the subsea vehicle including the skid and the TMS shall not exceed the safe working load of the LARS.

6.15.4 Design

A typical skid with the four ROV attachment dowels is shown in figure 45 below. Figure 46 provides details of the subsea vehicle skid mounting holes in the bottom of the vehicle.

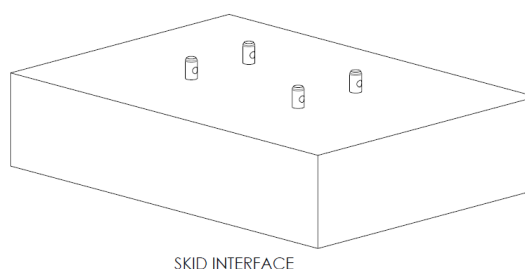


Figure 45—Typical Subsea Vehicle Skid Interface

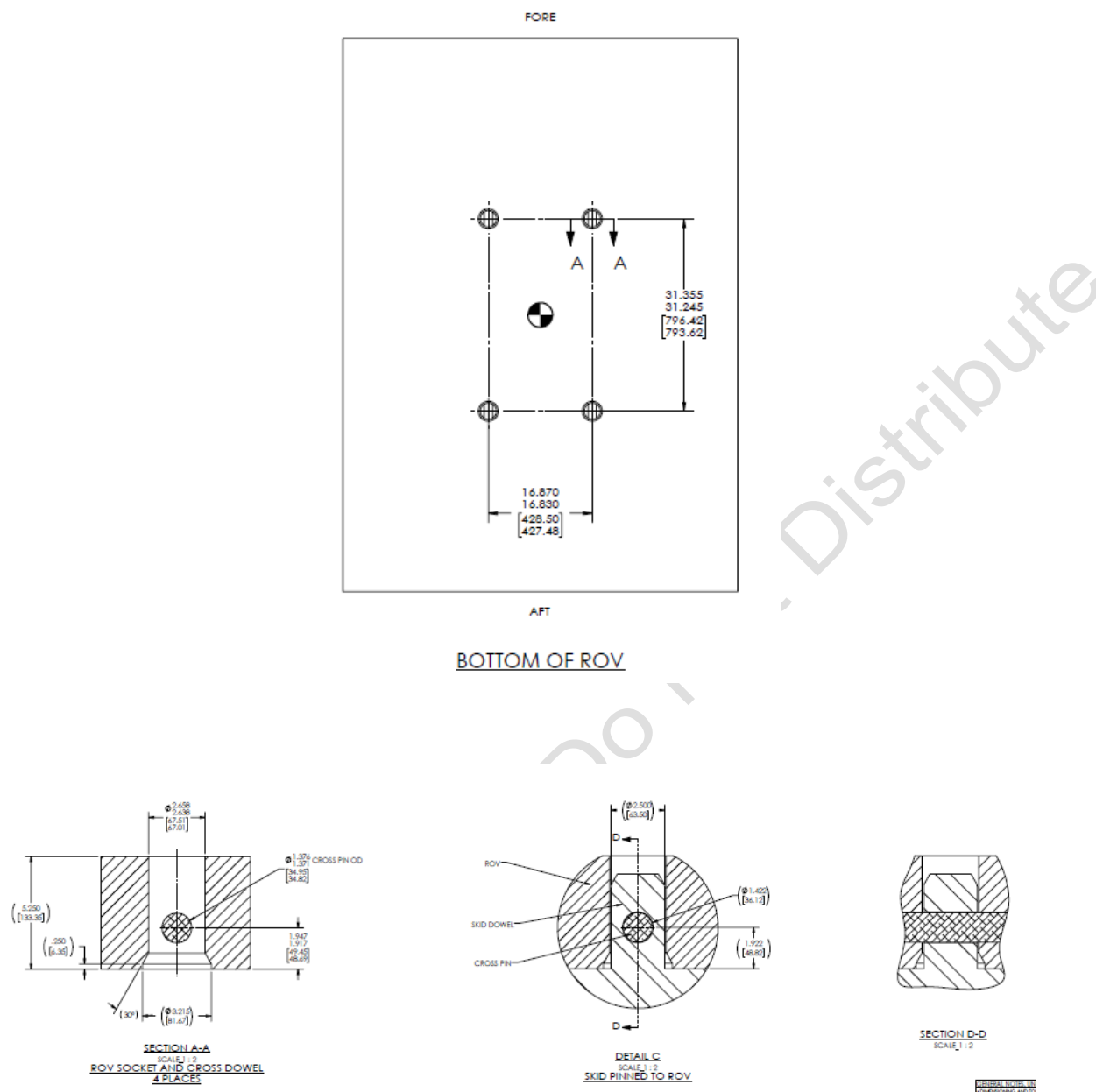


Figure 46—Typical Subsea Vehicle Skid Interface Details

7 Subsea Docking Stations

7.1 General

Untethered Underwater Vehicles (UUV) are required to interface with elements of a subsea system. This section lists the key elements that should be addressed during the design of the Subsea Docking Station. Specifically, the design should take account of the issues listed in the sections below.

7.2 Docking Base

The Subsea Docking Station (SDS) is a structure installed on the seabed (e.g. standalone suction anchor/gravity base, integrated in SPS structures, or empty well slot) to support and interface resident

Underwater Intervention Drones (UID). The SDS provides power and means for data transfer through inductive connectors suited for repeated subsea connection and disconnection.

The SDS typically consists of a Subsea Docking Base (SDB) and a replaceable Subsea Docking Module (SDM). Subsea Docking Stations can be standalone units or integrated into subsea structures or subsea production facilities where applicable and beneficial.

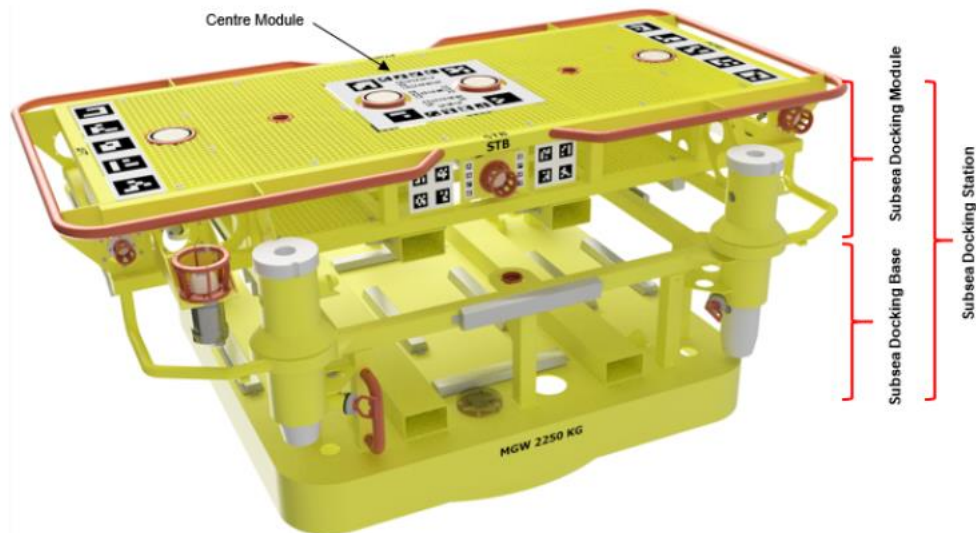


Figure 47—Type 1 Docking Arrangement



Figure 48—Subsea Docking Base

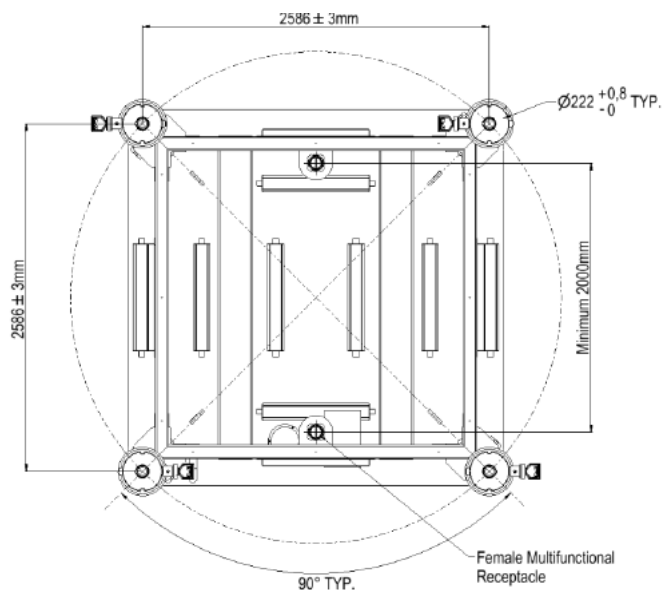


Figure 49—Docking Base Dimensional Details

Connections and subsea cabling to the docking base from the subsea facility or node are generally vendor specific and are not specified in this document. All connections shall be ROV or diver matable and allow for future replacement. Cables and connectors should be capable of delivering minimum data rates and recharging power recommended in 6.15, 6.16 and 6.17. The docking base connectors should be fitted with suitable, well-specified capped or dummy-plugged receptacle connections.

The structure and space frame should be designed according to API 17P. Electrical and hydraulic connections should meet the requirements of API 17F.

Described in this document is a cable and connector (wired or wireless) connection scenario for the connections between the docking base and the docking structure. Other types of power and communications connection styles are acceptable, such as those connections made automatically during the alignment of the docking base and docking structure.

The docking base should be equipped per the following guidelines/recommendations:

- Connection features may be wireless or utilize a subsea electrical connector but should meet the recommendations in 6.15, 6.16 and 6.17.
- The functions described in 6.15 and 6.16 may be combined into a single connector of suitable capacity if desired and all other requirements are met.
- It is recommended that the orientation and protection of the connections be designed to prevent buildup of silt and debris, and that dummy plugs or caps are utilized.
- The landed location of the docking base should conform to section 7 of this Recommended Practice, to ensure adequate navigational clearances.
- The docking base display markings should meet the requirements of section 10 of this Recommended Practice.

7.3 Docking Structure

The docking structure provides an easily removable/replaceable structure to allow adaptation to the docking, recharging, and data transfer needs of each specific class of AUVs and allow technology upgrades when necessary. In Figure 47 and Figure 48, Type 1 is indicative of a structure which accepts an AUV which is

intended to fly into its dock vertically; Type 2 is indicative of a structure which accepts an AUV which is intended to fly into its dock horizontally.

The docking structure should comply with the following guidelines/recommendations:

- The docking structure is intended to be fitted with guide cones to accept docking guide posts, allowing the docking structure to maintain its horizontal and angular position.
- remote-actuated clamping or lockdown features for mechanically fixing the docking structure to the docking base are acceptable but not required. If clamping or lockdown features are not used, the docking structure's weight in water should exceed 2T (1.8Te).
- The docking structure should be fitted with parking locations or dummy receptacles for the connectors which have been specified on the docking base.
- Jumper cable(s) connected to applicable power and communications connection features are recommended for the AUV intended for docking with this docking structure.
- The docking structure is intended to be fitted with docking features and power and signal connections to suit a particular vehicle or class of subsea vehicle.
- The docking structure is intended to be fitted with beacons as required to suit the navigational requirements of the subsea vehicle, both long-range and short-range.
- The docking structure may contain features that are remotely actuated such as latches, pull-in features, cameras, docked indications and winches.
- Guidepost used for landing the docking structure may be replaceable/removable to reduce obstacles for vehicle operations.

7.4 Subsea Docking Station Standoff Distance

UUV docking stations per this RP may either be integral to the subsea production equipment, or the docking station may be an independent structure separate from the subsea production equipment and tied back to the subsea production equipment for power and communications.

In the case of the independent docking station installation, it is recommended that all interfaces with subsea docking stations and their associated equipment should be at least 820 ft (250 m) from any active subsea production equipment to minimize the risk of a collision during operation and docking. Location of the docking station must allow for the given to the power and communications cable's path, extent, and installation.

NOTE The >820 ft restriction can be reduced if navigational aids and/or docking / collision avoidance technology are used to reduce the risk of collision.

7.5 Subsea Docking Station Vertical Approach Lane

An approach lane above the docking station should be kept clear of all potential points of interference. This approach lane extends upwards to the water surface, to ensure installation clearances are taken into account.

A vertical approach lane of at least 40ft (12.2m) diameter over the subsea docking station should be kept clear of all obstructions. This recommended minimum clear volume is independent of any environmental influences, and may require enlargement in specific cases.

7.6 Subsea Docking Station Horizontal Approach Lane

A horizontal approach lane centered on the subsea docking station with minimum 40ft (12.2m) wide x minimum 40ft (12.2m) high clearance should be kept clear of obstructions. This lane should extend at least 80ft (24.2m) from the docking station in the documented horizontal direction (which direction the dock

opening/entrance faces). This recommended minimum clear volume is independent of any environmental influences, and may require enlargement in specific cases, subject to concurrence from the field operator.

The bottom of the horizontal approach lane should be at least 8ft (2.4m) above the seafloor, to account for navigational inaccuracies and to minimize navigation instrumentation bottom interference. To help accommodate this requirement, the recommended height of the docking base's (described in Clause 6.14) uppermost landing area above the seafloor is given as a minimum of 8ft (2.4m) (See Figure 5).

7.7 Data Transfer

This subclause addresses the interface issues associated with long-term installations of subsea docking features for data transfer. The data transfer interfaces should comply with the following guidelines/recommendations:

- At least one spare cable and connector should be provided for an additional data transfer connection between the docking base and the docking structure. This is intended to only be connected in the event of a failure of the primary connection. The intention is that the backup is connected by a subsea vehicle, in the same manner as the primary connection.
- Data transfer is intended to be made to/from the docked vehicle through its own docking station connector(s).
- The data transfer connection at the vehicle/docking structure interface or the docking structure/docking base interface may be made wirelessly or through a cable and connector.
- Data protocol, transfer rates, and other details related to data transfer and the associated electronics per recognized industry standards. Recommend minimum transfer rates per IEEE 802.11 b/g/n, NEMA or another recognized industry standard.
- Communications protocols and/or electromagnetic interference (EMI) during subsea operations in proximity to the subsea facility should be addressed.

7.8 Communication/Data Harvesting

Subsea acoustic wireless communications are used to transmit data (e.g. control and monitoring data/signals) over relatively long distances subsea. The required data rate and range of operation can vary considerably between subsea applications. The data rate, directionality, and carrier frequency result in different ranges of operation.

An acoustic protocol that satisfies requirements of interoperability and interchangeability for acoustic data communication devices has been developed based on NATO ANEP-87 Edition A Version 1, (STANAG 4748/JANUS). See SWiGacoustic specification (2021) for additional guidance. The acoustic protocol supports monitoring and control applications including:

- Process control
- Equipment and process monitoring
- Diagnostics and maintenance

The SWiGacoustic specification (2021) specifies the minimum performance requirements of a transmitter and a receiver known as the physical layer in a communication link including Layers 1 & 2 in the OSI Model. The SWiGacoustic specification (2021) does not define the topology, geometry or material choices made by manufacturers to achieve the required functionality (e.g., low power consumption, increased transmitted power or receiver sensitivity or acoustically noisy environments).

The SWiGacoustic specification (2021) physical layer defines how the signals are modulated for each of the corresponding technologies. From a perspective of the OSI Layer Model this includes Layer 1 – Physical layer and Layer 2 – Data Link. These two layers are used for the communication over the physical medium between two devices.

Planning for the subsea vehicle data collection/transmission position should include access clearances, standoff requirements, duration of the transfer process, and hovering capabilities in currents. Acoustic and electromagnetic interferences should be addressed.

7.9 Energy Recharging

This clause addresses the interface issues associated with long-term installations of subsea docking features for subsea vehicle recharging purposes. The vehicle recharging interfaces should comply with the following guidelines/recommendations:

- At least one spare cable and connector should be provided for an additional recharging connection between the docking base and the docking structure. This should only be connected in the event of a failure of the primary connection. The intention is that the backup is connected by a subsea vehicle, in the same manner as the primary connection, as described above.
- Recharging is intended to be made to/from the docked vehicle through the docking station connector(s), using the technology that best suits the vehicle/docking structure.
- The recharging connection at either the vehicle/docking structure interface or the docking structure/docking base interface may be made wirelessly or through a cable and connector, using the technology that best meets the criteria.
- AC Battery recharging power cabling and supply to the docking base is recommended to be no less than 2kW

NOTE A low power line may be used for “trickle” recharging of batteries

- Battery recharging power supplied to the docking base is to be properly protected against overloads and monitored for ground faults in accordance with a recognized standard, for example IEEE Std 1120-2004, DNV-RP-F401, or another recognized industry standard.
- Battery recharging power supplied to the docking base is to be properly conditioned for quality per ANSI C84.1 and IEEE STD C62.41, or another recognized industry standard.
- Battery recharging rates should be carefully managed per the battery manufacturer’s instructions, either from on board the subsea vehicle or from the docking structure. Overall and individual recharging safety circuits should follow the battery manufacturer’s guidelines

Each subsea vehicle system manufacturer should develop its own written procedures and demonstrate that these procedures are safe to the satisfaction of the Operator prior to a subsea recharging operation. A log of all battery charges which includes, at a minimum, voltage versus time should be kept for all charges.

If divers are anticipated to be involved with interfacing with electricity relating to subsea vehicle interfaces, please reference IMCA AODC 035 (The Safe Use of Electricity Under Water)

8 Materials

8.1 General recommendations

The subsea vehicle system should meet the materials selection and materials recommendation requirements of API RP 17A. Material selection is the responsibility of the operator/end user.

The designer should 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 API 17A and associated subsea product requirements. 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;
- f) marine fouling.

8.2 Selection criteria

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

- a) the interface mounted on the subsea production system should exhibit greater inherent strength than the interface carried by the subsea vehicle, such that in the event of a mishap during operations the interface cannot be damaged or made inoperable;
- b) 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;
- c) 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;
- d) the method of mounting the interface assembly to a subsea structure should ensure that the interface remains secure during the interface operation.

9 Quality Control

The quality control requirements for equipment specified in this section should conform to API 6A as appropriate.

For components not covered in API 6A, specific quality control requirements should comply with the manufacturer's documented specifications.

Quality control and testing of welds on structural components should be as specified for "non-pressure containing" welds in accordance with API 2A.

10 Subsea Marking

10.1 General

NOTE: A commonality of abbreviation between subsea facilities and surface-operating equipment is essential. To minimize confusion and enhance safety where the control units are design for multiple applications, it is recommended that functions be identified both on the subsea packages and on their control units, using common abbreviations listed in this International Standard. Where the valve arrangements are unique, the documentation should clearly define the abbreviation used in the marking of equipment.

All equipment on the subsea production systems that is designed for subsea intervention shall have a color and marking system enabling easy and unique identification.

The color and marking system shall act as a guidance map for the intervention operations by:

- a) identifying the structure and orientation;

- b) identifying the equipment mounted on the structure and intervention interface;
- c) identifying the position of any given part of the structure relative to the complete structure;
- d) identifying the operational status of the equipment, e.g., connector lock/unlock and valve open/close.

When subsea vehicle intervention is used, coatings shall have a flat finish. Glare from the vehicle lights on a gloss or semi-gloss finish can cause undue reflective glare into the vehicles low-light-sensitive cameras, causing impaired vision or “ghosting” effects on the monitor.

10.2 Color Design

The main elements of the color design are:

- a) object color;
- b) background color;
- c) foreground color;
- d) relative object size.

The colors should be clearly distinguishable at a minimum distance of 10 m (32.8 ft) in air, in artificial lighting, with adjustable intensity and the red part of the light spectrum with the highest intensity.

The darker color should not be used on large structural parts. White colors on large structural elements should be avoided. Grating (which may be required to see through) should have darker colors, e.g., metallic grey (unpainted), to avoid light reflection. Furthermore, colors that may be misinterpreted (taken for shadows/bottom) should not be used. The foreground should appear less bright than the object and background. Elements such as handles, latches, locks, connectors, i.e., “active” parts during intervention, should be marked with orange color.

The subsea vehicle operating spindles (valve spindle/spindle extension) should not be painted due to the tolerance between the spindle and the torque tool.

The colors recommended for use on the subsea production systems, with the equivalent RAL [5, 6], Munsell [7, 8] and US Federal Standard 595A [9] codes, are given in Table 15.

10.3 Marking Guidelines

The marking is divided into primary and secondary marking. Primary marking is defined as marking of major structural members and systems that need to be identified for operational, installation and retrieval purpose. Recommended height for marking symbols is 7 in (170 mm) to 20 in (500 mm) character size.

Table 15—Marking Colors

	Black	Red	Orange	Yellow ^a	Unpainted	White ^a	Grey
Paint code: RAL	9017		2004	1004	NA	9002	7038
Paint code: Munsell	N 0,5		1,25YR 6/14	1,25Y 7/12	NA	10Y 8 5/1	5Y 7/1
Paint code: US Federal Standard 595A	27038	31136	32246	33655 33507	NA	27875	26440
a) Structures							
Protective structure	X (text)			X			
Base structure	X (text)			X		X	
Guideposts	X (markings)			X		X	

	Black	Red	Orange	Yellow ^a	Unpainted	White ^a	Grey
Pull-in porches (pull-in ramps)	X (markings)			X (ramps)		X (diver porches)	
Anodes or components with a zinc or aluminum treatment					x		
Pad eyes		X					
Hinges, subsea vehicle attachment /intervention points		X ^b	X ^b				
b) Process manifold							
Manifold structure				X		X	
Piping				X		X	
Manifold valves				X		X	
Valve reaction points, subsea vehicle attachment/intervention points			X				
Valve spindle					X		
Valve status	X (text)			X (back-ground)		X (back-ground)	
Termination hubs		X ^b	X ^b				
Termination hub clamps, protection caps		X ^b	X ^b				
c) control system							
Control-pod body			X				
Control-pod ROT hub					X		
Control-module connector clamp					X		
Panels for subsea vehicle operation				X			
subsea vehicle-operated valve handles, subsea vehicle attachment/intervention points			X				
Control distribution system structure				X			
d) Subsea tree system							
Tree structure				X		X	
Piping				X		X	
Tree valves				X		X	
Valve reaction points, subsea vehicle attachment/ intervention points			X				
Valve spindle					X		
Valve status	X (text)			X (back-ground)		X (back-ground)	
Termination hubs		X ^b	X ^b				
Termination hub clamps, protection caps		X ^b	X ^b				
Connector/termination landing position	X (markings)			X (back-		X (back-	

	Black	Red	Orange	Yellow ^a	Unpainted	White ^a	Grey
(swallow) or orientation				ground		ground	
e) ROT, ROV and replacement frame system							
Steel structures			X				
subsea vehicle-operated handles, subsea vehicle attachment/intervention points			X				
^a Usually yellow for subsea vehicle intervention and white for diver intervention							
^b Depending on project requirements							

Secondary marking is defined as marking used within a major system or location to identify components such as valves, hydraulically operated components, local tapping points used for sensing equipment, probes. Character size of 2 in (50 mm) to 6 in (150 mm) should be used.

Smaller sizes may be used when the specified size is impractical.

The location of the identification marks should be such that they do not obstruct intervention work to be carried out on equipment and components, and such that the risk of damaging or tearing off the marks is minimal.

Antifouling marking signs should be used on permanently installed equipment. The marks should be designed for mechanical attachments to the structure, equipment, or component such that they remain in place and are not damaged during intervention.

Welding attachments to production piping should not be used. If bonding is used, this should be based on thoroughly tested and verified techniques.

The following issues should be addressed:

a) visibility;

All marks should be designed to be clearly visible in artificial light from a minimum distance of 5m (16.4 ft) based upon the particle content of the water.

b) design life;

The marks should be protected against marine fouling for the design life of the subsea production system.

c) language;

All instructions written on the marks should be in the English language.

d) cross-reference;

All symbols, characters, figures, on the marks should be easily identified and cross-referenced with the operational documentation.

e) marking of structures;

Marking of subsea structures can be oriented such that rig headings and template headings are identical to simplify rig operations. The following designation markings can be used:

- 1) Front side of the structure: FORE;
- 2) Starboard side of the structure: STB;
- 3) Port side of the structure: PORT;
- 4) Back side of the structure: AFT.

On the port and starboard sides of the upper structure, main identification marks should be fitted to enable a positive identification of the entire subsea production system. The main identification marks should as a minimum display the field name, block number(s) and name of installation.

FORE on the protection structure should be defined according to FORE on the rig (i.e., same as the rig heading). For template structures, the numbering of the slots (referring to well slots) can start with slot number one in FORE-STB corner and continue the numbering clockwise. Numbering of other slots, not referring to well slots, follows by starting with slots on FORE side and follows clockwise. It is recommended to use the same method for the numbering well slots and guideposts as for the protection structures. The marks on the sides should be fitted on both top and bottom of the structures, such that they are clearly visible from the outside of the structures. Inside, the structure marks should be fitted to the structural members to enable positive and easy orientation. This should be done by fitting the marks on the vertical members surrounding e.g., a well slot, with the symbols facing towards the center of the slot. The marks should be fitted at an elevation suitable for the foreseen work to be carried out in the respective areas.

f) marking of guideposts;

Guidepost numbering should suit the expected rig heading, and a rig guideline numbering system based on the forward and starboard guideline being wire No. 1 and so on, going clockwise. The posts should be marked with black rings located 8 in (200 mm) below the top and indicating the post number. Retrievable guideposts should be fitted with easily readable status indicators showing locked ("L") and unlocked ("U") positions of the locking mechanism.

The marking system should enable positive verification of the end stop and locked position for retrievable components such as guideposts to lock-down clamps.

g) marking of manifold valves;

A unique valve numbering system should be established, providing easy identification of each valve and its function. All manifold valves should be marked with an "XY"-number where "X" identifies which slot the pipe is connected or which line the valve is isolating. The "Y" number should identify which number of the valve from the well slot (if several valves are inline) and the function of the line. The valves should be marked with a minimum of one mark near the valve body facing upwards. The mark can be fixed on a support plate attached to a valve interface flange between the valve body and bonnet or the near structure.

h) marking of piping system;

A unique numbering system for the manifold valves in the piping system should be established. The piping system (inclusive production and injection lines) between the well slots and pull-in porches should be marked to identify each pipe based on the established numbering system.

The piping may be marked with colored strips of antifouling material at different locations to facilitate inspection.

i) marking of pull-in porches;

The pull-in porches should be marked to reflect the type of lines.

The pull-in porches for the electric and hydraulic umbilicals should be marked with “E” or “H” on the upper side.

If combined electric and hydraulic umbilicals are used, the porch should be marked with “E/H”.

Pull-in porches for the flowlines and chemical injection/service lines should be marked as follows:

- 1) Production flowline: P;
- 2) Water injection flowline: WI;
- 3) Gas injection flowline: GI;
- 4) Test line: T;
- 5) Chemical injection: C;
- 6) Methanol injection: M.

In addition to these letters, a number should be added to each funnel reflecting the line or umbilical number.

j) marking of pull-in ramps;

The pull-in ramps, if fitted, should be marked with a line indicating the ideal centerline of the porch. In addition, a line on each side should be added to indicate the maximum angular misalignment allowed.

Transversal lines every meter from the pull-in funnel entry point should be included on the ramp. The distance should be marked at the side of the misalignment lines, enabling the subsea vehicle pilot to record the distance left during pull-in operations.

l) status indicators;

Status indicators should be marked with clearly readable reference points. Symbols “U” = unlock, “L” = lock, “N” = neutral, “O” = Open, “S” = shut, “B” = bleed should be used to define the reference points.

The distance between the status indicator arrow or marker and the reference points in the viewing direction, should be made as short as possible to reduce the sensitivity and effect of subsea vehicle viewing position. Direction of operation should be indicated with an arrow.

m) marking of control system components;

The control system should be marked to provide positive identification of its respective components. The marks should be fitted at regular intervals [for example, 6.5 ft (2 m)] to enable easy identification of all the control system components.

The control module should be marked with the identification number at a minimum of one location and be clearly visible by the subsea vehicle when approaching the module. The minimum character size should be 4 in (100 mm).

All the electrical and hydraulic lines should be marked, to allow easy identification of each line. The following guidelines should be used:

- 1) Each individual line should be marked with characters for unique identification of the line and its function at a suitable location close to its respective connection point;

2) lines entering a valve panel should be marked on both panel sides;

n) marking of retrievable guideposts (if used);

Guideposts should be marked with level indicator rings every meter, using the top of the guidepost receptacle as the reference level.

o) marking of subsea tree system;

All the subsea tree valves shall be marked with at least two letters, for easy observation with tool in position, e.g., production master valve

A number shall be fitted on the subsea valve panel providing a unique identification for each subsea tree. Likewise, the subsea tree cap shall be fitted with a unique identification number.

11 Validation and Verification

11.1 Design Verification

11.1.1 General

Design verification should be performed to ensure that the design output, as defined by the design plan, has been met.

All design verification activities should be documented. Non-conformances should be logged, followed up and closed prior to equipment handover to client.

Design verification is achieved by:

- a) operability and access verification;
- b) producing design documentation, e.g., drawings, specifications, and procedures;
- c) performing calculations;
- d) performing design reviews in accordance with latest version of API Q1, ISO 29001, ISO 9001, or another recognized standard;
- e) performing qualification testing;
- f) performing FAT.

11.1.2 Design Documentation

The design documentation should include:

- a) assembly drawings (including as-built);
- b) detail design drawings;
- c) structural analysis;
- d) piping analysis;
- e) pipe wall calculation;
- f) specifications and data sheets;

- g) design review MOM;
- h) test procedures and records;
- i) weight-control reports;
- j) access and operability verification;
- k) HAZOP and SAFOP reports;
- l) operating and maintenance manuals:
 - 1) storing and preservation procedures;
 - 2) planned normal operating modes;
 - 3) operating procedures;
 - 4) spare part lists;
 - 5) commissioning procedures;
 - 6) testing reports and records.

11.1.3 Access and Operability

11.1.3.1 General

Access and operability verifications should be performed at various stages during the design of the subsea intervention systems.

The main purpose is to verify the ability of the intervention system to perform its task on the subsea system.

This includes verification of subsea vehicle access to the worksite as follows:

- a) verification of the location and design of subsea vehicle stabilization supports, e.g., grabber bars, landing platforms;
- b) verification that the subsea vehicle can perform the task (e.g., weight, size, location of handles of the object to be handled).

Ways to perform the verification include the following:

- 1) state of the art 3D simulation software; The method provides a realistic, dynamic simulation of the subsea vehicle operation in a virtual 3D environment of the worksite. Physical properties of the subsea vehicle carried object may be modeled to add to the realism of the simulation.
- 2) use of 3D CAD drawings;
- 3) use of mock-up vehicles;
- 4) use of actual subsea vehicles as part of onshore tests.

11.1.3.2 3D Simulations

The use of 3D simulations may be used as design verification which can be used throughout the engineering, fabrication, and testing phases. 3D simulations should not be used to replace system integration testing.

The simulations should be performed based on the selected subsea vehicle configuration for each project, i.e., normally a left hand 5-function grabber arm and right hand 7-function manipulator.

Through the various project phases, the simulation/visualization activities should focus on:

- a) validation of subsea system layout and equipment packaging through high level access and operability simulations (typical concept development and systems engineering);
- b) subsystems, module and running tool design validation (detailed access and operability validation, typically during detail design, fabrication, and testing phase. These validation activities can include 3D models with built in physical properties (e.g., weight, buoyancy, center of gravity). The validation should focus on identifying the location of stabilizing feature for the subsea vehicle (e.g., platform, grabber bar), marking (status validation and readability) and interfaces to be operated;
- c) training and familiarization of personnel and development of animations for the best practice procedure (testing phase and operations preparation);
- d) real time operations support during installation and later on IMR activities. This will include both real time subsea vehicle navigation support and e-field functionality.

The same software should be used throughout the project and expanded with additional features and details as required. An overall program should be prepared prior to project start, and based on the proposed intervention and IMR strategy for the project.

11.1.4 Design Reviews

Design review of the subsea vehicle system and components should be performed in accordance with latest versions of API Q1, ISO 29001, ISO 9001, or another recognized standard.

The design review should include the following elements:

- a) review of design inputs;
- b) completion of subsea vehicle friendliness review;
- c) establish design outputs;
- d) material selection and review;
- e) review conformance to customer requirements;
- f) shop handling and fabrication;
- g) review internal interfaces;
- h) review external interfaces;
- i) establish design verification requirements;
- j) establish design validation requirements;
- k) review safety and environmental impact;
- l) ease of maintenance and operation.

11.1.5 Factory Acceptance Testing

A comprehensive acceptance test program should be undertaken by the manufacturer to ensure that components have been manufactured in accordance with specified requirements. The FAT should be performed to a predefined and approved procedure.

Any failure occurring should be repaired and analyzed to find reason for the failure and/or result in a review of the calculated reliability of the system to determine if the deviation can be accepted.

FAT is generally a multi-tiered approach, involving individual component checks, subsystem checks (i.e., control system), interface checks and unitized system checks. Modifications and changes to the equipment during testing and manufacture should be formally documented.

When using hot stabs during testing, the hot stabs should be locked into receptacles or restrained to prevent unintended decoupling resulting in a safety hazard.

A typical format for a subsea equipment factory acceptance testing procedure could include the following:

- a) purpose/objective;
- b) scope;
- c) requirements for fixtures/set-ups, facilities, equipment, environment, and personnel;
- d) performance data;
- e) acceptance criteria;
- f) reference information.

FAT typically covers the following items:

- 1) individual component testing;
- 2) assembly fit and function testing:
 - use actual subsea equipment and tools where possible.
- 3) interface checks:
 - use actual subsea equipment and tools where possible.
- 4) interchangeability testing;
- 5) hydrostatic testing;
- 6) structural load testing:
 - simulation of all loads subjected during installation and operation.
- 7) submerged tests (optional).

11.2 Design Validation

11.2.1 General

Design validation is achieved by:

- a) performing first article testing;

- b) performing qualification testing;
- c) performing system integration testing.

Design validation is performed to ensure that the specific operational requirements have been met. In certain cases, it is necessary to perform wet-simulation testing to prove center of buoyancy, correct functioning of components and systems underwater.

Tests should include simulations of actual field and environmental conditions for all phases or operations, from installation through maintenance. Special tests may be needed for handling and transport, dynamic loading, and backup systems. Performance tests may be appropriate and can supply data on response-time measurements, operating pressures, fluid volumes, fault-finding and operation of shut-down systems.

11.2.2 Qualification Test

Individual components (e.g., valves, actuators, fitting and control system components) should be qualified independently of the manifold/template system. The subsea vehicle system should be subjected to a pre-approved qualification test which is defined by the operational limits.

11.2.3 System Integration Test

A system integration test should be performed which includes tooling, vehicles, and control systems. The different tests performed during integration testing should be used to check reliability and should demonstrate tolerance requirements and correct functioning of the complete system.

The purpose of the test is to simulate all operations which could be performed offshore, to the extent practical, and verify all equipment/systems and procedures related to operation of the system.

Training of personnel, including familiarization with equipment and procedures, is an important factor during integration test activities. This aspect is particularly important to promote competence, safety and efficiency during installation and operation activities.

When using hot stabs during testing, the hot stabs should be locked into receptacles or restrained to prevent unintended decoupling resulting in a safety hazard.

System integration testing typically contains the following activities:

- a) a documented integrated function test of components and subsystems;
- b) a final documented function test, including bore testing and leak testing;
- c) a final documented function test of all electrical and hydraulic control interfaces;
- d) documented orientation and guidance fit tests of all interfacing components and modules;
- e) simulated installation, intervention, and production mode operations as practical to verify and optimize relevant procedures and specifications;
- f) operation under specified conditions, including extreme tolerance conditions, as practical, to reveal any deficiencies in system, tools and procedures;
- g) operation under relevant conditions as practical to obtain system data such as response times for shut-down actions;
- h) testing to demonstrate that equipment can be assembled as planned (wet conditions as necessary) and satisfactorily perform its functions as an integrated system;
- i) filling with correct fluids and lubricated, cleaned, preserved, and packed as specified;
- j) functional test of control system.

11.2.4 Shallow Water Test

A shallow water test can be performed which includes tooling, vehicles, and control systems. The different tests performed during integration testing should be used to check reliability and should demonstrate tolerance requirements and correct functioning of the complete system.

The purpose of the test is to simulate all operations which could be performed offshore, to the extent practical, and verify all equipment/systems and procedures related to operation of the subsea system.

Training of personnel, including familiarization with equipment and procedures, is an important factor during integration test activities. This aspect is particularly important to promote competence, safety and efficiency during installation and operation activities.

System integration testing typically contains the following activities:

- a) a documented integrated function test of components and subsystems;
- b) documented orientation and guidance fit tests of all interfacing components and modules;
- c) simulated installation, intervention, and production mode operations as practical to verify and optimize relevant procedures and specifications;
- d) operation under specified conditions, including extreme tolerance conditions, as practical, to reveal any deficiencies in system, tools and procedures;
- e) operation under relevant conditions as practical to obtain system data such as response times for shut-down actions;
- f) testing to demonstrate that equipment can be assembled as planned and satisfactorily perform its functions as an integrated system;
- g) filling with correct fluids and lubricated, cleaned, preserved, and packed as specified.

11.2.5 Deep Water Test

A deep water test can be performed, which includes tooling, vehicles, and control systems.

The test should be performed in addition to the system integration test and should focus on verifying the subsea intervention system functionality at the specified working depth. Tests performed during the deep water testing should be used to check reliability, demonstrate tolerance requirements, and functionality of the complete system during operation.

The purpose of the test is to simulate all operations which could be done offshore, to the extent practical, and verify all equipment/systems related to operation of the subsea system.

Training of personnel, including familiarization with equipment and procedures, is an important factor during deep water test activities. This aspect is particularly important to promote competence, safety and efficiency during installation and operation activities.

Deep water test testing can include the following activities:

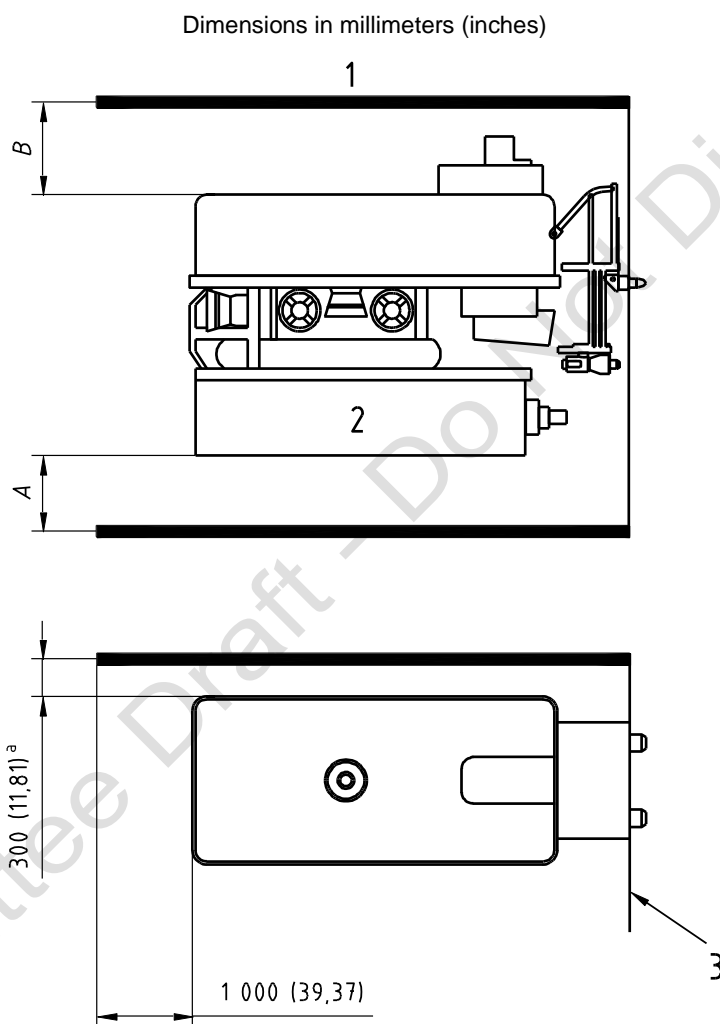
- a) documented orientation and guidance fit tests of all interfacing components and modules;
- b) simulated installation, intervention, and production mode operations as practical to verify and optimize relevant procedures and specifications;
- c) testing to demonstrate that equipment can be assembled as planned and satisfactorily perform its functions as an integrated system.

Annex A (informative)

Access

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

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



A clear distance to the bottom of the subsea vehicle or underslung tooling package of 500 mm (19,68 in) min. is recommended.

Clearance above the subsea vehicle should take account of the umbilical connection.

Key

- 1 structure
- 2 tooling package
- 3 face of structure

^a Typical.

Figure A.1—Clearances

Annex B (informative)

Manipulator operating envelopes

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

Scale in meters

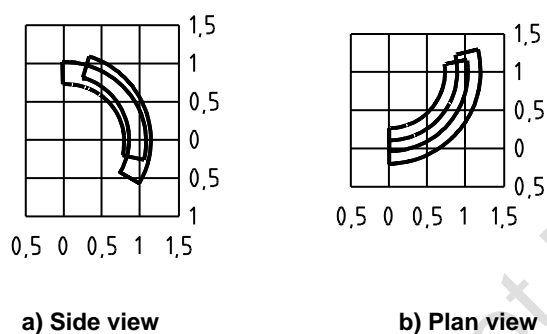


Figure B1—Typical Five-function Grabber Envelopes

Scale in meters

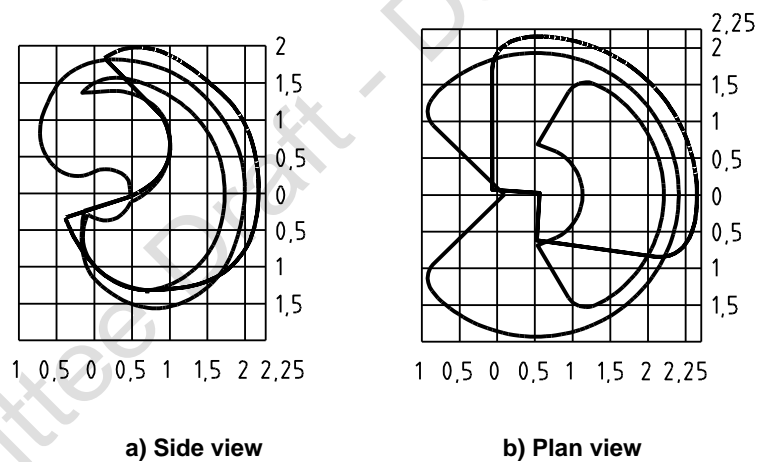


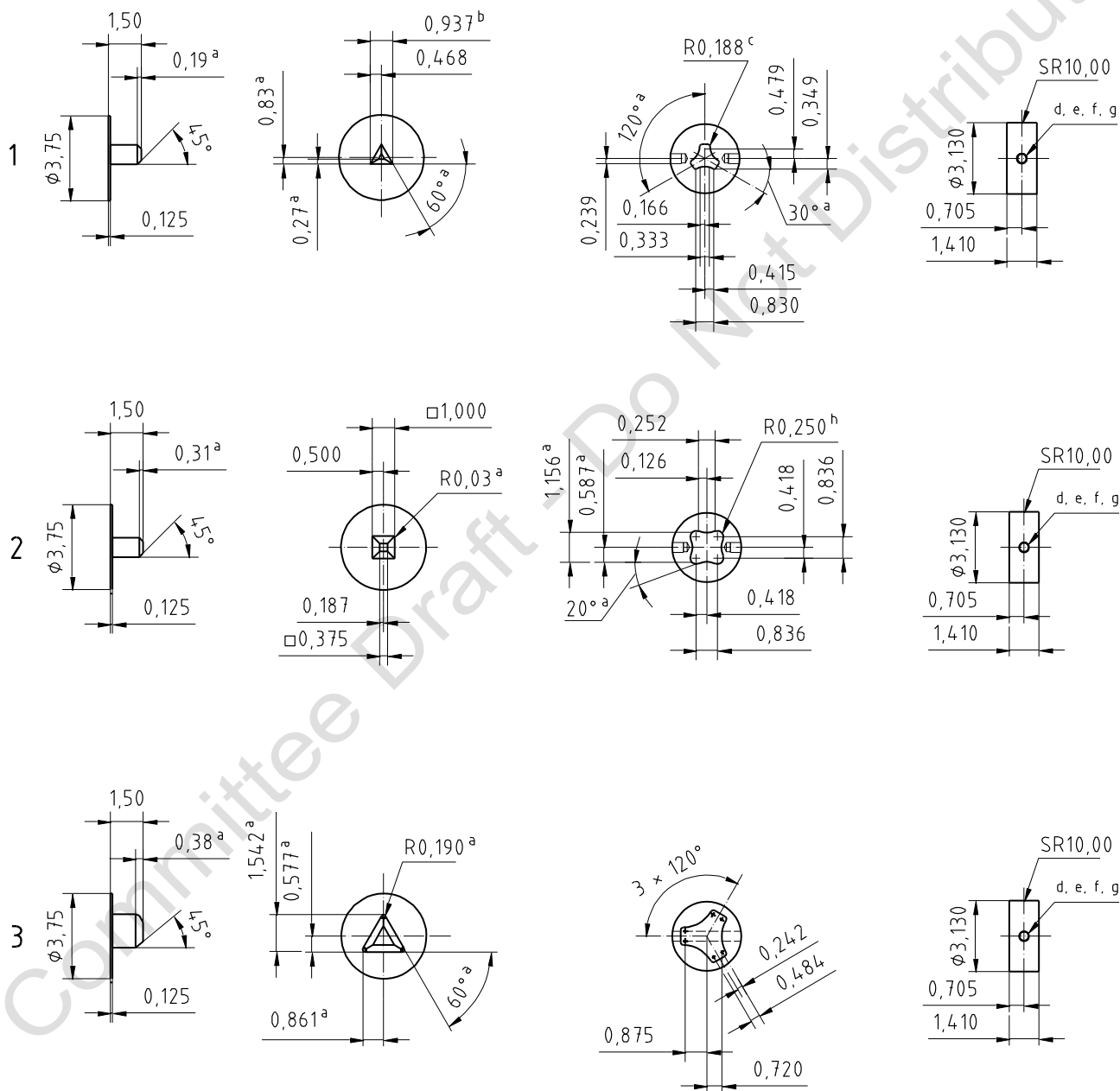
Figure B2—Typical Seven-function Manipulator Envelopes

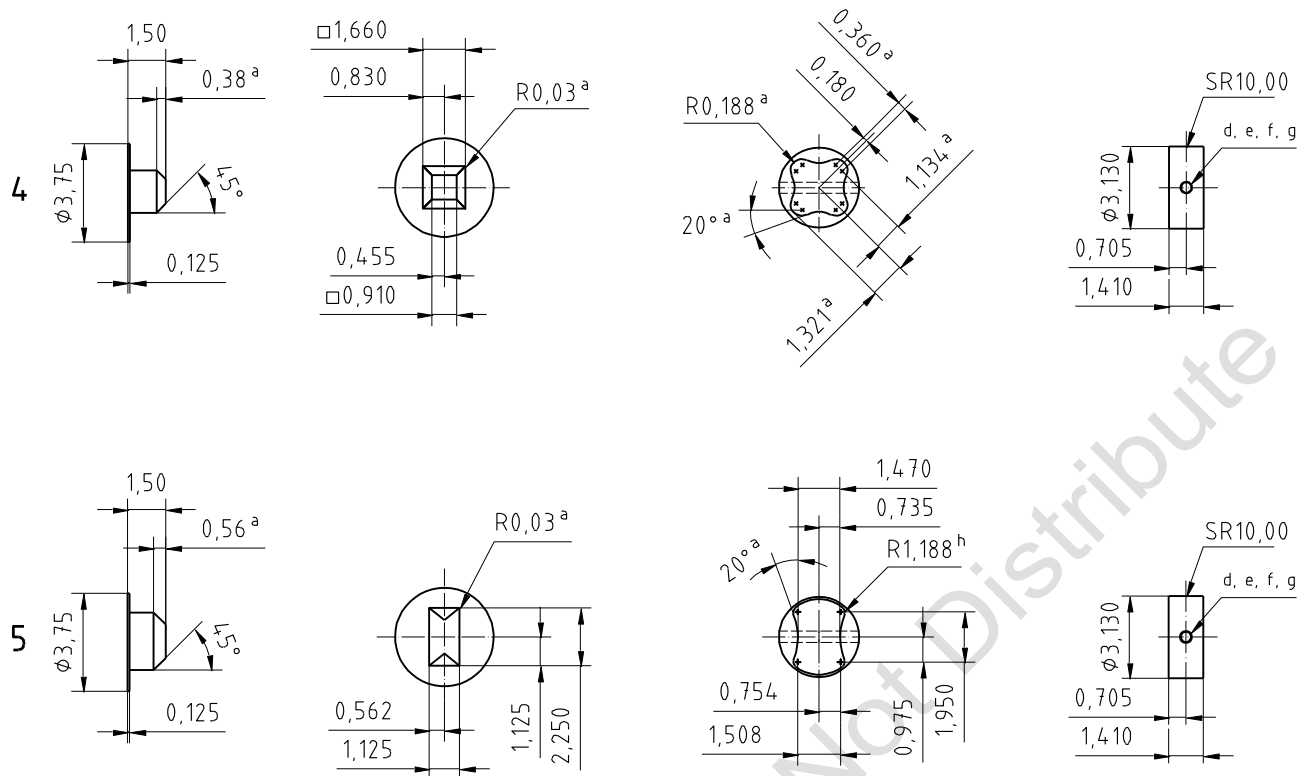
Annex C (informative)

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 lbf-ft to 2,000 lbf-ft (0 kN-m to 2,71 kN-m). Their designs are shown in Figure C.1.

Dimensions in millimeters (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 C1 — Alternative Profiles for End-effectors

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