

Configuration and Operation for Subsea Well Intervention Systems

API RECOMMENDED PRACTICE 17G1
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Introduction

API Recommended Practice (RP) 17G1 is a system-based configuration and operational recommended practice. The document provides a common road map to ensure that specific operations use appropriately designed, engineered, manufactured/fabricated and integrated subsea intervention systems to provide safe and effective well work.

API RP 17G1 defines system performance and operational requirements for use of equipment meeting the requirements set out in the API RP 17G series of documents. Operational guidance specifically includes barrier implementation and testing, equipment readiness and inspection, system monitoring and maintenance, along with management of change (MOC).

API RP 17G1 includes the following:

- Develop safety performance requirements for specified well conditions, planned operations and risks.
- Identify primary and secondary well barriers including their testing requirements.
- Identify technical and operational gaps.
- Recommend system configuration, individual hardware, procedural additions, or modifications.
- Identify the need for additional testing to reduce project risk.
- Identify the number, location, and performance requirements of safety functions.
- Establish safety function closure requirements based on the barrier philosophy for particular well intervention operations.
- Provide minimum requirements on inspection, maintenance, and reassessment.
- Conduct verification and validation testing to demonstrate readiness for use.
- Provide minimum requirements on system monitoring.
- Provide inputs and outputs for Global Riser Analysis.

This RP is not intended to restrict or deter the development of new operating practices or technology. Rather, it is intended to become a basis from which new subsea well intervention operating practices and technology can develop.

Configuration and Operation for Subsea Well Intervention Systems

1 Scope

API RP 17G1 provides guidance for the selection of a subsea well intervention system, defines minimum requirements of a subsea well intervention system for specific operation(s) and environments to ensure the selected system is fit for purpose. This RP applies to new and existing subsea well intervention systems irrespective of whether the equipment complies with the latest requirements of API 17G.

All subsea well intervention systems are covered by this RP and the equipment typically included in (but not limited to) the system is described in the suite of API 17G intervention documents.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Specification 6A, *Specification for Wellhead and Tree Equipment*

API Specification 16A, *Specification for Drill Through Equipment*

API Standard 17G, *Design and Manufacture of Subsea Well Intervention Equipment*

API 17G5; *Subsea Intervention Workover Control Systems*

API Standard 53, *Well Control Equipment Systems for Drilling Wells*

API Specification Q1, *Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry*

API Specification Q2, *Specification for Quality Management System Requirements for Service Supply Organizations for the Petroleum and Natural Gas Industries*

ASME Boiler and Pressure Vessel Code, Section IX—*Welding and Brazing Qualifications*

BS7910, *Guide to methods for assessing the acceptability of flaws in metallic structures*

DNVGL-RP C210, *Probabilistic methods for planning of inspection for fatigue cracks in offshore structures*

DNVGL-RP-C203, *Fatigue Design of Offshore Steel Structures*

IEC 61508, *Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems*

IEC 61511, *Functional safety - Safety instrumented systems for the process industry sector*

ISA-TR84.00.03, *Automation Asset Integrity of Safety Instrumented Systems (SIS)*

ISO 9001, *Quality management systems requirements*

ISO 9712, *Non-Destructive Testing—Qualification and Certification of NDT Personnel*

ISO 14224, *Petroleum, Petrochemical and Natural Gas Industries—Collection and Exchange of Reliability and Maintenance Data for Equipment*

3 Terms, Definitions, Abbreviations, and Symbols

3.1 Terms and Definitions

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

3.1.1

abnormal events

A change to operating conditions outside of normal range. For example, monitored functions, alarms, excessive riser loading, or a change in control pressure(s) or voltage(s).

3.1.2

accidental event

Accidental event means an unplanned or unexpected event or circumstance or series of events or circumstances that may lead to loss of life or damage to equipment, environment, or loss of well control.

3.1.3

accumulator system

An arrangement of hydraulic accumulators working together as a system. Unless otherwise specified, all accumulators of the IWOCS are located both subsea and on the surface.

3.1.4

autoshear

A controlled sequence that is designed to automatically isolate the well subsea following an unintentional disconnect. The system requires to be capable of performing the expected shearing and sealing action under MASP conditions as defined for the operation.

NOTE Specifics of the design are based upon system architecture and Safety Strategy requirements.

3.1.5

component/part

An individual piece or an identifiable portion of equipment that performs a defined function.

3.1.6

controls design basis

A document created to accompany the controls and shutdown logic documentation used to explain the reasoning behind the various controls and shutdown system design decisions.

NOTE This document is useful for any system where a justification or explanation of the design decisions is helpful in understanding design intent, especially when future changes are considered.

3.1.7

deadman

A controlled sequence that is designed to automatically isolate the well subsea in the event of loss of control. The system requires to be capable of performing the expected shearing and sealing action under MASP conditions as defined for the operation.

NOTE Specifics of the design are based upon system architecture and Safety Strategy requirements.

3.1.8

drift-off

Unintended lateral movement of a dynamically positioned vessel off its intended location relative to the wellhead, generally caused by loss of station-keeping control or propulsion.

3.1.9**drive-off**

Unintended movement of a dynamically positioned vessel off location driven by the vessel's main propulsion or station-keeping thrusters.

3.1.10**dynamic positioning**

Computerized means of maintaining a vessel on location by selectively activating thrusters.

3.1.11**end user**

Organization that authorizes the use of a subsea well intervention system for well operations.

NOTE 1 The end user is responsible for system engineering, system design and operation of the subsea well intervention system.

NOTE 2 The end user is also known as "Well Operator" within some industry documentation.

3.1.12**emergency disconnect sequence (EDS)**

A controlled sequence that is designed to isolate the well subsea and disconnect the LMRP in the event of an emergency situation.

NOTE The EDS is a programmed sequence that leaves the subsea BOP stack in a desired state and disconnects the lower marine riser package (LMRP) from the lower BOP stack. The sequence should activate at least one shear ram to seal the well prior to disconnect the LMRP connector. An EDS requires to be available on subsea BOP stacks that are run from a dynamically positioned vessel and is optional for moored vessels.

3.1.13**emergency quick disconnect (EQD)**

A controlled sequence that is designed to isolate the well subsea and disconnect the landing string/riser from the well in the event of an emergency situation. Includes closing barrier elements to achieve a safe-state and unlatching the landing string/riser.

3.1.14**emergency shutdown (ESD)**

A controlled sequence that is designed to isolate the well subsea in the event of an emergency. Includes closing barrier elements to achieve a safe-state.

3.1.15**equipment**

A single completed unit that can be used for its intended purpose within the scope of this document without additional components.

3.1.16**equipment operator**

Individual that is responsible for the (hands on) functional operation of a subsea well intervention system for well operations.

NOTE The Equipment Operator is also known as "Operator" within some industry standards/specifications.

3.1.17**extreme load condition**

Condition, where individual and combined loads as a result of environmental and operational criteria exceed the Normal Structural Design factor but are equal to or less than the Extreme Structural Design Factor.

NOTE API Standard 17G lists the Structural Design Factors

3.1.18**fail-close (FC)**

Actuated device designed to revert to the closed position when the actuator is de-energized.

3.1.19**fit for purpose**

“Fit for purpose” means able to perform the intended functions of the system.

3.1.20**functional load capacity**

Minimum capacity of relevant functional failure modes, i.e. minimum of preload exceedance, seal/gasket leak tightness, loss of functionality due to permanent deformations.

NOTE “Leak tightness” is a generic term used to describe non-exceedance of specific leak acceptance criteria.

3.1.21**functional specifications**

Features, characteristics, process conditions, boundaries, and exclusions that define the performance and use requirements of a managed product, including any end user specific requirements.

3.1.22**global riser analysis (GRA)**

Analysis of the complete subsea well intervention system from below mudline to traveling block, including tensioner joint, using beam elements.

NOTE Bending moments and effective tension distributions along the riser string due to functional loads, vessel motions, and environmental loads are determined by global riser analysis (GRA). Once the global loads are established, then these loads should be assessed against component capacities, thereby determining the operating limits for the system. Refer to API 17TR14 for more details.

3.1.23**In situ**

Equipment already in place, prior to intervention operations.

EXAMPLE Wellhead, tubing, production tree valves, SCSSVs.

3.1.24**interface management plan**

Defined process for the identification, management, exchange, agreement, and documentation of information between end user, manufacturers, service providers and vessel contactors whose equipment interface or interact together as part of a larger assembly or system. Interface information may include data such as dimensions, tolerances, weight, center of gravity, material properties, capacities, ratings, limitations, functional data, vessel data or operation requirements.

3.1.25**loading (load) classification**

Load classification refers to an assignment of either normal, extreme, or survival load conditions to an operational stage or load case to be analyzed within the GRA.

NOTE normal, extreme, and survival load limits for equipment are defined within API 17G.

3.1.26**loss of control**

Inability to initiate safety functions from surface due to loss of hydraulic supply and/or signal transmission.

EXAMPLE Direct Hydraulic System—loss of surface hydraulic supply; Electro-hydraulic System—loss of electrical signal transmission and/or surface hydraulic supply.

3.1.27**lower workover riser package (LWRP)**

Lowermost equipment package in the riser string when configured for subsea tree installation/workover and including any equipment between the riser stress joint and the subsea tree, and typically consisting of a lower riser package and emergency disconnect package.

NOTE 1 The lower workover riser package permits well control and ensures a safe operating status while performing coiled tubing/wireline and well servicing operations.

NOTE 2 LWRP is a combination of EDP and WCP.

3.1.28**manufacturer**

Organization that is responsible for the design and manufacture of equipment for use in subsea well intervention systems and sub-systems.

NOTE The manufacturer is responsible for creation of; design documentation, validation testing documentation, manufacturing record books and operating documentation for the equipment.

3.1.29**maintenance plan**

Structured and documented set of tasks that include the activities, procedures, resources and the time scales required to carry out maintenance.

NOTE The maintenance schedule and strategy are typically based on; specific time intervals, measurable wear limits, system condition status, function cycle accumulation, non-performance of equipment, environment, reliability data, regulatory requirements, and any other inspectable or monitored data.

3.1.30**modes of operation**

Used to describe the type of subsea well intervention equipment e.g. equipment that is connected to a fluid conduit tieback riser, either inside the marine riser (TBIRS) or open water (OWIRS), riser subsea well intervention system (RSWIS), downline connected equipment, and remotely operated vehicle (ROV) intervention equipment.

3.1.31**normal load condition**

Condition, where individual and combined loads as a result of environmental and operational criteria reach but do not exceed the Normal Structural Design factor.

NOTE API Standard 17G lists the Structural Design Factors.

3.1.32**operability**

Ability to safely perform the planned operation without exceeding the capacity and performance limits of the equipment being used.

3.1.33**operational scenarios**

Used to describe the stages of the operation, intervention activities, and the use of safety functions.

3.1.34**primary well barrier**

First well barrier that prevents flow from a potential source of inflow.

3.1.35**process shutdown (PSD)**

A controlled sequence that is designed to isolate the well at surface by closing the surface tree wing valve(s).

3.1.36**protection layer**

Any independent method that reduces risk by control, prevention, or mitigation. For the purposes of this document, this definition relates to reducing the probability and consequences of failures, hazards, and accidental events.

NOTE Risk is a function of probability and consequence.

3.1.37**refurbishment**

Process of disassembly, inspection, reassembly, and testing of equipment, with or without the replacement of components.

NOTE Sometimes referred to as repair, but does not include machining, welding, heat treating, or other manufacturing operations on components

3.1.38**remanufacture**

Process of disassembly, reassembly, and testing, with or without the replacement of parts, in which machining, welding, heat treatment, or other manufacturing is employed.

3.1.39**risk assessment**

Overall process of performing a risk assessment including establishment of the context, performance of the risk analysis, risk evaluation, and to assure that the communication and consultations, monitoring, and review activities, performed prior to, during and after the analysis has been executed, are suitable and appropriate with respect to achieving the goals for the assessment.

3.1.40**safety class device**

Device required to achieve a safe-state condition as a part of a safety function.

3.1.41**safety function**

Sequenced series of device actions intended to achieve a safe-state in relation to a specific hazardous event.

NOTE Safety functions for subsea well intervention systems typically include process shutdown (PSD), emergency shutdown (ESD), emergency quick disconnect (EQD), deadman, and autoshear.

3.1.42**safe-state**

Condition that exists when all safety class devices, defined by a safety function, have functioned as intended.

3.1.43**secondary well barrier**

Second well barrier that prevents flow from a potential source of inflow.

3.1.44**service life**

Duration of time in which the equipment performs under the specified design conditions, i.e. time in active connected riser operations, excluding storage periods.

NOTE The service life is normally a small fraction of the design life.

3.1.45**service provider**

Organization that provides subsea well intervention system services and products.

3.1.46**stroke**

Total upward and downward vertical movements of the vessel relative to the riser, e.g. travel of the riser tensioner, drawworks, and slick joint.

NOTE It includes effects from environmental loads, functional loads (e.g. top tension, temperature, mean static vessel offset, and pressure).

3.1.47**structural load capacity**

Minimum capacity of relevant structural failure modes, i.e. minimum of yielding, local failure, buckling, and mechanical disengagement.

3.1.48**system**

Collection of equipment used to perform its intended purpose within the scope of this document.

3.1.49**system integrator**

Organization that is responsible for bringing together sub-systems, ensuring that those sub-systems function together in a subsea well intervention system.

NOTE Responsible for the system integration, collection/collation of all manufacture data and manufacture record books (where applicable), collection of equipment assembled together, verification testing documentation, operation procedures, maintenance, and storage procedures.

3.1.50**system integration**

Process of bringing together equipment into one subsea well intervention system and ensuring that the equipment functions together as a system that is fit-for-purpose for use in end user's well specific conditions and operations.

3.1.51**system integration test (SIT)**

Test conducted to validate that the requirements for a specific intended use or application, of a set of products that form an integrated system, have been fulfilled.

3.1.52**survival load condition**

Condition, where individual and combined loads as a result of environmental and operational criteria exceed the Extreme Structural Design factor but are equal to or less than the Survival Structural Design Factor.

NOTE 1 API Standard 17G lists the Structural Design Factors.

NOTE 2 A survival load condition of a component means that the component does not fail, but it can present one or more kinds of degradations that may impact its specified performance or service life.

3.1.53**well barrier**

Envelope of one or several well barrier elements preventing fluids from flowing unintentionally from the reservoir to environment.

3.1.54**well barrier element (WBE)**

A physical element which in itself does not prevent flow but in combination with other WBE's forms a well barrier.

EXAMPLE Pressure containing bodies, connectors, seal/gasket connectors, pipes, components (e.g. valves, rams) and equipment (e.g. WCP, SSTT, and surface tree).

3.1.55**well control**

Collective expression for all measures that can be applied to prevent uncontrolled release of wellbore fluids to the environment or uncontrolled underground flow.

3.1.56**well control device**

A component that is designed to function as a well barrier.

EXAMPLE Blowout preventers, pipe rams, circulating heads, tubing injection heads, diverters, wireline lubricators and stuffing boxes, kelly cocks, stabbing valves, kill-lines, valves, choke lines and manifolds.

3.1.57**Well Specific Operating Criteria (WSOC)**

Guidelines on the operational, environmental and equipment performance limits for the location and specific operation.

NOTE This may also be known as *Well Specific Operating Guidelines* (WSOG).

3.2 Abbreviations and Symbols

For the purposes of this document, the following abbreviations and symbols apply.

BOP	Blowout Preventer
EDP	Emergency Disconnect Package
EQD	Emergency Quick Disconnect
ESD	Emergency Shutdown
FAT	Factory Acceptance Test
HPU	Hydraulic Power Unit
IWOCS	Intervention Workover Control System
LWRP	Lower Workover Riser Package
MASP	Maximum Anticipated Surface Pressure
MOC	Management of Change
MOP	Minimum Operating Pressure
OEM	Original Equipment Manufacturer
OWIRS	Open Water Intervention Riser System
POD	Point of Disconnect
PSD	Process Shutdown
P-Y	Numerical model curves for soil resistance. P is force per unit length and Y is resulting deflection.
RAO	Response Amplitude Operator
ROV	Remotely Operated Vehicle
RSWIS	Riserless subsea well intervention system
RWP	Rated Working Pressure
SAF	Stress Amplification Factor
SIT	System Integration Test

SITP	Shut-In Tubing Pressure
SPWIS	Subsea pumping well intervention system
TBIRS	Through-BOP Intervention Riser System
TOE	Tension-offset envelope
UPS	Uninterruptable Power Supply
VIV	Vortex-induced vibration
WKM	Well Kill Margin
$\Delta M-N$	Bending moment range vs number of cycles

4 System Requirements

4.1 General

The purpose of this section is to specify the minimum requirements for the well intervention system design and configuration when used for specific operation(s) and environments. These requirements apply to both new and existing systems to ensure the system is fit for purpose. The system includes both permanently and temporarily installed equipment planned to be used as a barrier during well work and recovery operations.

The scope of this section includes; System Definition, System Engineering, Barrier Requirements, Design Principles, Safety Strategy, Operational Principles, Safety Principles, Risk Assessment, System Design and System Review.

All subsea well intervention system modes of operation are covered within this section.

The end user or system integrator (on behalf of end user) is responsible for defining the equipment used in the System Design including the functional requirements. The System Review is required to ensure that subsea well intervention system meets requirements and is operated and maintained for its intended use, throughout its intended life.

The scope of equipment typically included in (but not limited to) the system requirements for the open-water riser intervention and through-BOP intervention modes are shown in API Standard 17G.

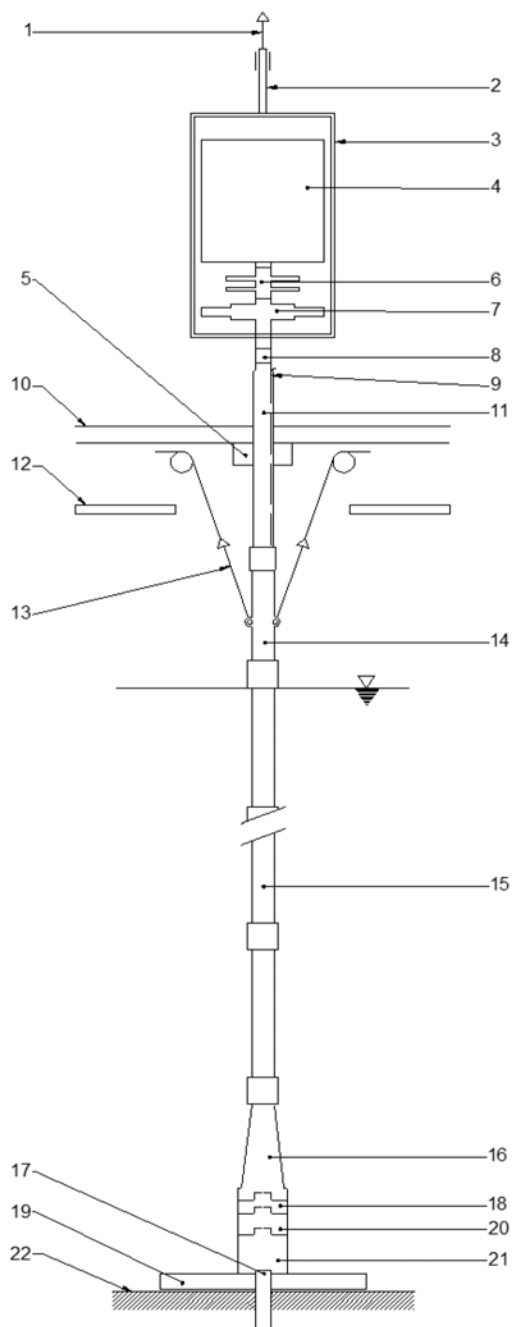
All equipment comprising the well intervention system shall be reviewed and determined to be fit for purpose for the specific application:

- New well intervention equipment shall conform to API Standard 17G series;
- Existing equipment used in a well intervention system shall be built in accordance with a recognized industry standard that was in effect at the time of manufacture;
- Equipment not in scope of the API 17G series (e.g. Surface PCE, Drawworks, well test, bails, elevators, riser tensioners), but required for functionality or interface to the Intervention system shall be built to a recognized industry standard that was in effect at the time of manufacture.

NOTE 1 Equipment nomenclature for a typical subsea well intervention system general arrangement in open-water intervention mode is shown in Figure 1.

NOTE 2 Equipment nomenclature for a typical subsea well intervention system general arrangement in through-BOP intervention mode is shown in Figure 2.

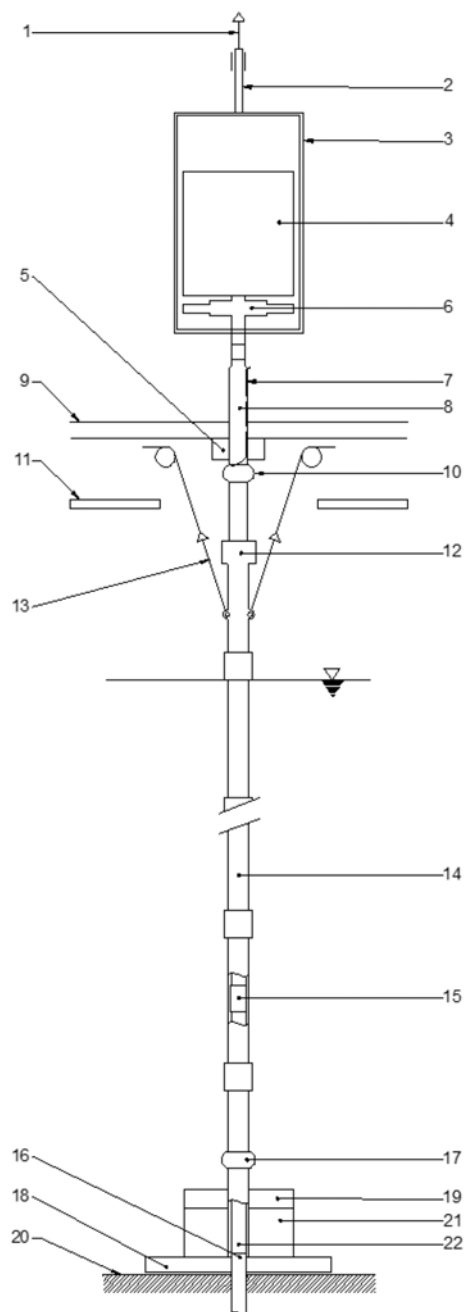
NOTE 3 Typical schematics for horizontal and vertical subsea trees are shown in Figures 3 through 6.



Key

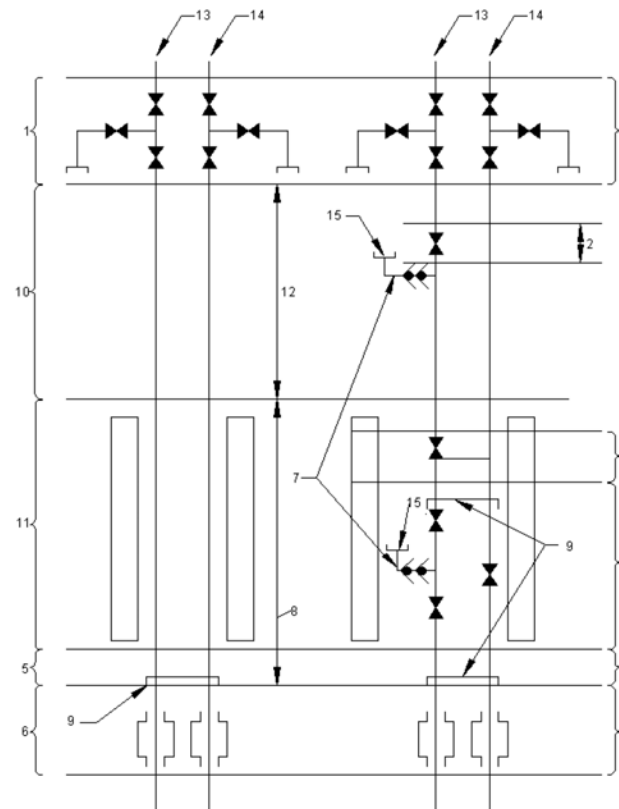
1	traveling block	7	surface tree	13	riser tension wires	19	guide base
2	drill sub	8	surface tree adapter joint	14	tension joint	20	well control package
3	surface-tree tension frame	9	umbilical (to hose reel)	15	standard C/WO riser joints	21	subsea tree
4	coiled tubing injector	10	drill floor	16	stress joint	22	seabed
5	rotary bushing	11	cased wear joint	17	wellhead		
6	well control stack	12	moonpool area	18	emergency disconnect package		

Figure 1—Typical Subsea Well Intervention System General Arrangement Open-Water Mode

**Key**

1	traveling block	6	well control stack	11	moonpool area	16	wellhead/subsea tree
2	drill sub	7	umbilical (to hose reel)	12	telescopic joint	17	flex joint
3	surface tree tension frame	8	cased wear joint/riser sealing mandrel	13	riser tension wires	18	guide base
4	surface equipment (wireline or coiled tubing stack)	9	drill floor	14	drilling riser joints	19	LMRP
5	rotary bushing	10	ball/flex joint	15	landing string or C/WO riser joints	20	seabed
						21	subsea drilling BOP
						22	SSTA or BOP spacer joint

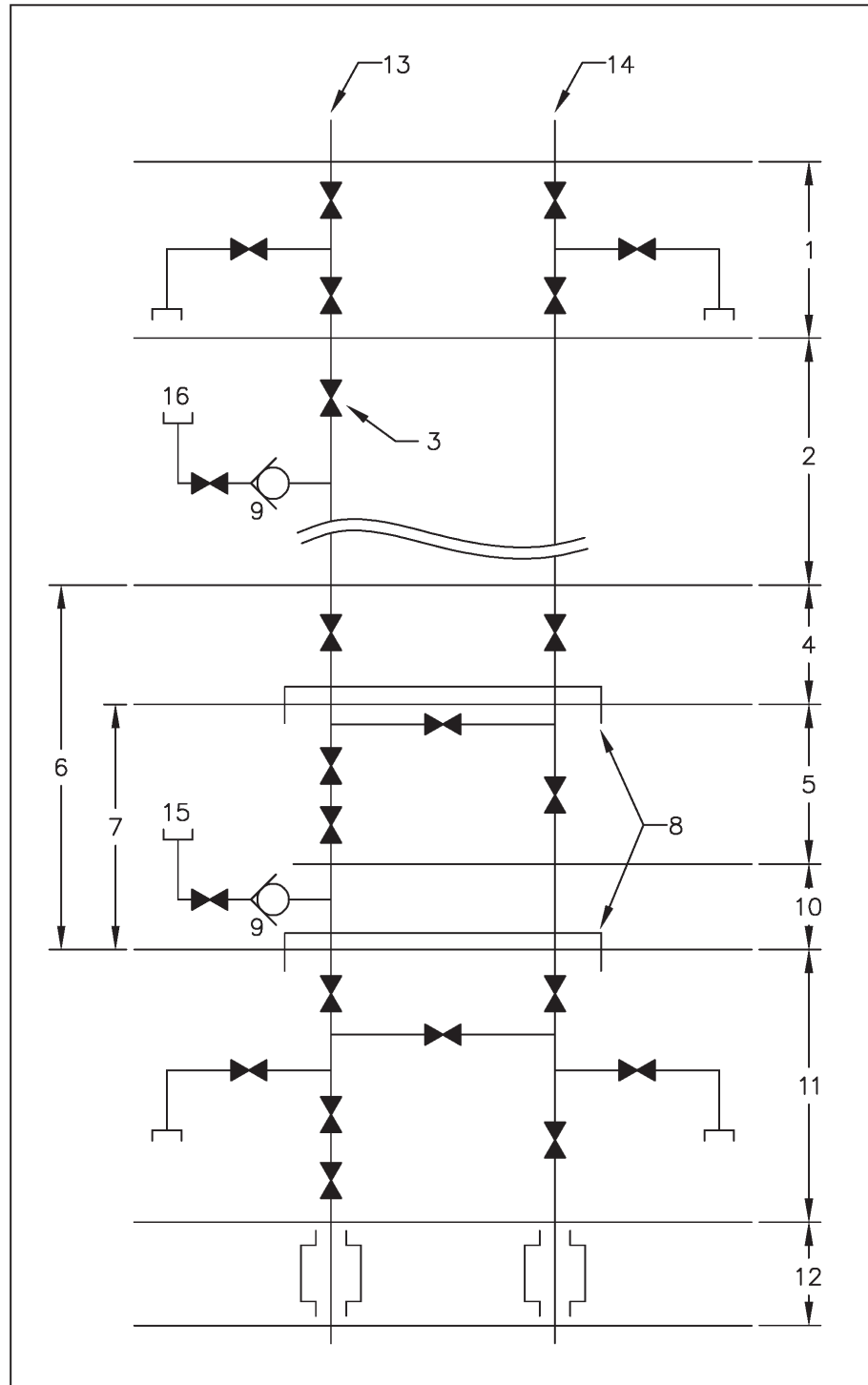
Figure 2—Typical Subsea Well Intervention System General Arrangement through BOP Intervention Mode



Key

- | | | |
|------------------------------|---|---|
| 1 surface tree | 6 tubing hanger | 11 subsea drilling BOP Stack |
| 2 lubricator valve | 7 chemical injection | 12 landing string or C/WO riser |
| 3 retainer valve | 8 subsea test tree assembly or BOP spacer joint | 13 production bore |
| 4 subsea test tree | 9 disconnect point | 14 annulus bore |
| 5 tubing hanger running tool | 10 drilling riser | 15 connection to landing string umbilical |

Figure 3—Typical Subsea Well Intervention System Schematic—Vertical Tree (Dual Bore) through BOP/Drilling Riser Intervention Mode



- | | | |
|--------------------------------|--------------------------------|--------------------------------|
| 1 surface tree | 6 lower workover riser package | 11 vertical tree |
| 2 C/WO riser | 7 well control package | 12 tubing hanger |
| 3 lubricator valve | 8 disconnect point | 13 production bore |
| 4 emergency disconnect package | 9 chemical injection | 14 annulus bore |
| 5 shear/seal device | 10 tree running tool | 15 connection to W/O umbilical |
| | | 16 connection to LV umbilical |

Figure 4—Typical Subsea Well Intervention System Schematic—Vertical Tree (Dual Bore) Open-Water Riser Intervention Mode

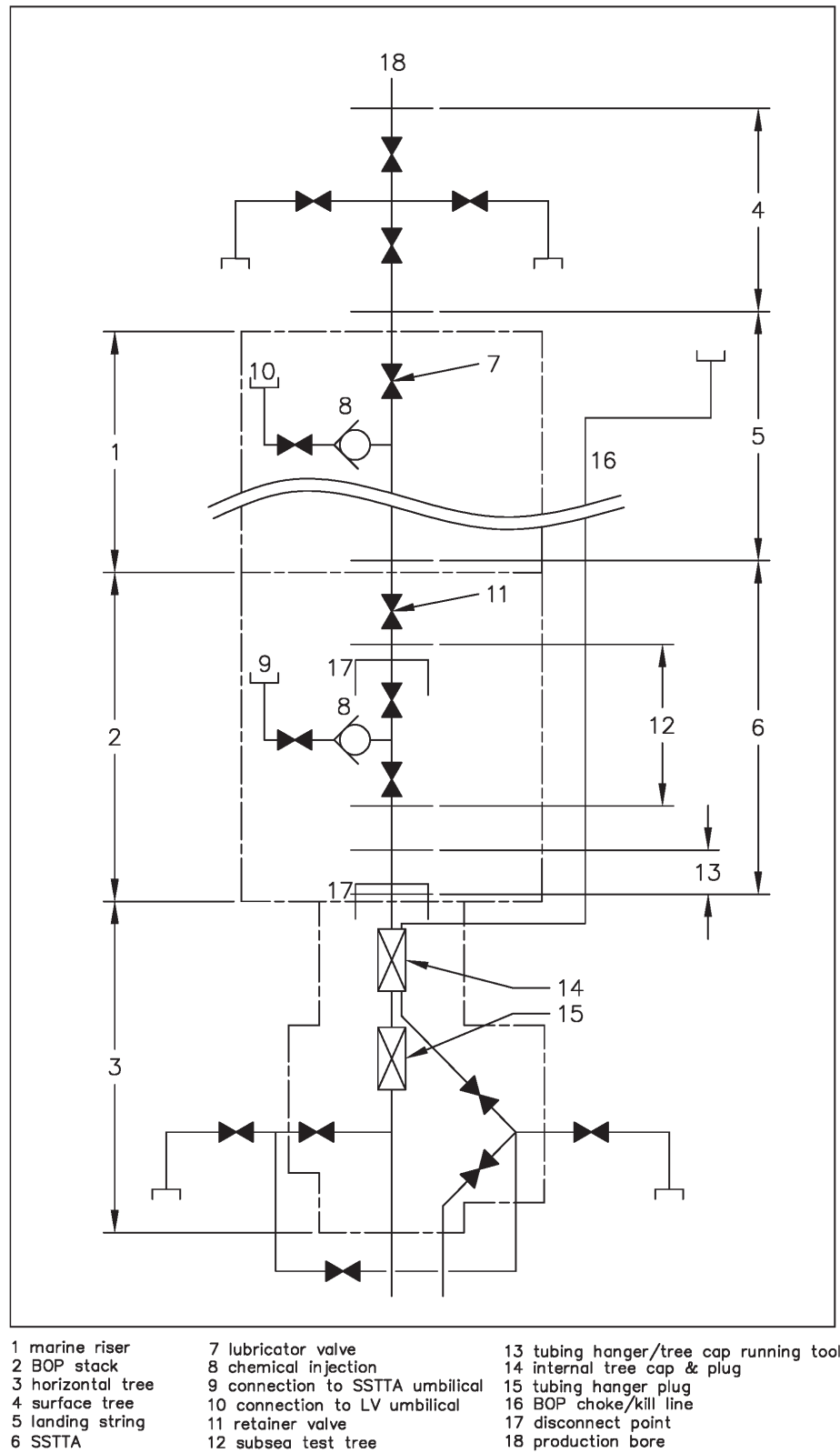


Figure 5—Typical Subsea Well Intervention System Schematic—Horizontal Tree through BOP/Drilling Riser Intervention Mode

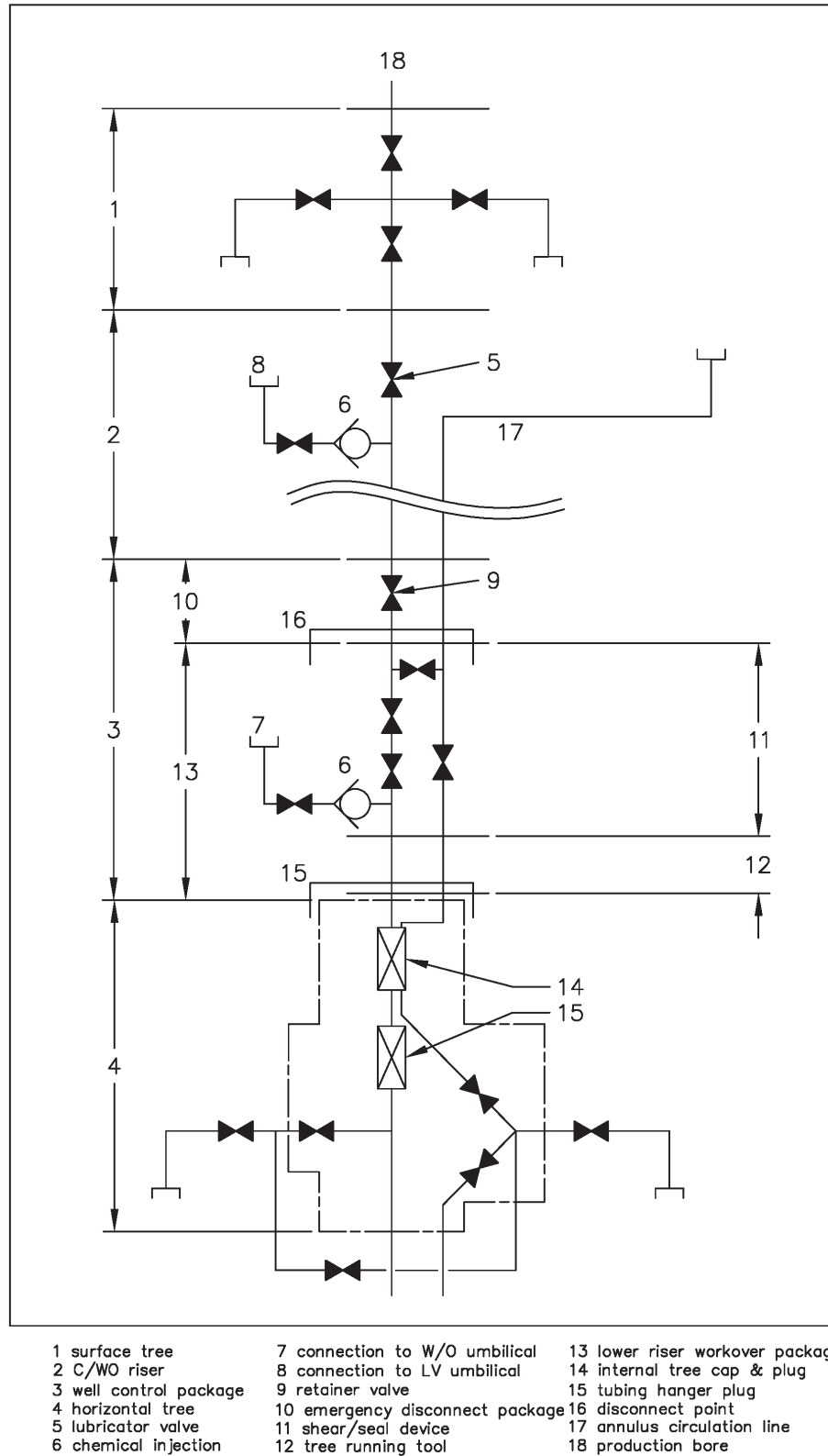


Figure 6—Typical Subsea Well Intervention System Schematic—Horizontal Tree Open-Water Riser Intervention Mode

4.2 System Engineering

4.2.1 General

System engineering is a multidisciplinary approach that covers the overall system, from the reservoir to the vessel, and considers the environment, interfaces, and requirements for all phases of the operations including emergency operations and re-establishment of the system to the well. The process ensures that the barrier philosophy between the reservoir, people and the environment is managed and mitigates escalation of a single point failure into a safety or environmental event.

To be effective, system engineering identifies each interface and application as to maintain focus on the installation of barriers during normal and emergency situations. It includes end user requirements as well as regulatory requirements and at a minimum, documents the following:

- System Functional Requirements which define the system;
- Design Basis;
- System Design;
- Interface Management;
- System Review;
- System verification and validation.

NOTE A typical engineering process flowchart is shown in Figure 7 and additional guidance is available in API 17A.

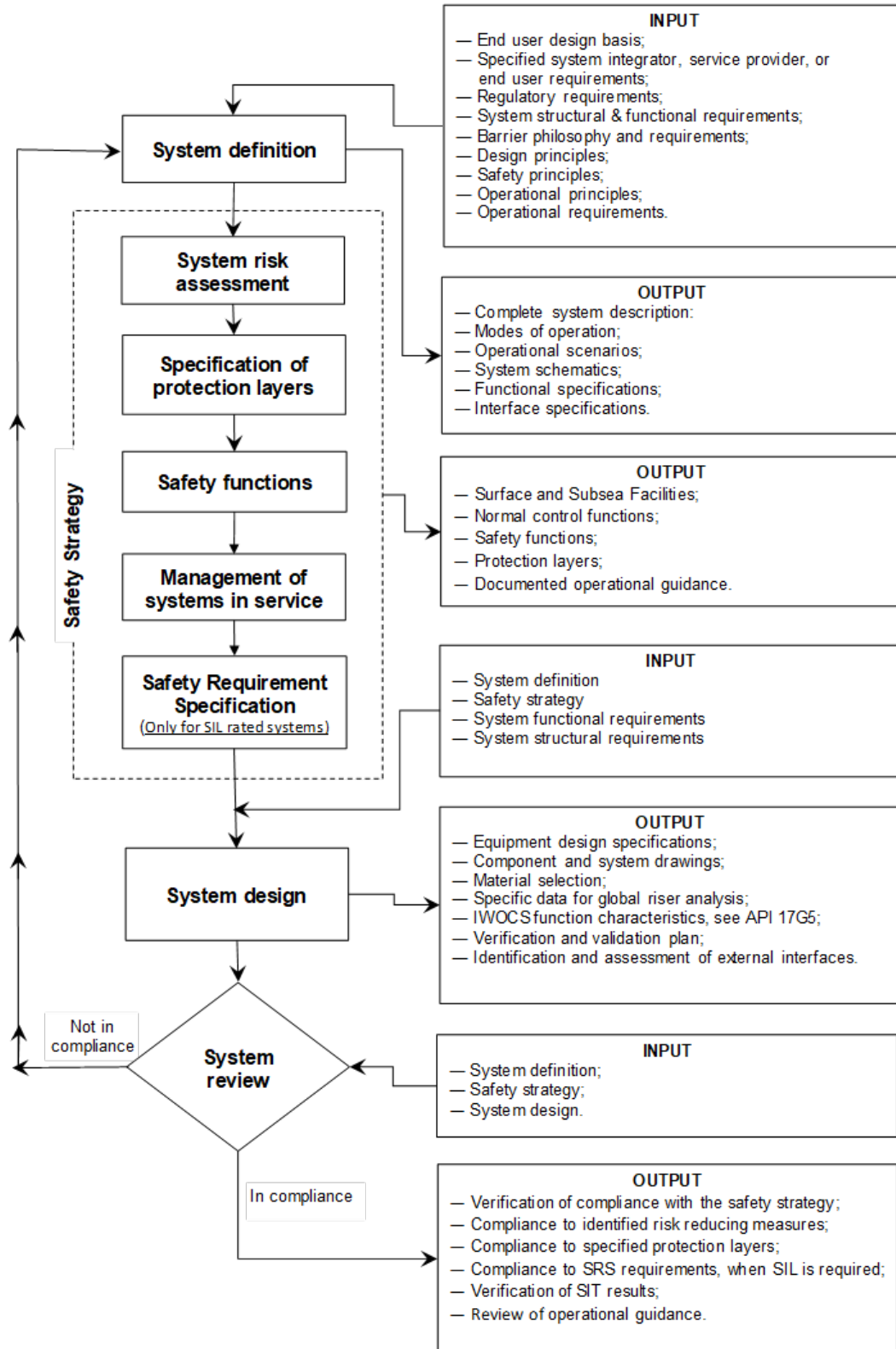


Figure 7—Typical System Engineering Flowchart

4.2.2 System Definition

The system shall be defined with regard to the following input information: