# INTERNATIONAL STANDARD

# ISO 13628-1

First edition
1999-02-15

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

## Part 1:
General requirements and recommendations



*Industries du pétrole et du gaz naturel — Conception et exploitation des systèmes de production immergés —*



*Partie 1: Exigences générales et recommandations*

## Contents







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Printed in Switzerland

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 13628-1 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment.*

ISO 13628 consists of the following parts, under the general title *Petroleum and natural gas industries — Design and operation of subsea production systems:*

— *Part 1: General requirements and recommendations*



— *Part 2: Flexible pipe systems for subsea and marine applications*

— *Part 3: Through flowline (TFL) systems*



— *Part 4: Subsea wellhead and tree equipment*

— *Part 5: Subsea control umbilicals*

— *Part 6: Subsea production control systems*

— *Part 7: Workover/completion riser systems*

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

— *Part 9: Remotely Operated Tool (ROT) intervention systems*

Annexes A, B, C, D, E and F of this part of ISO 13628 are for information only.

## Introduction

This part of ISO 13628 has been prepared to provide general requirements, recommendations and overall guidance for the user to the various areas requiring consideration during development of a subsea production system for the petroleum and natural gas industries. The functional requirements defined in this part of ISO 13628 will allow alternatives in order to suit specific field requirements. The intention is to facilitate and complement the decision process rather than replace individual engineering judgement and, where requirements are non-mandatory, provide positive guidance for the selection of an optimum solution.

This part of ISO 13628 constitutes the overall subsea production system standard, with the intention that the more detailed requirements for the subsystems are retained in the complementary parts of ISO 13628. However, in some areas (e.g. structures, manifolds, marking) detailed requirements are included herein, as these subjects are not covered in a subsystem standard.

This part of ISO 13628 was developed on the basis of API RP 17A, *Design and Operation of Subsea Production Systems,* and other relevant documents on subsea production systems.

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

# Part 1:
General requirements and recommendations

## 1 Scope

This part of ISO 13628 provides general requirements and overall recommendations for development of complete subsea production systems from the design phase to decommissioning. This part of ISO 13628 forms a top-level document to govern other standards dealing with subsystems typically forming a part of a subsea production system.

The complete subsea production system comprises several subsystems necessary to produce hydrocarbons from one or more subsea wells to a given processing facility located offshore (fixed, floating or subsea) or onshore, or to inject water/gas through subsea wells. This part of ISO 13628 and the subsystem standards apply as far as the interface limits described in clause 4.



Specialized equipment, such as split trees and trees and manifolds in atmospheric chambers, are not specifically discussed because of their limited use. However, the information presented is applicable to those types of equipment.



## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 13628. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 13628 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs.*

ISO 898-2, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 2: Nuts with specified proof load value.*

ISO 10423, *Petroleum and natural gas industries — Drilling and production equipment — Wellhead and christmas tree equipment.*

ISO 13628-3, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 3: Through flowline (TFL) systems.*

ISO 13628-4:—[1)], *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 4: Subsea wellhead and tree equipment.*

[1)] To be published.

ISO 13628-6, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 6: Subsea production control systems.*

ISO 13819-1, *Petroleum and natural gas industries — Offshore structures — Part 1: General requirements.*

ISO 13819-2, *Petroleum and natural gas industries — Offshore structures — Part 2: Fixed steel structures.*

ANSI/ASME B31.8, *Gas Transmission and Distribution Piping Systems.*

API RP 17C[2], *TFL (Trough Flowline) Systems.*

API RP 17G[3], *Design and Operation of Completion/Workover Riser Systems.*

ASTM A 193, *Specification for Alloy — Steel and Stainless Steel Bolting Materials for High Temperature Service.*

ASTM A 320, *Specification for Alloy Steel Bolting Materials for Low-Temperature Service.*

## 3 Terms, definitions and abbreviations

For the purposes of this part of ISO 13628, the following terms, definitions and abbreviations apply.

### 3.1 Terms and definitions

**3.1.1**
**sealine**
flowline, service line, cable, umbilical or pipeline



NOTE For description of pressure and temperature ratings, the definition given in the applicable subsystem standard and other relevant standards and design codes is used.



### 3.2 Abbreviations

ADS atmospheric diving suit

API American Petroleum Institute

BOP blow-out preventer

BS&W basic sediment and water

CRA corrosion-resistant alloy

DCV directional control valve

DFI design, fabrication, installation

DFO documentation for operation

EDP emergency disconnect package

EFC European Federation of Corrosion

ESD emergency shutdown

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[2] For the purposes of this part of ISO 13628, API RP 17C will be replaced by ISO 13628-3 when the latter becomes publicly available.

[3] For the purposes of this part of ISO 13628, API RP 17G will be replaced by ISO 13628-7 when the latter becomes publicly available.

ESP electrical submersible pump

FAT factory acceptance test

FPU floating production unit

GOR gas-oil ratio

GRP glass-fibre-reinforced plastic

HAT highest astronomical tide level

HAZOP hazards in operation analysis

HB Brinell hardness

HIPPS high integrity pipeline protection system

HPU hydraulic power unit

HV Vickers hardness

IMR inspection, maintenance and repair

IRJ instrument riser joint

ISO International Organization for Standardization



LAT lowest astronomical tide level

LMRP lower marine riser package (for drilling)



LMV lower master valve

LRP lower riser package (for workover)

MIV methanol injection valve

NACE National Association of Corrosion Engineers

NDE nondestructive examination

PC personal computer

PCDA plant control and data acquisition system

PCS production control system

PGB permanent guide base

PLC programmable logical controller

PMV production master valve

PRE pitting-resistance equivalent

PSD process shutdown

PSV production swab valve

PWV production wing valve

P&A plug and abandonment

RAL "Reichsausschuss für Lieferbedingungen". A colour system used by German paint manufacturers

ROT remotely operated tool

ROV remotely operated vehicle

SAS safety and automation system

SAFOP safety in operation analysis

SCM subsea control module

SCSSV surface-controlled subsurface safety valve

SEM subsea electronic module

SMYS specified minimum yield strength

TFL through-flowline system

THRT tubing hanger running tool

TLP tension leg platform

TRSCSSV tubing-retrievable surface-controlled subsurface safety valve



TRT tree running tool

UNS unified numbering system



UPS uninterruptable power supply

UTM universal transversal mercator

VDU visual display unit

WHP wellhead pressure

XT tree

XTRT tree running tool

# 4 Systems and interface descriptions

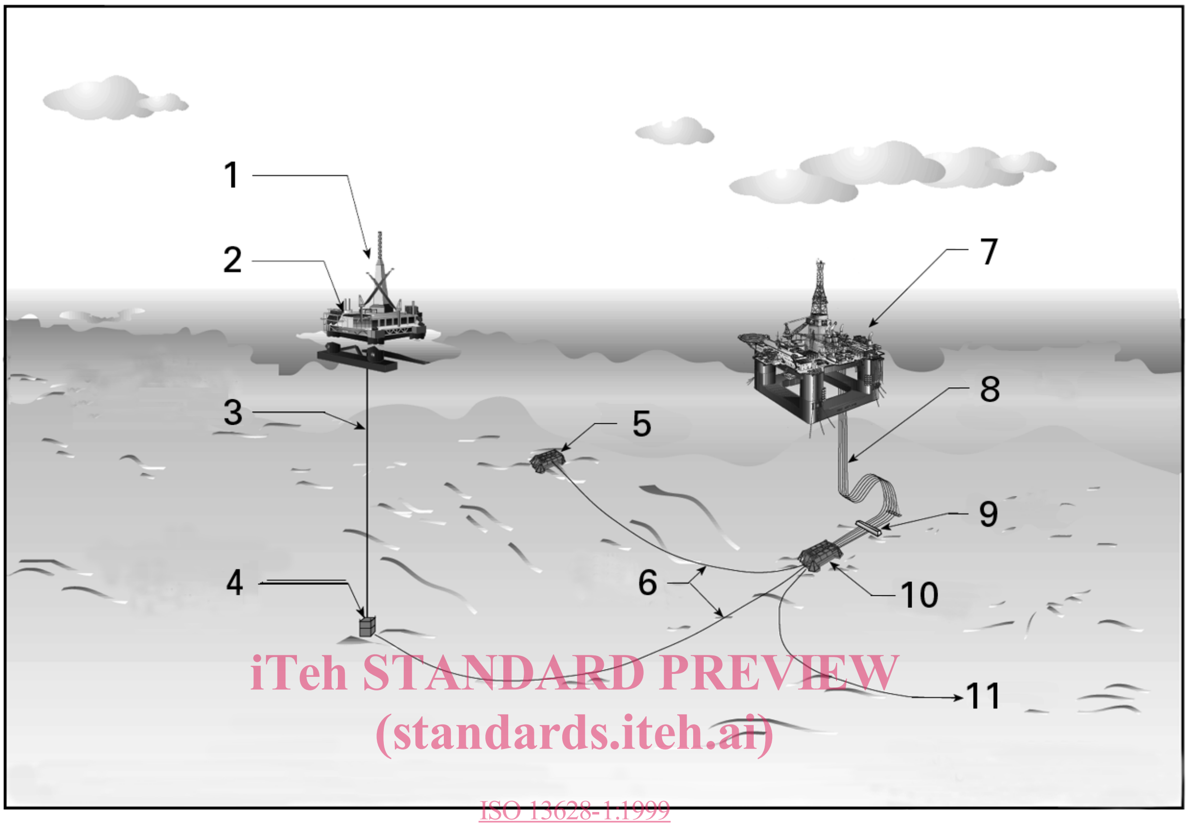
## 4.1 General

Complete subsea production systems range in complexity from a single satellite well with a flowline linked to a fixed platform, to several wells on a template producing to a floating facility.

The elements of a typical subsea production system are shown in Figure 1. These are wellheads (both subsea and mudline casing suspension systems) and trees, sealines and end connections, controls, control lines, single-well structures, templates and manifolds, ROVs/ROTs and completion/workover and production risers (both rigid and flexible). In some areas (not covered by subsystem standards), detailed requirements are included (these apply to structures, manifold piping, materials, colour and marking).

The objective of this subclause is to describe the systems in general and define the subsystem interfaces. For a detailed description of subsystems and components, see annex A.

A schematic drawing illustrating typical elements of a subsea production system is shown in Figure 2.

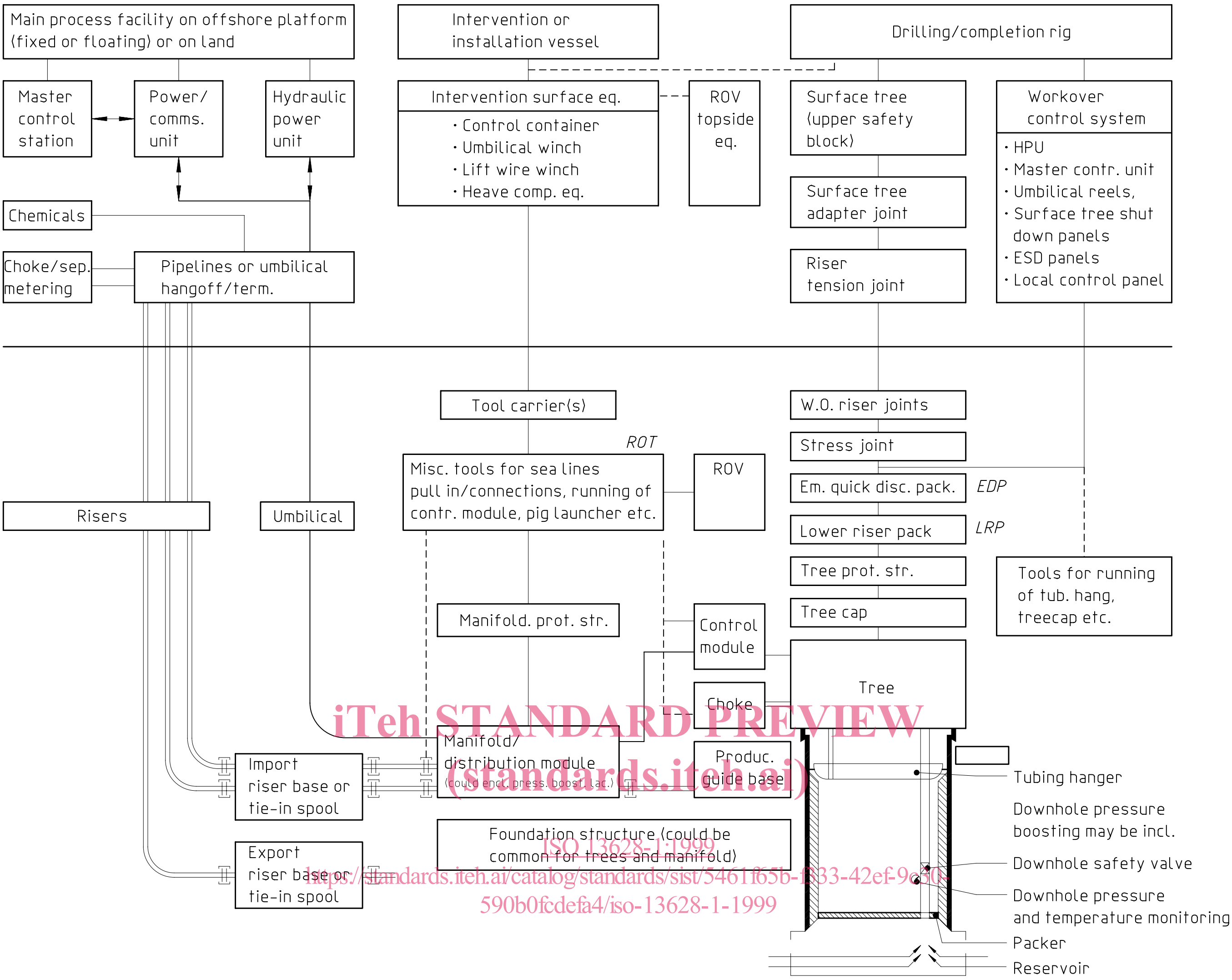





**Key**

1 Running and retrieving tools
2 Installation and workover controls
3 Completion riser and control lines
4 Satellite well
5 Template
6 Sealines
7 Production controls
8 Production riser
9 Riser base
10 Manifold
11 Export

**Figure 1 — Typical development scenarios**






NOTE For satellite wells directly tied back to the platform, several of the above-mentioned elements are eliminated.

**Figure 2 — Typical elements in a subsea production system**

## 4.2 Overall system description

### 4.2.1 General

Subsea production or injection systems are used to develop reservoirs, or parts of reservoirs, of a nature which dictates drilling of the wells from more than one location. Subsea production systems may also be used to develop reservoirs or parts of reservoirs beyond the reach of platform drilling facilities. Deep water may also in itself dictate development of a field by means of subsea completions.

The main elements of a subsea production or injection system are:

— a wellhead system with associated casing strings and production/injection tubing;

— a structural foundation and a guidance system for orientation and lateral guidance of modules during installation/retrieval. This unit is not always used;

— a set of flow and pressure control valves normally integrated in a tree;

— a production control system for remote monitoring and control of all subsea functions;

— a protective structure (optional);

— a sealine system;

— a manifold system (optional);

— installation and intervention equipment and tools with associated control systems.

The elements of the subsea production/injection system may be configured in numerous ways, dictated by specific field requirements and by operator strategy.

The most common configurations are:

— single satellite wells tied individually to a surface processing facility;

— one or more satellite wells tied individually to a subsea manifold located a given distance from the surface processing facility;

— multiple wells located on a common template incorporating a manifold.

In the following, the main characteristics of these scenarios are briefly described.

#### 4.2.2 Single satellites

For relatively shallow water, this configuration is characterized by short offset (outside the drilling reach of the host platform if this is a combined drilling production facility) and, if an infrastructure with a surplus of tie-in capacity exists, this scenario can be very effective. In terms of required permanent works this is basically a single satellite development copied a number of times over. Usually the flowline and umbilical are required to be installed as first-end tie-in at the infrastructure and second end pull-in at the satellites in order to limit congestion on the seabed around the infrastructure.



Flowline and umbilical are for some systems connected directly to the tree structure. This approach offers some rationalization in hardware.

#### 4.2.3 Manifold/satellite cluster

This concept is based on tie-in of a number of single satellites to a central manifold. The manifold in turn is tied to the infrastructure by means of one or more sealines. An arrangement including two production flowlines with same size, service and control lines is quite common. This arrangement facilitates operation of wells at two different pressure levels simultaneously, as well as convenient round-trip pigging.

The system has flexibility with respect to simultaneous drilling and production, which can save some drilling time, and has flexibility with respect to installing wells in optimal locations rather than in batches at the same location, ref. template arrangement described below.

#### 4.2.4 Template

This concept includes some of the features described in the previous subclause, but with some notable differences. The wells and the manifolds are located on the same structure. Headers and lines often have much of the same configuration as the manifold/cluster option. Template designs have some additional mechanical tolerance problems relative to cluster designs.

### 4.3 Subsea wellhead system

#### 4.3.1 General

The main function of a subsea wellhead system is to serve as a structural and pressure-containing anchoring point on the seabed for the drilling and completion systems and for the casing strings in the well. The wellhead system incorporates internal profiles for support of the casing strings and isolation of the annuli. In addition, the system incorporates facilities for guidance, mechanical support and connection of the systems used to drill and complete the well.

#### 4.3.2 Wellhead system elements

A typical wellhead system consists of the following elements:

a) a drilling guidebase with a central opening for drilling of the first section of the well and facilities for attachment of guidelines. The temporary guidebase, acts as a support for the permanent guidebase, providing a controlled reference point for wellhead elevation. Note that on single satellite wells the drilling guidebase may be omitted if there are no requirements for accurately controlled elevation of the wellhead. On multiple well templates, the drilling guidebase forms an integral part of the template;

b) a permanent guidebase with facilities for attachment to the conductor housing, and guidance of the drilling and completion equipment (universal guide frame, BOP, production tree). If used together with a temporary guidebase, the permanent guidebase incorporates a gimbal arrangement on the under side (curved profiles that interfaces with a cone landing area on the temporary guidebase) to compensate for any angular misalignment between the temporary guidebase and the permanent guidebase due to the seabed topography, and the verticality of the well;

NOTE On satellite wells, depending on the overall tree configuration, the permanent guidebase may be replaced by a production guidebase, prior to installation of the tree, incorporating facilities for pull-in and connection of the sealines and connection to the tree. Alternatively, a production guidebase can be designed to serve as both the drilling guidebase and the production guidebase. It can be either permanent or retrievable. The sealines may also be connected directly to the tree.

c) a conductor housing welded to the conductor casing, which forms the initial anchoring point to the seabed. The conductor housing incorporates an internal landing shoulder for the wellhead housing, and facilities on the outside for attachment of the permanent guidebase. The conductor housing may be installed together with the permanent guidebase;



d) a wellhead housing with internal profiles for support of all subsequent casing strings and the tubing hanger, and external profiles for attachment of the drilling and completion equipment (BOP, tree) and landing in 762 mm (30 in) housing;



e) casing hangers with seal and lock-down assemblies for suspension of the casing strings and isolation of the annuli.

#### 4.3.3 Running and retrieving tools

Dedicated tools are used to install, test and retrieve the various elements of the wellhead system. The tools are activated by either mechanical manipulation of the drill string (push, pull, rotation) or in some cases by hydraulic functions through the drill string or dedicated hydraulic lines. These tools interface with dedicated handling profiles in the associated equipment.

#### 4.3.4 Miscellaneous wellhead equipment

A set of wear bushings is used to protect the internals of the wellhead at various stages of the drilling/completion operation.

### 4.4 Subsea tree system and tubing hanger

#### 4.4.1 General

The equipment required to complete a subsea well for production or injection operations incorporates a tubing hanger and a tree. The subsea tree and the wellhead system form the barrier between the reservoir and the environment in the production mode. In the installation/ workover mode the barrier function is transferred to a LRP or BOP.

There are two main categories of trees, conventional and horizontal. The conventional tree is described as the main option, whilst the characteristics of the horizontal tree are described in 4.4.6.

In conventional subsea completions, the tubing hanger is installed inside the wellhead. The tree is installed on top of the wellhead. The tubing hanger forms the connection between the production/injection tubing and the tree. During installation and workover, the tree production/injection and annulus valves are locked open or held open hydraulically to allow access to the wellbores. The well barrier function is then covered by a lower riser package installed between the riser and the tree.

#### 4.4.2 Tubing hanger

The tubing hanger system supports the tubing string and isolates the annulus between the tubing and the casing. The tubing hanger is locked down inside the wellhead and includes seal bores for connection with bore extension subs from the tree.

#### 4.4.3 Tree

The tree consists of a valve block with bores and valves configured in such a manner that fluid flow and pressure from the well can be controlled for both safety and operational purposes. The tree includes a connector for attachment to the wellhead. The connector forms a pressure-sealing connection to the wellhead and includes bore extension subs from the tree to the tubing hanger, forming pressure-sealing conduits from the main bore and annulus of the well to the tree and additional conduits as required.

External flow loops provide fluid paths between the bores of the tree and the flowline connection point. The flowline may be connected either directly to the tree, or via flow loops on a production guidebase. The flowline connection joins the tree with the subsea flowline, using a choice of connections described in annex A.

#### 4.4.4 Tree cap

A tree cap is usually installed on top of the tree to prevent marine growth on the tree upper connection and seal bores. The cap may either be pressure-containing or purely a protective cap, depending on the barrier configuration of the tree. The tree cap could incorporate facilities to convert certain functions of the tree from workover control mode to production control mode.



#### 4.4.5 Tree running tool/lower riser package

The tree running tool is used to install the tree, and consists of a connector interfacing the top of the tree. It is often combined with a lower riser package containing a set of safety valves to control the well during installation/workover operations. The lower riser package may include valves capable of cutting wire and coiled tubing.



#### 4.4.6 Horizontal tree

The main difference between a conventional tree and a horizontal tree is that the horizontal tree is designed to be installed prior to the tubing hanger, and that the tubing hanger, when installed, is located inside the tree instead of the wellhead. Horizontal trees are configured with the valves located in the horizontal bore sections of the tree, in order to provide a large vertical bore through the tree. In installation/workover mode the well barrier function is covered by a conventional drilling BOP connected to the top of the tree, with a tubing safety valve inside the BOP, as part of the tubing hanger running string.

### 4.5 Completion/workover riser systems

**4.5.1** A completion riser is generally used to run the tubing hanger and tubing through the drilling riser and BOP into the wellbore. A workover riser is typically used in place of a drilling riser to reenter the well through the tree. The completion and workover riser may be a common system with items added or removed to suit the task being performed.

**4.5.2** Either type of riser provides communication between the wellbore and surface equipment. Both resist mass and pressure loads and accommodate wireline tools for necessary operations. The workover riser also resists external loading.

**4.5.3** The interfaces are naturally defined at the physical connection points with the other subsea and surface equipment to which they attach. For the completion riser, these are typically the subsea tree mandrel and surface tree riser-tensioning system.