

Subsea Umbilical Termination (SUT) Design Recommendations

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

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0 Introduction

General

This document was generated, by means of the UMSIRE Joint Industry Project (JIP) in response to the increasing difficulties in installation of high-functionality Subsea Umbilical Terminations (SUTs), due to their increasing size. The JIP committee comprised a representative cross section of experienced industry personnel from engineering, installation and operational organizations.

Whilst there are universally accepted standards for the design of an SUT and its sub-systems, none of these standards specifically address the subject of the risks of installation, and the measures required to minimize these risks.

The UMSIRE deliverables are two API documents, 17TR9, *Subsea Umbilical Termination (SUT) Selection and Sizing Recommendations* (under development) and 17TR10, *Subsea Umbilical Termination (SUT) Design Recommendations*.

This document is intended to be used as a reference guide by operators, UTA and umbilical specifiers, installers and FEED companies. It is also intended to be used as a reference document to enable reviews to be undertaken to ensure that installation risk has been properly considered as part of SUT design and operation reviews.

Additionally, the document has been designed to be educational such that persons new to the industry, or, less experienced persons within the industry, can understand the implications of UTA design on installation feasibility.

The intent with describing these project stages (see Figure 0.1) is to clarify when within the umbilical project timeline each UMSIRE document should be referenced, and the interested parties that should be involved in discussions during each stage.

Use of the Document

The users of these Design Recommendation TRs are primarily intended to be operators, SUT designers, and FEED companies. Umbilical system design and manufacturing roles and responsibilities are defined in Annex A.

Applicability

Figure 0.2 and Figure 0.3 are pictorial examples of the equipment covered by this TR.

This Design TR aims at capturing the primary aspects impacting on the overall dimensions and weight of the UTA, and highlighting the consequences of design choices.

This document excludes multibore hub connection-type (MHC) UTAs which can connect the umbilical directly to other subsea hardware. Although MHC UTAs are out of scope, many of the guidelines in this document would apply.

Designers should be aware that integration of multiple distribution outlets leads to a significant increase in size and therefore weight of the UTA. For the purpose of reducing the size and weight of the UTA, this document discourages the use of multiple distribution outlets wherever possible.

It is however acknowledged that having a separate Subsea Distribution Unit (SDU) may have an impact on the overall cost. This decision should be made with consideration for the limiting dimension and weight of the UTA.

The document has an educational purpose and is intended to be descriptive rather than prescriptive.

It is important to note that none of the following sections should be read in isolation.

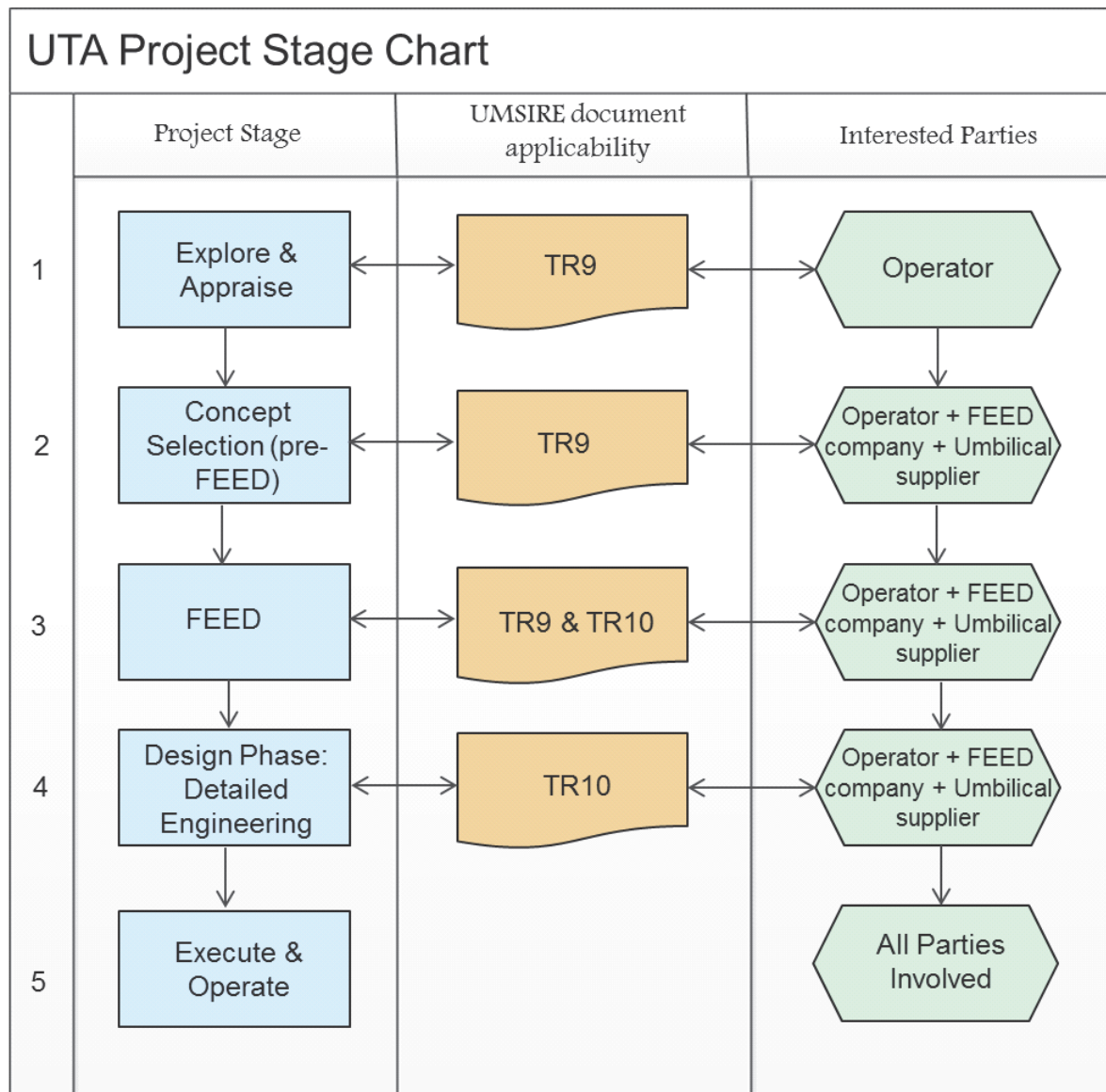


Figure 0.1—Project Stage Chart

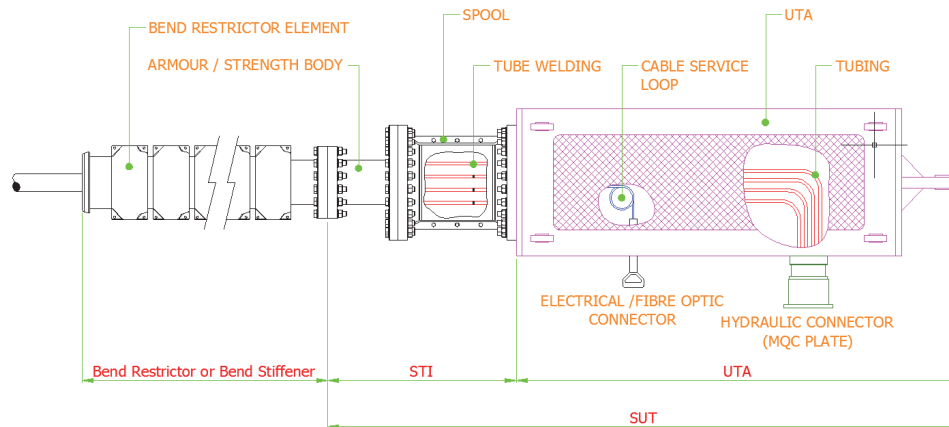


Figure 0.2—Steel Tube Umbilical or Thermoplastic Umbilical with Spool

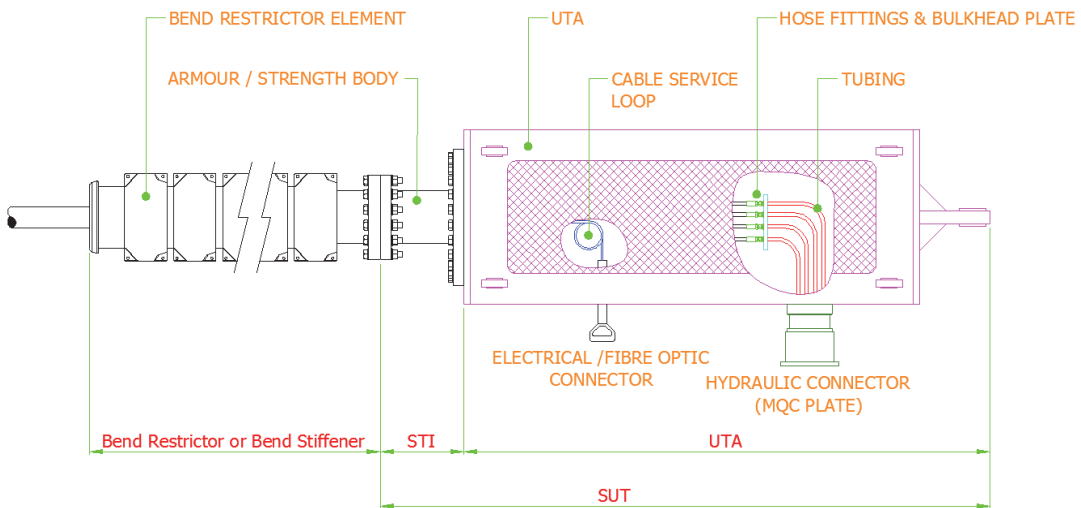


Figure 0.3—Thermoplastic Umbilical

Subsea Umbilical Termination (SUT) Design Recommendations

1 Scope

This document aims to provide best practice technical guidance for SUT design, in order to aid in making informed choices during the design phase.

This document is intended to be read in conjunction with API 17TR9 (under development), which highlights technical and commercial risks associated with high functionality umbilical terminations, the implications of decisions made early in the umbilical and SUT planning, selection and design phases, and provides guidance on specification and sizing of SUTs.

2 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 Recommended Practice 17A, *Design and Operation of Subsea Production Systems—General Requirements and Recommendations*

API Specification 17D, *Design and Operation of Subsea Production Systems - Subsea Wellhead and Tree Equipment*

API Specification 17E, *Specification for Subsea Umbilicals*

API Specification 17F, *Specification for Subsea Production Control Systems*

API Recommended Practice 17H, *Remotely Operated Vehicle (ROV) Interfaces for Subsea Production Systems*

API Recommended Practice 17P, *Design and Operation of Subsea Production Systems - Subsea Structures and Manifolds*

ASME B31.3 ¹, *Process Piping Guide*

ASME B16.5, *Pipe Flanges and Flanged Fittings, NPS 1/2 through NPS 24 Metric/Inch Standard*

ASME B16.47, *Large Diameter Steel Flanges, NPS 26 through NPS 60 Metric/Inch Standard*

DNV RP B401 ², *Cathodic Protection Design*

DNV RP F112, *Design of Duplex Stainless Steel Subsea Equipment Exposed to Cathodic Protection*

DNV RP H103 or DNV VMO (DNV-OS-H101 to H206), *Modeling and Analysis of Marine Operations*

3 Terms, Definitions, and Abbreviations

3.1 Terms and Definitions

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

¹ ASME International, Two Park Avenue, New York, New York 10016-5990, www.asme.org.

² Det Norske Veritas, Veritasveien 1, 1322, Hovik, Oslo, Norway, www.dnv.com.

3.1.1

bend limiter

(from the UMF Glossary of Terms)

Device for limiting the bend radius of the umbilical, usually by mechanical means, typically comprising a series of interlocking metal or polymeric collars designed to lock at a pre-defined radius.

NOTE This is sometimes known as “bend restrictor”.

3.1.2

bend stiffener

(from the UMF Glossary of Terms)

Device for controlling bending strain in the umbilical by providing a localised increase in stiffness; usually a moulded device, sometimes reinforced depending on the required duty, applied over the umbilical.

NOTE This is sometimes referred to as a “bend strain reliever”.

3.1.3

bulkhead plate

Typically a plate used to mount or locate a collection of hydraulic and/or electric and/or optical connectors.

3.1.4

bull nose termination

End termination of an umbilical being pulled into the production unit above sea level.

NOTE 1 This is another word for “pull-in head”.

NOTE 2 The word bull nose refers to the structural part of the termination containing the pull eye, to which a pull wire is connected during pull in operation.

3.1.5

connector

Device, fitted to the end of an electrical or optical fiber cable enabling quick and safe connection and disconnection.

NOTE 1 A connector may be of a fixed design (bulkhead or MQC mounted) or non-fixed (free) design; such connectors are either plug or receptacle configuration.

NOTE 2 Connectors used in a UTA are wet-mateable by diver or ROV.

3.1.6

coupler (hydraulic)

Mechanical fitting for forming a pressure seal between hydraulic components, typically mated under a nominal pressure.

NOTE Couplers normally populate a stabplate [see multi quick connect (MQC)].

3.1.7

coupler float

Free play of the coupler as mounted in its MQC plate, to account for misalignments and fabrication tolerances.

3.1.8

design working pressure

(from API 17E)

Maximum working pressure at which a hose or tube is rated for continuous operation.

3.1.9

electric and fiber optic termination

Cable terminations for either the electric cable or optical fiber cable.

3.1.10

first end lay UTA

With reference to the order of installation of the umbilical, the UTA enters the water before the umbilical and is typically supported by the installation vessel crane.

NOTE The loads on the UTA are generally low when compared to second end lay.

3.1.11

flying lead (jumper)

(from API 17F)

Single or multiple composite grouping of hydraulic, chemical, electrical power, electrical signal, and/or optical signal carrying conduits used to interconnect various items of subsea equipment.

NOTE 1 This type of umbilical jumper is typically relatively lightweight and hence may be picked up from a deployment basket on the seabed and maneuvered into position.

NOTE 2 This is sometimes known as a bridging jumper.

NOTE 3 Flying leads may be designed for remotely operated vehicle (ROV) or remotely operated tool (ROT) assisted deployment.

3.1.12

infield umbilical

Umbilical that is installed in a subsea-to-subsea configuration, stepping out from an umbilical tied back to the host facility.

NOTE This is sometimes known as a static umbilical.

3.1.13

logic plate

logic cap

Free and fixed MQC Plate assembly which is attached to the UTA and through which all or some of the umbilical functions within the UTA are routed.

NOTE 1 The Free MQC Logic Plate is equipped with multiple loops which connect an input coupling (from the umbilical) to an output coupling (to the UTA output plates) and which may be reconfigured at a later date, e.g. to utilize spare lines in case of a line blockage.

NOTE 2 Reconfiguration of the loops is performed topside after retrieval of the Free MQC Logic Plate.

3.1.14

mono-coupler

Connector (subsea stab connector) for a single hydraulic line

3.1.15

multi quick connector

MQC

Multi-way connector arrangement comprised of two mating stabplate sub-assemblies, one of which is made of a number of hydraulic and/or chemical (or potentially electric and/or optical) coupler halves, each carrying a separate service, that mate simultaneously with corresponding coupler halves on the other sub-assembly when the two sub-assemblies are brought together.

NOTE 1 In practice the vast majority of MQC plates only carry hydraulic and/or chemical fluids.

NOTE 2 This is sometimes referred to as a multi coupler or 'Hydraulic Junction Plates' or 'ROV Stab Plates'.

3.1.16

mudmat

(from API 17E)

Typically a shallow structure used to support a subsea structure by distributing the load to the seabed via a structural plate or shallow skirt.

3.1.17

oil filled junction box

Pressure compensated housing used for the distribution of several electrical and/or fiber optic circuits between different connectors either through splicing conducted within or simply routing the conductors or fibers internally between each connector and is typically be filled with a dielectric fluid such as silicone oil.

NOTE The oil filled junction box can either be compensated using internal compensators (also known as bladders) or through the oil-filled hoses that lead to connectors.

3.1.18

padeye

Lift or handling point typically consisting of a plate with a hole through which a shackle may be attached.

NOTE See API 17D for design of pad eyes.

3.1.19

plug

Electrical plug connector has a male mechanical interface/housing, which typically houses female electrical sockets.

NOTE See also 3.1.22, receptacle.

3.1.20

pressure balanced oil filled hose

Hose assembly usually carrying electrical wires between an electrical cable termination assembly or harness distribution system and an electrical connector, the internal volume of which is filled with a dielectric oil as second seawater barrier, which is connected either to a hydrostatic depth pressure equalizing mechanism (in a cable termination or distribution harness hub) or designed to be long enough that the contained oil volume and the flexible hose construction permits self-depth pressure equalization of the connected oil filled hose network.

3.1.21

protective cover (electric, hydraulic)

'Dummy' connection that mates with the connector interface to be protected, this ensures the mating parts are not damaged during transit/installation.

NOTE Protective caps can take various forms, ranging from simple polymer protective 'blanks' to functional parts such as electrical looping or pressure monitoring provision.

3.1.22

receptacle

An electrical receptacle connector has a female mechanical interface, which typically houses male electrical pins.

NOTE 1 This often leads to confusion, as the mechanical gender is opposite to the electrical gender.

NOTE 2 See also: 3.1.18, plug.

3.1.23**ROV grab bar**

Standard interface for an intervention system for ROV station keeping during the execution of tasks.

NOTE Refer to API 17H for further design guidance.

3.1.24**subsea distribution unit****SDU**

Separately installed structure that receives hydraulic and/or electric and/or optical functions from the UTA and distributes those functions to multiple locations such as manifolds or trees

3.1.25**second end lay UTA**

With reference to the order of installation of the umbilical, the UTA enters the water after the umbilical and is typically supported by the installation vessel crane.

NOTE The loads on the UTA are generally higher when compared to first end lay due to the umbilical weight hanging from it.

3.1.26**service loop**

Excess cable required during a cable termination in the event the cable separated from the rest of the umbilical is not suitable for terminating or the cable requires re-terminating at a later date which prevents the need to remove the entire umbilical from the structure to perform the rework and also prevents cable or hose axial forces from being transferred to components such as connector seals.

3.1.27**stabplate**

See 3.1.14, multi quick connect (MQC).

3.1.28**subsea termination interface****STI**

Mechanism that forms the transition between the umbilical and the UTA.

3.1.29**subsea umbilical termination****SUT**

Mechanism for mechanically, electrically, optically and/or hydraulically connecting an umbilical or jumper bundle to a subsea system and contains the UTA (Umbilical Termination Assembly) and STI (Subsea Termination Interface) but does not include bend restrictors or stiffeners.

NOTE Figure 1 illustrates the terminology that will be adopted in the context of the UMSIRE JIP which is aligned with API's nomenclature.

3.1.30**umbilical line**

Component within the umbilical, providing hydraulic/electrical or optical function.

NOTE API 17E states that functional components are hoses, tubes, electric/optical fiber cables included within an umbilical which are required to fulfill the operational service needs.

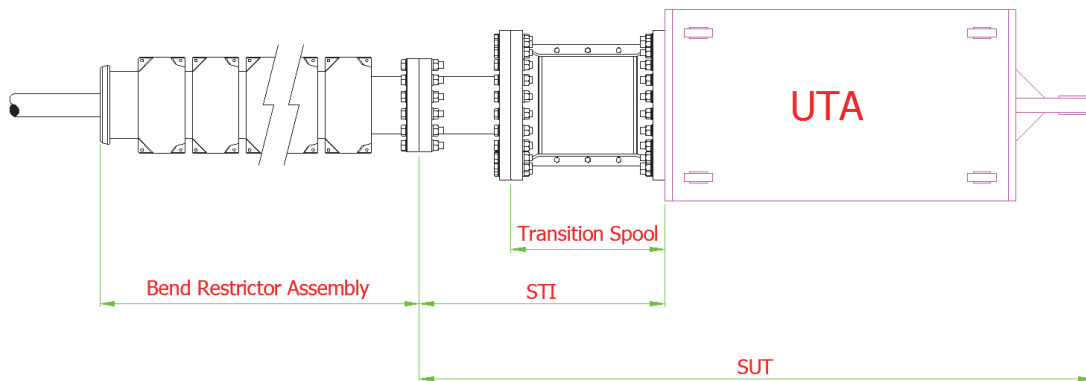


Figure 1—SUT Illustration

3.1.31 umbilical termination assembly

UTA

Mechanism for mechanically, electrically, optically, and hydraulically, as required, connecting an umbilical or jumper bundle to a subsea system.

3.1.32 umbilical termination head

UTH

Small termination head tied in directly to the manifold.

3.1.33 wet mate connector

Connector made for subsea use.

NOTE See 3.1.5, connector.

3.2 Abbreviations

API	American Petroleum Institute
CoG	center of gravity
CP	cathodic protection
FEED	front-end engineering design
ID	internal diameter
JIP	joint industry project
HP	high pressure
LP	low pressure
MP	medium pressure
MHC	multibore hub connection UTA
MQC	multi quick connect
NDE	nondestructive examination
OD	outer diameter
PBOF	pressure balanced oil filled
PPS	portable pipelay system

ROV	remotely operated underwater vehicle
UMF	umbilical manufacturers' federation
UMSIRE	Umbilical Size Reduction [name of the JIP that created this document]
SDU	subsea distribution unit
SEAFOM	international joint industry forum (subsea fiber optic monitoring)
SPS	subsea production system
STI	subsea termination interface
SUT	subsea umbilical termination
TDU	tooling deployment unit
TR	technical report
UMF	Umbilical Manufacturers Federation
UTA	umbilical termination assembly
UTH	umbilical termination head
VLS	vertical lay system

4 UTA Configuration

4.1 General

This section highlights features that can directly affect UTA configuration and size and should therefore be given due consideration. They are subdivided into three main categorizations in order to simplify and group together similar features. The three categorizations are:

- mechanical considerations,
- controls services,
- controls components.

4.2 Mechanical Considerations

4.2.1 Physical Configuration

UTAs come in many shapes and sizes and are dependent on the actual service specification of the umbilical and its control system functional requirements with which to provide the relevant functions to the SPS. Along with the subsea controls functions to be provided by the umbilical system the UTA will operate as a lifting, handling, and installation fixture for the umbilical so it will feature several mechanical lifting and installation/tie-in interfaces to be arranged around the unit.

Where UTAs are separately installable and recoverable from its subsea foundation structure, interfacing features between it and the foundation structure are provided to enable simpler and less risky installation/recovery/re-installation.

Many UTAs are configured to split the controls outputs to each side of the UTA although this is not an exclusive arrangement. Controls outputs may be configured through the top of the UTA if this is considered a feasible option for the unit under consideration. The UTA will be longer if the SPS functionality or field topology requires all outputs along one side of the UTA compared to UTA with outputs emerging from opposing sides.

Section 6 provides an in depth explanation of the typical UTA geometrical configuration as currently produced; again this is not exclusive.

4.2.2 Diver UTA

As opposed to ROV UTAs, diver UTAs can come in the same range of shapes and sizes depending on the specifics of the service they are to provide.

They use diver mateable connectors, mono-couplers, and smaller diver operable MQC assemblies. No provision need be made for ROV access in diver UTAs; however, access must be provisioned for diver intervention and operation of mono-couplers and isolation valves and all controls features.

4.2.3 Static/Dynamic Umbilicals

The influence on UTA configuration by umbilical type, i.e. static or dynamic is unlikely to be a prime design consideration. The basic UTA 'box' dimensions are fundamentally driven by functional considerations, mechanical 'lift' rating and installation equipment constraints (e.g. VLS closed tensioner maximum aperture) as opposed to umbilical type.

The STI interface between the UTA and the umbilical may potentially be larger where a dynamic umbilical is terminated to the UTA utilizing the full dynamic cross section of the umbilical design. The dynamic section of an umbilical is mechanically reinforced to resist the induced flexural loads. However dynamic umbilicals can incorporate a cross section change into a static section (reduced mechanical reinforcement) beyond the seabed touch down point and so could more typically be representative of a smaller, static umbilical STI interface.

4.2.4 Infield Umbilicals

Consideration should be given to the direction of installation of an infield umbilical and whether each end should be suitable for a first or second end lay (or both). Where a UTA needs to be recovered, this effectively is the same load case as second end lay (only in reverse) so needs to be catered for. Therefore, consideration should be given to designing for the worst loading case scenario of a second end lay and so covers all eventualities.

4.2.5 ROV Grab Bars and Protection Interfaces

If the use of protruding ROV grab bars is unavoidable it is essential that the UTA overall dimensions are kept to a minimum. The specification and location of ROV grab bars affect the overall dimensions and weight of the UTA.

They may be made removable to minimize the UTA size to allow it to pass through the lay tensioner, however, additional installation vessel time is required to re-install them.

In addition, grab bars can be used or added to the existing bump bars protecting the connectors, couplers, and MQCs on the sides of the UTA. In cases where their removal is required during installation additional temporary protection may be required.

4.2.6 CP Anodes

Sacrificial anodes are fitted to UTAs as part of the corrosion protection system. They should be mounted so as to avoid encumbering interventions (ROV or diver) and flying lead connections.

When designing CP systems the UTA should not be thought of as an isolated unit. The CP requirements for the umbilical termination and hydraulic flying leads may also need to be considered, leading to a greater volume and surface area of anodes to be mounted on or within the UTA. Cathodic protection system shall be designed in accordance with the system (such as prescribed in DNV-RP-B401, DNV RP F112).

To reduce the size of the UTA, some of the anodes could be installed on the foundation structure. This choice requires having a positive earth bonding connection between these two potentially discrete items of equipment. This can be

achieved by component to component connection through bolted joints, other mechanical connections or by discrete earth bonding flying lead where UTA and foundation structure are not physically connected.

The UTA supplier should interface with the umbilical supplier to ensure CP systems for umbilical and umbilical termination are adequate and compatible.

4.2.7 Marking

UTA shall be marked to clearly show its internal diameter (ID) within the SPS and also identify each connection/interface points. Several industry standards (such as API 17D, API 17F, and API 17H) have prescriptive requirements for UTA marking. These and alternative codes and standards should be considered when deciding on a suitable and effective marking regime.

The markings should meet the guidelines given in API 17H.

The clarity of first end and last end markings are also essential as the UTAs at opposing ends are not likely to be interchangeable offshore and an essential requirement for umbilical packing onto reels or into carousels.

4.3 Controls Services

4.3.1 General

4.3.1.1 Impact on UTA

There are a many umbilical cross-sectional cable, tube, or hose functions which have a notable impact on UTA configuration, size, and weight:

- the number, size, and manufacturing specification of the cables, tubes, or hoses in the umbilical;
- the cables, tubes, or hose end termination requirements;
- internal routing and distribution of the tubes or hoses (which is generally carried out in hard piping to minimize MBR and required space within the UTA).

The above items are discussed in greater detail below. These are general in nature and apply to provision of all fluid services.

4.3.1.2 Number, Size, Construction, and Materials

It is likely that any increase in the quantity and diameter of the umbilical service lines will have impact on the UTA dimensions. As the number of umbilical functions increases, and/or the outside diameter (OD) of the hoses/tubes/cables increase, this is likely to result in growth of the umbilical OD and the weight per meter. This subsequently impacts the umbilical termination steel work and in particular the interface flange which connects the UTA to the SUT. This is all detrimental to the UTA structure in terms of dimensions and weight.

Caution shall be taken during the design when using the materials in conjunction with a cathodic protection (CP) system. The tubing materials could be susceptible to hydrogen induced stress corrosion cracking (HISC) under certain combined conditions, such as coarse grain, high stress, and low cathodic potential. Consequently, larger bend radii on tubing may require larger UTA size.