

Design and Operation of Subsea Production Systems—General Requirements and Recommendations

API RECOMMENDED PRACTICE 17A
SIXTH EDITION, MAY 2022



American
Petroleum
Institute

Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed. The use of API publications is voluntary. In some cases, third parties or authorities having jurisdiction may choose to incorporate API standards by reference and may mandate compliance.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be used. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

All rights reserved. No part of this work may be reproduced, translated, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher, API Publishing Services, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001-5571.

Foreword

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

The verbal forms used to express the provisions in this document are as follows.

Shall: As used in a standard, “shall” denotes a minimum requirement to conform to the standard.

Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required to conform to the standard.

May: As used in a standard, “may” denotes a course of action permissible within the limits of a standard.

Can: As used in a standard, “can” denotes a statement of possibility or capability.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 200 Massachusetts Avenue, Suite 1100, Washington, DC 20001. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually by API, 200 Massachusetts Avenue, Suite 1100, Washington, DC 20001.

Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, Suite 1100, Washington, DC 20001, standards@api.org.

Contents

	Page
1	Scope..... 1
2	Normative References 1
3	Terms, Definitions, Acronyms, and Abbreviations 2
3.1	Terms and Definitions 2
3.2	Acronyms and Abbreviations 3
4	Subsea Production Systems..... 5
4.1	General 5
4.2	System Configuration 5
4.3	Overview of API 17-series Documents by Categories 5
5	Systems Engineering 9
5.1	General 9
5.2	Systems Engineering Process..... 10
5.3	Subsea System Production Assurance and Reliability Management 11
6	Equipment Design Requirements 11
6.1	Design Basis 11
6.2	Safety..... 12
6.3	Barrier and Isolation Considerations..... 13
6.4	Materials 16
6.5	Structural Analysis 16
6.6	Pumps, Piping, and Valves 17
6.7	Dropped Objects and Fishing Gear Loads 18
6.8	Lifting Components, Padeyes, and Unpressurized Structural Components..... 18
6.9	Colors and Marking..... 18
6.10	Tolerance Evaluation 18
6.11	Design for Installation 19
6.12	Environmental Considerations..... 19
6.13	Evaluation of Subsea Pressure Testing Limitations 19
6.14	Design for Intervention..... 20
7	Technology Management Guidance 20
7.1	Technology Development and Qualification..... 20
7.2	Obsolescence Management 21
8	Manufacture, Assembly, Testing, Installation, and Commissioning Guidance 22
8.1	Manufacture 22
8.2	Assembly 22
8.3	Testing 23
8.4	Transportation, Preservation, and Storage 24
8.5	Load-out and Installation 25
8.6	Commissioning/Systems Completion 26
9	Operations Guidance..... 26
9.1	Integrity Management..... 26
9.2	Production Management..... 27
10	Well Intervention Guidance..... 28

Contents

	Page
11 Decommissioning Guidance	28
Annex A (informative) Generic Terms for Use in API 17-series Documents	30
Annex B (informative) Systems Engineering Processes	40
Bibliography.....	42

Figures

1 Basic Subsea Systems	5
B.1 The NASA Systems Engineering Engine	41

Design and Operation of Subsea Production Systems—General Requirements and Recommendations

1 Scope

API 17A provides general requirements and recommendations for the development and operation of subsea production/injection systems, from the concept development phase to decommissioning and abandonment. This document references other API 17-series documents, as well as various relevant industry documents.

A complete subsea production/injection system comprises several subsystems necessary to produce hydrocarbons from one or more subsea wells and transfer them to a processing/host facility located offshore (fixed, floating, or subsea) or onshore, or to inject water/gas via subsea facilities and/or wells (as shown in Figure 1).

NOTE The term “subsea production system” is used generically throughout this document to describe both production and injection systems.

Flexible pipe standards form part of the API 17-series of documents (see 4.3.3); however, RP 17A does not generally cover flowlines/pipelines or production/injection risers (associated with flowlines/pipelines). These components form part of a complete Subsea Production System (SPS), as shown in Figure 1.

If requirements as stated in this document are in conflict with, or are inconsistent with, requirements as stated in other API 17-series documents, the specific requirements in the subsystem series document(s) take precedence.

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 Recommended Practice 17B, *Recommended Practice for Flexible Pipe*

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

API Specification 17E, *Specification for Subsea Umbilicals*

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

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

API Recommended Practice 17G3, *Design of Subsea Well Intervention Systems Using Non-Ferrous Alloys*

API Recommended Practice 17G5, *Intervention Workover Control Systems (IWOCS)*

API Recommended Practice 17H, *Remotely Operated Tools and Interfaces on Subsea Production Systems*

API Specification 17J, *Specification for Unbonded Flexible Pipe*

API Specification 17K, *Specification for Bonded Flexible Pipe*

API Specification 17L1, *Specification for Flexible Pipe Ancillary Equipment*

API Recommended Practice 17L2, *Recommended Practice for Flexible Pipe Ancillary Equipment*

API Recommended Practice 17N, *Recommended Practice for Subsea Production System Reliability and Technical Risk Management*

API Standard 17O, *Standard for Subsea High Integrity Pressure Protection Systems (HIPPS)*

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

API Recommended Practice 17Q, *Recommended Practice on Subsea Equipment Qualification*

API Recommended Practice 17R, *Recommended Practice for Flowline Connectors and Jumpers*

API Recommended Practice 17S, *Recommended Practice for the Design, Testing, and Operation of Subsea Multiphase Flow Meters*

API Recommended Practice 17U, *Recommended Practice for Wet and Dry Thermal Insulation of Subsea Flowlines and Equipment*

API Recommended Practice 17V, *Recommended Practice for Analysis, Design, Installation, and Testing of Safety Systems for Subsea Applications*

API Recommended Practice 17W, *Recommended Practice for Subsea Capping Stacks*

API Recommended Practice 17X, *Recommended Practice for Subsea Pump Module Systems*

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*

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

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

3.1.1

barrier

Element forming part of a pressure-containing envelope that is designed to prevent unintentional flow of production/injected fluids, particularly to the external environment.

3.1.2

extended factory acceptance test

EFAT

Test(s) conducted to verify that the specified requirements, for a set of interfacing products, have been fulfilled. Refer to Annex A for examples.

3.1.3

factory acceptance test

FAT

Test(s) conducted to verify that the specified requirements for a product, have been fulfilled. Refer to Annex A for examples.

3.1.4**high-pressure/high-temperature****HPHT**

Any environment above 15,000 psi (103.5 MPa) working pressure and/or operating above 350 °F (177 °C).

3.1.5**interchangeability test****ICT**

A test(s) conducted to verify the interchangeability requirements of “identical” products (including products of like design, with respect to the relevant interface(s)), which may be interfaced with other mating products at the installation site, have been fulfilled. Refer to Annex A for examples.

3.1.6**life cycle**

A series of identifiable stages through which an item goes, from its conception to disposal.

3.1.7**pre-deployment test**

A test(s) conducted to verify that the specified requirements, for a product that is ready for deployment, are still fulfilled. Refer to Annex A for examples.

3.1.8**site received test****SRT**

A test(s) conducted to verify that the specified requirements, for a product that has been transported from one site to another, are still fulfilled. Refer to Annex A for examples.

3.1.9**system function test****SFT**

Test(s) conducted to validate that the requirements for a specific intended use or application, of a set of products that form a “complete” functional system, have been fulfilled. Refer to Annex A for examples.

3.1.10**system integration test****SIT**

A test(s) 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. Refer to Annex A for examples.

3.1.11**validation testing**

A test(s) conducted to confirm that the requirements for a specific intended use or application of a product have been fulfilled. Refer to Annex A for examples.

3.1.12**verification testing**

A test(s) conducted to confirm that the specified requirements for a product have been fulfilled. Refer to Annex A for examples.

3.2 Acronyms and Abbreviations

BOP	blowout preventer
CRA	corrosion-resistant alloy
C/WO	completion/workover
EFAT	extended factory acceptance test

EFL	electrical flying lead
FAT	factory acceptance test
FMEA	failure modes and effects analysis
FMECA	failure mode, effects, and criticality analysis
HAZOP	hazard and operability study
HFL	hydraulic flying lead
HIPPS	high integrity pressure protection system
HPHT	high-pressure/high-temperature
HPU	hydraulic power unit
HSE	health, safety, and environment
ICT	interchangeability test
IWOCS	installation workover control system
LRFD	load and resistance factored design
MCS	master control station
MODU	mobile offshore drilling unit
MPFM	multiphase flow meter
NORM	naturally occurring radioactive materials
OEM	original equipment manufacturer
OREDA	offshore and onshore reliability data
PDT	pre-deployment test
PLEM	pipeline end manifold
QRA	quantitative risk assessment
RAM	reliability, availability, and maintainability
ROT	remotely operated tool
ROV	remotely operated vehicle
SCM	subsea control module
SFT	system function test
SIT	system integration test
SRT	site received test
SUDU	subsea umbilical distribution unit
SUT	subsea umbilical termination
TCRT	tree cap running tool
THRT	tubing hanger running tool
TRT	tree running tool
USV	underwater safety valve
VIV	vortex induced vibration
WSD	working stress design

4 Subsea Production Systems

4.1 General

Subsea production systems range in complexity from a single satellite well linked to an offshore or onshore installation to several wells comingled in a subsea manifold producing to a fixed, floating, or onshore facility.

Subsea production systems can be used to produce from shallow-water or deepwater reservoirs. Deepwater conditions can inherently dictate development of a field by means of a subsea production system, since fixed structures such as a steel-piled jacket might be either technically infeasible or uneconomical due to the water depth.

Subsea equipment may be used for the injection of water/gas into various formations for disposal and/or to provide pressure maintenance to the reservoir, and/or for gas lifting operations.

4.2 System Configuration

The elements of the subsea production or injection system may be configured in numerous ways, as dictated by the specific requirements and the field development strategy. For a description of the various components, assemblies, and subsystems that can be combined to form a complete subsea system, refer to API 17TR13. Figure 1 provides an overview of a basic subsea system with references to the relevant API 17-series documents.

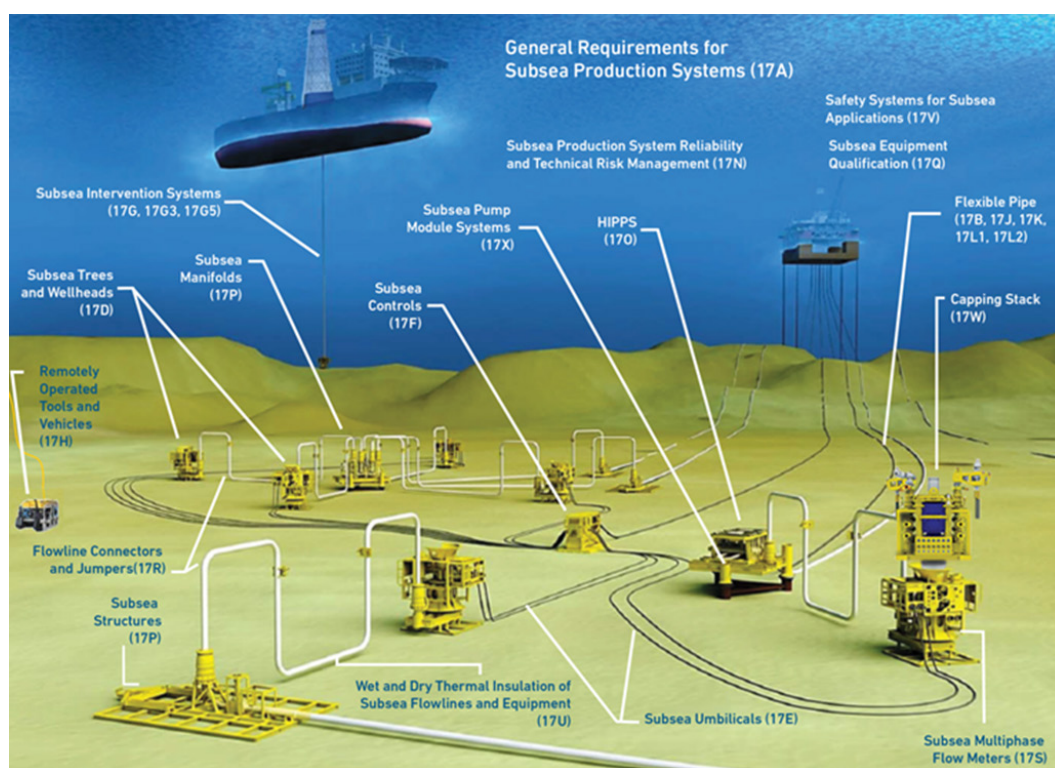


Figure 1—Basic Subsea Systems

4.3 Overview of API 17-series Documents by Categories

4.3.1 System Level Documents

Subsea documents that address system requirements include:

- **API 17A, Recommended Practice for the Design and Operation of Subsea Production Systems—General Requirements and Recommendations.** Provides general requirements and recommendations for

the development of subsea production systems, from the design phase to decommissioning and abandonment. This document also provides guidance to other API 17-series and related documents.

- **API 17N, Recommended Practice for Subsea Production System Reliability and Technical Risk Management.** Reliability is critical to subsea production system design and operation. This recommended practice (RP) provides a comprehensive approach to help ensure that reliability needs are achieved with subsea systems. It is broadly referenced in the deepwater technical community as a foundation document for addressing reliability.
- **API 17O, Recommended Practice for High Integrity Pressure Protection Systems (HIPPS).** This standard establishes criteria for high integrity pressure protection systems (HIPPS) that are seeing increased utilization in industry as a means to safely provide overall system pressure capability while restricting the section that requires full shut-in pressure rating to a segment that is close to the source.
- **API 17Q, Recommended Practice for Subsea Equipment Qualification.** This RP provides guidance on relevant qualification methods that may be applied to facilitate subsea project execution.
- **API 17V, Recommended Practice for Analysis, Design, Installation, and Testing of Safety Systems for Subsea Applications.** This RP provides a comprehensive treatment of the requirements for safety systems necessary for a variety of subsea applications.
- **API 17TR5, Avoidance of Blockages in Subsea Production Control and Chemical Injection Systems.** In addition to addressing the avoidance of blockages, this report also includes requirements and gives recommendations for the design and operation of subsea production systems with the aim of preventing blockages in control and production chemical fluid conduits and associated connectors/fittings.
- **API 17TR6, Attributes of Production Chemicals in Subsea Production Systems.** Production chemicals delivered to a subsea production system via a chemical injection system can be complex formulations that have a wide range of chemical and physical properties. In service, the production chemicals can come into contact with other fluids, metallic and polymeric materials, and a range of physical conditions related to temperature and pressure. This report was developed with the objective of minimizing the risk of a production chemical not being delivered at the required volumetric rate due to inadequate specification of the production chemical delivery system or formation of restrictions or blockages in that system.
- **API 17TR13, General Overview of Subsea Production Systems.** This document provides descriptions and basic design guidance on subsea production systems.

4.3.2 Subsea Hardware (Wellheads, Trees, Manifolds, Structures, Connectors, and Pumps)

Subsea documents that address assembled equipment include:

- **API 17D, Specification for Subsea Wellhead and Tree Equipment.** This specification provides specifications for subsea wellheads, mudline wellheads, drill-through mudline wellheads, vertical and horizontal subsea trees, and the associated tooling for handling, testing, and installing this equipment.
- **API 17P, Recommended Practice for Structures and Manifolds of Subsea Production Systems.** This RP addresses recommendations for subsea structures and manifolds used for pressure control in both subsea production of oil and gas and subsea injection services.
- **API 17X, Recommended Practice for Subsea Pump Module Systems.** This RP provides guidance for the design, manufacture, installation, and operation of subsea pumps, including rotary displacement and rotodynamic types for single-phase and multiphase services. This RP applies to all subsea pump modules placed at or above the mudline.
- **API 17TR3, An Evaluation of the Risks and Benefits of Penetrations in Subsea Wellheads Below the BOP Stack.** This report documents the results of a study of the risks and benefits of additional penetrations in subsea wellheads below the blowout preventer (BOP) stack for the purpose of monitoring activities.

casing annuli for sustained casing pressure. Special attention was paid to the risk and benefits introduced by monitoring annuli other than the “A” annulus (the annulus between the production tubing and the production casing strings).

- **API 17TR4, *Subsea Equipment Pressure Ratings*.** The impact of operation in deep water on the pressure rating of equipment is a special concern. The objective of this document is to foster a better understanding of the effects of simultaneous internal and external pressures on the rated working pressure of equipment covered by the scope of API 17D.
- **API 17TR7, *Verification and Validation of Subsea Connectors*.** This document provides requirements and recommendations for the verification and validation of subsea connectors along the vertical centerline of subsea hardware (i.e., tree, tubing head, tree cap, tree running tool, well control package connectors, and EDP connectors), the subsea wellhead, and the completion/workover riser. The methodology provided herein may also be used in other connector designs. Connectors outboard of the vertical centerline are addressed in API 17R.
- **API 17TR8, *High-Pressure High-Temperature (HPHT) Design Guidelines*.** Current API standards for deep water typically cover applications where the shut-in pressure is 15,000 psi or less. In recent years, industry has been pursuing deepwater assets that have shut-in pressures above 15,000 psi, and operators and regulatory agencies have had to address these applications on a singular basis. API 17TR8 establishes a standardized industry approach to the analysis, design, material selection, testing, and application of subsea component hardware for these HPHT applications.
- **API 17TR11, *Pressure Effects on Subsea Hardware During Flowline Testing in Deep Water*.** This report provides guidance to the industry on allowable pressure loading of subsea hardware components that can occur during hydrotesting of subsea flowlines and risers and during pre-commissioning leak testing of these systems. There are potential problems with confusion arising from high hydrostatic pressure in deep water, partially due to the variety of applicable test specifications and partly from the inconsistent use of a variety of acronyms for pressure terminology.
- **API 17TR12, *Consideration of External Pressure in the Design and Pressure Rating of Subsea Equipment*.** Historically, consideration of the benefit of external pressure in deepwater applications has been accepted in some applications involving the design and pressure rating of pipe. This report provides a detailed review of the full system considerations that must be taken into account if one is to consider external pressure in the design of an irregular-shaped subsea pressure-containing or pressure-controlling device.

4.3.3 Flowlines and Risers

Subsea documents that address risers and flowlines include:

- **API 17B, 17J, 17K, 17L1, and 17L2, *Flexible Pipe and Ancillary Equipment*.** These documents provide a comprehensive treatment of the design, manufacture, testing, packaging, and utilization criteria for both bonded and unbonded flexible pipe, as well as the ancillary equipment necessary to control the flexible pipe behavior, protect a transition area, or provide a means of attachment and seal.
- **API 17R, *Recommended Practice for Flowline Connectors and Jumpers*.** This RP provides applicable criteria for all types of remote connections, and associated pipework, made between subsea flowline/pipeline end connections, manifolds, and subsea trees. This RP covers subsea flowline connectors and jumpers used for pressure containment in both subsea production of oil and gas and subsea injection services.
- **API 17U, *Recommended Practice for Wet and Dry Thermal Insulation of Subsea Flowlines and Equipment*.** This RP provides guidance for the performance, qualification, application, quality control, handling, and storage requirements of wet and dry thermal insulation for subsea applications in the petroleum and gas industries. This document also covers the inspection of the insulation and the repair of insulation defects.

- **API 17TR1, *Evaluation Standard for Internal Pressure Sheath Polymers for High Temperature Flexible Pipes*.** This report defines the methodology and test procedures necessary for the evaluation of polymeric materials suitable for use as the internal pressure sheath of unbonded flexible pipes in high-temperature applications. It describes the processes by which the critical material properties, both static and dynamic, can be measured and evaluated against relevant performance criteria.
- **API 17TR2, *The Aging of PA-11 in Flexible Pipes*.** This report provides comprehensive guidance on materials and pipe issues regarding the use and operation of PA-11 in flexible pipe applications, typically in production and gas handling applications up to 100 °C. It concentrates on the use of PA-11 in the internal sheath of flexible pipes, although similar considerations may also apply to other uses of PA-11 within flexibles, e.g., anti-wear layers, intermediate sheathes, and outer sheathes.

4.3.4 Control Systems

Subsea documents that address control system requirements include:

- **API 17E, *Specification for Subsea Umbilicals*.** This document specifies requirements for the design, material selection, manufacture, design verification, testing, installation, and operation of subsea umbilicals and their ancillary equipment. It applies to umbilicals for static or dynamic service, with surface-surface, surface-subsea, and subsea-subsea routings.
- **API 17F, *Standard for Subsea Production Control Systems*.** This standard provides criteria for the design, manufacture, testing, and operation of various types of surface control system equipment, subsea control systems, and requirements for the associated control fluids. This equipment is used for control of subsea production of oil and gas and for subsea water and gas injection services.
- **API 17S, *Recommended Practice for Design, Testing, and Operation of Subsea Multiphase Flow Meters*.** This RP provides minimum requirements for subsea multiphase flow meters to help assure mechanical and electrical integrity, communications capability, and measurement performance for reliable use.
- **API 17TR9, *Subsea Umbilical Termination (SUT) Selection and Sizing Recommendations*.** The primary purpose of this document is to be a reference guide during the early field development planning stage to ensure that due consideration is given to the implications of the size of UTAs and possible consequences during installation.
- **API 17TR10, *Subsea Umbilical Termination (SUT) Design Recommendations*.** This report was generated in response to the increasing difficulties in the installation of high-functionality subsea umbilical terminations (SUTs), due to their increasing size. While there are universally accepted standards for the design of a SUT and its subsystems, none of these standards specifically address the subject of the risks of installation and the measures required to minimize these risks.

4.3.5 Intervention Systems

Subsea documents that address requirements for intervention systems include:

- **API Standard 17G, *Design and Manufacture of Subsea Well Intervention Systems*.** This standard defines a minimum set of requirements for performance, design, materials, testing and inspection, hot forming, welding, marking, handling, storing, and shipping of new build subsea well intervention equipment [through-BOP intervention riser system (TBIRS) and open-water intervention riser system (OWIRS)].
- **API Recommended Practice 17G3, *Design of Subsea Well Intervention Systems Using Non-Ferrous Alloys*.** This recommended practice provides design guidelines for the use of non-ferrous materials in subsea intervention systems and components.
- **API Recommended Practice 17G5, *Intervention Workover Control Systems (IWOCS)*.** This document provides the requirements for the design, manufacture, and testing of intervention workover control system (IWOCS) equipment.

- **API Recommended Practice 17H, *Recommended Practice for Remotely Operated Tools and Interfaces on Subsea Production Systems*.** This RP provides recommendations for the development and design of remotely operated subsea tools and interfaces on subsea production systems to maximize the potential of standardizing equipment and design principles. Criteria for standardized interfaces found in this document are used in nearly all other subsea operations (e.g., drilling, construction, etc.) that require remotely operated vehicle (ROV) support or interaction.
- **API Recommended Practice 17W, *Recommended Practice for Subsea Capping Stacks*.** This document captures the best practices in the design and operation of existing capping stacks and provides a foundation for consistent practices in the design, manufacture, testing, and utilization of future stacks. It is intended to be applied to the construction of new subsea capping stack components, but can be also used to improve existing subsea capping stacks.

5 Systems Engineering

5.1 General

Consistent with the following definitions provided by the International Council on Systems Engineering (INCOSE), system engineering of subsea production systems should address the complete system, from the reservoir to the host facility.

- “A system is an arrangement of parts or elements that together exhibit behavior or meaning that the individual constituents do not.”
- “Systems Engineering is a transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods.”

A complete system can include the following:

- fluid processing/injection system(s), e.g., separation systems, water/gas injection systems);
- associated support systems, e.g., subsea control system, chemical injection system, installation/workover system.

System engineering should consider the requirements of each of the life-cycle phases of a development, including:

- concept development;
- startup/operation;
- workover/maintenance/modification;
- decommissioning.

System engineering should consider all of the project activities required to deliver a complete, functional subsea production system, including:

- technology development/qualification;
- contracting;
- engineering;
- procurement;

- construction;
- inspection/testing;
- installation;
- systems completion;
- training.

Systems engineering is a systematic and holistic engineering approach covering the entire scope and life cycle of a subsea production system. Systems engineering includes consideration of all of the interfacing systems to the subsea production system.

The objectives of adopting a systems engineering approach include but are not limited to:

- ensuring the system performs as required (refer to 5.3);
- maximizing value for the various stakeholders;
- minimizing value erosion;
- recognizing and managing system level risks effectively and efficiently.

One of the most fundamental drivers in the design of any subsea production system is flow assurance, including hydraulic modeling of the various fluid flows from within the reservoir itself to the product export point(s) at the host facility.

5.2 Systems Engineering Process

General guidance on the systems engineering process can be found in the following documents:

- INCOSE Systems Engineering Handbook;
- ISO/IEC/IEEE 15288 Systems and Software Engineering – Systems Life Cycle Processes;
- ISO 26702 Application and Management of the Systems Engineering Process;
- NASA Systems Engineering Handbook;
- Systems Engineering Body of Knowledge (SEBoK).

The benefits of performing systems engineering are maximized by completing an appropriate level of systems engineering early in the project life cycle (i.e., during concept development/selection and front end engineering). As the project progresses through front end engineering and detailed design, further systems engineering needs to be performed at increasing levels of detail.

Like many fundamental project processes, systems engineering is both iterative and recursive in nature; for example:

- Due to the many interdependencies of the various sub-systems, various aspects of the system may need to be analyzed multiple times to optimize the design.
- System requirements successively cascade down (and up) to sub-systems, assemblies, components, and parts in increasing levels of detail.

The overall systems engineering process consists of the management of all of the technical aspects of the project. An evaluation of the need for application of the various systems engineering processes should be performed for each specific field development, based upon the unique and specific characteristics of the development. The systems engineering process should maintain focus on the information that is required to transfer the system from one phase to another through the complete project life cycle.

Further information on the topic of systems engineering (including INCOSE work to refine ISO/IEC/IEEE 15288 to reflect Agile principles) is contained in Annex B.

5.3 Subsea System Production Assurance and Reliability Management

Production assurance and reliability management is important for the safe and efficient operation of subsea production systems.

Redundancy of equipment, components, and/or functions should be analyzed as a system and should consider safety, cost, reliability, and availability. API 17N should be used as the primary source of guidance on reliability management activities, including FMECA analysis during each of the life-cycle phases.

Competing options/alternatives can be compared using a life-cycle costing approach, as described in ISO 15663. Application of ISO 14224 is relevant to ensure that correct reliability data are used in the reliability work processes. The best available subsea reliability data should be used in these reliability activities and analyses from appropriate sources [e.g., in-house reliability data, offshore and onshore reliability data (OREDA), JIP databases and handbooks]. In-house reliability data should be documented and justified by in-service records, calculations, and/or empirical tests, and should be checked for relevance to the proposed service and environmental conditions.

Consideration should be given to comparing spare parts lists against existing spare parts inventories managed by operations, particularly for brownfield projects, to optimize required spare parts. A recommended list of spare parts and ROV/ROT tooling is typically needed at the start of design to allow time for operations to determine spare order quantity and as input to operations and maintenance activity/procedure development.

Obsolescence of equipment is inevitable and may result in a loss of system availability. Guidance on obsolescence management in subsea systems is provided in 7.2.

Reliability, integrity, and technical risk management during design (from concept to detailed design) manufacture, assembly, testing, installation, and commissioning/systems completion should be performed at a procedural level. Implementation of these activities can be performed by the operator's subsea system project team and/or by the supplier/contractor. Further information and guidance on this topic can be found in API 17N and ISO 20815.

6 Equipment Design Requirements

6.1 Design Basis

This RP recommends a systemwide approach when designing and implementing subsea systems. This section discusses general design requirements that should be applied to the equipment design and cites references to relevant documents.

A detailed design basis should be developed to document design input to the equipment design. The basis-of-design document provides the project-specific data and references to key documents such as philosophies used during the design process. The basis of design should be updated as the design advances through the project phases.

The basis of design typically includes the following:

- description of the subsea system;