Specification for Flexible Pipe Ancillary Equipment

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This standard is under the jurisdiction of the API Subcommittee on Subsea Production Systems. API Subcommittee 17 documents consists of the following:

— RP 17A, *Design and Operation of Subsea Production Systems—General Requirements and Recommendations*

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

— RP 17C, *Recommended Practice on TFL (Through Flowline) Systems*

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

— Spec 17E, *Specification for Subsea Umbilicals*

— Spec 17F, *Specification for Subsea Production Control Systems*

— RP 17G, *Recommended Practice for Completion/Workover Risers*

— RP 17H, *Remotely Operated Vehicle (ROV) Interfaces on Subsea Production Systems*

— Spec 17J, *Specification for Unbonded Flexible Pipe*

— Spec 17K, *Specification for Bonded Flexible Pipe*

— Spec 17L1, *Specification for Flexible Pipe Ancillary Equipment*

— RP 17L2, *Recommended Practice for Flexible Pipe Ancillary Equipment*

— RP 17M, *Recommended Practice on Remotely Operated Tool (ROT) Intervention Systems*

— RP 17N, *Recommended Practice for Subsea Production System Reliabilityand Technical Risk Management*

— RP 17O, *Recommended Practice for Subsea High Integrity Pressure Protection Systems (HIPPS)*

— RP 17P, *Subsea Structures and Manifolds* (in press)

— RP 17Q, *Subsea Equipment Qualification–Standardized Process for Documentation*

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Introduction

This specification is the result of a Joint Industry Project to develop a worldwide industry standard for the design, material selection, manufacture, documentation, testing, marking and packaging of flexible pipe ancillary equipment. The objective of this specification is to provide an integrated approach, together with API 17B, API 17J, API 17K and API 17L2, to the design of flexible pipe systems. Therefore it is intended that this document be used in close conjunction with these documents.

Within this document, “shall” is used to state that a provision is mandatory; “should” is used to state that a provision is not mandatory, but is recommended as good practice; “may” is used to state that a provision is optional.

Systeme Internationale (SI) units are identified first when cited in the document. United States Customary (USC) units may be given in brackets after the SI units.

Specification for Flexible Pipe Ancillary Equipment

1 Scope

This specification defines the technical requirements for safe, dimensionally and functionally interchangeable flexible pipe ancillary equipment that is designed and manufactured to uniform standards and criteria.

Minimum requirements are specified for the design, material selection, manufacture, testing, documentation, marking and packaging of flexible pipe ancillary equipment, with reference to existing codes and standards where applicable. See API 17L2 for guidelines on the use of ancillary equipment.

The applicability relating to a specific item of ancillary equipment is stated at the beginning of the particular section for the ancillary equipment in question.

This specification applies to the following flexible pipe ancillary equipment:

— bend stiffeners;

— bend restrictors;

— bellmouths;

— buoyancy modules and ballast modules;

— subsea buoys;

— tethers for subsea buoys and tether clamps;

— riser and tether bases;

— clamping devices;

— piggy-back clamps;

— repair clamps;

— I/J-tube seals;

— pull-in heads/installation aids;

— connectors;

— load-transfer devices;

— mechanical protection;

— fire protection.

This specification may be used for bonded flexible pipe ancillary equipment, though any requirements specific to these applications are not addressed.

The applicability of requirements to umbilicals is indicated in the applicable sections of this specification for the ancillary equipment in question.

This specification does not cover flexible pipe ancillary equipment beyond the connector, with the exception of riser bases and load-transfer devices. Therefore this document does not cover turret structures or I-tubes and J-tubes for example. In addition, this document does not cover flexible pipe storage devices such as reels, for example.

This specification is intended to cover ancillary equipment made from several material types, including metallic, polymer and composite materials. It may also refer to material types for particular ancillary components that are not commonly used for such components currently, but may be adopted more frequently in the future.

This specification applies to ancillary equipment used in association with the flexible pipe applications listed in API 17B, API 17J, and API 17K.

Annexes to this specification are intended only as guidelines or for information.

2 Normative References

The following referenced documents are indispensable for the application of this specification. 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 2A-WSD, *Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms—Working Stress Design*

API Specificiation 2F, *Specification for Mooring Chain*

API Standard 2RD, *Dynamic Risers for Floating Production Systems*

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

API Recommended Practice 17B:2008, *Recommended Practice for Flexible Pipe*

API Specification 17D, *Specification for Subsea Wellhead and Christmas Tree Equipment*

API Specification 17J:2008, *Specification for Unbonded Flexible Pipe*

API Specification 17K:2005, *Specification for Bonded Flexible Pipe*

API Recommended Practice 17L2:2013, *Recommended Practice for Flexible Pipe Ancillary Equipment*

AFNOR NF E 25030 [1], Fasteners, threaded fasteners, design, calculation and installation conditions

AISC [2], *Steel Construction Manual*

ASME *Boiler and Pressure Vessel Code* [3], *Section VIII: Rules for Construction of Pressure Vessels*

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[1] 11, rue Francis de Pressensé, 93571 La Plaine Saint-Denis Cedex, France, www.afnor.org/en.
[2] American Institute of Steel Construction, One East Wacker Drive, Suite 700, Chicago, Illinois 60601, www.aisc.org.
[3] ASME International, 3 Park Avenue, New York, New York 10016-5990, www.asme.org.

ASTM C177 [3], *Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus*

ASTM C518, *Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus*

ASTM D256, *Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics*

ASTM D570, *Standard Test Method for Water Absorption of Plastics*

ASTM D624, *Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers*

ASTM D638, *Standard Test Method for Tensile Properties of Plastics*

ASTM D648, *Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position*

ASTM D695-08, *Standard Test Method for Compressive Properties of Rigid Plastics*

ASTM D732, *Standard Test Method for Shear Strength of Plastics by Punch Tool*

ASTM D792, *Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement*

ASTM D1418, *Standard Practice for Rubber and Rubber Lattices—Nomenclature*

ASTM D2240, *Standard Test Method for Rubber Property—Durometer Hardness*

ASTM D4060, *Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser*

ASTM E1269, *Standard Test Method for Determining Specific Heat Capacity by Differential Scanning Calorimetry*

BS PD 5500 [4], *Specification for Unfired Fusion Welded Pressure Vessels*

BS 903-A9, *Physical Testing of Rubber. Determination of Abrasion Resistance*

BS/EN 10083-1, *Steels for quenching and tempering. General technical delivery conditions*

BS/EN 10083-2, *Steels for quenching and tempering. Technical delivery conditions for non alloy steels*

DNV OS-D301 [5], *Fire Protection*

DNV, *Rules for Certification of Lifting Appliances* (1994)

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[3] ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.
[4] British Standards Institution, Chiswick High Road, London, W4 4AL, United Kingdom, www.bsi-global.com.
[5] Det Norske Veritas, Veritasveien 1, NO-1322 Hovik, Oslo, Norway, www.dnv.com.

ISO 34-1 [7], *Rubber, vulcanized or thermoplastic—Determination of tear strength—Part 1: Trouser, angle and crescent test pieces*

ISO 37, *Rubber, vulcanized or thermoplastic—Determination of tensile stress-strain properties*

ISO 62, *Plastics—Determination of water absorption*

ISO 75-1, *Plastics—Determination of temperature of deflection under load—Part 1: General test method*

ISO 75-2, *Plastics—Determination of temperature of deflection under load—Part 2: Plastics and ebonite*

ISO 178, *Plastics—Determination of flexural properties*

ISO 179-1, *Plastics—Determination of Charpy impact properties—Part 1: Non-instrumented impact test*

ISO 179-2, *Plastics—Determination of Charpy impact properties—Part 2: Instrumented impact test*

ISO 180, *Plastics—Determination of izod impact strength*

ISO 527-1, *Plastics—Determination of tensile properties—Part 1: General principles*

ISO 527-2, *Plastics—Determination of tensile properties—Part 2: Test conditions for moulding and extrusion plastics*

ISO 604, *Plastics—Determination of compressive properties*

ISO 868, *Plastics and ebonite—Determination of indentation hardness by means of a durometer (Shore hardness)*

ISO 1183, (all parts) *Plastics—Methods for determining the density of non-cellular plastics*

ISO 1431-1, *Rubber, vulcanised or thermoplastic—Resistance to ozone cracking—Part 1: Static and dynamic strain testing*

ISO 1827, *Rubber, vulcanized or thermoplastic—Determination of shear modulus and adhesion to rigid plates—Quadruple-shear methods*

ISO 4649:2010, *Rubber, vulcanized or thermoplastic—Determination of abrasion resistance using a rotating cylindrical drum device*

ISO 7743, *Rubber, vulcanized, or thermoplastic—Determination of compressive stress-strain properties*

ISO 7784-2, *Paints and varnishes—Determination of resistance to abrasion—Part 2: Rotating abrasive rubber wheel method*

ISO 10425, *Steel wire ropes for the petroleum and natural gas industries—Minimum requirements and terms of acceptance*

ISO 10474:2013, *Steel and steel products—Inspection documents*

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[7] International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland, www.iso.org.

ISO 15156, *Petroleum and natural gas industries—Materials for use in H_2S containing environments in oil and gas production*

NOTE For the purposes of this standard, NACE MR0175, *Materials for use in H_2S containing environments in oil and gas production,* is equivalent.

ISO 19902, *Petroleum and natural gas industries—Fixed steel offshore structures*

Lloyd's Register of Shipping [8], *Code for Lifting Appliances in a Marine Environment*

NORSOK M-501 [9], *Surface Preparation and Protective Coating*

NORSOK U-001, *Subsea Production Systems*

Waløen, Å. Ø.: *Maskindeler 2*, Tapir, NTNU (In Norwegian)

3 Terms, Definitions, Abbreviations, and Symbols

3.1 Terms and Definitions

For the purposes of this document, the terms and definitions given in API 17B, API 17K, API 17J, and the following apply. For description and additional information, see 4.2 of API 17L2:2013.

3.1.1
accidental load
Load caused by accidental occurrence.

3.1.2
anchor base
Structure used to secure one end of a tether to the seabed.

3.1.3
ancillary component
Component that is attached to the flexible pipe in order to perform one or more of the following functions:

a) to control the flexible pipe behavior;

b) to provide a structural transition between the flexible pipe and adjacent structures;

c) to attach other structures to the flexible pipe;

d) to protect or repair the flexible pipe;

e) to provide a seal along the flexible pipe length.

3.1.4
audit
Documented investigation conducted by the purchaser to verify that applicable requirements are being implemented.

3.1.5
ballast module
Negatively buoyant component of which a number are used at discrete points over a length of flexible pipe to provide added weight.

[8] Lloyd's Register of Shipping, 71 Fenchurch Street, London EC3M 4BS, United Kingdom, www.lr.org.
[9] Norwegian Technology Centre, Oscarsgt. 20, Postbox 7072 Majorstuen, NO-0306 Oslo, Norway, www.nts.no/norsok.

3.1.6
banding
Device used to secure mechanical protection to the flexible pipe.

3.1.7
batch
Quantity of product produced during one operation.

3.1.8
bend restrictor element
vertebra
Unit part of bend restrictor, of which a series are linked together to form the complete length of the bend restrictor.

3.1.9
bend stiffener base
Face of the interface structure on the support structure side at which the bend stiffener begins.

3.1.10
bend stiffener body
Polymeric part of a bend stiffener that provides extra stiffness to the flexible pipe to prevent it from overbending.

NOTE The bend stiffener body, for a particular bend stiffener configuration, is shown in Figure 1.

3.1.11
bend stiffener cap
Structural component of some bend stiffener designs comprising a cylindrical metallic shell that fits externally around part of the bend stiffener length adjacent to the bend stiffener base.

NOTE 1 An example of a bend stiffener cap, for a particular bend stiffener configuration, is shown in Figure 1.

NOTE 2 Bend stiffener caps often incorporate the male part of the bend stiffener mechanism, and the bellmouths often incorporate the female part.

3.1.12
bend stiffener latching mechanism
A structure or mechanism that connects a bend stiffener to a supporting structure allowing the bending moment to be transferred from the bend stiffener to the supporting structure.

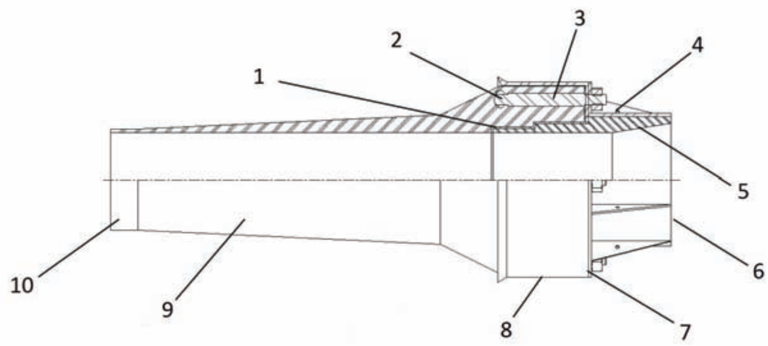
3.1.13
bend stiffener protective liner
Polymeric sleeve that internally covers the end fitting recess in an end fitting adjacent interface structure, avoiding contact between flexible pipe's external sheath and metallic parts of the interface structure.

NOTE 1 An example of a bend stiffener protective liner, for a particular bend stiffener configuration, is shown in Figure 1.

NOTE 2 Protective liner may be applied to other equipment, e.g. bend restrictors.

3.1.14
bend stiffener tip
End of the bend stiffener body opposite the base.

NOTE The bend stiffener tip, for a particular bend stiffener configuration, is shown in Figure 1.



Key

1 interface structure	5 flared liner	9 body
2 reinforced structure	6 top structure	10 tip
3 stud bolt	7 flange	
4 structural ribs	8 cap	

Figure 1—Example of I-tube Bend Stiffener

3.1.15
bending stress
Portion of primary stress proportional to the distance from the centroid of a cross section, excluding the effects of discontinuities and stress concentrations.

NOTE Definition taken from API 2RD.

3.1.16
blown foam
Polymer foam containing no microspheres or macrospheres.

3.1.17
bridle
Rigging components chain, with a Y-shape that may be used to connect a device attached to a flexible pipe (typically a tether clamp) to a fixed point.

3.1.18
buoyancy element
Part of a buoyancy module or some subsea buoys that gives uplift to the module or buoy.

NOTE The buoyancy element comprises a buoyant material that may have a protective external skin. It does not include buoyancy tanks.

3.1.19
buoyancy module
Discrete component, consisting of a buoyancy element, an internal clamp and any necessary fasteners to secure these components in position, used to provide net uplift to flexible pipes by attaching a series of such components along a length of pipe.

3.1.20
buoyancy tank
Part of some subsea buoys that consists of a pressure vessel filled with gas at ambient or higher pressure that gives uplift to the subsea buoy.

3.1.21
chemical ageing
Degradation of a material over time, due to exposure to chemicals, caused by changes at the molecular level.

3.1.22
Chinese finger
Device used during flexible pipe installation that consists of a meshed structure that grips around the flexible pipe outer sheath.

NOTE The mesh is configured such that the higher the load applied to it the tighter its grip.

3.1.23
clamp body
Part of a clamp that is in surface contact with the flexible pipe outer sheath.

3.1.24
clamp inner-liner
Part of some clamp bodies that consists of a compliant lining of material in contact with the flexible pipe outer sheath that allows for variations in the flexible pipe external diameter.

3.1.25
composite
Combination of a polymer material and a reinforcing material that enhances the properties of the polymer.

3.1.26
composite syntactic foam
Composite material consisting of a polymer matrix containing both microspheres and macrospheres.

3.1.27
connector
Device used to provide a leak-tight structural connection between the end fitting and adjacent piping.

NOTE It does not include flexible pipe end fittings.

3.1.28
crushing capacity
Maximum localized radial compressive load that a flexible pipe can resist.

3.1.29
deformed locking radius
Radius of a bend restrictor during lock-up with applied loading.

3.1.30
design methodology verification report
Evaluation report prepared by an independent verification agent at the time of an initial review, for a specific manufacturer, confirming the suitability and appropriate limits on the manufacturer's design methodologies.

NOTE The design methodology verification report can include occasional amendments or revisions to address extensions beyond previous limits or revisions of methodologies.

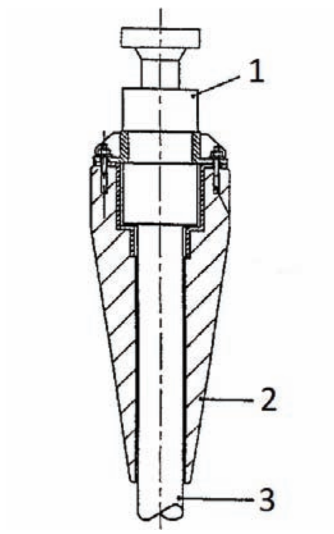
3.1.31
design verification
Process of proving design by analysis and/or testing.

3.1.32
dry repair
Repair of a flexible pipe that has been retrieved from the water.

3.1.33
dynamic bend restrictor
Design scenario where there is intermittent lock-up between bend restrictor elements induced by external forces such as wave and current environmental loads.

3.1.34
end fitting adjacent interface structure
Bend stiffener interface structure where the end fitting is positioned within the interface structure.

NOTE An example of an end fitting adjacent structure is shown in Figure 2.



Key

1 end fitting
2 bend stiffener
3 flexible pipe

Figure 2—Example of Bend Stiffener End Fitting Adjacent Interface Structure

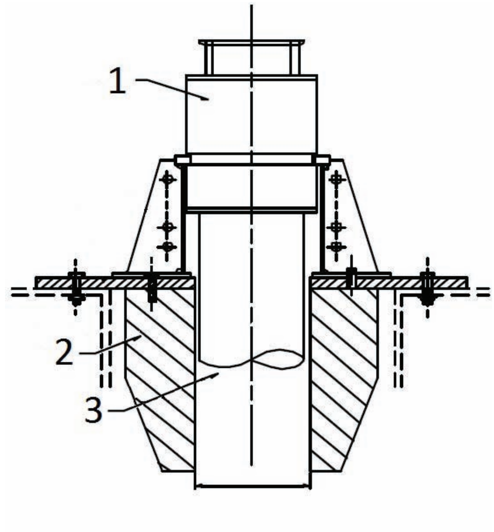
3.1.35
end fitting remote interface structure
Bend stiffener interface structure where the end fitting is positioned outside the interface structure.

NOTE An example of an end-fitting remote interface structure is shown in Figure 3.

3.1.36
environmental load
Load induced by external environmental parameters.

3.1.37
final net buoyancy
Net buoyancy at the end of the service life.

3.1.38
fire protection
Layer of material that provides passive fire protection to the flexible pipe for a specified duration of time in the event of a fire.



Key

1 end fitting
2 bend stiffener
3 flexible pipe

Figure 3—Example of Bend Stiffener End Fitting Remote Interface Structure

3.1.39
flexible pipe system
Fluid conveyance system for which the flexible pipe(s) is the primary component and which includes ancillary components attached directly or indirectly to the pipe.

3.1.40
flexible riser base connection
Part of a riser base that forms the transition between the flexible pipe end fitting and the riser base structure.

3.1.41
free-locking radius
Radius of a bend restrictor during lock-up without applied loading.

3.1.42
functional loads
All loads on the ancillary equipment during operation.

3.1.43
galling
Gradual removal of material from a surface due to repetitive relative motion with an adjacent surface.

3.1.44
gutter
Part of a subsea arch that the flexible pipe rests on and may be clamped to.

3.1.45
heat distortion temperature
Temperature at which an applied load causes a test sample to deflect by a specified amount.

3.1.46
high power buoyancy
Buoyant length of a flexible pipe with relatively high net buoyancy per unit length.

3.1.47
hybrid bend restrictor
Bend restrictor with a combination of polymer and metallic elements.

3.1.48
hydrogen embrittlement
Weakening of metallic material due to connection to CP system.

3.1.49
hysteresis
Bending behavior of a flexible pipe characterized by a change in the bending stiffness, observable in the moment-curvature relationship, when the friction of the flexible pipe tensile armour layers is overcome and the contribution of the polymer layers to the bending stiffness dominates.

NOTE When the direction of curvature is changed, the higher stiffness due to friction resumes until it is again overcome. The moment-curvature relationship is similar to an elastic-plastic response and, for regular cyclic bending, forms a closed loop.

3.1.50
I/J-tube seal
Device that fits around a flexible pipe and is used to provide a pressure-tight seal in an I/J-tube in order to contain corrosion-inhibited fluid within.

3.1.51
independent verification agent
Independent party or group, selected by the manufacturer, that can verify the indicated methodologies or performance based on the technical literature, analyses, test results and other information provided by the manufacturer.

NOTE The independent verification agent is also called upon to witness some measurements and tests related to material qualification.

3.1.52
initial net buoyancy
Net buoyancy before immersion in seawater.

3.1.53
installation
Integration of the ancillary equipment into the flexible pipe system.

NOTE This term does not refer to installation of the flexible pipe unless specifically stated.

3.1.54
interface structure
Structure that transfers loads from a bend stiffener or bend restrictor to the adjacent structure.

3.1.55
internal clamp strap
Part of some buoyancy modules that secures the internal clamp body to the flexible pipe.

NOTE The internal clamp strap is positioned within the interior of the buoyancy element.

3.1.56
I-tube bend stiffener
Bend stiffener attached at the topside connection to a flexible pipe that is hung-off the vessel/platform via an I-tube.

NOTE An example of an I-tube bend stiffener is shown in Figure 1.

3.1.57
lifting point
Connection point on a structure used to interface with lifting equipment.

3.1.58
load-transfer device
Device that is used to transfer loads from the flexible pipe end fitting or bend limiter interface structure to the topsides structures but does not have any pressure-containing capacity.

3.1.59
lock-up
Locking together of individual bend restrictor elements.

3.1.60
low power buoyancy
Buoyant length of a flexible pipe with relatively low net buoyancy per unit length.

3.1.61
lower catenary
Length of flexible pipe between the riser base and the subsea buoy.

3.1.62
macrosphere
Ceramic, polymer or composite spheres greater than 1 mm in diameter that form a structural part of composite syntactic foams.

3.1.63
manufacturer
For the purposes of this specification, the manufacturer of the ancillary equipment.

3.1.64
mechanical protection
Layer of material that encloses a prescribed length of flexible pipe in order to protect it against abrasion and impact loads or to provide clearance between the flexible pipe and other subsea lines.

3.1.65
membrane stress
σ_m
Average stress value across the thickness of a solid section, excluding the effects of discontinuities and stress concentrations.

NOTE Definition taken from API 2RD.

EXAMPLE The general primary membrane stress in a pipe loaded in pure tension is the tension divided by the cross-sectional area. σ_m may include global bending as in the case of a simple pipe loaded by a bending moment.

3.1.66
microsphere
Ceramic, polymer or composite sphere between 1 μm and 1000 μm in diameter that forms a structural part of syntactic and composite syntactic foams.

3.1.67
mix
Unique mix of polymer material constituent components.

3.1.68
module element
Part of a buoyancy or ballast module that gives uplift or added weight to the module.

NOTE The module element does not include buoyancy tanks.

3.1.69
net buoyancy
Resulting buoyancy after considering all buoyant and nonbuoyant components in a subsea buoy or buoyancy module.

3.1.70
overboarding chute
Arch-shaped structure positioned at the edge of a vessel that is used as an installation aid for flexible pipe.

3.1.71
oxidative ageing
Degradation of a material over time, due to exposure to oxygen, caused by changes at the molecular level.

3.1.72
passive fire protection
Coating, cladding, or free-standing system that provides thermal protection in the event of a fire and that requires no manual, mechanical or other means of initiation, replenishment or sustenance.

NOTE Definition taken from DNV OS-D301.

3.1.73
permanent ancillary equipment
Ancillary equipment that is to be used for the entire service life of the flexible pipe.

3.1.74
permanent bend stiffener
Bend stiffener that is to be used for the entire service life of the flexible pipe.

3.1.75
piggy-back clamp
Spacer in a piggy-back system that is clamped to the supporting and supported pipe and does not allow relative movement of the supported pipe.

3.1.76
piggy-back guide
Spacer in a piggy-back system that is clamped to the supporting pipe and allows relative movement of the supported pipe.

3.1.77
pull-in head
Device used during flexible pipe installation to connect the flexible pipe end fitting to a pull-in wire, consisting of structure that connects to end-fitting and a connection that interfaces with lifting equipment.

3.1.78
purchaser
Flexible pipe system provider who is purchaser to ancillary equipment manufacturer.

3.1.79
raw materials supplier
Supplier of raw materials for any of the components of an item of ancillary equipment.

3.1.80
reaction collar
Bend restrictor interface structure comprising a split-shell configuration that clamps around the flexible pipe end fitting.

3.1.81
reaction flange
Bend restrictor interface structure comprising a split flange arrangement that bolts directly to the support structure over which a bend restrictor element is assembled.

3.1.82
repair clamp
Clamp that is positioned over a damaged area of flexible pipe as a means to repair such an area.

3.1.83
riser base
Structure positioned on the seabed used to provide a structural and pressure-tight connection between a flexible riser and a flowline.

NOTE The riser base can be a pipeline end termination or a pipeline end manifold.

3.1.84
seabed connection
Connection between flexible riser end fitting and riser base.

3.1.85
seal element
Part of an I/J-tube seal that provides the seal.

3.1.86
secant modulus
Slope of line drawn through the origin of a stress strain curve and intersecting a point on the stress strain curve corresponding to specified strain.

3.1.87
setting time
Time required for polymer or composite component to reside in mould before being removed.

3.1.88
snatch load
Sudden load that acts on a slack tether with resulting dynamic amplification up to several times the applied tension.

3.1.89
spacer
Discrete component of which a number in series are used to piggy-back one or more supported pipes to a supporting pipe over a prescribed length.

3.1.90
subsea buoy frame
Structural part of a subsea buoy. Includes the gutters, housings for clamps and buoyancy tanks or buoyancy elements and connection points for tether connection hardware.

3.1.91
support structure
Structure that supports and transfers loads from a flexible pipe or bend limiter at either the topside, seabed or intermediate connection.

3.1.92
supported pipe
Pipe that is attached via a series of piggy-back clamps or guides to a supporting pipe over a prescribed length.

NOTE A supported pipe can be a flexible pipe.

3.1.93
supporting pipe
Pipe that supports one or more pipes via a series of piggy-back clamps or guides over a prescribed length.

NOTE A supporting pipe can be a flexible pipe.

3.1.94
syntactic foam
Composite material consisting of a polymer matrix containing microspheres and/or macrospheres.

3.1.95
system owner
Purchaser of flexible pipe system from flexible pipe system provider.

3.1.96
tear strength
Measure of the force necessary to cause tearing of a sample of material (nicked or un-nicked) under specified conditions.

3.1.97
temporary bend stiffener
Bend stiffener that is required to satisfy its functional requirements temporarily for flexible pipe installation, handling or other activities but not in service.

3.1.98
tether
Chain or rope used to connect a flexible pipe or a subsea buoy to a tether base, including connecting hardware necessary at each end termination.

3.1.99
tether base
Structure that secures one or a group of tethers to the seabed, including tether connection points and lifting points.

3.1.100
thermal ageing
Degradation of a material over time, due to temperature, caused by changes at the molecular level.

3.1.101
thermal shock
Exposure to a large temperature variation within a short time period.

3.1.102
topside connection
Connection between flexible pipe end fitting and platform.

3.1.103
truss
Structural member, made up of several individual slender parts welded or bolted together, designed to carry a tension or compression force with the complete structure acting as a beam.

3.1.104
upper catenary
Length of flexible pipe between the platform and the subsea buoy.

3.1.105
wet repair
Repair of a flexible pipe *in situ.*

3.2 Symbols and Abbreviated Terms

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

C_a allowable stress factor
$C_a = 0,67$

NOTE See API 2RD

C_f design case factor

NOTE See API 2RD

σ_b bending stress

σ_m membrane stress

σ_q secondary stress

σ_{sc} stress at structural capacity

$(\sigma_x)_e$ Von Mises component of stress for σ_x

EXAMPLE $(\sigma_m)_e$ is the Von Mises membrane stress.

AISI American Iron and Steel Institute

AWS American Welding Society

BS standard issued by BSI

BSI British Standards Institute

BV Bureau Veritas

CEN Committee on European Normalisation

CP corrosion protection

DIN Deutsches Institut für Normung e.V.

EEMUA	Engineering Equipment & Materials Users' Association
EPDM	ethylene propylene diene monomer
FAT	factory acceptance testing
FEA	finite element analysis
HMPE	high modulus polyethylene
GVI	general visual inspection
IAPSO	International Association for Physical Sciences of the Ocean
MBL	minimum breaking load
MBR	minimum bend radius
MBS	minimum breaking strength
MWL	mean water line
N/A	non-applicable
NDE	nondestructive examination
PCD	pitch circle diameter
PD	Published Document, terminology used by BSI
PLEM	pipeline end manifold
PLET	pipeline end termination
ROV	remotely operated vehicle
SBR	styrene butadiene rubber
SWL	safe working load
UKOOA	United Kingdom Offshore Operators Association
UV	ultraviolet
VIV	vortex-induced vibration

4 General Requirements

4.1 Description

All flexible pipe/umbilical ancillary equipment shall comply with Section 4 (General Requirements). Specific ancillary equipment shall comply with the subsequent sections (Section 5 onward). Clamping devices (buoyancy module clamps, subsea buoy clamps, tether clamps, piggy-back clamps and guides, repair clamps and I/J-tubes seals with clamps) shall comply with Section 12 (General Clamping Device Requirements).

This section covers minimum requirements for flexible pipe ancillary equipment that are general in nature. For a particular item of ancillary equipment, all applicable requirements in this section are cross-referenced in the subsequent sections.

Requirements of other standards included by reference in this specification are essential to the safety and interchangeability of the product provided.

Standards referenced in this specification may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard. Manufacturers who choose to use other standards in lieu of standards referenced herein are responsible for documenting the equivalency of the standards.

National standards and requirements (which may not all be referenced in this specification) may be relevant for some ancillary equipment in this document. In some countries it may be required to design and certify platforms/vessels and their associated equipment in accordance with the standards of the certifying agency.

4.2 Functional Requirements

4.2.1 General

The purchaser shall specify their functional requirements for the ancillary equipment. The purchasing guidelines in Annex A to Annex R give a sample format for the specification of the functional requirements.

Functional requirements not specifically required by the purchaser which may affect the design, materials, manufacturing and testing of the ancillary equipment shall be specified by the manufacturer.

4.2.2 Overall Requirements

The minimum overall functional requirements of the ancillary equipment that shall be demonstrated by the manufacturer are as follows.

a) The ancillary equipment shall be capable of withstanding all design loads defined in the design requirements section applicable to the ancillary equipment in question.

b) The ancillary equipment shall perform its function for the specified service life.

c) The ancillary equipment materials shall be compatible with the environment to which the material is exposed.

d) Ancillary equipment metallic materials shall conform as a minimum to the corrosion requirements specified in 4.3.11 and in the corrosion requirements section applicable to the ancillary equipment in question.

4.2.3 Flexible Pipe/Umbilicals Design Parameters

The purchaser shall provide a data sheet for all the flexible pipes to which the ancillary equipment is attached.

4.2.4 Temperature

4.2.4.1 Air

The purchaser shall specify, for ancillary equipment that is to comprise polymer or composite components, the minimum and maximum air temperatures associated with the following conditions:

a) storage;

b) transport;

c) installation;

d) service, where applicable (only relevant to ancillary equipment situated wholly or partly above the mean water line (MWL)).

4.2.4.2 Seawater

The purchaser shall specify the minimum and maximum seawater temperatures for the following conditions:

a) ancillary equipment polymer or composite components that are to be submerged wholly or partly in seawater;

b) ancillary equipment metallic components that are to be submerged wholly or partly in seawater and that are required to be protected by a dedicated corrosion protection (CP) system.

4.2.4.3 Pipe Outer Surface

Where polymer or composite components of the ancillary equipment are in direct contact with the pipe outer surface, on either a continuous or intermittent basis, the purchaser shall specify one of the following:

a) minimum and maximum temperature of the pipe outer surface due to the internal fluid temperature, on the basis of the following minimum set of considerations associated with the flexible pipe:

    1) operating temperatures;

    2) upset temperatures (number and range of cycles);

    3) gas cooling effects (time/temperature curve);

    4) fluid thermal characteristics;

    5) flow characteristics;

    6) storage, transport and installation conditions where applicable.

b) U-value of the pipe and minimum and maximum internal fluid temperature on the basis of the considerations in Item 1) to Item 6) above. The purchaser shall specify the reference diameter (internal or external) used to calculate the U-value. Where U-value is specified per unit length, the purchaser shall specify to which reference length this refers.

4.2.5 External Environment

The purchaser should specify whether ancillary equipment external polymer or composite components will be exposed to abnormally high levels of sunlight. This is relevant to hotter climates such as west of Africa. The purchaser should consider the expected cumulative length of exposure during storage, transport, installation and operation (if applicable). The manufacturer should, in turn, have defined allowable levels of ultraviolet (UV) exposure (see 4.7.5 of API 17L2:2013).

4.2.6 Corrosion Protection

The corrosion protection coating requirements for metallic structures, including interface structures and fasteners, should be specified. These requirements may include a particular coating material. The purchaser may also specify a particular corrosion allowance instead of or in combination with a coating material. Alternatively, the purchaser may specify a corrosion-resistant material. Corrosion-resistant metals may obviate the requirement for a corrosion protection system.

The CP system requirements for metallic structures should be specified. The requirement for a CP system may include a preference for a particular anode material. It should be taken into account that it is not necessary to connect some components to a CP system because they are corrosion-resistant materials. All surfaces electrically connected to the CP system shall be taken into account when designing the CP system anodes quantity.

4.2.7 Installation

The purchaser shall specify ancillary equipment installation procedures and/or flexible pipe installation procedures that involve the ancillary equipment, as soon as they are available. These installation procedures shall provide sufficient information to the manufacturer to be able to determine the installation loads (if not specified separately, see 4.2.8) on the ancillary equipment and any parameters that could have implications on the ancillary equipment design.

4.2.8 Design Loads

Ancillary equipment loadcases that are induced by the flexible pipe shall be specified as in accordance with all load conditions specified in Table 6 of API 17J: 2008.

The purchaser shall specify any safety factors and their corresponding magnitude that have been incorporated into the design loads that they have specified.

The purchaser shall specify whether all the load-bearing components of permanent ancillary equipment are to be inspected during operation under an integrity and condition-monitoring program such that the manufacturer can determine the fatigue safety factor to use in accordance with 4.3.6.5.

The purchaser shall, where applicable, specify the points of application of design loads acting on the ancillary equipment. The purchaser shall also, where applicable, describe the axis system relating to the direction of the design loads acting on the ancillary equipment such that there is sufficient information for the manufacturer to convert the loads to another axis system.

4.2.9 Quantities

The purchaser shall specify, where applicable, the required quantity of the ancillary equipment required.

4.2.10 Spares

The purchaser should specify any requirements for numbers of spare items or components of ancillary equipment to offset any losses due to damage, for example.

4.2.11 Marking

The purchaser should specify any requirements for marking of the ancillary equipment. Minimum marking requirements are given in 4.8.1.

4.2.12 Pigmentation

The purchaser should specify any preferences for pigmentation of the ancillary equipment.

4.2.13 Documentation

The purchaser should specify the documentation, as listed in 4.6, to be delivered by the manufacturer.

4.2.14 Project Information

The purchaser shall specify, as a minimum, the following information relating to the project in question:

a) project title;

b) location of development;

c) delivery date;

d) location of delivery;

e) delivery terms and conditions.

4.3 Design Requirements

4.3.1 General

The ancillary equipment design is based on the information supplied by the purchaser (see guidelines of Annex A to Annex R) in accordance with the functional requirements section for the ancillary equipment in question. All this information shall be defined in the design premise (see 4.6.2), including design load cases and design acceptance criteria.

The design load cases shall be defined to analyze, as applicable, the effect on the ancillary equipment of functional, environmental and accidental loads, where applicable.

4.3.2 Load Combinations and Conditions

The ancillary equipment design shall be shown to meet the design requirements under all load combinations specified in this section and the subsequent section applicable to the ancillary equipment. Variation of the loads in time and space, load effects from the flexible pipe and its supports as well as environmental conditions shall be analyzed.

The design load conditions that shall be analyzed are, where applicable, flexible pipe transportation, installation, operation, fatigue, accidental and testing of the flexible pipe (where loads are induced in the ancillary equipment). Load combinations shall be as defined in the notes for Table 5 and the column headings in Table 6 of API 17J:2008. Load combinations with a yearly probability of occurrence less than 10^{-4} can be ignored. Factory acceptance test (FAT) load combinations, where applicable, shall be defined by the manufacturer based on the FAT procedures.

Results of the design load case analyses shall be shown to meet the design acceptance criteria and shall be documented in the design report

Design checks shall be carried out for any temporary conditions specified by the purchaser or the manufacturer. These shall include temporary conditions experienced by the ancillary equipment during storage, transport and installation. These shall be subject to the same design criteria as the design load conditions, as specified in the design criteria sections of this specification.

The simultaneous occurrence of different load combinations shall be defined in the manufacturer's design premise (see 4.6.2). The probability of specific load classes or subclasses may be specified by the purchaser based on project-specific conditions. The probabilities of accidental and installation-related events should be specified by the purchaser. If the purchaser does not specify probabilities, the manufacturer shall propose the probabilities that will be used for the individual events in the design premise.

4.3.3 Load Interface Management

The manufacturer shall have documented procedures to ensure that global loads supplied by the purchaser are applied in the correct position in local analyses of the ancillary equipment. The manufacturer shall also have documented procedures to ensure that any differences between global and local axis systems are accounted for in the transfer of loads between global and local analyses.

4.3.4 Design Load Effects

For fatigue analysis, the distribution of loads over the service life of the ancillary equipment shall be based on methods which include all load parameters. Simplified methods are acceptable if the resulting load distribution can be shown to be conservative.

4.3.5 Design Methodology

4.3.5.1 Design Documentation

Initially and whenever revisions occur, the design methodology and manufacturing processes for permanent ancillary equipment shall be verified by an independent verification agent. The documentation submitted for verification of the design methodology shall include methodologies, any calculations performed and software tools used for the following, as a minimum:

a) description of theoretical basis, including calculation procedures for the design parameters required for the design report;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) validation of design methodologies and software tools with prototype tests, initially and whenever the current design is outside the envelope or set of previously verified designs (4.3.7). See API 17L2 for guidelines on when the design is outside the envelope of previously verified designs. The validation shall include the capacity of all the ancillary equipment components. Simplified conservative analysis methods for checking of noncritical components are acceptable if the method does not influence the reliability of the calculation of stresses in the other components, and if approved by the purchaser;

d) documented basis for stress concentration factors used including results of supporting finite element analysis (FEA) analysis;

e) documented basis for utilization factors, if these factors are not already specified;

f) documented basis for polymer and composite material endurance limits or fatigue safety factors where applicable;

g) overview of CP system design methodology where applicable;

h) manufacturing and design tolerances;

i) description of procedures and devices used to control manufacturing processes;

j) calculations demonstrating that design satisfies functional requirements accounting for variations within manufacturing tolerance envelopes;

k) description of welds used for metallic components;

l) other effects that influence structural capacity;

m) documentation of service life methodology, subject to the requirements of 4.3.8 to 4.3.10.

4.3.5.2 Independent Verification

The independent verification agent shall review and evaluate the design methodology and the manufacturing processes to establish the range of applications for which they are suitable. The independent verification agent shall issue a certificate and a Design Methodology Verification Report describing the limits and constraints of the design methodology. The certificate shall be included by the manufacturer in the design report (see 4.6.3) and the Design Methodology Verification Report shall be available for review by the purchaser and flexible pipe system owner at the manufacturers' premises.

The design methodology shall account for the effects of the following unless the design is documented not to suffer from such effects:

a) corrosion of metallic components unless the metal is documented to be corrosion-resistant in the specified environment;

b) creep of polymer and composite materials subjected to constant loading;

c) water absorption of polymer and composite materials in subsea ancillary equipment or ancillary equipment in contact with water;

d) ageing of polymer and composite materials (due to mechanical, chemical and thermal degradation), see 4.4.4;

e) exposure of polymer and composite materials to sudden temperature variations;

f) effects of nonlinear material properties;

g) effect of design temperatures on material properties;

h) rupture or cracking of polymer and composite materials.

If the ancillary equipment design is outside the envelope of previously verified designs, then the manufacturer shall perform sufficient prototype tests to verify the design methodology for this new design and obtain a revision or amendment of the Design Methodology Verification Report by an independent verification agent. The determination of whether the ancillary equipment design is outside the envelope of previously verified designs should be determined by the purchaser based on the guidance provided in 4.6.3 of API 17L2:2013 and the subsequent applicability of prototype tests sections therein. The prototype tests shall verify fitness for-purpose for those design parameters which are outside the previously validated envelope. See API 17L2 for guidelines on the tests which should be performed and recommendations on the test procedures.

4.3.6 Design Criteria

4.3.6.1 Steel Components

Steel components (but not truss structures, pressure vessels, or ancillary equipment that performs a lifting function) shall be designed to the criteria specified in Table 1, and components comprising other materials (i.e. other metallic and polymer and composite components) shall be designed to independently verified and documented criteria specified by the manufacturer [see 4.3.5.1 e)], subject to the requirements of this section. For truss structures, allowable deformations shall be in accordance with an appropriate international standard such as API 2A or AISC *Steel Construction Manual*. Ancillary equipment that performs a lifting function shall be designed in accordance with national regulations and an appropriate international standard such as those listed in Table 2. Allowable stresses for the other structures shall be in accordance with appropriate international standards of which examples are listed in the relevant sections of this specification.

4.3.6.2 Corrosion

Corrosion analysis (as per 4.3.11.5) shall show that the material loss from corrosion does not cause utilization factors to exceed the criteria of this section under all load combinations.

4.3.6.3 Stress

The utilizations as specified in Table 1, which are not applicable to truss structures, pressure vessels, ancillary equipment that perform a lifting function or tethers, shall be calculated as the ratio of peak stress, at a point in the structure, to structural capacity. The stress shall be calculated using the design methodology specified in 4.3.5 and the subsequent design methodology sections, subject to the design requirements of 4.3.7 and the subsequent design sections. The calculated value shall include dynamic loads where applicable. The structural capacity shall be the minimum of the yield strength and 0,9 times the ultimate tensile strength of the material where tensile testing will accurately identify only this latter property. The yield or ultimate strength value used for design shall be either the mean value minus two standard deviations from the documented test data, or the minimum value as certified by the supplier.

NOTE The steel utilization values have been selected in order to be consistent with the utilizations specified for steel components of the flexible pipe in API 17J. In accordance with 4.3.5.1 e), the manufacturer is required to submit as part of the design methodology a documented basis for utilization values not already specified in this specification, i.e. nonsteel metallic materials and polymer and composite materials.

4.3.6.4 Polymers/Composites

Polymer and composite material utilizations may be a factor of either the maximum allowable strain or stress and shall account for the following:

a) material stress/strain behavior established by small-scale material testing;

b) reduction in mechanical properties due to ageing in the specified environment, if the maximum allowable strains or stresses are for un-aged material. Accounting for the effect of the reduction in properties through utilization factors may be ignored for loads that act at the start of the service life (installation and FAT/Flexible Pipe Hydrostatic Test loads);

c) creep behavior, if component is subjected to constant loading. The utilization factor shall be such as to prevent creep failure or loss of functional requirements during the service life, unless a creep analysis has been performed and demonstrated that there will not be any creep failure of the material or loss of functional requirements.

4.3.6.5 Fatigue

Fatigue life calculations shall be performed in accordance with the requirements of 4.3.10. Where calculated, the predicted fatigue life of steel components whose external surfaces are noninspectable for crack sizes that are critical for fatigue, shall be at least 10 times the required service life. Where calculated, the predicted fatigue life of other metallic materials (e.g. titanium) and polymer and composite components shall use an independently verified fatigue safety with a documented basis. However, this fatigue safety factor shall be at least 10 times the required service life for noninspectable components and at least 3 for inspectable components. Where it is practical to inspect all the surfaces of all the load-bearing components of the ancillary equipment for crack sizes that are critical for fatigue under the integrity and condition-monitoring program, this factor may be reduced to 3. See the relevant integrity and condition monitoring sections of API 17L2 for guidelines and recommendations on integrity and condition monitoring.

NOTE The fatigue life factor of 10 has been selected in order to be consistent with the corresponding factor of the flexible pipe fatigue life in API 17J. This factor relates to the steel pressure and tensile armour layers of the pipe. The factor of 3 represents industry practice, such as in API 2RD, for steel components where all potential fatigue-induced flaws are accessible for inspection.

4.3.6.6 Reliability-based Design

Reliability-based design may be applied as an alternative design method. All relevant design criteria for the reliability-based design cases should then be considered. It shall be proven that the level of safety obtained is not less than that given by this specification for comparable design cases.

Table 1—Steel Permissible Utilization Factors (Not Applicable to Truss Structures, Pressure Vessels, Ancillary Equipment That Perform a Lifting Function or Tethers)

Design Criteria	Service Conditions [a]			Installation		Hydrostatic Pressure Test—Field Acceptance [a b]
	Normal operation					
	Recurrent operation	Extreme operation	Abnormal operation			
	Functional & environ-mental	Functional, environ-mental & accidental	Functional, environ-mental & accidental	Functional & environ-mental	Functional, environ-mental & accidental	
Stress	0,67/0,55 [c]	0,85	0,85	0,67	0,85	0,91

[a] The load conditions in the table refer to the load conditions of the flexible pipe to which the ancillary equipment is attached.
[b] Applicable to ancillary equipment that restrain flexible pipe outer diameter variations such as clamping devices, for example.
[c] Pressure-retaining ancillary equipment only.

Table 2—Lifting Standards

Designation	Title
API RP 2A	*Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms*
DNV	*Certification Notes 2.7-1 Offshore Containers*
DNV	*Rules for Certification of Lifting Appliances, 1994*
DNV	*Rules for Planning and Execution of Marine Operations*
Lloyd's Register of Shipping	*Code for Lifting Appliances in a Marine Environment*

4.3.7 Ancillary Equipment Design Requirements

It shall be demonstrated through calculation (in accordance with 4.3.6.3) that stresses and strains in ancillary equipment are within allowable limits for their respective materials. See 4.3.6 for requirements on utilizations for metallic, polymer and composite materials. The analysis shall account for the following:

a) design loads specified by the purchaser in accordance with the functional requirements section and the design loads specified in the loads section for the ancillary equipment in question;

b) preloads in fasteners and straps;

c) stresses in all components, including fasteners and welds;

d) any stress concentrations, in areas of geometric discontinuity such as bolt holes and fillet radii. Stress concentrations shall be determined using FEA.

Local stress analysis of metallic structures shall be carried out in accordance with an appropriate international standard some of which are listed in Table 3. Although some of the standards apply to fixed structures, some of the requirements are relevant to structures that are not fixed.

Table 3—Examples of Metallic Structural Design Standards

Designation	Title
ISO 19902	*Petroleum and natural gas industries—Fixed offshore steel structures*
API RP 2A	*Planning, Designing, and Constructing Fixed Offshore Platforms—Working Stress Design*
API Std 2RD	*Dynamic Risers for Floating Production Systems*
BS 6235	*Code of Practice for Fixed Offshore Structures*
DNV OS-C101	*Design of Offshore Steel Structures, General (LRFD Method)*
NORSOK N-001	*Structural Design*

Preload in fasteners for static applications shall be selected in order to provide sufficient compression in the bolted members to resist external loads and to create sufficient frictional forces between members to resist shear loads without exceeding the design criteria of Table 1 or, if not applicable, the relevant structural design standard. In dynamic applications, the preloads shall additionally be sufficient to limit the proportion of the cyclic stresses taken by the bolt such that the fatigue life criteria of 4.3.6.5 are satisfied.

4.3.8 Service Life—General

The service life of permanent ancillary equipment shall be as a minimum equal to the required service life of the flexible pipe to which it is attached, if it is not explicitly specified by the purchaser.

4.3.9 Service Life—Static Applications

The service life analysis of permanent ancillary equipment shall document the properties of the materials for the specified service life, in accordance with the requirements of the materials requirements section for the ancillary equipment in question. The minimum strength for metallic materials and minimum strength or elongation at break for polymer and composite materials, during the service life of the pipe, shall be used in the design calculations.

The analysis shall include as a minimum the following:

a) creep due to long term loads, dimensional changes, and strain to failure in the operating environment;

b) corrosion of metallic components unless the metal is documented to be corrosion-resistant in the specified environment;

c) ageing of polymer and composite materials (due to mechanical, chemical and thermal degradation).

Further to 4.3.9.1 a), it shall be documented in the design report that creep of polymer and composite components that are subjected to constant loading does not cause stresses/strains in the material to exceed allowable limits or cause the product to fail to meet its functional requirements over the specified service life. The manufacturer shall have available documentation from the material supplier or other party that supports the material creep properties being used in the design.

4.3.10 Service Life—Dynamic Applications

The requirements of 4.3.9 shall apply.

For metallic components in dynamic applications, if it has been demonstrated from material testing that all material stress ranges inclusive of stress concentrations (including fasteners and welds) are below a documented and verifiable endurance limit established by testing and approved by purchaser, fatigue calculations are not required. If any fatigue stress is above this endurance limit or an endurance limit cannot be established, fatigue damage shall be based on Miner's method, or other methods from an appropriate international standard, using design S-N curves that have been validated for the metallic materials used, under the applicable service environments.

Fatigue analysis of metallic components shall be performed in accordance with an appropriate international standard.

For polymer and composite components in dynamic applications where it has been demonstrated from material testing that all material stress ranges inclusive of stress concentrations are below a documented and verifiable endurance limit approved by the purchaser, fatigue calculations are not required. When any fatigue stress is above this endurance limit or an endurance limit cannot be established, fatigue damage shall be calculated, using design fatigue curves that have been validated for the materials used for the specified cyclic load frequencies and under the applicable service environments. The fatigue life may also be demonstrated by prototype testing. Where prototype testing is used, the test conditions including as a minimum the load range magnitude and material temperature shall be representative of the specified application. The number of load cycles shall be sufficient to demonstrate the required fatigue safety factor. The demonstration of fatigue life shall account for the effects of the manufacturing process and the dimensions of the full-scale product on the materials fatigue life.

4.3.11 Corrosion Protection

All external metallic surfaces of permanent ancillary equipment shall be prepared and coated in accordance with an appropriate international standard such as NORSOK M-501 for corrosion protection in the environmental conditions in question, unless the material is documented to be corrosion-resistant in the specified environment or a suitable corrosion allowance is being employed. The selection of the corrosion protection system shall consider the length of time that the component will be in storage and shall, if applicable, consider the length of time that the component is to be located in a subsea environment before installation operations commence. Temporary ancillary equipment shall be protected in accordance with above requirements should its storage duration before use either onshore, offshore or subsea lead to corrosion that would affect its functional requirements.

Selection of materials shall consider the effect of galvanic corrosion, if this could increase utilization factors above allowable limits. If there is the possibility of galvanic corrosion, dissimilar metals shall be isolated from one another with insulation, a coating, a sufficient corrosion allowance or a CP override.

Requirements for internal and external corrosion allowances shall be evaluated in accordance with the location, conditions of installation, and the requirements specified in the functional requirements section for the ancillary equipment in question. The manufacturer shall document this evaluation and its effect on the ancillary equipment components.

Corrosion-resistant overlay or corrosion-resistant alloys may be used in preference to a corrosion allowance. The manufacturer shall have documented records on the suitability of the corrosion-resistant overlay or alloys for the specified application and environment. Corrosion-resistant fasteners shall be selected in accordance with an appropriate international standard such as those listed in Table 4.

Table 4—Corrosion-resistant Fastener Standards

Designation	Title
ISO 3506-1	*Mechanical properties of corrosion-resistant stainless-steel fasteners—Part 1: Bolts, screws and studs*
ASTM A276	*Standard Specification for Stainless Steel Bars and Shapes*
ASTM A484/A484M	*Standard Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings*
ASTM A1014	*Standard Specification for Precipitation-Hardening Bolting Material (UNS N07718) for High Temperature Service*
ASTM B348	*Standard Specification for Titanium and Titanium Alloy Bars and Billets*
ASTM B446	*Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625), Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219), and Nickel-Chromium-Molybdenum-Tungsten Alloy (UNS N06650) Rod and Bar*
ASTM B637	*Standard Specification for Precipitation-Hardening Nickel Alloy Bars, Forgings, and Forging Stock for High-Temperature Service*
ASTM F2281	*Standard Specification for Stainless Steel and Nickel Alloy Bolts, Hex Cap Screws, and Studs, for Heat Resistance and High Temperature Applications*
NOTE This table is not an exhaustive list. In accordance with Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.	

The calculation of thickness for permanent metallic components shall include allowances for uniform corrosion rates calculated for the service life, unless the material is documented to be corrosion-resistant in the specified environment or protected by a CP system.

The effect of corrosion of metallic components shall account for permanent contact with seawater of appropriate salinity and oxygen content.

All external metallic surfaces shall be protected by a dedicated CP system, which shall have sufficient capacity to provide corrosion protection for the specified service life, in accordance with an appropriate international standard such as DNV RP-B401 or ISO 15589-2, unless any/all of the following apply.

a) The material is documented to be corrosion-resistant in the specified environment.

b) A sufficient corrosion allowance is being employed.

c) The structure is being protected by an adjacent CP system.

d) The structure is only required on a temporary basis, i.e. for installation, maintenance or repair.

The cathodic protection system design methodology shall be documented. If the ancillary equipment is reliant on the CP system of an adjacent structure, then the manufacturer shall have documented justification in the design report that this adjacent CP system is both compatible with and has sufficient capacity to give protection to the ancillary equipment for the specified service life.

The manufacturer shall design the ancillary equipment such that it is compatible with the CP system (if any) specified by the purchaser.

4.4 Material Requirements

4.4.1 General

The manufacturer shall have records of tests demonstrating that the materials selected for a specific application meet the functional requirements specified for the ancillary equipment, for the service life for storage, transport, installation and operation conditions. The documented test records shall conform to the qualification requirements sections for the ancillary equipment in question. Where suitable qualification records do not exist, the manufacturer shall arrange testing relevant to the application according to the qualification requirements section for the ancillary equipment in question.

All materials used in the ancillary equipment construction shall be documented to be compatible with seawater at the design temperatures where applicable.

The manufacturer shall document that all lubricants and coatings are compatible with all materials in the ancillary equipment with which they are in contact.

4.4.2 Qualification Requirements—General

The physical, mechanical, chemical and performance characteristics of all materials in the ancillary equipment shall be verified by the manufacturer through a documented qualification program. The program shall confirm the adequacy of each material based on test results and analyses, which shall demonstrate the documented fitness for purpose of the materials for the specified service life of the ancillary equipment. As a minimum, the qualification program shall include the tests specified in the qualification requirements section for the ancillary equipment in question. The qualification of materials by testing should consider all processes (and their variation) adopted to produce the ancillary equipment, which may impair the properties and characteristics required by the design.

Documented operational experience may be accepted as validation of long-term properties in environments that are equal to or less severe than the documented experience. This may be supplied in the form of a bridging document that relates previous experience to the current material application and operating conditions on the basis of surveyable logic and clearly defined acceptance criteria in terms of the following:

a) fatigue load mean stresses/strains, stress/strain ranges and associated numbers of cycles;

b) stresses/strains due to constant loads (creep loads);

c) temperature, including air and seawater temperatures and temperatures due to proximity to the flexible pipe as applicable;

d) UV exposure where applicable;

e) corrosivity of environment with respect to metallic materials, including temperature and seawater dissolved oxygen content and salinity;

f) environmental parameters that cause ageing of polymer and composite materials (see 4.4.4.3).

The bridging document shall include any combinations of the above that will affect the long term properties of materials.

The test methods shall be as specified in Table 5 or, if not, shall have their equivalency documented (as stated in Section 2). Modifications to standard test procedures may be performed if the modifications and corresponding sound justifications are documented in the material qualification documentation. The manufacturers may use their own methods/criteria or other ones developed by the raw material suppliers. In such cases, the methods/criteria shall be documented and the results correlated with the specific material application. The documented qualification performance shall be verified by an independent verification agent.

The manufacturer shall define allowable levels of UV exposure for polymer and composite materials that may be subjected to sunlight exposure during storage, transport, installation or service. This requirement may apply to the coating materials.

The manufacturer shall have documented methods for predicting the polymer properties for the specified service life. The manufacturer shall have available for review by the purchaser records of tests and evaluations, which demonstrate that the methods yield conservative results.

Table 5—General Test Procedures for Polymer Materials

Tests	Test Procedure
Abrasion resistance	ISO 7784-2 [a], ASTM D4060 [a], BS 903-A9, DIN 53516
Ageing resistance	See 4.4.4
Creep resistance	ASTM D2990 [d]
Compressive strength, modulus, strain at break	ISO 604 [b], ASTM D695 [b], ISO 7743
Density	ISO 1183, ASTM D792
Hardness	ISO 868 [b], ASTM D2240
Heat distortion temperature	ISO 75-1 [c], ISO 75-2 [c], ASTM D648 [c]
Impact resistance	ISO 179, ISO 180 [b], ASTM D256
Ozone resistance	ISO 1431-1
Shear strength, modulus, strain at break	ISO 1827, ASTM D732
Tear strength	ISO 34-1, ASTM D624
Tensile strength, modulus, strain at break	ISO 37, ISO 527-1 [b], ISO 527-2 [b], ASTM D638 [b]
Water absorption	ISO 62 [b], ASTM D570 [b]

[a] Standards similar in content but not technically equivalent.

[b] Standards are technically equivalent or identical for the test in question.

[c] The test method described as Method B of this test method, and test methods Ae and Be of ISO 75-1:1993 and ISO 75-2:1993 are technically equivalent.

[d] A creep test should be carried out if it can be demonstrated to be relevant to the design of the product.

Abrasion resistance and impact strength as measured using small-scale material tests shall only be used as comparative measures since it is difficult to accurately simulate the response to specific abrasion or impact loading scenarios.

4.4.3 Qualification Requirements—Metallic Materials

Metallic materials for structural components shall conform to the grades or quality levels specified in appropriate international standards such as those listed in Table 6, for example. See the qualification requirements—metallic materials section for the ancillary equipment in question for more specific standards, where applicable.

Table 6—Examples of Metallic Material Selection Standards

Designation	Title
API 2A	*Planning, Designing, and Constructing Fixed Offshore Platforms—Working Stress Design*
DNV OS-B101	*Metallic Materials*
EN/BS 10025	*European Structural Steel Standard*
NORSOK M-001	*Materials Selection*
NORSOK M-120	*Material Data Sheets for Structural Steel*

Metallic materials selection for permanent ancillary equipment shall consider corrosive attack appropriate to the environment that the material will be exposed to over the specified service life of the ancillary equipment.

Metallic materials for fasteners shall be selected in accordance with the grades or quality levels specified in appropriate international standards such as those listed in Table 7.

Table 7—Fastener Standards

Designation	Title
ISO 898-1	*Mechanical properties of fasteners made of carbon steel and alloy steel—Part 1: Bolts, screws and studs*
ISO 3506-1	*Mechanical properties of corrosion-resistant stainless-steel fasteners—Part 1: Bolts, screws and studs*
ASTM A193	*Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications*
ASTM A276	*Standard Specification for Stainless Steel Bars and Shapes*
ASTM A320	*Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service*
ASTM A484	*Standard Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings*
ASTM A1014	*Standard Specification for Precipitation-Hardening Bolting Material (UNS N07718) for High Temperature Service*
ASTM B637	*Standard Specification for Precipitation-Hardening Nickel Alloy Bars, Forgings, and Forging Stock for High-Temperature Service*
ASTM F2281	*Standard Specification for Stainless Steel and Nickel Alloy Bolts, Hex Cap Screws, and Studs, for Heat Resistance and High Temperature Applications*
EN 10025	*European Structural Steel Standard*
EN/BS 10083-1	*Steels for quenching and tempering. General technical delivery conditions*
EN BS 10083-2	*Steels for quenching and tempering. Technical delivery conditions for non alloy steels*
EEMUA 194	*Guidelines for Materials Selection and Corrosion Control for Subsea Oil and Gas Production Equipment*
NORSOK M-001	*Materials Selection*
NOTE This table is not an exhaustive list. As stated in Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.	

Metallic materials that are to be connected to CP systems shall be documented not to suffer hydrogen evolution resulting from cathodic charging to the extent that hydrogen embrittlement is experienced during the specified service life. Specifically, titanium materials connected to CP systems shall be protected against the formation of titanium hydrides, by the inclusion of electrically resistive coatings or otherwise. Qualification of metallic materials against hydrogen embrittlement shall establish, based on test results, the acceptable ranges of mechanical properties (e.g. hardness and yield strength) of processed materials (finished products). Qualification process shall also include the definition of appropriate test methods to check these properties during manufacturing.

There shall be measures in place to prevent galling of titanium components by use of protective coatings, lubrication or otherwise.

Corrosion rate should be measured through testing. The general corrosion rate and occurrence of pitting should be documented and used to identify a minimum and most likely service life based upon expected mean service conditions.

4.4.4 Ageing Resistance

The manufacturer shall have documented ageing prediction models for polymer and composite materials in the ancillary equipment. The models shall be based on testing and experience and shall predict the ageing or deterioration under the influence of environmental and load conditions that have been identified to be relevant through testing. Special attention should be given to deplasticization, hydrolysis, water absorption, creep and changes of dimensions. The ageing models may include accumulated damage concepts based on blocks of time or operational cycles of temperature/pressure under different exposure conditions. Ageing may be determined by change in either specified mechanical properties or in specified physicochemical characteristics, which includes reduction in the plasticizer content of the material. The ageing resistance should be documented through accelerated ageing testing in accordance with ISO 2578.

The manufacturer shall document, as part of the material qualification program, methods for predicting the material properties of polymer and composite materials for the specified service life. The manufacturer shall have available for review by the purchaser records of tests and evaluations that demonstrate that the methods yield conservative results. The prediction of material properties at the end of the service life shall account for all expected ageing phenomena, including thermal, oxidative and chemical ageing, where applicable, and other failure mechanisms of the material.

The manufacturer shall have documentation that demonstrates that the material does not degrade over the service life to an extent such that the functional requirements are not satisfied. The effects and parameters that shall be considered in evaluating material degradation should include the following:

a) exposure to seawater;

b) exposure to ozone in the air, if material is susceptible to ozone degradation;

c) exposure to sunlight;

d) maximum design temperature;

e) mechanical loads.

The qualification requirements section of this document specifies which polymer or composite material properties shall be documented and tested for aged samples of materials.

4.4.5 Quality Assurance Requirements—General

All materials used in the ancillary equipment shall be purchased in accordance with either a written material specification or an industry standard. The specification shall include measurable physical, mechanical, chemical and performance characteristics and tolerances.

All suppliers to the manufacturer shall have a documented quality assurance system.

As a minimum, metallic materials shall be certified to 3.1of ISO 10474:2013. Materials shall be tested at raw materials suppliers' or manufacturers' work site in accordance with the requirements of Table 8. Test results shall be recorded on material test certificates.

Test results shall conform to the manufacturer's specifications. The results of all tests made by the manufacturer and/or raw material suppliers shall be available for review by the purchaser.

Quality control of raw metallic materials shall be performed in accordance with the standard that the particular grade or quality level of metal has been selected in accordance with.

4.4.6 Quality Assurance Requirements—Documentation Requirements

The manufacturers' written specifications for metallic, polymer and composite materials shall include as a minimum the requirements of Table 9.

4.4.7 Quality Assurance Requirements—Storage

The manufacturers' quality plan shall show procedures for handling, storage and control of raw materials, which reflects the importance of material cleanliness, dryness, purity and traceability during each stage of manufacture.

4.4.8 Quality Assurance Requirements—Traceability

Materials shall be traceable and suitably marked for easy identification. In the case of polymer and composite constituent materials the type of material and the supplier's name and designation shall be identified.

Table 8—Minimum Raw Material Quality Control Test Requirements

Material	Test	Frequency
Polymer	Gel time [a]	One per batch
Microspheres and macrospheres	Hydrostatic crush pressure	One per batch
Metal	See 4.4.5	See 4.4.5

[a] Applies to mixed system.

Table 9—Requirements of Material Specifications

Requirements	Metallic Materials	Polymer and Composite Materials
Material composition/chemistry requirements, with tolerances	X	
Generic base polymer (ASTM D1418)		X
Physical and mechanical property requirements	X	X
Storage and age control requirements	X	X
Nondestructive examination (NDE) requirements	X	X
Acceptance and/or rejection criteria	X	X
Certification and records requirements	X	X
Marking, packaging, handling and traceability requirements	X	X

All raw hydroscopic polymer materials shall be bulk packaged in sealed containers having a moisture-resistant liner. Damaged packages shall be evaluated to determine if the damage has resulted in contamination of the material. Contaminated material shall be rejected.

4.5 Manufacturing Requirements

4.5.1 Quality Assurance Requirements—General

Manufacturing operations shall be performed in accordance with the manufacturer's written specifications, which shall conform to the requirements of this section and the manufacturing requirements section for the item of ancillary equipment in question.

Quality control requirements for materials to be used in the ancillary equipment manufacture shall be as specified in 4.4.6 to 4.4.8.

4.5.2 Quality Assurance Requirements—Documentation

All processing that converts or affects material properties, including moulding, curing, finishing, welding and coating, shall be documented in the manufacturer’s specifications. The specification shall include a statement of applicable scope, limits on critical process parameters, inspection and test methods and acceptance/rejection criteria. The specifications shall be approved by the engineering and manufacturing personnel designated by the manufacturer. The manufacturer’s specifications shall be controlled documents and shall be readily available to the process machine operator.

The manufacturer's specification documentation shall be available for review by the purchaser at the manufacturer’s premises and shall document the following, as a minimum:

a) methodology for all manufacturing procedures, including quality control and NDE, for the ancillary equipment, i.e. all components including fasteners, straps, lubricants, and any other items forming an integral part of the final product. See 4.5.3 for processes that require a documented methodology. See the factory acceptance testing section for the particular ancillary equipment in question for FAT requirements for the finished product;

b) references to specifications and sources of all materials used in the manufacture of the ancillary equipment, including materials such as lubricants and coating materials. See Table 6 for examples of specifications for metallic materials;

c) all parameters related to the quality of the final product that can be monitored during the manufacturing process. Both nominal values and ranges of these parameters shall be specified. See 4.5.3.4 for a minimum set of parameters that shall be monitored for polymer and composite components.

The manufacturer shall keep on file for the service life of the ancillary equipment all documentation pertaining to manufacture, including manufacturing records, certificates, inspection and FAT documentation.

4.5.3 Quality Assurance Requirements—Process Control

4.5.3.1 General

All the main steps in the manufacturing process shall be subject to inspection. The manufacturer's quality plan shall specify inspection points, inspection methods and acceptance criteria. Results of all inspections shall be recorded. The manufacturer shall record every nonconformance verified during manufacture of the ancillary equipment.

4.5.3.2 Metallic Components

The manufacturer shall as a minimum have a documented methodology, where applicable, for the following manufacturing processes for metallic components:

a) machining;

b) welding of structural members of components together;

c) NDE of welds;

d) application of coatings such as corrosion protection and anti-fouling coatings;

e) attachment of CP system anodes where applicable.

Manufacturing processes for metallic components including welding operations shall be carried out in accordance with an appropriate international standard. Examples of such standards for welding are listed in Table 10.

4.5.3.3 Fasteners

Manufacturing processes for fasteners shall be carried out in accordance with an appropriate international standard such as those listed in Table 7.

The fastener manufacturer shall have documented procedures for the quality control of the heat treatment of the fasteners. These procedures shall include requirements on temperature monitoring and duration of heat treatment that will ensure that the yield strength/hardness, required to avoid hydrogen embrittlement or ensure other functional requirements, is in accordance with the relevant fastener standard.

The fastener manufacturer shall have appropriate test methods during manufacture to ensure that acceptable ranges of mechanical properties in accordance with the relevant fastener standard (e.g. hardness and yield strength) of processed materials (finished products), required to avoid hydrogen embrittlement or ensure other functional requirements, are satisfied.

4.5.3.4 Polymer Components

The manufacturer shall as a minimum have a documented methodology for the following manufacturing processes for polymer components:

a) mixing of constituent components;

b) preparation of mould;

c) moulding process;

d) removal from mould;

e) curing;

f) finishing of surfaces, i.e. removal of flash;

g) application of protective coatings such as abrasion resistance and anti-fouling coatings.

The manufacturer shall have procedures to ensure that constituent raw materials for polymer and composite materials are mixed in the ratios specified in the raw materials supplier's instructions. The manufacturer shall have available records of the mix ratios that have been used during manufacture, and these records shall be approved by the responsible manufacturing personnel.

The manufacturer's fabrication specification shall include procedures that ensure that, when mixing polymer material constituent components, the resulting temperatures from exothermic reactions do not cause damaging residual stresses that may result in allowable temperature limits for the materials being exceeded.

4.5.3.5 Moulding

During the moulding process for polymer and composite components, the following process parameters shall as a minimum be monitored and recorded:

a) temperature of mould;

b) injection rate of material into mould, where applicable;

c) curing temperature;

d) curing time.

The manufacturer shall determine and document an acceptable curing time for polymer and composite components, based on the result of small-scale or full-scale tests, that demonstrates that the material properties required to satisfy the functional requirements (in accordance with the relevant material requirements sections of this specification) are attained. This curing time shall be adhered to during manufacture.

4.5.3.6 Hand Lay-up Manufacturing

The manufacturer shall, as a minimum, have a documented methodology for the following hand lay-up manufacturing processes for composite components:

a) processes listed in 4.5.3.4;

b) coating of fiber reinforcements;

c) brushing layers of matrix material;

d) laying of fiber reinforcements;

e) use of roller, if required to removed trapped air between layers;

f) application of matrix material.

4.5.3.7 Coatings

Where applicable, the manufacturer's fabrication specification shall include procedures to ensure that the process for applying coatings gives a uniform coating to the thickness specified. The manufacturer shall have available records of the monitored procedures during manufacture. The records shall be approved by the responsible manufacturing personnel.

4.5.3.8 Nonconforming Components

The acceptance of a component that is nonconforming shall be at the discretion of the purchaser.

4.5.3.9 Bolts

Bolts shall be tightened in accordance with an appropriate international standard such as as AFNOR NF E 25030 or Maskindeler 2 (Waløen, Å. Ø).

Table 10—Examples of Fabrication and Welding Standards

Designation	Title
ISO 15607, ISO 15609, ISO 15610, ISO 15611, ISO 15612, ISO 15613, ISO15614	*Specification and qualification of welding procedures for metallic materials*
API RP 2A	*Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms*
AWS A1.1	*Structural Welding Code Steel*
BS 6235	*Code of Practice for Fixed Offshore Structures*
NORSOK M-101	*Structural Steel Fabrication*

4.5.4 Quality Assurance Requirements—Handling During Manufacture

The manufacturer shall have documented procedures for handling of intermediate and finished products during manufacture, packaging and storage. The procedures shall include requirements for the following:

a) minimizing the damage to protective coatings on components;

b) avoiding damage to components by handling devices that have sharp or pointed parts, such as bolts or rivets;

c) avoiding damage to components by them being dragged along the ground or impacted against sharp objects.

4.5.5 Manufacturing Tolerances

The manufacturer shall specify dimensional tolerances for all dimensions of the ancillary equipment on engineering drawings. These tolerances shall be verified in the design process to be acceptable, such that the functional requirements are unaffected by variations within the specified tolerances.

If dimensional criteria are based on manufacturing considerations rather than design considerations, the manufacturer shall document that the criteria used meet the design requirements.

4.5.6 Repairs

The manufacturer shall have documented qualified procedures for performing repairs, where applicable, and these procedures shall be available for review by the purchaser. The manufacturer shall document by additional tests and/or calculations that the repairs to the ancillary equipment do not compromise the structural or long-term requirements of the ancillary equipment.

Procedures for repair of damage to surface protection coatings shall be available for review by the purchaser.

4.6 Documentation

4.6.1 General

The minimum documentation that the manufacturer is to have available for the purchaser shall be as specified below. The documentation requirements for materials and manufacturing shall be as specified in the relevant sections of this specification and are summarized in this section.

The manufacturer shall have available for the purchaser the following documents for permanent ancillary equipment under the circumstances outlined, and should have them available at the times specified:

a) design methodology documentation—prior to design, if latest revision of manufacturers' design methodology has not yet been verified by an IVA (see design methodology sections of this specification);

b) bridging document—prior to design, if documented operational experience is being submitted as validation of long-term material properties (see 4.4.2.3);

c) design premise—prior to design;

d) design report—prior to manufacture or at an agreed date after manufacture;

   Fatigue analysis may be incorporated in later revisions of the design report at an agreed later date, if supply of the fatigue loads is unavoidable at such a date that precludes inclusion in premanufacture revisions of the design report or if there is other valid reasoning for such exclusion.

e) manufacturing quality plan—prior to manufacturing;

f) installation procedures—prior to installation;

g) as-built documentation—with supplied ancillary equipment;

h) detailed engineering drawings—prior to manufacture.

i) Engineering drawings may be referenced in the design report.

If time permits, the design report may be made available prior to manufacture. The purchaser should consult with the manufacturer if such a requirement is necessary.

4.6.2 Design Premise

The design premise shall contain the following parameters:

a) parameters specified by the purchaser in accordance with the functional requirements section for the ancillary equipment in question;

   NOTE The purchasing guidelines in Annex A to Annex R may be used as a basis for this. If this consists of a large quantity of data, then the data may be referenced or included in an annex.

b) design load cases;

c) design criteria, including utilizations and safety factors.

If the manufacturer has made assumptions on any design parameters, then it shall be specified in the design premise that the values are assumed. All design changes should be reflected in subsequent revisions of the design premise. See API 17L2 for guidelines relating to the design premise.

4.6.3 Design Report

The design report shall contain a description of the ancillary equipment, including the following:

a) ancillary equipment identification;

b) identification of flexible pipe(s) to which the ancillary equipment is associated;

c) identification of the function, geometry and properties of each component in the ancillary equipment;

d) brief description of the design principle and methodology;

e) material designation for all components, including material grades;

f) mass in air and seawater;

g) density of materials;

h) description of fasteners used, with the following minimum information:

   1) materials and coatings;

   2) grade;

   3) tensile strength;

   4) yield strength.

i) description of corrosion protection system;

j) design criteria;

k) results from analyses of load cases defined in the design premise;

l) calculated stresses and strains in all the structural ancillary equipment components including fasteners for each design load case or where a component of the ancillary equipment design is based solely on structural strength, stresses and strains for only the most onerous design load case for that component;

m) demonstration that calculated stresses and strains do not exceed the design criteria;

n) demonstration that calculated cyclic stresses do not exceed the material's documented and verifiable endurance limit (approved by purchaser) or, if not, demonstration that fatigue damage does not exceed the design criteria.

The design report shall make reference to the codes and standards used in the design of the ancillary equipment.

The design report shall state any assumptions that have been made on any of the input data. As a minimum, the manufacturer shall specify the source for all purchaser-supplied data, inclusive of design loads. The manufacturer shall specify in the design report or have available the source for all remaining input data that are used in the ancillary equipment design.

Unless separate material specification documentation is issued, material specification and data shall be included in the design report. Metallic material data shall include yield or tensile strengths and fatigue parameters for dynamic service (S-N curve slope, intercept and endurance limit). Polymer or composite material data shall include the material properties specified in the qualification requirements section for the ancillary equipment in question.

Each component shall be documented to have sufficient structural capacity to sustain the design loads and stresses listed in the design report, with the utilizations or safety factors specified in the design premise. Design loadcase conditions shall be clearly described in accordance with 4.2.8.

The independent verification agent's certificate for the design methodology (as required in 4.3.5.1) shall be included in the design report.

4.6.4 Manufacturing Quality Plan

The manufacturing quality plan shall specify all quality control procedures, including inspection points and test procedures. The manufacturing quality plan may be included in the fabrication specification. The manufacturer's quality plan shall be in accordance with 4.4.7 and 4.5.3.1.

4.6.5 Installation Procedures

The manufacturer shall submit to the purchaser installation procedures for the ancillary equipment. The procedure shall contain where applicable the following as a minimum:

a) equipment required;

b) fastening forces for fasteners and straps;

c) identification of which particular fasteners (e.g. M16) are to be used for securing a particular component;

d) step-by-step installation procedures.

The above procedures shall ensure that, if the procedures are followed, the repeatability is such that the functional requirements of the ancillary equipment are satisfied.

4.6.6 As-built Documentation

The as-built documentation shall include, as a minimum, the following:

a) purchase order reference number;

b) equipment descriptions;

c) references to design specifications and drawings;

d) material certificates;

e) dimension control measurements;

f) FAT and prototype test procedures and test reports including test results. See 9.4.5 of API 17B:2008 for recommendations on the contents of prototype test procedures and test reports;

g) all nonconformances identified during manufacture and repairs performed;

h) welding procedure specifications and qualifications;

i) welder qualification records;

j) weld map;

k) NDE operator qualifications and NDE test records;

l) heat treatment records.

4.7 Factory Acceptance Tests

4.7.1 General

See the factory acceptance testing section for the ancillary equipment in question for specific FATs.

The ancillary equipment shall be subjected to factory acceptance tests, as specified in the factory acceptance testing sections of this specification, to verify the manufacture of the ancillary equipment to these requirements. The purchaser shall have the option of witnessing all tests and shall be given appropriate notice of the timing by the manufacturer.

A report for each factory acceptance test shall be submitted to the purchaser as part of the as-built documentation (see 4.6.6). Current certification/calibration certificates for all test equipment shall be included in the test report. Where applicable, all pressure-recording equipment shall be calibrated against a deadweight tester at least every three months.

4.7.1.4 If the acceptance criteria for a test are not met, the cause of the failure shall be investigated and a report submitted to the purchaser. Proposed corrective action shall be included in the report. The purchaser shall have the option of either rejecting the ancillary equipment or requiring a retest.

4.7.2 Visual Examination—Metallic Components

The surface of metallic components shall be visually examined for flaws, including dents, cracks, scratches, shavings, gouges, corrosion and discolored areas such as blurring, scorching, staining, except discoloring at welds. Any flaws that are identified that exceed the limits allowed in the manufacturer's procedures shall be recorded and subject to review by the purchaser.

NDE of welds shall be performed in accordance with an appropriate international standard such as those listed in Table 10. See API 2A for a description of the various NDE techniques and their applications.

4.7.3 Visual Examination—Polymer and Composite Components

The surface of finished polymer and composite components shall be visually examined for any flaws such as warping, cracks, scratches, bubbles, discoloring or indentations. Any flaws that are identified that exceed the limits allowed in the manufacturers procedures shall be recorded and subject to review by the purchaser.

4.7.4 Factory Acceptance Test Frequency

Where FATs on polymer and composite components apply to a fraction of production rather than the whole of the production, as specified in the subsequent factory acceptance test sections of this specification, such FATs shall include the first item moulded, and their frequency shall be evenly distributed between the first and last items moulded.

4.8 Marking and Packaging

4.8.1 Marking

The ancillary equipment marking shall make it permanently identifiable for the specified service life. The marking on ancillary equipment shall include the following as a minimum:

a) API Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) mass in air;

e) markings specified by the purchaser.

4.8.2 Packaging

The ancillary equipment shall be packaged in accordance with the manufacturers' specifications. Ropes/wires, shackles, and other required handling equipment shall be identified in the packaging procedures. All packages shall be accompanied by a packing list.

The packaging shall be such that the ancillary equipment is protected against all expected environmental occurrences when stored outdoors.

Packaging of the ancillary equipment shall ensure its safety in all transport stages prior to installation, or usage as agreed upon between manufacturer and purchaser.

5 Bend Stiffeners

5.1 Applicability

The requirements of Section 4 shall apply.

This section applies to static and dynamic bend stiffeners, temporary bend stiffeners and permanent bend stiffeners.

The requirements in this section shall be applied to umbilicals and there are some specific requirements given for umbilical bend stiffeners.

NOTE The requirements relating to internal fluid and outer sheath temperature may not be relevant for umbilicals.

5.2 Functional Requirements

5.2.1 General

Purchasing guidelines for bend stiffeners are given in Annex A.

The minimum overall functional requirements of the bend stiffener that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to maintain the flexible pipe operating minimum bend radius (MBR) above that specified by the purchaser for the specified service life;

c) to remain securely attached to the flexible pipe end fitting or support structure for the specified service life;

d) to transfer loads from the flexible pipe to the support structure.

5.2.2 Flexible Pipe Design Parameters

For the flexible pipe to which the bend stiffener is associated, the purchaser shall specify the following parameters as a minimum:

a) internal diameter;

b) service type;

c) service life. Service life shall only be specified for permanent bend stiffeners;

d) external diameter;

e) tolerance on external diameter;

f) operating and storage MBR;

g) relationship between MBR and effective tension, for umbilicals. The relationship may be submitted in the form of a graph or in tabulated form;

h) values of bending stiffness applicable for all design/operating conditions. These values shall account for the combinations of internal fluid temperature and ambient temperature (air or seawater as applicable) as well as internal pressure relating to such design/operating conditions. In addition, the bending stiffnesses should account for the hysteresis behavior of the flexible pipe;

i) axial stiffness, if required by the manufacturer. Axial stiffness may be used as an input for some bend stiffener local analysis design methodologies. The purchaser should consult with the manufacturer to determine whether this parameter is required;

j) detailed drawing of the end fitting at the bend stiffener end of the flexible pipe for end fitting adjacent interface structures.

5.2.3 Bend Stiffener Design Parameters

For the bend stiffener, the purchaser shall specify the following parameters:

a) whether the bend stiffener is dynamic or static;

b) whether the bend stiffener is temporary or permanent;

c) departure and azimuth angle, including tolerance, of bend stiffener relative to mean orientation of the flexible pipe;

d) any constraints relating to physical dimensions of bend stiffener, expressed in terms of maximum length and maximum diameter;

e) temperatures to which the bend stiffener is exposed (in accordance with 4.2.4).

5.2.4 Purchaser Support Structure

The purchaser shall provide detailed drawings of the support structure to which the bend stiffener interface structure is to be connected, such as a flange, end fitting [in accordance with 5.2.2 j)], I-tube, intermediate connection, need for a latching mechanism, for example.

See 5.2.6 of API 17L2 for recommendations relating to the interfacing of the support structure with the interface structure.

Where applicable, the purchaser shall include any constraints relating to I-tube dimensions to reflect the fact that the bend stiffener requires dimensional compatibility with the I-tube.

The purchaser shall specify the support structure material, the corrosion protection coatings applied to it, and provide details of the support structure CP system.

The purchaser shall specify the maximum allowable bending moment and shear force at the purchaser support structure.

The designer of the bend stiffener shall specify all necessary mounting components.

NOTE The above requirement has been transferred directly from Annex B of API 17J:2008.

5.2.5 External Environment

Environmental functional requirements relating to sunlight exposure should be specified in accordance with 4.2.5. Further to 4.2.5, whether the bend stiffener is exposed to sunlight will depend on the particular location of the bend stiffener and whether or not any structures provide any shielding in part or totally from sunlight.

The purchaser shall specify the bend stiffener location in terms of whether it is connected at the topside, intermediate or seabed connection, and whether the bend stiffener is exposed to seawater during the course of its service life.

5.2.6 Corrosion Protection

The corrosion protection requirements for the bend stiffener interface structure and fasteners should be specified in accordance with 4.2.6, if an adjacent CP system is available. Alternatively, the purchaser may specify a requirement for a corrosion-resistant material for the interface structure.

5.2.7 Integrity and Condition Monitoring

The purchaser shall specify any requirements for protective inner liners for I-tube bend stiffeners to be replaceable by divers.

5.2.8 Design Loads

Where the global analysis is not in the manufacturer's scope of work, the purchaser shall specify the following:

a) the design loads for bend stiffeners in terms of effective tensions and angle variations from its mean position;

   These data may be given in the form of a plot of effective tension versus angle. The combinations of effective tension and angle that are analyzed should be sufficient to cover all possible load cases, including installation, with reference to the load cases specified for the flexible pipe in 5.1 of API 17J:2008. The convention used for the definition of angle shall be defined.

b) the maximum shear force and bending moments acting on the base of the bend stiffener.

   The purchaser shall specify fatigue loads for dynamic bend stiffeners in terms of ranges of bending moment and shear force acting at the base of the bend stiffener, along with the corresponding numbers of cycles for each bending moment and shear force range. Alternatively these data may be given in the form of plots of effective tension versus angle for all fatigue wave loads. The above loads shall be derived from three-dimensional global finite-element analysis with the bend stiffener modeled, and hence these loads shall be specified after initial or subsequent revisions of the bend stiffener design have been determined by the manufacturer. If a linear stiffness value is used for the bend stiffener in these global analyses, then it should be demonstrated that this gives conservative results.

Where the global analysis is within the manufacturer's scope of work, the purchaser shall specify the necessary data required to perform a global analysis of the flexible pipe system in order to calculate such loadings. These data shall include details of the entire flexible pipe system, the platform/vessel that it is connected to, and the external environment acting on it. See Section 4 of API 17J:2008 for the data that are required, in addition to the flexible pipe properties, to conduct a global analysis.

5.2.9 Spares

The purchaser should specify the required quantity of spare fasteners for the interface structure. Spares may be used to offset any losses due to damage or misplacement, for example.

5.3 Design Requirements

5.3.1 Loads

Local load classes and subclasses for bend stiffeners are listed in Table 11. The table distinguishes between loads acting on static bend stiffeners and those acting on dynamic bend stiffeners.

5.3.2 Design Methodology

The documentation submitted for verification of the design methodology shall include methodologies, any calculations performed and software tools used for the following, as a minimum:

a) documentation listed in 4.3.5.1;

b) dimensions of all components, including as a minimum:

   1) bend stiffener body,

   2) interface structure,

   3) external coatings,

   4) fasteners.

c) fastening forces for securing bend stiffener to support structure (in accordance with 5.3.6);

d) bond design (in accordance with 5.3.7);

e) external coatings:

   1) surface coating specification,

   2) coating log and result of adhesion test from manufacturer's coating supplier,

   3) qualification status of coating system applied.

f) service life performance, subject to the requirements of 5.3.10 or 5.3.11.

The design methodology shall consider the end fitting or support flange mounting failure.

NOTE The above requirement has been transferred directly from Annex B of API 17J:2008.

5.3.3 Design Criteria

The bend stiffener shall not allow the flexible pipe operating MBR to fall below the minimum specified by the purchaser accounting for all possible load combinations of the flexible pipe over its specified service life as detailed in 5.1.3 of API 17J:2008. Where the bend stiffener body comprises two separately moulded parts, i.e. an inner and outer sleeve, the design shall be documented to satisfy this MBR criteria with the loss or partial loss (i.e. the inner sleeve has slid from its intended position) of the inner sleeve if requested by Purchaser.

Table 11—Local Load Classes and Subclasses for Bend Stiffeners

Load Classes and Subclasses	Applicability	
Functional Loads	**Static**	**Dynamic**
Loads due to expansion and contraction of the flexible pipe by tension, internal pressure and temperature effects during service, leak tests or structural integrity tests, see 11.5.3 of API 17B:2008.	X	X
Loads due to noncyclic bending of the flexible pipe.	X	X
Loads due to fasteners securing interface structure to purchaser support structure.	X	X
Loads due to reeling of flexible pipe.	X	X
Loads during handling, transport and installation.	X	X
Thermal shock loads.	X	X
Hydrostatic pressure. [a]	X	X
Loads due to positioning installation tolerances (with respect to the mean unstressed position of the bend stiffener).	X	X
Environmental Loads		
Loads due to cyclic bending of the flexible pipe in dynamic applications over specified service life.		X
Loads due to vortex-induced vibration (VIV) of the flexible pipe (causing vibrations in bend stiffener components) [b]. See 5.4.6 of API 17L2:2013 for guidelines on VIV.		X
Accidental Loads		
Flexible pipe accidental loads that affect the flexible pipe configuration and/or bend stiffener, where specified by purchaser, as follows: a) internal over-pressure; b) vessel compartment damage or unintended flooding where applicable; c) failure of vessel thrusters where applicable; d) DP failure where applicable; e) anchor line failure; f) failure of FPSO turret drive system where applicable.	X	X

[a] May be ignored where material is documented not to suffer from such effects at the design water depth. Includes hydrostatic pressure due to storage or abandonment of bend stiffener on the seabed.

[b] The VIV loading on the flexible pipe depends on the geographic location of the field development and in particular on the current loading in the location.

5.3.4 Bend Stiffener Design—General

Reaction loads generated by the bend stiffener including bending moment and shear shall be reported at the bend stiffener base.

The local analysis methodology shall be validated by full-scale static bend tests, see 5.5.3 of API 17J:2008, using current or representative previous designs. Specific designs may be validated by static bend tests on purchaser request.

The manufacturer shall document that the design meets the specified requirements, accounting for all possible combinations of flexible pipe bend stiffness. The bend stiffener global design should account for the nonlinear bend stiffness of the flexible pipe due to its hysteresis behavior.

If the bend stiffener is to be attached to a support structure such as an end fitting, the bend stiffener shall be designed to safely transfer loads to the support structure (i.e. support structure maximum shear force and bending moment are not exceeded). The design of the bend stiffener shall ensure that it is restrained axially.

NOTE The above requirement has been transferred from Annex B of API17J:2008.

The design of the bend stiffener shall ensure that it is restrained axially.

NOTE The above requirement has been transferred directly from Annex B of API 17J:2008.

5.3.5 Bend Stiffener Body Design

The manufacturer shall demonstrate that the flexible pipe does not infringe its specified MBR either within the length of the bend stiffener or in the region immediately beyond the stiffener tip. The bend stiffener body shall be modeled using nonlinear material properties (when the MBR criteria are being checked analytically in a local analysis).

Further to the requirements of 4.3.5.2, the design shall account for the material properties of the bend stiffener body when exposed to the combinations of flexible pipe outer sheath temperature and surrounding ambient air or seawater temperature, as applicable, that induce the minimum and maximum temperatures in the material.

When large stiffness transitions in the bend stiffener are necessary, such as the transition to the interface structure, the design methodology shall be such as to minimize the maximum strains and the strain variations in the vicinity of these regions.

The manufacturer shall account for fabrication defects (if any) in the bend stiffener design or manufacture procedures that its inspection methods cannot detect after manufacture.

Ovalization of the bend stiffener tip shall be documented not to affect the performance of the bend stiffener.

NOTE The above requirement has been transferred directly from Annex B of API 17J:2008.

5.3.6 Interface Structure Design

A fastener pre-tension for securing the bend stiffener to the support structure shall be calculated and specified in the installation procedures, in accordance with the following. The pre-tension shall be high enough to ensure that all components of the bend stiffener are held securely in position for the specified service life, yet does not cause damage to any of the bend stiffener components. The level of pre-tension in the fasteners shall be checked to ensure that the fatigue life of the bend stiffener is achieved (in accordance with 5.3.11). Further to 4.3.7, the stresses in all fasteners that attach the bend stiffener to the support structure shall be checked in the design and be determined to be within allowable limits.

The interface structure shall be dimensionally compatible either with the support structure or any intermediate structure, accounting for all tolerances on these structures. In turn, any intermediate structures shall be similarly dimensionally compatible with the support structure. End fitting adjacent and end fitting mounted interface structures shall be compatible with the dimensions, including tolerances of the end fitting.

The interface structure shall be designed so as not to cause any damage to the flexible pipe during installation or the specified service life due to contact with the flexible pipe outer sheath by use of a protective liner (see 5.3.8) or otherwise.

5.3.7 Bond Design

All interfaces, including metal-polymer interfaces, where a bond is required for structural strength or water tightness shall be designed to sustain all debonding forces identified from local analysis of operational conditions and fabrication (including volumetric contraction). The design methodology of a particular bond configuration between the bend stiffener body and the interface structure shall be verified by at least one full-scale fatigue test, see 5.5.4 of API 17L2:2013.

Possible leak paths in bonded surfaces shall be documented and analyzed for the extreme operational conditions, taking into account the volumetric contraction due to fabrication and volumetric expansion of corrosion pits.

The specification of the bonding solution shall consider the extreme debonding forces and unfavorable (but possible) conditions of the interface structure (e.g. rusty, unpolished, etc.).

5.3.8 I-tube Bend Stiffeners

The design of bend stiffener caps, where applicable, shall account for the gap including dimensional tolerances between the cap and the I-tube bellmouth/guide funnel.

Where an internal protective liner is used to prevent damage to the flexible pipe by metallic components of the bend stiffener, it shall be designed for the same service life as the bend stiffener and shall be readily replaceable by divers (where required by the purchaser). The wear rate of this liner shall be documented and validated by tests. The protective liner shall not have sharp edges which may cause adverse damage to the flexible pipe when there is relative motion between them. The liner's material shall be specified to avoid surface damage to the flexible pipe external sheath in case of friction and abrasion between the respective surfaces; under such conditions the flared liner shall suffer wear instead.

5.3.9 Bend Stiffener Design Verification

After the manufacturer has determined the final bend stiffener design based on local analyses, a global analysis verification shall be performed using a three-dimensional finite element analysis. The verification shall be performed for each load case of the flexible pipe system and shall incorporate the latest bend stiffener design. This global analysis shall account for the bend stiffener material properties due to the temperatures experienced in service (see 5.3.5). If a linear stiffness value is used for the bend stiffener in these global analyses, then it should be demonstrated that this gives conservative results. It shall verify that the design criteria of the flexible pipe including the MBR and fatigue life criteria are satisfied. Where such design criteria are not satisfied, the system designer and the manufacturer shall liaise to perform further iterations of the design until the design criteria are satisfied. See 5.2.3 of API 17L2 for recommendations on this verification process.

5.3.10 Service Life—Static Applications

Creep shall be considered in the design process for the following:

a) a static bend stiffener that is bent in one direction for an appreciable time period with respect to the materials creep behavior;

b) a bend stiffener that is subjected to a constant load due to positioning outside its mean unstressed position due to the flexible pipe departure angle from the support structure.

Creep analysis shall account for the temperature induced in the bend stiffener material by the flexible pipe outer sheath and direct sunlight, where applicable.

5.3.11 Service Life—Dynamic Applications

The requirements of 5.3.10.b) shall apply.

Further to the requirements of 4.3.10, fatigue analysis of dynamic bend stiffener interface structures and associated fasteners shall account for the following cyclic loads:

a) bending moments and shear forces induced by wave and current loading;

b) variations in effective tensions in the flexible pipe induced by wave and current loading;

c) fatigue loads induced by VIV of the flexible pipe, where applicable.

Where fatigue analysis is to be supplied retrospectively with respect to manufacture, the initial fatigue loading data shall be based on conservative assumptions.

The fatigue analysis shall determine a suitable pre-tension that provides the required fatigue life to the bend stiffener, see 5.3.6.

The fatigue performance of the bend stiffener body may be demonstrated by fatigue testing of the bend stiffener material in accordance with 4.3.10, demonstrating that stress ranges inclusive of stress concentrations are below a documented and verifiable endurance limit approved by the purchaser, or by developing a graph of strain range versus number of cycles. The latter approach shall be fully validated by comparison with full-scale testing.

The design of a bend stiffener shall account for an increase in polymer temperature due to the frequency of bending as may occur during an extreme storm or cyclic bending fatigue testing of flexible pipes. In addition, the maximum strain which a bend stiffener polymer material can facilitate during a high frequency cyclic bending event may be significantly lower than the strain which can be facilitated for a low frequency cyclic bending event. The design of a bend stiffener shall therefore account for the frequency of bending it is expected to experience. Accounting for the increase in polymer temperature and frequency of bending in the design may be accomplished by using representative loading frequencies in small-scale material fatigue testing in accordance with 5.4.2, or otherwise.

5.3.12 Corrosion Protection

See 4.3.11 for minimum corrosion protection requirements for the interface structure.

The manufacturer shall design the corrosion protection system such that the area of the interface structure that bonds to the bend stiffener body, as well as the external metallic surfaces, is protected against corrosion.

5.4 Material Requirements

5.4.1 General

The requirements of this section shall apply to polymer materials for the bend stiffener body and metallic materials for the interface structure.

5.4.2 Qualification Requirements—Polymer Materials

In the qualification program, the manufacturer shall test and document the bend stiffener body polymer material properties specified in Table 12, except bonding to the interface structure material, which if not measured by small-scale testing, may be considered in the design process, see 5.2.4 of API 17L2:2013.

Where indicated, the material properties in Table 12 shall be measured at the minimum and maximum temperatures of the material in service, in addition to measurement at room temperature. Where indicated, the material properties shall also be measured for aged samples of material. See 4.4.4 for minimum ageing test requirements.

Bend stiffener materials in dynamic applications shall have sufficient fatigue resistance to sustain the cyclic bending of the flexible pipe. Small-scale fatigue testing of the bend stiffener body material shall simulate the mean stress/strain, stress/strain ranges, number of cycles and loading frequency that the material will be subjected to in service.

Small-scale bonding tests of the bend stiffener body material with the interface structure material shall be used only as a comparative measure to indicate bonding performance. The design methodology of a particular bond configuration between the bend stiffener body and the interface structure shall be verified by at least one full-scale fatigue test, see 5.5.4 of API 17L2:2013.

Table 12—Qualification Requirements for Bend Stiffener Body Polymer Materials

Tests	Test Procedure [a]	Section	Test Temperature [b]	Aged Sample
Bonding to interface structure material		See 5.3.7	Max temperature	X
Fatigue resistance		See 5.3.6	At temperature representative of temperature during service	
Hardness	ISO 868 [c], or ASTM D2240			
Tear strength	ISO 34-1 [d], or ASTM D624		Max temperature	
Tensile strength, modulus, strain at break [e]	ISO 527-1 [c], ISO 527-2 [c], ISO 37 [d], ASTM D638 [c]		Min and Max temperature	X
Water absorption	ISO 62 [c], ASTM D570 [c]		Max temperature	X

[a] As stated in Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.
[b] The material shall undergo sufficient testing to qualify the materials fatigue resistance for the temperature range under consideration.
[c] Standards are technically equivalent or identical for the test in question.
[d] Standards are identical.
[e] Property shall be expressed in the fiber direction and transverse to the fiber direction for composite materials.

5.4.3 Qualification Requirements—Metallic Materials

See 4.4.3 for minimum qualification requirements for the interface structure metallic material.

Further to the requirements of 4.3.11, galvanic corrosion of the interface structure and its fasteners shall be avoided either by appropriate selection of metallic materials based on compatibility with the purchaser support structure material, see 5.2.4, or by isolating the interface structure by use of protective coatings.

5.5 Manufacturing Requirements

5.5.1 Quality Assurance Requirements—Process Control

5.5.1.1 General

Further to the requirements of 4.5.3.7, and where the bend stiffener polymer material is not translucent, the manufacturer's fabrication specification shall include procedures for moulding of the bend stiffener body to eliminate the presence of subsurface defects such as voids as it is being filled and cured in the mould. The capability of these procedures to remove subsurface defects shall be verified and documented by previous dissections of bend stiffener mouldings.

The manufacturer shall as a minimum have a documented methodology for the following interface structure manufacturing processes:

a) processes listed in 4.5.3.2;

b) application of bonding solution (for bonding with bend stiffener body);

c) moulding of bend stiffener incorporating both bend stiffener body and interface structure.

5.5.1.2 Procedures

The manufacturer's fabrication specification shall include procedures that ensure the following:

a) the surfaces of the interface structure are clean and free from any dust, dirt or other contamination and are prepared properly prior to application of bonding solution;

[1] the required surface finish of the interface structure prior to application of bonding solution that is necessary to ensure bond integrity. The procedure shall be in accordance with an appropriate international standard such as NACE 1/SSPC-SP5, *White Metal Blast Cleaning*;

b) the ergonomic and geometrical constraints that are imposed where the bonding solution is applied manually or by spray are accounted for;

c) avoidance of damage to the applied bonding solution coating such that the integrity of the bond is not compromised when handling the interface structure.

5.5.1.3 Storage Time

The manufacturer shall document in the fabrication specification a maximum time that an interface structure with applied bonding agent can be stored without affecting the bond integrity. The manufacturer shall comply with this time limit.

5.5.1.5 Surface Finish

When finishing the surface of the bend stiffener body, i.e. by activities such as grinding of bubbles taking off flash, or repair of surface defects extreme care shall be taken not to introduce any cuts or punctures into the surface of the material which may initiate a failure point in the bend stiffener body. The manufacturer shall have documented procedures in place that specify how this requirement is satisfied.

5.5.1.6 Polymer or Composite Material Properties

For each mix of polymer or composite material, a sample of material shall be retained and tested to verify that it is consistent with the properties measured in the qualification tests and to the manufacturer's specifications. The following properties shall be tested as a minimum:

a) tensile strength: ISO 527-1, ISO 527-2, ISO 37, or ASTM D638;

b) hardness: ISO 868, or ASTM D2240.

The above tests shall also apply to each mix of repair material, where used.

5.5.2 Handling During Manufacture

When the bend stiffener is being handled, extreme care shall be taken to avoid cuts or punctures into the surface. It shall not be dragged along the ground or allowed to impact against sharp objects. The manufacturer shall have documented procedures in the fabrication specification to avoid such mishandling.

5.5.3 Repairs

Further to 4.5.6, the manufacturer shall have a documented qualified procedure for performing repairs to the surface of the bend stiffener body, if repair material is used. Such repair procedures shall be qualified by small-scale testing as a minimum, and full-scale tests if necessary. Wherever repair material is used, it shall be shown that the bond between the repair material and the original material is stronger than the original material (i.e. cohesive failure when tested). This shall apply to internal or external repairs. Where external repair of the bend stiffener body surface by grinding of bubbles is performed, the fabrication specification shall include procedures for such repairs. The procedures shall be in accordance with an appropriate International Standard and shall ensure that the remaining material is homogeneous and that no surface flaws are left that could compromise the structural integrity of the bend stiffener. Allowable limits for defects should be specified in terms of defect size, geometry and allowable number of defects of a particular size/geometry.

5.6 Documentation

5.6.1 Design Report

5.6.1.1 The bend stiffener description in the design report shall include as a minimum the following:

a) minimum parameters specified in 4.6.3;

b) bend stiffener body internal diameter;

c) bend stiffener body base external diameter;

d) length of bend stiffener body;

e) design temperature;

f) minimum bending radius for storage, installation and operation;

g) maximum angle with respect to mean position and associated effective tension during operation;

h) performance curve demonstrating the locus of effective tension and angles at which the MBR criteria are achieved;

i) stress/strain curve for each temperature condition analyzed in design.

5.6.1.2 The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this document;

e) documented basis for polymer and composite material endurance limits or fatigue safety factors where applicable;

f) overview of CP system design methodology where applicable;

g) manufacturing and design tolerances;

h) calculations demonstrating that design satisfies functional requirements accounting for variations within manufacturing tolerance envelopes;

i) description of welds used for metallic components;

j) service life analysis, subject to the requirements of 4.3.8 to 4.3.10;

k) calculation of the dimensions of all components, including as a minimum:

    1) bend stiffener body,

    2) interface structure,

    3) external coatings,

    4) fasteners.

l) calculation of the fastening forces for securing bend stiffener to support structure (in accordance with 5.3.6);

m) bond design (in accordance with 5.3.7);

n) service life analysis, subject to the requirements of 5.3.10 or 5.3.11.

The design report shall include or make reference to any calculations performed for or software tools used for these items.

5.6.1.3 The fatigue analysis may be supplied retrospectively if the fatigue loads (see 5.3.11) are supplied at such a date that precludes inclusion in earlier revisions of the design report or there is other valid reasoning for such exclusion.

5.6.2 Installation Procedures

Further to the requirements of 4.6.5, the manufacturer shall submit to the purchaser guidelines for mounting the bend stiffener onto the flexible pipe and procedures for connecting the interface structure to the adjacent structure, including fastening forces to apply.

5.7 Factory Acceptance Tests

5.7.1 General

The manufacturer shall perform the FAT tests specified in Table 13 on the bend stiffener components.

5.7.2 Dimensional Measurement

5.7.2.1 Dimensional measurement of the bend stiffener shall verify that the dimensions are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances.

The dimensions that shall be measured for the bend stiffener body shall include the following as a minimum:

a) internal diameter;

b) base external diameter;

c) length.

5.7.2.2 The dimensional measurement of the interface structure shall include verification that the requirements of 5.3.6 have been satisfied.

5.7.3 Visual Examination

The surface of the bend stiffener body shall be visually examined for any obvious flaws such as cracks, scratches, gouges and bubbles. Any flaws that are identified that exceed allowable limits as specified in the manufacturer's repair procedures shall be subject to review by the purchaser.

Table 13—Factory Acceptance Tests for Bend Stiffeners

Component	Test	Section/Test Procedure
Bend stiffener body	Dimensional	See 5.7.2
	Visual	See 4.7.3 and 5.7.3
	Hardness	ISO 868 [a], ASTM D2240
Interface structure	Dimensional	See 5.7.2.2
	Visual	See 4.7.2
	NDE of welds	See 4.7.2

[a] Standards are technically equivalent or identical for the test in question.

5.8 Marking

5.8.1 See 4.7.4 of ISO/WD 13628-17 for general marking recommendations.

5.8.2 The bend stiffener marking shall make it permanently identifiable for the specified service life. The marking shall include the following as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser.

e) operating MBR.

f) identification of flexible pipe to which bend stiffener is to be attached.

6 Bend Restrictors

6.1 Applicability

The requirements in Section 4 shall apply.

This section gives requirements for bend restrictors used in static service conditions, but contains some additional requirements for dynamic bend restrictors. The following sections apply to both polymer and metallic bend restrictors and hybrid bend restrictors.

The requirements in this section shall also be applied to umbilicals.

NOTE Requirements relating to internal fluid and outer sheath temperature may not be relevant for umbilicals.

6.2 Functional Requirements

6.2.1 General

Purchasing guidelines for bend restrictors are given in Annex B.

The minimum overall functional requirements of the bend restrictor that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to maintain the flexible pipe operating MBR above the minimum specified by the purchaser for the specified service life;

c) to remain securely attached to the support structure.

6.2.2 Flexible Pipe Design Parameters

For the flexible pipe to which the bend restrictor is attached, the purchaser shall specify the following parameters, as a minimum:

a) internal diameter;

b) service type;

c) service life;

d) external diameter;

e) tolerance on external diameter;

f) operating and storage MBR;

g) mass per unit length of flexible pipe;

h) outer sheath material;

i) detailed drawing showing the external dimensions and tolerances of the end fitting at the bend restrictor end of the flexible pipe, for bend restrictors with reaction collar interface structures;

j) ovalization of flexible pipe at operating MBR, specified in terms of the minimum and maximum diameters due to the out-of-roundness of the pipe;

k) values of bending stiffness applicable for all design/operating conditions. These values shall account for the combinations of internal fluid temperature and ambient temperature (air or seawater, as applicable) as well as internal pressure relating to such design/operating conditions. In addition, the bend stiffnesses shall account for the hysteresis behavior of the flexible pipe.

6.2.3 Bend Restrictor Design Parameters

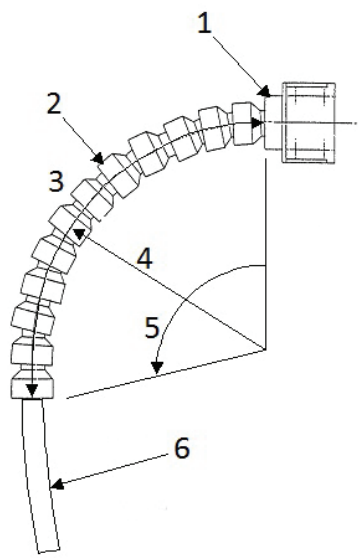
6.2.3.1 Required Parameters

The purchaser shall specify the following parameters, as a minimum:

a) whether the bend restrictor is static or dynamic;

b) length of coverage required. This should be specified in terms of an angle of coverage. Alternatively it may be specified in terms of the length of coverage at the flexible pipe operating MBR. Figure 4 shows these coverage parameters for a typical polymer-type bend restrictor;

c) temperatures to which the bend restrictor is exposed (in accordance with 4.2.4).



Key

1 interface structure	4 operating MBR
2 bend restrictor	5 angle of coverage
3 length of coverage	6 flexible pipe

Figure 4—Bend Restrictor Coverage

6.2.3.2 Additional Parameters

The purchaser should consider specifying the following parameters.

a) Any requirements on the weight of the bend restrictor.

b) It may be desirable, for example, to have a neutrally buoyant bend restrictor. This may be specified in terms of a required density.

c) Any constraints relating to physical dimensions of the bend restrictor, expressed in terms of maximum external diameter.

d) The bend restrictor might, for example, be pulled into a J-tube in which case this will impose a constraint on its external dimensions.

6.2.4 Purchaser Support Structure

The purchaser shall provide detailed drawings of the support structure to which the bend restrictor interface structure is to be connected, such as a flange, end fitting [see 6.2.2 i)], J-tube, tether clamp (where the bend restrictor is not in the tether clamp manufacturer's scope of supply), for example. The drawings shall be sufficient to determine the required dimensions and tolerances for the bend restrictor interface structure and any fasteners that are required to secure the bend restrictor in position. See 6.2.5 of API 17L2:2013 for recommendations relating to the interfacing of the support structure with the interface structure.

The purchaser shall specify the support structure material, the corrosion protection coating applied to it, and also provide details of the CP system for the support structure, or the corrosion allowance adopted for its design.

The purchaser shall specify the maximum allowable bending moment and shear force at the purchaser support structure.

The designer of the bend restrictor shall specify all necessary mounting components.

6.2.5 External Environment

Environmental functional requirements relating to sunlight exposure should be specified in accordance with 4.2.5. Further to 4.2.5, whether the bend restrictor is exposed to sunlight will depend on the particular location of the bend restrictor and whether or not any structures provide any shielding in part or totally from sunlight.

The purchaser shall specify the bend restrictor location in terms of whether it is connected at the topside or seabed connection or other intermediate location, and whether the bend restrictor is exposed to seawater during the course of its service life or is located or used temporarily at the surface and is therefore exposed predominantly to air.

6.2.6 Corrosion Protection

The corrosion protection requirements for the bend restrictor interface structure, fasteners and metallic bend restrictor elements should be specified in accordance with 4.2.6.

6.2.7 Installation Requirements

The purchaser shall submit engineering drawings of any over-boarding chute over which the bend restrictor is to be installed.

6.2.8 Design Loads

The purchaser shall specify loadcases of bending moment and shear forces acting on the bend restrictor when it locks up. The bending moment and shear force loads shall account for the maximum expansion of any subsea structures adjacent to the bend restrictor. Where installation design loads are specified, these loads shall account for the installation tolerances, for example tolerance on lay angle.

The purchaser shall specify, if applicable, impact loads on the bend restrictor.

6.2.9 Spares

The purchaser should specify the required percentage quantity of spare bend restrictor elements and spare fasteners for the interface structure. Spares may be used to offset any losses due to damage or misplacement, for example.

6.3 Design Requirements

6.3.1 Loads

Local load classes and subclasses for bend restrictors are listed in Table 14.

Table 14—Local Load Classes and Subclasses for Bend Restrictors

Load Classes and Subclasses
Functional Loads
Hydrostatic pressure [a]. Loads due to self-weight (in air and water). Loads due to weight of flexible pipe. Loads due to fasteners (used to connect half shells together and to connect bend restrictor elements to the support structure). Loads transmitted from flexible pipe to bend restrictor during lock-up (shear force and bending moment). Static reaction loads from interface structure.
Environmental Loads
Loads transmitted from flexible pipe to bend restrictor during repetitive lock-up (resulting in intermittent impact forces between adjacent elements [b]).
Accidental Loads
Flexible pipe accidental loads that affect the flexible pipe configuration and in turn the bend restrictor, where specified by purchaser, as follows: a) internal over-pressure; b) vessel compartment damage or unintended flooding where applicable; c) failure of vessel thrusters where applicable; d) DP failure where applicable; e) anchor line failure; f) failure of FPSO turret drive system where applicable.
[a] May be ignored where material is documented not to suffer from such effects at the design water depth. [b] Dynamic bend restrictors only.

6.3.2 Design Methodology

The documentation submitted for verification of the design methodology shall include documentation, including any calculations performed, methodologies and software tools used, for the following, as a minimum:

a) documentation listed in 4.3.5.1;

b) dimensions of all components, including as a minimum:

   1) bend restrictor elements (length, external and internal diameters, etc.);

   2) interface structure;

   3) external coatings;

   4) fasteners;

   5) sizes of CP system anodes;

c) the free and deformed locking radii of the bend restrictor (to verify bend-restricting capability in accordance with 6.3.8);

d) fastening forces for securing bend restrictor to support structure and securing element half-shells together where applicable (in accordance with 6.3.7 and 6.3.5);

e) external coatings:

   1) surface coating specification;

   2) coating log and result of adhesion test from manufacturer's coating supplier;

   3) qualification status of coating system applied;

f) service life performance, subject to the requirements of 6.3.9 or 6.3.10 (if the bend restrictor is used in a dynamic application).

The local analysis methodology shall be validated by full-scale testing, see 6.5.3 of API 17L2:2013, using current or representative previous designs.

The design methodology shall consider the end fitting or support flange mounting failure.

6.3.3 Bend Restrictor Design Criteria

The bend restrictor deformed locking radius using end of life material properties and temperature representative of service conditions shall be at least equal to the flexible pipe operating MBR specified by the purchaser, which shall be at least 1,0 times and 1,5 times the storage MBR of the flexible pipe for static and dynamic applications, respectively, in accordance with API 17J.

6.3.4 Bend Restrictor Design—General

The design should ensure that bending moments and shear forces transferred along the length of the bend restrictor do not damage the flexible pipe at either end of the bend restrictor.

The manufacturer shall document that the design meets the specified requirements under all possible combinations of flexible pipe bend stiffness. The bend restrictor design should account for the nonlinear bend stiffness of the flexible pipe due to its hysteresis behavior.

Bend restrictors may be connected at a location remote from the end fitting, requiring clamping directly to the pipe, and in this case the clamping system design should ensure that no damage occurs to the flexible pipe.

The design of the bend restrictor shall ensure that it is restrained axially.

6.3.5 Bend Restrictor Element Design—General

Further to the requirements of 4.3.7, it shall be documented that the contact forces between adjacent bend restrictor elements during lock-up do not cause stresses or strains to exceed the allowable levels for the material in question, see 6.2.4 of API 17L2:2013.

The sizing of the bend restrictor bore shall account for tolerances on the external diameter of the flexible pipe, as well as the increased external diameter of the flexible pipe due to ovalization when the flexible pipe bends to the maximum curvature predicted during installation or operation.

Where applicable, fastening force shall be calculated and specified in the installation procedures for securing bend restrictor half-shells together, see 6.6.2. The fastening force shall be determined to ensure that there is no separation of individual half-shells during the specified service. The bearing stress applied by the fastening force shall not cause stresses or strains to exceed the allowable levels in the bend restrictor material.

6.3.6 Polymer Bend Restrictor Element Design

The material properties used for the design of the bend restrictor shall be representative of the properties of the material in a full-scale element after manufacture determined through full-scale testing, see 6.5.2 of API 17L2:2013.

Further to the requirements of 4.3.5.2, the design shall account for the material properties of bend restrictor element polymer materials when exposed to the combinations of flexible pipe outer sheath temperature and surrounding ambient air or seawater temperature, as applicable, that induce the minimum and maximum temperatures in the material.

The determination of the deformed locking radius in the design methodology shall account for the deflection of polymer bend restrictor elements beyond the free locking radius due to the elastic deformation of the material inclusive of any deformation due to the temperature of the material.

Bend restrictor elements shall be designed such that adjacent elements will be dimensionally compatible with each other when the bend restrictor is assembled. The dimensional compatibility shall be confirmed after manufacture by dimensional measurement and fit-up and assembly testing (see 6.7.2 and 6.7.3).

6.3.7 Interface Structure Design

Fastening forces shall be calculated in order to secure the bend restrictor in position via the interface structure and as specified in the installation procedures, see 6.6.2. The fastening forces shall ensure that the bend restrictor is held in position for the specified service life. The bearing stress applied by the fastening force shall not cause stresses or strains to exceed the allowable levels in the bend restrictor or interface structure.

The interface structure shall be compatible with the dimensions of the support structure, accounting for all tolerances on this structure. In particular, reaction collars shall be compatible with the dimensions including tolerances of the flexible pipe end fitting.

The stresses or strains caused by the fastening force between the interface structure and the support structure, (e,g. through bolting, contact forces or otherwise), shall not exceed allowable levels i n the interface structure or support structure. See Table 7 of API 17J:2008 for end-fitting permissible utilization factors.

6.3.8 Bend Restrictor Design Verification

After design of the bend restrictor elements, the free and deformed locking radius of the bend restrictor shall be calculated based on the configuration of the individual elements to demonstrate that the required locking radii are achieved.

6.3.9 Service Life—Static Applications

Further to 4.3.9, it shall be demonstrated that creep of polymer bend restrictors due to constant loading during lock-up does not cause strains to exceed allowable levels or cause the product to fail to meet its functional requirements over the service life.

6.3.10 Service Life—Dynamic Applications

See 6.4.6 of API 17L2 for guidelines and recommendations on the use of bend restrictors in dynamic applications.

6.3.11 Corrosion Protection

See 4.3.11 for minimum corrosion protection requirements for metallic bend restrictor elements and the interface structure.

Polymer bend restrictor element half-shells shall be fastened together using fasteners manufactured from a corrosion-resistant metal.

Further to the requirements of 4.3.11, galvanic corrosion of the interface structure and its fasteners shall be avoided either by appropriate selection of metallic materials based on compatibility with the support structure material (see 6.2.4) or by electrically isolating the interface structure by use of protective coatings or otherwise.

6.4 Material Requirements

6.4.1 General

The requirements of this section shall apply to metallic and polymer bend restrictor elements and metallic interface structures.

6.4.2 Qualification Requirements—Polymer Materials

In the qualification program, the manufacturer shall test and document for the bend restrictor polymer materials the properties specified in Table 15. Where indicated, the material properties in Table 15 shall be measured at the minimum and maximum temperature of the material in service in addition to measurement at room temperature. Where indicated, the material properties shall also be measured for aged samples of material. See 4.4.4 for minimum ageing test requirements.

6.4.3 Qualification Requirements—Metallic Materials

See 4.4.3 for minimum metallic material qualification requirements for metallic bend restrictor elements and the bend restrictor interface structure.

Where the bend restrictor is manufactured from standard pipe, the pipe metallic materials shall conform to the grades or quality levels specified in appropriate International Standards for pipe, such as those listed in Table 16.

6.5 Manufacturing Requirements

6.5.1 Quality Assurance Requirements—Process Control

The manufacturer shall as a minimum have a documented methodology for the polymer bend restrictor element manufacturing processes listed in 4.5.3.4.

The manufacturer shall have a documented methodology for machining polymer bend restrictor elements, where applicable.

The manufacturer shall as a minimum have a documented methodology for the manufacturing processes listed in 4.5.3.2 for metallic bend restrictor elements and the interface structure.

For each mix of polymer material, a sample of material shall be retained and tested to verify that it is consistent with the properties measured in the qualification tests.

The following properties shall be tested, as a minimum:

a) tensile strength: ISO 527-1, ISO 527-2, ASTM D638 or ISO 37;

b) hardness: ISO 868, ASTM D2240 or BS 2782-3 Method 365B.

Table 15—Qualification Requirements for Bend Restrictor Polymer Materials

Tests	Test Procedure [a]	Section	Min. Temperature	Max. Temperature	Aged Sample
Abrasion resistance	ISO 7784-2 [b], ASTM D4060 [b], BS 903-A9, DIN 53516	See 4.4.2.7			
Compressive strength, modulus, strain at break	ISO 604 [c], ASTM D695 [c], ISO 7743				
Density [d]	ASTM D792, ISO 1183				
Hardness	ISO 868 [c], ASTM D2240, BS 2782 Pt 3 Method 365B [c]				
Heat distortion temperature	ISO 75-1, ISO 75-2, ASTM D648 [e]		Not Applicable	Not Applicable	
Impact strength	ISO 179, ISO 180 [c], ASTM D256	See 4.4.2.7	X		
Shear strength, modulus, strain at break	ISO 1827, ASTM D732				
Tensile strength, modulus, strain at break	ISO 527-1 [c], ISO 527-2 [c], ASTM D638 [c], ISO 37			X	X

[a] As stated in Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.

[b] Standards similar in content but not technically equivalent.

[c] Standards are technically equivalent or identical for the test in question.

[d] The density of the polymer is of importance if the manufacturer has specified a weight requirement on the bend restrictor, see 6.2.3.2.

[e] The test method described as Method B of this test method, and test methods Ae and Be of ISO 75-1:1993 and ISO 75-2:1993 are technically equivalent.

Table 16—Examples of Metallic Pipeline Material Selection Standards

Designation	Title
API 5L	*Line Pipe*
BS 8010	*Code of Practice for Pipelines, Part 3. Pipelines subsea: design, construction and installation.*
DNV OS-F101	*Submarine Pipeline Systems*

6.5.2 Quality Assurance Requirements—Handling During Manufacture

The manufacturer shall have documented handling procedures in place for polymer bend restrictor elements.

6.5.3 Manufacturing Tolerances

Tolerances for bend restrictor elements shall be selected such that, with variations within these tolerances, the bend restrictor elements shall be dimensionally compatible with each other.

Tolerances for the interface structure shall be selected such that, with variations within these tolerances, it shall still be dimensionally compatible with the purchaser support structure.

6.5.4 Repairs

Polymer bend restrictor elements that are determined to be unfit for purpose in accordance with 4.7.3 shall not be repaired and shall therefore be replaced.

6.6 Documentation

6.6.1 Design Report

6.6.1.1 Bend Restrictor Description

The bend restrictor description in the design report shall include, as a minimum, the following:

a) minimum parameters specified in 4.6.3;

b) bend restrictor element internal bore dimensions;

c) bend restrictor element maximum external diameter;

d) length of individual bend restrictor elements and overall bend restrictor length;

e) free and deformed locking radii;

f) design temperature;

g) maximum allowable bending moment and shear force;

h) minimum bending radius for storage, installation and operation.

6.6.1.2 Bend Restrictor Design Report Content

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) documented basis for polymer and composite material endurance limits or fatigue safety factors where applicable;

f) overview of CP system design methodology where applicable;

g) manufacturing and design tolerances;

h) calculations demonstrating that design satisfies functional requirements accounting for variations within manufacturing tolerance envelopes;

i) description of welds used for metallic components;

j) documentation of service life methodology, subject to the requirements of 4.3.8 to 4.3.10;

k) calculation of the dimensions of all components, including as a minimum:

   1) bend restrictor elements (length, external and internal diameters etc.);

   2) interface structure;

   3) external coatings;

   4) fasteners;

   5) sizes of CP system anodes;

l) calculation of the free and deformed locking radii of the bend restrictor (to verify bend-restricting capability in accordance with 6.3.8);

m) calculation of the fastening forces securing bend restrictor to support structure and securing element half-shells together, where applicable (in accordance with 6.3.5 and 6.3.7);

n) service life analysis, subject to the requirements of 6.3.9 or 6.3.10 (if the bend restrictor is used in a dynamic application).

The design report shall include or make reference to any calculations performed or software tools used for these items.

6.6.2 Installation Procedures

The manufacturer's procedures for installation shall include the following:

a) procedures listed in 4.6.5;

b) procedure for connecting the interface structure to the adjacent structure, including fastening forces to apply;

c) procedure for assembling bend restrictor elements together. This shall include the fastening forces to secure half-shells together, where applicable;

d) procedures for attaching the CP system cables to metallic bend restrictors.

6.7 Factory Acceptance Tests

6.7.1 General

The manufacturer shall perform the FAT tests specified in Table 17 on the bend restrictor components. A minimum of 1 metallic and 1 polymer bend restrictor element from a hybrid bend restrictor shall be tested.

6.7.2 Dimensional Measurement

Dimensional measurement of bend restrictor elements and the interface structure shall verify that the dimensions of these components are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances.

The dimensions that shall be measured for the bend restrictor element shall include the following as a minimum:

a) internal diameter;

b) external diameters;

c) length.

6.7.3 Fit-up and Assembly Test

6.7.3.1 Procedure

All bend restrictor elements shall be assembled onto the interface structure or onto dimensionally and geometrically representative mock-ups of the interface structure. This structure shall, in turn, be assembled onto a structure that is dimensionally and geometrically representative of the support structure. These structures shall be fastened together using fasteners of the same specification and fastened to the same fastening force as determined at the design stage for service. Where bend restrictor elements consist of half-shells, the bend restrictor elements shall be fastened together using fasteners of the same specification and fastened to the same fastening force as determined at the design stage for service (see 6.3.5). The length of the bend restrictor shall be measured.

6.7.3.2 Acceptance Criteria

All the components of the bend restrictor shall be dimensionally compatible with each other and the interface and support structures or dimensionally and geometrically representative mock-ups of these structures. The bend restrictor elements shall not experience any adverse damage from application of the fastener fastening forces. The length of the bend restrictor shall be in accordance with the length specified in the engineering drawings, allowing for dimensional tolerances.

6.7.4 Measurement of Free-locking Radius

6.7.4.1 Procedure

The measurement of the bend restrictor free-locking radius shall involve measuring the locking radius of the assembled bend restrictor (assembled in accordance with 6.7.3) without any applied loads.

6.7.4.2 Acceptance Criteria

The measured locking radius shall be in between the maximum and minimum free-locking radius calculated at the design stage. The locking radius under load shall be greater than the flexible pipe MBR.

6.7.5 Visual Examination

Polymer bend restrictor elements shall be inspected for any ovality. The manufacturer shall define allowable levels of ovality in the fabrication specification.

6.8 Marking and Packaging

6.8.1 Marking

6.8.1.1 See 4.7.4 of API 17L2:2013 for general marking recommendations.

6.8.1.2 The bend restrictor marking shall make it permanently identifiable for the specified service life.

The marking shall include the following as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) free-locking radius;

f) identification of flexible pipe to which bend restrictor is to be attached.

6.8.2 Packaging

Polymer bend restrictor elements shall be packaged in suitably protective material such as bubble-wrap. All packages shall be accompanied by a packing list.

Table 17—Factory Acceptance Tests for Bend Restrictor Components

Component	Test	Percentage of Total Production to be Tested	Section/Test Procedure
Metallic bend restrictor elements	Dimensional	5 % [a] for machined elements but minimum of 2	See 6.7.2
	Visual	100 %	See 4.7.2
	Fit-up and assembly [b]	1 for each bend restrictor design	See 6.7.3
	Free-locking radius [b]	1 for each bend restrictor design	See 6.7.4
Polymer bend restrictor elements	Dimensional [c]	5 % [a] but minimum of 2	See 6.7.2
	Visual	100 %	See 4.7.3 and 6.7.5
	Fit-up and assembly [b]	1 for each bend restrictor design	See 6.7.3
	Hardness	5 % [a] but minimum of 1	ISO 868 [b], ASTM D2240,
	Free-locking radius [b]	1 for each bend restrictor design	See 6.7.4
Interface structure	Dimensional	100 %	See 6.7.2
	Visual	100 %	See 4.7.2
	NDE of welds	100 %	See 4.7.2

[a] Value is consistent with current industry practice.
[b] Only 1 fit-up and assembly and free-locking radius test required per hybrid bend restrictor design.
[c] As per 4.7.4, the dimensional check shall include the first item moulded and the frequency shall be evenly distributed between the first and last items moulded.

7 Bellmouths

7.1 Applicability

The requirements of Section 4 shall apply.

This section applies to bellmouths that are used for static and dynamic bend control.

The requirements in this section shall also be applied to umbilicals.

7.2 Functional Requirements

7.2.1 General

Purchasing guidelines for bellmouths are given in Annex C.

The minimum overall functional requirements of the bellmouth that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to maintain the flexible pipe operating MBR above that specified by the purchaser;

c) to remain securely attached to the support structure for the specified service life;

d) to transfer loads from the flexible pipe to the support structure.

7.2.2 Flexible Pipe Design Parameters

For the flexible pipe which the bellmouth is protecting the purchaser shall specify the following parameters as a minimum:

a) internal diameter;

b) service type;

c) service life;

d) external diameter;

e) tolerance on external diameter;

f) operating and storage MBR;

g) relationship between MBR and effective tension, for umbilicals where applicable. The relationship may be submitted in the form of a graph or in tabulated form;

h) crushing capacity of the flexible pipe.

7.2.3 Bellmouth Design Parameters

7.2.3.1 Required Parameters

For the bellmouth, the purchaser shall specify the following parameters:

a) required bellmouth profile, if the purchaser has determined the bellmouth profile. This should be provided in the form of detailed engineering drawings;

b) angle of bellmouth in mean position with respect to vertical axes;

c) any constraints relating to physical dimensions of bellmouth expressed in terms of maximum length and maximum external exit dimensions.

NOTE A pre-engineering by the manufacturer might be required to determine a bellmouth profile suitable for both the flexible pipe and for the manufacturing process.

7.2.3.2 Additional Parameters

The purchaser shall specify the following parameters:

a) any requirements on bellmouth mass, in order to minimize the mass of the bellmouth and reduce the overall weight of the vessel/platform or flexible pipe system;

b) requirement for anti-fouling coatings.

7.2.4 Purchaser Support Structure

The purchaser shall provide detailed drawings of the support structure to which the bellmouth is to be connected, such as an I-tube or tether clamp (where the bellmouth is not in the tether clamp manufacturer's scope of supply), for example. The drawings shall be sufficient to determine the required dimensions and tolerances for the bellmouth in order to interface with the support structure.

The purchaser shall specify the support structure material, the corrosion protection coating applied to it, and also provide details of the CP system for the support structure.

7.2.5 I-tube Design Parameters

Where the bellmouth is attached to an I-tube, the purchaser shall specify the as-built internal diameter of the I-tube if available, or alternatively the external diameter and wall thickness including tolerances. The purchaser shall submit detailed drawings of the I-tube, if available, to the manufacturer.

7.2.6 External Environment

Environmental functional requirements relating to sunlight exposure for composite bellmouths should be specified in accordance with 4.2.5.

The purchaser shall specify whether the bellmouth is exposed to seawater during the course of its service life, or is located at the surface and is therefore exposed only to air.

7.2.7 Design Loads

The purchaser shall specify the design loads for the bellmouth in terms of effective tension and offset angle of the flexible pipe from the bellmouth axes, [if the purchaser has not specified the profile of the bellmouth in accordance with 7.2.3.1 a)]. The effective tension and angle shall account for all possible flexible pipe load cases, with reference to the load cases specified in 5.1 of API 17J:2008.

Where the purchaser has designed the bellmouth, the purchaser shall specify the maximum permissible contact pressure exerted on the inner surface of the bellmouth by the flexible pipe.

The purchaser shall specify any fatigue loads acting on the bellmouth, specified in terms of flexible pipe effective tension and offset angle ranges and the corresponding number of cycles.

7.3 Design Requirements

7.3.1 Loads

The manufacturer shall document in the design report that the bellmouth satisfies the design criteria when subjected to the loading applied by the flexible pipe (both static and dynamic as applicable) as it contacts the bellmouth surface and flexible pipe accidental loads that affect the flexible pipe configuration and/or bellmouth, where specified by purchaser, as follows:

a) internal over-pressure;

b) vessel compartment damage or unintended flooding, where applicable;

c) failure of vessel thrusters where applicable;

d) DP failure, where applicable;

e) anchor line failure;

f) failure of FPSO turret drive system, where applicable.

7.3.2 Design Methodology

The documentation submitted for verification of the design methodology shall include documentation, methodologies, calculations and software tools used for the following, as a minimum:

a) documentation listed in 4.3.5.1;

b) dimensions of all components including as a minimum:

    1) bellmouth length,

    2) bellmouth exit dimensions,

    3) bellmouth thickness(es),

    4) external coatings,

    5) CP system calculations,

    6) fasteners securing bellmouth to support structure or tether clamp.

c) bellmouth profile (where manufacturer determines profile), see API 17L2 for recommendations on selection of bellmouth profiles,

d) external coatings:

    1) surface coating specification,

    2) coating log and result of adhesion test from manufacturer's coating supplier,

    3) qualification status of coating system applied.

e) service life performance, subject to the requirements of 4.3.9 or 4.3.10.

Further to the requirements of 4.3.5.2, the design shall account for the material properties of composite bellmouths due to the proximity to the flexible pipe outer sheath temperature and surrounding ambient air or seawater temperatures, as applicable, that induce the minimum and maximum temperatures in the material.

7.3.3 Design Criteria

The bellmouth profile shall not allow the flexible pipe bending radius to fall below its operating MBR, accounting for all possible load combinations.

The bellmouth profile shall protect the flexible pipe from excessive dynamic loading leading to fatigue failure of the pipe within the specified service life.

The pressure that is exerted on the flexible pipe outer sheath due to contact with the bellmouth shall not exceed the flexible pipe allowable contact pressure.

There is a maximum allowable compressive force applied to the flexible pipe when the flexible pipe is in contact with the inner surface of the bellmouth, defined by the flexible pipe crushing capacity. The design shall ensure that the crushing capacity criteria are satisfied, accounting for the most critical effective tension when the flexible pipe is in contact with the bellmouth.

The entry angle shall be at least 5º greater than that calculated to be required from all design load cases, accounting for all effects including vessel rotation.

NOTE The above requirement has been transferred directly from API 17B.

7.3.4 Bellmouth Design

The bellmouth profile may be manufactured by connecting individual sections together. In such cases, the bend-limiting performance given by the bellmouth profile shall be documented not to be affected by the transition between adjacent sections to the extent that the required flexible pipe MBR criteria are not satisfied or the fatigue performance of the flexible pipe is adversely affected.

Damage to pull-in wires or to the bellmouth, due to abrasion of the pull-in wire with the bellmouth during installation, shall be avoided by the design of the bellmouth profile.

There shall be measures in place in the bellmouth design to prevent build-up of marine growth or debris in the bellmouth that might cause the flexible pipe MBR criteria to be violated, damage being caused to the flexible pipe, or the fatigue performance of the flexible pipe to be adversely affected.

The bellmouth profile shall be designed to prevent flexible pipe curvature ranges within the bellmouth structure that will cause the flexible pipe fatigue criteria to be violated.

7.3.5 Bellmouth Design—Composite Bellmouths

The manufacturer shall check in the design that the elastic deformation of the bellmouth when the flexible pipe makes contact with the bellmouth interior does not cause the flexible pipe operating MBR to fall below the allowable level.

Connections between composite bellmouths and metallic guide tubes shall be designed to maintain such a connection for the specified service life under the applied bending loads. The performance of the bond design shall be verified by full-scale testing, see 7.6.3 of API 17L2:2013.

7.4 Material Requirements

7.4.1 General

The requirements of this section shall apply to metallic and composite materials for the bellmouth.

Materials used to coat the interior surface of the bellmouth shall be documented not to increase the surface roughness to an extent such that the bend-limiting performance of the bellmouth profile is adversely affected.

7.4.2 Qualification Requirements—Fiber-reinforced Composite Materials

The manufacturer shall document the material properties of composite bellmouths, as specified in Table 18. The material properties refer to material properties of the composite material and not the constituent components. Where indicated, the material properties in Table 18 shall be measured at the minimum temperature of the material in service. Where indicated, the material properties shall also be measured for aged samples of material. See 4.4.4 for minimum ageing test requirements.

Bellmouth composite materials in dynamic applications shall have sufficient fatigue resistance to sustain the cyclic bending due to contact with the flexible pipe. Small-scale fatigue testing of the bellmouth material shall simulate the mean stress/strain, stress/strain ranges and number of cycles that the material will be subjected to in service.

Table 18—Qualification Requirements for Fiber-reinforced Composite Bellmouth Materials

Tests	Test Procedure [a]	Section	Min. Temperature	Max. Temperature	Aged Sample
Abrasion resistance	ISO 7784-2 [b], ASTM D4060 [b], BS 903-A9 or DIN 53516	See 4.4.2			
Compressive strength, modulus, strain at break [c]	ISO 604 [d], ASTM D695 [d], ISO 7743				
Density	ISO 1183, ASTM D792				
Fatigue resistance		See 7.4.2	X [e]	X [e]	
Impact strength	ISO 179, ISO 180 [d], ASTM D256		X		
Tensile strength, modulus, strain at break [c]	ISO 527-1 [d], ISO 527-2 [d], ASTM D638 [d], ISO 37			X	X

[a] As stated in Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.

[b] Standards similar in content but not technically equivalent.

[c] Property shall be expressed both in the fiber direction and transverse to the fiber direction.

[d] Standards are technically equivalent or identical for the test in question.

[e] The material shall undergo sufficient testing to qualify the material's fatigue resistance for the temperature range under consideration.

7.5 Manufacturing Requirements

7.5.1 Quality Assurance Requirements—Process Control

The manufacturer shall as a minimum have a documented methodology for the manufacturing processes listed in Section 4 and filament winding of tubular bellmouth sections and hand lay-up of profiled sections for composite bellmouths.

For each mix of composite material, a sample of material shall be retained and tested to verify that it is consistent with the properties measured in the qualification tests.

The following properties shall be tested as a minimum:

a) tensile strength: ISO 527-1, ISO 527-2, ASTM D638 or ISO 37;

b) hardness: ISO 868, or ASTM D2240.

7.5.2 Surface Finish

The bellmouth interior surface shall be continuously smooth and shall be free from any sharp points or edges that may damage the flexible pipe outer sheath. All weldments made to the interior surface shall be ground smooth. The manufacturer shall have procedures in the fabrication specification to ensure that these requirements are satisfied.

7.5.3 Manufacturing Tolerances

The dimensional tolerances on the bellmouth profile shall be such that with variations within such tolerances the flexible pipe operating MBR criteria and fatigue criteria are still satisfied.

7.6 Documentation

7.6.1 Design Report

7.6.1.1 Bellmouth Description

The bellmouth description in the design report shall include, as a minimum, the following:

a) minimum parameters specified in 4.6.3;

b) description of profile;

c) entrance and exit internal dimensions;

d) wall thickness;

e) length;

f) maximum allowable flexible pipe angle with respect to bellmouth axes and associated effective tension during operation.

7.6.1.2 Bellmouth Design Report Content

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis, including calculation procedures for the design parameters required for the design report;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used, including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) documented basis for polymer and composite material endurance limits or fatigue safety factors, where applicable;

f) overview of CP system design methodology, where applicable;

g) manufacturing and design tolerances;

h) calculations demonstrating that design satisfies functional requirements, accounting for variations within manufacturing tolerance envelopes;

i) description of welds used for metallic components;

j) documentation of service life methodology, subject to the requirements of 4.3.8 to 4.3.10;

k) calculation of the dimensions of all components, including as a minimum:

   1) bellmouth length;

   2) bellmouth exit dimensions;

   3) bellmouth thickness(es);

   4) external coatings;

   5) CP system calculations;

   6) fasteners securing bellmouth to support structure or tether clamp;

l) calculation of bellmouth profile (where manufacturer determines profile), see API 17L2 for recommendations on selection of bellmouth profiles;

m) service life analysis, subject to the requirements of 4.3.9 or 4.3.10.

The design report shall include or make reference to any calculations performed for or software tools used for these items.

7.6.2 Installation Procedures

Further to 4.6.5, the manufacturer shall submit to the purchaser procedures for attaching the bellmouth to the support structure, including fastening forces to apply where applicable.

The manufacturer shall submit to the purchaser procedures for assembling bellmouth half-shells together where applicable, including fastening forces to apply.

7.7 Factory Acceptance Tests

7.7.1 Dimensional Measurement

Dimensional measurement of the bellmouth shall verify that the required profile as specified in engineering drawings is achieved, allowing for the dimensional tolerances.

The dimensions that shall be measured shall include the following, as a minimum:

a) entrance diameter;

b) exit diameter;

c) length;

d) diameters at sufficient points along bellmouth length to verify that as-designed profile is achieved.

7.7.2 Visual Examination

The interior surface of the bellmouth and the edges at the bellmouth exit shall be inspected for any sharp points that could damage the flexible pipe. The interior surface shall be inspected for any surface imperfections, such as weld splatter, that affect the designed profile such that the functional requirements are not satisfied. The surface finish shall be inspected to verify that it is in accordance with the design.

7.8 Marking

See 4.7.4 of API 17L2:2013 for general marking recommendations.

The bellmouth marking shall make it permanently identifiable for the specified service life.

The marking shall include the following as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) identification of flexible pipe to which bellmouth is associated;

e) mass in air.

8 Buoyancy and Ballast Modules

8.1 Applicability

The requirements in Section 4 and Section 12 shall apply.

This section applies to buoyancy modules and ballast modules. For requirements on continuous added weight, see Section 22 which addresses abrasion and impact protection.

The requirements in this section shall also be applied to umbilicals, except those requirements relating to clamping force design in 8.4.6.

The requirements in this section apply to all the components in the module, including the module element, internal clamp and securing fasteners. Some requirements relating to the internal clamp are given by way of cross-reference to Section 12 (General Clamp Design Requirements), which applies to general clamping device requirements.

8.2 Functional Requirements

8.2.1 General

Purchasing guidelines for buoyancy and ballast modules are given in Annex D.

The minimum overall functional requirements of the buoyancy or ballast modules that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to provide the required net buoyancy or net weight to the flexible pipe for the specified service life;

c) to remain securely clamped in its specified position on the flexible pipe for the specified service life.

8.2.2 Flexible Pipe Design Parameters

For the flexible pipe to which the modules are attached, the purchaser shall specify the following parameters as a minimum:

a) internal diameter;

b) service type;

c) service life;

d) flexible pipe design parameters required for the clamp design in 12.2.1;

e) operating MBR.

8.2.3 Buoyancy Module Design Parameters

For the buoyancy modules, the purchaser shall specify the following parameters as a minimum:

a) final or initial net buoyancy, as appropriate, required per unit length of flexible pipe. The choice of initial or final net buoyancy will depend on which is critical to the system design, and shall be clearly identified;

b) length of buoyant/weighted section;

c) in lieu of Item a) and Item b), the purchaser may specify a combination of size and number of modules, with the required center to center spacing. The purchaser shall specify whether this is based on initial or final net buoyancy, and shall clarify whether alternative combinations of size, number of modules and spacing, resulting in the overall required buoyancy/weight, may be considered.

See 8.2.3 of API 17L2:2013 for a discussion on the circumstances in which initial or final net buoyancy is appropriate.

The purchaser should consider specifying permissible tolerances on net buoyancy and buoyant length required. See 8.6.9 of API 17L2:2013 for guidelines on buoyancy module tolerances. Where there is more than one buoyancy module type, the above tolerance parameters shall be specified for each buoyancy module type.

8.2.4 Ballast Module Design Parameters

For the ballast modules, the purchaser shall specify the following parameters as a minimum:

a) net mass required per unit length, including tolerances;

b) length of weighted section;

c) in lieu of Item a) and Item b), the purchaser may specify a combination of size and number of modules, with the required center-to-center spacing. The purchaser shall clarify whether alternative combinations of size, number and spacing, resulting in the overall required weight, may be considered.

The purchaser should consider specifying permissible tolerances on net mass and the weighted length required, where these parameters are specified, see 8.6.3. Where there is more than one ballast module type, the above tolerance parameters shall be specified for each ballast module type.

8.2.5 General Module Design Parameters

For the modules, the purchaser should consider specifying the following parameters.

a) Center-to-center spacing.

b) Any constraints relating to physical dimensions of modules, expressed either in terms of maximum length and maximum outer dimensions or as preferred dimensions.

   NOTE The physical dimensions of buoyancy modules may constrain, to an extent, the net buoyancy achievable.

c) Requirement for anti-fouling coatings.

See 8.2.6 of API17L2:2013 for a discussion on the effects of module spacing.

8.2.6 External Environment

Environmental functional requirements relating to sunlight exposure should be specified in accordance with 4.2.5. Further to 4.2.5, the purchaser should specify whether any modules will be installed at a water depth to which sunlight can penetrate.

The purchaser shall specify the maximum water depth of the particular length of modules in question, accounting for both installation and operating water depths.

The purchaser shall specify the marine growth density and thickness at the water depth range of the modules in question.

8.2.7 Corrosion Protection

The purchaser may specify a requirement for a particular corrosion-resistant material for the module fasteners.

8.2.8 Installation Requirements

Further to 4.2.7, the purchaser shall provide detailed drawings of moonpool areas of the platform/lay vessel where applicable, if the modules are to be installed through a moonpool. The purchaser shall specify the proper interface data regarding the lay spread (moonpool dimensions, deck heights, maximum crane heights, etc.) intended to be used in the installation, to the manufacturer.

Where installation is to be carried out using an installation tower, the purchaser should indicate the space available in the installation tower in terms of the dimensional constraints imposed on the modules.

8.2.9 Design Loads

The purchaser shall specify the axial loads transferred from the module element to the clamp for both installation and operating conditions.

The purchaser shall specify the maximum flexible pipe curvature along the length of flexible pipe with modules attached.

8.2.10 Quantities

Subject to 8.2.3 c) or 8.2.4 c) and 8.2.5, the manufacturer may offer combinations of number and size of module to meet the global requirements specified in 8.2.3 or 8.2.4 as appropriate.

8.2.11 Spares

Further to 4.2.10, the purchaser should specify the required number of spare modules and spare fasteners for each type of module.

8.3 Design Requirements—Loads

Local load classes and subclasses for buoyancy and ballast modules are listed in Table 19. The table distinguishes between functional loads acting on the buoyancy element and those acting on the internal clamp.

8.4 Design Methodology

8.4.1 Documentation

The documentation submitted for verification of the design methodology shall include documentation, including any calculations performed, methodologies and software tools used, for the following, as a minimum:

a) documentation listed in 4.3.5.1;

b) dimensions of all components including as a minimum:

   1) module element;

   2) thickness of external skins on the module element;

   3) fasteners (used to secure internal clamp and used to secure module element half shells, where applicable);

   4) internal clamp body;

   5) internal clamp strap;

6) external strap, where applicable;

c) buoyancy/weight losses over service life (in accordance with 8.4.3/8.4.4);

d) internal clamp contact pressure and fastening forces (in accordance with 8.4.6);

e) external fastening force for securing module element half-shells together (in accordance with 8.4.7);

f) slamming force calculations (in accordance with 8.4.6);

g) tolerance on individual modules and tolerance on buoyancy/weight of modules collectively;

h) service life performance, subject to the requirements of 8.4.9.

Table 19—Local Load Classes and Subclasses for Buoyancy and Ballast Modules

Load Classes and Subclasses
Functional Loads
Loads acting on module element: a) Hydrostatic pressure. b) Impact and abrasion loads during handling, transport and installation. Loads acting on internal clamp: a) Loads dues to expansion and contraction of the flexible pipe due to tension, internal pressure and temperature effects during service, installation and during leak tests or structural integrity tests, see 11.5.3 of API 17B:2008. b) Loads induced by fastening systems, for example internal clamp strap. c) Loads transferred from the buoyancy element (includes buoyancy-element buoyancy, ballast module weight, mass in air). Thermal expansion and contraction loads due to temperature of flexible pipe outer sheath (where different materials in the module are expanding at different rates). Thermal shock loads.
Environmental Loads
Loads acting on internal clamp: a) Hydrodynamic loads and inertial loads transferred from the buoyancy element due to waves, currents and vessel thrusters (these will transfer to the internal clamp); b) Slamming loads transferred from the buoyancy element as module passes through MWL during installation. Loads due to cyclic bending of the flexible pipe.
Accidental Loads
Flexible pipe accidental loads that affect the flexible pipe configuration and/or buoyancy module, where specified by purchaser, as follows: a) internal over-pressure; b) vessel compartment damage or unintended flooding where applicable; c) failure of vessel thrusters where applicable; d) DP failure where applicable; e) anchor line failure; f) failure of FPSO turret drive system where applicable.

8.4.2 Design Criteria—General

The module shall be designed so that the flexible pipe operating MBR does not fall below the minimum specified by the purchaser due to bending about the areas either side of the module where the flexible pipe exits the bore.

8.4.3 Buoyancy Module Design Criteria

Buoyancy collectively shall be designed not to reduce or increase outside the net buoyancy requirement specified by the purchaser over the specified service life due to variations in buoyancy induced by, but not limited to, the following effects:

a) water absorption of polymer or composite components of the module;

b) initial elastic compression at operating depth;

c) creep;

d) marine growth;

e) manufacturing tolerances.

NOTE 8.2.4 of API17L2:2013 gives recommendations on the number of modules whose loss the flexible pipe should be able to withstand. The above variations are distinct from such losses in that they represent variations in buoyancy of material that is still physically in contact with the flexible pipe in its designated location.

The hydrostatic crush pressure of the buoyancy element at the start of the service life, determined using a full-scale hydrostatic testing (see 8.8.4), shall be at least 1,5 times the hydrostatic pressure at the service depth. This value shall account for the statistical distribution of the buoyancy element material crush pressures measured during testing.

NOTE This value has been based on the value that the industry has started to use in order to be consistent with the factors of safety for the flexible pipe in normal operation (a more commonly used value of 1,25 had been used previously).

8.4.4 Ballast Module Design Criteria

Ballast modules collectively shall be designed not reduce or increase outside the net weight requirement specified in 8.2.4 a) over the specified service life due to variations in weight induced by, but not limited to, the following effects:

a) marine growth;

b) water absorption of polymer or composite components of the module;

c) manufacturing tolerances.

8.4.5 Module Design—General

The determination of the center-to-center module spacing shall as a minimum be large enough such that no interference occurs between adjacent modules at the maximum curvature of the flexible pipe during installation or operation. The center-to-center module spacing shall also be compatible with any installation constraints specified by the purchaser, such as moonpool door thickness for example, in which case there shall be sufficient spacing between modules for the moonpool doors to shut between installation of adjacent modules.

The module shall be provided with suitable recesses or lifting points that are compatible with lifting equipment used for handling both during manufacture and during transport and installation.

8.4.6 Internal Clamp Design

The module internal clamp shall be designed to exert sufficient contact pressure to prevent sliding of the module for the specified service life including installation conditions.

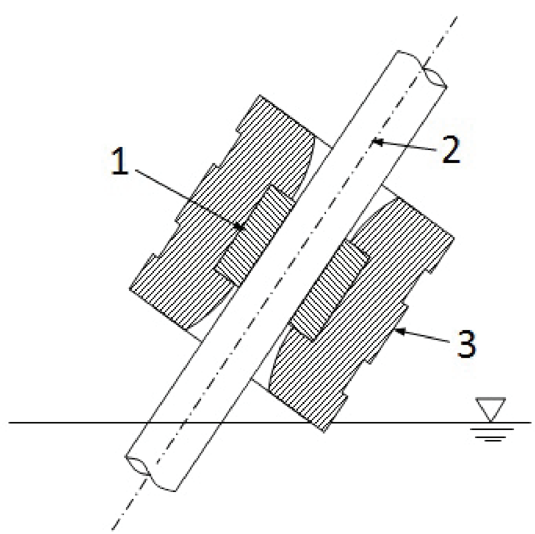
The calculation of contact pressure shall account for the following:

a) effects listed in 12.3.3;

b) loads transferred from the module element to the clamp including those induced by self-buoyancy/self-mass in air and drag forces.

The calculation of contact pressure shall account for those loads transferred from the module element to the clamp as the module is being passed through the MWL and is subjected to slamming loads. This calculation shall account for the geometry of the module element. These forces shall be considered when the module length is offset with respect to the vertical, and resulting bending moments tend to twist the internal clamp against the flexible pipe. This is illustrated in Figure 5 which shows a section through a typical buoyancy module and internal clamp as they are being passed through the MWL.

For fastening systems such as fasteners or straps, for example, used to secure the internal clamp in position, an appropriate fastening force (such as bolt torque and strap tension) shall be calculated and specified in the installation procedures (see 8.7.2). The specified force shall be calculated to prevent module sliding but shall not cause the flexible pipe allowable contact pressure to be exceeded or cause adverse damage to the internal clamp body.



Key

1 internal clamp
2 flexible pipe
3 buoyancy element

Figure 5—Module Deployment Through MWL

8.4.7 External Fastenings

The external fastening system shall be designed to keep the module element half-shells securely attached together for the specified service life. An appropriate fastening force (such as bolt torque or strap tension) shall be calculated and specified in the installation procedures, see 8.7.3 of API 17L2:2013. The specified force shall be calculated to prevent strap loosening where applicable and module element half-shell separation, but shall not cause adverse damage to the module element. The calculation of strap tension shall account for any compression of the module element over the service life such that the strap does not loosen and move out of position.

The external fastening system shall be designed to resist the mass in air of the module and the buoyancy force applied by the module.

8.4.8 System Design Requirements—Global Analysis

Further to the requirements of 5.4.1.3 of ISO API 17J:2008, interference/clashing of modules with other subsea structures shall be checked in the global analysis of the flexible pipe. The interference clashing analysis shall account for the external dimensions of modules on all the interfering lines. Such interference shall not be allowed to occur. Therefore if it is determined through analysis to occur, then the design shall be modified in order to avoid it.

The global analysis of the flexible pipe system shall account for both the initial and final net buoyancies of the system.

8.4.9 Service Life—Dynamic Applications

Further to 4.3.10, fatigue analysis of the internal clamp body and internal clamp strap shall be performed using a methodology to be agreed between the purchaser and manufacturer.

Further to the requirements of 4.3.9, for the buoyancy element and other polymer or composite components it shall be documented in the design report that the level of creep and water absorption does not cause the net buoyancy to go below that specified by the purchaser. This documentation shall account for the temperature of the internal clamp body due to contact with the flexible pipe outer sheath.

The internal clamp components shall be designed not to creep to an extent that the clamping capacity is reduced to a level where the module can slide out of position under the applied loads or that allowable stress/strain levels in the material are exceeded.

8.4.10 Corrosion Protection

Metallic components in the modules shall be manufactured from a corrosion-resistant metal.

8.5 Material Requirements

8.5.1 General

The requirements of this section shall apply to composite syntactic foam materials for the buoyancy element, metallic and composite materials for the internal clamp strap, and polymer and composite materials for the internal clamp body.

The manufacturer shall have documented records on the suitability of either anti-fouling coatings or the module external skin itself, for marine growth resistance, if such properties are required.

8.5.2 Qualification Requirements—Blown, Syntactic and Composite Syntactic Foam Buoyancy

The manufacturer shall test and document the material properties of composite syntactic foams, as specified in Table 20. The material properties refer to properties of the composite material and not the constituent components such as the matrix, microspheres and macrospheres. Where indicated, the material properties shall be measured for aged samples of material. See 4.4.4 for ageing test requirements.

The measurement of water absorption shall account for the applied hydrostatic pressure as well as the material temperature while in service. The measurement of water absorption shall be such that the water absorption at the end of the service life may be extrapolated.

8.5.3 Qualification Requirements—Polymer External Skin Materials

The manufacturer shall test and document the material properties of polymer external skin materials, as specified in Table 21. Where indicated, the material properties in Table 21 shall be measured at the minimum temperature of the material in service in addition to measurement at room temperature. Where indicated, the material properties shall also be measured for aged samples of material. See 4.4.4 for minimum ageing test requirements.

8.5.4 Qualification Requirements—Internal Clamp and Internal Clamp Strap Composite Materials

The manufacturer shall test and document the material properties of composite materials for use in the internal clamp and internal clamp strap, as specified in Table 22 and Table 23, respectively. The material properties refer to properties of the composite material and not the constituent components. Where indicated, the material properties in Table 22 and Table 23 shall be measured at the maximum temperatures of the material in service in addition to measurement at room temperature. Where indicated, the material properties shall also be measured for aged samples of material. See 4.4.4 for minimum ageing test requirements.

8.5.5 Qualification Requirements—Metallic Materials

See 4.4.3 for minimum qualification requirements for metallic components of the module such as straps and bolts.

The grade of titanium materials shall conform to an appropriate international standard such as ASTM B265 for strip sheet and plate or ASTM B348 for bars and billets, for example.

8.5.6 Quality Assurance Requirements—General

Further to the requirements of 4.4.5, the hydrostatic crush strength of microspheres shall be measured at a frequency of once per batch at raw materials supplier’s or manufacturer’s work site.

8.6 Manufacturing Requirements

8.6.1 Quality Assurance Requirements—Process Control

8.6.1.1 Syntactic Foam Buoyancy

The following manufacturing processes for composite syntactic foam buoyancy elements shall be documented in the fabrication specification:

a) processes listed in 4.5.3;

b) injection of composite syntactic foam into external skin where applicable;

c) manufacture or application of external skin;

d) coating of microspheres and macrospheres;

e) mixing of microspheres and macrospheres with matrix material (syntactic and composite syntactic foams only).

8.6.1.2 Ballast Module

The following manufacturing processes for ballast module elements shall be documented in the fabrication specification:

a) manufacture of external skin, see 4.5.3.7;

b) injection of weight material into external skin.

8.6.1.3 Welding of Titanium

Further to 4.5.3.2, welding of titanium shall be carried out in accordance with an appropriate international or national standard such as AWS A5.16.

Table 20—Qualification Requirements for Blown, Syntactic and Composite Syntactic Foam Buoyancy Materials

Material Property	Test Procedure [a]	Section
Bulk modulus		
Compressive strength, modulus, strain at break	ISO 604 [b], ASTM D695 [b], ISO 7743	
Density	ISO 1183, ASTM D792	
Hydrostatic creep resistance		
Hydrostatic strength		
Shear strength, modulus, strain at break	ISO 1827, ASTM D732,	
Tensile strength, modulus, strain at break	ISO 527-1 [b], ISO 527-2 [b], ASTM D638 [b], ISO 37	
Water absorption	ISO 62 [c], ASTM D570 [c]	See 8.5.2.2

[a] As stated in Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.
[b] Standards are technically equivalent or identical for the test in question.
[c] Standards similar in content but not technically equivalent.

NOTE: The suitability of the buoyancy materials is to be agreed between Purchaser and Supplier

Table 21—Qualification Requirements for Polymer External Skin Materials

Material Property	Test Procedure [a]	Section	Min. Temperature	Aged Sample
Abrasion resistance	ISO 7784-2 [b], ASTM D4060 [b], BS 903-A9, DIN 53516	See 4.4.2.7		
Density	ISO 1183, ASTM D792			
Hardness	ISO 868 [c], ASTM D2240			
Impact strength	ISO 179, ISO 180 [c], ASTM D256	See 4.4.2.7	X	
Tensile strength, modulus, strain at break	ISO 527-1 [c], ISO 527-2 [c], ASTM D638 [c], ISO 37			X

[a] As stated in Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.
[b] Standards similar in content but not technically equivalent.
[c] Standards are technically equivalent or identical for the test in question.

8.6.1.4 Internal Clamp Body Surface

The fabrication specification shall include procedures to ensure that surfaces of the internal clamp body in contact with the flexible pipe outer sheath shall be free of any sharp points or edges left by the moulding process that can cause damage to the flexible pipe.

8.6.1.5 Composite Syntactic Foam Material Properties

For each mix of composite syntactic foam material, a sample of material shall be retained and tested to verify that it is consistent with the properties measured in the qualification tests.

The following properties shall be tested:

a) density: ISO 1183, or ASTM D792;

b) hydrostatic strength.

Table 22—Qualification Requirements for Internal Clamp Composite Materials

Material Property	Test Procedure [a]	Max. Temperature	Aged Sample
Compressive strength, modulus, strain at break	ISO 604 [b], ISO 7743 [c], ASTM D695 [b]	X	X
Creep resistance		X	
Density	ISO 1183, ASTM D792		
Tensile strength, modulus, strain at break	ISO 527-1 [b], ISO 527-2 [b], ISO 37 [c], ASTM D638 [b], ISO 37 [c]	X	X

[a] As stated in Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.
[b] Standards are technically equivalent or identical for the test in question.
[c] Standards are identical.

Table 23—Qualification Requirements for Module Internal Clamp Strap Fiber-reinforced Composite Materials

Material Property	Test Procedure [a]	Section	Max. Temperature	Aged Sample
Abrasion resistance	ISO 7784-2 [b], ASTM D4060 [b], BS 903-A9, DIN 53516	See 4.4.2		
Creep resistance			X	
Tensile strength, modulus, strain at break [c]	ISO 527 [d], ASTM D638 [d], ISO 37		X	X

[a] As stated in Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.
[b] Standards similar in content but not technically equivalent.
[c] Property shall be expressed in the fiber direction.
[d] Standards are technically equivalent or identical for the test in question.

8.6.1.6 Composite or Polymer Material Properties

For each mix of composite (e.g. internal clamp body) or polymer material (e.g. external skin), a sample of material shall be retained and tested to verify that it is consistent with the properties measured in the qualification tests.

The following properties shall be tested as a minimum:

a) tensile strength: ISO 527-1, ISO 527-2, ASTM D638 or ISO 37;

b) hardness: ISO 868, or ASTM D2240.

8.6.2 Storage

The manufacturer shall determine the maximum height (in terms of number of modules high) to which modules can be stacked without causing adverse damage. The stacking height shall not exceed this level during storage, transport or at any other stage.

8.6.3 Manufacturing Tolerances

The net buoyancy/net weight of each module and the net buoyancy/net weight of the buoyant/weighted section of the flexible pipe shall be within any agreed tolerances as specified in 8.2.3.

Tolerances for the module components shall be selected such that, with variations within these tolerance, they shall fit together without difficulty.

Tolerances for the internal clamp body shall be selected such that, with variations within these tolerances, it shall still be dimensionally compatible with the flexible pipe.

The manufacturing tolerances on macrosphere half-spheres shall be such that the half-spheres can fit together correctly when assembled.

8.7 Documentation

8.7.1 Design Report

8.7.1.1 Module Description

The module description in the design report shall include as a minimum the following:

a) items listed in 4.6.3;

b) module internal and external dimensions, and diameter of any recesses;

c) module length;

d) design depth;

e) internal clamp design temperature.

f) Initial and final net buoyancy or net weight overall and per module.

8.7.1.2 Module Design Report Content

The module design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) documented basis for polymer and composite material endurance limits or fatigue safety factors where applicable;

f) manufacturing and design tolerances;

g) description of procedures and devices used to control manufacturing processes;

h) calculations demonstrating that design satisfies functional requirements, accounting for variations within manufacturing tolerance envelopes;

i) description of welds used for internal clamp strap;

j) service life analysis, subject to the requirements of 4.3.8 to 4.3.10;

k) calculation of the dimensions of all components, including as a minimum:

   1) module element;

   2) thickness of external skins on the module element;

   3) fasteners (used to secure internal clamp and used to secure module element half-shells, where applicable);

   4) internal clamp body;

   5) internal clamp strap;

   6) external strap, where applicable;

l) calculation of buoyancy/weight losses over service life (in accordance with 8.4.3 and 8.4.4);

m) calculation of internal clamp contact pressure and fastening forces (in accordance with 8.4.6);

n) calculation of external fastening force for securing module element half shells together (in accordance with 8.4.7);

o) slamming force calculations (in accordance with 8.4.6);

p) tolerance on individual modules and tolerance on buoyancy/weight of modules collectively;

q) service life analysis, subject to the requirements of 8.4.10.

The design report shall include or make reference to any calculations performed for or software tools used for these items.

8.7.2 Installation Procedures

The manufacturer's procedures for installation shall include the following:

a) procedures listed in 4.6.5;

b) procedure for securing internal clamp and internal clamp strap, including bolt torque to fasten internal clamp strap;

c) procedure for assembling modules together. This shall include the fastening forces to apply to external straps or bolts securing module element segments together.

8.8 Factory Acceptance Tests

8.8.1 General

The manufacturer shall carry out the FAT tests for module components as given in Table 24, except the hydrostatic test, as a minimum. The hydrostatic test shall be carried out at the purchaser's request on a number of buoyancy elements as specified by the purchaser.

8.8.2 Dimensional Measurement

Dimensional measurement of module components shall verify that the dimensions of these components are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances.

The dimensions that shall be measured for the module shall include the following as a minimum:

a) bore diameter of element and internal clamp;

b) external diameter of element and internal clamp;

c) length of module element;

d) dimensions of internal clamp recess.

8.8.3 Fit-up and Assembly Testing

8.8.3.1 Procedure

The module shall be assembled on a sample of flexible pipe, where available, or a dimensionally representative mock-up of the flexible pipe considering the outer diameter tolerances. The assembly shall include all components that make up the buoyancy module, including the internal clamp, the buoyancy elements and all fasteners necessary to secure these components in position. The components shall be fastened together using fasteners of the same specification and fastened to the same fastening force as determined at the design stage for service, see 8.4.6.

8.8.3.2 Acceptance Criteria

The acceptance criteria shall be that all the components of the module are dimensionally compatible with each other.

8.8.4 Full-scale Hydrostatic Test

8.8.4.1 Procedure

The hydrostatic pressure test shall be carried out at a hydrostatic pressure equivalent to at least 110 % of the design depth for a period specified by the purchaser. The hydrostatic pressure shall remain stabilized for a time equal to the specified period of the test.

NOTE The testing at a hydrostatic pressure equivalent to at least 110 % of the design depth percentage is representative of current industry practice.

8.8.4.2 Acceptance Criteria

No permanent deformation or damage shall be observed on the buoyancy element. The measured buoyancy after the test, when extrapolated to an end of service life value and multiplied by the total number of buoyancy elements, satisfies the net buoyancy requirement.

8.8.5 Buoyancy Testing

8.8.5.1 Procedure

The buoyancy element shall be fully immersed in seawater or fresh water and its buoyancy measured. Where buoyancy is measured in fresh water, the measured value shall be factored to take account of the specified seawater density. As a minimum, 10 % or 1, whichever is highest, of the buoyancy elements shall be buoyancy-tested. The buoyancy of the remaining buoyancy elements can be calculated by correlating their mass in air and dimensions to those of the buoyancy elements that have been buoyancy-tested.

Table 24—Factory Acceptance Testing Tests for Buoyancy Module Components

Component	Test	Percentage of Total Production to be Tested	Section
Module	Fit-up and assembly	5 % [a] but minimum of 2 (not those components subjected to a dimensional test)	See 8.8.3
Module element	Dimensional [b]	5 % [a] but minimum of 2 (not those subjected to a fit-up and assembly test)	See 8.8.2
	Mass in air	100 % [c]	
	Visual	All	See 4.7.3
Buoyancy element	Buoyancy	10 % [d]	See 8.8.5
	Full-scale hydrostatic pressure test [e]	Specified by purchaser	See 8.8.4
Internal clamp body	Dimensional [b]	5 % [a] but minimum of 2 (not those subjected to a fit-up and assembly test)	See 8.8.2
	Mass in air	All	
	Visual	All	See 4.7.3
Internal clamp strap	Dimensional [b]	5 % [a] but minimum of 2 (not those subjected to a fit-up and assembly test)	
	Visual	All	See 4.7.2 or 4.7.3
	NDE of welds [f]	100 %	See 4.7.2

[a] Value is consistent with current industry practice.
[b] As per 4.7.4, the dimensional check shall include the first item moulded and the frequency shall be evenly distributed between the first and last items moulded.
[c] 100 % mass in air measurement is specified, since it is practical within current manufacturing practices.
[d] The testing frequency of 10 % represents current industry practice.
[e] Test shall be carried out only at the purchaser's request.
[f] Metallic internal clamp straps only.

8.8.5.2 Acceptance Criteria

The buoyancy shall be within the agreed tolerances. These tolerances shall be those specified by the purchaser or alternatively those specified by the manufacturer.

8.9 Marking and Packaging

8.9.1 Marking

See 4.7.4 of API 17L2:2013 for general marking recommendations.

The module marking shall make it permanently identifiable for the specified service life.

The marking shall include the following as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) design depth;

f) net buoyancy or net weight in seawater;

g) mass in air;

h) identification of flexible pipe to which module is to be attached.

8.9.2 Packaging

Each buoyancy module shall be packaged with all components necessary for its assembly onto the flexible pipe. This shall include, as applicable, the internal clamp body, the internal clamp strap, buoyancy elements, external straps and fasteners. All packages shall be accompanied by a packing list.

9 Subsea Buoys

9.1 Applicability

The requirements in Section 4 shall apply.

This section applies to the subsea buoy frame, buoyancy tanks and buoyancy elements of a subsea buoy system. For specific requirements on tethers, tether bases and subsea buoy clamps, see Section 10, Section 11 and Section 12, respectively. Where relevant, requirements relating to these components are given by way of cross-reference to Section 10 to Section 12. This section does not address nonbuoyant riser support structures.

Distinction is made in this section between requirements applicable to subsea buoys with buoyancy tanks and those with buoyancy elements. Sections marked “General” are applicable to both systems.

The requirements in this section shall also be applied to umbilicals.

9.2 Functional Requirements

9.2.1 General

Purchasing guidelines for subsea buoys are given in Annex E.

The minimum overall functional requirements of the subsea buoy that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to provide the required net buoyancy to all the attached flexible pipes for the specified service life;

c) to ensure that all the flexible pipes remain securely attached to the subsea buoy for the specified service life;

d) to remain securely tethered to the tether base for the specified service life, where applicable.

9.2.2 Flexible Pipe Design Parameters

The purchaser shall specify the number of flexible pipes to be attached to the subsea buoy.

For all the flexible pipes that are attached to the subsea buoy the purchaser shall specify the following parameters as a minimum:

a) internal diameter;

b) service type;

c) service life;

d) detailed drawings of any preliminary configuration that is available, specifying position of subsea buoy in flexible pipe system and with respect to seabed or MWL;

e) operating MBR;

f) mass per unit length, empty and full. This may be specified as a mass per unit length empty and an internal fluid density. The purchaser should specify any variations in mass per unit length over the service life;

g) length of flexible pipe and associated mass per unit length that will allow the weight of the flexible pipe to be calculated.

9.2.3 Temperature—Buoyancy Tanks

For installation of buoyancy tank subsea buoys by the purchaser or by a company appointed by the purchaser, the purchaser shall specify the minimum and maximum air temperatures associated with the following conditions:

a) pressurization;

b) storage;

c) transport;

d) installation.

9.2.4 Subsea Buoy Design Parameters

The purchaser shall specify as a minimum the final or initial net buoyancy required, including tolerance.

See 9.2.3 of API 17L2:2013 for a discussion on the circumstances where initial or final net buoyancy is appropriate.

The purchaser should specify any requirements for anti-fouling coatings.

The purchaser shall specify the weight in water of the tether system, if the tether system is not in the subsea buoy manufacturer's scope of supply.

The purchaser shall specify the weight in air or water, as relevant, of the tether base or any other attached weights, if these structures are freely suspended from the subsea buoy during installation and these structures are not in the subsea buoy manufacturer's scope of supply.

9.2.5 Subsea Buoy Design Parameters—Buoyancy Tanks

The purchaser shall specify their requirement for multiple buoyancy tanks and compartmentalization of buoyancy tank(s), in order to provide redundancy in the design in the event of loss of a tank/compartment. The purchaser shall also specify their requirement for redundancy in the tether design. See 9.2.11 of API 17L2:2013 for guidelines on factors to consider in determining these requirements.

9.2.6 External Environment—General

The purchaser should specify the marine growth density and thickness at the water depth of the subsea buoy.

The purchaser shall specify the maximum water depth at which the subsea buoy is to be located.

The purchaser shall specify wave and current data corresponding to the most critical hydrodynamic loads on the subsea buoy, if required by the manufacturer. When specifying current data, the purchaser shall specify the current velocity profile with water depth required to calculate the current velocity at the subsea buoy location. The purchaser shall also specify the current direction. When specifying wave data, the purchaser shall specify significant wave heights or amplitudes, associated periods, directionality, and any other parameters associated with the wave spectrum being used.

9.2.7 External Environment—Buoyancy Elements

Environmental functional requirements relating to sunlight exposure should be specified in accordance with 4.2.5.

9.2.8 Corrosion Protection

The corrosion protection requirements for metallic components of the subsea buoy may be specified by the purchaser in accordance with 4.2.6. These metallic components may include the subsea buoy frame, buoyancy tanks, connection hardware and fasteners. The use of dissimilar metals shall be avoided, e.g. stainless steel fasteners on a carbon steel structure.

9.2.9 Inspection and Conditioning Monitoring—General

The purchaser should consider specifying any requirements regarding integrity and condition monitoring for the subsea buoy, as follows:

a) positioning of anodes to facilitate inspection of CP system during general vision inspection;

b) requirement for inclusion of an inclinometer on the subsea buoy to indicate tilt of subsea buoy, where practical.

9.2.10 Inspection and Conditioning Monitoring—Buoyancy Tanks

The purchaser should consider specifying leak-detection devices for buoyancy tanks, where practical.

9.2.11 Installation Requirements

The purchaser should specify whether installation of the subsea buoy structure is to employ diver intervention or is to be diverless.

For installation by the purchaser or a company appointed by the purchaser, the purchaser should specify any requirements for the subsea buoy to interface with remotely operated vehicle (ROV) tools during installation.

For installation by the purchaser, the purchaser shall specify the maximum subsea buoy mass in air that can be supported by available lifting equipment and shall specify requirements for compatibility of the subsea buoy with lifting equipment.

For installation by the purchaser, the purchaser shall specify the space available in terms of width, height and length to accommodate the subsea buoy structure.

9.2.12 Design Loads

The purchaser shall specify the crushing capacity of the flexible pipe.

The purchaser should specify the minimum allowable effective tension in the tethers.

Where global analysis of the flexible pipe system is not in the manufacturer’s scope of work, the flexible pipe system designer shall specify the following:

a) maximum effective tensions in the tether system (including the tether and any bridles) attached to the subsea buoy frame;

b) fatigue loads consisting of minimum, maximum and mean tether tensions and angles in three dimensions, along with corresponding numbers of cycles for each tether tension and angle range;

c) minimum and maximum effective tensions in the lower and upper catenaries of each of the flexible pipes attached to the subsea buoy at the departure points from the subsea buoy;

d) minimum and maximum departure angles of each flexible pipe from the subsea buoy in the horizontal plane, the vertical plane in the flexible pipe longitudinal direction, and the vertical plane transverse to the flexible pipe longitudinal direction.

The above design loads shall account for all possible flexible pipe load combinations and conditions in accordance with 5.1.3 of API 17J:2008, and for the effects of all accidental loads detailed in Table 29 unless the yearly probability of occurrence of such design loads is less than 10^{-4}. The above design loads shall account for the effect of installation tolerances on the tether base and the riser bases, including the effects on the effective tension and departure angles of the flexible pipes and other loads in Table 25.

9.2.13 Marking

The purchaser may specify requirements for marking of the subsea buoy frame and the buoyancy elements. Minimum marking requirements are given in 9.8.

9.2.14 Pigmentation

The purchaser should specify pigmentation requirements for the subsea buoy frame and buoyancy tanks or buoyancy elements.

9.3 Design Requirements

9.3.1 Loads

Further to the requirements of 4.3.2, the probability of specific load classes or subclasses may be specified by the purchaser based on project-specific conditions. The probabilities of accidental events (buoyancy tank flooding and tether failure) should be specified by the system owner. If the purchaser does not specify probabilities and probabilities are required, the manufacturer shall propose the probabilities that will be used for the individual events in the design premise.

NOTE The above requirements are consistent with the approach adopted in API 17J.

Load classes and subclasses for subsea buoys are listed in Table 25.

Table 25—Local Load Classes and Subclasses for Subsea Buoys

Load Classes and Subclasses
Functional, Environmental and Accidental Loads
a) Loads acting on subsea buoy tether, see Table 27. b) Loads acting on tether base, see Table 30. c) Loads acting on subsea buoy clamp where applicable, see Table 35.
Functional Loads
a) Hydrostatic pressure. b) Loads applied by flexible pipes (effective tensions). c) Loads due to self-buoyancy (including dynamic amplification effects). d) Loads due to self-weight while at surface or before buoyancy is applied. e) Loads due to weight of flexible pipes attached to subsea buoy (weight in water) including internal fluid. f) Slugging in flexible pipe. g) Static and dynamic reaction loads from tether. h) Installation and transportation loads: 1) loads due to weight of flexible pipes (weight in air) attached to subsea buoy if flexible pipes are attached at surface. 2) loads due to attached clump weights/tether base where applicable. 3) loads during transport of subsea buoy including loads due to transport vessel motions. 4) effective tensions and curvatures of the flexible pipe during installation. 5) wave slamming loads as subsea buoy approaches MWL. 6) load due to wet tow, where applicable. i) Loads acting on buoyancy tanks: 1) internal pressure during pressure testing and during operation. Includes dynamic pressure effects due to motions of subsea buoy. Includes changes in pressure (from pressurization to installation) due to ambient air temperature. 2) loads due to self-weight where buoyancy tanks are ballasted. j) Loads acting on buoyancy elements: 1) hydrostatic pressure. 2) impact and abrasion loads during handling, transport and installation.
Environmental Loads
a) Hydrodynamic loads. b) Wind loads during installation.
Accidental Loads
Flexible pipe accidental loads that affect the flexible pipe configuration and/or the subsea buoy, where specified by purchaser, as follows: a) internal over-pressure; b) vessel compartment damage or unintended flooding where applicable; c) failure of vessel thrusters where applicable; d) DP failure where applicable; e) anchor line failure; f) failure of FPSO turret drive system where applicable; g) loads due to flooding of one buoyancy tank compartment or one buoyancy tank [a]; h) loads due to failure of one tether [b].
[a] See 9.3.4.1 for scenarios where this loadcase needs to be analyzed. [b] See 10.3.4 for scenarios where this loadcase needs to be analyzed.

9.3.2 Design Methodology

The documentation submitted for verification of the design methodology shall include documentation, methodologies, calculations and software tools used, for the following, as a minimum:

a) documentation listed in 4.3.5.1;

b) buoyancy element documentation as follows:

   1) dimensions of buoyancy element;

   2) thickness of external skins on the element;

   3) buoyancy losses over service life (in accordance with 8.4.3);

   4) tolerance on individual modules and tolerance on buoyancy/weight of modules collectively;

   5) service life performance, subject to the requirements of 9.3.13;

c) tether documentation listed (in accordance with 10.3.2), where applicable;

d) tether base documentation (in accordance with 11.5.2);

e) clamp documentation (in accordance with 12.3.1), where applicable;

f) dimensions of all components including as a minimum:

   1) profile of gutters (in accordance with 9.3.3 and 9.3.7);

   2) spacing between flexible pipes (in accordance with the recommendations of 9.2.5 of API 17L2:2013);

   3) sizes of structural members of subsea buoy frame (in accordance with 9.3.7);

   4) clearance between flexible pipe and gutter walls (in accordance with 9.3.7);

   5) fasteners;

   6) protective coatings;

   7) sizes of CP system anodes;

g) fastening forces for securing structural members of subsea buoy frame together;

h) service life performance, subject to the requirements of 9.3.11.

9.3.3 Design Criteria—General

The crushing capacity in the flexible pipes over the gutters shall not be exceeded, accounting for the most critical flexible pipe effective tension and the particular gutter radius.

The three-dimensional bending radius of the flexible pipes on the gutters shall be at least 1,25 times the largest storage MBR of the supported flexible pipes.

NOTE The value of 1,25 is based on the MBR requirements of API Spec 17J for flexible pipe. However there is more certainty with this radius, as the flexible pipe is being supported by a fixed object.

The subsea buoy shall not reduce or increase in buoyancy outside the net buoyancy requirement for the specified service life due to variations in buoyancy induced by but not limited to the following effects:

a) marine growth;

b) manufacturing tolerances, see 9.5.6;

c) losses in buoyancy of polymer and composite buoyancy tanks, where applicable, due to the effects of water absorption, initial elastic compression at design depth and creep;

d) any residual water in buoyancy tanks, where applicable, if tanks are ballasted for installation for example;

e) losses in buoyancy of syntactic foam or composite syntactic foam buoyancy elements, where applicable, due to the effects of water absorption, initial elastic compression at design depth and creep;

f) damage to the buoyancy element protective coating.

9.3.4 Design Criteria—Buoyancy Tanks

The subsea buoy shall be able to satisfy its functional requirements under all load combinations and conditions after loss of one buoyancy tank compartment with all tethers intact and loss of one tether with all buoyancy tanks intact, unless otherwise specified by the purchaser (see 9.2.5). Any of these events may be ignored if it can be demonstrated that the yearly probability of the event occurring is below 10^{-4} (in accordance with API 17J). The requirements to sustain all load combinations and conditions may be relaxed if it can be demonstrated that the probability of such omitted load conditions is less than the probability of a 10^{-4} yearly probability event occurring over the service life [e.g. 0,2 % for a 20-y (twenty-year) service life] during the time period between integrity and condition-monitoring inspections. Alternatively, a suitably high tether safety factor that can be demonstrated to give the same probability of failure as the above criteria using reliability analysis in accordance with 4.3.6.6 or otherwise may be applied to obviate the requirement to design for the tether loss. The requirements of certifying authorities shall take precedence over these requirements.

NOTE The probability of 10^{-4} has been selected in order to be consistent with the allowance in 5.1.3.2 of API 17J:2008 that load combinations with a yearly probability of occurrence less than 10^{-4} can be ignored.

9.3.5 Design Criteria—Buoyancy Elements

The hydrostatic crush pressure of the buoyancy element at the start of the service life, determined using a full-scale hydrostatic test (see 8.8.4), shall be at least 1,5 times the hydrostatic pressure at the service depth. This value shall account for the statistical distribution of the buoyancy element material crush pressures measured during testing.

Small scale buoyancy elements may be tested if agreed upon between manufacturer and purchaser.

9.3.6 Subsea Buoy Design—General

See 13.3.2 for subsea buoy clamp design requirements where applicable, see 11.5 for tether base design requirements, and 10.3.5 for tether design requirements.

The external dimensions of the subsea buoy shall be compatible with the space available on the installation vessel deck.

9.3.7 Subsea Buoy Frame Design—General

Further to 4.3.7, the frame of the subsea buoy shall be designed in accordance with an appropriate international standard for structural design, such as those listed in Table 3.

The design of the subsea buoy frame shall account for scenarios where the subsea buoy is installed before the flexible pipes are attached to it, and therefore there is more buoyancy acting on it than would be the case in operation where the weight of the flexible pipes is counteracting this buoyancy.

The design of the gutters shall account for the range of departure angles of the flexible pipes in both the horizontal and vertical planes, based on the angles specified by the purchaser. The design of the gutter shall ensure that there is no localized over-bending of the flexible pipe at the gutter edges, below the specified operating MBR.

The clearance between the gutter walls and the flexible pipe shall account for variations in the flexible pipe external diameter due to tension, internal pressure and temperature effects.

The subsea buoy frame shall be dimensionally compatible with the other components of the subsea buoy as follows:

a) buoyancy elements or buoyancy tanks, as applicable;

b) tether connection hardware;

c) clamps, where applicable.

The rotations of the subsea buoy due to any unequal effective tensions in the attached flexible pipes and any unsymmetrical hydrodynamic loads shall be assessed in the design by use of three-dimensional finite element analysis to determine if they cause any loads on the subsea buoy or flexible pipe to exceed allowable limits. The departure angles (supplied by the flexible pipe system designer where global analysis of the flexible pipe system is not in the manufacturer’s scope of work) of the flexible pipe from the subsea buoy should be accounted for in this assessment.

NOTE This requirement is based on the recommendation in 8.2.5.4 of API 17B:2008.

The vertical position of the clamps on the subsea buoy frame relative to the gutters shall be designed such that there is no over-bending of the flexible pipes either side of the clamp.

9.3.8 Subsea Buoy Frame Design—Buoyancy Elements

The subsea buoy frame shall be designed such that the buoyancy elements are held securely by the subsea buoy structure for the specified service life. The manufacturer shall have available calculations or other documented justification demonstrating the security of the buoyancy elements within the frame.

9.3.9 Subsea Buoy Design—Buoyancy Tanks

Buoyancy tanks designed as pressure vessels shall be designed in accordance with ASME VIII or Published Document (PD) 5500.

Where redundancy is included in the buoyancy tank design (see 9.3.4), the distribution of buoyancy tanks (in the case of a multiple-tank design) or compartments [in the case of compartmentalization of the buoyancy tank(s)] shall be designed such that, in the event of one compartment/tank flooding, the resulting imbalance in tension in the tethers will not lead to tether snatch loads, loss of tether tension or the tether tension to fall below the minimum allowable effective tension specified by the purchaser (see 10.3.5).

The design of the buoyancy tank shall ensure that flooding of a buoyancy tank compartment shall not increase the propensity for adjacent compartments to fail.

The buoyancy tank filling valves shall be designed to sustain the applied pressure for the service life. There shall be suitable provision in the design to protect the valves against normal handling operations.

9.3.10 System Design Requirements—Global Design

The global design of the subsea buoy shall account for installation tolerances on the tether base and the riser base, as well as tolerances on the flexible pipe topside hang-off angle.

The global analysis of the flexible pipe system shall account for both the initial and final net buoyancies of the system.

9.3.11 Service Life—Dynamic Applications—General

9.3.11.1 Fatigue Analysis

Further to 4.3.10, fatigue analysis of the subsea buoy frame shall include the following areas:

a) tether connection points (see 10.3.5);

b) support work of gutters;

c) support work of clamps, where applicable.

9.3.11.2 Cycle Loads

The fatigue analysis shall account for any of the following cyclic loads that cause the documented and verifiable endurance limit of the material (that has been approved by the purchaser) to be exceeded:

a) tether effective tensions;

b) flexible pipe effective tensions.

9.3.12 Service Life—Buoyancy Tanks

Further to 4.3.9, the manufacturer shall document by calculations that any loss in buoyancy due to creep of polymer and composite buoyancy tanks does not cause reduction below the net buoyancy requirement.

9.3.13 Service Life—Buoyancy Elements

Further to the requirements of 4.3.9, it shall be documented in the design report that the level of creep and water absorption in buoyancy elements does not cause reduction below the net buoyancy requirement.

9.3.14 Corrosion Protection—General

See 4.3.11 for minimum corrosion protection requirements for the subsea buoy frame and metallic buoyancy tanks.

Further to the requirements of 4.3.11, the design of the CP system shall ensure that all metallic components on the subsea buoy frame, as well as attached connection hardware in direct contact with the subsea buoy frame, are given protection for the specified life. These components shall include all structural members of the subsea buoy frame, including bolts, shackles, tri-plates, pad-eyes, gutters and clamps (if the clamp does not have a dedicated CP system). The manufacturer's CP calculations shall demonstrate such protection is provided to the above components.

The design of the CP system shall account for drain of the system from the attached tethers and any bridles.

9.3.15 Corrosion Protection—Buoyancy Tanks

Corrosion protection coatings shall be applied to the inner surfaces of buoyancy tanks if they are to be filled with water at any stage, such as during pressure testing or ballasting during installation, unless the following apply:

a) the buoyancy tank is manufactured from a corrosion-resistant material;

b) a suitable corrosion allowance is used;

c) a suitable corrosion inhibitor has been added to the water.

9.4 Material Requirements

9.4.1 General

The requirements of this section shall apply to metallic materials for the subsea buoy frame, metallic, polymer and composite materials for the buoyancy tanks and blown foam, and syntactic foam and composite syntactic foam materials for the buoyancy element.

The manufacturer shall have documented records on the suitability of any anti-fouling coatings applied to the subsea buoy for the specified application and environment.

9.4.2 Qualification Requirements—Metallic Materials

See 4.4.3 for minimum qualification requirements for metallic components of the subsea buoy frame, such as structural members, gutters and fasteners.

Metallic materials for buoyancy tanks designed as pressure vessels shall be qualified in accordance with ASME VIII or PD 5500.

9.4.3 Qualification Requirements—Blown, Syntactic and Composite Syntactic Foam Buoyancy

See 8.5.2 for qualification requirements for buoyancy element blown foam, syntactic foam or composite syntactic foam materials.

9.4.4 Qualification Requirements—Polymer External Skin Materials

Polymer external skins for buoyancy elements shall be qualified in accordance with 8.5.3.

9.5 Manufacturing Requirements

9.5.1 Quality Assurance Requirements—General Process Control

See 10.5.1, 11.7.2, and 13.5 for minimum process control requirements for tethers, tether bases and clamps (where applicable), respectively.

The manufacturer shall as a minimum have a documented methodology for the manufacturing processes listed in 4.5.3.2 for the subsea buoy frame.

9.5.2 Quality Assurance Requirements—Buoyancy Tank Process Control

The manufacture of buoyancy tanks that are designed as pressure vessels shall be in accordance with ASME VIII or PD 5500.

For each mix of composite buoyancy tank material, a sample of material shall be retained and tested to verify that it is consistent with the properties measured in the qualification tests. The following properties shall be tested as a minimum:

a) tensile strength: ISO 527, ASTM D638 or ISO 37;

b) hardness: ISO 868, or ASTM D2240.

9.5.3 Quality Assurance Requirements—Buoyancy Element Process Control

The manufacturer shall as a minimum have a documented methodology for the following manufacturing processes for blown foam, syntactic foam and composite syntactic foam buoyancy elements:

a) processes listed in 4.5.3.4, 4.5.3.5, and 4.5.3.7;

b) manufacture or application of external skin;

c) coating of microspheres and macrospheres (syntactic and composite syntactic foams only);

d) mixing of microspheres and macrospheres with matrix material (syntactic and composite syntactic foams only).

For each mix of blown foam, syntactic foam or composite syntactic foam material, a sample of material shall be retained and tested to verify that it is consistent with the properties measured in the qualification tests.

The following properties shall be tested:

a) density: ISO 1183, or ASTM D792;

b) hydrostatic strength.

9.5.4 Quality Assurance Requirements—Handling During Manufacture

Lifting of the subsea buoy shall be in accordance with national regulations and an appropriate international or national standard, such as those listed in Table 2.

9.5.5 Gutter

The manufacturer shall ensure that all gutter metal in the vicinity of the flexible risers is ground smooth to prevent damage to them.

9.5.6 Manufacturing Tolerances

Dimensional and manufacturing tolerances shall be such that with variations within these tolerances the subsea buoy still satisfies the net buoyancy requirements.

Dimensional and manufacturing tolerances for the gutters shall be such that, with variations within these tolerances, the gutters still satisfy the requirements specified in 9.3.3 and 9.3.7.

9.6 Documentation

9.6.1 Design Report

9.6.1.1 Subsea Buoy Description

The subsea buoy description in the design report shall include as a minimum the following:

a) minimum parameters specified in 4.6.3.1;

b) height from seabed to top of gutter radius;

c) physical dimensions of frame;

d) length of tethers;

e) gutter radius;

f) weight contribution of individual components and overall net buoyancy;

g) initial and final net buoyancies of overall subsea buoy system;

h) buoyancy tank parameters:

   1) internal pressure, where applicable;

   2) internal and external pressure rating;

   3) length and diameter;

4) wall thickness;

5) initial and final net buoyancies for each composite buoyancy tank;

i) buoyancy element parameters:

1) dimensions;

2) design depth;

3) initial and final net buoyancies per element.

9.6.1.2 Subsea Buoy Design Report Content

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used, including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) documented basis for polymer and composite material endurance limits or fatigue safety factors where applicable;

f) overview of CP system design methodology;

g) manufacturing and design tolerances;

h) description of procedures and devices used to control manufacturing processes;

i) calculations demonstrating that design satisfies functional requirements, accounting for variations within manufacturing tolerance envelopes;

j) description of welds used for the subsea buoy frame;

k) service life analysis, subject to the requirements of 4.3.8 to 4.3.10;

l) buoyancy element documentation, where applicable, as follows:

1) calculation of dimensions of buoyancy element;

2) calculation of thickness of external skins on the element;

3) calculation of buoyancy losses over service life (in accordance with 8.4.3);

4) tolerance on individual modules and tolerance on buoyancy/weight of modules collectively.

m) service life analysis, subject to the requirements of 9.3.13;

n) tether documentation listed (in accordance with 10.6.1), where applicable;

o) tether base documentation (in accordance with 11.8.1);

p) clamp documentation (in accordance with 13.6.1), where applicable;

q) calculation of the dimensions of all components including as a minimum:

   1) profile of gutters (in accordance with 9.3.3 and 9.3.7);

   2) spacing between flexible pipes (in accordance with the recommendations of 9.2.5 of API 17L2:2013);

   3) sizes of structural members of subsea buoy frame (in accordance with 9.3.7);

   4) clearance between flexible pipe and gutter walls (in accordance with 9.3.7);

   5) fasteners;

   6) protective coatings;

   7) sizes of CP system anodes.

r) calculation of the fastening forces securing structural members of subsea buoy frame together;

s) service life analysis, subject to the requirements of 9.3.11.

The design report shall include or make reference to any calculations performed for or software tools used for these items.

9.6.2 Installation Procedures

The installation contractor's procedures for installation shall include procedures for the following, where applicable:

a) procedures listed in 4.6.5;

b) required lifting equipment;

c) flooding of buoyancy tanks;

d) lowering of buoyancy tanks;

e) pressurizing of buoyancy tanks;

f) attachment of clamps;

g) attachment of tethers;

h) lowering of tether base.

The manufacturer shall provide guidelines on which the installation contractors may base their procedures.

9.7 Factory Acceptance Tests

9.7.1 General

The manufacturer shall as a minimum perform the FAT tests specified in Table 26, except the buoyancy element hydrostatic test. The hydrostatic test shall be carried out at the purchaser's request.

9.7.2 Mass Measurement

The mass in air of all the as-built subsea buoy components shall be measured as a whole or on an individual basis; in the latter case a total mass will be calculated.

9.7.3 Proof-loading of Tether Connection Points and Lifting Points

Tether connection points shall be proof-loaded if required by either the governing standard or government regulations. Subsea buoy frame lifting points shall be proof-loaded in accordance with an appropriate international standard such as Lloyd's Register of Shipping *Code for Lifting Appliances in a Marine Environment*. Where proof-loading can be shown to be impractical in the available test facilities, due to the magnitude of the loads, the size of the structure or lack of suitable reaction points, there shall be agreement from the purchaser and certifying authorities to forego the proof-loading and that in such cases verification of the load-bearing capacity may be dependent solely on calculations, NDE and raw material quality control.

9.7.4 Dimensional Measurement

Dimensional measurement of subsea buoy components shall verify that the dimensions of these components are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances.

The dimensions that shall be measured for the module shall include the following, as a minimum:

a) frame height, width and breadth;

b) buoyancy tank diameter and length;

c) buoyancy element height, width and breadth;

d) subsea buoy frame tether connection point dimensions, including hole diameter.

9.7.5 Fit-up and Assembly Testing

9.7.5.1 Procedure

Tether connection hardware shall be tested to verify that they are compatible with the corresponding connection points on the subsea buoy frame. Buoyancy elements, where applicable, shall be slotted into position to verify that they are compatible with their housing in the subsea buoy frame. Clamps, where applicable, shall be tested to verify that they can be secured to the subsea buoy frame, where the clamp is a separate structure to the subsea buoy.

9.7.5.2 Acceptance Criteria

The acceptance criteria shall be that all the components of the subsea buoy are dimensionally compatible with each other.

9.7.6 Buoyancy Tank Testing

Buoyancy tanks that have been designed as pressure vessels shall be pressure-tested in accordance with ASME VIII or PD 5500 or an appropriate international standard.

Buoyancy tanks that have not been designed as pressure vessels shall be leak-tested in accordance with an appropriate international standard.

9.7.7 Buoyancy Element Testing

9.7.7.1 Procedure

Buoyancy may be determined directly by immersing the buoyancy element in water. Alternatively, the buoyancy may be calculated using the buoyancy element dimensions, if such immersion is impractical in the available test facilities due to the buoyancy element dimensions. As a minimum, 10 % or 1, whichever is highest, of the buoyancy elements shall be buoyancy-tested. The buoyancy of the remaining buoyancy elements may be calculated by correlating their mass in air and dimensions to those of the buoyancy elements that have been buoyancy-tested.

9.7.7.2 Acceptance Criteria

The weight in water of all non-buoyant components of the subsea buoy shall be subtracted from the total buoyancy of the buoyancy elements, allowing for variations in buoyancy over the service life. The result shall be such that the net buoyancy requirement is satisfied.

Table 26—Factory Acceptance Tests for Subsea Buoys

Component	Test	Percentage of Total Production to be Tested	Section
Subsea buoy	Fit-up and assembly	100 %	See 9.7.5
Subsea buoy frame	Dimensional	100 %	See 9.7.4
	Visual	100 %	See 4.7.2
	NDE of welds	100 %	See 4.7.2
	Mass in air	100 %	See 9.7.2
	Tether connection points	100 %	See 9.7.3
	Proof loading of lifting points	100 %	See 9.7.3
Buoyancy tank	Pressure test [a]	100 %	See 9.7.6
	Leak test [b]	100 %	See 9.7.6
Buoyancy element	Dimensional	100 %	See 9.7.4
	Visual	100 %	See 4.7.2
	Buoyancy	10 % or minimum of 1 buoyancy element, whichever is highest	See 9.7.7
	Mass in air	100 %	See 9.7.7
	Full-scale hydrostatic pressure test [c]	Specified by purchaser	See 8.8.4
Tethers	See 10.7.1		
Tether base	See Table 33		
Clamps [d]	See Table 36		

a Pressure vessel buoyancy tanks only.
b Nonpressure vessels buoyancy tanks.
c Test shall be carried out only at purchaser request.
d Where subsea buoy includes clamps.

9.8 Marking

9.8.1 General

See 4.7.4 of API 17L2 for general marking recommendations.

9.8.2 Subsea Buoy Frame

The subsea buoy marking shall make it permanently identifiable for the specified service life.

The marking on the subsea buoy frame shall include the following, as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) flexible pipe identification for each gutter;

f) mass in air.

9.8.3 Buoyancy Tanks and Elements

The marking on buoyancy tanks and buoyancy elements shall include the following, as a minimum:

a) manufacturer's name or mark;

b) manufacturer's serial number;

c) markings specified by the purchaser;

d) design depth;

e) net buoyancy;

f) mass in air.

10 Tethers

10.1 Applicability

The following sections apply to subsea buoy tethers and tethers that are used in tethered flexible riser configurations. For requirements on subsea buoys and tether clamps, see Section 9 and Section 12, respectively. The following sections may also be used for a hybrid tether system, i.e. where there is a combination of a chain or wire rope and synthetic tether.

The parameters specified in accordance with 10.2.2 and 10.2.5 may only be applicable if the tether is purchased separately by the subsea buoy or tether clamp manufacturer.

API 2F and ISO 10425 contain raw material, mechanical testing, inspection and marking requirements for flash-welded chain and wire rope of various grades and construction, respectively. Therefore reference is made to these standards throughout this section.

10.2 Functional Requirements

10.2.1 General

10.2.1.1 Minimum Tether Manufacturer Requirements

The minimum overall functional requirements of the tether that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to provide the required minimum breaking load/minimum breaking strength (MBL/MBS);

c) to provide the required tether length.

Purchasing guidelines for tethers are given in Annex F.

10.2.1.2 Minimum Buoy or Tether Clamp Manufacturer Requirements

The minimum overall functional requirements of the tether that shall be demonstrated by the subsea buoy or tether clamp manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to securely attach the subsea buoy frame or tether clamp to the tether base for the specified service life;

c) to provide the tethered flexible pipe with the specified configuration.

Purchasing guidelines for tethers are given in Annex F.

10.2.2 Tether Design Parameters

For the tethers, the purchaser shall specify the following parameters as a minimum:

a) required length, including tolerances;

b) type of tether required, i.e. chain, wire rope or synthetic;

c) grade of material for chain;

d) for the type of tether required, further details of construction required, for example as follows:

   1) chain: stud or studless;

   2) wire rope: six-strand, spiral-strand or multi-strand;

   3) synthetic tether: polyester, aramid, high modulus polyethylene or nylon;

e) jacket material required for wire rope or synthetic tethers, e.g. polyurethane or polyethylene;

f) required MBL/MBS to withstand maximum tension during installation and operation.

The tolerance(s) that are specified shall be in accordance with an International Standard applicable to the type of tether being purchased where applicable. See API 2F, ISO 10425 and an appropriate international standard for chain, wire rope and synthetic tether tolerance requirements, respectively.

10.2.3 Corrosion Protection

The corrosion protection requirements for the tether and/or its end terminations may be specified in accordance with 4.2.6. The CP system requirements should be specified if adequate provision has not been made for the extra capacity in the subsea buoy, tether clamp or tether base CP system calculations.

NOTE As well as applying to chain and wire rope tethers, the CP system requirements are relevant to synthetic tether metallic end terminations.

10.2.4 Inspection and Conditioning Monitoring

The purchaser should consider specifying any requirements for tension-monitoring equipment to be operational for the service life.

10.2.5 Interface Requirements

The purchaser shall specify the type of tether end termination required (i.e. splice, socket, etc.).

The purchaser should specify any requirements for connection hardware in order to interface with connections on the tether base and the subsea buoy frame or tether clamp. Connection hardware may also be required to connect different tether types in a hybrid tether system. The type and the required safe working load (SWL) of any connection hardware shall be specified.

10.2.6 Design Loads

The purchaser shall specify the fatigue loads acting on the tether, based on the results of global analysis of the flexible pipe system. The fatigue loads specified shall consist of minimum, maximum and mean tether tensions and angles in three dimensions, along with corresponding numbers of cycles for each tether tension and angle range.

10.2.7 Quantities

The purchaser shall specify the required number of tethers.

10.2.8 Spares

The purchaser may specify a required number of spare tethers.

The purchaser should specify at least one spare tether in order to have a replacement ready for a failed tether event in which the subsea buoy is designed for a failed tether scenario.

10.2.9 Pigmentation

The purchaser should specify any preferences for pigmentation of the tether protective jacket for wire rope and synthetic tethers.

10.3 Design Requirements

10.3.1 Loads

Local load classes and subclasses for tethers are listed in Table 27. The table distinguishes between loads acting on subsea buoy tethers and those acting on flexible pipe tethers.

10.3.2 Design Methodology

The documentation submitted for verification of the design methodology shall include documentation, including any calculations performed, methodologies and software tools used, for the following, as a minimum:

a) documentation listed in 4.3.5.1;

b) demonstration that the tether can sustain maximum loads (in accordance with 10.3.5);

c) service life performance, subject to the requirements of 10.3.9.

10.3.3 Design Criteria—General

Strength safety factors for tethers shall be in accordance with an appropriate International Standard applicable to the tether type. Examples of such standards are given in Table 28. The chosen safety factor shall give a level of safety equal to or greater than the utilization factors in Table 1 for the given load condition.

Table 27—Local Load Classes and Subclasses for Subsea Buoy and Flexible Pipe Tethers

Load Classes and Subclasses	Applicability	
Functional Loads	**Subsea Buoy Tether**	**Flexible Pipe Tether**
Normal impact and abrasion loads during handling, transport and installation.	X	X
Abrasion against seabed.	X	X
Weight of tether base, where applicable	X	X
Environmental Loads		
Tension loads due to flexible pipe system motions, inclusive of initial and final net buoyancy for subsea buoy systems (including VIV of flexible pipe, and slugging and bore contents transition in the flexible pipe).	X	X
Accidental Loads		
Flexible pipe accidental loads that affect the flexible pipe configuration and/or tether, where specified by purchaser, as follows: a) vessel compartment damage or unintended flooding where applicable; b) failure of vessel thrusters where applicable; c) DP failure where applicable; d) anchor line failure; e) failure of FPSO turret drive system where applicable.	X	X
Excess loading due to failure of other tether(s).	X	X
Excess loading due to buoyancy tank leakage in subsea buoy.	X	

10.3.4 Design Criteria—Subsea Buoy Tethers

The tether shall be able to satisfy its functional requirements under all load combinations and conditions after loss of one buoyancy tank compartment with all tethers intact, and loss of one tether with all buoyancy tanks intact. Any of these events may be ignored if it can demonstrate that the equivalent yearly probability of the event occurring is below 10^{-4} (in accordance with API 17J). The requirements to sustain all load combinations and conditions may be relaxed if it can be demonstrated that the yearly probability of such omitted load conditions is less than the probability of a 10^{-4} yearly probability event occurring over the service life (e.g. 0,2 % for a 20-y (twenty-year) service life) during the time period between integrity and condition-monitoring inspections. The requirements of certifying authorities shall take precedence over these requirements. Alternatively, a suitably high safety factor that can be demonstrated to give the same probability of failure as the above criteria, using reliability analysis in accordance with 4.3.6.6 or otherwise, may be applied to the tether design.

NOTE The probability of 10^{-4} has been selected in order to be consistent with the allowance in 5.1.3.2 of API 17J:2008 that load combinations with a yearly probability of occurrence less than 10^{-4} can be ignored.

10.3.5 Design Methodology

The documentation submitted for verification of the design methodology shall include documentation, including any calculations performed, methodologies and software tools used, for the following, as a minimum:

a) documentation listed in 4.3.5.1;

b) demonstration that the tether can sustain maximum loads (in accordance with 10.3.5);

c) service life performance, subject to the requirements of 10.3.9.

10.3.6 Design Criteria—General

Strength safety factors for tethers shall be in accordance with an appropriate International Standard applicable to the tether type. Examples of such standards are given in Table 28. The chosen safety factor shall give a level of safety equal to or greater than the utilization factors in Table 1 for the given load condition.

Table 28—Examples of Mooring Standard Safety Factors

Designation	Title
ISO/TR 13637	*Petroleum and natural gas industries—Mooring of mobile offshore drilling units (MODUS)—Design and analysis*
BV RP	*Quasi-Dynamic Analysis of Mooring Systems*
DNV OS-E301	*Position Mooring*
DNV	*Rules for Classification of Mobile Offshore Units—Part 6 Chapter 2: Position Mooring (POSMOOR)*

10.3.7 Subsea Buoy Tether Design

Where the subsea buoy is designed for a failed tether event the tether configuration shall facilitate replacement of the tether after such an event.

10.3.8 Flexible Pipe Tether Design

The strength of the tether shall allow the flexible pipe to separate from the tether prior to failure of the pipe structure (unless a pipe failure or load-limiting joint is designed at the tether connection).

NOTE The above requirement has been transferred directly from API 17B.

10.3.9 Service Life—Dynamic Applications

The subsea buoy/tether clamp manufacturer shall have a documented basis demonstrating that the tether and the adjacent connection hardware shall be able to withstand the effects of wear between their mutual contact surfaces for the specified service life.

Further to 4.3.10, fatigue analysis of the tether shall account for the cyclic tether tension identified from global analyses. The fatigue analysis shall include all connection hardware. The determination of cyclic stresses shall be in accordance with 10.3.5.

The increase in length of the tether due to creep shall be documented not to exceed the tolerance specified in 10.2.2 a).

10.3.10 Corrosion Protection

See 4.3.11 for minimum corrosion protection requirements for chain and wire rope tethers.

Corrosion allowances for chain tethers shall be in accordance with an appropriate standard, such as DNV OS-E301.

10.4 Material Requirements

10.4.1 General

The requirements of this section shall apply to metallic and synthetic materials for the tether.

The manufacturer shall have documented records on the suitability of protective jackets for abrasion resistance against the seabed which demonstrate that the functional requirements of the tether will be satisfied.

10.4.2 Qualification Requirements—Chain and Wire Rope Tether Materials

Chain and wire rope tether materials shall be qualified in accordance with the requirements of an appropriate standard such as API 2F for chain and ISO 10425 for wire rope.

10.4.3 Qualification Requirements—Synthetic Tether Materials

Synthetic tether materials shall be qualified in accordance with the requirements of an appropriate standard such as those listed in Table 29.

The manufacturer shall have documented records on the suitability of synthetic tether materials for resistance against particle ingress that demonstrate that the functional requirements of the tether will be satisfied.

10.4.4 Quality Assurance Requirements

Quality control of raw tether chain materials and raw tether wire rope materials shall be in accordance with an appropriate standard such as API 2F for chain and ISO 10425 for wire rope.

Quality control of raw synthetic tether material shall be in accordance with an appropriate standard such as those listed in Table 29.

Table 29—Examples of Synthetic Tether Standards

Designation	Title
BV	*Certification of Synthetic Fiber Ropes for Mooring Systems Guidance Note*
DNV 2.9 1-504.1	*Synthetic Fiber Ropes for Towing, Mooring and Anchoring of Ships and High Speed and Light Craft*
DNV 2.13	*Certification of Offshore Mooring Fiber Ropes*

10.5 Manufacturing Requirements

Process control of the manufacturing process and tether length manufacturing tolerances for steel chain and wire rope shall be in accordance with an appropriate standard such as API 2F for chain and ISO 10425 for wire rope.

Process control of the manufacturing process and tether length manufacturing tolerances for synthetic tethers shall be in accordance with an appropriate standard such as those listed in Table 29.

10.6 Documentation—Design Report

10.6.1 Tether Description

The tether description in the design report shall include, as a minimum, the following:

a) minimum parameters specified in 4.6.3.1;

b) MBL (chain and wire rope) or MBS (synthetic tethers);

c) length and diameter;

d) description of any protective jackets;

e) description of end terminations;

f) description of any connection hardware and associated SWL rating;

g) ultimate length increase in synthetic tethers due to creep.

10.6.2 Tether Design Report Content

The design report shall specify the maximum tether tensions and the tether fatigue loadcases.

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used for connection hardware, including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) documented basis for polymer and composite material endurance limits or fatigue safety factors, where applicable;

f) manufacturing and design tolerances;

g) calculations demonstrating that design satisfies functional requirements, accounting for variations within manufacturing tolerance envelopes;

h) description of welds used for metallic components;

i) service life analysis, subject to the requirements of 4.3.8 to 4.3.10;

j) demonstration that the tether can sustain maximum loads (in accordance with 10.3.5);

k) service life analysis, subject to the requirements of 10.3.9.

The design report shall include or make reference to any calculations performed for or software tools used for these items.

10.7 Factory Acceptance Tests

All tethers shall be proof and break load tested in accordance with an appropriate standard, such as API 2F for chain tethers, API 9A for wire rope tethers and Bureau Veritas Certification of Synthetic Fiber Ropes for Mooring Systems for synthetic tethers. Hybrid tether proof and break load tests shall include the connection hardware connecting the different tether types together.

10.8 Marking and Packaging

10.8.1 Marking

See 4.7.4 of API 17L2:2013 for general marking recommendations.

As recommended by API 2SM, a clearly visible marking on the jacket or visible portion of the rope should be provided to allow for monitoring of twisting in the rope.

The marking on the tether shall be in accordance with an appropriate standard such as API 2F for chain, ISO 10425 for wire rope and standards in Table 29 for synthetic tethers.

Connection hardware marking shall be in accordance with an appropriate international standard such as Lloyd’s Register of Shipping *Code for Lifting Appliances in a Marine Environment*.

10.8.2 Packaging

Each tether shall be packaged with all associated connecting hardware purchased. All packages shall be accompanied by a packing list.

11 Riser and Tether Bases

11.1 Applicability

The following sections apply to riser bases and tether bases, the latter of which may be used in a subsea buoy system or a tethered flexible riser system. For subsea buoy, tether and tether clamp requirements, see Section 4, Section 10 and Section 12, respectively. Where relevant, requirements relating to tethers are given by way of cross-reference to Section 10.

Riser base requirements in the following sections are based primarily on transfer of loads from the flexible pipe. Similarly, tether base requirements are based in terms of load transfer from the tethers. Foundation design and design of riser base valves are not addressed, but appropriate standards for these areas are referenced. However the functional requirements section includes requirements for the purchaser to specify data that are used in foundation design.

11.2 Functional Requirements—General

11.2.1 General

This section refers to functional requirements common to both riser bases and tether bases. For specific riser and tether base requirements, see 11.3 and 11.4, respectively.

Purchasing guidelines for riser and tether bases are given in Annex G.

11.2.2 Base Design Parameters

The purchaser should consider specifying any constraints relating to physical dimensions of base, expressed in terms of maximum length, width and height.

11.2.3 External Environment

The purchaser shall specify the following soil data at the base location:

a) description;

b) undrained shear strength;

c) angle of internal friction;

d) submerged weight.

The variation in these properties with depth shall be specified, where applicable.

The purchaser shall specify the maximum water depth at the base location.

The purchaser shall specify wave and current data corresponding to the most critical hydrodynamic loads on the base. The purchaser shall specify the current velocity at the seabed and any additional current velocities required to calculate the current velocity at a height above the seabed equal to the base height.

11.2.4 Corrosion Protection

The corrosion protection requirements for the base should be specified in accordance with 4.2.6.

11.2.5 Integrity and Condition Monitoring

The purchaser may specify requirements regarding the positioning of anodes to facilitate CP system integrity and condition-monitoring inspections.

11.2.6 Installation Requirements

For installation by the purchaser, the purchaser should specify the following:

a) compatibility of the base with lifting equipment;

b) any constraints relating to mass of base in order to provide compatibility with lifting equipment;

c) any constraints relating to the dimensions of the base in order to fit onboard the installation vessel.

11.3 Functional Requirements—Riser Bases

11.3.1 General

The minimum overall functional requirements of the riser base that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to maintain position securely on the seabed in the specified location for the specified service life;

c) to provide a pressure-tight connection between the flexible pipes and flowlines.

11.3.2 Flexible Pipe Design Parameters

Accounting for all the flexible pipes that are connected to the riser base, the purchaser shall specify the following parameters, as a minimum:

a) internal diameter;

b) service type;

c) service life;

d) number of flexible pipe connections required;

e) built-in angle required for flexible pipe connection. This indicates the orientation of the flexible pipe where it connects to the base.

11.3.3 Riser Base Design Parameters

Accounting for all the flowlines that are connected to the riser base, the purchaser shall specify the following parameters, as a minimum:

a) number of flowline connections required;

b) internal and external diameters and associated tolerances.

11.3.4 Connectors

The purchaser shall provide detailed drawings of the flexible pipe to riser base and flowline to riser base connectors.

11.3.5 Internal Fluid Parameters

The internal fluid parameters for each flexible pipe attached to the riser base shall be specified in accordance with 4.4 of API 17J:2008.

11.3.6 Thermal Insulation

The purchaser should specify any requirements for thermal insulation for the riser base components. The requirement for thermal insulation for tubular components should be specified in terms of U-value.

11.3.7 Installation Requirements

In addition to the installation requirements given in 11.2.6, the purchaser shall specify requirements for the riser base to interface with ROV tools during installation, where applicable.

The purchaser should specify any requirements for diver access to the riser base, where applicable.

11.3.8 Design Loads

For all the flexible pipes attached to the riser base, the purchaser shall specify the maximum and fatigue loads transferred from the flexible pipe to the riser base. The specified loads shall include effective tensions, shear forces and bending moments based on the results of global analysis of the flexible pipe. The purchaser shall specify fatigue loads consisting of minimum, mean and maximum effective tensions, shear forces and bending moments and corresponding numbers of cycles for each load range. This load transfer is through the flexible pipe end fitting or bend stiffener, or both. The specified loads shall account for all translational and rotational installation tolerances.

The purchaser shall specify the maximum internal pressure and operational internal pressure to which the riser base piping will be subjected.

11.4 Functional Requirements—Tether Bases

11.4.1 General

The minimum overall functional requirements of the tether base that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to provide secure attachment to all tethers for the specified service life;

c) to maintain position securely on the seabed in the specified location for the specified service life.

11.4.2 Tether Base Design Parameters

The purchaser shall specify the following parameters, as a minimum:

a) details of tethers to attach to base, in terms of tether type and tether connection hardware;

b) details of tether connections required on tether base, for example pad-eyes required to fit tether shackles (see 10.2.5).

11.4.3 Tether Base Design Loads

The purchaser shall specify the maximum and fatigue tether tension loads acting on the tether base from the tether, based on the results of global analysis of the flexible pipe (see 4.3.3). Maximum loads specified shall consist of a maximum tether tension and tether angle ranges in three dimensions. The fatigue loads specified shall consist of minimum, maximum and mean tether tensions and angles in three dimensions, along with corresponding numbers of cycles for each tether load and angle range.

11.4.4 Marking

The purchaser may specify requirements for marking of the tether base. Minimum marking requirements are given in 11.10.2.

11.5 Design Requirements

11.5.1 Loads

Local load classes and subclasses for riser and tether bases are listed in Table 30. The table distinguishes between riser base loads and tether base loads.

11.5.2 Design Methodology

The documentation submitted for verification of the design methodology shall include documentation, including any calculations performed, methodologies and software tools used, for the following, as a minimum:

a) documentation listed in 4.3.5.1;

b) dimensions of all components including as a minimum (see 11.5.3):

    1) overall base;

    2) mud mat;

    3) pile dimensions, where applicable;

    4) sizes of structural members of base;

    5) fasteners;

    6) protective coatings;

    7) sizes of CP anodes;

c) foundation design (in accordance with 11.5.3);

d) design of valves (in accordance with 11.5.4);

e) service life performance, subject to the requirements of 11.5.6.

11.5.3 Base Design

The base foundation design shall be in accordance with an appropriate standard, such as those listed in Table 31.

The base structural design shall be in accordance with an appropriate international structural design standard, such as those listed in Table 3.

Table 30—Local Load Classes and Subclasses for Riser and Tether Bases

Load Classes and Subclasses	Applicability	
Functional Loads	**Riser Base**	**Tether Base**
Internal fluid pressure	X	
Static and dynamic reaction loads from attached tethers accounting for initial and final net buoyancy of subsea buoy and buoyant flexible pipe systems		X
Loads due to self-weight (including ballast)	X	X
Static and dynamic reaction loads from flexible pipe	X	
Slugging in the flexible pipe	X	X
VIV of flexible pipe	X	X
Forces due to fluid flow in particular at elbows, for example	X	
Flow-induced vibrations caused by gas flow over flexible pipe carcass [a]	X	
Expansion loads due to adjacent pipelines		
Installation loads:		
a) wave-slamming loads as base is lowered through MWL;		
b) loads due to attached temporary buoyancy.	X	X
Environmental Loads		
Wind loads during installation	X	X
Hydrodynamic loads	X	X
Accidental Loads		
Flexible pipe accidental loads that affect the flexible pipe configuration and/or riser and tether base, where specified by the purchaser, as follows: a) vessel compartment damage or unintended flooding where applicable; b) failure of vessel thrusters where applicable; c) DP failure where applicable; d) anchor line failure; e) failure of FPSO turret drive system where applicable. Dropped objects.	X	X
[a] Riser bases connected to flexible pipes with gas service only.		

Table 31—Examples of Foundation Design Standards

Designation	Title
API 2A	*Planning, Designing, and Constructing Fixed Offshore Platforms—Working Stress Design*
BS 6235	*Code of Practice for Fixed Offshore Structures*
DNV	*Classification Notes No. 30.4 Foundations*
DNV OS-C101	*Design of Offshore Steel Structures, General (LRFD Method)*

11.5.4 Riser Base Design

The design of valves in the riser base shall be in accordance with an appropriate standard such as API 6A.

Riser bases shall be located in relation to the overall system such that the pipe does not exceed operating MBR in any load case and the maximum excursion capability of the flexible pipe top end is facilitated.

NOTE This section is based on a recommendation in API 17B.

Further to 4.3.7, the stress and foundation analyses of the riser base shall account for the maximum flexible pipe reaction forces, inclusive of the effects of installation tolerances on these forces. These analyses shall also account for the directions of the forces in three dimensions and their points of application.

Installation tolerance for the riser base shall be accounted for in the riser system design.

NOTE This section is based on a recommendation in API 17B.

The pipe and J-tubes shall, where applicable, be arranged such that no bending moments are imposed on the end fitting of the static pipe.

NOTE The above requirement has been transferred directly from API 17B.

11.5.5 Tether Base Design

Further to 4.3.7, the stress and foundation analyses of the tether base shall account for the maximum tether tensions and the angles that the tethers subtend in three dimensions under all load combinations and conditions. Local stress analysis shall be performed by the subsea buoy/tether clamp manufacturer on tether connection points, and documented in the design report. The stress analysis shall account for stress concentrations at tether connection points by incorporating accurate modeling of any local geometries (see 10.3.5).

Further to the requirements of 5.4.1.3 of API 17J:2008, interference of the flexible pipe with the tether base should be checked in the global design.

11.5.6 Service Life—Dynamic Applications

Further to 4.3.10, fatigue analysis of the riser base shall account for any cyclic loads that cause the documented and verifiable endurance limit of the material (that has been approved by the purchaser) to be exceeded. The cyclic loads that shall be considered shall include flexible pipe reaction forces (accounting for their direction and their points of application) and for vibrations caused by gas flow, where applicable (see ISO 17L2 for a discussion on this type of loading). The fatigue analysis shall include checks of the supports of any clamp interfaces.

Further to 4.3.10, the fatigue analysis of the tether base shall account for any cyclic tether tensions and angles in three dimensions that cause the documented and verifiable endurance limit of the material (that has been approved by the purchaser) to be exceeded. The fatigue analysis shall include the tether connection points and the connection hardware.

11.5.7 Corrosion Protection

The design of the CP system shall account for any drain of the system protective electric current from attached chain and wire rope tethers or metallic synthetic tether end terminations.

Cathodic protection calculations shall consider the surface area of all connection hardware in direct contact with the tether base for the computation of the required anode masses.

11.6 Material Requirements

See the relevant sections of 4.4 for minimum metallic material requirements.

11.7 Manufacturing Requirements

11.7.1 General

See the relevant sections of 4.5 for minimum manufacturing requirements.

The manufacture of riser base valves shall be in accordance with an appropriate standard such as API 6A.

11.7.2 Process Control

The manufacturer shall as a minimum have a documented methodology for the following manufacturing processes for riser and tether bases:

a) processes listed in 4.5.3.2;

b) integration of ballast material;

c) attachment of pad-eyes or lifting eyes.

11.8 Documentation—Design Report

11.8.1 Riser Base Design Report

The riser base design report shall include, as a minimum, the following:

a) minimum parameters specified in 11.3;

b) major dimensions;

c) description of valves;

d) description of lifting points;

e) description of ROV interfaces;

f) internal pressure rating.

11.8.2 Tether Base Description

The tether base description in the design report shall include, as a minimum, the following:

a) minimum parameters specified in 11.4;

b) major dimensions;

c) description of lifting points;

d) description of tether connection hardware.

11.8.3 Design Report Content

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used, including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) overview of CP system design methodology, where applicable;

f) manufacturing and design tolerances;

g) calculations demonstrating that design satisfies functional requirements, accounting for variations within manufacturing tolerance envelopes;

h) description of welds used;

i) service life analysis, subject to the requirements of 4.3.8 to 4.3.10;

j) calculation of the dimensions of all components, including, as a minimum (see11.5.3):

   1) overall base;

   2) mud mat;

   3) pile dimensions, where applicable;

   4) sizes of structural members of base;

   5) fasteners;

   6) protective coatings;

   7) sizes of CP anodes;

k) foundation design (in accordance with 11.5.3);

l) design of valves (in accordance with 11.5.4);

m) service life analysis, subject to the requirements of 11.5.6.

The design report shall include or make reference to any calculations performed for or software tools used for these items.

11.9 Factory Acceptance Tests

11.9.1 General

This section specifies FAT requirements common to both riser bases and tether bases. For specific riser and tether base factory acceptance test requirements, see 11.9.2 and 11.9.3, respectively.

Mass in air measurement of the base shall verify that the base is within the allowable mass for the lifting equipment being used and, in combination with dimensional measurements, shall verify that the riser base weight in seawater will be in accordance with the design. The as-built position of the center of gravity shall be determined.

Base lifting points shall be proof-loaded in accordance with an appropriate international standard such as Lloyd's Register of Shipping *Code for Lifting Appliances in a Marine Environment*.

11.9.2 Riser Bases

The manufacturer shall perform the FAT tests specified in Table 32 on the riser base where applicable.

Dimensional measurements shall verify that the dimensions of all components are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances. Dimensional tests shall verify the dimensional compatibility of the riser base with the flexible pipe and pipeline end terminations or the intermediate connectors being used. The dimensions that shall be measured for the riser base shall include all dimensions critical for the riser base function and installation (e.g. its height, width and length, lifting-point hole diameters, etc.). Dimensional measurements in combination with mass in air measurements shall verify that the riser base weight in seawater will be in accordance with the design.

NDE of welds shall be performed in accordance with an appropriate international standard such as those listed in Table 10.

The fit-up and assembly tests shall verify that all connectors can be attached successfully to the riser base and that any ROV tools being used are compatible with the riser base. See API 17A for recommendations on fit-up and assembly tests of subsea equipment.

The piping in the riser base shall be hydrotested to at least 1,5 times the design pressure to verify that it is pressure-tight. A higher test pressure may be required by local codes or regulators (e.g. NPD, MMS, HSE) and in such cases the requirements of these authorities shall take precedence over these requirements.

NOTE This factor has been selected in order to be consistent with the hydrostatic test pressure factor specified for the flexible pipe in 9.3 of API17J:2008.

Where riser bases have retractable mud mats (to reduce their profile when being installed), mud mat retraction shall be successfully tested prior to installation.

11.9.3 Tether Bases

The manufacturer shall perform the FAT tests specified in Table 33, on the tether base.

Dimensional measurements shall verify that the dimensions of all components are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances. The dimensions that shall be measured for the tether base shall include all dimensions critical for the tether base function and installation (e.g. its height, width and length, lifting point and tether connection point dimensions, including hole diameters, etc.). Dimensional measurements in combination with mass in air measurements shall verify that the tether base weight in seawater will be in accordance with the design.

The fit-up and assembly tests shall verify that all connection hardware can be attached successfully to the tether base, and that any ROV tools being used are compatible with the tether base.

Connection hardware shall be proof-loaded in accordance with an appropriate international standard such as Lloyd's Register of Shipping *Code for Lifting Appliances in a Marine Environment*.

Table 32—Factory Acceptance Tests for Riser Bases

Test	Section
Dimensional	See 11.9.2
Visual	See 4.7.2
Mass in air and center of gravity	See 11.9.1
NDE of welds	See 11.9.2
Fit-up and assembly	See 11.9.2
Hydro-test	See 11.9.2
Mudmat retraction [a]	See 11.9.2
Proof loading of lifting points	See 11.9.1

[a] For riser bases with retractable mudmats.

Table 33—Factory Acceptance Tests for Tether Bases

Test	Section
Dimensional	See 11.9.3
Visual	See 4.7.2
Mass in air and center of gravity	See 11.9.1
NDE of welds	See 11.9.2
Fit-up and assembly	See 11.9.3
Load test of connection hardware	See 11.9.3
Proof-loading of tether connection points	See 9.7.3
Proof-loading of lifting points	See 11.9.1

11.10 Marking

11.10.1 Marking—Riser Base

The riser base marking shall make it permanently identifiable for the specified service life.

The marking on the riser base shall include the following, as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) identification of flexible pipe for each flexible pipe connection;

f) identification of pipeline for each pipeline connection;

g) mass in air;

h) pressure rating of components.

11.10.2 Marking—Tether Base

The tether base marking shall make it permanently identifiable for the specified service life.

The marking on the tether base shall include the following, as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) mass in air.

12 General Clamping Device Requirements

12.1 Applicability

This section covers minimum requirements for clamping devices that are general in nature. Further requirements that relate to specific clamping devices are given in other sections of this specification.

12.2 Functional Requirements

12.2.1 General

The purchaser shall specify as a minimum for clamping devices the following flexible pipe design parameters:

a) external diameter, including tolerances;

   When a design based on as-built external diameter is agreed the purchaser shall specify the as-built external diameter at the clamp location as soon as this is available.

b) outer sheath material;

c) governing coefficient of friction within the flexible pipe;

   If the governing coefficient of friction is not within the flexible pipe, the purchaser and manufacturer should agree on a method to obtain the friction properties between the clamp and the flexible pipe outer sheath. Different values of friction shall be specified to account for installation and operating conditions. The flexible pipe manufacturer shall have available documentation that supports the friction properties being specified (in accordance with 5.4.1.4 of API 17J:2008).

d) reduction in external coating thickness, where applicable, due to creep or otherwise over the service life;

e) maximum ovalization of flexible pipe during installation and operation, specified in terms of the minimum and maximum diameters due to the out-of-roundness of the pipe.

   See 5.4.1.5.2 and 5.4.1.8 of API 17B:2008 for guidelines on ovalization of the flexible pipe.

12.2.2 Clamp Design Loads

The purchaser shall specify variations in the flexible pipe external diameter due to tension, internal pressure and temperature effects over the specified service life, accounting for both installation and operation.

The purchaser shall specify the maximum permissible contact pressure that may be applied to the flexible pipe via the clamping mechanism.

Fatigue loads, if required, shall consist of the number of cycles for each flexible pipe expansion/contraction range and each flexible pipe bending range. The bending range shall include the minimum and maximum bend radii, and shall indicate the directionality of the bending (i.e. positive or negative).

12.3 Design Requirements

12.3.1 Clamp design methodology

The documentation submitted for verification of the design methodology shall include methodologies, any calculations performed and software tools used for the following, as a minimum:

a) documentation listed in 4.3.5.1;

b) dimensions of all components including, as a minimum:

   1) clamp internal and external dimensions;

   2) internal and external diameter of inner liner, where applicable;

   3) external coatings;

   4) fasteners.

c) fastening force for securing clamp segments together (in accordance with 12.3.3);

d) external coatings:

   1) surface coating specification;

   2) coating log and result of adhesion test from manufacturer's coating supplier;

   3) qualification status of coating system applied;

e) service life performance, subject to the requirements of 12.3.4.

12.3.2 Clamp Design Criteria

The axial component of the clamping capacity shall be at least 1,5 times the maximum axial force experienced by the flexible pipe, in order to prevent axial slippage. This safety factor shall not be applied to flexible pipe expansions and contractions.

NOTE This factor has been based on the minimum value that has been adopted in current industry practice.

The contact pressure applied by the clamp shall not exceed the allowable contact pressure specified by the purchaser.

12.3.3 Clamp Design Requirements

Further to 4.3.7, stress analysis of the clamp shall account for the fastener and/or strap tensions as applicable used to apply the clamping force.

For fastening systems such as bolts or straps, an appropriate fastening force for securing clamp segments together shall be calculated and specified in the design report and installation procedures. The specified force shall prevent clamp slippage, but shall not allow the flexible pipe allowable contact pressure to be exceeded or exceed utilization limits for the clamp body. Fastening systems shall have some means of preventing the system loosening during the service life.

The calculation of clamping capacity and the clamp design shall account for the following:

a) expansion and contraction of the flexible pipe;

b) maximum curvatures and effective tensions in the flexible pipe;

c) expansion and contraction of the clamp due to temperatures induced by the flexible pipe outer sheath;

d) maximum ovality of the pipe and internal clamp, during both installation and service;

e) creep behavior of the clamp components (see 12.3.4);

f) governing friction which may be between clamp and flexible pipe or within the flexible pipe between flexible pipe layers;

g) reduction in thickness of the flexible pipe and/or flexible pipe external coatings over the service life due to creep;

h) hydrostatic pressure at design water depth.

The maximum allowable contact pressure specified by the purchaser shall account for stresses and strains in all of the flexible pipe layers with respect to the permissible utilization or maximum allowable strains specified in Table 6 of API 17J:2008. In addition, the allowable contact pressure shall be such that creep of the flexible pipe polymer layers beyond allowable limits into recesses in the metallic layers does not occur. The flexible pipe manufacturer shall document the incorporation of these parameters into the calculation of the maximum allowable contact pressure.

The distribution of contact pressure exerted by the clamp around the pipe circumference shall be documented not to cause the ovality of the flexible pipe to exceed allowable levels. See 5.4.1.5.2 and 5.4.1.8 of API 17B:2008 for recommendations on ovalization.

12.3.4 Clamp Service Life

Further to 4.3.9, it shall be documented that polymer inner liners or clamp bodies do not experience compressive creep induced by the flexible pipe and clamping force during the service life to the extent that the clamp is loosened and the flexible pipe is allowed to move relative to it.

12.4 Material Requirements—Polymer Inner-liner Materials

The manufacturer shall test and document the material properties of polymer inner-liner materials for use in clamping devices, as specified in Table 34 Where indicated, the material properties in Table 34 shall be measured at the maximum temperature of the material in service, in addition to measurement at room temperature. Where indicated, the material properties shall also be measured for aged samples of material. See 4.4.4 for minimum ageing test requirements.

Table 34—Qualification Requirements for Polymer Inner-Liner Materials for Clamping Devices

Material Property	Test Procedure [a]	Section	Max. Temperature	Aged Sample
Abrasion resistance	ISO 7784-2 [b], ASTM D4060 [b], BS 903-A9 or DIN 53516	See 4.4.2.7		
Hardness	ISO 868 [c], or ASTM D2240			
Ozone resistance [d]	ISO 1431-1			
Tensile strength, modulus, strain at break	ISO 527 [c], ISO 37, ASTM D638 [c]		X	X

[a] As stated in Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.
[b] Standards similar in content but not technically equivalent.
[c] Standards are technically equivalent or identical for the test in question.
[d] Applicable during storage.

12.5 Documentation—Clamp Design Report

The clamp description in the design report shall include, as a minimum, the following:

a) minimum parameters specified in 12.2;

b) internal and external diameter;

c) other external dimensions;

d) length;

e) design depth;

f) design temperature;

g) clamping capacity;

h) description of inner liners, where applicable;

i) description of lifting points, where applicable;

j) weight in air and in seawater.

13 Subsea Buoy Clamps

13.1 Applicability

The requirements in Section 4 and Section 12 shall apply.

Some requirements relating to subsea buoy clamps are given by way of cross-reference to Section 12, which specifies general clamping device requirements.

The requirements in this section apply to clamping devices for use on flexible pipes, and are not intended for umbilical clamping devices.

13.2 Functional Requirements

13.2.1 General

Purchasing guidelines for subsea buoy clamps are given in Annex H.

The minimum overall functional requirements of the subsea buoy clamp that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to securely attach the flexible pipe to the subsea buoy for the specified service life.

13.2.2 Flexible Pipe Design Parameters

For the flexible pipe to which the clamp is attached, the purchaser shall specify the following parameters as a minimum:

a) internal diameter;

b) service type;

c) service life;

d) flexible pipe design parameters required for the clamp design in 12.2.1.

13.2.3 External Environment

The purchaser shall specify the maximum water depth at which the clamp is to be located.

13.2.4 Corrosion Protection

The corrosion protection requirements for metallic components of the clamp, such as the clamp body and fasteners, may be specified in accordance with 4.2.6, where the corrosion protection requirements are different from those of the subsea buoy frame (see 9.2.8).

13.2.5 Installation Requirements

The purchaser should specify any requirements for compatibility of the clamp with lifting equipment.

The purchaser should specify whether connection of the clamp to the subsea buoy structure requires diver intervention or diverless connection. The purchaser should specify any requirements for the clamp to interface with ROV tools, if diverless connection is a requirement. This shall be based on the requirements specified in 9.2.11 or based on the appropriate statutory or regulatory requirements.

13.2.6 Design Loads

The purchaser shall specify variations in the flexible pipe external diameter due to tension, internal pressure and temperature effects over the specified service life, accounting for both installation and operation.

The purchaser shall specify the maximum permissible contact pressure that may be applied to the flexible pipe via the clamping mechanism.

Fatigue loads, if required, shall consist of the number of cycles for each flexible pipe expansion/contraction range and each flexible pipe bending range. The bending range shall include the minimum and maximum bend radii, and shall indicate the directionality of the bending (i.e. positive or negative).

The purchaser shall specify the minimum and maximum flexible pipe effective tensions in the lower and upper catenaries of the flexible pipe acting either side of the subsea buoy clamp.

13.2.7 Spares

The purchaser should specify the required quantity of spare subsea buoy clamps and required percentage of spare fasteners for the clamps to offset any losses due to damage, for example.

13.3 Design Requirements

13.3.1 Loads

Local load classes and subclasses for subsea buoy clamps are listed in Table 35.

13.3.2 Subsea Buoy Clamp Design

Further to 12.3.3, the calculation of clamping capacity and the clamp design shall account for force required to resist the maximum differential effective tension in the flexible pipe between the upper and lower catenaries.

13.3.3 Service Life—Dynamic Applications

Further to 4.3.9, it shall be checked in the design that polymer inner liners do not experience compressive creep induced by the flexible pipe and clamping force during the service life to the extent that the clamp is loosened and the flexible pipe is allowed to move relative to it.

Further to 4.3.10, fatigue analysis of the subsea buoy clamp shall account for stress fluctuations induced by the flexible pipe.

The fatigue analysis shall account for any of the following cyclic loads that cause the documented and verifiable endurance limit of the material (that has been approved by the purchaser) to be exceeded:

a) expansion and contraction of the flexible pipe;

b) variations in effective tensions in the flexible pipe;

c) bending of the flexible pipe.

The fatigue analysis shall include the clamp support work.

Table 35—Local Load Classes and Subclasses for Subsea Buoy Clamps

Load Classes and Subclasses
Functional Loads
Effective tensions in the flexible pipe (effective tensions in lower and upper catenary).
Loads due to bending of the flexible pipe. In dynamic applications the flexible pipe will undergo cyclic bending.
Loads due to fastening systems.
Loads due to expansion and contraction of the flexible pipe by tension, internal pressure and temperature effects during service, leak tests or structural integrity tests, see 11.5.3 of API 17B:2008.
Thermal expansion and contraction loads due to temperature of flexible pipe outer sheath (where different materials are expanding at different rates).
Loads due to normal handling operations, such as impact and abrasion.
Accidental Loads
Flexible pipe accidental loads that affect the flexible pipe configuration and/or subsea buoy clamp, where specified by purchaser, as follows: a) internal over-pressure; b) vessel compartment damage or unintended flooding where applicable; c) failure of vessel thrusters where applicable; d) DP failure where applicable; e) anchor line failure; f) failure of FPSO turret drive system, where applicable.

13.3.4 Corrosion Protection

Further to 4.3.11, the subsea buoy clamp shall be protected by a dedicated CP system if adequate provision has not been made for the extra capacity in the subsea buoy CP system calculations.

13.4 Material Requirements

13.4.1 General

The requirements of this section shall apply to metallic materials for the clamp body and polymer materials for the clamp inner-liner.

13.4.2 Qualification Requirements—Clamp Body Metallic Materials

See 4.4.3 for minimum metallic material qualification requirements for metallic clamp bodies.

13.5 Manufacturing Requirements—Process Control

The manufacturer shall, as a minimum, have a documented methodology for the following manufacturing processes:

a) manufacture of metallic clamps (see 4.5.3.2 for specific manufacturing procedures);

b) attachment of lifting points.

For each mix of polymer internal liner material, a sample of material shall be retained and tested to verify that it is consistent with the properties measured in the qualification tests.

The following properties shall be tested, as a minimum:

a) tensile strength: ISO 527, ISO 37, or ASTM D638;

b) hardness: ISO 868, or ASTM D2240.

13.6 Documentation

13.6.1 Subsea Buoy Clamps Design Report

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used, including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) overview of CP system design methodology, where applicable;

f) manufacturing and design tolerances;

g) calculations demonstrating that design satisfies functional requirements, accounting for variations within manufacturing tolerance envelopes;

h) description of welds used;

i) service life analysis, subject to the requirements of 4.3.8 to 4.3.10;

j) calculation of the dimensions of all components, including as a minimum:

   1) clamp internal and external dimensions;

   2) internal and external diameter of inner liner, where applicable;

   3) external coatings;

   4) fasteners;

k) calculation of fastening force for securing clamp segments together (in accordance with 12.3.3);

l) service life analysis, subject to the requirements of 12.3.4.

The design report shall include or make reference to any calculations performed for or software tools used for these items.

13.6.2 Installation Procedures

Further to the requirements of 4.6.5, the manufacturer shall supply step-by-step procedures for assembling the subsea buoy clamp and attaching it to the flexible pipe. The manufacturer shall also specify procedures for attaching the subsea buoy clamp to the subsea buoy frame, where applicable.

13.7 Factory Acceptance Tests

13.7.1 General

The manufacturer shall perform the FAT tests as specified in Table 36 on subsea buoy clamps.

13.7.2 Dimensional Measurement

Dimensional measurement of subsea buoy clamp components shall verify that the dimensions of these components are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances.

The dimensions that shall be measured for the subsea buoy clamp shall include the following, as a minimum:

a) bore diameter;

b) external diameter;

c) length.

13.7.3 Fit-up and Assembly Testing

13.7.3.1 Procedure

The clamp shall be assembled to a sample of the flexible pipe, where available, or a dimensionally representative mock-up of the flexible pipe considering the outer diameter tolerances. The assembly shall include all components that make up the clamp, including any inner liner used and all fasteners necessary to secure these components in position. The clamp components shall be fastened together using fasteners of the same specification and the same fastening forces as determined at the design stage for service.

13.7.3.2 Acceptance Criteria

After the subsea buoy clamp has been assembled, its bore shall be compatible with the dimensions of the flexible pipe. All the components of the clamp shall be dimensionally compatible with each other.

13.7.4 NDE of Welds

NDE of welds shall be performed in accordance with an appropriate international standard such as those listed in Table 10.

Table 36—Factory Acceptance Tests for Subsea Buoy Clamps

Test	Comment
Dimensional	See 13.7.2
Visual	See 4.7.2 and 4.7.3
Fit-up and assembly	See 13.7.3
NDE of welds	See 13.7.4
Mass in air	See 9.7.2

13.8 Marking

See 4.7.4 of API 17L2 for general marking recommendations.

The subsea buoy clamp marking shall make it permanently identifiable for the specified service life.

The marking shall include the following, as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) identification of flexible pipe to which clamp is to be attached.

f) identification such that clamp segments can be re-assembled to their positioning before the clamp segments were cut out during manufacture, where applicable.

14 Tether Clamps

14.1 Applicability

The requirements in Section 4 and Section 12 shall apply.

Some requirements relating to tether clamps are given by way of cross-reference to Section 4, which specifies general clamping device requirements. This section does not address the tether- or bend-limiting devices attached to the tether clamp. For tether requirements, see Section 10. For requirements for bend limiters that are attached to tether clamps, see Section 5, Section 6 or Section 7 as appropriate.

The requirements in this section apply to clamping devices for use on flexible pipes, and are not intended for umbilical clamping devices.

14.2 Functional Requirements

14.2.1 General

The minimum overall functional requirements of the tether clamp that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to securely attach the flexible pipe to the tether for the specified service life.

Purchasing guidelines for tether clamps are given in Annex I.

14.2.2 Flexible Pipe Design Parameters

For the flexible pipe to which the tether clamp is attached the purchaser shall specify the following parameters, as a minimum:

a) internal diameter;

b) service type;

c) service life;

d) flexible pipe design parameters required for the clamp design in 12.2.1;

e) operating MBR.

14.2.3 Tether Clamp Design Parameters

The purchaser shall specify the location of the tether clamp along the flexible pipe.

The purchaser should consider specifying the following parameters:

a) requirements on the mass, including tolerances of the tether clamp;

b) requirements for bend-limiting devices where the flexible pipe exits the clamp;

c) requirements for swiveling pad-eyes;

d) requirement for anti-fouling coatings.

14.2.4 Bend Limiter Functional Requirements

Where a bend limiter is required at the tether clamp exits to prevent flexible pipe over-bending, the purchaser shall specify the functional requirements for the bend limiter in the specified sections as follows:

a) bend stiffeners, see 5.2;

b) bend restrictors, see 6.2;

c) bellmouths, see 7.2.

14.2.5 External Environment

The purchaser shall specify the maximum water depth at which the clamp is to be located.

Where the tether clamp incorporates polymer or composite components, environmental functional requirements relating to sunlight exposure should be specified in accordance with 4.2.5.

The purchaser should specify the marine growth density and thickness at the water depth range of the tether clamp.

14.2.6 Corrosion Protection

The corrosion protection requirements for metallic components of the clamp that may include the clamp body and fasteners may be specified in accordance with 4.2.6.

14.2.7 Installation Requirements

The purchaser should specify any requirements for compatibility of the clamp with lifting equipment.

14.2.8 Design Loads

The purchaser shall specify variations in the flexible pipe external diameter due to tension, internal pressure and temperature effects over the specified service life, accounting for both installation and operation.

The purchaser shall specify the maximum permissible contact pressure that may be applied to the flexible pipe via the clamping mechanism.

The purchaser shall specify the maximum flexible pipe curvature at the clamp location.

The purchaser shall specify the maximum tether tension and the range of tether angles in three dimensions. The purchaser shall consider any loads resulting from the weight of the tether base, if installation of the tether clamp involves lowering it to the seabed with the tether base attached.

The purchaser shall specify the fatigue loads acting on the tether clamp from the tether, based on the results of global analysis of the flexible pipe system. The fatigue loads specified shall consist of minimum, maximum and mean tether tensions and angle ranges in three dimensions, along with corresponding numbers of cycles for each tether tension range.

Other fatigue loads, if required, shall consist of the number of cycles for each flexible pipe expansion/contraction range and each flexible pipe bending range. The bending range shall include the minimum and maximum bend radii and shall indicate the directionality of the bending (i.e. positive or negative).

14.2.9 Spares

Further to 4.2.10, the purchaser should specify the required quantity of spare tether clamps and required percentage of spare fasteners for the clamps.

14.3 Design Requirements

14.3.1 Loads

Local load classes and subclasses for subsea buoy clamps are listed in Table 37.

Table 37—Local Load Classes and Subclasses for Tether Clamps

Load Classes and Subclasses
Functional Loads
Effective tensions in the flexible pipe.
Loads due to self-weight.
Loads due to cyclic bending of the flexible pipe.
Loads due to tether tensions.
Loads acting on attached bend-limiting device, see Table 11, Table 13 or 7.3.1, as appropriate.
Loads due to fastening systems.
Loads due to expansion and contraction of the flexible pipe by tension, internal pressure and temperature effects during service, leak tests or structural integrity tests, see 11.5.3 of API 17B:2008.
Thermal expansion and contraction loads due to temperature of flexible pipe outer sheath (where different materials are expanding at different rates).
Loads due to normal handling operations, such as impact and abrasion.
Accidental Loads
Flexible pipe accidental loads that affect the flexible pipe configuration and/or tether clamp, where specified by the purchaser, as follows: a) internal over-pressure; b) vessel compartment damage or unintended flooding, where applicable; c) failure of vessel thrusters, where applicable; d) DP failure, where applicable; e) anchor line failure; f) failure of FPSO turret drive system, where applicable.

14.3.2 Tether Clamp Design

Further to 12.3.3, the calculation of clamping capacity and the clamp design shall account for force required to resist the most critical combination of tether tension and the angle subtended by the tether in three dimensions during installation or operation.

The flexible pipe operating MBR shall not fall below the minimum specified by the purchaser due to bending about the areas either side of the clamp where the flexible pipe exits the clamp bore. Global finite element analyses of the flexible pipe system shall be performed to check whether over-bending of the flexible pipe about these areas occurs under any of the flexible pipe load combinations and conditions, and the design modified if such over-bending occurs. The purchaser may specify a bend-limiting device in order to prevent such over-bending (in accordance with 14.2.4).

Further to 4.3.7, stress analysis of the tether clamp shall account for the range of effective tensions and the range of angles that the tether subtends in three dimensions. Local stress analysis shall be performed on tether end terminations and connection hardware, and documented in the design report. The stress analysis shall incorporate accurate modeling of any local geometries that will lead to stress concentrations.

14.3.3 Service Life—Dynamic Applications

Further to 4.3.9, it shall be documented in the design report that polymer or composite inner liners or clamp bodies do not experience compressive creep induced by the flexible pipe and clamping force during the service life, to the extent that the clamp is loosened and slides out of position, or that allowable stress/strain levels in the material are exceeded.

Further to 4.3.10, fatigue analysis of the clamp shall account for stress fluctuations induced by the flexible pipe and tethers.

The fatigue analysis shall account for any of the following cyclic loads that cause the documented and verifiable endurance limit of the material (that has been approved by the purchaser) to be exceeded:

a) expansion and contraction of the flexible pipe;

b) bending of the flexible pipe;

c) effective tensions in tethers, accounting for the range of angles that the tether subtends, in three dimensions.

14.3.4 Corrosion Protection

Cathodic protection calculations shall consider the surface area of all connection hardware in direct contact with the tether clamp for the computation of the required anode masses.

14.4 Material Requirements

14.4.1 General

The requirements of this section shall apply to metallic and composite materials for the clamp body and polymer materials for the clamp inner-liner.

14.4.2 Qualification Requirements—Composite Clamp Body Materials

The manufacturer shall document the material properties of composite tether clamp bodies, as specified in Table 38. The material properties refer to material properties of the composite material and not the constituent components. Where indicated, the material properties in Table 38 shall be measured at the minimum and maximum temperatures of the material in service, in addition to measurement at room temperature. Where indicated, the material properties shall also be measured for aged samples of material. See 4.4.4 for minimum ageing test requirements.

14.4.3 Qualification Requirements—Clamp Body Metallic Materials

See 4.4.3 for minimum metallic material qualification requirements for metallic clamp bodies.

Table 38—Qualification Requirements for Composite Clamp Body Materials for Clamping Devices

Material Property	Test Procedure	Section	Min. Temperature	Max. Temperature	Aged Sample
Abrasion resistance	ISO 7784-2 [a], ASTM D4060 [a], BS 903-A9 or DIN 53516	See 4.4.2			
Compressive strength, modulus, strain at break [b]	ISO 604 [c], ASTM D695 [c], ISO 7743			X	
Creep resistance				X	
Density	ISO 1183, ASTM D792				
Impact strength	ISO 179, ISO 180 [c], ASTM D256		X		
Tensile strength, modulus, strain at break [b]	ISO 527 [c], ASTM D638 [c], ISO 37			X	X

[a] Standards similar in content but not technically equivalent.
[b] Property shall be expressed in both the fiber direction and transverse to the fiber direction for fiber reinforced composites.
[c] Standards are technically equivalent or identical for the test in question.

14.5 Manufacturing Requirements—Process Control

14.5.1 Manufacturer Processes

The manufacturer shall, as a minimum, have a documented methodology for the following manufacturing processes:

a) manufacture of metallic clamps, see 4.5.3.2 for specific manufacturing procedures;

b) manufacture of composite clamps, see 4.5.3.4 for specific manufacturing procedures;

c) manufacture of attached bend limiter, where applicable, see 5.5.1, 6.5.1 and 7.5.1 for bend stiffeners, bend restrictors and bellmouths, respectively;

d) attachment of lifting points;

e) attachment of tether connection points to tether clamp;

f) attachment of bend limiters to tether clamp, where applicable.

14.5.2 Inner-liner and Composite Tether Clamp Material

For each mix of polymer inner-liner material or composite tether clamp body material, a sample of material shall be retained and tested to verify that it is consistent with the properties measured in the qualification tests.

The following properties shall be tested as a minimum:

a) tensile strength: ISO 527, ISO 37, or ASTM D638;

b) hardness: ISO 868 or ASTM D2240.

14.6 Documentation

14.6.1 Design Report

14.6.1.1 Clamp Description

The clamp description in the design report shall include, as a minimum, the following:

a) minimum parameters specified in 12.5;

b) description of attached bend limiting devices;

c) description of connection hardware.

14.6.1.2 Clamp Design Report Content

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) overview of CP system design methodology where applicable;

f) manufacturing and design tolerances;

g) calculations demonstrating that design satisfies functional requirements, accounting for variations within manufacturing tolerance envelopes;

h) description of welds used for metallic components;

i) service life analysis, subject to the requirements of 4.3.8 to 4.3.10;

j) calculation of the dimensions of all components, including as a minimum:

    1) clamp internal and external dimensions;
    2) internal and external diameter of inner liner, where applicable;
    3) external coatings;
    4) fasteners.

k) calculation of fastening force for securing clamp segments together (in accordance with 12.3.3);

l) service life analysis, subject to the requirements of 12.3.4.

The design report shall include or make reference to any calculations performed for or software tools used for these items.

14.6.2 Installation Procedures

The manufacturer’s procedures for installation shall include the following.

a) Procedures listed in 4.6.5.

b) Step-by-step procedures for assembling the tether clamp and attaching it to the flexible pipe.

c) Procedures for assembly of attached bend restrictors (see 6.6.2) or bellmouths (see 7.6.2), where applicable.

d) Procedures for attaching the bend limiter to the tether clamp where applicable.

14.7 Factory Acceptance Tests

14.7.1 General

The manufacturer shall perform the FAT tests as specified in Table 39 on tether clamps, where applicable.

14.7.2 Dimensional Measurement

Dimensional measurement of tether clamp components shall verify that the dimensions of these components are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances.

The dimensions that shall be measured for the tether clamp shall include the following, as a minimum:

a) bore diameter;

b) external diameter;

c) length.

14.7.3 Fit-up and Assembly

14.7.3.1 Procedure

The tether clamp shall be assembled to a sample of the flexible pipe, where available, or a dimensionally representative mock-up of the flexible pipe. The assembly shall include all components that make up the clamp, including any inner liner used and all fasteners necessary to secure these components in position. Where used, bend-limiting devices shall be attached to the assembly. The clamp components and bend limiters shall be fastened using fasteners of the same specification and the same fastening forces as determined at the design stage for service. The tether connection hardware shall be attached to the connection points on the tether clamp.

14.7.3.2 Acceptance Criteria

After the tether clamp has been assembled, its bore shall be compatible with the dimensions of the flexible pipe. All the components of the clamp, including tether-connecting hardware and any bend limiters, shall be dimensionally compatible with each other.

14.7.4 NDE of Welds

NDE of welds shall be performed in accordance with an appropriate international standard such as those listed in Table 10.

14.7.5 Mass in Air

The mass in air of the as-built tether clamp shall verify that any weight requirements are satisfied.

Table 39—Factory Acceptance Tests for Tether Clamps

Test	Comment
Dimensional	See 14.7.2
Visual	See 4.7.2 or 4.7.3
Fit-up and assembly	See 14.7.3
NDE of welds [a]	See 14.7.4
Mass in air	See 14.7.5
Attached bend stiffener testing	See Table 12
Attached bend restrictor testing	See Table 14
Attached bellmouth testing	See Table 11, Table 13 or Table 17
[a] Metallic tether clamps only.	

14.8 Marking

See 4.7.4 of API 17L2 for general marking recommendations.

The tether clamp marking shall make it permanently identifiable for the specified service life. The marking shall include the following as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) identification of flexible pipe to which clamp is to be attached;

f) identification such that clamp segments can be re-assembled to their positioning before the clamp segments were cut out during manufacture, where applicable.

Connection hardware marking shall be in accordance with an appropriate international standard, such as Lloyd's Register of Shipping *Code for Lifting Appliances in a Marine Environment*.

15 Piggy-back Systems

15.1 Applicability

The requirements in Section 4 and Section 12 shall apply.

The following section applies to piggy-back clamps and guides. Some requirements relating to piggy-back clamps are given by way of cross-reference to Section 4, which specifies general clamping device requirements.

The requirements in this section shall also be applied to umbilicals, except those requirements relating to clamping force design in sections 12.3.1, 15.3.2 a), 15.3.3, and 12.3.3 to 15.3.4.

NOTE The requirements relating to internal fluid and outer sheath temperature may not be relevant for umbilicals.

15.2 Functional Requirements

15.2.1 General

Purchasing guidelines for piggy-back systems are given in Annex J.

The minimum overall functional requirements of the piggy-back system that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to ensure that the supported pipe(s) are securely attached to the supporting pipe for the specified service life;

c) to provide adequate clearance between the supporting and the supported pipe(s).

15.2.2 Flexible Pipe Design Parameters

For flexible pipes in the piggy-back system, the purchaser shall specify the following parameters, as a minimum:

a) internal diameter;

b) service type;

c) service life;

d) flexible pipe design parameters required for piggy-back clamp design in 12.2.1;

e) flexible pipe design parameters necessary to perform global analysis of the piggy-back system, where the global analysis of the piggy-back system is in the manufacturer's scope of work.

   See Section 4 of ISO API 17J:2008 for data that are required to conduct a global analysis.

The information specified in Item e) above is not required if the purchaser has determined the number of clamps in accordance with 15.2.8 and has specified design loads reflecting the global loads exerted on the piggy-back system in accordance with 15.2.7.

15.2.3 Piggy-back System Design Parameters

The purchaser shall specify if clearance is required to allow the supported pipe(s) axial freedom, i.e. piggy-back guide rather than piggy-back clamp. The purchaser may specify this requirement in terms of respective quantities of piggy-back clamps and guides, in accordance with 15.2.8.

The purchaser may specify the following parameters:

a) required clearances between supporting and supported pipe(s);

b) any requirements on inter piggy-back clamp/guide spacing (where the purchaser has not specified number of piggy-back spacers in accordance with 15.2.8);

c) maximum permissible axial force transmitted by piggy-back guide;

d) changes in piggy-back clamp functional requirements post-installation;

e) requirement for any piggy-back clamps to change functionality from piggy-back clamp to guide during use, or visa-versa.

See 15.2.2 of API 17L2:2013 for a discussion of some of the above issues.

15.2.4 Other Supporting or Supported Pipes

For other supporting or supported pipes in the piggy-back system (that are not flexible pipes), the purchaser shall specify the following parameters, as a minimum:

a) number of supported pipes;

b) reference diameter;

c) functionality of pipe (i.e. umbilical or other);

d) external diameter, including tolerances;

   When a design based on as-built external diameter is agreed, the purchaser shall specify the as-built external diameters at the clamp locations as soon as these are available. If the as-built external diameter is unavailable, the manufacturer should use a suitably small tolerance on the external diameter.

e) the pipe outer material;

f) governing coefficient of friction between piggy-back spacer and the pipe;

   If the governing coefficient of friction is not within the pipe, the purchaser and manufacturer should agree on a method to obtain the friction properties between the piggy-back spacer and the pipe outer surface. Different values of friction should be specified to account for installation and operating conditions. The supported pipe manufacturer shall have available documentation that supports the friction properties being specified.

g) reduction in external coating thickness, where applicable, due to creep or otherwise over the service life;

h) maximum ovalization of pipe during installation and operation, specified in terms of the minimum and maximum diameters due to the out-of-roundness of the pipe;

i) pipe design parameters necessary to perform global analysis of the piggy-back system, where the global analysis of the piggy-back system is in the manufacturer's scope of work.

15.2.5 Temperature

The purchaser shall specify other supporting and supported pipe outer surface temperatures.

15.2.6 Corrosion Protection

The corrosion protection requirements for the piggy-back spacer fasteners or associated tensioning assemblies should be specified in accordance with 4.2.6.

15.2.7 Design Loads

See 4.2.8 for minimum requirements on specifying design loads.

The purchaser shall specify variations in both the supporting and supported pipe external diameters due to tension, internal pressure and temperature effects.

The purchaser shall specify the maximum permissible contact pressure that may be applied via the clamping mechanism to the supporting pipe and supported pipe(s) that are connected by piggy-back clamps.

The purchaser shall specify the maximum effective tensions and curvatures in the supporting and supported pipes, computed from global finite element analyses.

The purchaser shall specify the maximum axial loads and loads normal to the pipe transferred to the piggy-back clamps and guides from the supporting and the supported pipes, including dynamic effects, and those during installation. Alternatively, the purchaser may specify the flexible pipe data necessary for the manufacturer to carry out global analyses in accordance with 15.2.2 e) and 15.2.4 i).

15.2.8 Quantities

The purchaser shall specify the number of piggy-back clamps and piggy-back guides required, whether they have determined these numbers through global analysis or otherwise.

15.3 Design Requirements

15.3.1 Loads

Local load classes and subclasses for piggy-back spacers are listed in Table 40.

Table 40—Local Load Classes and Subclasses for Piggy-back Spacers

Load Classes and Subclasses
Functional Loads
Loads due to weight of supporting and supported pipes (including dynamic amplification effects and weights during installation).
Loads due to fastening systems, such as fasteners and straps.
Loads due to expansion and contraction of supporting and supported pipes by tension, internal pressure and temperature effects during service, leak tests or structural integrity tests, see 11.5.3 of API 17B:2008.
Loads due to bending of supporting and supported pipes.
Relative changes in length between the supporting and supported pipes, including those induced by thermal expansion.
Temperature-induced loads: a) thermal expansion and contraction loads due to temperature of the supporting and supported pipe(s) outer surface; b) thermal shock loads.
Loads due to normal handling operations, such as impact and abrasion.
Effective tensions in the supporting and supported pipes during installation and service.
Environmental Loads
Drag forces on clamp due to waves and currents.
Accidental Loads
Flexible pipe accidental loads that affect the flexible pipe configuration and/or piggy-back clamp/guides, where specified by the purchaser, as follows: a) internal over-pressure; b) vessel compartment damage or unintended flooding where applicable; c) failure of vessel thrusters where applicable; d) DP failure where applicable; e) anchor line failure; f) failure of FPSO turret drive system where applicable.

15.3.2 Design Methodology

The documentation submitted for verification of the design methodology shall include documentation, including any calculations performed, methodologies and software tools used, for the following, as a minimum:

a) documentation listed in 12.3.1 for piggy-back clamps and the clamping component of piggy-back guides (in accordance with 15.3.4);

b) determination of piggy-back guide dimensions (in accordance with 15.3.4);

c) global parameters as follows, for designs where such parameters are not specified by the purchaser (in accordance with 15.3.5):

   1) determination of piggy-back clamp/guide spacings;

   2) determination of clearances between supporting and supported pipes.

d) service life performance, subject to the requirements of 15.3.6.

15.3.3 Design Criteria

The circumferential component of the clamping capacity shall be at least 1,5 times the maximum circumferential force required to resist rotation of the supported pipe about the supporting pipe axis.

NOTE This factor has been selected in order to be consistent with the factor of safety on the axial clamping capacity for other ancillary equipment in this specification.

Where piggy-back guides are used, slack of the supported pipe shall be checked in global finite element analyses by the flexible pipe system designer. Such slack shall be documented in the design report not to result in a configuration that reduces the supported pipe operating MBR below the allowable specified by the purchaser during the specified service life.

15.3.4 Piggy-back System Design

Further to 15.3.3, the clamping capacity of the piggy-back spacers in position shall be designed to prevent rotation of the spacer about the supporting pipe. The clamping capacity and maximum rotational force to resist shall be documented in the design report.

Piggy-back clamps shall be designed not to allow relative movement of the supported pipe, accounting for the maximum decrease in the supported pipe external diameter during service and the tolerance on the supported pipe external diameter or the as-built external diameter.

Piggy-back guides shall be designed to allow relative movement of the supported pipe or, where specified, transmit an axial force no greater than that specified by the purchaser. The design for this requirement shall account for the maximum increase in the supported pipe external diameter during service and the tolerance on the supported pipe external diameter or the as-built external diameter.

The flexible pipe shall be sufficiently protected against pipe and steel scuffing and the potential transfer of high temperatures from the steel to the flexible pipe, if a flexible pipe is piggy-backed to a steel pipeline or other steel structure.

NOTE The above requirement has been transferred directly from API 17B.

15.3.5 Global Design

15.3.5.1 Piggy-back System Design Criteria

The piggy-back system spacings, and the positioning and combination of piggy-back clamps and piggy-back guides, shall be shown through global finite element analyses, documented in the design report, to satisfy the design criteria of the supporting and supported pipes. The length tolerances of the supporting and supported pipes shall be accounted for in determination of these parameters.

Design criteria specific to piggy-back systems that shall be satisfied in accordance with the above global analyses include the following:

a) operating MBR of supported pipe between piggy-back clamps and guides;

b) effective tension in supported pipe between piggy-back clamps;

c) buckling of supported pipe between piggy-back clamps.

Acceptable effective tensions in the supporting and supported pipes shall be determined by the flexible pipe system designer for the installation of the piggy-back system.

Based on length tolerances of the supporting and supported pipes, the piggy-back system shall be designed by the flexible pipe system designer such that length differences, as the last lengths of the supporting and supported pipe are paid out, are predicted.

15.3.5.2 Piggy-back System Design Considerations

The piggy back system shall be designed with the following considerations, where an umbilical or smaller diameter line is piggy backed to a flexible pipe:

a) relative motion between the lines;

b) relative changes in length between the two lines (particularly due to different expansion coefficients between flexible and steel lines);

c) internal pressure, tension, external pressure, bending and torsion-induced change in cross-section geometry of the pipe.

NOTE The above requirement has been transferred directly from API 17B.

15.3.6 Service Life

Further to 4.3.9, it shall be documented in the design report that creep and aging of the piggy-back system polymer and composite materials do not cause the spacer to be loosened to the extent that axial slippage or rotation about the clamped pipe occurs, accounting for the following:

a) compressive creep of piggy-back clamp spacers induced by the supporting or supported pipe and clamping force;

b) compressive creep of piggy-back guide spacers induced by the supporting pipe and clamping force;

c) tensile creep of straps, accounting for the range of tensions experienced by the straps;

d) fiber-reinforced composite straps delamination in seawater environment.

15.3.7 Corrosion Protection

See 4.3.11 for minimum corrosion protection requirements for piggy-back clamp fasteners and tensioning assemblies.

Metallic components in the piggy-back clamp shall be manufactured from a corrosion-resistant metal unless the piggy-back system is only for temporary use, i.e. during installation.

15.4 Material Requirements

15.4.1 General

The requirements of this section shall apply to metallic and fiber-reinforced composite materials for fasteners and straps, and to polymer and composite materials for the spacer body.

15.4.2 Qualification Requirements—Piggy-back Spacer Body Polymer Materials

The manufacturer shall test and document the material properties of piggy-back spacers, as specified in Table 41. Where indicated, the material properties in Table 41 shall be measured at the minimum and maximum temperatures of the material in service, in addition to measurement at room temperature. Where indicated, the material properties shall also be measured for aged samples of material. See 4.4.4 for minimum ageing test requirements.

15.4.3 Qualification Requirements Materials—Piggy-back Spacer Strap Fiber-reinforced Composite Materials

The manufacturer shall test and document the material properties of fiber-reinforced composite piggy-back spacer straps, as specified in Table 42. The material properties refer to the properties of the composite material and not the constituent components. Where indicated, the material properties in Table 42 shall be measured at the maximum temperature of the material in service, in addition to measurement at room temperature. Where indicated, the material properties shall also be measured for aged samples of material. See 4.4.4 for minimum ageing test requirements.

15.4.4 Qualification Requirements—Metallic Fasteners and Strap Materials

See 4.4.3 for minimum qualification requirements for the metallic fasteners and straps.

Table 41—Qualification Requirements for Piggy-back Spacer Polymer Materials

Tests	Test Procedure [a]	Section	Min. Temperature	Max. Temperature	Aged Sample
Abrasion resistance	ISO 7784-2 [b], ASTM D4060 [b], BS 903-A9 or DIN 53516	See 4.4.2			
Density	ISO 1183, ASTM D792				
Hardness	ISO 868 [c], or ASTM D2240				
Impact resistance	ISO 179, ISO 180 [c], ASTM D256	See 4.4.2	X		
Tensile strength, modulus, strain at break	ISO 527 [c], ASTM D638 [c], ISO 37			X	X

[a] As stated in Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.

[b] Standards similar in content but not technically equivalent.

[c] Standards are technically equivalent or identical for the test in question.

Table 42—Qualification Requirements for Piggy-back Spacer Strap Fiber-reinforced Composite Materials

Material Property	Test Procedure [a]	Section	Max. Temperature	Aged Sample
Abrasion resistance	ISO 7784-2 [b], ASTM D4060 [b], BS 903-A9 or DIN 53516	See 4.4.2		
Creep resistance			X	
Tensile strength, modulus, strain at break [c]	ISO 527 [d], ASTM D638 [d], ISO 37		X	X

[a] As stated in Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.
[b] Standards similar in content but not technically equivalent.
[c] Property shall be expressed in the fiber direction.
[d] Standards are technically equivalent or identical for the test in question.

15.5 Manufacturing Requirements

15.5.1 Quality Assurance Requirements—Process Control

The manufacturer shall as a minimum have a documented methodology for the manufacturing processes listed in 4.5.3 for the piggy-back spacers.

The manufacturer shall, as a minimum, have a documented methodology for the manufacturing processes listed in 4.5.3.2, where applicable, for metallic tensioning assemblies.

The manufacturer shall, as a minimum, have a documented methodology for the manufacturing processes listed in 4.5.3.2, where applicable, for fiber-reinforced composite piggy-back spacer strap materials.

For each mix of piggy-back spacer polymer material, a sample of material shall be retained and tested to verify that it is consistent with the properties measured in the qualification tests.

The following properties shall be tested, as a minimum:

a) tensile strength: ISO 527, ASTM D638 or ISO 37;

b) hardness: ISO 868 or ASTM D2240.

15.5.2 Manufacturing Tolerances

The manufacturer shall have available supporting documentation that demonstrates the following:

a) the manufacturing tolerances on the internal diameter of piggy-back guide supported pipe recesses are such that variations within this tolerance still allow axial freedom of the supported pipe (in accordance with 15.3.4);

b) the manufacturing tolerances on the internal diameter of piggy-back clamps are such that variations within this tolerance still restrict relative movement of the supporting pipe (in accordance with 15.3.4).

15.6 Documentation

15.6.1 Design Report

15.6.1.1 Piggy-back Description

The piggy-back system description in the design report shall include, as a minimum, the following:

a) minimum parameters specified in 4.6.3.1;

b) number of piggy-back clamps and guides;

c) piggy-back spacer external dimensions;

d) internal diameter of all pipe recesses in piggy-back spacers;

e) clearances between supported pipe(s) and supporting pipe;

f) design temperature;

g) description of fastening system (fasteners or straps and tensioning assemblies);

h) strap and tensioning assembly design loads;

i) clamping capacity of piggy-back clamps with respect to the supporting and supported pipes, and clamping capacity of piggy-back guides with respect to the supporting pipe.

15.6.1.2 Design Report Content

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) manufacturing and design tolerances;

f) calculations demonstrating that design satisfies functional requirements accounting for variations within manufacturing tolerance envelopes;

g) description of welds used for tensioning assemblies;

h) service life analysis, subject to the requirements of 4.3.8 to 4.3.10;

i) determination of piggy-back guide dimensions (in accordance with 15.3.4);

j) calculation of global parameters as follows for designs where such parameters are not specified by the purchaser (in accordance with 15.3.5):

   1) determination of piggy-back clamp/guide spacings;

2) determination of clearances between supporting and supported pipes.

k) service life analysis, subject to the requirements of 15.3.6.

The design report shall include or make reference to any calculations performed for or software tools used for these items.

15.6.2 Installation Procedures

Further to 4.6.5, the manufacturer's installation procedures shall include the fastening forces for securing the piggy-back spacers to the supporting and supported pipe.

15.7 Factory Acceptance Tests

15.7.1 General

The manufacturer shall perform the FAT tests specified in Table 43, on the piggy-back system components. The tests are divided into those relating to injection-moulded clamp components and those moulded by other means.

NOTE The test frequencies for injection-moulded components are relatively low, since this process typically has a high level of repeatability.

15.7.2 Fit-up and Assembly Testing

15.7.2.1 Procedure

A piggy-back spacer shall be assembled around samples of the supporting and supported pipe(s), where available, or dimensionally representative mock-ups of these pipes. The assembly shall include all components that make up the piggy-back clamp/guide, including all fasteners, straps and tensioning assemblies necessary to secure these components in position. The spacer shall be fastened together using fasteners and straps of the same specification and the same fastening forces as determined at the design stage for service.

15.7.2.2 Acceptance Criteria

The piggy-back spacer body recesses shall fit around the supporting pipe(s) and supported pipe. All the components of the piggy-back clamp/guide including shall be dimensionally compatible with each other.

Piggy-back guides shall allow relative movement of the supported pipe structure or, where specified, transmit an axial force no greater than that specified by the purchaser. Piggy-back clamps shall not allow relative movement of the supported pipe structure.

15.7.3 Dimensional Measurement

Dimensional measurement of piggy-back system components shall verify that the dimensions of these components are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances.

The dimensions that shall be measured for the piggy-back spacer shall include the following, as a minimum:

a) supporting pipe recess diameter;

b) supported pipe(s) recess diameter(s);

c) clearance allowed between supporting and supported pipe(s).;

d) length.

15.7.4 Visual Inspection

The visual inspection of the spacer shall include inspection for any sharp edges that can damage the supporting or supported pipes. If such flaws are found, they shall be removed or the component rejected.

Injection-moulded piggy-back components shall be inspected for any obvious flaws as they are removed from the mould.

15.7.5 Proof Loading

The strap and tensioning assembly shall be proof-loaded to a level agreed between the manufacturer and purchaser.

Table 43—Factory Acceptance Tests for Piggy-back Spacers

Component	Test	Percentage of Total Production to be Tested	Section
All	Fit-up and assembly	5 % [a] including proportionate numbers of clamps and guides, but minimum of 1 clamp and 1 guide (not those components subjected to a dimensional test)	See 15.7.2
Spacer	Dimensional [b]	5 % [a] including proportionate numbers of clamps and guides, but minimum of 1 clamp and 1 guide (not those subjected to a fit-up and assembly test)	See 15.7.3
	Visual	100 %	See 4.7.3 and 15.7.4
Strap	Dimensional [b]	5 % [a] (not those subjected to a fit-up and assembly test)	
	Visual	100 %	See 4.7.2 or 4.7.3
Strap and tensioning assembly	Proof load	1 for each unique assembly configuration	See 15.7.5
Injection-moulded components	Fit-up and assembly	1 prior to bulk manufacture plus minimum of 1 or 0,01 %	See 15.7.2
	Dimensional [b]	1 prior to bulk manufacture plus minimum of 1 or 0,01 %	See 15.7.3
	Visual	100 %	See 4.7.3 and 15.7.4
	Strap proof load	1 prior to bulk manufacture plus minimum of 1 or 0,01 %	See 15.7.5

[a] Value is consistent with current industry practice.

[b] As per 4.7.4, the dimensional check shall include the first item moulded and the frequency shall be evenly distributed between the first and last items moulded.

15.8 Marking

See 4.7.4 of API 17L2 for general marking recommendations.

The positions of the piggy-back spacers on the supporting pipe outer surface shall be clearly marked by the flexible pipe or supporting pipe manufacturer.

The piggy-back spacer marking shall make it permanently identifiable for the specified service life.

The marking shall include the following, as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) identification of supporting and supported pipes to which spacer is to be attached.

Each piggy-back spacer shall be packaged with all components necessary for its assembly onto the flexible pipe. This shall include, as applicable, fasteners, external straps and tensioning assemblies.

Piggy-back spacers shall be packaged in suitably protective material, such as bubble-wrap.

16 Repair Clamps

16.1 Applicability

The requirements in Section 4 and Section 12 shall apply.

This section applies to repair clamps. Some requirements are given by way of cross-reference to Section 12, which applies to general clamping device requirements.

The requirements in this section apply to clamping devices for use on flexible pipes, and are not intended for umbilical clamping devices.

16.2 Functional Requirements

16.2.1 General

Purchasing guidelines for repair clamps are given in Annex K.

The minimum overall functional requirements of the repair clamp that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to give a water-tight or pressure-tight repair, as required, to an area of flexible pipe. It may be required for the clamp to resist remedial operations that will produce a pressure differential between the damaged area and the surrounding seawater.

16.2.2 Flexible Pipe General Design Parameters

For the flexible pipe to which the repair clamp is attached the purchaser shall specify the following parameters, as a minimum:

a) flexible pipe design parameters required for the clamp design in 12.2.1;

b) internal diameter;

c) service type;

d) service life;

e) length of time flexible pipe has been in service;

   The required service life of the clamp shall be, as a minimum, the service life of the flexible pipe less this amount.

f) type of damage, and size of damaged area;

g) water depth at damaged area.

16.2.3 Repair Clamp Design Parameters

The purchaser shall specify the following parameters, as a minimum:

a) whether a water-tight or pressure-tight seal is required;

b) any chemicals that will be used to flush the flexible pipe annulus and therefore will come into contact with the repair clamp;

c) any requirement for the clamp to vent off trapped gases that can build up in the flexible pipe annulus;

d) any requirement for the clamp to provide monitoring equipment for flexible pipe annulus fluid;

e) temperatures to which the repair clamp is exposed (in accordance with 16.2.4).

16.2.4 Temperature

Further to 4.2.4, if in-service internal fluid temperature data are available for the damaged flexible pipe, then this should be reflected in the specification of temperature.

16.2.5 External Environment

The purchaser shall specify the maximum water depth at which the repair clamps are to be located.

16.2.6 Installation

The purchaser shall specify the requirements of the repair clamp that are necessary to interface correctly with ROV tools in order to install the clamp.

16.2.7 Design Loads

The purchaser shall specify the repair clamp design loads in accordance with 12.2.2.

The purchaser shall specify the pressure differential in the damaged areas that the clamp must resist, where applicable.

The purchaser shall specify the maximum flexible pipe curvature at the clamp location.

16.2.8 Spares

The purchaser may specify a required percentage quantity of spare repair clamps and spare fasteners.

16.3 Design Requirements

16.3.1 Loads

Local load classes and subclasses for repair clamps are listed in Table 44.

Table 44—Local Load Classes and Subclasses for Repair Clamps

Load Classes and Subclasses
Functional and Environmental Loads
Effective tensions in the flexible pipe
Loads due to self-weight, including marine growth where applicable
Pressure differential between seawater and flexible pipe annulus, where applicable
Loads due to bending of the flexible pipe. In dynamic applications the flexible pipe will undergo cyclic bending
Loads due to fastening systems, and external hydrostatic pressure
Loads due to expansion and contraction of the flexible pipe by tension, internal pressure and temperature effects during service, leak tests or structural integrity tests, see 11.5.3 of API 17B:2008
Thermal expansion and contraction loads due to temperature of flexible pipe outer sheath
Thermal shock loads
Loads due to normal handling operations, such as impact and abrasion
Accidental Loads
Flexible pipe accidental loads that affect the flexible pipe configuration and/or repair clamp, where specified by purchaser, as follows: a) internal over-pressure; b) vessel compartment damage or unintended flooding where applicable; c) failure of vessel thrusters where applicable; d) DP failure where applicable; e) anchor line failure; f) failure of FPSO turret drive system where applicable.

16.3.2 Design Methodology

The documentation submitted for verification of the design methodology shall include documentation, including any calculations performed, methodologies and software tools used, for the following, as a minimum:

a) documentation listed in 12.3.1;

b) demonstration of sealing capability of clamp (in accordance with 16.3.3).

16.3.3 Repair Clamp Design

As a minimum, the clamp shall be designed to provide the damaged area of the flexible pipe with a water-tight seal for the specified service life, accounting for all loads and clamp failure modes and mechanism.

Further to 12.3.3, the repair-clamp clamping capacity shall be designed to resist the pressure differential between the damaged area and the surrounding seawater, if required by the purchaser.

The repair clamp shall be designed to be compatible with any ROV tools that are to be used to install it onto the flexible pipe.

Where applicable, the following design requirements shall apply to the repair clamp gas-venting system.

a) The gas-venting system shall be designed for safe removal of diffused components.

b) Gas relief valves used as part of a venting system shall not allow ingress of seawater.

c) The valve design shall account for the specified marine growth conditions.

NOTE The above requirements are based on similar requirements for gas-venting systems for flexible pipes in API 17J.

16.3.4 Global Design

The effect of the repair clamp mass on the global design of the flexible pipe shall be checked by three-dimensional global analysis of the flexible pipe system, if the effect is considered significant. The added mass of the repair clamps shall not cause any of the design criteria of the flexible pipe to be violated in accordance with 5.1.3 of API 17J:2008.

16.3.5 Service Life—Dynamic Applications

Further to 4.3.9, the service life analysis shall account for the effects on contact of the repair clamp materials with any chemicals used to flush the flexible pipe annulus. This analysis shall include the corresponding effects on corrosion of metallic materials, and on ageing of polymer and composite materials. All materials shall be documented to not be adversely affected by any such chemicals over the specified service life.

Also further to 4.3.9, it shall be documented in the design report that polymer or composite inner liners or clamp bodies do not experience compressive creep induced by the flexible pipe and clamping force during the service life to the extent that the clamp is loosened and slides out of position.

Further to 4.3.10, fatigue analysis of the clamp shall account for stress fluctuations induced by the flexible pipe. The fatigue analysis shall account for any of the following cyclic loads that cause the documented and verifiable endurance limit of the material (that has been approved by the purchaser) to be exceeded:

a) expansion and contraction of the flexible pipe;

b) bending of the flexible pipe.

16.4 Material Requirements

The requirements of this section shall apply to metallic materials for the clamp body and polymer materials for the clamp inner-liner and injected sealant, where applicable.

See 4.4.3 for minimum metallic material qualification requirements for the clamp body.

Where applicable, the metallic materials involved in gas-venting pipework shall be documented to be chemically resistant for the specified service life to all gases released through the venting system in the presence of seawater.

16.5 Manufacturing Requirements

See 4.5 for minimum manufacturing requirements.

For each mix of polymer inner-liner material, a sample of material shall be retained and tested to verify that it is consistent with the properties measured in the qualification tests.

The following properties shall be tested, as a minimum:

a) tensile strength: ISO 527, ISO 37, or ASTM D638;

b) hardness: ISO 868 or ASTM D2240.

16.6 Documentation

16.6.1 Design Report

16.6.1.1 Repair Clamp Description

The repair description in the design report shall include, as a minimum, the following:

a) minimum clamp parameters specified in 12.5;

b) ROV tool interfaces;

c) description of sealing system;

d) pressure-tight seal design pressure.

16.6.1.2 Repair Clamp Design Report Content

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used, including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) overview of CP system design methodology where applicable;

f) manufacturing and design tolerances;

g) calculations demonstrating that design satisfies functional requirements accounting for variations within manufacturing tolerance envelopes;

h) description of welds used;

i) service life analysis, subject to the requirements of 4.3.8 to 4.3.10;

j) calculation of the dimensions of all components including as a minimum:

   1) clamp internal and external dimensions;

   2) internal and external diameter of inner liner, where applicable;

   3) external coatings;

   4) fasteners;

k) calculation of fastening force for securing clamp segments together (in accordance with 12.3.3);

l) service life analysis, subject to the requirements of 12.3.4;

m) demonstration of sealing capability of clamp (in accordance with 16.3.3).

The design report shall include or make reference to any calculations performed for or software tools used for these items.

16.6.2 Installation Procedures

The manufacturer’s procedures for installation shall include the following:

a) procedures listed in 4.6.5;

b) preparation of the flexible pipe outer sheath;

c) procedure for attaching repair clamp to flexible pipe;

d) procedure for creating seal, where applicable;

e) procedure for testing integrity of seal.

16.7 Factory Acceptance Tests

16.7.1 General

The manufacturer shall perform the FAT tests specified in Table 45 on repair clamps.

16.7.2 Dimensional Measurement

Dimensional measurement of repair clamp components shall verify that the dimensions of these components are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances.

The dimensions that shall be measured for the repair clamp shall include the following, as a minimum:

a) bore diameter;

b) external diameter;

c) length.

16.7.3 Fit-up and Assembly Testing

16.7.3.1 Procedure

The clamp shall be assembled to a sample of the flexible pipe, or a dimensionally representative mock-up of the flexible pipe considering the outer diameter tolerances. The assembly shall include all components that make up the clamp, including any inner liner used and all fasteners necessary to secure these components in position. The clamp components shall be fastened together using fasteners of the same specification and the same fastening forces as determined at the design stage for service. Where ROV tools are necessary to install the repair clamp, the interface of these tools with the repair clamp shall be tested.

16.7.3.2 Acceptance Criteria

After the subsea buoy clamp has been assembled, its bore shall be compatible with the dimensions of the flexible pipe. All the components of the clamp shall be dimensionally compatible with each other. The repair clamp shall be compatible with any ROV tools necessary to install the clamp.

16.7.4 Seal Test

16.7.4.1 Procedure

The repair clamp shall be assembled in accordance with the fit-up and assembly test procedure in 16.7.3. A differential pressure up to the design pressure shall be applied between the inner area of the clamp and the surrounding air.

16.7.4.2 Acceptance Criteria

The repair clamp shall provide the required seal at the applied differential pressure.

16.7.5 NDE of Welds

NDE of welds shall be performed in accordance with an appropriate international standard such as those listed in Table 10.

Table 45—Factory Acceptance Tests for Repair Clamps

Test	Section
Dimensional	See 16.7.2
Visual	See 4.7.2
Fit-up and assembly	See 16.7.3
Seal test	See 16.7.4
NDE of welds	See 16.7.5
Mass in air	

16.8 Marking

See 4.7.4 of API 17L2:2013 for general marking recommendations.

The repair clamp marking shall make it permanently identifiable for the specified service life.

The marking on the repair clamp shall include the following, as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) identification of flexible pipe to which clamp is to be attached;

f) design pressure;

g) repair clamp number.

17 I/J-tube Seals

17.1 Applicability

The requirements in Section 4 shall apply. The requirements in Section 12 shall apply to I/J-tube seals with clamping devices.

Some requirements relating to I/J-tube seals with clamping devices are given by way of cross-reference to Section 4, which applies to general clamping device requirements.

The requirements in this section shall also be applied to umbilicals except those requirements relating to diverless I/J-tube clamping force design in 12.3.1, 12.3.3 and 17.3.4.

17.2 Functional Requirements

17.2.1 General

Purchasing guidelines for I/J-tube seals are given in Annex L.

The minimum overall functional requirements of the I/J-tube seal that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to give a pressure-tight seal in the I/J-tube, thus keeping the corrosion-inhibited water within the I/J-tube.

17.2.2 Flexible Pipe Design Parameters

For the flexible pipe to which the I/J-tube seal is attached, the purchaser shall specify the following parameters, as a minimum:

a) internal diameter;

b) service type;

c) service life;

d) length and mass per unit length;

e) external diameter;

f) tolerance on external diameter;

g) flexible pipe design parameters in 12.2.1 required for the clamp design for I/J-tube seals with clamping devices;

h) angle and/or curvature of flexible pipe at I/J-tube exit.

17.2.3 I/J-tube Design Parameters

The purchaser shall specify the following parameters, as a minimum:

a) as-built internal diameter of I/J-tube if available or, alternatively, external diameter and wall thickness, including tolerances. The purchaser shall submit detailed drawings of the I/J-tube where available;

b) surface finish/profile on interior of I/J-tube, if available;

c) thickness of any internal coatings;

d) whether there are any weld protrusions within the I/J-tube that will effectively reduce the internal diameter of the tube;

e) Such protrusions are only of relevance if they are in the vicinity of the I/J-tube seal. If such protrusions are present, their thickness shall be specified;

f) I/J-tube material;

g) the purchaser should specify the length of time an existing I/J-tube has been in service, as well as the condition that the bore is in, if the latter is available.

The purchaser should start to source the above data as soon as possible, as it may take some time to retrieve. The purchaser should consider arranging for an inspection of existing I/J-tubes in order to have the above data if previous documentation with such data is not available.

17.2.4 I/J-tube Modification

The purchaser should discuss with the manufacturer whether modifications such as built-on extensions or internal weld grinding are necessary.

17.2.5 External Environment

Environmental functional requirements relating to sunlight exposure should be specified in accordance with 4.2.5 for polymer sealing elements.

The purchaser shall specify the maximum water depth at the I/J-tube seal location.

17.2.6 Corrosion Protection

The corrosion protection requirements for metallic components of the I/J-tube seal may be specified in accordance with 4.2.6.

The purchaser shall provide a data sheet for the corrosion inhibitor used in the I/J-tube, and shall specify the concentration of the corrosion inhibitor within the I/J-tube seawater.

17.2.7 Installation

The purchaser shall specify requirements for either a diverless or diver-assisted makeup of the I/J-tube seal. This requirement shall be based on statutory and regulatory requirements.

The purchaser shall specify the topside pulling capacity, including its sensitivity, that is available in the field, for diverless I/J-tube seals.

17.2.8 Design Loads

The purchaser shall specify the I/J-tube differential pressure between the I/J-tube internal pressure and the external hydrostatic pressure.

The purchaser shall specify the clamp design loads in accordance with 12.2.2 for I/J-tube seals that incorporate a clamping device.

17.2.9 Spares

The purchaser should specify the required quantity of spare fasteners for making up the I/J-tube seal.

17.3 Design Requirements

17.3.1 Loads

Local load classes and subclasses for I/J-tube seals are listed in Table 46.

17.3.2 Design Methodology

The documentation submitted for verification of the design methodology shall include documentation of, including any calculations performed, methodologies and software tools used, for the following, as a minimum:

a) documentation listed in 4.3.5.1;

b) dimensions of all components including as a minimum:

   1) seal outer diameter;

   2) fasteners;

   3) protective coatings.

c) fastening force for securing I/J-tube seal segments together (in accordance with 17.3.3);

d) pulling force required to create diverless I/J-tube seals (in accordance with 17.3.4);

e) service life performance, subject to the requirements of 17.3.6 or 17.3.7 as applicable.

Table 46—Local Load Classes and Subclassses for I/J-tube Seals

Load Classes and Subclasses
Functional Loads
Differential pressure between I/J-tube and surrounding seawater.
Loads due to fasteners connecting I/J-tube seal components together.
Loads due to pull-in of flexible pipe [a].
Flexible pipe effective tension at I/J-tube exit.
Compressive loads from I/J-tube inner wall due to creation of seal.
Loads due to expansion and contraction of the flexible pipe by tension, internal pressure and temperature effects during service, leak tests or structural integrity tests, see 11.5.3 of API 17B:2008.
Temperature induced loads: a) thermal expansion and contraction cyclic loads due to flexible pipe internal fluid temperature. b) thermal shock loads.
Accidental Loads
Flexible pipe accidental loads that affect the flexible pipe configuration and/or I/J-tube seal, where specified by purchaser, as follows: a) internal over-pressure; b) vessel compartment damage or unintended flooding where applicable; c) failure of vessel thrusters where applicable; d) DP failure where applicable; e) anchor line failure; f) failure of FPSO turret drive system where applicable.
[a] Diverless I/J-tube seals only.

17.3.3 I/J-tube Seal Design—General

Fastening forces for securing the components of the I/J-tube seal shall be calculated by the manufacturer and specified in the installation procedures. The specified force shall be calculated to ensure that the integrity of the seal is maintained and the components remain in position for the specified service life, but shall not cause stresses and strains in the I/J-tube seal components to exceed allowable levels.

The I/J-tube design shall account for the following:

a) initial interference/clearance between the I/J-tube and the seal;

b) nonlinear stress-strain relationship of the seal material;

c) frictional forces between seal and I/J-tube inner walls.

17.3.4 Diverless I/J-tube Seal Design

Further to 12.3.3, the calculation of clamping capacity and the clamp design shall account for the force required to resist the force due to pull-in of the I/J-tube seal.

I/J-tube seals shall be designed to create a pressure-tight seal between the I-tube corrosion-inhibited water and surrounding seawater using the pull-in force within the topside pulling capacity. The seal shall remain pressure-tight at the required sealing pressure for the specified service life. The pull-in force should be verified by a full-scale pull-in load test, see 17.4.4.

17.3.5 Diver-assisted I/J-tube design

Diver-assisted I/J-tube seals shall be designed to create a pressure tight seal between the I-tube corrosion inhibited water and surrounding seawater using the forces applied by the fasteners. The seal shall remain pressure-tight at the required sealing pressure for the specified service life.

17.3.6 Service Life—Static Applications

Further to 4.3.9, it shall be documented in the design report that polymer inner-liners in I/J-tube seals with clamping devices do not experience compressive creep induced by the flexible pipe and clamping force during the service life to the extent that the clamp is loosened and slides out of position.

It shall be documented in the design report that creep of the sealing elements due to constant compressive forces applied by the I/J-tube inner walls does not compromise the seal integrity during the specified service life. The temperature of the sealing elements induced by the flexible pipe shall be considered in the assessment of creep.

17.3.7 Service Life—Dynamic Applications

Further to 4.3.10, fatigue analysis of the I/J-tube seal shall account for stress fluctuations induced by the flexible pipe in dynamic applications.

The fatigue analysis shall account for any of the following cyclic loads that cause the documented and verifiable endurance limit of the material (that has been approved by the purchaser) to be exceeded:

a) expansion and contraction of the flexible pipe;

b) variations in effective tensions in the flexible pipe;

c) bending of the flexible pipe.

17.3.8 Corrosion Protection

The metallic components of the I/J-tube seal shall be protected by a CP system, if requested by the purchaser.

17.4 Material Requirements

17.4.1 General

The requirements of this section shall apply to metallic materials for I/J-tube seal clamp bodies and polymer materials for I/J-tube seal clamp inner-liners and sealing elements.

17.4.2 Qualification Requirements—Metallic Materials

See 4.4.3 for minimum metallic material qualification requirements for diverless I/J-tube seal clamp bodies.

17.4.3 Qualification Requirements—Polymer Sealing Element Materials

The manufacturer shall test and document the material properties for polymer sealing elements specified in Table 44. Where indicated, the material properties in Table 44 shall be measured at the minimum and maximum temperatures of the material in service, in addition to measurement at room temperature. The maximum temperature shall account for the temperature induced by the flexible pipe outer sheath. Where indicated, the material properties shall also be measured for aged samples of material. See 4.4.4 for minimum ageing test requirements.

The manufacturer shall have documented records on the compatibility of the sealing element material with the corrosion inhibitor being used in the I/J-tube for the specified service life.

17.4.4 Ageing Resistance

If the corrosion inhibitor data sheet specifies compatibility with the sealing element materials and there are sufficient supporting data available for compatibility for the specified service life, then the ageing tests may be restricted to using water as an ageing medium. Otherwise, ageing tests using representative concentrations of corrosion inhibitor shall be performed.

Table 47—Qualification Requirements for Polymer Sealing Element Materials

Tests	Test Procedure [a]	Section	Min. Temperature	Max. Temperature	Aged Sample
Abrasion resistance	ISO 7784-2 [b], ASTM D4060 [b], BS 903-A9, or DIN 53516	See 4.4.2			
Hardness	ISO 868 [c], or ASTM D2240				
Impact strength	ISO 179, ISO 180 [c], ASTM D256	See 4.4.2	X		
Resistance to corrosion inhibitor		See 17.4.4			
Tensile strength, modulus, strain at break	ISO 527 [c], ISO 37, or ASTM D638 [c]			X	X

[a] As stated in Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.

[b] Standards similar in content but not technically equivalent.

[c] Standards are technically equivalent or identical for the test in question.

17.5 Manufacturing Requirements

17.5.1 Quality Assurance Requirements—Process Control

For each mix of polymer sealing element material, a sample of material shall be retained and tested to verify that it is consistent with the properties measured in the qualification tests.

The following properties shall be tested, as a minimum:

a) tensile strength: ISO 527, ISO 37, or ASTM D638;

b) hardness: ISO 868, or ASTM D2240.

17.5.2 Manufacturing Tolerances

The manufacturer shall have supporting documentation that demonstrates that manufacturing tolerances on the sealing elements and on all I/J-tube seal components are such that, with variations within this tolerance, the sealing performance is still satisfied in accordance with17.3.4.

17.6 Documentation

17.6.1 Design Report

17.6.1.1 I/J-tube Seal Description

The I/J-tube seal description in the design report shall include, as a minimum, the following:

a) minimum parameters specified in 4.3.6.1;

b) sealing element internal and external diameters;

c) diverless I/J-tube seal parameters:

   1) minimum clamp parameters specified in 12.5,

   2) number of sealing rings,

   3) design pull-in load.

17.6.1.2 I/J-tube Seal Design Report Content

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) overview of CP system design methodology, where applicable;

f) manufacturing and design tolerances;

g) calculations demonstrating that design satisfies functional requirements, accounting for variations within manufacturing tolerance envelopes;

h) description of welds used for clamp where applicable;

i) service life analysis, subject to the requirements of 4.3.8 to 4.3.10;

j) calculation of the dimensions of all components, including, as a minimum:

   1) clamp internal and external dimensions;

   2) internal and external diameter of inner liner, where applicable;

   3) external coatings;

   4) fasteners.

k) calculation of fastening force for securing clamp segments together, where applicable (in accordance with 12.3.3);

l) calculation of the dimensions of all components, including, as a minimum:

   1) seal outer diameter;

   2) fasteners;

   3) protective coatings.

m) calculation of fastening force for securing I/J-tube seal segments together (in accordance with 17.3.3);

n) calculation of pulling force required to create diverless I/J-tube seals (in accordance with 17.3.4);

o) service life analysis, subject to the requirements of 12.3.4 and 17.3.6 or 17.3.7, as applicable.

The design report shall include or make reference to any calculations performed for or software tools used for these items.

17.6.2 Installation Procedures

The manufacturer's procedures for installation shall include the following:

a) procedures listed in 4.6.5;

b) preparation of flexible pipe outer sheath;

c) procedure for attaching I/J-tube seal to flexible pipe;

d) procedure for creating seal, including specification of required pull-in load for diverless I/J-tube seals.

17.7 Factory Acceptance Tests

17.7.1 General

The manufacturer shall as a minimum perform the FAT tests as specified in Table 48, except the pull-in and pressure test. The pull-in and pressure tests should be performed, and shall be performed on purchaser request.

17.7.2 Dimensional Measurement

Dimensional measurement of the I/J-tube seal components shall verify that the dimensions of these components are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances. The dimensions that shall be measured for the I/J-tube seal elements shall include the diameter to the sealing rings.

The dimensions that shall be measured for the I/J-tube seal clamps shall include the following, as a minimum:

a) bore diameter;

b) external diameter;

c) length.

Dimensional measurement of the I/J-tube seal shall verify that it has the as-designed dimensions within tolerances that were determined to satisfy the requirements of 17.3.4.

17.7.3 Fit-up and Assembly Testing

17.7.3.1 Procedure

The I/J-tube seal shall be secured to a sample length of the flexible pipe, where available, that is representative of the properties of the actual length of the flexible pipe. Otherwise, it shall be secured to a dimensionally representative mock-up of the flexible pipe. The I/J-tube seal components shall be assembled and fastened together using fasteners of the same specification and the same fastening forces as determined at the design stage for service.

17.7.3.2 Acceptance Criteria

After the I/J-tube seal has been assembled, it shall be compatible with the dimensions of the flexible pipe. All the components of the I/J-tube seal shall be dimensionally compatible with each other.

17.7.4 Pull-in Load Test

17.7.4.1 Procedure

This test applies only to diverless I/J-tube seals. The I/J-tube seal shall be assembled in accordance with the fit-up and assembly test procedure in 17.7.3. The I/J-tube seal shall be pulled into a tube representative of the dimensions of the I/J-tube in the specified application. The manufacturer shall determine a suitable tube dimension to use in the test based on as-built data or design tolerances that represents the most critical dimension for the seal pull-in. The load required to pull in the seal shall be recorded.

17.7.4.2 Acceptance Criteria

The load required to pull in the seal shall be within the topside pulling capacity for the specified application.

17.7.5 Pressure Test

17.7.5.1 Procedure

Diver-assisted I/J-tube seals shall be assembled in a tube representative of the I/J-tube in the specified application in accordance with the fit-up and assembly test procedure in 17.7.3. Diverless I/J-tube seals shall be pulled into this tube in accordance with the pull-in test procedure in 17.7.4. The tube shall be pressurized gradually to a pressure representative of that in the specified application. The pressure shall be applied for a sufficient time period in order to achieve a stabilized pressure. During the period at which the pressure is applied, the parts of the seal external to the tube shall be inspected for leakage. The pressure shall be reduced and the I/J-tube seal removed. The seal elements shall be inspected.

17.7.5.2 Acceptance Criteria

The seal shall sustain the I/J-tube differential pressure in the specified application. No leakage shall be observed during the test. No permanent deformation or damage shall be observed in the I/J-tube seal components.

17.7.6 NDE of Welds

NDE of welds shall be performed in accordance with an appropriate international standard such as those listed in Table 10.

Table 48—Factory Acceptance Tests for I/J-tube Seals

Component	Test	Diverless Seal	Diver-assisted Seal	Percentage of Total Production to be Tested	Section
I/J-tube seal	Dimensional	X	X	5 % [a] but minimum of 2 (not those subjected to a fit-up and assembly test)	See 17.7.2
	Visual	X	X	100 %	See 4.7.2 and 4.7.3
	Fit-up and assembly	X	X	5 % [a] but minimum of 1 (not those components subjected to a dimensional test)	See 17.7.3
	Pressure test [b]	X	X	1 I/J-tube seal design	See 17.7.5
Diverless I/J-tube seal	Pull-in test [b]	X		1 I/J-tube seal design	See 17.7.4
Clamp body	NDE of welds [c]	X		100 %	See 17.7.6

a Value is consistent with current industry practice.
b Test shall be carried out only at purchaser request.
c Where applicable; the clamp body may be connected together entirely by fasteners.

17.8 Marking and Packaging

17.8.1 Marking

See 4.7.4 of API 17L2 for general marking recommendations.

The I/J-tube seal marking shall make it permanently identifiable for the specified service life.

The marking on the I/J-tube seal shall include the following, as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) identification of flexible pipe to which I/J-tube seal is to be attached;

f) differential pressure rating;

g) For I/J-tube seals with clamping devices, identification such that clamp segments can be re-assembled to their positioning before the clamp segments were cut out during manufacture, where applicable.

17.8.2 Packaging

Each I/J-tube seal shall be packaged with all components necessary for its assembly onto the flexible pipe. This shall include, as applicable, the clamp, the inner liner, the sealing elements, the nose section and fasteners.

Sealing elements shall be packaged in suitably protective material, such as bubble-wrap. All packages shall be accompanied by a packing list.

18 Pull-in Heads

18.1 Applicability

The requirements in Section 4 shall apply.

Pull-in heads may be incorporated into other ancillary equipment, such as load-transfer devices. Load-transfer device requirements are given in Section 21.

The requirements in this section shall also be applied to umbilicals.

18.2 Functional Requirements

18.2.1 General

Purchasing guidelines for pull-in heads are given in Annex M.

The minimum overall functional requirements of the pull-in head that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to remain securely attached to the flexible pipe end fitting and pull-in wire during pull-in operations.

18.2.2 Flexible Pipe Design Parameters

For the flexible pipe to which the pull-in head is attached the purchaser shall specify the following parameters, as a minimum:

a) internal diameter;

b) service type;

c) detailed drawing of the end fitting at the applicable end of the flexible pipe.

18.2.3 Pull-in Head Design Parameters

The purchaser shall specify the following parameters, as a minimum:

a) requirements for interfacing with lifting equipment;

b) where pull-in head is to pass through I-tubes or guide tubes, detailed drawings of these structures;

c) any requirements for vents in the pull-in head, defined in terms of number of vents and required diameter;

d) any requirements for the pull-in head to have pressure-containing capacity;

e) requirements for re-use of pull-in head.

18.2.4 Corrosion Protection

Where the pull-in head is intended for re-use or corrosion protection is required for storage conditions, the corrosion-protection coating requirements for the pull-in head may be specified in accordance with 4.2.6.

18.2.5 Design Loads

The purchaser shall specify the required SWL of the pull-in head.

Where the pull-head is to have pressure-containing capacity, the purchaser shall specify the maximum internal pressure.

18.2.6 Spares

The purchaser should specify the required number of spare fasteners required for securing the pull-in head to the flexible pipe end-fitting.

18.3 Design Requirements

18.3.1 Loads

Local load classes and subclasses for pull-in heads are listed in Table 49.

Table 49—Local Load Classes and Subclasses for Pull-in Heads

Load Classes and Subclasses
Functional Loads
Internal pressure, where applicable. Loads due to fasteners. Normal abrasion and impact loads against the I-tube during pull-in of flexible pipe. Loads due to normal handling operations, such as impact and abrasion.
Environmental Loads
Effective tension at end of flexible pipe adjacent to pull-in head, inclusive of dynamic effects.
Accidental Loads
Flexible pipe internal over-pressure, where applicable.

18.3.2 Design Criteria

The utilizations used for the pull-in head design shall be in accordance with an appropriate international standard for lifting equipment. See Table 2 for examples of lifting equipment standards.

18.3.3 Pull-in Head Design

The design of the pull-in head shall be in accordance with an appropriate international standard for lifting equipment. See Table 2 for examples of lifting equipment standards.

The applied bearing stress on the end fitting shall not exceed the permissible utilization as specified in Table 7 of API 17J:2008.

The dimensions of the pull-in head shall be compatible with the dimensions, including tolerances, of the flexible pipe end fitting, lifting equipment, I-tube and any latching devices.

A fastening force shall be calculated in order to secure the pull-in head to the flexible pipe end fitting, and specified in the design report and installation procedures. The resulting force shall securely attach the pull-in head to the end fitting, accounting for the maximum flexible pipe effective tension and any internal pressure at the pull-in head location. The fastening force shall be designed not to cause the utilization in the end fitting to exceed the levels specified in Table 7 of API 17J:2008.

Where applicable, the following design requirements shall apply to the pull-in gas-venting system:

a) the gas-venting system shall be designed for safe removal of diffused components;

b) gas relief valves used as part of a venting system shall not allow ingress of seawater, where applicable.

NOTE The above requirements are based on similar requirements for gas-venting systems for flexible pipes in API 17J.

18.3.4 Service Life

Where the pull-in head is to be re-used, there shall be a documented evaluation that the pull-in head can sustain the loads associated with its re-use, accounting for any degradation between use due to corrosion or otherwise. This shall consider the loads specified in 18.2.5 for each re-use application. Re-use of the pull-in head shall be in accordance with an appropriate lifting standard, such as Lloyd's Register of Shipping Code for Lifting Appliances in a Marine Environment (which specifies requirements on re-testing of lifting equipment).

18.4 Manufacturing Requirements—Tolerances

The manufacturing tolerance on the pull-in head shall be such that, with variations within this tolerance, the requirements of 18.3.3.3 are still satisfied.

18.5 Documentation Requirements

18.5.1 General

The minimum documentation that the manufacturer is to have available for the purchaser shall be as specified in this section. The documentation requirements for materials and manufacturing shall be as specified in the relevant sections of this specification, and are summarized in this section. This section is intended to collate together the documentation requirements throughout this specification into a central section.

The manufacturer shall have available for the purchaser the following documents under the circumstances outlined, and should have them available at the specified times:

a) design report: prior to manufacture or at an agreed date after manufacture;

b) manufacturing quality plan: prior to manufacturing;

c) installation procedures: prior to installation;

d) as-built documentation: when FATs have been completed;

e) detailed engineering drawings: prior to manufacture;

f) engineering drawings may be referenced in the design report;

g) pull proof test and weld NDE certificates: prior to installation.

If time permits, the design report may be made available prior to manufacture. The purchaser should consult with the manufacturer if such a requirement is necessary.

Issue of the above documents by manufacturer to purchaser shall be in accordance with the requirements of 4.2.13.

18.5.2 Design Report

18.5.2.1 Pull-in Head Description

The pull-in head description in the design report shall include, as a minimum, the following:

a) minimum parameters specified in 4.6.3;

b) description of lifting points;

c) description of vents;

d) pressure rating;

e) load rating.

18.5.2.2 Pull-In Head Design Report Content

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used, including results of supporting FEA analysis;

d) documented basis for utilization factors;

e) manufacturing and design tolerances;

f) calculations demonstrating that design satisfies functional requirements, accounting for variations within manufacturing tolerance envelopes;

g) description of welds used;

h) service life analysis, where applicable, subject to the requirements of 18.3.4;

i) dimensions of all components, including, where applicable, the following:

   1) flanges;

   2) fasteners;

   3) other dimensions of component;

j) strength analysis of pull-in head (in accordance with 18.3.3);

k) calculation of fastening force for securing pull-in head to flexible pipe end fitting (in accordance with 18.3.3).

The design report shall include or make reference to any calculations performed for or software tools used for these items.

18.5.3 Installation Procedures

Further to 4.6.5, the manufacturer's procedures for installation shall include the procedures for attaching the pull-in head to the flexible pipe end fitting.

18.6 Factory Acceptance Tests

18.6.1 General

The manufacturer shall perform the FAT tests specified in Table 50 on the pull-in head.

18.6.2 Dimensional Measurement

Dimensional measurement of the pull-in head shall verify that its dimensions are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances. The dimensional measurement of the pull-in head shall include verification that the requirements of 18.3.3 have been satisfied. The dimensions that shall be measured for the pull-in head shall include its external diameter and the diameter of any vents, where applicable.

18.6.3 Fit-up and Assembly Testing

18.6.3.1 Procedure

The pull-in head shall be fastened to the flexible pipe end-fitting using fasteners of the same specification and the same fastening forces as determined at the design stage for service (see18.3.3).

18.6.3.2 Acceptance Criteria

The pull-in head shall be dimensionally compatible with the flexible pipe end-fitting and shall attach successfully to the end-fitting. Where vents are incorporated in the pull-in head design, these shall align with the vents on the end fitting.

18.6.4 Proof Loading

Pull-in heads shall be proof-loaded to a load specified in an appropriate international standard for lifting appliances, such as those listed in Table 2, and in accordance with government regulations.

18.6.5 NDE of Welds

NDE of welds shall be performed in accordance with an appropriate international standard, such as those listed in Table 10.

18.6.6 Pressure Test

Where the pull-in head is to have pressure-containing capacity the rated pressure shall be greater than the FAT pressure. The pull-in head shall be pressure-tested to at least 1,5 times the design pressure to verify that it is pressure-tight. A higher test pressure may be required by local codes or regulators (e.g. NPD, MMS, HSE), and in such cases the requirements of these authorities shall take precedence over these requirements. Alternatively, a back seal test using nitrogen can be done. Back seal test pressure is typically 200 bar.

NOTE This factor has been selected in order to be consistent with the hydrostatic test pressure factor specified for the flexible pipe in 9.3 of ISO API 17J:2008.

Table 50—Factory Acceptance Tests for Pull-in Heads

Test	Section
Dimensional	See 18.6.2
Visual	See 4.7.2.1
Fit-up and assembly	See 18.6.3.1
Proof load	See 18.6.4
NDE of welds	See 18.6.5
Pressure test	See 18.6.6

18.7 Marking and Packaging

18.7.1 Marking

See 4.7.4 of API 17L2:2013 for general marking recommendations.

The pull-in head marking shall make it permanently identifiable for its specified period of use.

The marking on the pull-in head shall include the following, as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) identification of flexible pipe to which pull-in head is to be attached;

f) SWL;

g) mass in air;

h) internal pressure rating, where applicable.

18.7.2 Packaging

The pull-in head shall be packaged with all components, including fasteners, necessary for its assembly onto the flexible pipe end fitting. All packages shall be accompanied by a packing list.

19 Chinese Fingers/Cable Grips

19.1 Applicability

The requirements in Section 4 shall apply.

The requirements in this section shall also be applied to umbilicals.

19.2 Functional Requirements

19.2.1 General

Purchasing guidelines for Chinese fingers are given in Annex N.

The minimum overall functional requirements of the Chinese finger that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to remain securely attached to the flexible pipe and lifting equipment during lifting operations;

c) to provide sufficient lifting capacity for the specified design load.

19.2.2 Flexible Pipe Design Parameters

For the flexible pipe to which the Chinese finger is attached, the purchaser shall specify the following parameters, as a minimum:

a) internal diameter and service type;

b) external diameter;

c) tolerance on external diameter;

d) outer sheath material.

19.2.3 Corrosion Protection

Where the Chinese finger is intended for re-use, or corrosion protection is required for storage conditions, the corrosion-protection coating requirements for the Chinese finger may be specified in accordance with 4.2.6.

19.2.4 Installation Requirements

The purchaser shall specify requirements for the Chinese finger to interface with lifting equipment connection hardware, such as lifting wire shackles.

19.2.5 Design Loads

The purchaser shall specify the SWL requirement of the Chinese finger based on the maximum effective tension in the flexible pipe during lifting operations, inclusive of any dynamic effects.

The purchaser shall specify the maximum curvature in the flexible pipe during installation lifting operations at the Chinese finger location.

The purchaser shall specify variations in the flexible pipe external diameter during the period in which the Chinese finger is attached, due to tension, internal pressure and temperature effects.

19.2.6 Marking

The purchaser may specify requirements for marking of the Chinese finger tagging. Minimum marking requirements are given in 19.8.1.

19.3 Design Requirements

19.3.1 Design Criteria

The utilizations used for the Chinese finger design shall be in accordance with an appropriate international standard for lifting equipment. See Table 2 for examples of lifting equipment standards.

19.3.2 Chinese Finger Design

The Chinese finger shall be designed such that it maintains a grip on the specified flexible pipe external diameter at the applied lifting force, accounting for external diameter tolerances and variations in the external diameter during installation.

19.3.3 Service Life

Where the Chinese finger is to be re-used, there shall be a documented evaluation that the Chinese finger can sustain the loads associated with its re-use, accounting for any degradation between use, due to corrosion or otherwise. This shall consider the loads specified in 19.2.5 for each re-use application. Re-use of the Chinese finger shall be in accordance with an appropriate lifting standard, such as Lloyd's Register of Shipping Code for Lifting Appliances in a Marine Environment (which specifies requirements on re-testing of lifting equipment).

19.4 Material Requirements

The wire material in the Chinese finger shall be qualified in accordance with an appropriate standard, such as AISI 316.

19.5 Manufacturing Requirements

19.5.1 General

The wire material in the Chinese finger shall be manufactured in accordance with an appropriate standard, such as AISI 316.

19.5.2 Manufacturing Tolerances

The manufacturing tolerance on the Chinese finger shall be such that, with variations within this tolerance, the requirements of 19.3.2 are still satisfied.

19.6 Documentation Requirements

19.6.1 Certificate

The manufacturer shall have available for the purchaser a certificate for the Chinese finger. The Chinese finger description in the certificate shall include, as a minimum, the following:

a) description of Chinese finger configuration;

b) flexible pipe external diameter range for which compatibility is provided;

c) SWL;

d) results of proof-load test.

19.6.2 Installation Procedures

Further to 4.6.5, the manufacturer's procedures for installation shall include: flexible pipe outer sheath cleaning, lacing-up procedure for attaching the Chinese finger to the flexible pipe, and Chinese finger gripping.

19.7 Factory Acceptance Tests

19.7.1 General

The manufacturer shall perform the FAT tests specified in Table 51 on the Chinese finger.

19.7.2 Dimensional Measurement

Dimensional measurement of the Chinese finger shall verify that its dimensions are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances. The dimensional measurement of the Chinese finger shall verify the dimensional compatibility of the Chinese finger with the flexible pipe. The dimensional measurement of the Chinese finger shall include measurement of its internal diameter.

19.7.3 Fit-up and Assembly Testing

19.7.3.1 Procedure

The Chinese finger shall be laced up on a sample of the flexible pipe, or a dimensionally representative mock-up of the flexible pipe.

19.7.3.2 Acceptance Criteria

The Chinese finger shall be dimensionally compatible with the flexible pipe.

19.7.4 Proof Loading

The Chinese finger and any associated connection hardware shall be proof-loaded in accordance with an appropriate international standard for lifting equipment.

Table 51—Factory Acceptance Tests for Chinese Fingers

Test	Section
Dimensional	See 19.7.2
Visual	See 4.7.2
Fit-up and assembly	See 19.7.3
Proof load	See 19.7.4

19.8 Marking

See 4.7.4 of API 17L2:2013 for general marking recommendations.

The Chinese finger marking/tagging shall make it permanently identifiable for its specified period of use.

The marking on the Chinese finger or associated tagging attached to it shall include the following, as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) external diameter of flexible pipe with which Chinese finger is compatible.

20 Connectors

20.1 Applicability

The requirements in Section 4 shall apply.

This section applies to tubular connections that are used in a load-transfer and pressure-containing capacity. For requirements on structures that are required to transfer loads only without any pressure-containing capacity, see Section 21. Some connectors may combine a pull-in head into the design. In such cases, the requirements of Section 18 shall apply also. See API 6A for general flanged connector requirements.

20.2 Functional Requirements

20.2.1 General

Purchasing guidelines for connectors are given in Annex O.

The minimum overall functional requirements of the connector that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to provide a pressure-tight connection between the flexible pipe end fitting and adjacent piping for the specified service life;

c) to provide access/piping to vent ports, when needed.

20.2.2 Flexible Pipe Design Parameters

For the flexible pipe to which the connector is attached, the purchaser shall specify the following parameters, as a minimum:

a) internal diameter;

b) service type;

c) service life;

d) detailed drawing of end fitting.

20.2.3 Connector Design Parameters

The purchaser shall specify the following parameters, as a minimum:

a) location of connector, including whether a seabed or topside connector;

b) type of connector required, as follows:

    1) flange;

    2) clamped hub;

    3) swivel flange;

    4) other.

20.2.4 Adjacent Piping and Structures

The purchaser shall specify the internal and external diameters, including tolerances of the piping to which the flexible pipe end-fitting is to be connected via the connector.

The purchaser shall provide detailed drawings of the I-tube into which the connector is to be attached, where the connector is to be located within an I-tube. The drawings shall include the internal diameter, including tolerances of the I-tube.

The purchaser shall specify the material grade of all adjacent piping and structures. The purchaser shall specify whether or not it is required that the manufacturer has responsibility for ensuring compatibility of materials in the connector with those of the adjacent piping and structures.

20.2.5 Internal Fluid Parameters

The internal fluid parameters, including H_2S, CO_2 and chloride content, for the flexible pipe attached to the connector shall be specified in accordance with 4.4 of API 17J:2008.

20.2.6 Installation Requirements

The purchaser shall specify their requirement for either a diverless or diver-assisted make-up of the connector.

20.2.7 Design Loads

The purchaser shall specify the maximum internal pressure to which the connector is to be subjected.

The purchaser shall specify the maximum static and dynamic effective tensions, bending moment and shear forces transferred by the flexible pipe to the connector location under all applicable design load combinations and conditions for the flexible pipe. The purchaser shall specify fatigue loads consisting of minimum, mean and maximum effective tensions, bending moment and shear forces and corresponding numbers of cycles for each load range.

20.2.8 Spares

The purchaser should specify the required number of spare connectors required.

20.3 Design Requirements

20.3.1 Loads

Local load classes and subclasses for connectors are listed in Table 52.

Table 52—Local Load Classes and Subclasses for Connectors

Load Classes and Subclasses
Functional Loads
Hydrostatic pressure (for subsea connectors). Internal pressure during service, installation and during leak tests or structural integrity tests, see 11.5.3 of API 17B:2008. Loads due to fasteners. Expansion and contraction of submarine pipeline (for flowline connectors). Loads due to removal and disconnection. Temperature induced loads: a) Thermal expansion and contraction loads due to internal fluid temperature. b) Thermal shock loads. Loads due to normal handling operations, such as impact and abrasion.
Environmental Loads
Loads transferred from flexible pipe during installation and service, including effective tension, bending moment and shear forces, inclusive of dynamic effects.
Accidental Loads
Flexible pipe accidental loads that affect the flexible pipe configuration and/or connector, where specified by purchaser, as follows: a) internal over-pressure; b) vessel compartment damage or unintended flooding where applicable; c) failure of vessel thrusters where applicable; d) DP failure where applicable; e) anchor line failure; f) failure of FPSO turret drive system where applicable.

20.3.2 Design Methodology

The documentation submitted for verification of the design methodology shall include documentation, including any calculations performed, methodologies and software tools used, for the following, as a minimum:

a) documentation listed in 4.3.5.1;

b) dimensions of all components, including, as a minimum:

   1) tubular section;

   2) threads, where applicable;

   3) external coatings;

   4) fasteners.

c) strength analysis of connector;

d) fastening force for securing connector into position (in accordance with 20.3.4);

e) external coatings:

   1) surface coating specification;

   2) coating log and result of adhesion test from manufacturer's coating supplier;

   3) qualification status of coating system applied;

f) service life performance, subject to the requirements of 20.3.5.

20.3.3 Design Criteria

See API 6A for permissible utilizations for flanged connector materials.

See API 17J for permissible utilizations for nonwelded tubular connectors.

20.3.4 Connector Design

Design of flanged connectors shall be in accordance with API 17D. Design of nonwelded tubular connectors shall be in accordance with ISO 19902.

Swivel flanges shall be designed to provide rotational freedom during installation operations.

The dimensions of the connector shall be compatible with the dimensions, including tolerances, of the end fitting and adjacent structures, such as I-tubes and adjacent piping.

Where applicable, fastening forces for securing the connector in position shall be calculated and specified in the design report and installation procedures. For standard (nonswivel) connector flanges, appropriate bolting torques shall be in accordance with API 6A.

The force shall be calculated to ensure for the specified service life the following:

a) connector is held in position;

b) connector is pressure-tight;

c) no damage is caused to the connector components;

d) pre-tension in fasteners gives a fatigue life (in accordance with 4.3.6.5).

The materials from which connectors are to be manufactured shall be compatible with those within the flexible pipe and any interfacing topside piping or seabed pipeline. The purchaser shall agree with the system designer as to who is to have responsibility to ensure compatibility of the connector material with the adjacent piping and structures. This responsibility shall be stated in the design premise. The responsibility may be passed on to the manufacturer (see 20.2.4).

NOTE The requirement in the first sentence in 20.3.4 has been transferred directly from API 17B.

Any exposed valves, either open or closed, shall be capable of sustaining such pressures if strength- or leak-testing of a flexible pipe is to be carried out through a connector.

NOTE The above requirement has been transferred directly from API 17B.

20.3.5 Service Life—Dynamic Applications

The design of connector seals shall ensure the seal remains pressure-tight at the specified internal pressure for the specified service life, accounting for the effects listed in 4.3.9.

Further to 4.3.10, fatigue analysis of the connector components shall account for any of the following cyclic loads transferred by the flexible pipe that cause the documented and verifiable endurance limit of the material (that has been approved by the purchaser) to be exceeded:

a) effective tension;

b) bending moment;

c) shear force;

d) internal pressure;

e) VIV of the flexible pipe, where applicable.

20.4 Material Requirements

Qualification tests for metallic materials for flange connectors, and the type and frequency of quality control tests for raw metallic materials, shall be in accordance with an appropriate international standard such as API 17D and API 6A. Materials intended for inner part of connectors intended for sour service utilization shall be in accordance with ISO 15156/NACE MR 0175.

20.5 Manufacturing Requirements

Manufacturing requirements (including documentation, process control, FAT and marking requirements) for flange-type connectors shall be in accordance with an appropriate international standard such as API 6A.

20.6 Documentation

20.6.1 Design Premise

The responsibilities for ensuring compatibility of materials in the connector to those of the adjacent piping and structures shall be clearly defined prior to design, in the design premise.

If release functions are required in connector design, their abandonment philosophy shall be clearly identified and detailed in the design premise prior to manufacturing commencement. See API 17L2 for a description of typical disconnection systems.

NOTE The above requirement has been based on a recommendation in API 17B.

20.6.2 Design Report

20.6.2.1 Connector Description

The connector description in the design report shall include, as a minimum, the following:

a) minimum parameters specified in 4.6.3;

b) internal and external diameters;

c) description of sealing system;

d) design pressure;

e) design temperature;

f) design pull-in load, where applicable.

20.6.2.2 Connector Design Report Content

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used, including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) overview of CP system design methodology, where applicable;

f) manufacturing and design tolerances;

g) calculations demonstrating that design satisfies functional requirements accounting for variations within manufacturing tolerance envelopes;

h) description of welds used;

i) service life analysis, subject to the requirements of 4.3.8 to 4.3.10;

j) calculation of the dimensions of all components, including, as a minimum:

   1) tubular section;

   2) threads where applicable;

   3) external coatings;

   4) fasteners;

k) strength analysis of connector;

l) calculation of fastening force for securing connector into position (in accordance with 20.3.4);

m) service life analysis, subject to the requirements of 20.3.5.

The design report shall include or make reference to any calculations performed, or software tools used, for these items.

20.6.3 Installation Procedures

Further to 4.6.5, the manufacturer’s procedures for installation shall include the procedures for assembling the connector and attaching it to the end fitting.

20.7 Factory Acceptance Tests

See API 17A for recommendations on FAT of connectors.

20.8 Marking and Packaging

20.8.1 Marking

See 4.7.4 of API 17L2:2013 for general marking recommendations.

The connector marking shall make it permanently identifiable for the specified service life.

The marking on the connector shall include the following, as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) rated working pressure;

f) size;

g) identification of flexible pipe to which connector is attached.

20.8.2 Packaging

The manufacturer shall supply all necessary components in order to ensure proper installation of the connector between the flexible pipe end fitting and support structure. Such components typically include fasteners, gaskets, and sealing rings.

Connectors shall be packaged with provision of suitable protection for protective coatings, such that coatings are not scratched or chipped. All packages shall be accompanied by a packing list.

21 Load-transferring Devices

21.1 Applicability

The requirements in Section 4 shall apply.

The following sections apply to structures that are used to transfer loads from the flexible pipe to the topsides structures without pressure- or fluid-containing capacity. These structures including collars, load-transfer flanges and clamps, and may interface with the flexible pipe end fitting, I-tube base flanges or bend stiffener interface structures.

21.2 Functional Requirements

21.2.1 General

Purchasing guidelines for load-transfer devices are given in Annex P.

The minimum overall functional requirements of the load-transfer device that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to transfer loads from the flexible pipe end-fitting or bend stiffener interface structure to the topside structures;

c) to successfully lock into position, where applicable.

21.2.2 Flexible Pipe Design Parameters

For the flexible pipe to which the load-transfer device is attached, the purchaser shall specify the following parameters, as a minimum:

a) internal diameter;

b) service type;

c) service life;

d) detailed drawing of end fitting including materials and dimensional tolerances, if the load-transfer device is to interface with the end fitting.

21.2.3 Load-transfer Device Design Parameters

The purchaser shall specify any requirements for self-locking of the load-transfer device.

The purchaser shall specify any requirements for unlocking of the load-transfer device for pull-out operations.

Where applicable, the purchaser should specify any requirements relating to internal radii within the load-transfer device structure in order to respect the MBR criteria of the flexible pipe.

21.2.4 Support Structure Design Parameters

The purchaser shall specify the following parameters:

a) support structures that interface with load-transfer device;

b) detailed drawing of bend stiffener interface structure, if the load-transfer device is to interface with the bend stiffener.

21.2.5 Adjacent Structures

The purchaser shall specify the material grade of all adjacent structures. The purchaser shall specify whether or not it is required that the manufacturer has responsibility for ensuring compatibility of materials in the load-transfer device with those of the adjacent structures.

21.2.6 I-tube Parameters

Where the load-transfer device interfaces with an I-tube, e.g. where the load-transfer device assembly requires a female component to be attached at the base of the I-tube, the purchaser shall specify, where applicable, the following:

a) detailed drawing of I-tube, including base flange;

b) external and internal diameters, including tolerances of the I-tube if connection is made to a new-build I-tube;

c) as-built external and internal diameters of I-tube, if available (otherwise, design external and internal diameter including tolerance), if connection is made to an existing I-tube;

d) the angle of the I-tube centerline axis with the vertical axis shall be specified, if these are not co-linear.

The purchaser should arrange a dimensional survey of existing turrets in order to determine accurate dimensions, where these are not already available.

21.2.7 Corrosion Protection

The purchaser shall specify details of the CP systems for the structures that are adjacent to the load-transfer device.

The corrosion-protection requirements for the load-transfer device structure and fasteners should be specified in accordance with 4.2.6.

21.2.8 Installation Requirements

The purchaser shall specify the following, where applicable:

a) requirement for a diverless or diver-assisted make-up of the load-transfer device;

b) the available space for installation of the load-transfer device;

c) requirements for disconnection and reconnection of the load-transfer device;

d) maximum misalignment angle with respect to the vertical axis to be accommodated during pull-in;

e) the topside pulling capacity, including its sensitivity in terms of pulling force, that is available in the field for pulling in the load-transfer device;

f) requirements for self-aligning of the load-transfer device during pull-in.

It should be considered whether any guidance systems such as guide funnels are incorporated into the topside receptacle for the load-transfer device.

21.2.9 Design Loads

Where the load-transfer device interfaces with an I-tube, the purchaser shall specify the maximum allowable tension and bending moment at the I-tube base flange.

The purchaser shall specify the maximum static and dynamic effective tensions, bending moments and shear forces at the topside connection, under all applicable design load combinations and conditions for the flexible pipe. The purchaser shall specify fatigue loads consisting of minimum, mean and maximum effective tensions, bending moment and shear forces, and corresponding numbers of cycles for each load range.

21.2.10 Spares

The purchaser should specify required percentage quantity of spare fasteners for the load-transfer device.

21.3 Design Requirements

21.3.1 Loads

Local load classes and subclasses for load-transfer devices are listed as in Table 53.

Table 53—Local Load Classes and Subclasses for Load-Transfer Devices

Load Classes and Subclasses
Functional Loads
Topside piping interface loads. Pre-tensions in the fasteners securing the load-transfer device in position. Loads due to normal handling operations, such as impact and abrasion. Loads generated by locking of load-transfer device. Loads due to pull-in of flexible pipe where applicable. Loads due to removal and disconnection.
Environmental Loads
Environmental loads transferred from the flexible pipe including effective tension, bending moment and shear forces.
Accidental Loads
Flexible pipe accidental loads that affect the flexible pipe configuration and/or load-transfer device, where specified by purchaser, as follows: a) internal over-pressure; b) vessel compartment damage or unintended flooding, where applicable; c) failure of vessel thrusters, where applicable; d) DP failure, where applicable; e) anchor line failure; f) failure of FPSO turret drive system, where applicable.

21.3.2 Design Methodology

The documentation submitted for verification of the design methodology shall include documentation, including any calculations performed, methodologies and software tools used, for the following, as a minimum:

a) documentation listed in 4.3.5.1;

b) dimensions of all components including, where applicable, the following:

   1) flanges;

   2) collars;

   3) clamps;

   4) fasteners;

   5) locking pins where applicable;

   6) external coatings.

c) strength analysis of load-transfer device;

d) fastening force for securing load-transfer device into position (in accordance with 21.3.4);

e) design methodology for hydraulic systems, where applicable (in accordance with 21.3.4);

f) external coatings:

   1) surface-coating specification;

   2) coating log and result of adhesion test from manufacturer's coating supplier;

   3) qualification status of coating system applied.

g) service life performance, subject to the requirements of 21.3.6.

21.3.3 Design Criteria

The applied bearing stress exerted by the load-transfer device on the flexible pipe end fitting shall not exceed the permissible utilization as specified in Table 7 of API 17J:2008.

21.3.4 Load-transfer Device Design

Fastening forces shall be calculated in order to secure components of the load-transfer device together, and specified in the design report and installation procedures.

The forces shall be calculated to ensure for the specified service life the following:

a) provision of sufficient residual load in order to secure the components together;

b) no damage caused to the load-transfer device components or adjacent structures (see 21.3.3);

c) pre-tension in fasteners gives a fatigue life (in accordance with 4.3.6.5)

The design of the load-transfer device shall ensure compatibility with all dimensions, including tolerances, of interfacing components which may include the following:

a) flexible pipe end-fitting, with access/piping to vent ports where applicable;

b) flanges;

c) I-tubes;

d) bend stiffener interface structure.

Where applicable, the load-transfer device shall be designed to ensure that there is sufficient hydraulic power available to perform disconnection/connection activities required by the purchaser.

The dimensions of the load-transfer device shall be compatible with the dimensions, including tolerances, of the end fitting and adjacent structures such as I-tubes, where applicable.

The purchaser shall agree with the system designer as to who is to have responsibility to ensure compatibility of the load-transfer device material with the adjacent structures. This responsibility shall be stated in the design premise. The responsibility may be passed on to the manufacturer (see 21.2.5).

The design of self-locking load-transfer devices shall account for the following:

a) the topside pulling capacity that is available in the specified application;

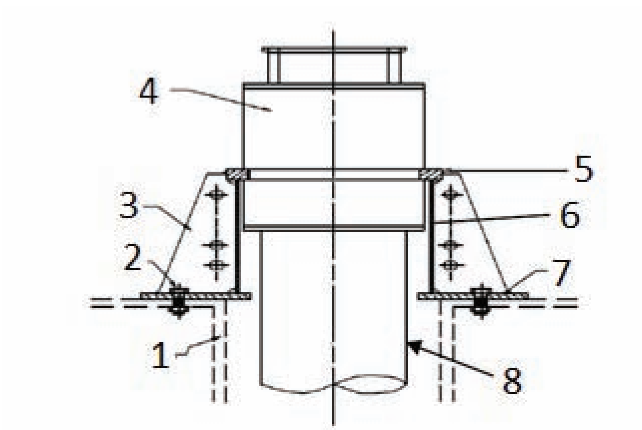
b) ensuring that the load-transfer device is safely locked in position after pull-in;

c) ensuring that vibrations (due to VIV or otherwise) post-locking that may adversely affect the fatigue life of the flexible pipe, load-transfer device or adjacent structures are mitigated;

d) allowing unlocking for pull-out operations, where required by the purchaser.

In cases where the bend stiffener cannot accommodate a vertical top connection and the I-tube needs to be modified to a J-tube, the curvature of the flexible pipe at the exit of the load-transfer device inside the J-tube shall be determined, and the requirement for centralizers in the curved section of the J-tube in order to respect the API 17J MBR requirements assessed. All curvatures in this area shall be in accordance with API 17J.

The buckling of clamp rings as shown in Figure 6 shall be checked in the design, and shall be in accordance with allowable levels specified in AISC (*Steel Construction Manual*) or another appropriate international standard.



Key

1 deck turret	5 collar
2 bolts	6 ring
3 clamp	7 flange
4 end fitting	8 flexible pipe

Figure 6—Example of Hang-off Arrangement

21.3.5 Installation Design

The design of the load-transfer device shall allow a connection to be made between topsides piping and all the production, vent bore and other fluid- or gas-containing interfaces on the flexible pipe end-fitting, where required.

Where applicable, the manufacturer shall calculate the required pull-in load for the load-transfer device, accounting for the following:

a) weight of load-transfer device;

b) effective tension in flexible pipe inclusive of any dynamic effects;

c) maximum misalignment angle.

21.3.6 Service Life—Dynamic Applications

Further to 4.3.10, fatigue analysis of the load-transfer device components shall account for any of the following cyclic loads that cause the documented and verifiable endurance limit of the material (that has been approved by the purchaser) to be exceeded:

a) flexible pipe effective tensions;

b) reaction forces from flexible pipe including bending moments and shear forces;

c) VIV of the flexible pipe, where applicable.

21.3.7 Corrosion Protection

Further to 4.3.11, the load-transfer device shall be protected by a CP system, if adequate provision has not been made for the extra capacity in the CP system calculations of adjacent structures.

Also further to 4.3.11, there shall be a check in the CP system design to determine if there any local spots in the vicinity of the load-transfer device that are unprotected by the CP systems of adjacent structures, if the load-transfer device is reliant on an adjacent CP system.

21.4 Material Requirements

The load-transfer device materials shall be documented to be compatible with those of the adjacent structures.

21.5 Manufacturing Requirements

Any discontinuities in the internal surface geometry or any sharp corners of the load-transfer device that are to come into contact with the flexible pipe or pull-in cables shall be ground smooth in order to avoid adverse wear of the flexible pipe outer sheath or rupture of pull-in cables, respectively.

21.6 Documentation

21.6.1 Design Premise

The responsibilities for the load-transfer device design with respect to the manufacturer and the manufacturer of the adjacent structures, and the responsibilities for ensuring compatibility of materials in the load-transfer device to those of the adjacent piping and structures, shall be clearly defined prior to design, in the design premise.

21.6.2 Design Report

21.6.2.1 Load Transfer Description

The load transfer description in the design report shall include as a minimum the following:

a) minimum parameters specified in 4.6.3;

b) internal and external diameters where applicable;

c) length;

d) description of load-transfer device components and their respective functions;

e) description of locking system, where applicable;

f) fastener preloads;

g) design temperature;

h) design pull-in load, where applicable;

i) description of hydraulic systems, where applicable.

21.6.2.2 Load Transfer Design Report Content

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) overview of CP system design methodology where applicable;

f) manufacturing and design tolerances;

g) calculations demonstrating that design satisfies functional requirements accounting for variations within manufacturing tolerance envelopes:

h) description of welds used;

i) service life analysis, subject to the requirements of 4.3.8 to 4.3.10;

j) calculation of the dimensions of all components, including, where applicable, the following:

    1) flanges;

    2) collars;

    3) clamps;

    4) fasteners;

    5) locking pins, where applicable;

    6) external coatings.

k) strength analysis of load-transfer device;

l) calculation of fastening forces for securing load-transfer device into position (in accordance with 21.3.4);

m) design of hydraulic systems where applicable (in accordance with 21.3.4);

n) service life analysis, subject to the requirements of 21.3.6.

The design report shall include or make reference to any calculations performed for or software tools used for these items.

21.6.3 Installation Procedures

Further to 4.6.5, the manufacturer's procedures for installation shall include the assembly sequence for the load-transfer device components.

The manufacturer's procedures for installation of pull-in load-transfer devices shall include the following:

a) procedures listed in 4.6.5;

b) assembly of the male part of the load-transfer device onto the flexible pipe/pull-in head arrangement;

c) application of lubricant;

d) procedure for alignment of load-transfer device with the guide funnel and pulling the assembly up through the I-tube;

e) centralizing the assembly in the I-tube;

f) activation of the locking system to ensure lock-in into the female part of the load-transfer device.

21.7 Factory Acceptance Tests

21.7.1 General

The manufacturer shall perform the FAT tests specified in Table 54 on the load-transfer device.

21.7.2 Dimensional Measurement

Dimensional measurement of the load-transfer device components shall verify that the dimensions of these components are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances. The dimensional measurement of the load-transfer device shall include verification that the requirements of 21.3.4 have been satisfied.

21.7.3 Fit-up and Assembly

21.7.3.1 Procedure

The load-transfer device shall be assembled around the interfacing structures or dimensionally and geometrically representative mock-ups of these structures. The assembly shall include all components that make up the load-transfer device. The components shall be fastened together using fasteners of the same specification and the same fastening forces as determined at the design stage for service (see 21.3.4).

21.7.3.2 Acceptance Criteria

After the assembly the load-transfer device components shall be dimensionally compatible with the adjacent structures.

21.7.4 Hydraulic Systems Operation

Where the load-transfer device features hydraulic systems, the manufacturer shall demonstrate through testing that the hydraulic systems are operating correctly.

21.7.5 Pull-in Test

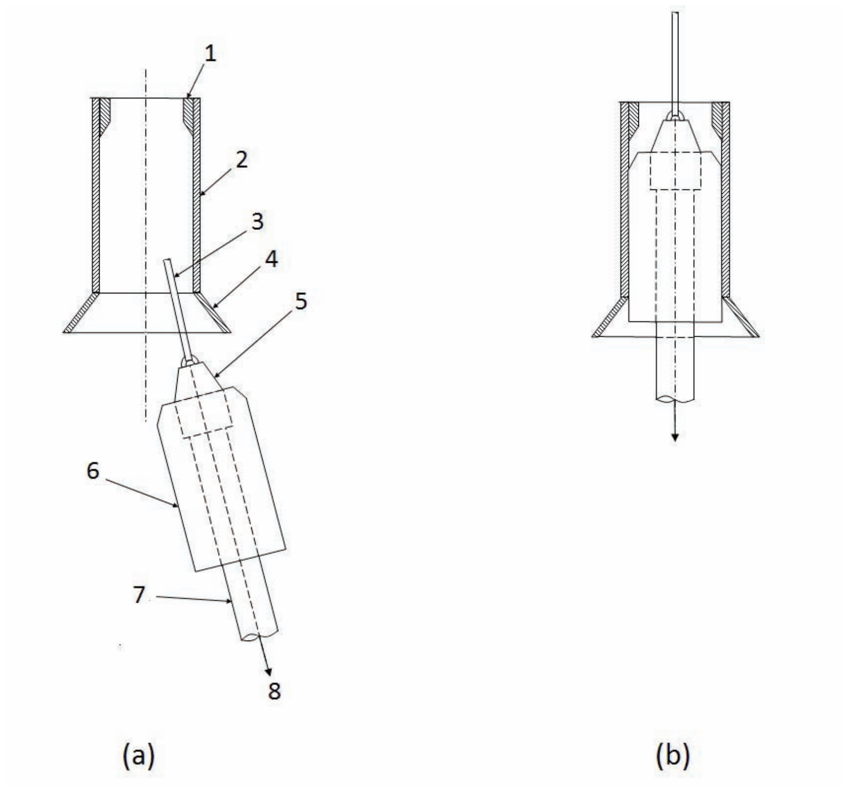
21.7.5.1 Procedure

The male part of the load-transfer device, along with the pull-head, shall be assembled around a dimensionally representative mock-up of a length of the flexible pipe as shown in Figure 7 a). The female part of the load-transfer device shall be attached and assembled within a dimensionally and geometrically representative mock-up of the I-tube and guide funnel. The assemblies shall include all components that make up the load-transfer device. The components shall be fastened together using fasteners of the same specification and the same fastening forces as determined at the design stage for service (see 21.3.4.1). The weight of the flexible pipe shall be simulated by applying a load to the end of the mock-up of a length of the flexible pipe. The male load-transfer device assembly shall be pulled in at the largest angle that has been determined to occur during installation. The pull-in force required to successful lock the male part of the load-transfer device in position shall be recorded.

21.7.5.2 Acceptance Criteria

The pull-in test shall demonstrate the ability to successfully lock the load-transfer device in position in an offshore environment within the pull-in capacity that is available in the field.

After the assembly, the load-transfer device components shall be dimensionally compatible with the adjacent structures.



Key

1 female part of load-transfer device
2 mock-up of I-tube
3 pull-in wire
4 guide funnel
5 pull-head
6 male part of load-transfer device
7 mock-up of flexible pipe
8 load simulating flexible pipe weight

Figure 7—Load-transfer Device Pull-in Test

21.7.6 NDE of Welds

NDE of welds shall be performed in accordance with an appropriate international standard such as those listed in Table 10.

Table 54—Factory Acceptance Tests for Load-transfer Devices

Test	Section
Dimensional	See 21.7.2
Visual	See 4.7.2
Fit-up and assembly	See 21.7.3
Hydraulic systems operation	See 21.7.4
Pull-in test	See 21.7.5
NDE of welds	See 21.7.6

21.8 Marking and Packaging

21.8.1 Marking

See 4.7.4 of API 17L2:2013 for general marking recommendations.

The load-transfer device marking shall make it permanently identifiable for the specified service life.

The marking shall include the following, as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) identification of flexible pipe to which load-transfer device is associated;

f) mass in air;

g) identification such that segments may be re-assembled to their positioning before the segments were cut out during manufacture, where applicable.

21.8.2 Packaging

Load-transfer devices shall be packaged with provision of suitable protection for protective coatings, such that coatings are not scratched or chipped. All packages shall be accompanied by a packing list.

22 Mechanical Protection

22.1 Applicability

This section applies to two types of mechanical protection: abrasion and impact protection, and polymer blanket protection.

As well as specifying requirements for abrasion and impact protection, this section may also be used in cases where the abrasion and impact protection also provides continuous added weight or buoyancy to the flexible pipe. For requirements on discretely added buoyancy (i.e. buoyancy modules) or discretely added weight (i.e. ballast modules), see Section 8.

The requirements in this section shall also be applied to umbilicals.

NOTE The requirements relating to internal fluid and outer sheath temperature may not be relevant for umbilicals.

22.2 Functional Requirements—General

22.2.1 Flexible Pipe Design Parameters

For the flexible pipe to which the mechanical protection is attached, the purchaser shall specify the following parameters, as a minimum:

a) internal diameter;

b) service type;

c) service life;

d) external diameter;

e) tolerance on external diameter (this is only necessary for abrasion and impact protection);

f) flexible pipe impact load acceptance criteria, if required.

22.2.2 External Environment

The purchaser shall provide a description of the contact surfaces against which mechanical protection is required. This shall include a description of the seabed at the touchdown location or shall include a description of other offshore components and structures, such as pipelines and mooring lines, against which mechanical protection is required.

The purchaser shall specify the maximum water depth at which the mechanical protection is to be located.

22.2.3 Design Loads

The purchaser should specify impact resistance requirements for the mechanical protection in terms of impact energies and impact velocities for specified diameters of dropped object or otherwise.

22.3 Functional Requirements—Abrasion and Impact Protection

22.3.1 General

The minimum overall functional requirements of the abrasion and impact protection that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to protect a specified length of the flexible pipe from abrasive and impact loads for the specified service life;

c) to provide a specified amount of added weight or buoyancy to the flexible pipe, where required.

22.3.2 Abrasion and Impact Protection Design Parameters

22.3.2.1 Purchaser Specifications

For the abrasion and impact protection, the purchaser shall specify the following parameters as a minimum:

a) length of coverage required;

b) temperatures to which the abrasion and impact protection is exposed (in accordance with 4.2.4).

22.3.2.2 Purchaser Options

The purchaser may specify the following parameters:

a) protection thickness required;

b) requirements on density of abrasion and impact protection material;

   The purchaser should specify whether continuous added weight, buoyancy or neutral buoyancy is required.

c) requirements for lightweight banding material, i.e. polymer banding;

d) requirement for marine growth resistance;

   It may be desirable from a global design viewpoint to minimize any added weight due to marine growth.

e) requirement for the length of individual lengths.

   The purchaser may have a preference for a particular length, based on handling and transportation constraints.

22.3.3 Corrosion Protection

The purchaser should specify the required grade of metallic banding material for the abrasion and impact protection, where metallic banding is used.

22.3.4 Thermal Insulation

The purchaser should specify any requirements for thermal insulation for the abrasion and impact protection. The requirement for thermal insulation for tubular components should be specified in terms of U-value and required cool-down time.

22.3.5 Fire Resistance

The purchaser should specify any fire resistance requirements for surface abrasion and impact protection, where the protected length of the flexible pipe may pass through topside areas that are at risk from fire events. Fire resistance may also be required by the purchaser during storage.

22.3.6 Design Loads

The purchaser shall specify the maximum flexible pipe curvature during operation.

22.3.7 Spares

The purchaser should specify the required number of spare lengths of abrasion and impact protection and required quantity of spare banding.

22.4 Functional Requirements—Blanket Protection

22.4.1 General

The minimum overall functional requirements of the blanket protection that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to protect a specified length of the flexible pipe from abrasive and impact loads and/or from pipeline crossing, for the specified service life.

22.4.2 Blanket Protection Design Parameters

For the blanket protection, the purchaser shall specify the following parameters, as a minimum:

a) surface area of coverage required;

b) protection thickness required (see 22.6.1);

c) requirements on density or mass of blanket protection material.

22.4.3 Crossing Lines

The purchaser shall specify details of any lines crossing the blanket protection as follows, and where applicable:

a) number of crossing lines;

b) functionality of line;

c) external diameter;

d) outer surface temperature or U-value in accordance with 4.2.4.3.

22.4.4 Installation

The purchaser should specify any requirements for compatibility with ROV (or other) lifting equipment and the maximum payload.

22.4.5 Design Loads

The purchaser shall specify the maximum mass per unit length of any crossing lines.

22.5 Design Requirements—General

22.5.1 Loads

Local load classes and subclasses for mechanical protection are listed in Table 55. The table distinguishes between loads acting on abrasion and impact protection and those acting on blanket protection.

22.5.2 Design Methodology

The documentation submitted for verification of the design methodology shall include documentation, including any calculations performed, methodologies and software tools used, for the following, as a minimum:

a) documentation listed in 4.3.5.1;

b) demonstration that the selected thickness of mechanical protection can satisfy the abrasion and impact requirements (in accordance with 22.6.1);

c) band tension for securing abrasion and impact protection to the flexible pipe (in accordance with 22.6.2);

d) service life performance, subject to the requirements of 4.3.9.

22.5.3 Design Criteria

The abrasion and impact protection shall provide protection against impact such that the flexible pipe manufacturer's flexible pipe impact load criteria are satisfied.

22.6 Design Requirements—General

22.6.1 Mechanical Protection Design

The mechanical protection shall be designed such that it provides protection to the flexible pipe from abrasive loads in the specified application. In addition, the mechanical protection shall be designed to withstand impact energies, if required, from specified dropped-object diameters as specified in NORSOK U-001 or as specified by the purchaser.

The parameters that shall be accounted for in the design shall include the following:

a) thickness of mechanical protection;

b) impact energy of object;

c) velocity of impacting object;

d) size and weight of impacting object;

e) type of seabed i.e. soil, sand, clay (where the protected flexible pipe rests on the seabed);

f) temperature range to which the material is exposed in service;

g) surfaces against which abrasion protection is required.

Table 55—Local Load Classes and Subclasses for Mechanical Protection

Load Classes and Subclasses	Applicability	
Functional Loads	**Abrasion and Impact Protection**	**Blanket Protection**
Loads dues to expansion and contraction of the flexible pipe due to tension, internal pressure and temperature effects during service, installation and during leak tests or structural integrity tests, see 11.5.3 of API 17B:2008	X	
Loads due to bending of the flexible pipe	X	
Weight of crossing lines		X
Loads applied by banding	X	
Temperature-induced loads		
Thermal expansion and contraction loads due to temperature of flexible pipe outer sheath	X	
Thermal shock loads	X	X
Loads due to normal handling operations, such as impact and abrasion, for example	X	X
Impact and abrasion against seabed including sharp objects such as coral or rock formations, against other subsea lines such as mooring lines and other flexible pipes, for example	X	
Impact loads from dropped objects	X	X
Abrasion against crossing lines	X	X
Environmental Loads		
Loads due to cyclic bending of the flexible pipe.	X	
Accidental Loads		
Flexible pipe accidental loads that affect the flexible pipe configuration and/or mechanical protection , where specified by purchaser, as follows: a) internal over-pressure; b) vessel compartment damage or unintended flooding, where applicable; c) failure of vessel thrusters, where applicable; d) DP failure, where applicable; e) anchor line failure; f) failure of FPSO turret drive system, where applicable.	X	

22.6.2 Abrasion and Impact Protection Design

A banding tension shall be calculated and specified in the design report and installation procedures. The specified banding tension shall be designed to ensure that the abrasion and impact protection is held securely in the required position for the specified service life. The banding tension shall not cause stresses and strains in the banding material or the abrasion and impact protection material to exceed allowable limits.

The abrasion and impact protection shall be dimensionally compatible with the flexible pipe and with the dimensions of the banding that is to be employed, where applicable.

The effect of the abrasion and impact protection on the global design of the flexible pipe shall be checked by three-dimensional global analysis of the flexible pipe system. The added weight or buoyancy of the abrasion and impact protection shall not cause any of the design criteria of the flexible pipe to be violated.

22.6.3 Blanket Protection Design

The blanket protection shall be designed to have stability to remain in a protective position on the flexible pipe for the specified service life.

There shall be suitable provision in the blanket protection design for lifting devices required to install and handle it.

22.7 Material Requirements

22.7.1 General

The requirements of this section shall apply to polymer materials for mechanical protection, and to polymer and metallic banding materials.

22.7.2 Qualification Requirements—Mechanical Protection Polymer Materials

The manufacturer shall test and document the material properties of mechanical protection polymer materials, as specified in Table 56. Where indicated, the material properties in Table 56 shall be measured at the minimum and maximum temperatures of the material in service, in addition to measurement at room temperature. Where indicated, the material properties shall also be measured for aged samples of material. See 4.4.4 for minimum ageing test requirements.

The abrasion and impact protection material strain at break should be selected in order to accommodate the maximum predicted flexible pipe curvature during installation or operation, such that it does not experience stresses or strains exceeding allowable limits.

22.7.3 Qualification Requirements—Banding Materials

See 4.4.3 for minimum qualification requirements for metallic banding materials. The manufacturer shall document the impact resistance and tensile strength of metallic and polymer banding materials.

22.8 Manufacturing Requirements—Process Control

The manufacturer shall have a documented methodology for the manufacturing processes listed in 4.5.3 for mechanical protection polymer components.

The manufacturer shall, as a minimum, have a documented methodology for the manufacturing processes listed in 4.5.3.2 for metallic banding.

For each mix of polymer material, a sample of material shall be retained and tested to verify that it is consistent with the properties measured in the qualification tests.

The following properties shall be tested, as a minimum:

a) tensile strength: ISO 527, ASTM D638 or ISO 37;

b) hardness: ISO 868 or ASTM D2240.

Table 56—Qualification Requirements for Mechanical Protection Materials

Tests	Test Procedure [a]	Section	Min. Temperature	Max. Temperature	Aged Sample
Abrasion resistance	ISO 7784-2 [b], ASTM D4060 [b], BS 903-A9 or DIN 53516	See 4.4.2	X	X	X
Density [c]	ISO 1183, ASTM D792				
Hardness	ISO 868 [d], or ASTM D2240				
Impact resistance	ISO 179, ISO 180 [d], ASTM D256	See 4.4.2	X		
Specific heat capacity [e]	ASTM E1269			X	
Tear strength	ISO 34-1, or ASTM D624			X	
Tensile strength, modulus, strain at break	ISO 527-1 [d], ISO 527-2 [d], ASTM D638 [d], ISO 37	See 22.7.2		X	X
Thermal conductivity [e]	ISO 8301, ISO 8302, ASTM C177, ASTM C518			X	
Water absorption	ISO 62 [d], ASTM D570 [d]	See 8.5.2			

[a] As stated in Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.
[b] Standards similar in content but not technically equivalent.
[c] May be more applicable to high density or buoyant grades of abrasion and impact protection.
[d] Standards are technically equivalent or identical for the test in question
[e] Thermal grades of abrasion and impact protection only.

22.9 Documentation

22.9.1 Design Report

22.9.1.1 Abrasion and Impact Protection Description

The abrasion and impact protection description in the design report shall include as a minimum the following:

a) minimum parameters specified in 4.6.3;

b) internal and external diameter;

c) individual lengths;

d) number of lengths supplied;

e) overall mass per unit length in air and water;

f) design temperature;

g) description of surfaces to which abrasion and impact protection gives abrasion resistance;

h) design impact energy and associated dropped-object diameter or other impact resistance measure;

i) description of banding;

j) thickness and width of banding.

22.9.1.2 Blanket Protection Description

The blanket protection description in the design report shall include as a minimum the following:

a) minimum parameters specified in 4.6.3;

b) length and width;

c) thickness;

d) design temperature;

e) description of surfaces to which blanket protection gives abrasion resistance;

f) design impact energy and associated dropped-object diameter or other impact resistance measure.

22.9.1.3 Abrasion and Impact Protection Design Report Content

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) manufacturing and design tolerances;

f) calculations demonstrating that design satisfies functional requirements, accounting for variations within manufacturing tolerance envelopes;

g) service life analysis, subject to the requirements of 4.3.8 to 4.3.10;

h) demonstration that the selected thickness of mechanical protection can satisfy the abrasion and impact requirements (in accordance with 22.6.1);

i) calculation of band tension for securing abrasion and impact protection to the flexible pipe (in accordance with 22.6.2);

j) service life analysis, subject to the requirements of 4.3.9.

The design report shall include or make reference to any calculations performed for or software tools used for these items.

22.9.2 Installation Procedures

The manufacturer's procedures for installation shall include the following:

a) procedures listed in 4.6.5;

b) instructions for use of banding tensioning equipment;

c) procedure for securing abrasion and impact protection to flexible pipe, including the fastening forces to apply to banding;

d) spacing between banding, where banding recesses are not provided.

22.10 Factory Acceptance Tests

22.10.1 General

The manufacturer shall perform the FAT tests specified in Table 57 on the mechanical protection.

22.10.2 Dimensional Measurement

Dimensional measurement of the mechanical protection shall verify that the dimensions are in accordance with the dimensions specified in the engineering drawings, allowing for dimensional tolerances.

The dimensions that shall be measured for abrasion and impact protection shall include the following, as a minimum:

a) internal diameter;

b) external diameter;

c) length.

The dimensions that shall be measured for blanket protection shall include the following, as a minimum:

a) length;

b) width;

c) thickness.

Dimensional measurement of abrasion and impact protection shall verify that the requirements of 22.6.2 have been satisfied.

22.10.3 Visual Inspection

Visual inspection of mechanical protection shall as a minimum include inspection for any sharp points that could damage the flexible pipe outer sheath.

Table 57—Factory Acceptance Tests for Mechanical Protection

Tests	Test Procedure	Frequency		Section
		Abrasion and Impact Protection	Blanket Protection	
Dimensional		5 % [a] of lengths but minimum of 2	5 % of blankets but minimum of 2	See 22.10.2
Visual		100 % of lengths	100 % of blankets	See 4.7.3 and 22.10.3
Hardness	ASTM D2240, ISO 868 [b]	5 % [a] of lengths but minimum of 1	5 % of blankets but minimum of 1	
Mass in air		100 % of lengths	100 % of lengths	

a Value is consistent with current industry practice.
b Standards are technically equivalent or identical for the test in question.

22.11 Marking and Packaging

22.11.1 Marking

See 4.7.4 of API 17L2:2013 for general marking recommendations.

22.11.1.1 Mechanical Protection Marking

The mechanical protection marking shall make it permanently identifiable for the specified service life. The abrasion and impact protection marking shall make it permanently identifiable for the specified service life.

The marking shall include the following, as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) net buoyancy or net weight per length, where applicable;

f) mass in air;

g) identification of flexible pipe to which abrasion and impact protection is to be attached.

22.11.1.2 Blanket Protection Marking

The blanket protection marking shall make it permanently identifiable for the specified service life.

The marking shall include the following, as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser;

e) mass in air.

22.11.2 Packaging

The abrasion and impact protection shall be packaged with all banding necessary for its assembly around the flexible pipe.

Mechanical protection shall be packaged in suitably protective material. All packages shall be accompanied by a packing list.

23 Fire Protection

23.1 Applicability

The requirements of Section 4 shall apply.

This section applies to fire protection material that is bonded to the flexible pipe outer sheath and that which is used to protect the flexible pipe end fitting.

The requirements in this section shall also be applied to umbilicals.

NOTE The requirements relating to internal fluid and outer sheath temperature may not be relevant for umbilicals.

23.2 Functional Requirements

23.2.1 General

Purchasing guidelines for fire protection are given in Annex R.

The minimum overall functional requirements of the fire protection that shall be demonstrated by the manufacturer are as follows:

a) functional requirements given in 4.2.2;

b) to protect the flexible pipe system from a specified type of fire for a specified period of time, such that it can satisfy its pressure-containing functional requirement;

c) where fire protection is bonded to the flexible pipe, to remain securely bonded for the specified service life.

23.2.2 Flexible Pipe Design Parameters

For the flexible pipe to which the fire protection is applied, the purchaser shall specify the following parameters, as a minimum:

a) internal diameter;

b) service type;

c) service life;

d) external diameter;

e) length of flexible pipe over which fire protection required;

f) if required by the manufacturer or other party for numerical fire- or heat-transfer simulations, flexible pipe layer thermal properties, including density, thermal conductivity, heat capacity. If available, these properties shall be specified for the range of temperatures experience by these layers during the fire;

g) outer sheath material.

23.2.3 Fire Protection Design Parameters

For each component in the flexible pipe system for which fire protection is required, the purchaser shall specify the following parameters:

a) type of fire from which protection is required;

b) level of protection specified in terms of heat flux (energy per unit area);

c) duration for which fire protection is required;

d) level of protection required;

e) the purchaser shall specify whether to have a fully intact structure or to have the pressure-containing function of the flexible pipe be maintained after the specified fire duration;

f) temperatures to which the fire protection is exposed in normal operation, excluding fire events (in accordance with 4.2.4).

The purchaser should consider, when specifying the above parameters, the items listed in 6.4.6.1 of API 17J:2008.

The purchaser should consider specifying a requirement for anti-fouling coatings.

23.2.4 Hang-off Structures

Where fire protection is required for hang-off structures, the purchaser shall submit detailed drawings of the hang-off structures and arrangement showing respective positions of end-fitting, flexible pipe, bend limiter and adjacent structures.

23.2.5 Internal Fluid Parameters

The internal fluid thermal properties, including density, thermal conductivity and heat capacity for the flexible pipe, shall be specified, if required by the manufacturer for thermal simulations or otherwise.

23.2.6 External Environment

Environmental functional requirements relating to sunlight exposure should be specified in accordance with 4.2.5.

23.2.7 Installation Requirements

The purchaser shall specify the reel diameter, if fire protection bonded to the flexible pipe is to be stored on a reel.

For fire protection bonded to the flexible pipe, the purchaser shall specify the crush pressure and tension to be applied by tensioners during installation of the flexible pipe, where applicable.

23.2.8 Design Loads

The purchaser shall specify the maximum stresses and strains in fire protection bonded to the flexible pipe over its length of coverage due to the curvature of the flexible pipe, under all load combinations and conditions.

The purchaser shall specify any blast loads that the fire protection is required to sustain, in terms of blast pressure and duration of pressure pulse or otherwise.

23.3 Design Requirements

23.3.1 Loads

Local load classes and subclasses for fire protection are listed in Table 58. The table distinguishes between loads acting on fire protection directly bonded to the flexible pipe/bend stiffener and fire protection bonded to fixed hang-off structures.

Table 58—Local Load Classes and Subclasses for Fire Protection

Load Classes and Subclasses	Applicability	
Functional Loads	**Fire Protection Bonded to Flexible Pipe/Bend Stiffener**	**Fire Protection Bonded to Fixed Hang-off Structures**
Loads due to expansion and contraction of the flexible pipe due to tension, internal pressure and temperature effects during service, installation and during leak tests or structural integrity tests, see 11.5.3 of API 17B:2008	X	
Loads due to bending of the flexible pipe	X	
Impact and abrasion loads during handling, transport, installation and service	X	X
Loads applied by fastening systems		X
Loads due to normal handling operations	X	X
Temperature-induced loads:		
a) thermal expansion and contraction loads due to temperature of flexible pipe outer sheath;	X	
b) thermal shock loads.	X	
Installation loads:	X	
a) loads due to bending of flexible pipe over reel;	X	
b) crush loads from tensioners during flexible pipe installation.	X	
Specified fire event	X	X
Explosion (blast loads)	X	X
Environmental Loads		
Loads due to cyclic bending of the flexible pipe	X	
Accidental Loads		
Flexible pipe accidental loads that affect the flexible pipe configuration and/or fire protection, where specified by purchaser, as follows: a) internal over-pressure; b) vessel compartment damage or unintended flooding, where applicable; c) failure of vessel thrusters, where applicable; d) DP failure where applicable; e) anchor line failure; f) failure of FPSO turret drive system, where applicable.	X	

23.3.2 Fire Protection Design Methodology

The documentation submitted for verification of the design methodology shall include documentation, including any calculations performed, methodologies and software tools used, for the following, as a minimum:

a) documentation listed in 4.3.5.1;

b) thickness of fire protection required (in accordance with 23.3.4), including results of fire simulation analysis;

c) integrity of attachment system (in accordance with 23.3.4);

d) service life performance, subject to the requirements of 23.3.6.

23.3.3 Design Criteria

Over the required duration of fire protection, the temperatures induced in the flexible pipe and end fitting layers that are critical to the pipe intactness or pressure-containing function, as required, shall not exceed associated temperature limits for these layers. The utilizations in these layers shall not exceed the allowable levels specified in Table 6 and Table 7 of API 17J:2008.

23.3.4 Fire Protection Design

See DNV OS-D301 for some general passive fire protection requirements. DNV OS-D301 addresses fire protection for a much broader range of offshore structures.

The thickness of the fire protection material applied shall be designed so that the protection requirements specified in 23.2.3 d) are satisfied. The methodology for calculating the required thickness shall account for thinning of the fire protection, due to bending to the operating bend radius of the flexible pipe along the fire protection length of coverage. The methodology of determining the required thickness shall be verified by performing full-scale prototype tests in accordance with API 17L2 or numerical fire- and/or blast-load simulations validated by full-scale tests.

The determination of the required thickness of fire protection shall account for the following:

a) type of fire;

b) duration of protection required;

c) flexible pipe cross-section configuration;

d) loads as given in Table 58.

The fire protection shall be designed to remain securely attached in the required position for the specified service life. The manufacturer shall demonstrate by testing that fire protection directly bonded to surfaces has sufficient bond integrity for the service life (in accordance with 23.4.1). The fire protection designer shall have documented calculations that demonstrate the integrity of attachment systems of fire protection held in position by other means, i.e. via clamps, fasteners or otherwise. The attachment system shall be designed to perform its function at the temperatures induced by the specified fire for the specified duration.

23.3.5 Service Life—Static Applications

See 4.3.9 for minimum service life requirements for fire protection material that is contact with fixed hang-off structures and is not subjected to cyclic loading.

Further to 4.3.9, for fire protection that is subjected to constant loads due to constant curvature in the flexible pipe, creep shall be considered in the design process.

23.3.6 Service Life—Dynamic Applications

Further to 4.3.10, fatigue analysis of the fire protection shall account for stress fluctuations induced by the flexible pipe. The fatigue analysis shall account for any of the following cyclic loads that cause the documented and verifiable endurance limit of the material (that has been approved by the purchaser) to be exceeded:

a) expansion and contraction of the flexible pipe;

b) bending of the flexible pipe;

c) effective tensions in the flexible pipe.

The fatigue performance of the fire protection may be demonstrated by full-scale fatigue testing of the fire protection, see API 17L2.

23.4 Material Requirements

23.4.1 Qualification Requirements—Fire Protection Materials

The manufacturer shall test and document the material properties of fire protection material directly bonded to the flexible pipe, as specified in Table 59. Where indicated the material properties in Table 60 shall be measured at the minimum and maximum temperatures of the material in service, in addition to measurement at room temperature. The maximum temperature refers to the temperature due to contact with the flexible pipe outer sheath. Where indicated, the material properties in Table 59 shall also be measured for aged samples of material. See 4.4.4 for minimum ageing test requirements. For fire protection materials that are not directly bonded to the flexible pipe, the purchaser should specify which material properties in Table 59, in addition to fire resistance, shall be documented by the manufacturer. The material properties that are important depend on the particular application and whether there are any significant load-bearing requirements for the material.

The manufacturer shall demonstrate, through testing, the integrity of the bond between the fire protection material and the specified flexible pipe outer sheath material.

Table 59—Qualification Requirements for Fire Protection Materials

Tests	Test Procedure [a]	Section	Min. Temperature	Max. Temperature	Aged Sample
Abrasion resistance	ISO 7784-2 [b], ASTM D4060 [b], BS 903-A9 or DIN 53516	See 4.4.2			
Bonding with flexible pipe outer sheath		See 23.4.1		X	X
Chemical resistance		See 23.4.1			
Compressive strength, modulus, strain at break	ISO 604 [c], ASTM D695 [c], ISO 7743			X	
Density	ISO 1183, ASTM D792				
Fatigue resistance		See 23.4.1	X [d]	X [d]	
Fire resistance		See 23.4.1			
Hardness	ISO 868 [c], or ASTM D2240				
Impact strength	ISO 179, ISO 180 [c], ASTM D256	See 4.4.2	X		
Ozone resistance	ISO 1431-1				
Shear strength, modulus, strain at break	ISO 1827, ASTM D732			X	
Tensile strength, modulus, strain at break	ISO 527 [c], ISO 37, ASTM D638 [c]			X	X

[a] As stated in Section 2, standards referenced in this table may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard.

[b] Standards similar in content but not technically equivalent.

[c] Standards are technically equivalent or identical for the test in question.

[d] The material shall undergo sufficient testing to qualify the materials fatigue resistance for the temperature range under consideration (not including the fire temperature).

The fire resistance of the fire protection material shall be in accordance with an appropriate international standard. See page 13 of DNV OS-D301 for a list of fire resistance codes and standards.

The manufacturer shall have documented records on the compatibility of the fire protection material with any chemicals, identified by the purchaser, that it will come into contact with over the service life.

Fire protection materials in dynamic applications shall have sufficient fatigue resistance to sustain the cyclic bending due to contact with the flexible pipe. Small-scale fatigue testing of the material shall simulate the mean stress/strain, stress/strain ranges and number of cycles that the material will be subjected to in service.

23.5 Manufacturing Requirements

23.5.1 Process Control

23.5.1.1 Manufacturing Processes

The manufacturer shall, as a minimum, have a documented methodology for the following manufacturing processes for application of fire protection:

a) minimum processes listed in 4.5.3.7;

b) mixing of constituent components;

c) preparation of flexible pipe outer sheath;

d) curing of applied fire protection.

The manufacturer's fabrication specification shall include procedures that ensure that, before application of the fire protection, the surface of the flexible pipe is free from contaminants such as grease or dirt.

23.5.1.2 Material Qualification Test

For each mix of polymer material, a sample of material shall be retained and tested to verify that it is consistent with the properties measured in the qualification tests.

The following properties shall be tested as a minimum:

a) tensile strength: ISO 527, ISO 37, or ASTM D638;

b) hardness: ISO 868 or ASTM D2240.

23.5.2 Manufacturing Tolerances

The manufacturer shall have available supporting documentation that demonstrates that the manufacturing tolerances on the thickness for fire protection are such that, with variations within these tolerances, there is a sufficient thickness of fire protection to satisfy the functional requirements.

23.6 Documentation

23.6.1 Design Report

23.6.1.1 Fire Protection Description

The fire protection description in the design report shall include, as a minimum, the following:

a) minimum parameters specified in 4.3.6.1;

b) thickness of protection;

c) description of any other layers in addition to dedicated fire protection layers, including mechanical protection and anti-fouling layers;

d) design fire events and associated duration of protection;

e) design blast events;

f) description of any attachment systems used to secure the fire protection in position.

23.6.1.2 Fire Protection Design Report Content

The design report shall include a description of and results obtained for any numerical fire simulations performed.

The design report shall include or make reference to documentation containing the items listed as follows:

a) description of theoretical basis;

b) overview of stress/strain analysis methodology (in accordance with 4.3.7);

c) documented basis for stress concentration factors used, including results of supporting FEA analysis;

d) documented basis for utilization factors, if these factors are not already specified in this specification;

e) documented basis for polymer and composite material endurance limits or fatigue safety factors, where applicable;

f) manufacturing and design tolerances;

g) calculations demonstrating that design satisfies functional requirements, accounting for variations within manufacturing tolerance envelopes;

h) service life analysis, subject to the requirements of 4.3.8 to 4.3.10;

i) determination of thickness of fire protection required, (in accordance with 23.3.4) including results of fire simulation analysis;

j) demonstration of integrity of attachment system (in accordance with 23.3.4);

k) service life analysis, subject to the requirements of 23.3.6.

The design report shall include or make reference to any calculations performed for or software tools used for these items.

23.6.2 Installation Procedures

Further to 4.6.5, the manufacturer's procedures for installation of fire protection for hang-off structures shall include procedures for assembly of the fire protection sections and assembly around the hang-off structures.

23.7 Factory Acceptance Tests

The manufacturer shall carry out the FAT tests for fire protection as given in Table 60. The frequency of tests is given for fire protection bonded to the flexible pipe and for other types of fire protection that are prefabricated (for the end fitting, for example).

Table 60—Factory Acceptance Tests for Fire Protection

Test	Frequency		Section
	Fire Protection Directly Bonded to Flexible Pipe	**Other Types of Prefabricated Fire Protection**	
Thickness	Every 10 m of flexible pipe for first 50 m, and subsequently at intervals verified by the manufacturer to be acceptable [a].	A number of thickness checks verified by the manufacturer to be acceptable.	
Hardness	1 per mix of material	1 per mix of material	
Visual	Entire length of flexible pipe	All	See 4.7.3

[a] The test frequency for thickness measurement of fire protection directly bonded to the flexible pipe has been selected in order to be consistent with the frequency specified for anti-wear and insulation layers in API 17J.

23.8 Marking

See 4.7.4 of AP I17L2:2013 for general marking recommendations.

The fire protection marking shall make it permanently identifiable for the specified service life.

The marking shall include the following, as a minimum:

a) API specification designation, Specification 17L1;

b) manufacturer's name or mark;

c) manufacturer's serial number;

d) markings specified by the purchaser.

The marking on fire protection for fixed hang-off structures shall additionally include, as a minimum, identification of flexible pipe/hang-off structure to which the fire protection is to be attached.

Annex A
(informative)

Purchasing Guidelines for Bend Stiffeners

Table A.1 gives purchasing guidelines for bend stiffeners. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each bend stiffener.

Table A.1—Purchasing Guidelines for Bend Stiffeners

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser’s technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				

FLEXIBLE PIPE DESIGN PARAMETERS

Flexible pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Flexible pipe data sheet reference:	
*Internal diameter (mm):	
*Service type:	
*Service life [a] (years):	
*External diameter (mm):	
*Tolerance on external diameter (mm):	
*Storage MBR (m):	
*Operating MBR (m):	
Axial stiffness (kN):	
Drawings of end fitting *at bend stiffener end* of flexible pipe attached? [b]	☐ Yes ☐ No

Umbilical MBR-Effective Tension Relationship

Curve of MBR versus effective tension attached?	☐ Yes ☐ No
If no, specify relationship below:	

Case No.	Effective Tension (kN)	MBR (m)

*Bending Stiffnesses

Design/Operating Condition	Bending Stiffness ($kN \cdot m^2$)	Ambient Temperature (°C)	Internal Fluid Temperature (°C)	Internal Pressure (MPa)

a Permanent bend stiffeners only.
b For end-fitting adjacent interface structures only.

BEND STIFFENER DESIGN PARAMETERS	
*Static or dynamic bend stiffener:	☐ Static ☐ Dynamic
*Temporary or permanent bend stiffener:	☐ Temporary ☐ Permanent
*Angle in mean position with respect to vertical axis (°):	
*Tolerance on angle in mean position (°):	
Constraints Relating to Physical Dimensions	
*Maximum length (m):	
*Maximum external diameter at base (mm):	
Purchaser Support Structure	
*Type of structure:	
*Structure material:	
Drawings attached? [a]	☐ Yes ☐ No
*CP system present?	☐ Yes ☐ No
*If yes, details of CP system attached?	☐ Yes ☐ No
*Corrosion protection coating:	
*Maximum allowable bending moment (kN·m):	
*Maximum allowable shear force (kN):	

[a] Only necessary if it is not feasible for manufacturer to determine bolt pitch circle diameter, bolt size and number of bolts for the purchaser support structure.

TEMPERATURE	
Internal Fluid Temperature	
*Internal fluid design minimum temperature (°C):	
*Internal fluid design maximum temperature (°C):	
U-value of flexible pipe (please indicate whether this is based on internal or external diameter and, if specified per unit length, please specify to which length it refers):	
OR	
Temperature of flexible pipe external sheath at internal fluid design minimum temperature (°C):	
Temperature of flexible pipe external sheath at internal fluid design maximum temperature (°C):	
Internal fluid temperature profile over service life attached?	☐ Yes ☐ No
Air Temperature	
*Minimum temperature during service [a] (°C):	
*Maximum temperature during service [a] (°C):	
*Minimum storage/transport/installation temperature (°C):	
*Maximum storage/transport/installation temperature (°C):	
Seawater Temperature [b]	
*Minimum temperature at bend stiffener location (°C):	
*Maximum temperature at bend stiffener location (°C):	
a For surface bend stiffeners only. b For subsea bend stiffeners or bend stiffeners that are pre-laid on the seabed.	

EXTERNAL ENVIRONMENT	
*Location of bend stiffener	☐ Topside connection ☐ Intermediate connection, please specify:________________________________ ☐ Seabed connection
*If topside bend stiffener, exposure to seawater?	☐ Yes ☐ No
*Abnormally high levels of sunlight exposure (during storage, transport, installation, operation)? *If so, specify details of geographical location and approximate length of exposure (days):	☐ Yes ☐ No
*Design water depth (m):	

CORROSION PROTECTION	
If support structure CP system present, required corrosion protection coating for interface structure:	
If support structure CP system not present, required interface structure corrosion resistant material:	
Required corrosion protection coating for interface structure fasteners:	
INTEGRITY AND CONDITION MONITORING	
Requirement for protective flared inner liners to be replaceable by divers?	☐ Yes ☐ No

DESIGN LOADS

*Tension Angle

Load Case No.	Load Case Description [a]	Effective Tension (kn)	Angle (°)

*Support Structure Reaction Loads

Maximum bending moment at base (kN·m):	
Maximum shear force at base (kN):	

*Fatigue Loads [b]

Fatigue load given in terms of local shear force and bending moment ranges or in terms of global flexible pipe system and environmental data?	☐ Local data ☐ Global data
Fatigue load in terms of effective tension-angle plots attached?	☐ Yes ☐ No

Load Case No.	Load Case Description	Resultant Shear Force Range (kN)	Resultant Bending Moment Range (kN·m)	No. of Cycles

Global data attached (see ISO API 17J for data to specify)?	☐ Yes ☐ No

[a] Include specification of load condition i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.

[b] Dynamic bend stiffeners only.

SPARES	
No. of spare fasteners required for securing interface structure to purchaser support structure (%):	
MARKING	
Marking requirements:	
PIGMENTATION	
Pigmentation requirements:	

Annex B
(informative)

Purchasing Guidelines for Bend Restrictors

Table B.1 gives purchasing guidelines for bend restrictors. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each bend restrictor.

Table B.1—Purchasing Guidelines for Bend Restrictors

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser's technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				

FLEXIBLE PIPE DESIGN PARAMETERS	
Flexible pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Flexible pipe data sheet reference:	
*Internal diameter (mm):	
*Service type:	
*Service life (years):	
*External diameter (mm):	
*Tolerance on external diameter (mm):	
*Storage MBR (m):	
*Operating MBR (m):	
*Mass per unit length (kg/m):	
*Outer sheath material	
*Drawings of end fitting *at bend restrictor end* of flexible pipe attached? [a]	☐ Yes ☐ No
*Minimum diameter due to ovalization (mm):	
*Maximum diameter due to ovalization (mm):	

*Bending Stiffness Range				
Bending Stiffness		**Ambient Temperature (°C)**	**Internal Fluid Temperature (°C)**	**Internal Pressure (MPa)**
Minimum bending stiffness (kN·m^2)				
Maximum bending stiffness (kN·m^2)				

[a] If bend restrictor interface structure is to fit around end fitting.

BEND RESTRICTOR DESIGN PARAMETERS	
*Static or dynamic bend restrictor:	☐ Static ☐ Dynamic
*Required locking radius (m):	
Mass requirements (kg/m^3):	
Length of Coverage	
*Angle (°): *OR*	
*Length at operating MBR (m):	
Constraints Relating to Physical Dimensions	
Maximum external diameter of elements (mm):	
PURCHASER SUPPORT STRUCTURE	
*Type of structure:	
*Structure material:	
Drawings attached?	☐ Yes ☐ No
*CP system present?	☐ Yes ☐ No
*If yes, details of CP system attached?	☐ Yes ☐ No
*Corrosion protection coating:	
*Maximum allowable bending moment (kN·m):	
*Maximum allowable shear force (kN):	
TEMPERATURE	
Internal Fluid Temperature [a]	
Internal fluid design minimum temperature (°C):	
Internal fluid design maximum temperature (°C):	
U-value of flexible pipe (please indicate whether this is based on internal or external diameter and, if specified per unit length, please specify to which length it refers):	
Internal fluid temperature profile over service life attached?	☐ Yes ☐ No
Flexible Pipe Outer Sheath Temperature [a]	
Temperature of flexible pipe external sheath at internal fluid design minimum temperature (°C):	
Temperature of flexible pipe external sheath at internal fluid design maximum temperature (°C):	
Air Temperature	
*Minimum storage/transport/installation temperature (°C):	
*Maximum storage/transport/installation temperature (°C):	
Seawater Temperature [b]	
*Minimum temperature (°C):	
*Maximum temperature (°C):	

a Specify either internal fluid design minimum and maximum temperatures together with flexible pipe U-value or alternatively specify temperature of flexible pipe external sheath at internal fluid design minimum and maximum temperatures.

b For subsea bend restrictors only.

EXTERNAL ENVIRONMENT	
*Location of bend restrictor	☐ Topside connection ☐ Seabed connection ☐ Other, please specify__________________
*Exposure to seawater?	☐ Yes ☐ No
*Abnormally high levels of sunlight exposure (during storage, transport, installation, operation)? *If so, specify details of geographical location and approximate length of exposure (days):	☐ Yes ☐ No
*Design water depth [a] (m):	
[a] For subsea bend restrictors.	

CORROSION PROTECTION	
Required corrosion protection coating for metallic bend restrictor elements:	
Required corrosion protection coating for interface structure:	
Required corrosion protection coating for interface structure fasteners:	
If support structure CP system not connectable to interface structure, interface structure CP system requirements:	
INSTALLATION	
*Installation procedures attached?	☐ Yes ☐ No
*Drawings of overboarding chute profile attached [a]?	☐ Yes ☐ No
[a] Where installation involves placing bend restrictor on chute.	

DESIGN LOADS			
***Static Loads**			
Load Case No.	**Load Case Description** [b]	**Bending Moment (kN)**	**Shear Force (kN)**

***Impact Loads** [a]				
Load Case No.	**Load Case Description**	**Impact Energy (kJ):**	**Impact Velocity (m/s)**	**Diameter of Dropped Object (mm)**

[a] Where applicable, e.g. to resist specified dropped objects.

[b] Include specification of load condition, i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.

SPARES	
No. of spare bend restrictor elements required (%):	
No. of spare fasteners required for securing interface structure to purchaser support structure (%):	
MARKING	
Marking requirements:	
Pigmentation	
Pigmentation requirements:	

Annex C
(informative)

Purchasing Guidelines for Bellmouths

Table C.1 gives purchasing guidelines for bellmouths. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each bellmouth.

Table C.1—Purchasing Guidelines for Bellmouths

REVISION HISTORY					
Revision:					
Date of revision:					

GENERAL INFORMATION	
Client:	
Client reference:	
Phone:	
Fax:	
Email:	
Project title:	
Location:	
Enquiry date:	
Required response date:	
Required delivery date:	
Purchaser's technical contact:	
Conformance to API Spec 17L1 required?	☐ Yes ☐ No

FLEXIBLE PIPE DESIGN PARAMETERS	
Flexible pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Flexible pipe data sheet reference:	
*Internal diameter (mm):	
*Service type:	
*Service life (years):	
*External diameter (mm):	
*Tolerance on external diameter (mm):	
*Operating MBR (m):	
*Storage MBR (m):	
*Crushing capacity (kN):	
BELLMOUTH DESIGN PARAMETERS	
*Static or dynamic bellmouth:	☐ Static ☐ Dynamic
*Angle in mean position with respect to vertical axis (°):	
*Profile of bellmouth attached [a]?:	☐ Yes ☐ No
*Mass requirements (kg):	
*Requirement for anti-fouling coatings?	☐ Yes ☐ No
Constraints Relating to Physical Dimensions	
*Maximum length (m):	
*Maximum external exit diameter (mm):	
a Where manufacturer has determined bellmouth profile.	

PURCHASER SUPPORT STRUCTURE	
*Type of structure:	☐ I-tube ☐ Tether clamp ☐ Other, please specify______________________
If I-tube, specify I-tube parameters in next section:	
*Structure material:	
Drawings attached?	☐ Yes ☐ No
*CP system present?	☐ Yes ☐ No
*If yes, details of CP system attached?	☐ Yes ☐ No
*Corrosion-protection coating:	

I-TUBE PARAMETERS	
*As-built internal diameter available?	☐ Yes ☐ No
If yes, specify internal diameter (mm):	
If no, specify external diameter and wall thickness including tolerances, below	
Drawings of I/J-tube attached?	☐ Yes ☐ No
External diameter (mm):	
Tolerance on external diameter (mm):	
Wall thickness (mm):	
Tolerance on wall thickness (mm):	
TEMPERATURE [a]	
Internal Fluid Temperature [b]	
Internal fluid design minimum temperature (°C):	
Internal fluid design maximum temperature (°C):	
U-value of flexible pipe (please indicate whether this is based on internal or external diameter and, if specified per unit length, please specify to which length it refers):	
Internal fluid temperature profile over service life attached?	☐ Yes ☐ No
Flexible Pipe Outer Sheath Temperature [b]	
Temperature of flexible pipe external sheath at internal fluid design minimum temperature (°C):	
Temperature of flexible pipe external sheath at internal fluid design maximum temperature (°C):	
Air Temperature [c]	
*Minimum storage/transport/installation temperature (°C):	
*Maximum storage/transport/installation temperature (°C):	
Seawater Temperature [d]	
*Minimum temperature (°C):	
*Maximum temperature (°C):	

[a] Composite bellmouths only.

[b] Specify either internal fluid design minimum and maximum temperatures together with flexible pipe U-value or alternatively specify temperature of flexible pipe external sheath at internal fluid design minimum and maximum temperatures.

[c] For surface bellmouths only.

[d] For subsea bellmouths only.

EXTERNAL ENVIRONMENT [a]	
*Exposure to seawater?	☐ Yes ☐ No
* Abnormally high levels of sunlight exposure (during storage, transport, installation, operation)? *If so, specify details of geographical location and approximate length of exposure (days):	☐ Yes ☐ No
[a] Composite bellmouths only.	

CORROSION PROTECTION	
Required corrosion-protection coating for bellmouth surfaces:	
If support structure CP system not connectable to bellmouth, interface structure CP system requirements:	
DESIGN LOADS	
*Maximum offset angle from the mean (°):	
*Associated effective tension in flexible pipe (kN):	
*Contact pressure exerted by flexible pipe on bellmouth (MPa) [a]:	

*Dynamic Loads					
	Effective Tension (kN)				
Load Case	Min.	Mean.	Max.	Range	No. of Cycles
	Offset Angle (°)				
Load Case	Min.	Mean.	Max.	Range	No. of Cycles

[a] Where purchaser has designed the bellmouth.

MARKING	
Marking requirements:	
PIGMENTATION	
Pigmentation requirements:	

Annex D
(informative)

Purchasing Guidelines for Buoyancy and Ballast Modules

Table D.1 gives purchasing guidelines for buoyancy modules. Parameters marked with an asterisk (*) are mandatory.

Table D.2 gives purchasing guidelines for ballast modules.

A separate form should be completed for each length of flexible pipe.

Table D.1—Purchasing Guidelines for Buoyancy Modules

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser's technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				

FLEXIBLE PIPE DESIGN PARAMETERS	
Flexible pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Flexible pipe data sheet reference:	
*Internal diameter (mm):	
*Service type:	
*Service life (years):	
*Clamp design based on as-built external diameter agreed?	☐ Yes ☐ No
*If yes, as-built external diameter (mm):	
*If no, design external diameter (mm):	
*If no, tolerance on external diameter (mm):	
*Outer sheath material	
*Governing coefficient of friction for flexible pipe:	
*Operating MBR (m):	
*Reduction in external coating thickness over service life [a]:	
*Minimum diameter due to ovalization (mm):	
*Maximum diameter due to ovalization (mm):	
[a] Where external coatings such as insulation have been applied.	

NUMBER OF BUOYANCY MODULE TYPES REQUIRED [a]	
Number of different buoyancy module types required:	
[a] Some flexible pipes may require different buoyancy module designs for different areas along its length. For example it may be desirable to have relative low buoyancy per unit length in one area and relative high buoyancy per unit length in another.	

BUOYANCY MODULE DESIGN PARAMETERS [a]	
Buoyancy module type:	
Net Buoyancy [b]	
Final net buoyancy required per unit length (kN/m):	
OR	
Initial net buoyancy required per unit length (kN/m):	
Further Buoyancy Module Design Parameters	
Tolerance required on net buoyancy (kN/m):	
Length of buoyant section [b] (m):	
Tolerance on length of buoyant section (kN/m):	
Center to center spacing (m):	
Anti-fouling coating required?	☐ Yes ☐ No
Required buoyancy module external diameter [c] (m):	
Required buoyancy module length [c] (m):	
Constraints Relating to Physical Dimensions [d]	
Maximum buoyancy module length (m):	
Maximum buoyancy module external diameter (m):	

[a] Please make a copy of this table for each buoyancy module type attached to the flexible pipe.

[b] In lieu of these parameters, purchaser may specify a combination of size and number of buoyancy modules with the required center-to-center spacing. See the Quantities sub-table, below, for specifying the number of buoyancy modules.

[c] To be specified as an alternative to net buoyancy and length of buoyant section, and in combination with the number of buoyancy modules required. See the Quantities sub-table, below, for specifying the number of buoyancy modules.

[d] Where buoyancy module dimensions have not been specified.

TEMPERATURE	
Internal Fluid Temperature [a]	
Internal fluid design minimum temperature (°C):	
Internal fluid design maximum temperature (°C):	
U-value of flexible pipe (please indicate whether this is based on internal or external diameter and, if specified per unit length, please specify to which length it refers):	
Internal fluid temperature profile over service life attached?	☐ Yes ☐ No
Flexible Pipe Outer Sheath Temperature [a]	
Temperature of flexible pipe external sheath at internal fluid design minimum temperature (°C):	
Temperature of flexible pipe external sheath at internal fluid design maximum temperature (°C):	
Air Temperature	
*Minimum storage/transport/installation temperature (°C):	
*Maximum storage/transport/installation temperature (°C):	
Seawater Temperature	
*Minimum temperature (°C):	
*Maximum temperature (°C):	
[a] Specify either internal fluid design minimum and maximum temperatures, together with flexible pipe U-value, or alternatively specify temperature of flexible pipe external sheath at internal fluid design minimum and maximum temperatures.	

EXTERNAL ENVIRONMENT [a]	
*Design water depth of buoyant section [b] (m):	
* Abnormally high levels of sunlight exposure (during storage, transport, installation, operation)? *If so, specify details of geographical location and approximate cumulative length of exposure to sunlight (days):	☐ Yes ☐ No
*Marine growth density at buoyant section location (kg/m^3):	
*Marine growth thickness at buoyant section location (mm):	
[a] Please make a copy of this table for each buoyancy module type attached to the flexible pipe. [b] Please account for both installation and operating water depths.	

CORROSION PROTECTION	
Required fastener corrosion resistant material:	
INSTALLATION	
*Installation procedures attached?	☐ Yes ☐ No
*Moonpool diameter [a]:	
*Moonpool door thickness [a]:	
*Available space in installation tower (e.g. maximum diameter) [b]:	
Other installation constraints:	

a Where installation involves passing buoyancy modules through a moonpool.

b Where installation vessel has an installation tower that will be used for installation of the flexible pipe with buoyancy modules attached.

DESIGN LOADS

Flexible Pipe Loads

Load Case Description	*Maximum Variation in Flexible Pipe External Diameter Due to Contraction (mm)	*Maximum Variation in Flexible Pipe External Diameter Due to Expansion (mm)
*Allowable contact pressure for flexible pipe (MPa):		
*Maximum axial load transferred to internal clamp during installation (kN):		

Load Case Description [a]	*Maximum Axial Load Transferred to Internal Clamp During Service (kN)

Flexible Pipe Induced Fatigue Loads [b]

Load Case No. [c]	Load Case Description	Flexible Pipe External Diameter (kN)			No. of Cycles
		Min.	Mean	Max.	

Load Case No. [c]	Load Case Description	Flexible Pipe Bending Radius (Indicate Directionality by ±) (kN)			No. of Cycles
		Min.	Mean	Max.	

Bending stiffnesses of flexible pipe for bending radii range assumed above attached?	☐ Yes ☐ No

[a] Include specification of load condition i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.

[b] If fatigue damage calculations are required for flexible pipe induced fatigue.

[c] Load case numbers shall correspond.

QUANTITIES [a]	
Buoyancy Module Type	**No. of Buoyancy Modules Required**

[a] To be specified as an alternative to net buoyancy and length of buoyant section and in combination with the dimensions of buoyancy modules required. See the Buoyancy Module Design Parameters sub-table, above, for specifying the required dimensions of buoyancy modules.

SPARES		
Buoyancy Module Type	**No. of Spare Fasteners Required for Buoyancy Modules, Including Bolts and Straps Where Applicable (%)**	**No. of Spare Buoyancy Modules Required (%)**
MARKING		
Marking requirements:		
PIGMENTATION		
Pigmentation requirements:		

Table D.2—Purchasing Guidelines for Ballast Modules

REVISION HISTORY					
Revision:					
Date of revision:					

GENERAL INFORMATION	
Client:	
Client reference:	
Phone:	
Fax:	
Email:	
Project title:	
Location:	
Enquiry date:	
Required response date:	

Required delivery date:	
Purchaser's technical contact:	
Conformance to API Spec 17L1 required?	☐ Yes ☐ No
FLEXIBLE PIPE DESIGN PARAMETERS	
Flexible pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Flexible pipe data sheet reference:	
*Internal diameter (mm):	
*Service type:	
*Service life (years):	
*Clamp design based on as-built external diameter agreed?	☐ Yes ☐ No
*If yes, as-built external diameter (mm):	
*If no, design external diameter (mm):	
*If no, tolerance on external diameter (mm):	
*Outer sheath material	
*Governing coefficient of friction for flexible pipe:	
*Operating MBR (m):	
*Reduction in external coating thickness over service life [a]:	
*Minimum diameter due to ovalization (mm):	
*Maximum diameter due to ovalization (mm):	

[a] Where external coatings, such as insulation, have been applied.

BALLAST MODULE DESIGN PARAMETERS [a]	
*Net mass required per unit length (kN/m):	
Tolerance required on net mass (kN/m):	
*Length of weighted section (m):	
Tolerance on length of weighted section (kN/m):	
Center-to-center module spacing (m):	
Anti-fouling coating required?	☐ Yes ☐ No
Constraints Relating to Physical Dimensions	
Maximum ballast module length (m):	
Maximum ballast module external diameter (m):	

[a] Please make a copy of this table for each ballast module type attached to the flexible pipe.

TEMPERATURE	
Internal Fluid Temperature	
*Internal fluid design minimum temperature (°C):	
Temperature of flexible pipe external sheath at internal fluid design minimum temperature (°C):	
*Internal fluid design maximum temperature (°C):	
Temperature of flexible pipe external sheath at internal fluid design maximum temperature (°C):	
OR	
U-value of flexible pipe (please indicate whether this is based on internal or external diameter and, if specified per unit length, please specify to which length it refers):	
Internal fluid temperature profile over service life attached?	☐ Yes ☐ No
Air Temperature	
*Minimum storage/transport/installation temperature (°C):	
*Maximum storage/transport/installation temperature (°C):	
Seawater Temperature	
*Minimum temperature (°C):	
*Maximum temperature (°C):	

EXTERNAL ENVIRONMENT	
*Design water depth of weighted section (m):	
*Abnormally high levels of sunlight exposure (during storage, transport, installation, operation)? *If so, specify details of geographical location and approximate length of exposure (days):	☐ Yes ☐ No
*Marine growth density at weighted section location (kg/m^3):	
*Marine growth thickness at weighted section location (mm):	
INSTALLATION	
*Installation procedures attached?	☐ Yes ☐ No
*Moonpool diameter [a]:	
*Moonpool door thickness [a]:	
Other installation constraints:	
[a] Where installation involves passing ballast modules through a moonpool.	

DESIGN LOADS

Flexible Pipe Loads

Load Case Description [a]	*Maximum Variation in Flexible Pipe External Diameter Due to Expansion (mm):	*Maximum Variation in Flexible Pipe External Diameter Due to Contraction (mm):

*Allowable contact pressure for flexible pipe (MPa):	
*Maximum axial load transferred to internal clamp during installation (kN):	

Load Case Description [a]	*Maximum Axial Load Transferred to Internal Clamp During Service (kN)

Flexible Pipe Induced Fatigue Loads [b]

Load Case No. [c]	Load Case Description	Flexible Pipe External Diameter (kN)			No. of Cycles
		Min.	Mean	Max.	

Load Case No. [c]	Load Case Description	Flexible Pipe Bending Radius (Indicate Directionality by ±) (kN)			No. of Cycles
		Min.	Mean	Max.	

Bending stiffnesses of flexible pipe for bending radii range assumed above attached?	☐ Yes ☐ No

[a] Include specification of load condition, i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.

[b] If fatigue damage calculations are required for flexible pipe induced fatigue.

[c] Load case numbers shall correspond.

QUANTITIES	
*No. of ballast modules required:	
SPARES	
No. of spare ballast modules required (%):	
No. of spare fasteners required for ballast modules including bolts and straps where applicable (%):	
MARKING	
Marking requirements:	
PIGMENTATION	
Pigmentation requirements:	

Annex E
(informative)

Purchasing Guidelines for Subsea Buoys

Table E.1 gives purchasing guidelines for subsea buoys. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each subsea buoy.

Table E.1—Purchasing Guidelines for Subsea Buoys

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser's technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				

NUMBER OF FLEXIBLE PIPES	
Number of flexible pipes attached to subsea buoy	
FLEXIBLE PIPE DESIGN PARAMETERS [a]	
General Flexible Pipe Design Parameters	
Flexible pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Flexible pipe data sheet reference:	
*Flexible pipe design parameters required for clamp attached, see Table H.2	☐ Yes ☐ No
*Internal diameter (mm):	
*Service type:	
*Service life (years):	
*Storage MBR (m):	
*Operating MBR (m):	
*Length of flexible pipe (m):	
Mass Per Unit Length	
*Mass per unit length in air empty (kg/m):	
Mass per unit length in air full of seawater (kg/m):	
Mass per unit length in air full of internal fluid (kg/m):	
*Mass per unit length in seawater empty (kg/m):	
Mass per unit length in seawater full of seawater (kg/m):	
Mass per unit length in seawater full of internal fluid (kg/m):	
Variation over service life in mass per unit length, in seawater, full of internal fluid (kg/m):	
Internal Fluid Density [b]	
Internal fluid density (kg/m^3):	
Variation over service life in internal fluid density (kg/m^3):	

[a] Please make a copy of this table for every flexible pipe attached to the subsea buoy.
[b] Specify internal fluid density, if mass per unit length full of internal fluid has not been specified.

SUBSEA BUOY DESIGN PARAMETERS	
Net Buoyancy	
*Final net buoyancy required (kN):	
OR	
*Initial net buoyancy required (kN):	
Further Subsea Buoy Design Parameters	
Tolerance required on net buoyancy (kN):	
Anti-fouling coating required?	☐ Yes ☐ No
*Weight in water of tether system [a] (kN):	
*Weight in water of tether base [b] (kN):	
*Weight in water of other attached weights [b] (kN):	
Buoyancy Tank Subsea Buoys Only	
*Multiple buoyancy tanks required in order to provide redundancy in buoyancy tank design? If so, specify required minimum number of individual tanks:	☐ Yes ☐ No
*Compartmentalization of tank(s) required in order to provide redundancy in buoyancy tank design? If so, specify required minimum number of compartments per tank:	☐ Yes ☐ No
Redundancy required in tether design?	☐ Yes ☐ No

[a] If the tether system is not in the subsea buoy manufacturer's scope of supply.
[b] Where these structures are freely suspended from the subsea buoy during installation and these structures are not in the subsea buoy manufacturer's scope of supply.

TEMPERATURE	
Seawater Temperature	
*Minimum temperature (°C):	
*Maximum temperature (°C):	
Buoyancy Tank Subsea Buoys Only	
Air Temperature	
*Pressurization temperature (°C):	
*Minimum /storage/transport/installation temperature (°C):	
*Maximum /storage/transport/installation temperature (°C):	

EXTERNAL ENVIRONMENT	
*Design water depth at subsea buoy location (m):	
*Marine growth density at subsea buoy location (kg/m^3):	
*Marine growth thickness at subsea buoy location (mm):	
Hydrodynamic Loads	
Wave and current velocity profile data corresponding to most critical hydrodynamic loads acting on subsea buoy attached?	☐ Yes ☐ No
Buoyancy Element Subsea Buoys Only	
* Abnormally high levels of sunlight exposure of buoyancy elements (during storage, transport, installation)? *If so, specify details of geographical location and approximate length of exposure (days):	☐ Yes ☐ No
CORROSION PROTECTION	
Required corrosion protection coating for subsea buoy frame:	
CP system requirements for subsea buoy frame:	
Required corrosion protection coating for fasteners:	
INTEGRITY AND CONDITION MONITORING	
Requirements for positioning of anodes on subsea buoy frame:	
Inclinometer required on subsea buoy?	☐ Yes ☐ No
Buoyancy Tank Subsea Buoys Only	
Leak-detection devices required in buoyancy tanks?	☐ Yes ☐ No
INSTALLATION	
Diver intervention or diverless?	☐ Diver intervention ☐ Diverless
Requirements to interface with ROV tools:	
*Maximum subsea buoy weight in air that can be supported by available lifting equipment [a] (kN):	
Requirements for compatibility with lifting equipment [a]:	
***Space Available on Installation Vessel [a]**	
Width (m)	
Height (m)	
Length (m)	
[a] For installation by the purchaser.	

DESIGN LOADS [a]	
Tether and bridle (where applicable) tensions attached, see Table F.1	☐ Yes ☐ No
Crushing capacity of flexible pipe at gutter radius (kN):	

***STATIC LOADS**

***Flexible Pipe Effective Tension**

No.	Flexible Pipe Internal Diameter and Service Type	Load Case Description [b]	Effective Tension at Lower Catenary Side of Subsea Buoy (kN)	Effective Tension at Upper Catenary Side of Subsea Buoy (kN)

***Flexible Pipe Departure Angles—Lower Catenary**

No.	Flexible Pipe Internal Diameter and Service Type	Load Case Description [b]	Vertical Plane Longitudinal to Flexible Pipe (°)	Vertical Plane Transverse to Flexible Pipe (°)	Horizontal Plane (°)

***Flexible Pipe Departure Angles—Upper Catenary**

No.	Flexible Pipe Internal Diameter and Service Type	Load Case Description [b]	Vertical Plane Longitudinal to Flexible Pipe (°)	Vertical Plane Transverse to Flexible Pipe (°)	Horizontal Plane (°)

*DYNAMIC LOADS							
*Flexible Pipe Effective Tension							
No.	Flexible Pipe Internal Diameter and Service Type	Effective Tension at Lower Catenary Side of Subsea Buoy (kN)			Effective Tension at Upper Catenary Side of Subsea Buoy (kN)		
		Min.	Mean	Max.	Min.	Mean	Max.

*Flexible Pipe Departure Angles—Lower Catenary							
No.	Flexible Pipe Internal Diameter and Service Type	Vertical Plane Longitudinal to Flexible Pipe (°)		Vertical Plane Transverse to Flexible Pipe (°)		Horizontal Plane (°)	
		Min.	Max.	Min.	Max.	Min.	Max.

*Flexible Pipe Departure Angles—Upper Catenary							
No.	Flexible Pipe Internal Diameter and Service Type	Vertical Plane Longitudinal to Flexible Pipe (°)		Vertical Plane Transverse to Flexible Pipe (°)		Horizontal Plane (°)	
		Min.	Max.	Min.	Max.	Min.	Max.

[a] Please make a copy of this table if there are more flexible pipes attached to the subsea buoy than there are rows provided in the table.

[b] Include specification of load condition, i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.

MARKING	
Marking requirements for subsea buoy:	
Marking requirements for buoyancy elements, where applicable:	
PIGMENTATION	
Pigmentation requirements for buoyancy elements:	

Annex F
(informative)

Purchasing Guidelines for Tethers

Table F.1 gives purchasing guidelines for tethers. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each subsea buoy or flexible pipe length as appropriate.

Table F.1—Purchasing Guidelines for Tethers

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser's technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				
TETHER DESIGN PARAMETERS [a]					
*Type of tether (i.e. chain, wire rope, synthetic):					
*Length of tether required (m):					
*Tolerance on length of tether required [b] (m):					
*Required MBL (kN):					
[a] May only be applicable if the tether is purchased separately by the subsea buoy or tether clamp manufacturer. [b] The tolerance that is specified shall be in accordance with an international standard applicable to the type of tether being purchased, where applicable.					

CORROSION PROTECTION [a]	
Required corrosion protection coating for tether, including end terminations:	
CP system requirements for tether and end terminations:	
a Metallic tethers only.	

INSPECTION AND CONDITION MONITORING	
Tether tension monitoring required?	☐ Yes ☐ No
If yes, specify details	
INTERFACE REQUIREMENTS [a]	
*Required type of end termination (i.e. splice, socket, etc.):	
*Connection hardware required?	☐ Yes ☐ No
If yes, required type of connection hardware:	
If yes, required SWL of connection hardware (kN):	
a May only be applicable if the tether is purchased separately by the subsea buoy or tether clamp manufacturer.	

DESIGN LOADS

*Maximum Load

Load Case Description[a]	Maximum Tether Tension (kN):

*Fatigue Loads

Load Case No. [b]	Load Case Description	Tether Tension (kN)			No. of Cycles [b]
		Min.	Mean	Max.	

Load Case No. [b]	Corresponding Tether Angle in Flexible Pipe Plane (°)			Corresponding Tether Angle in Vertical Plane Transverse to Flexible Pipe Plane (°)			Corresponding Tether Angle in Horizontal Plane (°)		
	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.

Load Case No. [b]	Load Case Description	Bridle Tension (kN) [c]			No. of Cycles [b]
		Min.	Mean	Max.	

[a] Include specification of load condition i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.

[b] Load case numbers shall correspond.

[c] Where subsea buoy system includes bridle between subsea buoy frame and tethers.

QUANTITIES	
*No. of tethers required:	
SPARES	
No. of spare tethers required:	
No. of connection hardware spares:	
MARKING	
Marking requirements:	
PIGMENTATION	
Pigmentation requirements for tether or tether jacket:	

Annex G
(informative)

Purchasing Guidelines for Riser and Tether Bases

Table G.1 gives purchasing guidelines for riser bases. Parameters marked with an asterisk (*) are mandatory. A separate form should be completed for each riser base.

Table G.2 gives purchasing guidelines for tether bases. Parameters marked with an asterisk (*) are mandatory. A separate form should be completed for each tether base.

Table G.1—Purchasing Guidelines for Riser Bases

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser’s technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				
FLEXIBLE PIPE DESIGN PARAMETERS [a]					
Flexible pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No				
Flexible pipe data sheet reference:					
*Internal diameter (mm):					
*Service type:					
*Service life (years):					
*Built-in angle (degrees):					
[a] Please make a copy of this page for every flexible pipe attached to the riser base.					

RISER BASE DESIGN PARAMETERS				
Constraints Relating to Physical Dimensions				
Maximum length (m):				
Maximum width (m):				
Maximum height (m):				
Flowline Parameters				
No. of flowline connections required:				
Flowline	**Internal Diameter (mm)**	**Tolerance on Internal Diameter (mm)**	**External Diameter (mm)**	**Tolerance on External Diameter (mm)**
INTERNAL FLUID PARAMETERS				
*Internal fluid parameters in accordance with 4.4 of API 17J:2008 attached for all flexible pipes attached to riser base?	☐ Yes ☐ No			
THERMAL INSULATION				
Thermal insulation required for riser base?	☐ Yes ☐ No			
If yes, specify required U-value [W/(m^2·K)]:				
CONNECTORS				
Drawings of flexible pipe connectors *at seabed connection* attached for all flexible pipes attached to riser base?	☐ Yes ☐ No			
Drawings of flowline connectors for all flowlines attached to riser base?	☐ Yes ☐ No			
TEMPERATURE [a]				
Seawater Temperature				
*Minimum temperature (°C):				
*Maximum temperature (°C):				
a Relevant to CP system calculations.				

EXTERNAL ENVIRONMENT				
*Maximum water depth at base location (m):				
Soil Data				
Depth Range (m)	**Description**	**Untrained Shear Strength (kPa)**	**Angle of Internal Friction (°)**	**Submerged Weight (kN/m^3)**
***Hydrodynamic Loads**				
Wave and current velocity profile data corresponding to most critical hydrodynamic loads acting on the base attached?	☐ Yes ☐ No			

CORROSION PROTECTION	
Required corrosion-protection coating for base:	
Required corrosion-protection coating for fasteners:	
CP system requirements:	

INTEGRITY AND CONDITION MONITORING	
Requirements for positioning of anodes on base:	

INSTALLATION	
Requirements for compatibility with lifting equipment:	
Maximum allowable mass in air (kg):	
Requirements for interfacing with ROV tools:	
Requirements for diver access:	
***Space Available on Installation Vessel [a]**	
Width (m):	
Height (m):	
Length (m):	

[a] For installation by the purchaser

DESIGN LOADS [a]

***Maximum Loads**

Load Case Description [b]	Maximum Internal Pressure in Riser Base Piping (MPa):

Effective Tension

Load Case No.	Load Case Description [b]	Effective Tension at Flexible Pipe Connection to Riser Base (kN)

Bending Moment

Load Case No.	Load Case Description	About Horizontal Axis in Flexible Pipe Plane at Flexible Pipe Connection (kN·m)	About Horizontal Axis Transverse to Flexible Pipe Plane At Flexible Pipe Connection (kN·m)	Resultant at Flexible Pipe Connection (kN·m)

Shear Force

Load Case No.	Load Case Description [b]	Horizontal Direction in Flexible Pipe Plane at Flexible Pipe Connection (kN)	Horizontal Direction Transverse to Flexible Pipe Plane at Flexible Pipe Connection (kN)	Resultant at Flexible Pipe Connection (kN)

(continued)

Fatigue Loads

Operational internal pressure in riser base piping (MPa):	

Effective Tension

Load Case No.	Load Case Description	Effective Tension at Flexible Pipe Connection to Riser Base (kN)			
		Min.	Mean	Max.	No. of Cycles

Bending Moment

Load Case No.	Load Case Description	About Horizontal Axis in Flexible Pipe Plane at Flexible Pipe Connection (kN·m)			About Horizontal Axis Transverse to Flexible Pipe Plane at Flexible Pipe Connection (kN·m)			Resultant at Flexible Pipe Connection (kN·m)			No. of Cycles
		Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	

Shear Force

Load Case No.	Load Case Description	Horizontal Direction in Flexible Pipe Plane at Flexible Pipe Connection (kN)			Horizontal Direction Transverse to Flexible Pipe Plane at Flexible Pipe Connection (kN)			Resultant at Flexible Pipe Connection (kN)			No. of Cycles
		Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	

a The specified loads shall account for all translational and rotational installation tolerances.

b Include specification of load condition i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.

MARKING	
Marking requirements:	
PIGMENTATION	
Pigmentation requirements for riser base:	

Table G.2—Purchasing Guidelines for Tether Bases

REVISION HISTORY					
Revision:					
Date of revision:					

GENERAL INFORMATION	
Client:	
Client reference:	
Phone:	
Fax:	
Email:	
Project title:	
Location:	
Enquiry date:	
Required response date:	
Required delivery date:	
Purchaser’s technical contact:	
Conformance to API Spec 17L1 required?	☐ Yes ☐ No

TETHER BASE DESIGN PARAMETERS				
Constraints Relating to Physical Dimensions				
Maximum length (m):				
Maximum width (m):				
Maximum height (m):				
Tether Connections				
Type of tethers attached to tether base (i.e. chain, wire rope or synthetic):				
Details of tether connection hardware:				
Tether connections required on tether base:				
EXTERNAL ENVIRONMENT				
*Maximum water depth at base location (m):				
Soil Data				
Depth Range (m)	**Description**	**Untrained Shear Strength (kPa)**	**Angle of Internal Friction (°)**	**Submerged Weight (kN/m^3)**
***Hydrodynamic Loads**				
Wave and current velocity profile data corresponding to most critical hydrodynamic loads acting on the base attached?	☐ Yes ☐ No			
CORROSION PROTECTION				
Required corrosion protection coating for base:				
Required corrosion protection coating for fasteners:				
CP system requirements:				
INTEGRITY AND CONDITION MONITORING				
Requirements for positioning of anodes on base:				

INSTALLATION	
Requirements for compatibility with lifting equipment:	
Maximum allowable mass in air (kg):	
Requirements for interfacing with ROV tools:	
Requirements for diver access:	
***Space Available on Installation Vessel [a]**	
Width (m):	
Height (m):	
Length (m):	
[a] For installation by the purchaser.	

DESIGN LOADS [a]

*Maximum Loads

Load Case Description [b]	Maximum Tether Tension (kN)

Load Case Description [b]	Tether Angle Range in Flexible Pipe Plane (°)		Tether Angle Range in Vertical Plane Transverse to Flexible Pipe Plane (°)		Tether Angle Range in Horizontal Plane (°)	
	Min.	Max.	Min.	Max.	Min.	Max.

*Fatigue Loads

Load Case No. [c]	Load Case Description	Tether Tension (kN)			No. of Cycles
		Min.	Mean	Max.	

Load Case No. [c]	Corresponding Tether Angle in Flexible Pipe Plane (°)		Corresponding Tether Angle in Vertical Plane Transverse to Flexible Pipe Plane (°)		Corresponding Tether Angle in Horizontal Plane (°)	
	Min.	Max.	Min.	Max.	Min.	Max.

[a] The specified loads shall account for all translational and rotational installation tolerances.

[b] Include specification of load condition i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.

[c] Load case numbers shall correspond.

MARKING	
Marking requirements:	
PIGMENTATION	
Pigmentation requirements for tether base:	

Annex H
(informative)

Purchasing Guidelines for Subsea Buoy Clamps

Table H.1 gives purchasing guidelines for subsea buoy clamps. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each subsea buoy clamp.

Table H.1—Purchasing Guidelines for Subsea Buoy Clamps

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser's technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				

FLEXIBLE PIPE DESIGN PARAMETERS	
Flexible pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Flexible pipe data sheet reference:	
*Internal diameter (mm):	
*Service type:	
*Service life (years):	
*Clamp design based on as-built external diameter agreed?	☐ Yes ☐ No
*If yes, as-built external diameter (mm):	
*If no, design external diameter (mm):	
*If no, tolerance on external diameter (mm):	
*Tolerance on external diameter (mm):	
*Outer sheath material	
*Governing coefficient of friction for flexible pipe	
*Reduction in external coating thickness over service life [a]:	
*Minimum diameter due to ovalization (mm):	
*Maximum diameter due to ovalization (mm):	

a Where external coatings, such as insulation, have been applied.

TEMPERATURE [a]	
Internal Fluid Temperature [b]	
*Internal fluid design minimum temperature (°C):	
*Internal fluid design maximum temperature (°C):	
U-value of flexible pipe (please indicate whether this is based on internal or external diameter and, if specified per unit length, please specify to which length it refers):	
Internal fluid temperature profile over service life attached?	☐ Yes ☐ No
Flexible Pipe Outer Sheath Temperature [b]	
Temperature of flexible pipe external sheath at internal fluid design minimum temperature (°C):	
Temperature of flexible pipe external sheath at internal fluid design maximum temperature (°C):	
Air Temperature [c]	
*Minimum storage/transport/installation temperature (°C):	
*Maximum storage/transport/installation temperature (°C):	
Seawater Temperature [d]	
*Minimum temperature at tether clamp location (°C):	
*Maximum temperature at tether clamp location (°C):	

[a] Please make a copy of this table for each flexible pipe attached to the subsea buoy. See Table E.1 for the number of and details of the flexible pipes attached to the subsea buoy.

[b] Specify either internal fluid design minimum and maximum temperatures together with flexible pipe U-value or, alternatively, specify temperature of flexible pipe external sheath at internal fluid design minimum and maximum temperatures.

[c] Relevant to polymer inner-liner materials.

[d] Relevant to CP system calculations.

EXTERNAL ENVIRONMENT	
*Design water depth (m):	
CORROSION PROTECTION	
Corrosion protection requirements different from those of subsea buoy?	☐ Yes ☐ No
If yes, specify corrosion protection requirements below:	
Required corrosion protection coating for clamp body:	
Required corrosion protection coating for fasteners:	
CP system requirements:	

INSTALLATION	
Requirements for compatibility with lifting equipment:	
Diver intervention or diverless, see Table E.1	☐ Diver intervention ☐ Diverless
Requirements to interface with ROV tools:	

DESIGN LOADS		
Load Case Description [a]	**Maximum Variation in Flexible Pipe External Diameter Due to Expansion (mm)**	**Maximum Variation in Flexible Pipe External Diameter Due to Contraction (mm)**
Allowable contact pressure for flexible pipe (MPa):		
Effective tensions in flexible pipe either side of clamp attached, see Table E.1		☐ Yes ☐ No

Fatigue Loads [b]

Load Case No.	**Load Case Description**	**Flexible Pipe External Diameter (kN)**			**No. of Cycles**
		Min.	**Mean**	**Max.**	

Load Case No.	**Load Case Description**	**Flexible Pipe Bending Radius (Indicate Directionality by ±) (kN)**			**No. of Cycles**
		Min.	**Mean**	**Max.**	

Load Case No.	Load Case Description	Flexible Pipe Lower Catenary Effective Tension (kN)			No. of Cycles
		Min.	Mean	Max.	
Load Case No.	**Load Case Description**	**Flexible Pipe Upper Catenary Effective Tension (kN)**			**No. of Cycles**
		Min.	**Mean**	**Max.**	
Bending stiffnesses of flexible pipe for bending radii range assumed above attached?			☐ Yes ☐ No		

[a] Include specification of load condition i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.
[b] If fatigue-damage calculations are required.

SPARES	
No. of spare clamps required:	
No. of spare fasteners required for clamp (%):	
MARKING	
Marking requirements:	
PIGMENTATION	
Pigmentation requirements same as subsea buoy, see Table E.1	☐ Yes ☐ No
If no, specify pigmentation requirements:	

Annex I
(informative)

Purchasing Guidelines for Tether Clamps

Table I.1 gives purchasing guidelines for tether clamps. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each tethered flexible pipe.

Table I.1—Purchasing Guidelines for Tether Clamps

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser's technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				

FLEXIBLE PIPE DESIGN PARAMETERS	
Flexible pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Flexible pipe data sheet reference:	
*Internal diameter (mm):	
*Service type:	
*Service life (years):	
*Clamp design based on as-built external diameter agreed?	☐ Yes ☐ No
*If yes, as-built external diameter (mm):	
*If no, design external diameter (mm):	
*If no, tolerance on external diameter (mm):	
*Outer sheath material	
*Governing coefficient of friction for flexible pipe	
*Operating MBR (m):	
*Reduction in external coating thickness over service life [a]:	
*Minimum diameter due to ovalization (mm):	
*Maximum diameter due to ovalization (mm):	
[a] Where external coatings, such as insulation, have been applied.	

TETHER CLAMP DESIGN PARAMETERS	
Location along flexible pipe (m):	
Mass requirements and tolerance (kg):	
Requirements for bend limiting device:	☐ Bend stiffener ☐ Bend restrictor ☐ Bellmouth
Requirements for swiveling pad-eyes?	☐ Yes ☐ No
Anti-fouling coating required?	☐ Yes ☐ No
BEND LIMITERS	
*Bend limiter required?	☐ Yes ☐ No
If yes, specify bend limiter type:	☐ Bend stiffener ☐ Bend restrictor ☐ Bellmouth
Bend limiter functional requirements attached?	☐ Yes ☐ No

TEMPERATURE	
Internal Fluid Temperature [a]	
*Internal fluid design minimum temperature (°C):	
*Internal fluid design maximum temperature (°C):	
U-value of flexible pipe (please indicate whether this is based on internal or external diameter and, if specified per unit length, please specify to which length it refers):	
Internal fluid temperature profile over service life attached?	☐ Yes ☐ No
Flexible Pipe Outer Sheath Temperature [a]	
Temperature of flexible pipe external sheath at internal fluid design minimum temperature (°C):	
Temperature of flexible pipe external sheath at internal fluid design maximum temperature (°C):	
Air Temperature [b]	
*Minimum storage/transport/installation temperature (°C):	
*Maximum storage/transport/installation temperature (°C):	
Seawater Temperature [b c]	
*Minimum temperature at tether clamp location (°C):	
*Maximum temperature at tether clamp location (°C):	
a Specify either internal fluid design minimum and maximum temperatures together with flexible pipe U-value or, alternatively, specify temperature of flexible pipe external sheath at internal fluid design minimum and maximum temperatures. b Relevant to polymer and composite components of the clamp. c Relevant to CP system calculations.	

EXTERNAL ENVIRONMENT	
*Design water depth (m):	
Marine growth density at tether clamp location (kg/m^3):	
Marine growth thickness at tether clamp location (mm):	
*Abnormally high levels of sunlight exposure (during storage, transport, installation, operation) [a]? *If so, specify details of geographical location and approximate length of exposure (days) [a]:	☐ Yes ☐ No
a Composite tether clamps only.	

CORROSION PROTECTION	
Required corrosion-protection coating for clamp body:	
Required corrosion-protection coating for fasteners:	
CP system requirements:	

INSTALLATION	
Requirements for compatibility with lifting equipment:	

DESIGN LOADS

***Flexible Pipe Loads**

Load Case Description [a]	Maximum Variation in Flexible Pipe External Diameter Due to Expansion (mm)	Maximum Variation in Flexible Pipe External Diameter Due to Contraction (mm)
Allowable contact pressure for flexible pipe (MPa):		

Load Case Description	Maximum Curvature at Tether Clamp Location (m^{-1})

***Maximum Load**

Maximum tether tension, including weight of tether base if installation of the tether clamp involves lowering with the tether base attached (kN):		
Maximum tether tension during service (kN):		
	Min.	**Max.**
Tether angle range in flexible pipe plane (°):		
Tether angle range in vertical plane transverse to flexible pipe plane (°):		
Tether angle range in horizontal plane (°):		

***Tether-induced Fatigue Loads**

Load Case No. [b]	Load Case Description	Tether Tension (kN)			No. of Cycles [b]
		Min.	**Mean**	**Max.**	

Load Case No. [b]	Corresponding Tether Angle in Flexible Pipe Plane (°)		Corresponding Tether Angle in Vertical Plane Transverse to Flexible Pipe Plane (°)		Corresponding Tether Angle in Horizontal Plane (°)	
	Min.	Max.	Min.	Max.	Min.	Max.

Flexible Pipe Induced Fatigue Loads [c]

Load Case No. [b]	Load Case Description	Flexible Pipe External Diameter (kN)			No. of Cycles
		Min.	Mean	Max.	

Load Case No. [b]	Load Case Description	Flexible Pipe Bending Radius (Indicate Directionality by ±) (kN)			No. of Cycles
		Min.	Mean	Max.	

Bending stiffnesses of flexible pipe for bending radii range assumed above attached?	☐ Yes ☐ No

[a] Include specification of load condition, i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.

[b] Load case numbers shall correspond.

[c] If fatigue-damage calculations are required for flexible pipe induced fatigue.

SPARES	
No. of spare clamps required:	
No. of spare fasteners required for clamp (%):	
MARKING	
Marking requirements:	
PIGMENTATION	
Pigmentation requirements:	

Annex J
(informative)

Purchasing Guidelines for Piggy-back Systems

Table J.1 gives purchasing guidelines for piggy-back systems. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each length of piggy-backed pipe.

Table J.1—Purchasing Guidelines for Piggy-back Systems

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser’s technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				

FLEXIBLE PIPE DESIGN PARAMETERS [a]	
Supporting or supported pipe?	☐ Supporting pipe ☐ Supported pipe
If supporting pipe, length of flexible pipe over which piggy-back spacers are required (m) [b]:	
Flexible pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Flexible pipe data sheet reference:	
Total length (m) [b]:	
*Internal diameter (mm):	
*Service type:	
*Service life (years):	
*Clamp design based on as-built external diameter agreed?	☐ Yes ☐ No
*If yes, as-built external diameter (mm):	
*If no, external diameter (mm):	
*If no, tolerance on external diameter (mm):	
*Outer sheath material:	
*Governing coefficient of friction for flexible pipe:	
*Reduction in external coating thickness over service life (mm) [c]:	
*Minimum diameter due to ovalization (mm):	
*Maximum diameter due to ovalization (mm):	
Flexible pipe design parameters necessary to perform global analysis of the piggy-back system attached? [d]	☐ Yes ☐ No

a Please make a copy of this table for every flexible pipe in the piggy-back system.

b May not be required if the purchaser has determined the number of clamps in accordance and specified design loads reflecting the weight of the pipes exerted on the piggy-back system.

c Where external coatings, such as insulation, have been applied.

d If the manufacturer is performing such an analysis. See Section 4 of API17J:2008 for data that is required to conduct a global analysis.

PIGGY-BACK SYSTEM DESIGN PARAMETERS				
No.	**Supported Pipe Reference Diameter and Service Type**	**Required Clearance from Supporting Pipe (mm)**	**Spacing [a] (m)**	**Drawing Indicating Spacings Attached? [b]**
				☐ Yes ☐ No
				☐ Yes ☐ No
				☐ Yes ☐ No
Maximum permissible axial force transmitted by piggy-back guide (kN):				
Any changes in piggy-back clamp functional requirements post-installation? If yes, specify details:		☐ Yes ☐ No		
Any requirements for any piggy-back clamps to change functionality from piggy-back clamp to guide during use or visa-versa? If yes, specify details:		☐ Yes ☐ No		

a If spacing is uniform along the piggy-backed length of the supporting pipe.
b If spacing is not uniform along the piggy-backed length of the supporting pipe.

SUPPORTING PIPE DESIGN PARAMETERS [a]	
Supporting pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Supporting pipe data sheet reference:	
*Reference diameter:	
*Functionality:	
*Clamp design based on as-built external diameter agreed?	☐ Yes ☐ No
*If yes, as-built external diameters at clamp locations attached?	☐ Yes ☐ No
*If no, design external diameter (mm):	
*If no, tolerance on external diameter (mm):	
Outer material:	
*Governing coefficient of friction between piggy-back spacer and pipe:	
*Reduction in external coating thickness over service life (mm) [b]:	
*Minimum diameter due to ovalization (mm):	
*Maximum diameter due to ovalization (mm):	
Pipe design parameters necessary to perform global analysis of the piggyback system attached?	☐ Yes ☐ No

a If flexible pipe is not the supporting pipe.
b Where external coatings, such as insulation, have been applied.

*SUPPORTED PIPE(S) DESIGN PARAMETERS [a]	
Supported pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Supported pipe data sheet reference:	
Number of supported pipes:	

External Parameters

No.	Supported Pipe Reference Diameter and Functionality	External Diameter (mm)	Tolerance on External Diameter (mm)	Outer Material	Governing Coefficient of Friction

OVALIZATION

No.	Supported Pipe Reference Diameter and Functionality	Diameters Due to Out-of-Roundness	
		Minimum Diameter (mm)	Maximum Diameter (mm)

a For supported pipes that are not flexible pipes.

TEMPERATURE	
Internal Fluid Temperature of Flexible Pipe [a b]	
*Internal fluid design minimum temperature (°C):	
*Internal fluid design maximum temperature (°C):	
U-value of flexible pipe (please indicate whether this is based on internal or external diameter and if specified per unit length please specify which length it refers to):	
Internal fluid temperature profile over service life attached?	☐ Yes ☐ No
Flexible Pipe Outer Sheath Temperature [b]	
Temperature of flexible pipe external sheath at internal fluid design minimum temperature (°C):	
Temperature of flexible pipe external sheath at internal fluid design maximum temperature (°C):	
Temperature of Supporting Pipe [c]	
Maximum design external surface temperature (°C):	
Minimum design external surface temperature (°C):	

Temperature of Supported Pipes [d]

No.	Supported Pipe Reference Diameter and Functionality	External Surface Temperature (°C)	
		Min.	Max.

Air Temperature	
*Minimum storage/transport/installation temperature (°C):	
*Maximum storage/transport/installation temperature (°C):	
Seawater Temperature	
*Minimum temperature over piggy-backed length of supporting pipe (°C):	
*Maximum temperature over piggy-backed length of supporting pipe (°C):	

[a] Please make a copy of this section of the table for every flexible pipe in the piggy-back system.

[b] Specify either internal fluid design minimum and maximum temperatures together with flexible pipe U-value or, alternatively, specify temperature of flexible pipe external sheath at internal fluid design minimum and maximum temperatures.

[c] If flexible pipe is not the supporting pipe.

[d] For supported pipes that are not flexible pipes.

EXTERNAL ENVIRONMENT	
*Abnormally high levels of sunlight exposure (during storage, transport, installation, operation)? *If so, specify details of geographical location and approximate cumulative length of exposure to sunlight (days):	☐ Yes ☐ No
CORROSION PROTECTION	
Required material for spacer body fasteners:	
Required corrosion protection coating for spacer body fasteners [a]:	
Required material for piggy-back strap tensioning assemblies:	
Required corrosion protection coating for piggy-back strap tensioning assemblies [a]:	
[a] Only for materials that are not inherently corrosion-resistant.	

DESIGN LOADS		
***Supporting Pipe Loads**		
Load Case Description	**Maximum Variation in Supporting Pipe External Diameter Due to Expansion (mm)**	**Maximum Variation in Supporting Pipe External Diameter Due to Contraction (mm)**
Allowable contact pressure for supporting pipe (MPa):		
Load Case Description	***Maximum Axial Load Transferred to Piggy-Back Spacers During Service (kN)**	***Maximum Axial Load Transferred to Piggy-back Spacers During Installation (kN)**
Load Case Description [a]	***Maximum Load Normal to the Pipe Transferred to Piggy-Back Spacers Due to Weight of Supporting Pipes, Including Any Dynamic Amplification and Accounting for Installation (kN)**	

Load Case Description [a]	*Maximum Curvature in Supporting Pipe (m^{-1})	*Maximum Effective Tension in Supporting Pipe (kN)

***Supported Pipe Loads**

No.	Supported Pipe Reference Diameter and Functionality	Maximum Variation in External Diameter (mm)		Allowable Contact Pressure (MPa)
		Due to Contraction	Due to Expansion	

No.	Supported Pipe Reference Diameter and Functionality	Maximum Axial Load Transferred to Piggy-back Spacer (kN)		Maximum Load Normal to Pipe Transferred to Piggy-back Spacer (kN)	
		During Installation	During Service	During Installation	During Service

No.	Supported Pipe Reference Diameter and Functionality	Maximum Effective Tension (kN)	Maximum Curvature

[a] Include specification of load condition, i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue. Load case numbers shall correspond.

QUANTITIES [a]

No. of piggy-back clamps:	
No. of piggy-back guides:	

[a] If purchaser has determined such quantities.

MARKING	
Marking requirements:	
PIGMENTATION	
Pigmentation requirements:	

Annex K
(informative)

Purchasing Guidelines for Repair Clamps

Table K.1 gives purchasing guidelines for repair clamps. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each length of flexible pipe.

Table K.1—Purchasing Guidelines for Repair Clamps

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser’s technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				

FLEXIBLE PIPE DESIGN PARAMETERS	
Flexible pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Flexible pipe data sheet reference:	
*Internal diameter (mm):	
*Service type:	
*Remaining service life (years):	
*Outer sheath material	
*Governing coefficient of friction for flexible pipe:	
*Reduction in external coating thickness over remaining service life [a]:	
Minimum diameter due to ovalization (mm):	
Maximum diameter due to ovalization (mm):	

Details of Damaged Areas and Associated External Diameters

*As-built external diameters available?	☐ Yes ☐ No
*If yes, specify below	

No.	Damaged Area Identification	As-built External Diameter (mm)	Type of Damage	Approximate Area of Damage (mm^2)

If no, specify as designed diameter and tolerance, below	
*External diameter (mm):	
*Tolerance on external diameter (mm):	

[a] Where external coatings such as insulation have been applied.

REPAIR CLAMP DESIGN PARAMETERS	
*Water- or pressure-tight seal required?	☐ Water-tight ☐ Pressure-tight
*Data sheets of chemicals used to flush flexible pipe annulus attached?	☐ Yes ☐ No
*Venting system required for flexible pipe annulus gases?	☐ Yes ☐ No
*Monitoring equipment required for flexible pipe annulus fluid?	☐ Yes ☐ No

TEMPERATURE	
Internal Fluid Temperature [a]	
*Internal fluid design minimum temperature (°C):	
*Internal fluid design maximum temperature (°C):	
U-value of flexible pipe (please indicate whether this is based on internal or external diameter and, if specified per unit length, please specify to which length it refers):	
Operational internal fluid temperature profile over service life attached?	☐ Yes ☐ No
Flexible Pipe Outer Sheath Temperature [a]	
Temperature of flexible pipe external sheath at internal fluid design minimum temperature (°C):	
Temperature of flexible pipe external sheath at internal fluid design maximum temperature (°C):	
Air Temperature [b]	
*Minimum storage/transport/installation temperature (°C):	
*Maximum storage/transport/installation temperature (°C):	
Seawater Temperature [b c]	
*Minimum temperature at repair clamp locations (°C):	
*Maximum temperature at repair clamp locations (°C):	

[a] Specify either internal fluid design minimum and maximum temperatures together with flexible pipe U-value or, alternatively, specify temperature of flexible pipe external sheath at internal fluid design minimum and maximum temperatures.
[b] Relevant to polymer inner-liner materials.
[c] Relevant to CP system calculations for metallic materials.

EXTERNAL ENVIRONMENT	
*Design water depth (m):	
INSTALLATION	
*Requirements to interface with ROV tools:	

DESIGN LOADS

Load Case Description [a]	Maximum Variation in Flexible Pipe External Diameter Due to Expansion (mm)	Maximum Variation in Flexible Pipe External Diameter Due to Contraction (mm)
Allowable contact pressure for flexible pipe (MPa):		

Load Case Description	Maximum Curvature at Repair Clamp Locations (m^{-1})
Repair clamp required to resist pressure differential?	☐ Yes ☐ No
If yes, maximum differential pressure to be resisted by repair clamp (kPa):	

Fatigue Loads [b]

Load Case No.	Load Case Description	Flexible Pipe External Diameter (kN)			No. of Cycles
		Min.	Mean	Max.	

Load Case No.	Load Case Description	Flexible Pipe Bending Radius (Indicate Directionality by ±) (kN)			No. of Cycles
		Min.	Mean	Max.	

Bending stiffnesses of flexible pipe for bending radii range assumed above attached?	☐ Yes ☐ No

[a] Include specification of load condition i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.

[b] If fatigue damage calculations are required.

QUANTITIES	
Repair Clamp Type	**No. of Repair Clamps Required**
SPARES	
No. of spare repair clamps required:	
No. of spare fasteners required (%):	
MARKING	
Marking requirements:	
PIGMENTATION	
Pigmentation requirements:	

Annex L
(informative)

Purchasing Guidelines for I/J-tube Seals

Table L.1 gives purchasing guidelines for I/J-tube seals. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each I/J-tube seal.

Table L.1—Purchasing Guidelines for I/J-tube Seals

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser's technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				

FLEXIBLE PIPE DESIGN PARAMETERS	
Flexible pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Flexible pipe data sheet reference:	
*Internal diameter (mm):	
*Service type:	
*Service life (years):	
*Length (m):	
*Mass per unit length (kg/m):	
*External diameter (mm):	
*Tolerance on external diameter (mm):	
Clamp Design Parameters [a]	
*I/J-tube design based on as-built external diameter agreed?	☐ Yes ☐ No
*If yes, as-built external diameter (mm):	
*If no, external diameter [b] (mm):	
*If no, tolerance on external diameter [b] (mm):	
*Reduction in external coating thickness over service life [c] (mm):	
*Minimum diameter due to ovalization (mm):	
*Maximum diameter due to ovalization (mm):	
*Outer sheath material:	
*Governing coefficient of friction for flexible pipe:	

a For I/J-tube seals with clamping devices.
b If as-built external diameter is unknown.
c Where external coatings, such as insulation, have been applied.

I/J-TUBE DESIGN PARAMETERS	
*As built internal diameter available?	☐ Yes ☐ No
If yes, specify internal diameter (mm):	
If no, specify external diameter and wall thickness including tolerances, below	
Drawings of I/J-tube attached?	☐ Yes ☐ No
External diameter (mm):	
Tolerance on external diameter (mm):	
Wall thickness (mm):	
Tolerance on wall thickness (mm):	
*Surface finish/profile on interior of I/J-tube:	
Thickness of any internal coatings (mm):	
*Any weld protrusions within I/J-tube in vicinity of I/J-tube seal?	☐ Yes ☐ No
If yes, specify thickness of such protrusions (mm):	
*Length of time in service [a] (years):	
Condition of bore, if available [a]:	
[a] Existing I/J-tubes only.	

TEMPERATURE	
Internal Fluid Temperature [a]	
*Internal fluid design minimum temperature (°C):	
*Internal fluid design maximum temperature (°C):	
U-value of flexible pipe (please indicate whether this is based on internal or external diameter and if specified per unit length please specify which length it refers to):	
Internal fluid temperature profile over service life attached?	☐ Yes ☐ No
Flexible Pipe Outer Sheath Temperature [a]	
Temperature of flexible pipe external sheath at internal fluid design minimum temperature (°C):	
Temperature of flexible pipe external sheath at internal fluid design maximum temperature (°C):	
Air Temperature	
Minimum storage/transport/installation temperature (°C):	
Maximum storage/transport/installation temperature (°C):	
Seawater Temperature	
Minimum temperature at I/J-tube exit (°C):	
Maximum temperature at I/J-tube exit (°C):	
[a] Specify either internal fluid design minimum and maximum temperatures together with flexible pipe U-value or, alternatively, specify temperature of flexible pipe external sheath at internal fluid design minimum and maximum temperatures.	

EXTERNAL ENVIRONMENT	
*Design water depth (m):	
*Abnormally high levels of sunlight exposure of polymer sealing elements (during storage, transport, installation, operation)? *If so, specify details of geographical location and approximate length of exposure (days):	☐ Yes ☐ No
CORROSION PROTECTION	
Required corrosion-protection coating for metallic components (not including fasteners):	
Required corrosion-protection coating for fasteners:	
CP system requirements:	
*I/J-tube corrosion inhibitor data sheet attached?	☐ Yes ☐ No
*Concentration of corrosion inhibitor within I/J-tube seawater ($\times 10^{-6}$)	
INSTALLATION	
*Diverless or diver assisted I/J-tube seal?	☐ Diverless ☐ Diver-assisted
Topside pulling capacity [a] (kN):	
[a] Diverless I/J-tube seals only.	

*DESIGN LOADS

I/J-tube internal pressure (kPa):		
Load Case Description [a]	**Maximum Variation in Flexible Pipe External Diameter Due to Expansion** [b] **(mm)**	**Maximum Variation in Flexible Pipe External Diameter Due to Contraction** [b] **(mm)**
Allowable contact pressure for flexible pipe [b] (MPa):		

Fatigue Loads [c]

Load Case No.	**Load Case Description**	**Flexible Pipe External Diameter (kN)**			**No. of Cycles**
		Min.	**Mean**	**Max.**	

Load Case No.	**Load Case Description**	**Flexible Pipe Bending Radius (Indicate Directionality by ±) (kN)**			**No. of Cycles**
		Min.	**Mean**	**Max.**	

Bending stiffnesses of flexible pipe for bending radii range assumed above attached?	☐ Yes ☐ No

[a] Include specification of load condition, i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.

[b] Diverless I/J-tube seals only.

[c] For I/J-tube seals with clamps and where fatigue damage calculations are required.

SPARES	
No. of spare fasteners required (%):	
MARKING	
Marking requirements:	
PIGMENTATION	
Pigmentation requirements:	

Annex M
(informative)

Purchasing Guidelines for Pull-in Heads

Table M.1 gives purchasing guidelines for pull-in heads. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each length of flexible pipe for which a pull-in head is required.

Table M.1—Purchasing Guidelines for Pull-in Heads

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser's technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				
FLEXIBLE PIPE DESIGN PARAMETERS					
*Internal diameter (mm):					
*Service type:					
*Drawings of end fitting *at pull-in head end* of flexible pipe attached?	☐ Yes ☐ No				

PULL-IN HEAD DESIGN PARAMETERS	
*Requirements for interfacing with lifting equipment:	
Vents required in pull-in head?	☐ Yes ☐ No
If yes, specify required number and diameter of vents (see also drawing of end fitting):	
*Pressure containing capacity required in pull-in head?	☐ Yes ☐ No
Pull-in head to pass through I-tube?	☐ Yes ☐ No
If yes, drawings of I-tube attached?	☐ Yes ☐ No
Pull-in head to be re-used?	☐ Yes ☐ No
CORROSION PROTECTION [a]	
Required corrosion protection coating for pull-in head:	
Required corrosion protection coating for pull-in head fasteners:	
[a] Where pull-in head is intended for re-use, or is in storage for extended periods or is abandoned on the seabed for extended periods.	

DESIGN LOADS	
*Required SWL (kN):	
Maximum internal pressure [a] (MPa):	
[a] If pressure-containing capacity is required of pull-in head.	

SPARES	
No. of spare fasteners required for securing pull-in head to flexible pipe end-fitting (%):	
MARKING	
Marking requirements:	

Annex N
(informative)

Purchasing Guidelines for Chinese Fingers/Cable Grips

Table N.1 gives purchasing guidelines for Chinese fingers. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each length of flexible pipe.

Table N.1—Purchasing Guidelines for Chinese Fingers

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser's technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				
FLEXIBLE PIPE DESIGN PARAMETERS					
*Internal diameter (mm):					
*Service type:					
*External diameter (mm):					
*Tolerance on external diameter (mm):					
*Outer sheath material:					

CORROSION PROTECTION [a]	
Required corrosion protection coating for Chinese finger:	
[a] Where the Chinese finger is intended for re-use or corrosion protection is required for storage conditions.	

INSTALLATION	
*Requirements for compatibility with lifting equipment:	
DESIGN LOADS	
*Required SWL (kN):	
*Maximum curvature of flexible pipe at Chinese finger location	
*Maximum variation in flexible pipe external diameter due to contraction (mm):	
*Maximum variation in flexible pipe external diameter due to expansion (mm):	
MARKING	
Marking requirements:	

Annex O
(informative)

Purchasing Guidelines for Connectors

Table O.1 gives purchasing guidelines for connectors. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each length of flexible pipe.

NOTE See API Spec 6A for purchasing guidelines for flange-type connectors.

Table O.1—Purchasing Guidelines for Connectors

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser’s technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				
FLEXIBLE PIPE DESIGN PARAMETERS					
*Internal diameter (mm):					
*Service type:					
*Service life (years):					
*Drawings of end fitting *at connector end* of flexible pipe attached?	☐ Yes ☐ No				

CONNECTOR DESIGN PARAMETERS	
*Location of connector	☐ Topside connector ☐ Seabed connector
Other details of connector location	
*Type of connector required	☐ Flange ☐ Clamped hub ☐ Swivel flange ☐ Other
*Drawings of end fitting *at connector end* of flexible pipe attached?	☐ Yes ☐ No
ADJACENT STRUCTURES	
*Internal diameter of adjacent piping (mm):	
*Tolerance on internal diameter of adjacent piping (mm):	
*External diameter of adjacent piping (mm):	
*Tolerance on external diameter of adjacent piping (mm):	
*Drawings of I-tube attached [a]?	☐ Yes ☐ No
*Grade of material for adjacent piping:	
*Manufacturer to have responsibility to ensure compatibility of connector materials with adjacent structures?	☐ Yes ☐ No
[a] Only for topside connectors and where applicable.	

INTERNAL FLUID PARAMETERS	
*Internal fluid parameters in accordance with 4.4 of API 17J:2008 attached for flexible pipe attached to connector?	☐ Yes ☐ No
CORROSION PROTECTION	
Required corrosion protection coating:	
CP system requirements:	
INSTALLATION	
*Diver-assisted or diverless make-up?	☐ Diver-assisted ☐ Diverless

DESIGN LOADS

*STATIC LOADS

Effective Tension

Load Case No.	Load Case Description	Effective Tension at Flexible Pipe Connection (kN)

Bending Moment

Load Case No.	Load Case Description [a]	About Horizontal Axis in Flexible Pipe Plane at Flexible Pipe Connection (kN·m)	About Horizontal Axis Transverse to Flexible Pipe Plane at Flexible Pipe Connection (kN·m)	Resultant at Flexible Pipe Connection (kN·m)

Shear Force

Load Case No.	Load Case Description [a]	Horizontal Direction in Flexible Pipe Plane at Flexible Pipe Connection (kN)	Horizontal Axis Transverse to Flexible Pipe Plane at Flexible Pipe Connection (kN)	Resultant at Flexible Pipe Connection (kN)

(continued)

*DYNAMIC LOADS

Effective Tension

Load Case No.	Load Case Description [a]	Effective Tension at Flexible Pipe Connection (kN)				No. of Cycles
		Min.	Mean.	Max.	Range	

*Bending Moment

Load Case No.	Load Case Description [a]	About Horizontal Axis in Flexible Pipe Plane at Flexible Pipe Connection (kN·m)				About Horizontal Axis Transverse to Flexible Pipe Plane at Flexible Pipe Connection (kN·m)				Resultant at Flexible Pipe Connection (kN·m)				No. of Cycles
		Min.	Mean	Max.	Range	Min.	Mean	Max.	Range	Min.	Mean	Max.	Range	

*Shear Force

Load Case No.	Load Case Description [a]	Horizontal Direction in Flexible Pipe Plane at Flexible Pipe Connection (kN)				Horizontal Axis Transverse to Flexible Pipe Plane at Flexible Pipe Connection (kN)				Resultant at Flexible Pipe Connection (kN)				No. of Cycles
		Min.	Mean	Max.	Range	Min.	Mean	Max.	Range	Min.	Mean	Max.	Range	

[a] Include specification of load condition, i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.

MARKING	
Marking requirements:	

Annex P
(informative)

Purchasing Guidelines for Load-transfer Devices

Table P.1 gives purchasing guidelines for load-transfer devices. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each length of flexible pipe.

Table P.1—Purchasing Guidelines for Load-transfer Devices

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser's technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				
FLEXIBLE PIPE DESIGN PARAMETERS					
*Internal diameter (mm):					
*Service type:					
*Service life (years):					
Drawings of end fitting *at load transfer device end* of flexible pipe attached [a]?	☐ Yes ☐ No				
[a] Where the load-transfer device is to interface with the end-fitting.					

LOAD-TRANSFER DEVICE DESIGN PARAMETERS	
*Minimum internal radius (m):	
*Requirements for self-locking?	☐ Yes ☐ No
SUPPORT STRUCTURE DESIGN PARAMETERS	
*Load transfer device interfacing with end-fitting?:	☐ Yes ☐ No
*Load transfer device interfacing with bend stiffener interface structure?:	☐ Yes ☐ No
If yes, drawings of bend stiffener interface structure attached?:	☐ Yes ☐ No
*Load transfer device interfacing with I-tube?:	☐ Yes ☐ No
ADJACENT STRUCTURES	
*Grade of material for adjacent structures:	
*Manufacturer to have responsibility to ensure compatibility of connector materials with adjacent structures?	☐ Yes ☐ No
I-TUBE DESIGN PARAMETERS	
If yes, drawings of I-tube attached (including base flange)?	☐ Yes ☐ No
As-built I-tube dimensions available?	☐ Yes ☐ No
If yes, as-built external diameter of I-tube [a] (m):	
Angle of I-tube centerline co-linear with vertical axis?	☐ Yes ☐ No
If no, specify angle of centerline with vertical axis:	
[a] Existing I-tubes only, and where available.	

CORROSION PROTECTION	
Details of CP system for adjacent structures:	
Required corrosion-protection coating for load transfer device:	
Required corrosion-protection coating for fasteners:	
CP system requirements:	

INSTALLATION	
*Diver-assisted or diverless make-up?	☐ Diver-assisted ☐ Diverless
Requirement for disconnection/reconnection of load-transfer device?	☐ Yes ☐ No
*Maximum misalignment angle with respect to vertical axis to be accommodated during pull-in [a] (º):	
*Topside pulling capacity [a] (kN):	
*Sensitivity of topside pulling capacity (N):	
*Requirements for self-aligning?	☐ Yes ☐ No
***Space Available for Load Transfer Device on Vessel/Platform**	
Width (m)	
Height (m)	
Length (m)	
[a] Where applicable.	

DESIGN LOADS		
*Maximum allowable bending moment at I-tube base flange [a] (kN·m)?		
*STATIC LOADS		
Effective Tension		
Load Case No.	**Load Case Description [b]**	**Effective Tension at Flexible Pipe Connection (kN)**

BENDING MOMENT				
Load Case No.	**Load Case Description [b]**	**About Horizontal Axis in Flexible Pipe Plane at Flexible Pipe Connection (kN·m)**	**About Horizontal Axis Transverse to Flexible Pipe Plane at Flexible Pipe Connection (kN·m)**	**Resultant at Flexible Pipe Connection (kN·m)**

Shear Force				
Load Case No.	**Load Case Description**	**Horizontal Direction in Flexible Pipe Plane at Flexible Pipe Connection (kN)**	**Horizontal Direction Transverse to Flexible Pipe Plane at Flexible Pipe Connection (kN)**	**Resultant at Flexible Pipe Connection (kN)**

(continued)

*DYNAMIC LOADS

Effective Tension

Load Case No.	Load Case Description [b]	Effective Tension at Flexible Pipe Connection (kN)				No. of Cycles
		Min.	Mean	Max.	Range	

*Bending Moment

Load Case No.	Load Case Description [b]	About Horizontal Axis in Flexible Pipe Plane at Flexible Pipe Connection (kN·m)				About Horizontal Axis Transverse to Flexible Pipe Plane at Flexible Pipe Connection (kN·m)				Resultant at Flexible Pipe Connection (kN·m)				No. of Cycles
		Min.	Mean	Max.	Range	Min.	Mean	Max.	Range	Min.	Mean	Max.	Range	

*Shear Force

Load Case No.	Load Case Description [b]	Horizontal Direction in Flexible Pipe Plane at Flexible Pipe Connection (kN)				Horizontal Direction Transverse to Flexible Pipe Plane at Flexible Pipe Connection (kN)				Resultant at Flexible Pipe Connection (kN)				No. of Cycles
		Min.	Mean	Max.	Range	Min.	Mean	Max.	Range	Min.	Mean	Max.	Range	

a Where the load-transfer device interfaces with an I-tube.

b Include specification of load condition, i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.

SPARES	
No. of spare fasteners required (%):	
MARKING	
Marking requirements:	

Annex Q
(informative)

Purchasing Guidelines for Mechanical Protection

Table Q.1 gives purchasing guidelines for abrasion and impact protection. Parameters marked with an asterisk (*) are mandatory.

Table Q.2 gives purchasing guidelines for blanket protection.

A separate form should be completed for each length of flexible pipe.

Table Q.1—Purchasing Guidelines for Abrasion and Impact Protection

REVISION HISTORY					
Revision:					
Date of revision:					
GENERAL INFORMATION					
Client:					
Client reference:					
Phone:					
Fax:					
Email:					
Project title:					
Location:					
Enquiry date:					
Required response date:					
Required delivery date:					
Purchaser's technical contact:					
Conformance to API Spec 17L1 required?	☐ Yes ☐ No				

FLEXIBLE PIPE DESIGN PARAMETERS	
Flexible pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Flexible pipe data sheet reference:	
*Internal diameter (mm):	
*Service type:	
*Service life (years):	
*External diameter (mm):	
*Tolerance on external diameter (mm):	
Flexible pipe damaged acceptance criteria attached?	☐ Yes ☐ No
ABRASION AND IMPACT DESIGN PARAMETERS	
*Required length of coverage (m):	
Required thickness (mm):	
Required density (kg/m^3):	
Lightweight banding material required?	☐ Yes ☐ No
Marine growth resistance required?	☐ Yes ☐ No
Requirement for length of individual lengths (m):	
CORROSION PROTECTION	
Required banding material:	
THERMAL INSULATION	
Thermal insulation required?	☐ Yes ☐ No
If yes, specify required U-value (W/m^2·K):	
If yes, specify required cooldown time (W/m^2·K):	

TEMPERATURE	
Internal Fluid Temperature [a]	
*Internal fluid design minimum temperature (°C):	
*Internal fluid design maximum temperature (°C):	
U-value of flexible pipe (please indicate whether this is based on internal or external diameter and, if specified per unit length, please specify to which length it refers):	
Internal fluid temperature profile over service life attached?	☐ Yes ☐ No
Flexible Pipe Outer Sheath Temperature [a]	
Temperature of flexible pipe external sheath at internal fluid design minimum temperature (°C):	
Temperature of flexible pipe external sheath at internal fluid design maximum temperature (°C):	
Air Temperature	
*Minimum storage/transport/installation temperature (°C):	
*Maximum storage/transport/installation temperature (°C):	
Seawater Temperature	
*Minimum temperature at abrasion and impact protection location (°C):	
*Maximum temperature at abrasion and impact protection location (°C):	
[a] Specify either internal fluid design minimum and maximum temperatures together with flexible pipe U-value or, alternatively, specify temperature of flexible pipe external sheath at internal fluid design minimum and maximum temperatures.	

EXTERNAL ENVIRONMENT	
Description of contact surfaces (i.e. seabed, mooring lines, etc.):	
*Design water depth (m):	
*Abnormally high levels of sunlight exposure (during storage, transport, installation, operation)? *If so, specify details of geographical location and approximate length of exposure (days):	☐ Yes ☐ No
FIRE RESISTANCE REQUIREMENTS	
Fire resistance requirements:	

DESIGN LOADS [a]	
Maximum flexible pipe curvature during operation (m^{-1}):	
Impact resistance requirements:	

Impact Load Details

Load Case No.	Load Case Description	Impact Energy (kJ)	Impact Velocity (m/s)	Diameter of Dropped Object (mm)

[a] To be specified if impact resistance requirements are different to NORSOK U-001.

SPARES	
No. of spare lengths of abrasion and impact protection required:	
Spare banding required (%):	
MARKING	
Marking requirements:	
PIGMENTATION	
Pigmentation requirements:	

Table Q.2—Purchasing Guidelines for Blanket Protection

REVISION HISTORY					
Revision:					
Date of revision:					

GENERAL INFORMATION	
Client:	
Client reference:	
Phone:	
Fax:	
Email:	
Project title:	
Location:	
Enquiry date:	
Required response date:	
Required delivery date:	
Purchaser's technical contact:	
Conformance to API Spec 17L1 required?	☐ Yes ☐ No

FLEXIBLE PIPE DESIGN PARAMETERS	
Flexible pipe data sheet attached for parameters not specified below?	☐ Yes ☐ No
Flexible pipe data sheet reference:	
*Internal diameter (mm):	
*Service type:	
*Service life (years):	
*External diameter (mm):	
Flexible pipe damaged acceptance criteria attached?	☐ Yes ☐ No

BLANKET PROTECTION DESIGN PARAMETERS	
*Surface area of coverage required (m^2):	
Required thickness (mm):	
Density or mass requirements:	

CROSSING LINES					
Line No.	**Functionality**	**Mass Per Unit Length (kg/m)**	**External Diameter (mm)**	**Max. Outer Temperature [a] (°C)**	**U-value [W/(m^2·K)]**

[a] Alternatively, specify U-value (in adjacent column).

TEMPERATURE	
Internal Fluid Temperature [a]	
*Internal fluid design minimum temperature (°C):	
*Internal fluid design maximum temperature (°C):	
U-value of flexible pipe (please indicate whether this is based on internal or external diameter and, if specified per unit length, please specify to which length it refers):	
Internal fluid temperature profile over service life attached?	☐ Yes ☐ No
Flexible Pipe Outer Sheath Temperature[a]	
Temperature of flexible pipe external sheath at internal fluid design minimum temperature (°C):	
Temperature of flexible pipe external sheath at internal fluid design maximum temperature (°C):	
Air Temperature	
*Minimum storage/transport/installation temperature (°C):	
*Maximum storage/transport/installation temperature (°C):	
Seawater Temperature	
*Minimum temperature at abrasion and impact protection location (°C):	
*Maximum temperature at abrasion and impact protection location (°C):	

[a] Specify either internal fluid design minimum and maximum temperatures together with flexible pipe U-value or, alternatively, specify temperature of flexible pipe external sheath at internal fluid design minimum and maximum temperatures.

EXTERNAL ENVIRONMENT	
Description of contact surfaces (i.e. seabed, mooring lines, etc.):	
*Design water depth (m):	
*Abnormally high levels of sunlight exposure (during storage, transport, installation, operation)? *If so, specify details of geographical location and approximate length of exposure (days):	☐ Yes ☐ No
INSTALLATION	
Requirements for compatibility with lifting equipment:	
Maximum payload (kg):	
MARKING	
Marking requirements:	
PIGMENTATION	
Pigmentation requirements:	

Annex R
(informative)

Purchasing Guidelines for Fire Protection

Table R.1 gives purchasing guidelines for fire protection. Parameters marked with an asterisk (*) are mandatory.

A separate form should be completed for each length of flexible pipe.

Table R.1—Purchasing Guidelines for Fire Protection

REVISION HISTORY					
Revision:					
Date of revision:					

GENERAL INFORMATION	
Client:	
Client reference:	
Phone:	
Fax:	
Email:	
Project title:	
Location:	
Enquiry date:	
Required response date:	
Required delivery date:	
Purchaser’s technical contact:	
Conformance to API Spec 17L1 required?	☐ Yes ☐ No

FLEXIBLE PIPE DESIGN PARAMETERS					
*Internal diameter (mm):					
*Service type:					
*Service life (years):					
*Nominal external diameter (mm):					
*Length of flexible pipe over which fire protection required (m):					
Outer sheath material:					
Thermal Properties [a]					
Specify as below or in graphical format:					
	Temperature				
Outer Sheath	____°C	____°C	____°C	____°C	____°C
Density (kg/m^3):					
Thermal conductivity [W/(m·K)]:					
Specific heat capacity [kJ/(kg·K)]:					
Tensile armour					
Density (kg/m^3):					
Thermal conductivity [W/(m·K)]:					
Specific heat capacity [kJ/(kg·K)]:					
Pressure armour					
Density (kg/m^3):					
Thermal conductivity [W/(m·K)]:					
Specific heat capacity [kJ/(kg·K)]:					
Carcass					
Density (kg/m^3):					
Thermal conductivity [W/(m·K)]:					
Specific heat capacity [kJ/(kg·K)]:					
Internal Pressure Sheath					
Density (kg/m^3):					
Thermal conductivity [W/(m·K)]:					
Specific heat capacity [kJ/(kg·K)]:					
Anti-wear Layer					
Density (kg/m^3):					
Thermal conductivity [W/(m·K)]:					
Specific heat capacity [kJ/(kg·K)]:					
______________________ Layer					
Density (kg/m^3):					
Thermal conductivity [W/(m·K)]:					
Specific heat capacity [kJ/(kg·K)]:					

[a] If required by the manufacturer or other party for numerical fire or heat-transfer simulations.

FIRE PROTECTION DESIGN PARAMETERS	
Flexible Pipe	
*Type of fire to resist:	
*Heat flux requirement (kW/m^2)	
*Time period over which fire protection required (h and min)	____ h ____ min
Level of fire protection:	☐ Pressure containment only ☐ Intact structure
End Fitting	
*Type of fire to resist:	
*Heat flux requirement (kW/m^2)	
*Time period over which fire protection required (h and min)	____ h ____ min
Level of fire protection:	☐ Pressure containment only ☐ Intact structure
Bend Stiffener	
*Type of fire to resist:	
*Heat flux requirement (kW/m^2)	
*Time period over which fire protection required (h and min)	____ h ____ min
Other Structures	
Please specify type of structure:	
*Type of fire to resist:	
*Heat flux requirement (kW/m^2)	
*Time period over which fire protection required (h and min)	____ h ____ min
HANG-OFF STRUCTURES	
Drawings of topside flexible pipe hang-off arrangement attached?	☐ Yes ☐ No
INTERNAL FLUID PARAMETERS [a]	
*Internal fluid design minimum temperature (°C):	
*Internal fluid design maximum temperature (°C):	
Internal fluid temperature profile over service life attached?	☐ Yes ☐ No
*Density (kg/m^3):	
*Thermal conductivity [W/(m·K)]:	
*Specific heat capacity [kJ/(kg·K)]:	

[a] If required by the manufacturer.

TEMPERATURE	
Air Temperature	
*Minimum storage/transport/installation temperature (°C):	
*Maximum storage/transport/installation temperature (°C):	
Seawater Temperature	
*Minimum temperature at fire protection location (°C):	
*Maximum temperature at fire protection location (°C):	
EXTERNAL ENVIRONMENT	
*Abnormally high levels of sunlight exposure (during storage, transport, installation, operation)? *If so, specify details of geographical location and approximate cumulative length of exposure to sunlight (days):	☐ Yes ☐ No
INSTALLATION	
*Reel diameter [a] (m):	
*Squeeze pressure applied by tensioners (kPa):	
*Tension applied by tensioner (kN):	
[a] Where installation involves placing bend stiffener on reel.	

DESIGN LOADS		
Load Case Description [b]	***Maximum Stress [a] in Outer Fiber of Fire Protection Material (MPa)**	***Maximum Strain [a] in Outer Fiber of Fire Protection Material (%)**
Fire protection required to resist blast loads? If yes, specify blast load parameters as required below:	☐ Yes ☐ No	
Blast load pressure (MPa):		
Blast load pressure pulse duration (ms):		
Other ballast load description:		
[a] Combined bending and tensile stress and strain. [b] Include specification of load condition i.e. Normal Operation (Recurrent Operation or Extreme Operation), Abnormal Operation, Installation, Accidental, FAT/Flexible Pipe Hydrostatic Test or Fatigue.		

MARKING	
Marking requirements:	
PIGMENTATION	
Pigmentation requirements:	

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14 Det Norske Veritas, Veritasveien 1, NO-1322 Hovik, Oslo, Norway, www.dnv.com.
15 Engineering Equipment and Materials Users' Association, 63 Mark Lane, London EC3R 7NQ, United Kingdom, www.eemua.co.uk.
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