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.

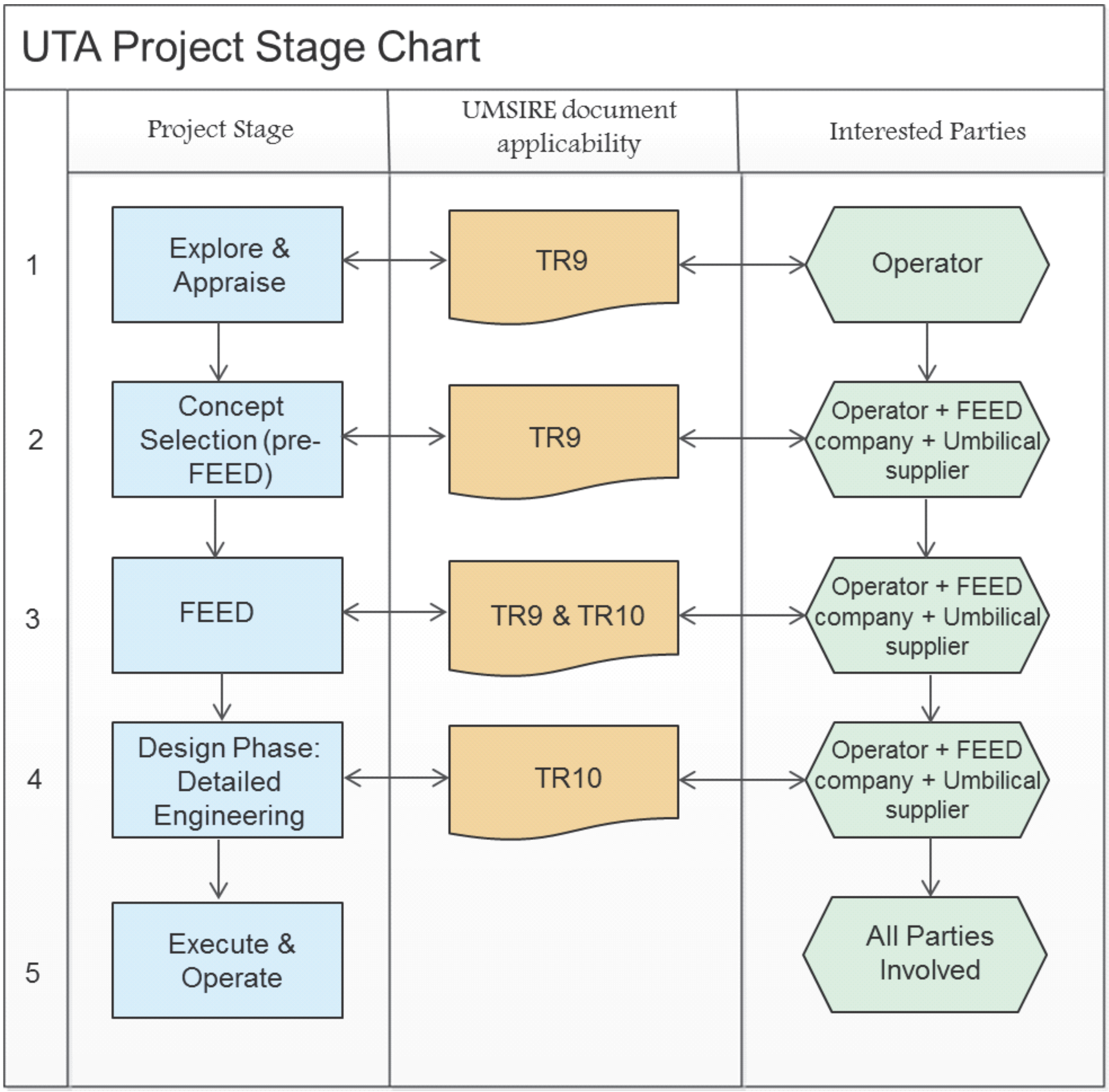


Figure 0.1—Project Stage Chart

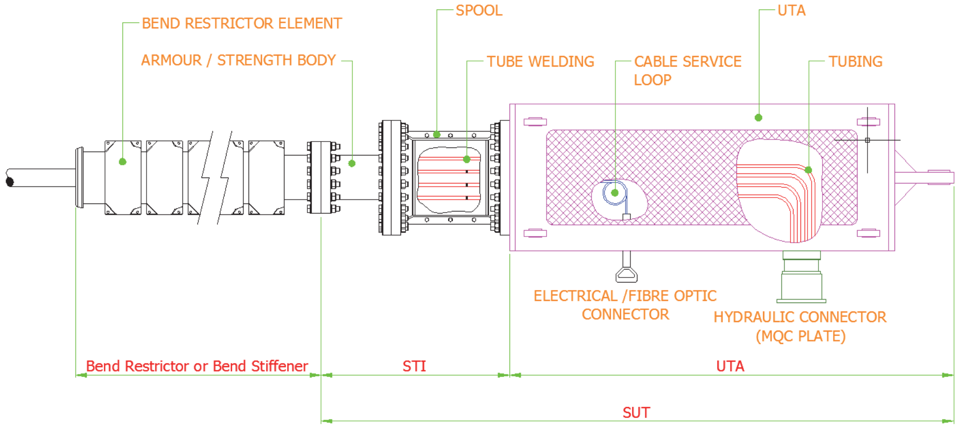


Figure 0.2—Steel Tube Umbilical or Thermoplastic Umbilical with Spool

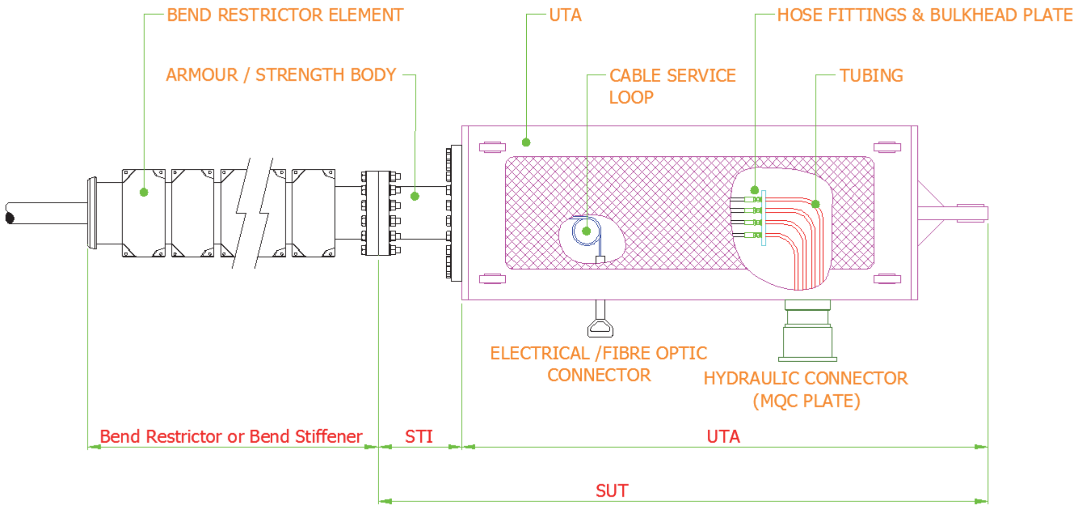


Figure 0.3—Thermoplastic Umbilical

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.

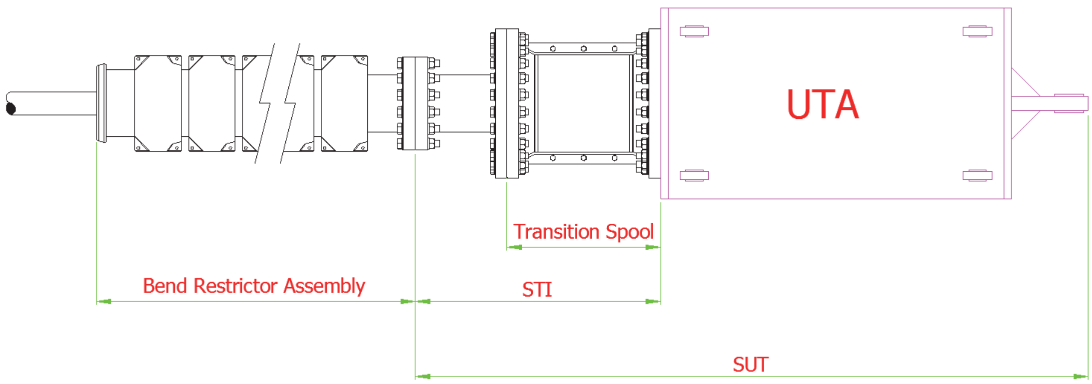


Figure 1—SUT Illustration

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.

4.3.2 Fluid Lines

4.3.2.1 Termination

Conventionally, thermoplastic hoses are terminated inside the UTA, where thought must be given to interfaces between umbilical hoses and UTA tubing. Alternatively, they can be terminated outside the UTA in a termination spool, although this is done less frequently.

Steel tube umbilicals will require access for welding the umbilical tubes to the UTA tubes. This typically requires the addition of a termination spool in which this connection can be made. The diameter and length of the termination spools also have an impact on SUT length.

Butt welding of the tubing is the preferred welding technique and consideration must be given to the space required. The welding method used (orbital vs. manual) can also have a significant impact on the size of the UTA interface opening and termination spool. The use of adapters needed for welding materials with different geometries may lead to a marginal increase in the SUT length. The use of socket welds is not a good industrial practice and is generally discouraged.

4.3.2.2 Internal Distribution

There may be one or more umbilical lines to each MQC coupler, and the lines may split within the UTA using tee fittings. Tee fittings take up space within the UTA frame.

It is possible to use machined manifolds rather than discrete tees to save space in distributing the fluid supplies, however these are custom made rather than off the shelf items.

Design pressure and tube materials may have a significant impact on the UTA size. For example, the use of a relatively low yield material, such as 316L stainless steel, for a large diameter high pressure line leads to a tube with either a very large bend radius or the requirement to use fittings, with the associated access requirements. Such problems may be avoided by the use of super duplex stainless steel or other appropriate material, wherever possible.

As required, tubing should be securely attached to the structure to reduce risk of damage due to movement. However, care should be taken to ensure float in the coupling on the MQC plate is retained.

4.3.3 Hydraulics

Hydraulic control fluids at various pressures are distributed (typically termed LP; MP; HP depending on line pressure) through the UTA. The HP systems are generally not considered to be particularly high flow as they are predominantly used for small sized actuators on sub surface safety valves so therefore line size is reduced. MP and LP systems drive multiple, larger size actuators operating large subsea system valves and consequently need larger ODs in order to meet the required valve actuator flow rates.

4.3.4 Chemical Injection Lines

Chemical fluids may also be distributed through a UTA. Larger diameter tubing for chemical services has a consequent impact on the UTA size.

It is recommended that “configured” UTAs do not contain tubes larger than 1 in. OD due to difficulty in connecting them to the required MQC plate. Beyond the 1 in.OD value the tubes will considerably affect the size of the UTA. Large diameter tubing from umbilicals may be stepped down to smaller diameter tubing within the UTA, providing that the pressure and flow-rate reductions are acceptable.

4.3.5 Service Lines

Service lines are sometimes provided, for instance to provide MEG or methanol, and for well venting. Such lines are generally larger in bore size so act as a driver for increased UTA size.

4.3.6 Spare Lines

Consideration should be given to the potential future use of spare lines in the umbilical when configuring a UTA (e.g. spare lines may be connected to both stabplates in readiness as a contingency in the case of a hydraulic or chemical service line failure). They are often included in umbilicals, but are sometimes hard to access or utilize due to system design and spatial constraints. The use of a logic cap (a cross connected MQC plate system) permits reconfiguration to access spare line(s) but the cost of an extra MQC plate system and associated small bore tubing require a significant size increase in the UTA.

4.3.7 Return Lines

Return lines are only required on closed hydraulic circuit systems, requiring extra line(s) in the umbilical, UTA, and MQCs. Return line tubing is usually of a large diameter to minimise back-pressure on the control system.

4.3.8 Gas Lift Lines

Gas lift lines fall into the “integrated production umbilical” category and are not included in the scope of this TR.

4.4 Controls Components

4.4.1 Electrical Cables and Optical Fiber Bundles

Electrical cables (for power and communications services) and optical fiber bundles (for communications services) are generally terminated inside the UTA enclosure. Typically extended lengths of cable and / or bundle are provided from the umbilical into the UTA for termination to the selected electrical and optical connector systems. This over length is not usually all trimmed back before termination—a spare length contained in a service loop is typically retained in case of failed termination at the first attempt. As electrical cables and optical fibers can require large bend radii, consideration of the available space and force required to form service loops within the UTA may dictate the overall UTA dimensions.

Additionally, the style and type of connector system can also affect the UTA size; see 4.4.2 for more details.

The reader should consult the cable termination manufacturer for their termination capabilities and O/I information, as Figure 2 simply contains sketches to differentiate between indirect and direct cable terminations.

As required, electrical and/or fiber optic cables and harnesses should be securely attached to the structure to reduce risk of damage during handling, packing and offshore installation.

4.4.2 Electrical and Optical Connectors

Electrical and optical connectors can be sub-divided into four groups:

— control connectors,

— power connectors,

— fiber optic connectors for subsea communications,

— hybrid electrical/optical connectors.

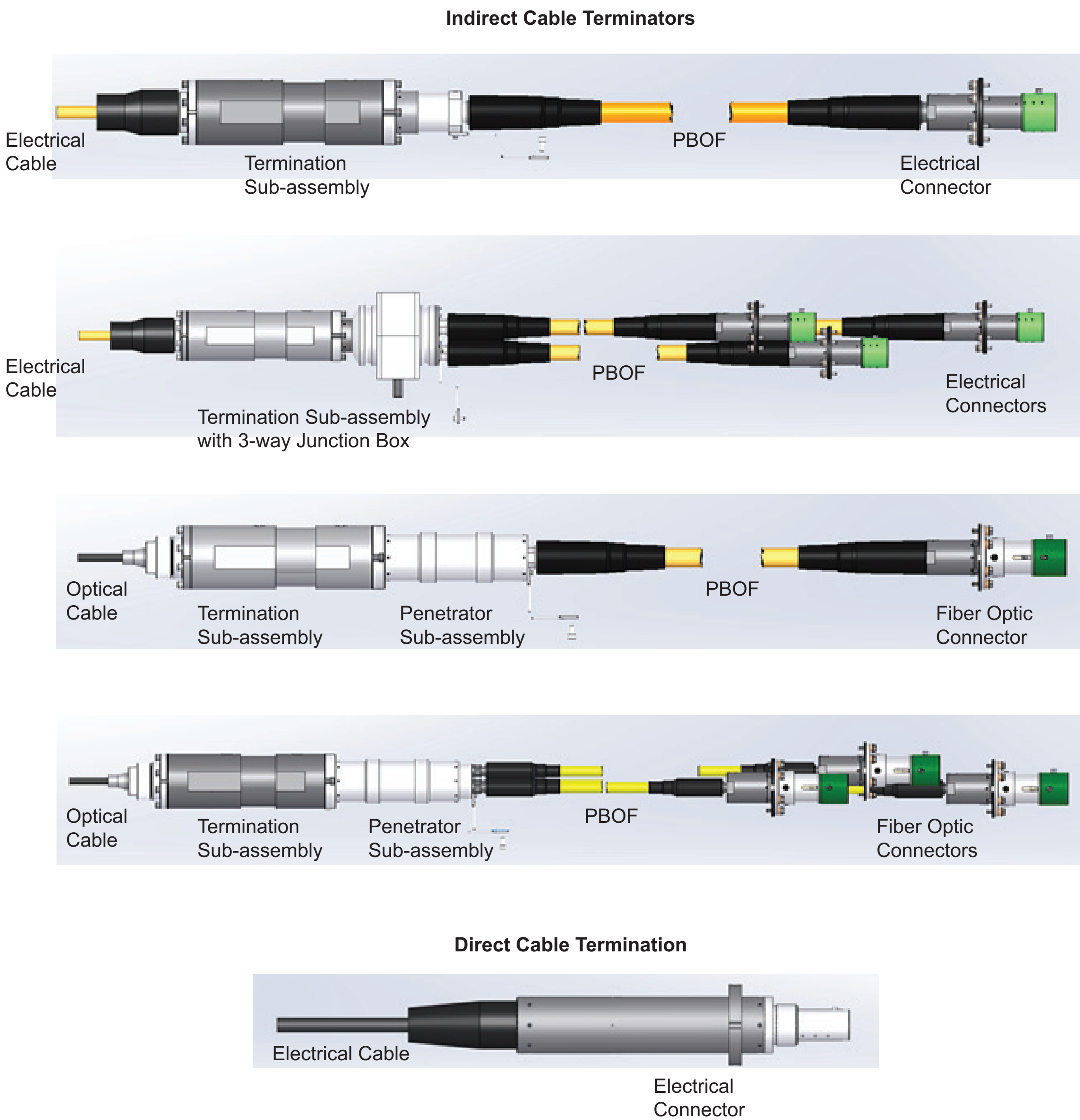


Figure 2—Indirect and Direct Cable Terminations

When positioning connectors, consideration must be given to the vertical and horizontal spacing between connectors, allowing for ROV or diver accessibility and how the flying lead will lay away from the connectors and hence the UTA.

The electrical and optical fiber cores in the umbilical may be connected to the UTA cabling by a termination assembly. These terminations fall into two categories: Direct and Indirect.

Direct terminations have the cable entering directly into the back of the relevant connector. This configuration can only be used to terminate electrical cables.

Indirect terminations have the cable terminating at a dedicated cable termination assembly before onward connection via a pressure balanced oil filled hose (PBOF) to the relevant connector(s). This configuration can be used to terminate both electrical and fiber optic cables. In addition to the fiber optic cable termination, a penetrator subassembly is required in order to house the necessary fiber splicing and the additional fiber management that is inherent to this process.

There is potential for limited distribution within the electric and fiber optic termination depending on the available space inside the junction box. Additional distribution requires additional junction boxes and more space in the UTA.

Selection of the electrical cable/optical bundle termination methodology has a significant effect on UTA outfitting and eventual overall size of the unit.

Provision of spare electrical and fiber optic connectors must be considered in-line with the project requirements including possible future expansion.

4.4.3 Multiple Quick Connect (MQC) Plates

MQCs are used to connect hydraulic couplers to convey hydraulic and chemical fluid from the umbilical to the field via flying leads or bridging jumpers.

MQC couplers should have some radial and axial float in accordance with the requirements of the coupler/MQC plate manufacturer.

Consideration must be given to the horizontal spacing between the MQC assemblies and the vertical clearance between other attachments, allowing for ROV or diver accessibility and how the flying lead lays away from the connectors.

Designers of the termination of the tubing to MQC plates and between plates needs to consider alignment during makeup of the MQC connection (e.g. float, compliance, etc). UTA tube routing shall be securely attached to the UTA to prevent movement or risk of damage from splash zone, currents, vibration, water hammer, etc., with the condition that tubing interfacing to the couplers on the inboard have radial and axial float as required to ensure successful interface of inboard and outboard MQC.

4.4.4 Mono-couplers

Mono-couplers are used to access a single line. Generally mono-couplers should be fitted with a locking nut or other restraining mechanism to ensure that the coupler is not accidentally disconnected. Mono-couplers are a good way to access spare line capacity.

4.4.5 Hot Stabs

Hot stabs as described in API 17H can be utilized to provide a temporary connection method for ROV hydraulic control intervention or chemical injection to subsea equipment. In addition to the guidance given in API 17H, the following items should be given special consideration.

— Consideration must be given to intervention access for hot stab receptacles and ROV docking locations after all other equipment is installed onto subsea structure.

— In the case of chemical injection use, consideration must be given to the location of venting ports and escaping fluids within enclosed areas.

— Consideration must be given to ensure the hot stab location is not in a high marine growth/debris area and suitable long-term protection should be provided.

4.4.6 Isolation Valves

The use of isolation valves is based on operator’s preference. They add flexibility, but reduce reliability as potential points of failure. They may be used to support double barrier isolation philosophy. The use of isolation valves increases the size of the UTA, not just in the addition of the valves, but in the tubing associated with the valves and the need to increase the length of tubing runs between the valves and couplers to permit sufficient coupler float.

Although valves may be positioned close together, consideration should be given to clear tagging, ROV and/or tooling accessibility. In addition they should meet the interface requirements of API 17H.

Designers are reminded that the valve size should typically reflect the tubing ID not OD.

Isolation valves are useful on lines with poppet-less or bleed couplers to reduce water ingress in the rest of the system when not connected.

4.4.7 Protective Caps—Electrical/Optical

Electrical protective caps are required during deployment of the UTA. A looping connector or a shunt connector may be required. This connects two pins together with either a resistor of a known value or a short circuit. This allows loop resistance monitoring of the umbilical conductors during installation.

4.4.8 Protective Caps—Hydraulic

Hydraulic protective caps will be required during deployment of the UTA. These may be short term or long term as dictated by the project requirement and may contain pressure retaining couplers. Protective caps may also contain hydraulic loops to allow the fluid in the lines to be circulated; this complexity could lead to an increase in the size of the protective cap.

The protective caps often define the widest point of the UTA and care should be taken that they minimize their effect on handling and installation operations. For this reason, protective caps may need to be removed temporarily during handling and installation operations.

5 Structural Design Requirements

5.1 UTA Structural Design Basis

When considering the design of a UTA the responsible party should assess the available industry standards and elect a suitable standard on which to base the design. For structural design, refer to guidance given in API 17P.

The UTA design should identify all the relevant mechanical loads and load combinations to be experienced by the UTA and present this in a Design Basis document. The Design Basis document is the statement of applied loads and load resistance requirements for the UTA load bearing structure.

It should be noted that generally design standards work on the basis of defining a static mass or weight (Static Rating) for the equipment to be lifted / handled. All then apply design factors to the static number in order to cover dynamic accelerations that will be experienced in an offshore lifting and handling environment. Given that the identity of the installation vessel/vessel crane/installation spread is rarely available at the time of design of the UTA, this is the most practical way forward for UTA structural design.

5.2 Loads and Load Combinations

During the life cycle of a UTA the unit is likely to be handled, lifted and tested in a number of different configurations and physical locations. The following is a list of potential lifting and handling scenarios likely to be encountered by a UTA.

- Onshore/detached from an umbilical:
  - Mechanical Load Test (of structural framework),
  - lifting of completed UTA.
- Onshore/quayside attached to umbilical:
  - integration with umbilical,
  - load out with umbilical onto storage reel or carousel,
  - transit loads for UTA/umbilical secured within reel or carousel,
  - deck handling with umbilical (across deck from storage location to installation spread),
  - handling through installation spread (horizontal or over VLS).
- Offshore/on-board installation vessel:
  - deck handling with umbilical (across deck from storage location to installation spread),
  - handling through installation spread [horizontal or over Vertical Lay Spread (VLS)],
  - lifting handling through the water column as first end installation,
  - land out/pull into host structure plus umbilical lay away,
  - lifting handling through the water column as second end installation,
  - land out/pull into host structure,
  - lifting handling through the water column as first end recovery,
  - lifting handling through the water column as second end recovery.

— Installed service load conditions:

  — ROV operational intervention loads,

  — ROV impact loads,

  — dropped object protection,

  — flying leads static/hang off load(s),

  — Loads associated with cases of UTA deployments when attached to a mud mat/support structure.

Recovery is another load case for consideration. In many cases this is very similar to second end installation with the additional seabed friction and burial suction forces being accounted for. If there is an additional requirement to pull the mudmat out of the seabed via the SUT, this must be incorporated in the design basis.

The UTA designer shall have considered the applicable load scenarios to which the UTA will be subjected. The defining UTA structural loads should be quantified and recorded in a Design Basis document.

As a minimum, the primary load bearing case(s) for the UTA must be identified which are basically those which could cause the total loss of or potentially significant damage to the umbilical system during an installation or recovery exercise by mechanical failure of the UTA. In general terms this is a structural assessment of the UTA as a lifting device for a second end installation or first end recovery of an umbilical system, i.e. the full weight of the umbilical through the water column and any length suspended above the sea surface; self-weight of the UTA and any other attachments; allowance for additional umbilical length as any catenary developed through the water column; all design factors to be applied by the elected Design Code.

The minimum input information for this assessment is the specific mass/weight parameters of the umbilical to which the termination is to be integrated; worst case installed water depth or specified design water depth; installation methodology.

NOTE Where installation story boards are available for typical installation and recovery scenarios, these may be used to assist in defining loads and load combinations. Without these data it is impossible to start any assessment of the primary structural loading to be resisted through the UTA. Assumptions may be made regarding non-critical load case scenarios, but are recorded and justified in the Design Basis document.

5.3 Umbilical Equipment Considerations

Umbilicals are finished with their own mechanical/structural termination hardware. This may or may not include installation lifting and handling points. The umbilical termination hardware is the mechanical load bearing feature that interfaces with the UTA (see 5.4) and is also used to secure other umbilical components such as bend restrictors and bend stiffeners.

There is a size and weight envelope associated with this equipment that must be identified and shall be considered when assessing the load capacity of the UTA. Assuming the UTA is the primary handling device for the umbilical system assembly, the static weight and the stiffness of these components should be taken into account in addition to the specific weight and handling parameters of the umbilical itself.

NOTE Bend restrictor versus bend stiffener.

— Umbilicals may be fitted with either a bend restrictor, or in some cases a bend stiffener depending upon application. The specific technique for the project is identified and agreed during the bid and upfront clarification of the owner of the project. In most cases a bend restrictor is required to prevent damage to the umbilical through over-bending during installation.

— A bend stiffener normally comprises an elastomeric (polyurethane) tapered sleeve attached to the umbilical termination hardware with the express intent of providing additional bending stiffness to the umbilical at this location.

— A bend restrictor normally comprises a discrete number of interlocking vertebrae attached to the umbilical termination hardware. The intent of this equipment is to limit the minimum bend radius attainable by the umbilical to that permitted within the design of the vertebrae when they lock out. It is not designed to provide any local stiffening or bending resistance to the umbilical. Individual vertebrae can be added or removed from the umbilical as required (normally being a split shell design) and so have the ability to be removed for handling or storage convenience of the umbilical system.

5.4 Structural Design Features

A UTA is comprised of a number of critical structural design features and interfaces. Key amongst these are as follows.

— UTA to umbilical mechanical interface

  — Normally comprises a circular flange bolt pattern interface. The UTA typically mirrors the umbilical flange termination and offers a direct face to face interface. This is the structural load handover interface between the umbilical and the UTA. It is essential that the load transfer requirements from umbilical to UTA are fully defined and agreed at this stage. Termination flange design and bolt hole pattern shall be in accordance with ASME B16.5 or ASME B16.47.

  — This interface signals a crossover in ruling design standards from API 17E for the umbilical to the elected design standard for the UTA. The mechanical load capacity of the umbilical is frequently well above the calculated Static Rating used as the input to the elected UTA design. For a UTA to match the physical strength of an umbilical would mean a significant increase in the load resisting structure of the UTA. For this reason the umbilical load capacity is rarely used as the structural load capacity of the UTA.

  — A notable exception could be a UTA without any umbilical function distribution within the unit—this would most likely take the form of a very compact ‘bull nose’ type termination only passing on umbilical functions not distributing them

— Primary installation lifting interface

  — May take a number of different forms but typically comprises a single or multiple pad eye system that is rated for first or second end installation/recovery, i.e. it is specified to cover the worst load case (see 5.2) identified for the umbilical system. It should be designed in accordance with the elected UTA design standard using all applicable design factors, such as but not limited to dynamic, skew, materials.

  — Consideration must be given to lifting and handling angles applied through the primary lifting interface; transition from vertical to horizontal and vice versa is a fairly common requirement. Hence the primary lifting interface may be required to accommodate UTA rotation through ± 90° from the horizontal axis of the UTA body.

  — Consideration shall be given to recovering (and refitting if required) of installation rigging whether this be by diver or ROV intervention. Installation rigging should not be left attached to a UTA subsea. Suitable access should be designed into the primary lifting handling interface to accommodate this requirement.

  - The primary installation lifting interface should be provided with a rated load capacity. This provides the installation contractor with an unambiguous load rating and known reserve factor when working through their UTA/umbilical handling and installation procedures.

- Secondary lifting handling interface

  - These features are extremely useful for controlling the movement of the umbilical system when handling, especially around installation spreads both offshore or at a quayside.

  - They are also used for securing the UTA within a reel.

  - May take a number of different forms but typically comprises single or multiple pad eyes or lifting/tugger points rated for handling of the UTA/Umbilical combination on and around the deck of an installation vessel.

  - The secondary installation lifting features should be rated for the weight of the SUT plus any bend restrictors or stiffeners and appropriate length of umbilical product. This rating shall be presented to the installation contractor. This provides the installation contractor with an unambiguous load rating and known reserve factor when working through their UTA/umbilical handling and installation procedures.

- Land out and lock down features with host structure

  - May take a number of different forms but all provide a location system that secures a UTA in place in its installed subsea location.

  - The landing and lock down features, where possible, should be provided with any installation specific load ratings, weight capacities, installation velocities or moment ratings to be observed. This provides the installation contractor with any UTA/umbilical set down and lay away loading limitations when working through their UTA/umbilical handling and installation procedures.

  - The installation host structure may take the form of a dedicated standalone mounting structure for the UTA. This should be considered as a discrete structure that is not physically attached to the UTA. This equipment may be installed separately from the UTA/umbilical combination in order to simplify UTA/umbilical handling.

NOTE This information is advised through interface drawings and operation manuals rather than marking on equipment. Therefore, explanation of all the above features shall primarily be achieved via the unit Interface Drawing and accompanying installation/handling procedures. In particular permissible usage and the relevant load ratings of specific features with their derivation is to be clearly indicated on the unit interface drawing and/or accompanying procedures. It is important that the UTA Supplier interfaces with the Umbilical Supplier and the Installation Contractor to ensure the UTA design facilitates proper integration to aid installation of the umbilical.

5.5 Structural Design Considerations

Consideration shall be given to the manufacture, assembly and testing of the UTA at the initial design stage, taking into account any project specific design requirements that could influence the design. These aspects can be key drivers for determining the overall size of the UTA structure. Specific considerations include the following.

- Normally, structural carbon steel is the material of choice for the UTA load bearing framework. High strength alloy steel or high strength corrosion resistant alloys (CRA) are normally not considered for this application.

- Steel grades should be selected to ensure that they are suitable for the service conditions, considering level of redundancy, operating temperature, and are relevant to the selected structural design code.

- Physical space and access to fabricate the load bearing structure including welding processes, inspection processes, and load testing as required.

NOTE Where load testing is required it must be carried out on the load bearing framework prior to final coating as welds and structural members will require to be non-destructively inspected. This cannot be carried out through a subsea coating. The project specific requirements must also be considered.

— Physical space and access to facilitate outfitting of the UTA with any required controls equipment such as MQC plates, small bore tubing, electrical cable termination assemblies, optical bundle termination assemblies.

— Physical space and access for adequate anode numbers to meet the Cathodic Protection (CP) system requirements, in addition to the role played by coating systems as described in API 17P.

— Physical space and access to be able to terminate umbilical functions into the finished UTA as delivered to the umbilical manufacturer. This can be particularly difficult with stiff electrical cables and larger diameter or HCR (high collapse resistant) umbilical hoses, as they require significant force to bend to their minimum bend radius.

— Long-term protective caps can be left in place subsea for extensive periods to protect spare MQC plates, electrical connectors and optical connectors from dirt, corrosion and damage. Where possible, physical space within the UTA structure should be provided for these protective caps. It is recognized that this is rarely possible given the access requirements for intervention with this equipment. They might also impede the UTA from passing through the tensioner during installation. Therefore, temporary protective cover plates may be considered for use during handling procedures that present significant risk to the controls components, instead of the normal component protective caps.

— Seismic consideration will impact the design of the foundation structure. UTA design characteristics are unlikely to be dependent on seismic activity.

— Recommendations on structural design (including relevant design codes and materials) of subsea production systems are provided in API 17D and API 17P. API 17H is to be referred to for remotely operated tools and interfaces of subsea production systems.

NOTE Normal component protective caps would be temporarily removed to fit the cover plates and refitted prior to installation.

6 Geometry

6.1 General

This section reviews the UTA design parameters that affect the basic size and shape of a UTA. It considers what functions and features affect primary UTA dimensions of length, width and height (or length and diameter), and considers what aspects affect design decisions on principal geometric shape.

6.2 UTA Categories

UMSIRE recommended UTA sizes fit within one of four categories:

— Category A: up to 1.2 m (47 in.) closed tensioner diameter,

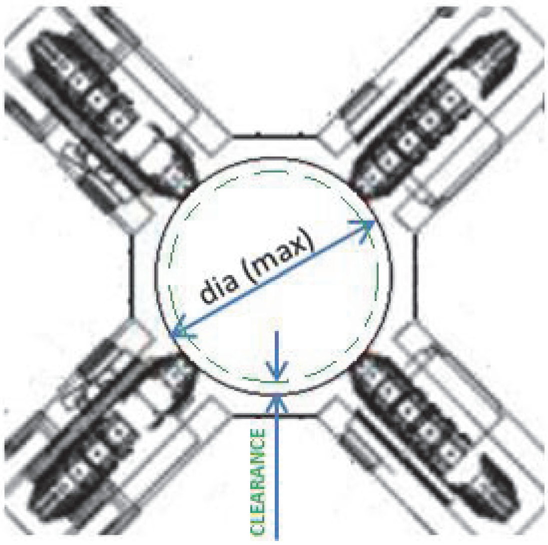
— Category B: up to 1.4 m (55 in.) closed tensioner diameter,

— Category C: up to 1.6 m (63 in.) closed tensioner diameter,

— Category D: >1.6 m (63 in.) [requires open tensioner].

The UTA categories are mostly defined by the closed tensioner aperture as shown in the Figure 3. The UTA cross-section must stay within and be free to rotate within the circle enclosed by the aperture. The diagram shows a typical four-track "closed" tensioner.

Clearance must be considered to allow the SUT to pass through the tensioner without issue. The minimum radial clearance to tensioner aperture should typically be 50 mm, depending on geometrical layout and handling constrains. Certain items may be temporarily removed to allow the SUT to pass freely through the closed tensioner.



Case	Tensioner Opening
A	≤ 1.2 m
B	≤ 1.4 m
C	≤ 1.6 m
D	> 1.6 m

Figure 3—Closed Tensioner Opening

6.3 Current UTA Convention

6.3.1 General

Typical UTAs conform to two basic geometrical types, the rectangular boxed enclosure or a cylinder shaped enclosure. There are other variations but these two configurations account for the significant proportion of current UTA designs.

Circular UTAs are frequently used for diver intervention where orientation subsea is less critical. Low functionality, diver installed/operated UTAs are a typical example.

Rectangular boxes are frequently used for ROV intervention, as they provide flat surfaces which are useful for easily mounting controls hardware, provide a flat, stable base on which to sit subsea, provide simple orientation (up/down) subsea, and provide horizontal or vertical intervention faces for conventional equipment interconnection. Figure 4 shows the geometric sketch of five faces of the UTA.

Using the rectangular box enclosure as an example for the purposes of the following description a typical UTA may be arranged geometrically as described in the 6.3.2 through 6.3.6.

6.3.2 Back Face

Interfaces directly with the umbilical to which it is attached. The Back Face is the mechanical, load bearing connection to the umbilical termination steel work and is normally connected via a bolt pattern based on the umbilical termination flange size and rating. Termination flange design and bolt hole pattern shall be in accordance with ASME B16.5 or ASME B16.47.

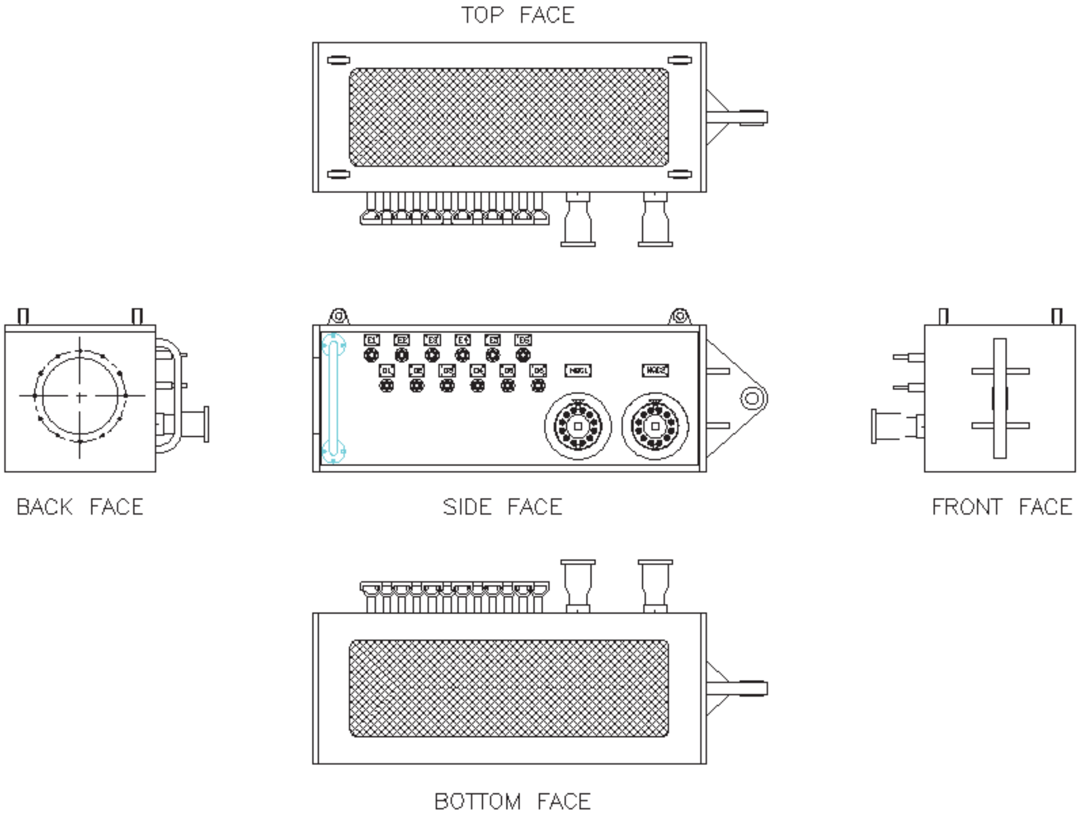


Figure 4—Geometric Sketch of Five Faces of the UTA

6.3.3 Front Face

Opposite end to the umbilical connection, it is typically used to mount installation lifting padeyes (axially in line with the umbilical where possible) and/or subsea installation/connection features to its mounting structure subsea.

6.3.4 Top Face

May be used to mount auxiliary lifting points for the UTA for use during its manufacture and when handling the unit as part of the larger Umbilical System Assembly. It can provide possible mounting points for CP anodes if requirements demand. Crucially can be used to provide access into the enclosure (by removable panels) to permit initial manufacturing outfit of small bore tubing and subsequent termination access space for cables and Optical bundles inside the UTA.

The top face can sometimes be used to mount connection hardware, although this should be carefully considered as it can have operational implications.

6.3.5 Bottom Face

Used primarily as the mounting face for the UTA both topsides and subsea. It is usually left featureless and flat for the purposes of mounting. It may house features to aid in positioning the UTA onto its host subsea structure, at the discretion of the UTA designer. As with the Top Face, it may crucially be used to provide access inside the enclosure, by removable panels or an open design. This permits initial manufacturing outfit, venting, and subsequent access for termination of cables and optical bundles inside the UTA.

6.3.6 Side Faces

Normally reserved for mounting controls connection hardware such as MQC plates, electrical connectors, optical connectors, and where required, limited numbers of isolation valves. The side faces normally comprise removable panels to aid manufacture, assembly and test of the UTA and also termination to the Umbilical itself. The side faces typically will also mount appendages such as ROV grab bars where required as well as further space for CP anodes.

6.4 Umbilical Interface

The umbilical interface is normally a flange pattern interface presented from the umbilical termination steelwork STI. It directly affects the height and width of the UTA, as the flange interface must fit comfortably onto the UTA Back Face. Consideration must be taken for recessing of outlet panels on the UTA Side Faces such that flange bolting is clear of side faces and panels. The back face of the UTA has been shown in Figure 4 as an example.

6.5 UTA Functionality

6.5.1 General

Typically this is predetermined before the UTA designer receives their brief and will include high level detail on the quantity of the termination and connection requirements required within the UTA. This may or may not require some level of local distribution within the UTA.

The following controls equipment used to terminate umbilical services have the following influence on UTA primary dimensions.

6.5.2 MQC Plates

Used to terminate hydraulic and chemical services, they tend to affect the width dimension of the UTA in the main as they are generally fitted to the vertical sides of a UTA, but have to accommodate small bore tubing running horizontally into the back of their hydraulic couplers. The small bore tubing has to reach down the length of the UTA (from the Back Face) and turn at right angles to interface with MQC plate couplers and provide compliance for couplers to float. This has a greater size constraint than the height of plate hence affects UTA width more than height. Where MQC plates require to be mounted on opposing sides of a UTA this greatly affects the final width dimension.

6.5.3 Isolation Valves (Where Used)

Typically affect the height, width and length of the UTA as small bore tubing has to route into and then out of the isolation valve before running onto MQC plates.

6.5.4 Electrical Cable Termination

Typically cable termination type units should be packaged into the UTA along with hose extension to output connectors. This tends to affect the length of UTAs as umbilical cables must be run inside the UTA before terminating. A level of cable over length is required to enable the cables to be terminated outside the enclosure and to ensure a second opportunity at terminating if the first attempt fails.

6.5.5 Optical Fibre Bundle Termination

These are similar to electrical terminations above.

6.6 Subsea Structure Layout

Subsea structure layout may affect the size of the UTA if controls connections are required on both sides of the UTA (see 6.5.2). A UTA configuration that requires flying leads either to cross one another is not preferred.

6.7 Installation Equipment

Where a UTA has to pass over and through a VLS system, space constraints may be critical for the UTA package.

Length of the UTA should be as short as is practically possible to simplify lifting and plunging of the UTA into the entry of the VLS tensioners without special handling activities. Long UTAs also create severe difficulties for reeled umbilical systems.

Where the VLS uses a closed tensioner system, UTA height and width is critical. Where the UTA dimensions do not permit passage through the tensioner maximum aperture then the UTA solution is not viable.

UTA dimensions should also permit it to rotate within the tensioner maximum aperture—this will permit the UTA to pass through the tensioner in any rotational position.

Please see Section 9, Installers' Handling Requirements, for further information.

6.8 Manufacture/Assemble/Test

All UTA dimensions are affected by the need to outfit the UTA and to terminate the umbilical to the UTA.

Physical space and access is a prime requirement in order to manufacture the UTA before it is delivered to the umbilical system. In particular this requires adequate space to fit any small bore tubing system which will include welding and NDE inside the UTA enclosure.

When terminating a UTA to the receiving umbilical space and access is critical in the UTA. Electrical cables and optical fiber bundles are connected to cable terminations at this stage; this normally takes place outside the UTA enclosure. Access is required to extract the cable termination canisters from the UTA, make the connection and test it, then reinstall inside the UTA enclosure whilst finding space for any electrical cable of optical bundle over length.

6.9 Subsea Operability (Onward Connections)

Most functional connections subsea are made horizontally, which requires that the connection points are generally to be found on the Side Face of the UTA. This obviously drives the general geometric arrangement of any UTA design. Connections are not limited to the Side Face(s) of the UTA and can potentially be fitted into the Top Face of the UTA, though this is not necessarily common.

The height and length of the UTA is mostly affected by the needs of the connection systems onboard the UTA.

6.10 Mounting/Installation Subsea

The final installed location of a UTA subsea can affect the configuration of the unit. Guidance and lockdown features may be placed anywhere practical onboard the UTA but typical locations are likely to be the Front Face or the Bottom Face of the UTA. This typically affects width, length and height of a UTA.

6.11 Interfaces

6.11.1 Subsea Termination Interface

6.11.1.1 General

A Subsea Termination Interface (STI) is a structural unit which forms an interface between the umbilical and the UTA, and it features a bolted flange for physical connection to the UTA. The STI is typically supplied by the umbilical supplier. Within the STI, all tensile-strength members of the umbilical such as armour wires, rods, or metallic tubes themselves are physically terminated by use of an approved method.

The STI normally includes a separate cathodic protection system.

The STI may be equipped with lifting points, yet these are normally intended for onshore handling only, as a UTA will be equipped with lifting points rated for offshore handling and use during installation.

The size of the STI is mainly driven by one or more of the following parameters:

— type and number of elements within the umbilical;

— method (size) of the physical termination of the tensile strength members and any other umbilical element to be terminated within the STI;

— sufficient space to allow for tube-jointing beyond the STI (i.e. access for welding apparatus/welding operators to perform the work, and also for NDE to be performed).

Total rigid length is described as in Figure 5.

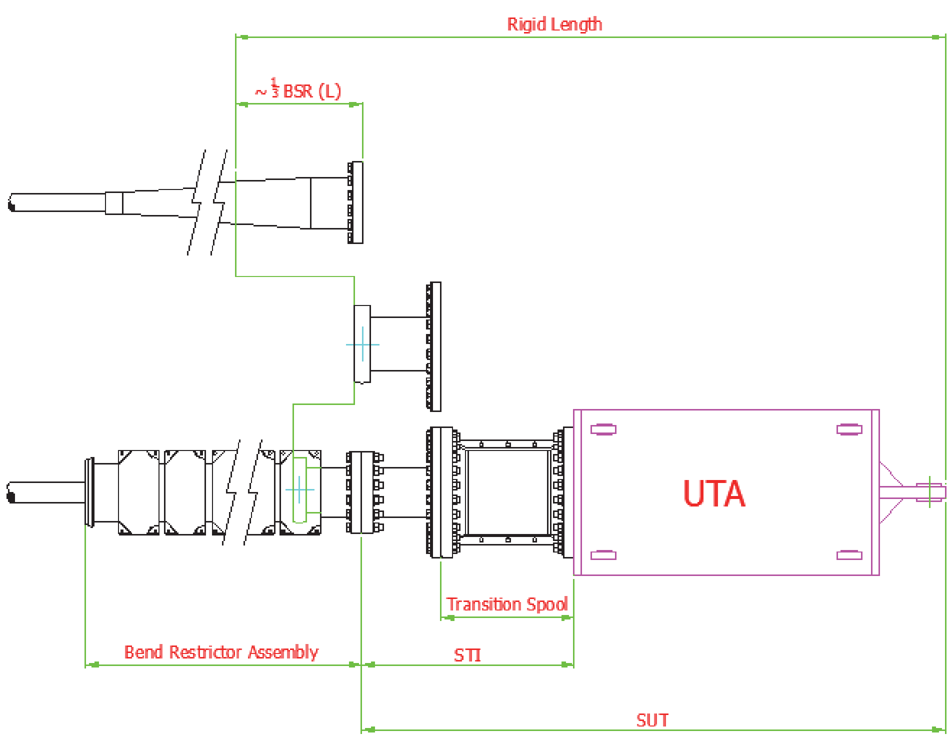


Figure 5—SUT Illustration

6.11.1.2 STI Length Reduction

Recommendations to reduce the STI length include the following.

a) Establish early interface communication between UTA and Umbilical manufacturer.

b) UTA tubes are normally distributed on circular patterns through the interface opening on the UTA to match the umbilical orientation. A static umbilical presents itself to the two UTAs in opposite handed configurations. This must be planned for and managed with early interface agreements.

c) Where it can be technically justified (see also 7.2), using the same dimension and material on both UTA tubing and Umbilical tubing at the interface can reduce or remove the need for weld adaptors inside the STI and might reduce the STI length. The UTA manufacturer should build the interfacing UTA tubing within the Transition Spool.

d) The position of the thermoplastic hose interface connection to a UTA bulkhead plate should be located to allow routing and interfacing of the hoses within the UTA. Umbilical thermoplastic hoses should be connected to the UTA internal pipework inside the UTA body (and not connect within the STI or transition spool as is often the case for steel tube umbilical connections).

Thermoplastic hoses frequently terminate to individual connectors or to a bulkhead plate within the UTA. The location of these connectors or bulkhead plate within the UTA should be toward the front (padeye end) of the UTA thus allowing the umbilical hoses adequate length and flexure for ease of routing inside the UTA. In practice adopting this approach frequently means that the hoses can be routed and terminated within the UTA without a requirement for a transition spool.

NOTE Positioning the bulkhead plate toward the rear of the UTA (STI end) means that the hoses can be very short and rigid which makes access and termination difficult as there is no 'slack' to play within the hose length—positioning the bulkhead plate at the rear of the UTA should be avoided.

6.11.2 Transition Spool

An STI may comprise a Transition Spool (split barrel) housing the transition between umbilical tubing and UTA tubing in case there is lack of space to perform tube joints inside the UTA.

The use of a Transition Spool increases the total length of the STI, yet in theory the length of the UTA may be reduced accordingly.

6.11.3 Bend Protection

The aft end of the STI normally includes an interface with a Bend Restrictor or a Bend Stiffener.

6.11.4 Electrical and Fiber Optical interface

The STI allows for a service loop to be created inside the UTA prior to being terminated either to Electrical and Fiber Optic Cable Terminations or directly to connectors mounted on the UTA.

6.11.5 Support Structure Interfaces

Typically UTAs are positioned on support structures clear of the seabed. This allows ROV or diver access for the connection of HFLs and EFLs, and reduces ingress of sand and mud. The size and type of these structures is dependent on many factors such as seabed conditions, access requirements and interfaces. UTAs may be mounted onto larger structures that themselves house a number of other units that are part of the subsea system, such as a production manifold, or a subsea distribution unit with electrical distribution units housed within it. In these cases the interface between the UTA and the host structure will be different from when the UTA is deployed with its own mounting base.

When being mounted on a larger structure the UTA will be deployed from the surface vessel without a mounting base and will interface to the subsea structure using a number of methods, such as stab and hinge over or guide posts. Smaller support structures are often attached to the UTA below the vessel's tensioner in the moon pool or worktable areas whilst larger support structures are landed on the seabed with the vessel's crane prior to the UTA being landed and locked on to it. For more detail on installation requirements, please refer to Section 9.

6.11.6 Miscellaneous Interfaces

It should be noted that the above list of interfaces is not comprehensive. The SUT has a complete lifecycle, from design and installation, through to service and decommission. It is impractical to account here for every interface in the SUT.

A short list of often overlooked interfaces is:

— Metocean Design Basis (geographic report of bottom, and current);

— requirements for retrieval: crane, ROV, diver;

— trawling or protection requirements;

— mudmat stability analysis;

— sea – land transportation interfaces.

7 Hoses and Tubing

7.1 Thermoplastic Hoses

The following are applicable to thermoplastic hoses.

— Flexibility is one of the major attributes of thermoplastic hoses, which translates into a simple means of terminating to the termination bulkhead connectors. This means that hoses can generally be routed straight to the connectors without any rigid intermediate pipework.

— Thermoplastic hoses are more prone to over bending; bends inside the UTA have to be carefully handled. This is a greater challenge as the UTA size decreases.

— Consideration for tooling and spanner access should be given for fittings permanently attached by means of crimping or swaging.

— Care should be taken not to infringe the MBR of the hose.

— Collapse resistance hoses may be required for deepwater operations, depending on collapse characteristics. Such hoses are stiffer and of larger MBRs than standard hoses.

— For further design guidance, refer to API 17E.

NOTE The stiffness and large MBRs associated with hoses of $^3/_4$ in. ID and above make them more difficult to accommodate within UTAs and must be given special consideration during UTA design.

7.2 Steel Tubing

UTAs are usually considered Production Controls Equipment so tubing design and selection is normally covered by ASME B31.3 as a normative reference in API 17F. This is different to the tubing design and selection philosophy within API 17E.

Steel Tube Umbilicals are commonly manufactured from Super Duplex stainless steel. Super Duplex is chosen for its high mechanical strength, corrosion resistance properties, and good weldability. It does not require assistance from cathodic protection systems to survive corrosion free in a subsea environment. However Super Duplex is susceptible to hydrogen induced stress cracking (HISC) in the presence of CP anodes. Given this, care should be taken when using Super Duplex tubing within the UTA. Refer to DNV RP-F112 for using Super Duplex with a CP system.

— Steel tubes are rigid and may require spool pieces to be accommodated in the termination to which the umbilical tubes are then welded. Welding of such tubes requires all round access to each tube to facilitate the welding operation; this usually results in the termination being bigger and longer.

— Consideration should be given for the geometry of and interface with the umbilical.

— Minimize the number of joints where possible.

— Butt weld joints are preferred over socket welded connections. The design allows for full opening through the tubing and welded area. The design also avoids any area where crevice corrosion may occur, and allows full inspection of the joint with radiography.

— Consideration should be given to the routing, manufacturability, and need for adaptors to manage transition between tubes of different sizes.

— UTA tubing should be:

  — generally corrosion resistant requiring no formal coating for corrosion prevention subsea,

  — compatible with the electro-chemical action of CP anodes within the UTA,

  — easily formable by cold working requiring no post forming heat treatment to survive subsea in an active CP environment,

  — easily weldable requiring no post welding heat treatment to survive subsea in an active CP environment,

  — of a size and strength to meet the pressure/flow requirements of the transported working fluid,

  — of a suitable size and stiffness to enable the correct flexibility of couplers within MQC plates,

  — compatible from a materials viewpoint with the relevant working fluids.

— Overly stiff tubing creates problems for the correct operation of MQC plate connections.

8 Electrical/Optical Design Requirements

8.1 Electrical Connectors

8.1.1 General

Electrical connectors are used to distribute power and communications between UTA and other subsea equipment. Electrical pin connectors are a generally accepted method of making subsea electrical connections. These pin connectors are supplied by several key equipment providers.

Connectors are generally divided into two categories: dry mate, which must be connected prior to deployment subsea; and wet mate, which can be connected subsea. Controlled environment connectors are a type of wet mate connector in which the female sockets are mechanically shielded from sea water when the connector pair is de-mated. Each connector type has specific installation, termination, and operational requirements. These should be taken into account when designing the UTA.

All electrical connectors, cables, and assemblies are fully qualified to specific requirements (temperature, hydrostatic pressure, voltage, current, water depth, equipment interface compatibility, mating, and de-mating requirements etc.) and are fully documented.

8.1.2 Ratings

The size and complexity of the connector increase as voltage rating increases, so it is important to understand electrical requirements.

Maximum operational current rating is dependent on the connector manufacturer and the type of connector.

8.1.3 Configurations (Including Fiber Connectors)

The foot-print and stack up of all electrical connectors needs to be managed and reviewed for accessibility (diver and ROV), clashes, interfaces, hose or cable lay as if this cannot be achieved the size of the UTA might increase

8.1.4 Contacts and Gender

The gender of the connectors mounted to the SUT is dependent on the operator's gender philosophy. Due to differing connector suppliers' gender terminology, it is necessary for the operator to communicate their gender philosophy clearly to prevent any misunderstanding resulting in added cost and delays to the project. However, it is important to note that energizing connectors with exposed pins in seawater will result in extremely accelerated corrosion to the pins causing irreparable damage.

Each connector configuration is typically available with a variety of electrical contacts; type, family, generation, and revision of connectors will impact interface and test connectors

8.2 Optical Connectors

8.2.1 Function

Fiber optic connectors are typically used to provide high speed data subsea to control modules, data transmission systems, umbilical terminations, and other subsea systems. They may also be used to support optical sensors.

8.2.2 Contacts and Gender

Fiber optic connectors are available with multiple contacts. Consult the connector manufacturer for contact options.

The connector's mechanical gender applies to these connectors, which is defined by the manufacturer.

Connector mounting interfaces vary between connector suppliers. The connector supplier must be consulted in order to ensure the appropriate space is allocated for mounting the connector.

8.2.3 Hybrid

Combining electrical and fiber optic circuits into one hybrid connector eliminates the dual redundancy resulting in a loss of power and communication if a single connector fails. However, combining both functions into a single hybrid connector reduces the number of terminations and connectors resulting in smaller, less costly UTAs. It is the responsibility of the operator to determine the feasibility/risk associated with the use of hybrid connectors in the system design.

8.3 Cable Termination

Cable terminations provide the necessary link between the umbilical cable and the wet mate connector(s).

Cable terminations come in a variety of designs to suit different applications. Significant variables to be considered include:

— water depth/external pressure;

— cable design;

— field requirements;

— type, family, generation and revision of connection;

— level of distribution;

— interfaces (cable to connector to UTA).

8.4 Oil-filled Boxes/Junction Boxes

In the instance of a single cable being allocated to more than one connector, oil-filled boxes, or junction boxes are used for distribution. These can either be connected to the cable termination remotely using an oil filled hose or directly onto the cable termination. The junction boxes consume a significant amount of space but using them to reduce the number of cable terminations is advantageous in UTA size reduction.

The junction boxes contain a significant amount of dead volume that requires compensation, with oil-filled hoses or other pressure-compensation means.

Oil-filled boxes/junction boxes can be used for distribution with electrical or optical cable terminations.

8.5 Cable Management

8.5.1 Umbilical Cables (Electrical and Fiber Optic)

Minimum Bend Radius (MBR) provided by the cable manufacturer must not be violated. UTA should be designed to provide suitable supports as required to ensure compliance with MBR.

Generally electrical/FO cables have larger MBRs than compensation systems thus having a bigger impact on the UTA size.

Service loops of cable adhering to the above mentioned MBR are recommended where practical for cable termination. Space must be indicated on the technical drawings in the instance a cable requires re-termination.

The connector manufacturer should indicate the minimum length of cable required for re-termination on technical drawings.

8.5.2 Oil-filled Hose Conduits

When designing the UTA, space must be allocated to manage the oil filled hoses within the parameters of diameter, minimum length and MBR.

8.6 Mounting—Connectors

ROV connector systems are generally floating relative to the host system earth bonding connection. Connector systems may require insulation from or inclusion with the CP system and should be installed in accordance with vendor recommendation.

Diver-mateable connector systems are generally fixed to the host system earth bonding connection. Connector systems may require insulation from or inclusion with the CP system and should be installed in accordance with the supplier recommendation.

9 Installers' Handling Requirements

9.1 General

The following handling requirements should be considered during SUT design, engineering and manufacturing phases to best comply with the constraints and requirements of the SUT and Umbilical Installers.

On the award of the installation contract it is recommended to interface with the contractor's team to make sure all elements of the installation requirements for the project have been addressed. When known, a close scrutiny of the installation vessel's specific capabilities needs to be carried out prior to implementing the installation schedule.

It is noted that for further details and guidance for subsea umbilical installation, reference is made to API 17E.

9.2 Storage Systems and Load Out

The umbilical with SUTs may be stored on a reel for direct spooling or lifting to the installation vessel. Alternatively it may be stored on a factory carousel for spooling onto the installation vessel's lay system. In the case of factory carousel, the umbilical systems are supported by flexible roller boxes and guiding systems bollards to bring the umbilical alongside the installation vessel required position for system.

Particular attention is needed when putting the umbilical on the storage reels to ensure that the end to be installed first is always last on the final reel.

9.3 Installers' Transport and Storage Systems

9.3.1 General

Onboard the installer's vessel (or barge), the umbilical with SUT is either packed and transported on a reel, a vertical carousel, or a horizontal basket (above or under deck).

9.3.2 Reel Storage

The umbilical with SUT is normally spooled with tension, packed and prepared by the umbilical supplier in the umbilical manufacturing unit. The reel is either transported to the installation vessel mobilization site or lifted onboard directly in the installation vessel. One end of the umbilical with SUT is normally packed in a partition on the inner drum of the reel accessible for testing, while the other UTA end is packed and secured on the extremity of the reel flange. (second end UTAs are stored at the inner drum of the reel as well).

It is strongly recommended and desired that no portion of the Umbilical or SUT protrudes outside the envelope of the reel (See Figure 6).

Figure 6—Umbilical Reel Packing

9.3.3 Carousel Storage (Above Deck Storage)

The Umbilical with SUT is normally spooled with tension via a quayside horizontal open tensioner system, packed and prepared by the installer in cooperation with the umbilical manufacturer by use of a carousel system with a cone shaped vertical inner drum. On the vessel, the umbilical is stored on the carousel by the use of a spooling tensioner, which keeps the umbilical tangent to and at the correct vertical position with respect to the drum to ensure efficient packing of the product.

The SUTs are normally stored on top of the upper flange for ease of crane access and handling while the umbilical is spooled bottom-up on the drum (see Figure 7). A suitable protection against damage to the umbilical is essential and must be applied.

9.3.4 Basket Carousel Storage

The Umbilical with SUT is normally spooled with low tension and under its own weight into the basket via an integrated open spooling and feeding control system. The packing operation into the carousel is normally controlled by the installer in cooperation with the umbilical manufacturer. Packing of the umbilical is achieved by aid of a spooling arm and through manual handling by qualified personnel. The SUTs are normally stored on top of the central drum or they can be stored with proper protection and support inside the carousel (see Figure 8).

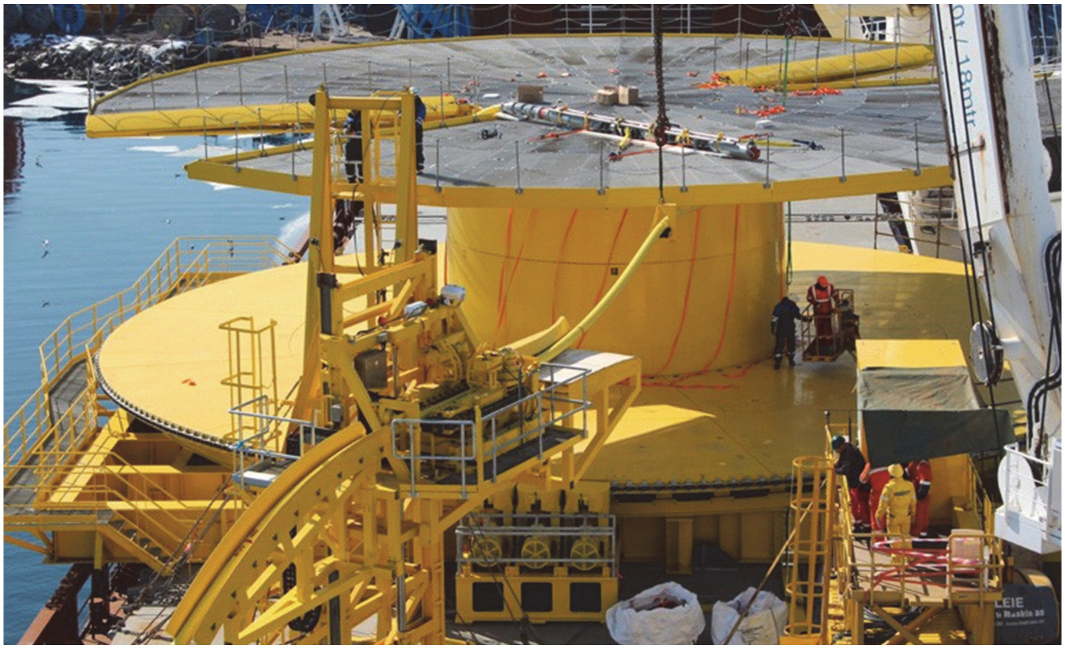


Figure 7—Umbilical Vertical Carousel Packing

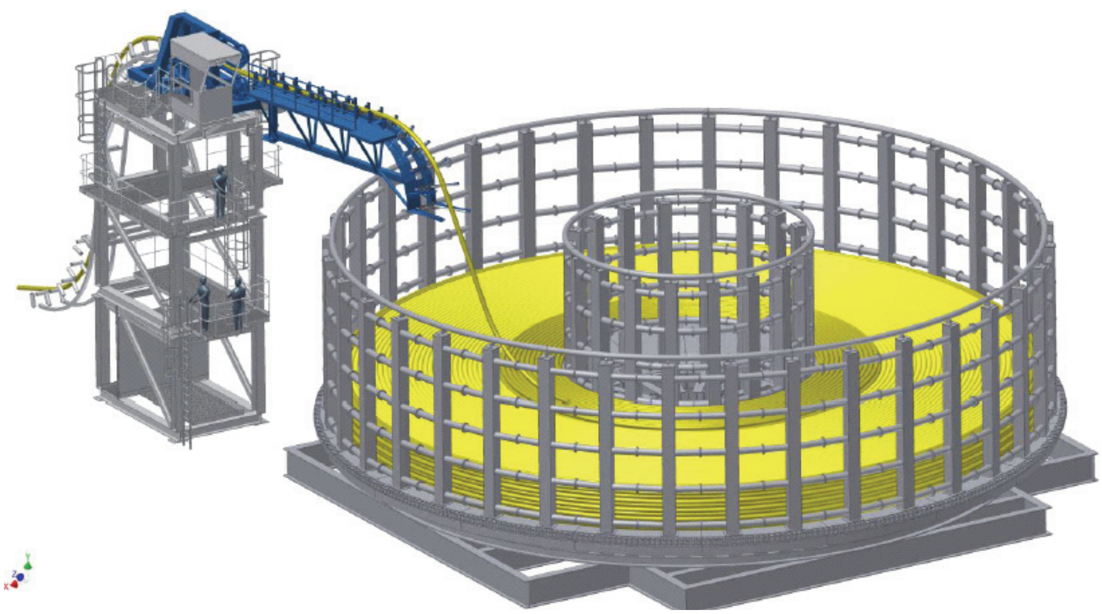


Figure 8—Umbilical Basket Carousel Packing

9.3.5 Under Deck Storage

The storage carousel (basket or carousel) can be located below the main deck of the installation vessel (see Figure 9). In this case, the umbilical with its SUT and accessories have to be routed to and from its storage destination through a deck opening of limited, vessel-dependent size. For the umbilical with SUT and other components to be installed for under-deck storage, the available size of the deck opening is constraining, as well as the capacity of the below deck handling systems. It is strongly recommend that if underdeck storage of the umbilical is possible then any possible restrictions of routing and handling be identified early to avoid design changes or vessel modifications.

Figure 9—Umbilical Under Deck Carousel

9.3.6 Deck Storage

In the event that the SUT is too large, or it is not possible to spool it safely through the receiving installation systems for storage, transport and installation offshore, it can in some particular instances be considered to spool only one end of the product into the storage means, leaving the oversized large SUT secured at deck level with the last section of the umbilical being part-spooled through the system. This solution would however normally expose equipment and product in an unfavorable temporary configuration with increased risk for compromised integrity prior to installation, as well as block the installation route and associated equipment for other activities.

While this method of SUT storage is possible it comes with many associated installation risks, as well as restrictions on installation schedules. It is strongly recommended to avoid this storage method, as it imposes unnecessary risk to the integrity of the SUT and umbilical.

9.4 Laying Systems

9.4.1 General

In all cases, a laying system is required onboard the installation vessel to safely and efficiently bring the umbilical with SUTs from the onboard storage location and to the subsea target location. The main laying systems normally used by the Umbilical Installers are summarised as follows:

9.4.2 Basic Horizontal Tensioner and Over Boarding System

This system typically consists of an umbilical packed on a free or mechanically rotating reel, routed through a horizontal tensioner and over boarded with relatively low tension (typically selected in shallow water) via a deck chute over vessel side or through the moon pool (see Figure 10).

Figure 10—Horizontal Tensioner and Over Boarding System

9.4.3 Horizontal Tensioner with Vertical Over Boarding System

This system typically consists of an umbilical packed on a rotating reel or a storage carousel/basket. The umbilical is routed with elevated supports around the deck via gutters and deflectors to approach a vertical launch configuration though a tensioner system into the moon pool or over vessel side (see Figure 11 and Figure 12).

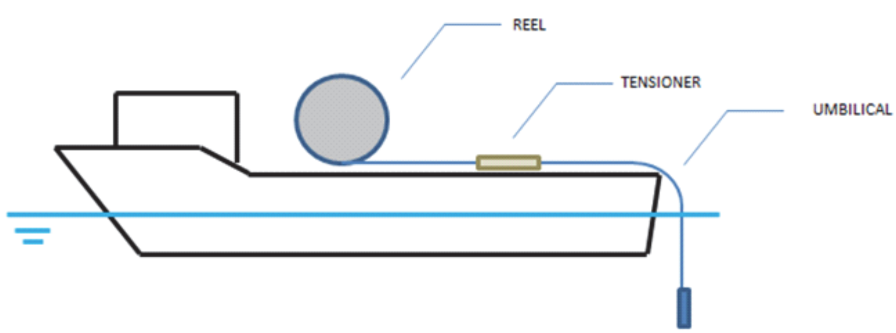


Figure 11—Horizontal Tensioner and Over Boarding System

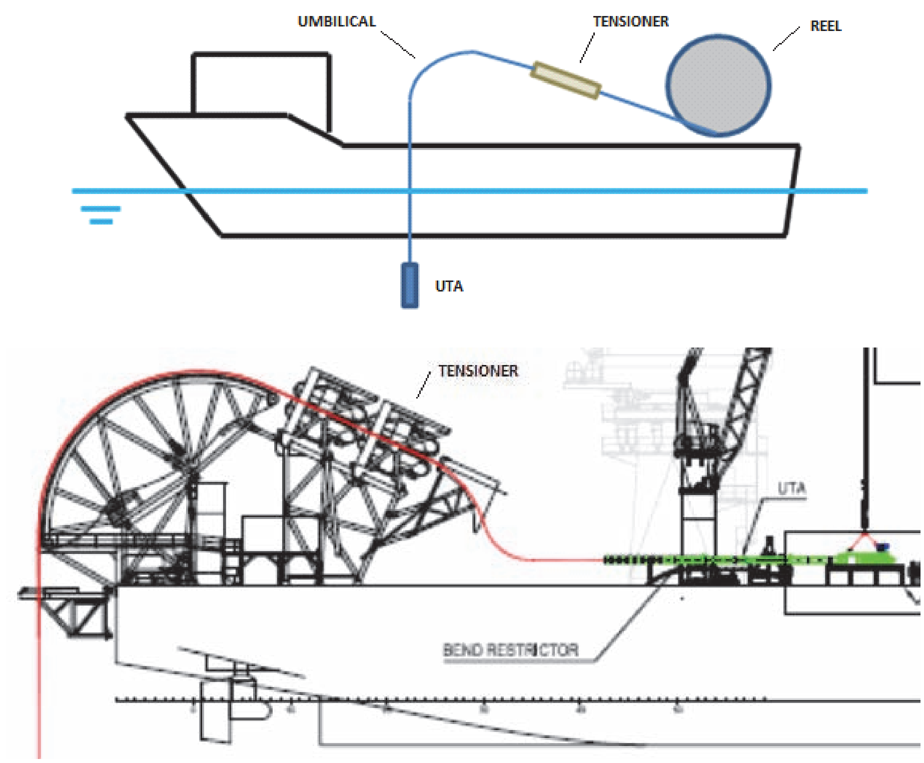


Figure 12—Horizontal Tensioner with Vertical Over Boarding System (May also be through a Moon Pool

9.4.4 Closed Vertical Lay System (VLS)

This system typically consists of an umbilical routed from the storage reel or carousel into the Vertical Laying System (VLS) (see Figure 13). The first end of the umbilical is routed over the top gutter and vertically through the closed tensioner system, down to the deck level above the moon pool. The umbilical is spooled through the tensioner system with tensioners engaging with the umbilical. The second end of the umbilical is routed over the top gutter, upright and vertically suspended with full catenary tension above the tensioners by means of an abandonment and recovery (A&R) winch, before being lowered through the open tensioners and down to the deck level above the moon pool. Any additional support structures, where required, can be installed on the SUT at the deck level above the moon pool before deployment. The VLS can be positioned over a moon pool, over the side or stern of the vessels. Over the moon pool configuration is shown in Figure 13 and Figure 14.

9.4.5 Open Vertical Lay System (VLS)

This system typically consists of an umbilical routed from its storage means on reel or carousel and into the Vertical Laying System (VLS) (see Figure 15, Figure 16, and Figure 17). The first end of the umbilical is routed over the top gutter and vertically down to the deck level above the moon pool. The open tensioner system is engaged to embrace the umbilical in its vertical configuration. The umbilical is spooled through the tensioner system. The second end of the umbilical is routed over the top gutter, upright and vertically suspended with full catenary tension above the tensioners by means of an A&R winch. The tensioner system is opened and retracted to release the umbilical, before lowering the umbilical and the SUT freely down to the deck level above the moon pool. Any additional support structures, where required, can be installed on the SUT at the deck level above the moon pool before deployment. The VLS can be positioned over a moon pool, over the side or stern of the vessels. Over the moon pool configuration is shown.

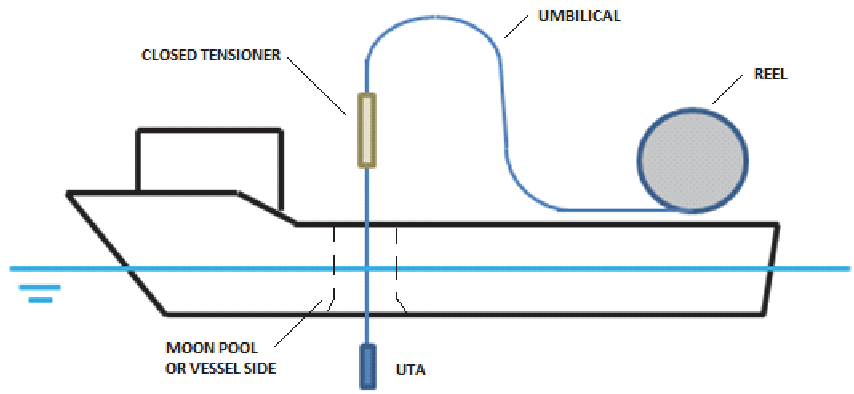


Figure 13—Closed Vertical Lay System

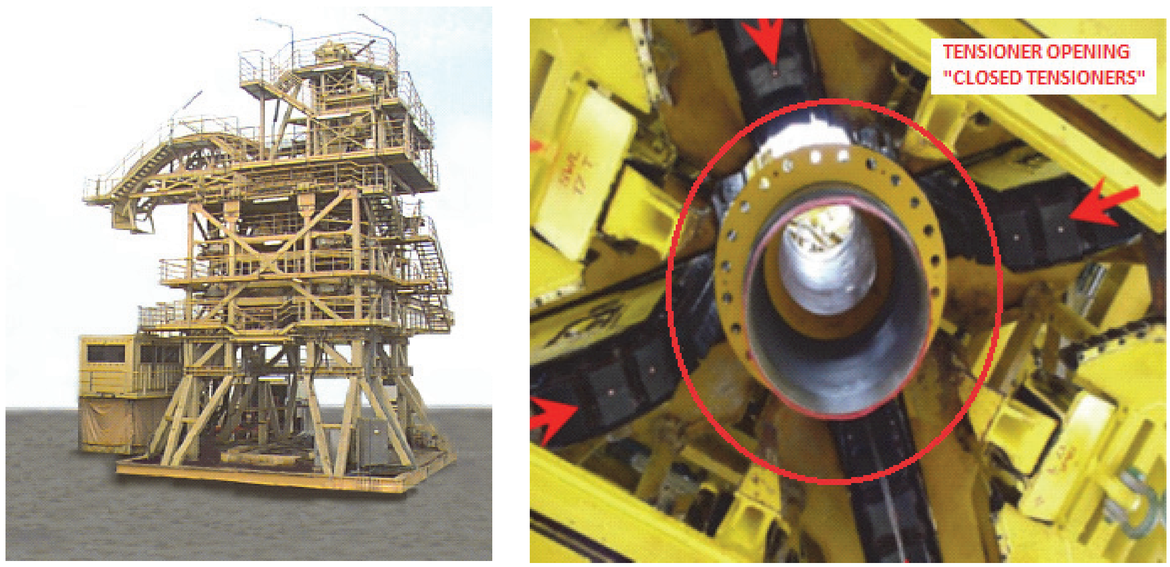


Figure 14—Closed Vertical Lay System Showing Tensioner Opening

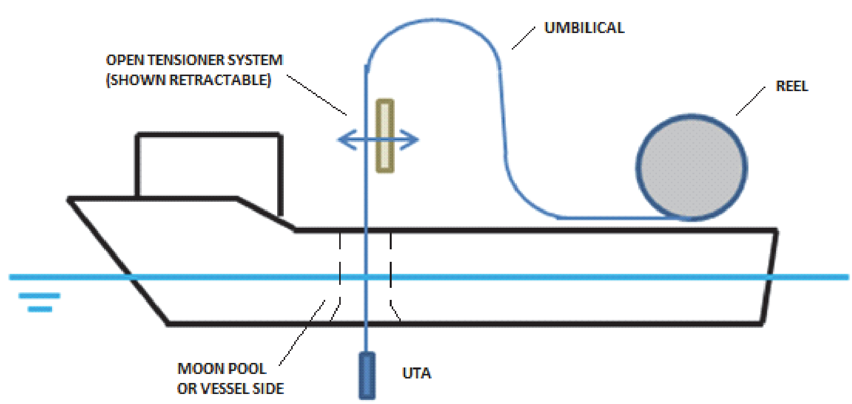


Figure 15—Illustration of Open Vertical Lay System (VLS)

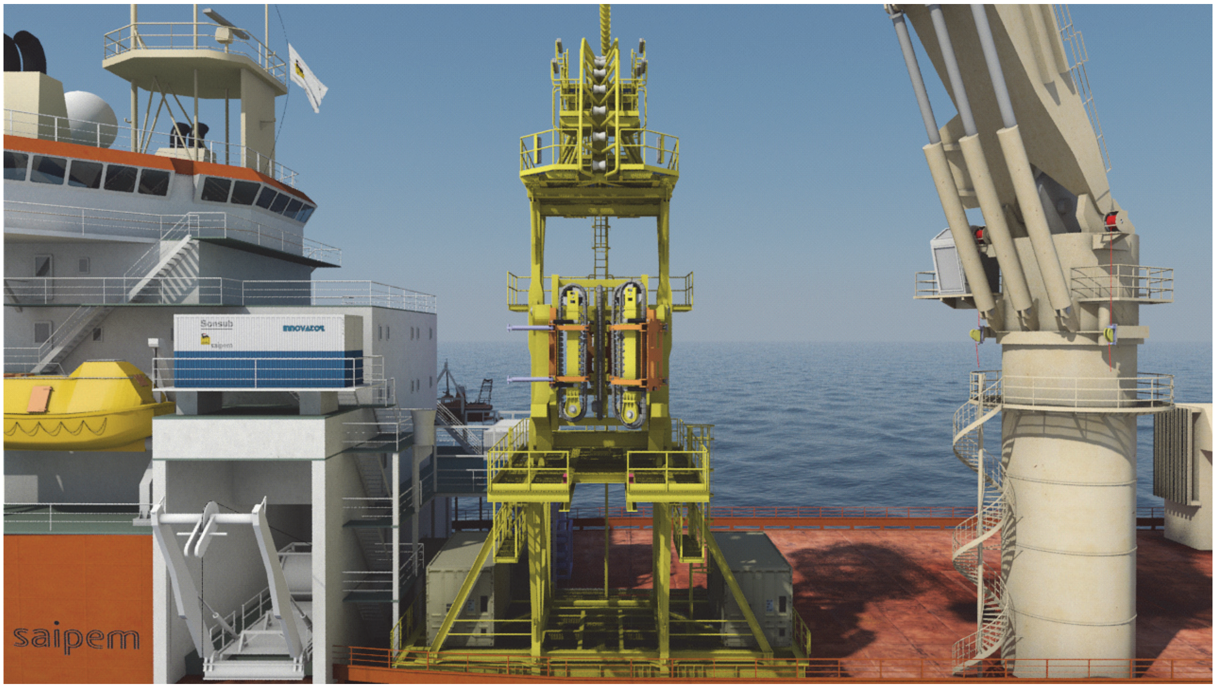


Figure 16—Side View of Open Vertical Lay System (VLS)

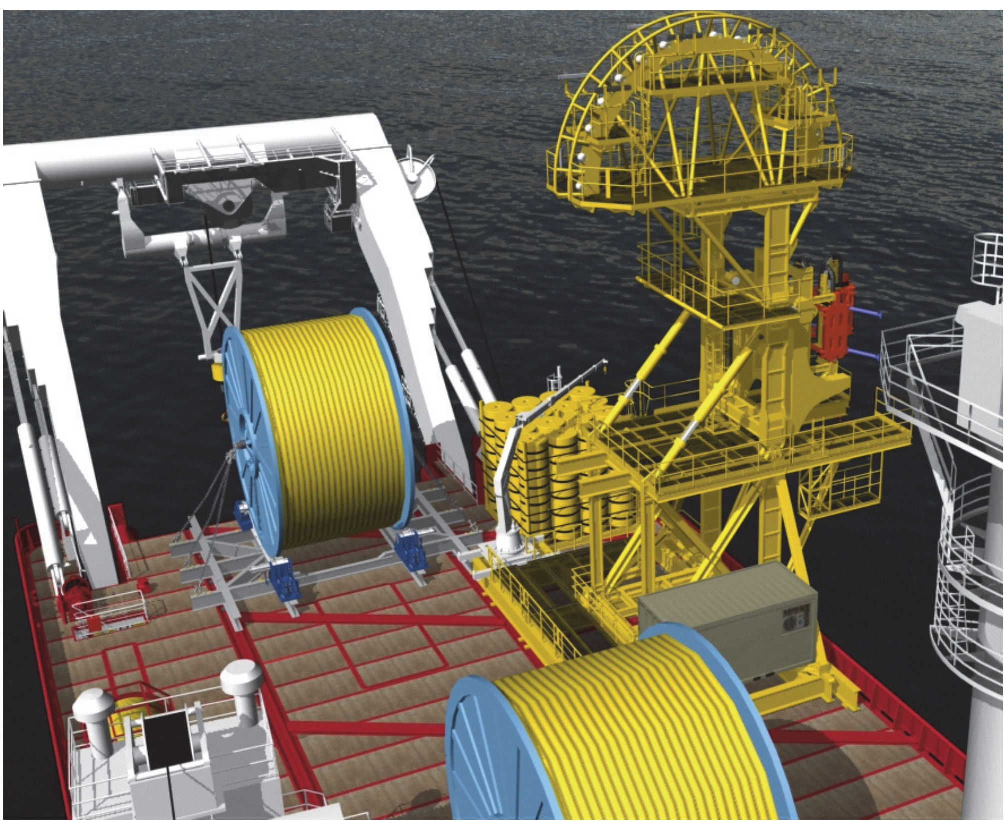


Figure 17—Open Vertical Lay System

9.4.6 Other Systems

Umbilicals are also installed from rigid pipelay vessels, where the umbilicals normally are stored onboard the vessel in dedicated below deck carousels, rigid pipe reels or individual installation reels. Installation of umbilicals by use of rigid pipelay vessels (see Figure 18) are normally associated with the pipelay installation campaigns and normally not as stand-alone umbilical installation campaigns. Umbilicals can be installed through the pipelay ramp system or combined with installation means as described in the above sections.

Figure 18—Rigid Pipelay Vessels

9.5 Loadout and Transport

The SUT geometrical design has to comply with the practical handling aspects of bringing the SUT/umbilical system from the factory through the installer's laying systems offshore and finally installed on the seabed, while complying with the constraints of the installation equipment geometries and functionalities. This involves the following main aspects:

— packing and storage of umbilical system on land;

— transport, handling, and transpooling to installer's receiving vessel including seafastening provisions as required;

— testing and transport to field;

— special local requirements like police escorts, bridges, weight restrictions, roads, and load out conditions;

— onboard handling and transpooling from storage systems to installation systems;

— installation, laydown, and testing of umbilical system/SUT;

— special lifting equipment or preparation like spreader bars, etc.;

— certificated and appropriate lifting equipment.

9.6 Packing

When packing on reels, it should generally be avoided to have the SUT protruding beyond the reel footprint. However, while the first end SUT to go off the reel could be packed outside the projected reel foot print, the second end rotates with the reel during spooling and must be securely packed within the area of the reel flange diameter. It should be noted that a large SUT which cannot be packed within the reel foot print takes extra deck space and reduce optimal deck space configuration (e.g. limiting the number of reels or other equipment)—possibly causing more trips/cost, as well as introducing a risk during handling to/from transportation and installation vessels (clashes).

For packing on reels, it should be possible to access the SUT easily for testing/monitoring purposes and to ensure enough room between the SUT and the reel flange for operators to work safely. Generally for all packing, access to the SUTs should be defined in the packing design.

Having the SUT protruding from the envelope of a reel has many knock-on effects, only some of which are described above. It is strongly recommended to avoid this type of packing.

9.7 Installation Sequence and Considerations

9.7.1 Closed Tensioner Vertical Lay Systems (VLS)

Generally, the total size and weight of the umbilical and shape of the SUT is very likely to contribute to or dictate how it is transpooled, handled and installed. This requirement is likely to be slightly different for every umbilical assembly, so will need to be risk assessed.

Transfer and handling of the SUT through the various laying systems requires a high level of control and proper handling points to minimise risk of compromising the product. The transfer from storage condition through laying systems is in some cases limited by the geometrical constraints of these systems (see Figure 19).

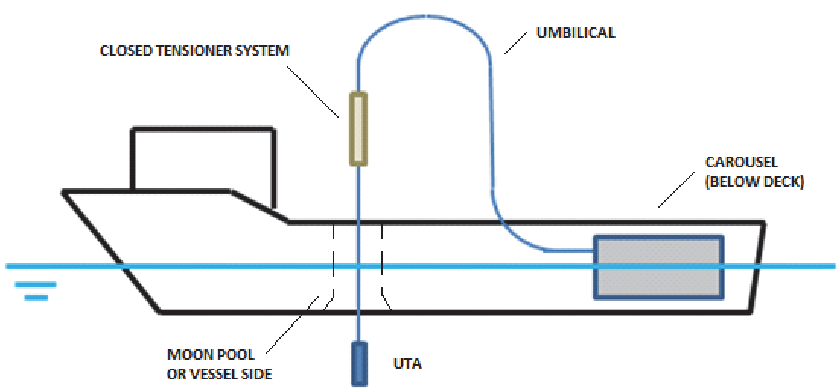


Figure 19—Below Deck Storage (with Vertical Lay System)

For further transfer into the vertical lay system (VLS), the SUT, bend restrictor and umbilical has to pass over the top gutter (see Figure 20). The gutter structure is normally limited with a fixed minimum design radius, so this radius needs to be assessed for suitability so it provides suitable support and access for the umbilical, SUT and ancillary components, during installation, transfer and for laying operations. The geometry of the SUT and its connections to rigid parts and bend restrictors should therefore be designed to comply with a smooth curved route transfer through this area. Various systems to aid the transfer over the gutter exist, all with some limit to the size and weight of structure it can handle.

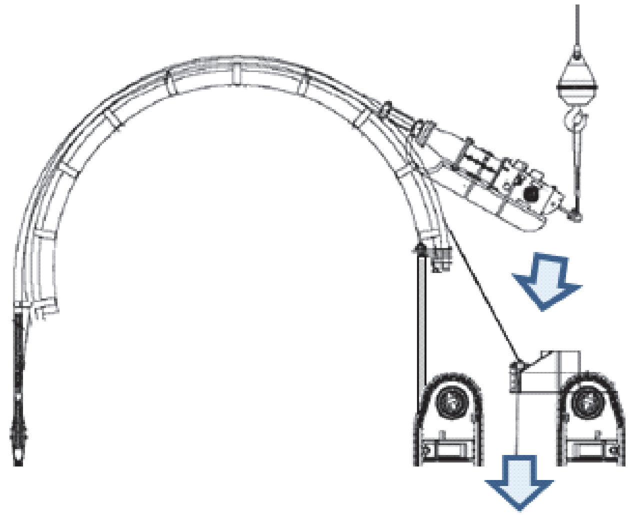


Figure 20—Transfer of UTS Over Gutter into VLS Tensioners

For a first end SUT that shall be inserted into a closed VLS, the approach angle of insertion over the gutter radius and into the tensioners will be limited by the rigid length of the SUT. Should the rigid length of the SUT exceed the maximum practical length of insertion into the tensioner system, the transfer operation over the gutter and "nose dive" into the VLS is not possible without the assistance of external means, e.g. lifting tools, vessel crane, shore crane, etc. (indicating schedule constraints, additional risks, and that the vessel may have to go to port to do this operation). The design length of the SUT should therefore be minimized as far as practical to suit the entry into these laying systems.

For an SUT that passes through a closed VLS, the available opening through the tensioner system is a specific constraint for the SUT including any protrusions (see Figure 21). The available passage opening varies for different closed tensioner systems of circular diameter, depending on the equipment.

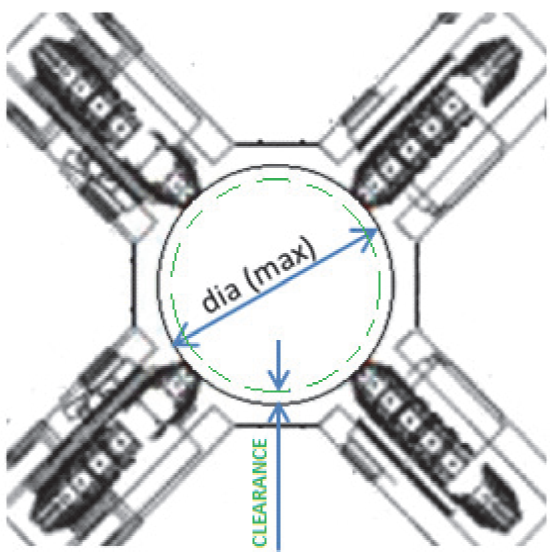


Figure 21—Closed Tensioner System—Maximum Cross Section Opening

When transferring the second end of the umbilical with SUT over the gutter, the full tension of the umbilical catenary and its attached components is taken by the suspended system from the top A&R wire (See Figure 22). The SUT shall therefore be designed with the limitations of the top tensioner in mind, or if known and verified, the limitations of the vessel intended for the installation. Incorporate a proper rigging arrangement (or by means of interfacing integrated ancillary rigging arrangement) in the axis of the umbilical so that the vertically suspended system is in natural equilibrium during hang-off and during the following passage through the tensioner system. The length of the SUT and outer diameter of the umbilical (including rigid sections and bend restrictor) is also limited by the available space between tensioners and A&R wire socket from the top.

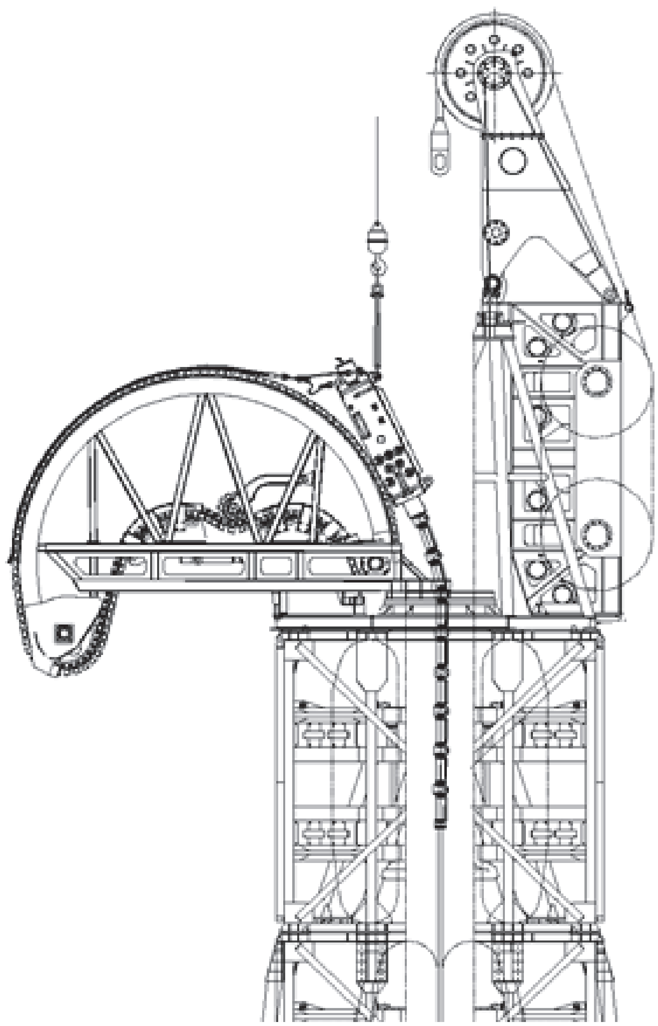


Figure 22—Second End UTA Transfer and Hang-off in VLS System

Following transfer of the second end to deck level below the VLS, the ultimate size of the SUT is restricted by the vertical distance available between the working deck and tensioners in the VLS (see Figure 23). It should be noted that the size of the SUT is also ultimately restricted by the size of the vessel moon pool for vertical lay systems positioned mid ships (for some vessels the VLS is positioned over the stern or vessel side).

Table 1 contains shows relevant height restrictions for some typical closed VLS systems, see Figure 13 for details.

It shall be noted that actual UTA size must be evaluated taking in account all dimensions, rigging, setup, etc, which can vary from one equipment to another, as well as geometry of adjacent VLS structure and equipment (hoists, winches, etc) to assess the free space for UTA handling and installation.

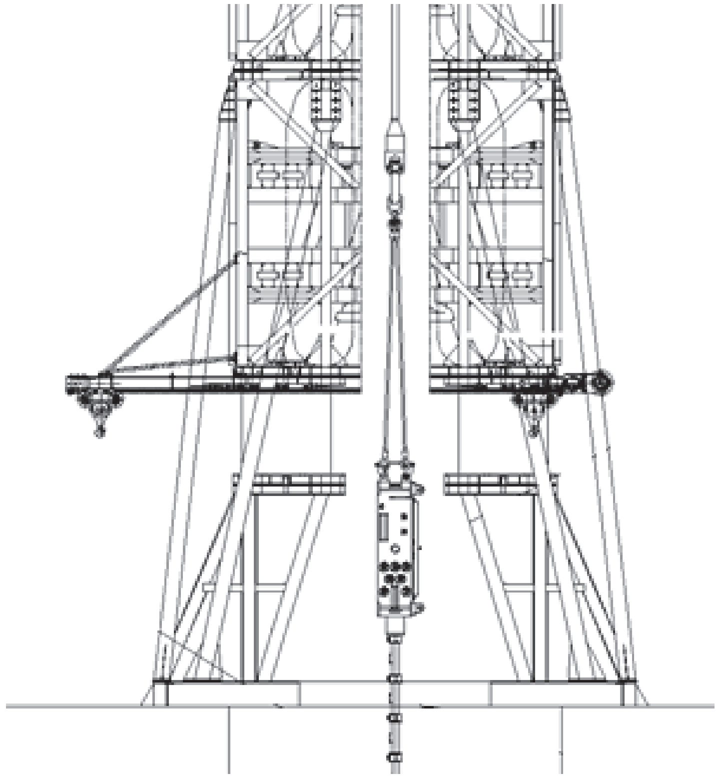


Figure 23—Second End UTA lowering Through VLS—Landing at Deck Level

Table 1—Height Restrictions

Vessel	Free Height From A&R Wire Socket to Top of Upper Tensioner (H_{max})	Free Height Between Lower Tensioner and Vessel Deck (Z_{max})	Height Between Handling Hoists and Vessel Deck (Z_h)
Typical Vessel "A"	10.5m	7.1m	6.1m
Typical Vessel "B"	9m	5.5m	4.7m

It shall also be noted that the structure geometry for entry of the first end UTA, when nose diving into the VLS when routed over the gutter, normally would limit the maximum rigid body length of the UTA for free passage into the tensioner system.

In the case where the SUT is oversized and will not pass through the closed tensioner, the umbilical system might have to be installed by means other than those laying systems described in 9.4.6.

9.7.2 Open Tensioner Vertical Lay System (VLS)

While open tensioner systems do not generally have the same limitation of tensioner approach angle and maximum opening diameter, other considerations become valid and still justify designs taking installation difficulties into account prior to committing to a certain UTA design. Handling of excessively large or heavy UTAs at height for open or closed systems (see Figures 24, 25, and 26) still retain sensitivity to dimensional increase and excessive weight impacts for both cases. Handling of a heavy UTA connected to a weak umbilical is inherently a high risk activity.

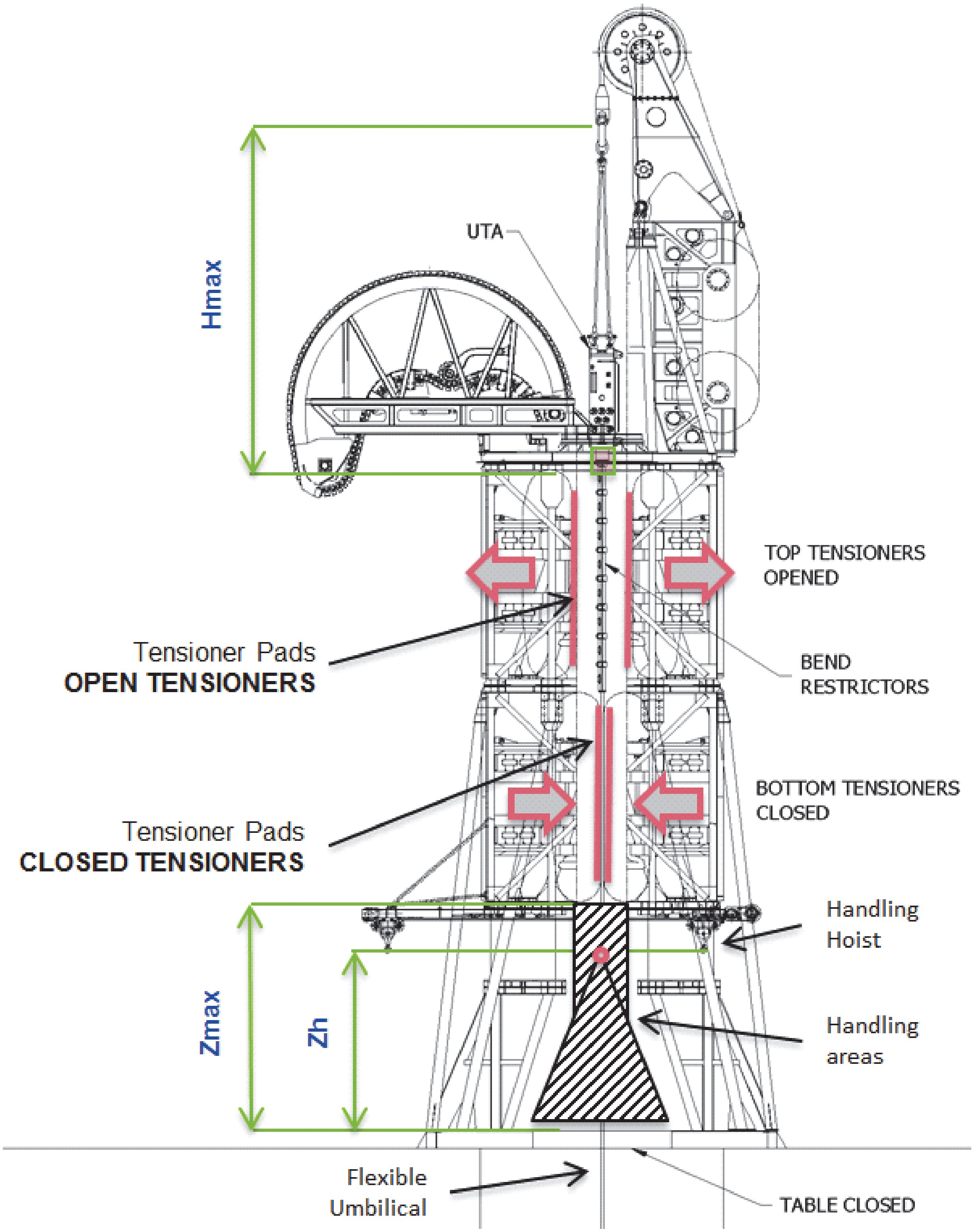


Figure 24—Height Restrictions for Typical Closed VLS Systems

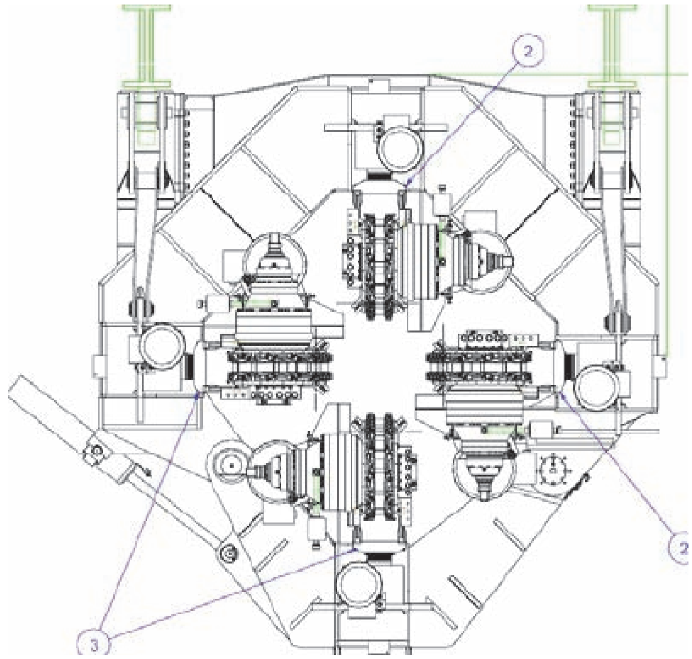


Figure 25—Closed for Use Tensioner Mode

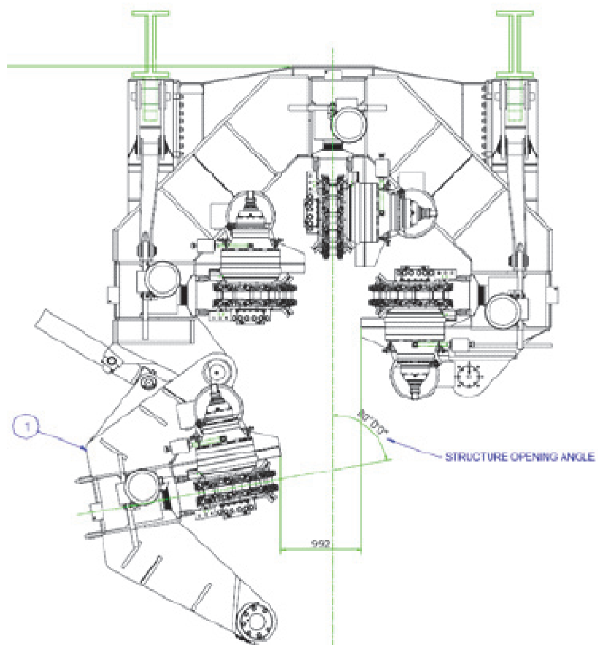


Figure 26—Open for Product Tensioner Mode

The flexibility of open tensioner systems still should not encourage oversized and overweight designed UTAs, due to the general handling requirements of the UTA on deck, at height, above laying systems and during insertion, as well as during over boarding as generally discussed within Section 9.

Figures 27, 28, and 29 show steps of UTA installation into a vertical open tensioner laying system, indicating limitations in handling a UTA with its umbilical and bend restrictor while supported by the vessel crane (or VLS top mounted crane), the operation being limited in capacity in terms of hook height and permissible load at required crane radius.

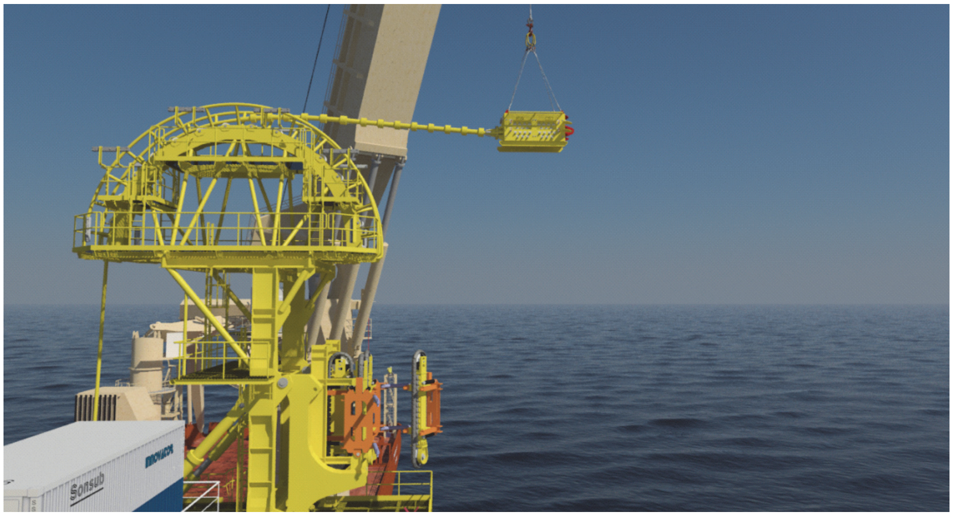


Figure 27—UTA Deployment Clear of Open Tensioner VLS System

Figure 28—Locating Umbilical into Open Tensioner System While Taking UTA Weight

9.8 Handling Requirements for Structures

It is normally preferred that mud mats and large ancillary components to the SUT are mounted after passage through the lay system. For SUTs with large mud mats to be connected during installation, foldable mud mat solutions should be considered to minimize handling and geometrical constraints. As an alternative to connectable mud mat systems, the design of these components can be based on subsea docking and connection systems to totally decouple the SUT installation with the mud mat installation.

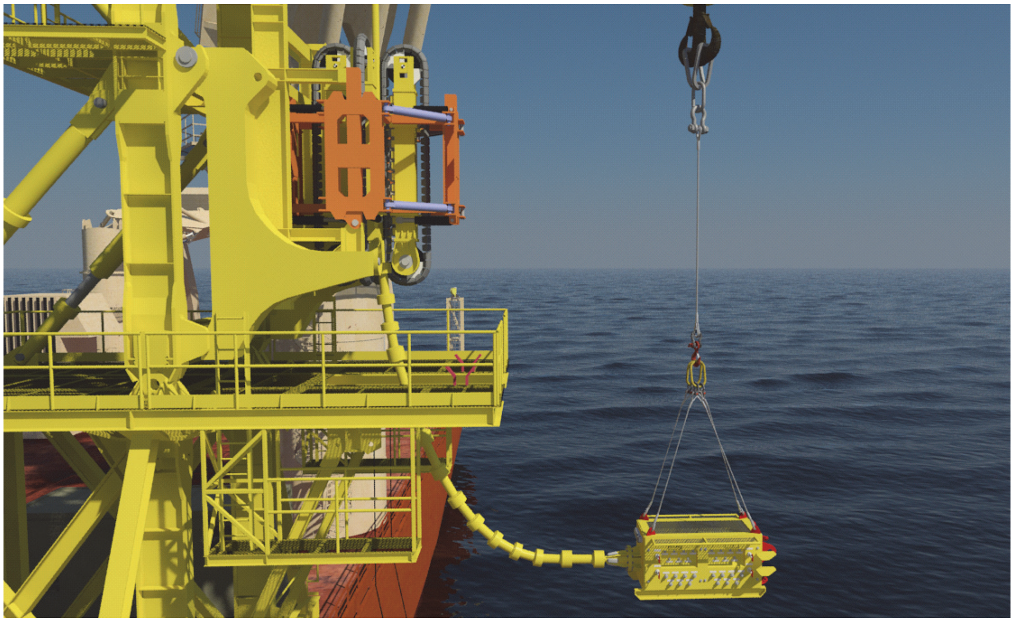


Figure 29—Open Tensioner Now Closed for UTA Deployment

Lightweight mud mats should be considered whenever possible, providing minimum additional loads (including subsea hydrodynamic loads) and reducing installation difficulties compared with heavier mud mats. In all cases, even with disconnectable equipment, the SUTs with mud mats or other ancillaries are all restricted by the size and access to the vessel's moon pool for installation or retrieval.

Deploying an SUT with its mud mat mounted normally introduces discussions relating to hydrodynamic coefficients (added mass and drag), rigging snap loads etc. In this case one solution is to have ROV foldable mud mats for the deployment and lowering phases, reducing the added mass and increasing operability—while at the same time providing sufficient support when in place at the seabed, as described in DNV RP H103 or DNV VMO.

To minimize vessel time during installation it is normally the installation contractor's preference to be able to install any support structures on the SUT in the moon pool or Deck/VLS worktable area. However every vessel has differing limitations on the size and weight of the support structure that can be installed in this location. Therefore it is advised to design support structures so they can be both attached to the SUT at deck level as well as being landed on the seabed with a crane prior to the SUT being landed on them so as not to reduce the number of installation vessels that can feasibly install the SUT and support structure.

9.9 Lifting and Handling

Short rigging normally allows easier and safer control when handling the SUT. However, installation rigging and deck handling equipment (see Figure 30) should normally be delivered by the installation contractor (unless agreed otherwise during interface processes between the relevant parties). The UTA designer normally delivers handling equipment for factory and onshore handling. Installation equipment and deck handling equipment should be delivered by the installation contractor, or by his recommendation/specification, because the installer knows the vessel and the installation procedures to be used..

The umbilical should ideally connect to the SUT on its axis to avoid non-natural configuration during lifting and handling. "off center" connections to SUTs normally require special handling considerations and special rigging so as not to compromise the integrity of the product (e.g. over bending, bending moment etc).

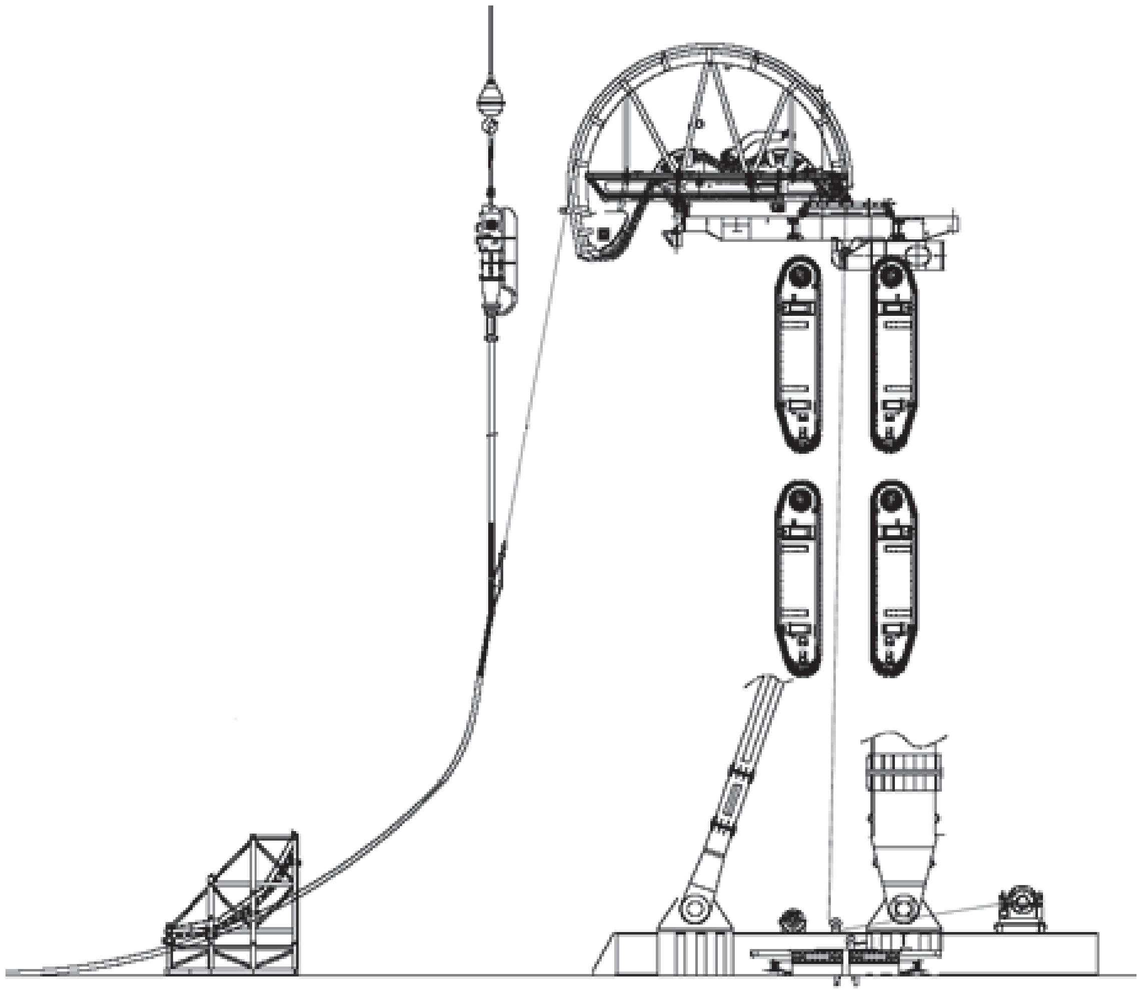


Figure 30—Deck Handling and Transfer of Umbilical Catenary with UTA

The SUT design should not have any obstructions or sharp edges that will interfere with the lifting and handling rigging, causing an integrity risk and utilization of non-practical rigging points.

Handling points for securing during packing, transport and unpacking/disconnection, are necessary to safely store and release the SUT. Auxiliary padeyes on the side of the SUT are useful for attaching tag lines and for securing the SUT within the reel or carousel. In addition, suitable handling points both for deck handling and landing (SUT in horizontal position) will be of importance for successful and efficient installation.

Padeyes on the SUT need to be adequate for offshore handling purposes in accordance with the relevant lifting codes, and not be designed for the self-weight of the SUT only. Handling on deck and over the lay system with some catenary load to deck should be considered during design. It is a common complaint of installers that SUTs have insufficient handling padeyes installed.

Preferred rigging arrangements for deck handling and installation varies from vessel to vessel. When possible, rigging methods should be identified at an early stage for consideration in the design of SUT lifting points, in order to comply with all the phases of SUT handling/lifting. Consultation with the Installation Contractor at an early stage is recommended.

It is recommended to include a suitable lifting point on the SUT for connecting a second crane/lifting device to assist upending the SUT from deck level and into the lay system or vertical orientation (see Figure 23). Such a lifting point should be designed to take the full load of the deck catenary with equipment for first end transfer and to take the full load of the total suspended catenary (static plus dynamic) of the umbilical system in suspended configuration for second end transfer and installation. If the sequence of installation is not known, both ends should be designed for the full catenary load.

In case of vertical lay, the second extremity (or intermediate if any) of the SUT must be hung off (full catenary load) at the VLS/PPS table in order to perform tests and rigging configurations. The design of the unit has to consider this operation

If the SUT size and weight is disproportionate with the umbilical and its bend restrictors, it results in a tricky and risky deck handling operation when unpacking. An efficient SUT design also avoids large installation spread (support structures).

During installation it may be necessary to remove long term protection covers (e.g. from stab plates) in the sides of the UTA if they protrude excessively and present a snagging hazard. This should be taken into account during the design.

9.10 Installation Aids

In general all installation aids should take into account the CoG of not just the SUT but the SUT as integrated with the umbilical during its installation cycle. The handling and installation must be within the agreed capacity of the SUT/umbilical system. Within this capacity the design of the SUT should make sure that any handling arrangement does not impose unwanted loads/moments into the combined SUT/umbilical system.

Installation yokes could be used and designed with particular attention and care to address the installation methodology and installation vessel storage system rather than limiting its options. In order to avoid over bending the umbilical when lifting the SUT over the tower, the yoke should be designed such that the lifting point is close to the SUT CoG, hence reduce the bending moment induced on the umbilical during handling. Consultation between manufacturer and installation contractor is recommended at the design stage.

UTA orientation can be an issue for lifting and handling the second end through the system. If, for example, the SUT is on the carousel floor it is best if the lifting yoke can be installed in any orientation so the SUT can be secured at deck level where it is easier to handle and obtain the correct orientation for upending and transfer over the tower.

Bolt-on items such as docking pins should be designed for easy handling and attachment. This is for reasons of safety and efficient use of vessel time.

9.11 Bend Restrictors and Bend Stiffeners

Bend restrictor damage is a common source of incidents and non-conformances during SUT handling and installation. Rigging arrangements and procedural instructions should recognize this and suitable means should be integrated into the design of the bend restrictor to minimize the risk. It may be necessary to attach soft slings to bend restrictors, umbilical end terminations or transition pieces between umbilical end termination and SUT. This possibility should be considered at the design stage of these items.

Bend restrictor design should consider handling and storage onshore and on vessel, as well as for transfer over and through laying systems—and for subsea installation and handling. Therefore, handling loads, installation loads, environmental conditions and in-place loads must be taken into account when designing bend restrictors

Special attention should be given to address the situation where bend restrictors need to be supported during handling by dedicated rigging (example: soft sling).

For bend stiffeners, care should be taken for protection of the soft polyurethane material and particularly to avoid any scratches or damages to the surface. Bend stiffeners can be delivered with suitable protection that can remain in place during transport storage and handling.

Annex A
(informative)

Responsibility Matrix

Typical Umbilical System Design, Manufacturing and Installation Roles				
Activity	**Oil Developer/ Operator**	**Umbilical Manufacturer**	**UTA Manufacturer**	**UTA Installer**
Umbilical System Requirements	Establishes and monitors communication between the umbilical and UTA manufacturers. Transmits Umbilical System configuration, functional and operational requirements.	The Umbilical Manufacturer is presented with the Umbilical System configuration.	The UTA Manufacturer is presented with the Umbilical System configuration.	N/A
Umbilical System Configuration	Establishes and monitors communication between the umbilical and UTA manufacturers. Approve the design solution and manufacturing process.	Design Umbilical Bundle, Structural and Mechanical Interfaces to the UTA to meet project requirements.	The UTA Manufacturer is provided the Umbilical configuration.	The Installer is presented with the Umbilical System configuration and properties for review and comments from Installation Perspective to ensure configuration is installable.
UTA Design	Establishes and monitors communication between the umbilical and UTA manufacturers. Approve the design solution and manufacturing process.	Review the UTA design and provide feedback to Oil Field Developer and UTA Manufacturer.	Design UTA to accommodate interfaces to the Umbilical Bundle and meet project requirements transmitted.	The Installer is to be informed about design parameters and layout/ interfaces of the UTA.
Umbilical Bundle and UTA Components	Takes ownership of the equipment designed and manufactured in compliance with the project technical requirements.	Coordinates with the Oil Field Developer the acceptance activities of the equipment manufactured.	Coordinates with the Oil Field Developer the acceptance activities of the equipment manufactured.	The Installer witnesses the acceptance activities where practicable and is made aware of any technical issues associated with the components to assess installation implications.
Umbilical Bundle and UTA Assembly Process and FAT	N/A	Assemble the Umbilical bundle to the UTA in accordance with the project requirements.	N/A	N/A
Umbilical Bundle and UTA SIT	Establishes the Site Integration test requirements, issues the Test Specification and is responsible for coordinating all activities.	Supports the SIT activities and can provide labor and resources.	Supports the SIT activities and can provide labor and resources.	The Installer witnesses the acceptance activities where practicable and is made aware of any technical issues arisen during SIT to assess installation implications and for warranty.

Typical Umbilical System Design, Manufacturing and Installation Roles				
Activity	**Oil Developer/ Operator**	**Umbilical Manufacturer**	**UTA Manufacturer**	**UTA Installer**
Umbilical System Assembly Post Load Out	Takes ownership of the equipment designed and manufactured in compliance with the project technical requirements.	Coordinates with the Oil Field Developer and acceptance activities of the equipment manufactured.	N/A	Takes custody of the designed, manufactured and tested equipment in compliance with the Oil Field Operators project technical requirements and installs items in line with installation design criteria.
Installation	Takes ownership of the equipment designed and manufactured in compliance with the project technical requirements and free issues where appropriate to Installer and monitors where appropriate via manufacturers installation activities in accordance with class design requirements.	Coordinates with the Installer the acceptance activities of the equipment manufactured in accordance with Oil Field/Company requirements.	Coordinates with the Installer the acceptance activities of the equipment manufactured in accordance with Oil Field / Company requirements.	Takes custody of the designed, manufactured and tested equipment in compliance with the Oil Field Operators project technical requirements and installs items in line with installation design criteria.
System Commissioning	Takes ownership of the post installation activity and verification of functionality prior to systems start up.	Supports the commissioning activity and can provide labor and resources.	Supports the commissioning activity and can provide labor and resources.	Supports the commissioning activity.

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