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Suggested revisions are invited and should be submitted to the Standards and Publications Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

This standard is under the jurisdiction of the API Standards Subcommittee on Subsea Production Systems (API SC17). This API standard is identical with the English version of ISO 13628-2:2006. ISO 13628-2 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment*.

For the purposes of this standard, the following editorial change has been made:

- A national informative annex (Annex C - API Monogram) has been included giving guidance to users.

Contents

Page

API Foreword	ii
Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Terms and definitions	4
4 Symbols and abbreviated terms	9
5 Functional requirements	9
5.1 General	9
5.2 Overall requirements	10
5.3 General design parameters	10
5.4 Internal fluid parameters	10
5.5 External environment	12
5.6 System requirements	13
6 Design requirements	16
6.1 Loads and load effects	16
6.2 Pipe design methodology	17
6.3 Pipe structure design	20
6.4 System design requirements	25
7 Materials	28
7.1 Material requirements	28
7.2 Qualification requirements	32
7.3 Quality assurance requirements	39
8 Manufacturing requirements	41
8.1 Quality assurance requirements	41
8.2 Carcass	43
8.3 Polymer extrusions	43
8.4 Pressure and tensile armour layers	45
8.5 Anti-wear and insulation layers	45
8.6 End fitting	46
8.7 Special processes	47
8.8 Manufacturing tolerances	49
8.9 Repairs	49
9 Documentation	50
9.1 General	50
9.2 Design premise	50
9.3 Design load report	51
9.4 Design report	51
9.5 Manufacturing quality plan	52
9.6 Fabrication specification	52
9.7 As-built documentation	52
9.8 Operation manual	53

10 **Factory acceptance tests** 54

10.1 **General**..... 54

10.2 **Gauge test** 54

10.3 **Hydrostatic pressure test** 54

10.4 **Electrical continuity and resistance tests**..... 55

10.5 **Gas-venting system test** 55

11 **Marking and packaging** 56

11.1 **Marking** 56

11.2 **Packaging** 56

Annex A (informative) Purchasing guidelines..... 57

Annex B (informative) Bend stiffeners and bend restrictors 64

Annex C (informative) API Monogram 69

Bibliography 72

Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13628-2 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment*.

This second edition cancels and replaces the first edition (ISO 13628-2:2000), which has been technically revised.

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

- *Part 1: General requirements and recommendations*
- *Part 2: Unbonded flexible pipe systems for subsea and marine applications*
- *Part 3: Through flowline (TFL) systems*
- *Part 4: Subsea wellhead and tree equipment*
- *Part 5: Subsea umbilicals*
- *Part 6: Subsea production control systems*
- *Part 7: Completion/workover riser systems*
- *Part 8: Remotely Operated Vehicle (ROV) interfaces on subsea production systems*
- *Part 9: Remotely Operated Tool (ROT) intervention systems*
- *Part 10: Specification for bonded flexible pipe*
- *Part 11: Flexible pipe systems for subsea and marine applications*

The following parts are under development:

- *Part 12 dealing with dynamic production risers*
- *Part 13 dealing with remotely operated tools and interfaces on subsea production systems*

Introduction

This part of ISO 13628 is based on API Specification 17J, *Specification for unbonded flexible pipe*, Second edition, November 1999, and the Amendment issued June 2002. This part of ISO 13628 has been technically revised and updated to cater to the needs of the international oil and natural gas industries.

Users of this part of ISO 13628 should be aware that further or differing requirements might be needed for individual applications. This part of ISO 13628 is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this part of ISO 13628 and provide details.

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

Part 2: Unbonded flexible pipe systems for subsea and marine applications

1 Scope

This part of ISO 13628 defines the technical requirements for safe, dimensionally and functionally interchangeable flexible pipes that are designed and manufactured to uniform standards and criteria. Minimum requirements are specified for the design, material selection, manufacture, testing, marking and packaging of flexible pipes, with reference to existing codes and standards where applicable. See ISO 13628-11 for guidelines on the use of flexible pipes and ancillary components.

This part of ISO 13628 applies to unbonded flexible pipe assemblies, consisting of segments of flexible pipe body with end fittings attached to both ends. This part of ISO 13628 does not cover flexible pipes of bonded structure. This part of ISO 13628 does not apply to flexible pipe ancillary components. Guidelines for bend stiffeners and bend restrictors are given in Annex B.

NOTE 1 Guidelines for other components are given in ISO 13628-11.

This part of ISO 13628 does not apply to flexible pipes that include non-metallic tensile armour wires. Pipes of such construction are considered as prototype products subject to qualification testing.

The applications addressed by this part of ISO 13628 are sweet and sour service production, including export and injection applications. Production products include oil, gas, water and injection chemicals. This part of ISO 13628 applies to both static and dynamic flexible pipes used as flowlines, risers and jumpers. This part of ISO 13628 does not apply to flexible pipes for use in choke-and-kill line applications.

NOTE 2 See API Specification 16C for choke-and-kill line applications.

NOTE 3 ISO 13628-10 provides guidelines for bonded flexible pipe.

2 Normative references

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

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 (all parts), *Plastics — Determination of Charpy impact properties*

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

ISO 306, *Plastics — Thermoplastic materials — Determination of Vicat softening temperature (VST)*

- ISO 307, *Plastics — Polyamides — Determination of viscosity number*
- 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 899-1, *Plastics — Determination of creep behaviour — Part 1: Tensile creep*
- ISO 974, *Plastics — Determination of the brittleness temperature by impact*
- ISO 1183 (all parts), *Plastics — Methods for determining the density of non-cellular plastics*
- ISO 3384, *Rubber, vulcanized or thermoplastic — Determination of stress relaxation in compression at ambient and at elevated temperatures*
- ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*
- ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*
- ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*
- ISO 8457-2, *Steel wire rod — Part 2: Quality requirements for unalloyed steel wire rods for conversion to wire*
- ISO 8692, *Water quality — Freshwater algal growth inhibition test with unicellular green algae*
- ISO 9352, *Plastics — Determination of resistance to wear by abrasive wheels*
- ISO 10423:2003, *Petroleum and natural gas industries — Drilling and production equipment — Wellhead and christmas tree equipment*
- ISO 10474:1991, *Steel and steel products — Inspection documents*
- ISO 11357-1, *Plastics — Differential scanning calorimetry (DSC) — Part 1: General principles*
- ISO 11357-4, *Plastics — Differential scanning calorimetry (DSC) — Part 4: Determination of specific heat capacity*
- ISO 11359-2, *Plastics — Thermomechanical analysis (TMA) — Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature*
- ISO 13628-4, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 4: Subsea wellhead and tree equipment*
- ISO 13847, *Petroleum and natural gas industries — Pipeline transportation systems — Welding of pipelines*
- ISO 15156 (all parts), *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production*
- API ¹⁾ Spec 16C, *Specification for Choke and Kill Systems*
- ASME ²⁾ Boiler and Pressure Vessel Code, Section IX, *“Welding and Brazing Qualifications”*
- ASTM ³⁾ A29, *Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for*

1) American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005, USA

2) American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990, USA

3) American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428, USA

ASTM A182, *Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service*

ASTM A388, *Standard Practice for Ultrasonic Examination of Heavy Steel Forgings*

ASTM A480, *Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip*

ASTM A668, *Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use*

ASTM A751, *Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products*

ASTM C177, *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 Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus*

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

ASTM D789, *Standard Test Methods for Determination of Relative Viscosity of Polyamide (PA)*

ASTM D1238, *Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer*

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

ASTM D1505, *Standard Test Method for Density of Plastics by the Density-Gradient Technique*

ASTM D1693, *Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics*

ASTM D5028, *Standard Test Method for Curing Properties of Pultrusion Resins by Thermal Analysis*

ASTM D6869, *Standard Test Method for Coulometric and Volumetric Determination of Moisture in Plastics Using the Karl Fischer Reaction (the Reaction of Iodine with Water)*

ASTM E94, *Standard Guide for Radiographic Examination*

ASTM E165, *Standard Test Method for Liquid Penetrant Examination*

ASTM E384, *Standard Test Method for Microindentation Hardness of Materials*

ASTM E428, *Standard Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Examination*

ASTM E709, *Standard Guide for Magnetic Particle Examination*

ASTM E1356, *Standard Test Method for Assignment of the Glass Transition Temperatures by Differential Scanning Calorimetry*

ASTM G48-03, *Standard Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution*

DNV ⁴⁾ Fire Test, *DNV Classification Note 6.1 Test (Fire Test)*

EN ⁵⁾ 287-1, *Qualification test of welders — Fusion welding — Part 1: Steels*

EN 288-1, *Specification and approval of welding procedures for metallic materials Part 1: General rules for fusion welding*

4) Det Norske Veritas, Veritasveien 1, 1322 Høvik, Norway

5) European Committee for Standardization, CEN Management Centre, 36, rue de Stassart, B-1050, Brussels

EN 288-2, *Specification and approval of welding procedures for metallic materials Part 2: Welding procedure specification for arc welding*

EN 288-3, *Specification and approval of welding procedures for metallic materials Part 3: Welding procedure tests for the arc welding of steels*

EN 10204:2004, *Metallic products — Types of inspection documents*

Lloyds ⁶⁾ Fire Test, *Lloyds Register of Shipping, Fire Testing — Memorandum ICE/Fire OSG 1000/499*

NACE ⁷⁾ TM 01-77, *Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H₂S Environments*

3 Terms and definitions

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

3.1

ancillary components

components used to control the flexible pipe behaviour, such as bend stiffeners and buoyancy modules

3.2

annulus

space between the internal pressure sheath and outer sheath

NOTE Permeated gas and liquid is generally free to move and mix in the annulus.

3.3

anti-wear layer

non-metallic layer, either extruded thermoplastic sheath or tape wrapping, used to minimize wear between structural layers

3.4

bellmouth

part of a guide tube, formed in the shape of a bellmouth, and designed to prevent overbending of the flexible pipe

3.5

bend limiter

any device used to restrict bending of the flexible pipe

NOTE Bend limiters include bend restrictors, bend stiffeners, and bellmouths.

3.6

bend radius

radius of curvature of the flexible pipe measured from the pipe centreline

NOTE Storage and operating minimum bend radius (MBR) are defined in 6.3.1.

3.7

bend restrictor

mechanical device that functions as a mechanical stop and limits the local radius of curvature of the flexible pipe to a minimum value

6) Lloyd's Register EMEA, 71 Fenchurch Street, London, EC3M 4BS, United Kingdom

7) NACE International, 1440 South Creek Drive, Houston, Texas 77084-4906 USA

3.8**bend stiffener**

ancillary conical shaped component, which locally supports the pipe to limit bending stresses and curvature of the pipe to acceptance levels

NOTE Bend stiffeners can be either attached to an end fitting or a support structure where the flexible pipe passes through the bend stiffener.

3.9**bending stiffness**

ability of a flexible pipe to resist deflection when subjected to bending loads at constant tension, pressure and temperature

3.10**bonded pipe**

flexible pipe in which the steel reinforcement is integrated and bonded to a vulcanized elastomeric material where textile material is included in the structure to obtain additional structural reinforcement or to separate elastomeric layers

3.11**burst disk**

weak points in the outer sheath designed to burst when the gas pressure in the annulus exceeds a specified value

NOTE The weak point is induced by reducing the thickness of the sheath over a localized area.

3.12**carcass**

interlocked metallic construction that can be used as the innermost layer to prevent, totally or partially, collapse of the internal pressure sheath or pipe due to pipe decompression, external pressure, tensile armour pressure, and mechanical crushing loads

NOTE The carcass may be used externally to protect the external surface of the pipe.

3.13**choke-and-kill line**

flexible pipe jumper located between choke manifold and blow-out preventer

3.14**connector**

device used to provide a leak-tight structural connection between the end fitting and adjacent piping

NOTE Connectors include bolted flanges, clamped hubs, and proprietary connectors. They may be designed for diver-assisted makeup or for diverless operation using either mechanical or hydraulic apparatus.

3.15**crossover**

flexible flowline crossing another pipe already laid on the seabed

NOTE The underlying pipe may be a steel pipe or another flexible pipe. It may be required to support the overlying pipe to prevent overbending or crushing of the new or existing pipes.

3.16**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 This report may include occasional amendments or revisions to address extensions beyond previous limits or revisions of methodologies.

3.17**design pressure**

minimum or maximum pressure, inclusive of operating pressure, surge pressure including shut-in pressure where applicable, vacuum conditions and static pressure head

3.18**dynamic application**

flexible pipe configuration that is subjected to loads that vary in time, or whose deflections or boundary conditions vary in time

3.19**end fitting**

mechanical device which forms the transition between the flexible pipe body and the connector whose different pipe layers are terminated in the end fitting in such a way as to transfer the load between the flexible pipe and the connector

3.20**fishscaling**

tendency of one tensile armour wire edge to lift off of the underlying layer because of deflection or incorrect twist deformation during armour winding

3.21**flexible flowline**

flexible pipe, wholly or in part, resting on the seafloor or buried below the seafloor, and used in a static application

NOTE The term flowline is used in this document as a generic term for flexible flowlines.

3.22**flexible pipe**

assembly of a pipe body and end fittings where the pipe body is composed of a composite of layered materials that form a pressure-containing conduit and the pipe structure allows large deflections without a significant increase in bending stresses

NOTE Normally the pipe body is built up as a composite structure composed of metallic and polymer layers. The term "pipe" is used in this document as a generic term for flexible pipe.

3.23**flexible riser**

flexible pipe connecting a platform/buoy/ship to a flowline, seafloor installation, or another platform where the riser may be freely suspended (free, catenary), restrained to some extent (buoys, chains), totally restrained or enclosed in a tube (I- or J-tubes)

3.24**independent verification agent**

independent party or group, selected by the manufacturer, who can verify the indicated methodologies or performance based on the technical literature, analyses, and test results and other information provided by the manufacturer

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

3.25**insulation layer**

additional layer added to the flexible pipe to increase the thermal insulation properties, usually located between the outer tensile armour layer and the outer sheath

3.26**intermediate sheath**

extruded polymer layer located between internal pressure and outer sheaths, which may be used as a barrier to external fluids in smooth bore pipes or as an anti-wear layer

3.27**internal pressure sheath**

polymer layer that ensures internal-fluid integrity

NOTE This layer may consist of a number of sub-layers.

3.28**jumper**

short flexible pipe used in subsea and topside, static, or dynamic applications

3.29**lay angle**

angle between the axis of a spiral wound element (for example, armour wires) and a line parallel to the flexible pipe longitudinal axis

3.30**outer sheath**

polymer layer used to protect the pipe against penetration of seawater and other external environments, corrosion, abrasion and mechanical damage, and to keep the tensile armours in position after forming

3.31**piggyback**

two pipes attached at regular intervals with clamps, where either or both of the pipes can be flexible

3.32**pressure armour layer**

structural layer with a lay angle close to 90°, that increases the resistance of the flexible pipe to internal and external pressure and mechanical crushing loads; structurally supports the internal-pressure sheath; and typically consists of an interlocked metallic construction, which may be backed up by a flat metallic spiral layer

3.33**quality**

conformance to specified requirements

3.34**quality assurance**

planned, systematic, and preventive actions that are required to ensure that materials, products, or services meet specified requirements

3.35**quality control**

inspection, test or examination to ensure that materials, products or services conform to specified requirements

3.36**quality programme**

established documented system to ensure quality

3.37**rough bore**

flexible pipe with a carcass as the innermost layer

3.38**service life**

period of time during which the flexible pipe fulfils all performance requirements

3.39**smooth bore**

flexible pipe with an internal pressure sheath as the innermost layer

3.40**sour service**

service conditions at the design pressure with a H₂S content exceeding the minimum specified by ISO 15156 (all parts)

3.41**static application**

flexible pipes not exposed to significant cyclically varying loads or deflections during normal operations

3.42**sweet service**

service conditions at the design pressure which have a H₂S content less than that specified by ISO 15156 (all parts)

3.43**tensile armour layer**

structural layer with a lay angle typically between 20° and 55°, which consists of helically wound metallic wires, and is used to sustain, totally or partially, tensile loads and internal pressure

NOTE Tensile armour layers are typically counter-wound in pairs.

3.44**torsional balance**

pipe characteristic that is achieved by designing the structural layers in the pipe, such that axial and pressure loads do not induce significant twist or torsional loads in the pipe

3.45**ultimate strength**

maximum tensile stress that a material can withstand before rupture

3.46**unbonded flexible pipe**

pipe construction consists of separate unbonded polymeric and metallic layers, which allows relative movement between layers

3.47**visual examination**

examination of parts and equipment for visible defects in material and workmanship

3.48**yield strength**

stress level at which a metal or other material ceases to behave elastically

4 Symbols and abbreviated terms

DSC	differential scanning calorimetry
FAT	factory acceptance test
GA	general arrangement
HAZ	heat-affected zone
HIC	hydrogen-induced cracking
HV	hardness on Vickers Scale
ID	internal diameter
MBR	minimum bend radius
NDE	non-destructive examination
PA	polyamide
PE	polyethylene
PSL	production specification level
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
RAO	response amplitude operator
SSC	sulfide stress cracking
S-N	curves showing stress range vs. number of cycles
TAN	titrated acid number
TFL	through-flowline
UNS	Unified National Standard or Unified Numbering System
UV	ultraviolet
σ_y	material yield stress
σ_u	material ultimate stress

5 Functional requirements

5.1 General

5.1.1 The purchaser shall specify his functional requirements for the flexible pipe. The purchasing guidelines in Annex A give a sample format for the specification of the functional requirements.

5.1.2 Functional requirements not specifically required by the purchaser and that can affect the design, materials, manufacturing, and testing of the pipe shall be specified by the manufacturer.

5.1.3 If the purchaser does not specify a requirement, and 5.1.2 does not apply, the manufacturer may assume that there is no requirement.

5.2 Overall requirements

5.2.1 Flexible pipe

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

- a) The pipe shall provide a leak-tight conduit.
- b) The pipe shall be capable of withstanding all design loads and load combinations defined herein.
- c) The pipe shall perform its function for the specified service life.
- d) The flexible pipe materials shall be compatible with the environment to which the material is exposed.
- e) The flexible pipe materials shall conform to the corrosion control requirements specified herein.

5.2.2 End fitting

The manufacturer shall demonstrate that the end fitting, as a minimum, meets the same functional requirements as the flexible pipe. Where relevant, the following shall be demonstrated.

- a) The end fitting shall provide a structural interface between the flexible pipe and the support structure.
- b) The end fitting shall provide a structural interface between the flexible pipe and bend-limiting devices, including bend stiffeners, bend restrictors and bellmouths, such that the bend-limiting devices meet their functional requirements.

5.3 General design parameters

The purchaser shall specify any project-specific design requirements, including the requirements of 5.4 to 5.6 and the following:

- a) nominal internal diameter;
- b) length and tolerances of flexible pipe, including end fittings;
- c) service life.

Purchasing guidelines are given in Annex A.

5.4 Internal fluid parameters

5.4.1 General

The purchaser shall specify the internal fluid parameters for the application. The parameters listed in Table 1 should be specified. When known, the minimum, normal and maximum conditions shall be specified for the internal fluid parameters of Table 1. Expected variations in the internal fluid parameters over the service life shall be specified.

Table 1 — Internal fluid parameters

Parameter	Comment
Internal pressure	See 5.4.2
Temperature	See 5.4.3
Fluid composition	See 5.4.4
Service definition	Sweet or sour in accordance with 5.4.4 a)
Fluid/flow description	Fluid type and flow regime
Flow rate parameters	Flow rates, fluid density, viscosity, minimum inlet pressure, and required outlet pressure
Thermal parameters	Fluid heat capacity

5.4.2 Internal pressure

5.4.2.1 The following internal pressures shall be specified:

- a) maximum design pressure;
- b) minimum design pressure.

5.4.2.2 The following internal pressures should be specified:

- a) operating pressure or pressure profile through service life;
- b) factory and field-test pressure requirements of governing and/or certifying authorities.

5.4.3 Temperature

5.4.3.1 The following temperatures shall be specified:

- a) design minimum temperatures;
- b) design maximum temperatures.

The operating temperature or temperature profiles through the service life should be specified.

5.4.3.2 The design minimum and maximum temperatures are the minimum and maximum temperatures that can be experienced by the flexible pipe throughout the service life. These design temperatures may be specified on the basis of the following minimum set of considerations:

- a) operating temperatures;
- b) upset temperatures (number and range of cycles);
- c) gas-cooling effects (time/temperature curve);
- d) fluid thermal characteristics;
- e) flow characteristics;
- f) storage, transport and installation conditions.

5.4.4 Fluid composition

The purchaser should specify produced fluids (composition of individual phases), injected fluids and continual and occasional chemical treatments (dosages, exposure times, concentrations, and frequency). In the specification of the internal fluid composition, the following should be defined:

- a) all parameters that define service conditions, including partial pressure of H_2S and CO_2 , pH of aqueous phase, TAN (in accordance with ASTM D664 or ASTM D974), and water content (produced water, seawater, and free water);
- b) gases, including oxygen, hydrogen, methane, and nitrogen;
- c) liquids, including oil composition and alcohols;
- d) aromatic components;
- e) corrosive agents, including bacteria, chlorides, organic acids, and sulfur-bearing compounds;
- f) injected chemical products including alcohols and inhibitors for corrosion, hydrate, paraffin, scale, and wax;
- g) solids, including sand, precipitates, scale, hydrates, wax, and biofilm.

5.5 External environment

The purchaser should specify the project external environmental parameters. The parameters listed in Table 2 should be considered. The design water depth shall be the maximum water depth to which the pipe section may be exposed.

Table 2 — External environment parameters

Parameter	Comment
Location	Geographical data for the installation location
Water depth	Design water depth, variations over pipe location and tidal variations
Seawater data	Density, pH value and minimum and maximum temperatures
Air temperature	Minimum and maximum during storage, installation and operation
Soil data	Description, shear strength or angle of internal friction, friction coefficients seabed scour, sand waves and variations along pipe route
Marine growth	Maximum values and variations along length
Ice	Maximum ice accumulation or drifting icebergs and ice floes
Sunlight exposure	Length of pipe exposed during operation and storage conditions
Current data	As a function of water depth, direction, and return period, and including the known effects of local current phenomena
Wave data	In terms of significant and maximum waves, associated periods, wave spectra, spreading functions and scatter diagrams, as a function of direction and return period
Wind data	As a function of direction, height above water level and return period

5.6 System requirements

5.6.1 Minimum system requirements

5.6.1.1 General

5.6.1.1.1 The purchaser shall specify the system functional requirements of the project. The requirements of 5.6.1.2, 5.6.1.9, and 5.6.1.10 shall be specified by the purchaser. Specification of the other system requirements defined in Clause 5 should be considered. Annex A may be referenced for guidelines.

5.6.1.1.2 The purchaser should specify the documentation, as listed in Clause 9, to be delivered by the manufacturer.

5.6.1.2 Application definition

The flexible pipe system shall be specified as either flowline, riser or jumper. The flexible pipe application shall be specified as either static or dynamic and the expected number of load cycles and magnitudes should be specified for dynamic cases.

5.6.1.3 Corrosion protection

The corrosion protection requirements for the flexible pipe should be specified, considering the following:

- a) end fitting internal and external corrosion protection;
- b) cathodic protection system for the pipe;
- c) protection voltage, current source and current density.

5.6.1.4 Thermal insulation

The purchaser should specify any performance requirements of the flexible pipe for heat loss or retention. Overall heat transfer coefficients shall be based on pipe nominal ID and shall differentiate between the pipe itself and any external effects, such as soil cover for buried pipe.

5.6.1.5 Gas venting

A gas-venting system shall be required to prevent excessive pressure build-up in the annulus of the pipe. Requirements the purchaser has for the gas-venting system should be specified, considering the following:

- a) gas-venting system components;
- b) allowable gas permeation rates;
- c) restrictions on gas-venting locations;
- d) interface requirements;
- e) gas-monitoring system.

5.6.1.6 Pigging and TFL requirements

Any performance requirements for allowing tools for pigging, TFL, workover, or other operations through the flexible pipe, including ID, bend radius, and end-fitting transitions should be specified.

5.6.1.7 Fire resistance

Fire resistance requirements for the pipe design should be specified, with reference to Lloyds or DNV fire test requirements (see 6.4.6.1).

5.6.1.8 Piggyback lines

Any piggyback requirements for the flexible pipe should be specified, including details of the piggyback pipe(s) and pipe-operating conditions.

5.6.1.9 Connectors

The connector requirements for both end fittings in the flexible pipe shall be specified. This shall include, as a minimum, connector type, welding specification, seal type, and sizes.

5.6.1.10 Interface definitions

Interface details including, but not limited to, the following shall be specified:

- a) regulations, codes, and standards, including definition of code breaks;
- b) geometric, dimensional, and imposed loading data;
- c) purchaser-supplied installation aids and equipment;
- d) purchaser-supplied pull-in and connection tools and terminations;
- e) manufacturer scope of supply.

5.6.1.11 Inspection and condition monitoring

The requirements for the manufacturer to design and implement flexible pipe inspection, monitoring, and condition assessment systems and procedures should be specified.

5.6.1.12 Installation requirements

5.6.1.12.1 The purchaser should specify performance requirements for installation services to be provided, considering the following as a minimum.

- a) For installation by the purchaser, he or she should specify any requirements on load restrictions, clamping/tensioner loads, overboarding chute requirements, installation tolerances and port facility limitations.
- b) For installation by the manufacturer, the purchaser should specify for any requirements for season, environment, vessel limitations, installation tolerances, restrictions due to conflicting activities and installation scope (including trenching, burial, testing, inspection, surveying, and documentation).

5.6.1.12.2 The purchaser should specify any requirements for recoverability and reusability of the flexible pipe within its service life.

5.6.1.13 Exothermal chemical reaction cleaning

The purchaser should specify the relevant parameters for the pipe-cleaning operations by means of exothermal chemical reaction, considering the following as a minimum:

- a) flow rate;
- b) pressure variation;
- c) maximum heat output;
- d) chemical composition.

5.6.2 Flowline parameters

The purchaser should specify to the manufacturer his requirements for design and analysis of the flowline (or static jumper) system additional to the requirements of Clause 6. The parameters listed in Table 3 should be considered.

5.6.3 Riser parameters

The purchaser shall specify to the manufacturer his requirements for design and analysis of the riser (or dynamic jumper) system additional to the requirements of Clause 6. The parameters listed in Table 4 should be considered.

Table 3 — Flowline parameters

Parameter	Details
Flowline routing	Route drawings, topography, seabed/soil conditions, obstacles, and installed equipment and pipelines
Guides and supports	Proposed geometry of guides, I-tubes, J-tubes, and bellmouths through which flowline is to be installed
Protection requirements	Trenching, rock dumping, mattresses, and extent of protection requirements over length of pipe. Design impact loads, including those from trawl boards, dropped objects, and anchors
On-bottom stability	Allowable displacements
Upheaval buckling	Specification of design cases to be considered by manufacturer
Crossover requirements	Crossing of pipes (flexible and rigid), including already installed pipes and gas lines
Pipe attachments	Bend restrictors, clamps, and attachment methods
Load cases	Definition of yearly probability for installation and normal and abnormal operation. Specification of accidental load cases and yearly probabilities

Table 4 — Riser parameters

Parameter	Details
Riser configuration	Specification of any requirements for the configuration, including description (lazy-S, steep wave, etc.), layout and components. Selection of configuration or confirmation of suitability of specified configuration
Connection systems	Descriptions of upper and lower connection systems, including quick disconnection systems and buoy disconnection systems, connection angles and location tolerances
Pipe attachments	Bend stiffeners, buoys, etc., and attachment methods
Attached vessel data	Data for attached floating vessels, including the following: <ul style="list-style-type: none"> a Vessel data, dimensions, drafts, and the like; b Static offsets; c First (RAOs) and second order motions; d Vessel motion phase data; e Vessel motion reference point; f Mooring system interface data; g Position tolerances.
Interference requirements	Specification of possible interference areas, including other risers, mooring lines, platform columns, vessel pontoons, tanker keel, and so on, and definition of allowable interference/clashing
Load cases	Definition of yearly probability for installation, and normal and abnormal operation specification of accidental load cases and yearly probabilities

6 Design requirements

6.1 Loads and load effects

6.1.1 General

The pipe design is based on the information supplied by the purchaser (see guidelines of Annex A), with reference to the requirements of Clause 5. All relevant information shall be defined in the design premise (see 9.2) including design load cases. Results of the design load case analyses shall be included in the design load report (see 9.3).

6.1.2 Definition of load classes

6.1.2.1 Loads are classified as functional, environmental (external), or accidental, defined as follows.

- a) Functional loads are all loads on the pipe in operation, including all loads that act on the pipe in still water except wind, wave or current loads.
- b) Environmental loads are loads induced by external environmental parameters.
- c) Accidental loads are loads caused by accidental occurrences.

Load classes and many subclasses are listed in the left column of Table 5.

6.1.2.2 The design load cases shall be defined to analyse, as applicable, the effect on the flexible pipe of functional, environment, and accidental loads. See ISO 13628-11 for guidelines on the analysis techniques to be used for the loads given in Table 5.

6.1.3 Load combinations and conditions

6.1.3.1 The flexible pipe design shall be shown to meet the design requirements under the load combinations specified in 6.1.3. All loads, including loads specified in 6.1.2.2, that act on the flexible pipe, shall be evaluated. Variation of the loads in time and space, load effects from the flexible pipe system and its supports as well as environmental and soil conditions shall be analysed.

6.1.3.2 The design load conditions that shall be analysed are installation, normal operation (recurrent and extreme), abnormal operation and factory acceptance testing. Load combinations shall be as defined in the notes for Table 5 and the column headings in Table 6. Load combinations with a yearly probability of occurrence less than 10^{-4} can be ignored. Factory acceptance test (FAT) load combinations shall be defined by the manufacturer based on the FAT procedures.

6.1.3.3 Design checks shall be carried out for any temporary conditions specified by the purchaser or the manufacturer. These shall be subject to the same design criteria as the design load conditions, as specified in Table 6.

6.1.3.4 The simultaneous occurrence of different load combinations shall be defined in the manufacturer's design premise (see 9.2). 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 (Tables 3 and 4). If the purchaser does not specify probabilities, the manufacturer shall propose the probabilities that are used for the individual events in the design premise.

6.1.3.5 The design-load cases analysed shall be derived from the loading conditions specified in 6.1.2.2 and the column headings in Table 6.

6.1.4 Design-load effects

6.1.4.1 In the pipe design, the manufacturer shall account for the effects of internal and external pressures. When the external hydrostatic pressure is included in the calculation of the design internal pressure for the pipe, then the manufacturer shall specify the water depth at which the design internal pressure is given. This shall also be specified in the pipe markings (see 11.1).

6.1.4.2 Hydrodynamic load effects shall be determined by validated and documented methods that account for the kinematics of the seawater and the interaction effects of the different environmental phenomena. See ISO 13628-11 for guidelines on analysis methods.

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

6.1.4.4 Any accidental loads or combinations thereof can damage or render unfit for service a flexible pipe. Load cases that include accidental loads (e.g., increased offsets due to anchor line or thruster failures) and do not violate the requirements of Table 6, define a limit on the safe occurrence of the accidental loads. Some accidental loads (e.g., fire and explosion) might not be easily analysed in terms of the requirements in Table 6. In such cases, testing shall be used to define safe working times of other limits associated with the accidental load.

6.2 Pipe design methodology

6.2.1 Initially and whenever revisions occur, the pipe design methodology shall be verified by an independent verification agent. The documentation submitted for verification of the design methodology shall include the following, as a minimum:

- a) description of theoretical basis, including calculation procedures for the pipe design parameters required for the design report, as specified in 9.4;
- b) calculation method for all pipe layers and components;
- c) verification of the theoretical basis with prototype tests. The verification shall include the capacity of all pipe structural layers. Simplified conservative analysis methods for checking of non-critical layers, such as anti-wear layers, are acceptable if the method does not influence the reliability of the calculation of stresses in the other layers.
- d) documented basis for stress concentration factors used for the steel materials, including stress concentrations at and within the end-fitting interface, at clamped accessories and due to contact with rigid surfaces, manufacturing tolerances and load-induced gaps;
- e) manufacturing and design tolerances, manufacturing-induced stresses, welds and other effects that influence structural capacity;
- f) documentation of the service life methodology, subject to the requirements of 6.3.4.

Table 5 — Load combinations of load classes, load conditions

Load classes and subclasses	Load conditions		
	Normal operation	Extreme operation	Abnormal operation
Recurrent operation			
Functional loads			
a Loads due to weight and buoyancy of pipe, contents, and attachments, both temporary and permanent.	X	X	X
b Internal pressure as specified in 5.4.2.	Max./Min. operating pressure	Design pressure	Design pressure
c Loads from pressure and temperature variations.	X	X	X
d External pressure.	X	X	X
e External soil or rock reaction forces for trenched, buried, or rock dumped pipes.	X	X	X
f Static reaction and deformation loads from supports and protection structures.	X	X	X
g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
k Interaction effects of bundled or clamped pipes.	X	X	X
l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
Accidental loads			
Loads and motions caused directly or indirectly by accidental occurrences, including the following:	Not applicable	See ^a	See ^b
1 Dropped objects	"	"	"
2 Trawl board impact	"	"	"
3 Internal over-pressure	"	"	"
4 Compartment damage or unintended flooding	"	"	"
5 Failure of thrusters	"	"	"
6 DP failure	"	"	"
7 Anchor line failure	"	"	"
8 Failure of turret drive system	"	"	"
Environmental loads shall be combined with the operation conditions to the specified probability of occurrence.			
^a Load combinations of the Functional, Environmental and Accidental Loads tabulated in Table 5, as shown in Table 6, shall be analysed if the yearly combined probability, P_c , of occurrence is equal to or greater than 10^{-2} .			
^b Load combinations, as shown in Table 6, of the functional, environmental and accidental loads tabulated in Table 5, shall be analysed if the yearly combined probability, P_c , of occurrence is between 10^{-2} and 10^{-4} .			

Table 5 — Load combinations of load classes, load conditions

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	Normal operation	Extreme operation	Abnormal operation
Functional loads			
a Loads due to weight and buoyancy of pipe, contents, and attachments, both temporary and permanent.	X	X	X
b Internal pressure as specified in 5.4.2.	Max./Min. operating pressure	Design pressure	Design pressure
c Loads from pressure and temperature variations.	X	X	X
d External pressure.	X	X	X
e External soil or rock reaction forces for trenched, buried, or rock dumped pipes.	X	X	X
f Static reaction and deformation loads from supports and protection structures.	X	X	X
g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
k Interaction effects of bundled or clamped pipes.	X	X	X
l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
Accidental loads			
Loads and motions caused directly or indirectly by accidental occurrences, including the following:	Not applicable	See ^a	See ^b
1 Dropped objects	"	"	"
2 Trawl board impact	"	"	"
3 Internal over-pressure	"	"	"
4 Compartment damage or unintended flooding	"	"	"
5 Failure of thrusters	"	"	"
6 DP failure	"	"	"
7 Anchor line failure	"	"	"
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c Loads from pressure and temperature variations.	X	X	X
d External pressure.	X	X	X
e External soil or rock reaction forces for trenched, buried, or rock dumped pipes.	X	X	X
f Static reaction and deformation loads from supports and protection structures.	X	X	X
g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
k Interaction effects of bundled or clamped pipes.	X	X	X
l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
Accidental loads			
Loads and motions caused directly or indirectly by accidental occurrences, including the following:	Not applicable	See ^a	See ^b
1 Dropped objects	"	"	"
2 Trawl board impact	"	"	"
3 Internal over-pressure	"	"	"
4 Compartment damage or unintended flooding	"	"	"
5 Failure of thrusters	"	"	"
6 DP failure	"	"	"
7 Anchor line failure	"	"	"
8 Failure of turret drive system	"	"	"
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c Loads from pressure and temperature variations.	X	X	X
d External pressure.	X	X	X
e External soil or rock reaction forces for trenched, buried, or rock dumped pipes.	X	X	X
f Static reaction and deformation loads from supports and protection structures.	X	X	X
g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
k Interaction effects of bundled or clamped pipes.	X	X	X
l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
Accidental loads			
Loads and motions caused directly or indirectly by accidental occurrences, including the following:	Not applicable	See ^a	See ^b
1 Dropped objects	"	"	"
2 Trawl board impact	"	"	"
3 Internal over-pressure	"	"	"
4 Compartment damage or unintended flooding	"	"	"
5 Failure of thrusters	"	"	"
6 DP failure	"	"	"
7 Anchor line failure	"	"	"
8 Failure of turret drive system	"	"	"
Environmental loads shall be combined with the operation conditions to the specified probability of occurrence.			
^a Load combinations of the Functional, Environmental and Accidental Loads tabulated in Table 5, as shown in Table 6, shall be analysed if the yearly combined probability, P_c , of occurrence is equal to or greater than 10^{-2} .			
^b Load combinations, as shown in Table 6, of the functional, environmental and accidental loads tabulated in Table 5, shall be analysed if the yearly combined probability, P_c , of occurrence is between 10^{-2} and 10^{-4} .			

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c Loads from pressure and temperature variations.	X	X	X
d External pressure.	X	X	X
e External soil or rock reaction forces for trenched, buried, or rock dumped pipes.	X	X	X
f Static reaction and deformation loads from supports and protection structures.	X	X	X
g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
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l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
Accidental loads			
Loads and motions caused directly or indirectly by accidental occurrences, including the following:	Not applicable	See ^a	See ^b
1 Dropped objects	"	"	"
2 Trawl board impact	"	"	"
3 Internal over-pressure	"	"	"
4 Compartment damage or unintended flooding	"	"	"
5 Failure of thrusters	"	"	"
6 DP failure	"	"	"
7 Anchor line failure	"	"	"
8 Failure of turret drive system	"	"	"
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i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
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l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
Accidental loads			
Loads and motions caused directly or indirectly by accidental occurrences, including the following:	Not applicable	See ^a	See ^b
1 Dropped objects	"	"	"
2 Trawl board impact	"	"	"
3 Internal over-pressure	"	"	"
4 Compartment damage or unintended flooding	"	"	"
5 Failure of thrusters	"	"	"
6 DP failure	"	"	"
7 Anchor line failure	"	"	"
8 Failure of turret drive system	"	"	"
Environmental loads shall be combined with the operation conditions to the specified probability of occurrence.			
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Table 5 — Load combinations of load classes, load conditions

Load classes and subclasses	Load conditions		
	Normal operation	Extreme operation	Abnormal operation
	Recurrent operation		
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c Loads from pressure and temperature variations.	X	X	X
d External pressure.	X	X	X
e External soil or rock reaction forces for trenched, buried, or rock dumped pipes.	X	X	X
f Static reaction and deformation loads from supports and protection structures.	X	X	X
g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
k Interaction effects of bundled or clamped pipes.	X	X	X
l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
Accidental loads			
Loads and motions caused directly or indirectly by accidental occurrences, including the following:	Not applicable	See ^a	See ^b
1 Dropped objects	"	"	"
2 Trawl board impact	"	"	"
3 Internal over-pressure	"	"	"
4 Compartment damage or unintended flooding	"	"	"
5 Failure of thrusters	"	"	"
6 DP failure	"	"	"
7 Anchor line failure	"	"	"
8 Failure of turret drive system	"	"	"
Environmental loads shall be combined with the operation conditions to the specified probability of occurrence.			
^a Load combinations of the Functional, Environmental and Accidental Loads tabulated in Table 5, as shown in Table 6, shall be analysed if the yearly combined probability, P_c , of occurrence is equal to or greater than 10^{-2} .			
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Table 5 — Load combinations of load classes, load conditions

Load classes and subclasses	Load conditions		
	Normal operation	Extreme operation	Abnormal operation
	Recurrent operation		
Functional loads			
a Loads due to weight and buoyancy of pipe, contents, and attachments, both temporary and permanent.	X	X	X
b Internal pressure as specified in 5.4.2.	Max./Min. operating pressure	Design pressure	Design pressure
c Loads from pressure and temperature variations.	X	X	X
d External pressure.	X	X	X
e External soil or rock reaction forces for trenched, buried, or rock dumped pipes.	X	X	X
f Static reaction and deformation loads from supports and protection structures.	X	X	X
g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
k Interaction effects of bundled or clamped pipes.	X	X	X
l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
Accidental loads			
Loads and motions caused directly or indirectly by accidental occurrences, including the following:	Not applicable	See ^a	See ^b
1 Dropped objects	"	"	"
2 Trawl board impact	"	"	"
3 Internal over-pressure	"	"	"
4 Compartment damage or unintended flooding	"	"	"
5 Failure of thrusters	"	"	"
6 DP failure	"	"	"
7 Anchor line failure	"	"	"
8 Failure of turret drive system	"	"	"
Environmental loads shall be combined with the operation conditions to the specified probability of occurrence.			
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f Static reaction and deformation loads from supports and protection structures.	X	X	X
g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
k Interaction effects of bundled or clamped pipes.	X	X	X
l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
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h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
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4 Compartment damage or unintended flooding	"	"	"
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4 Compartment damage or unintended flooding	"	"	"
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4 Compartment damage or unintended flooding	"	"	"
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i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
k Interaction effects of bundled or clamped pipes.	X	X	X
l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
Accidental loads			
Loads and motions caused directly or indirectly by accidental occurrences, including the following:	Not applicable	See ^a	See ^b
1 Dropped objects	"	"	"
2 Trawl board impact	"	"	"
3 Internal over-pressure	"	"	"
4 Compartment damage or unintended flooding	"	"	"
5 Failure of thrusters	"	"	"
6 DP failure	"	"	"
7 Anchor line failure	"	"	"
8 Failure of turret drive system	"	"	"
Environmental loads shall be combined with the operation conditions to the specified probability of occurrence.			
^a Load combinations of the Functional, Environmental and Accidental Loads tabulated in Table 5, as shown in Table 6, shall be analysed if the yearly combined probability, P_c , of occurrence is equal to or greater than 10^{-2} .			
^b Load combinations, as shown in Table 6, of the functional, environmental and accidental loads tabulated in Table 5, shall be analysed if the yearly combined probability, P_c , of occurrence is between 10^{-2} and 10^{-4} .			

Table 5 — Load combinations of load classes, load conditions

Load classes and subclasses	Load conditions		
	Normal operation	Extreme operation	Abnormal operation
	Recurrent operation		
Functional loads			
a Loads due to weight and buoyancy of pipe, contents, and attachments, both temporary and permanent.	X	X	X
b Internal pressure as specified in 5.4.2.	Max./Min. operating pressure	Design pressure	Design pressure
c Loads from pressure and temperature variations.	X	X	X
d External pressure.	X	X	X
e External soil or rock reaction forces for trenched, buried, or rock dumped pipes.	X	X	X
f Static reaction and deformation loads from supports and protection structures.	X	X	X
g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
k Interaction effects of bundled or clamped pipes.	X	X	X
l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
Accidental loads			
Loads and motions caused directly or indirectly by accidental occurrences, including the following:	Not applicable	See ^a	See ^b
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3 Internal over-pressure	"	"	"
4 Compartment damage or unintended flooding	"	"	"
5 Failure of thrusters	"	"	"
6 DP failure	"	"	"
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f Static reaction and deformation loads from supports and protection structures.	X	X	X
g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
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l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
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Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
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6 DP failure	"	"	"
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4 Compartment damage or unintended flooding	"	"	"
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6 DP failure	"	"	"
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g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
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4 Compartment damage or unintended flooding	"	"	"
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4 Compartment damage or unintended flooding	"	"	"
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4 Compartment damage or unintended flooding	"	"	"
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4 Compartment damage or unintended flooding	"	"	"
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Table 5 — Load combinations of load classes, load conditions

Load classes and subclasses	Load conditions		
	Normal operation	Extreme operation	Abnormal operation
	Recurrent operation		
Functional loads			
a Loads due to weight and buoyancy of pipe, contents, and attachments, both temporary and permanent.	X	X	X
b Internal pressure as specified in 5.4.2.	Max./Min. operating pressure	Design pressure	Design pressure
c Loads from pressure and temperature variations.	X	X	X
d External pressure.	X	X	X
e External soil or rock reaction forces for trenched, buried, or rock dumped pipes.	X	X	X
f Static reaction and deformation loads from supports and protection structures.	X	X	X
g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
k Interaction effects of bundled or clamped pipes.	X	X	X
l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
Accidental loads			
Loads and motions caused directly or indirectly by accidental occurrences, including the following:	Not applicable	See ^a	See ^b
1 Dropped objects	"	"	"
2 Trawl board impact	"	"	"
3 Internal over-pressure	"	"	"
4 Compartment damage or unintended flooding	"	"	"
5 Failure of thrusters	"	"	"
6 DP failure	"	"	"
7 Anchor line failure	"	"	"
8 Failure of turret drive system	"	"	"
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f Static reaction and deformation loads from supports and protection structures.	X	X	X
g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
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l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
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Environmental loads			
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j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
k Interaction effects of bundled or clamped pipes.	X	X	X
l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
Accidental loads			
Loads and motions caused directly or indirectly by accidental occurrences, including the following:	Not applicable	See ^a	See ^b
1 Dropped objects	"	"	"
2 Trawl board impact	"	"	"
3 Internal over-pressure	"	"	"
4 Compartment damage or unintended flooding	"	"	"
5 Failure of thrusters	"	"	"
6 DP failure	"	"	"
7 Anchor line failure	"	"	"
8 Failure of turret drive system	"	"	"
Environmental loads shall be combined with the operation conditions to the specified probability of occurrence.			
^a Load combinations of the Functional, Environmental and Accidental Loads tabulated in Table 5, as shown in Table 6, shall be analysed if the yearly combined probability, P_c , of occurrence is equal to or greater than 10^{-2} .			
^b Load combinations, as shown in Table 6, of the functional, environmental and accidental loads tabulated in Table 5, shall be analysed if the yearly combined probability, P_c , of occurrence is between 10^{-2} and 10^{-4} .			

Table 5 — Load combinations of load classes, load conditions

Load classes and subclasses	Load conditions		
	Normal operation	Extreme operation	Abnormal operation
Functional loads			
a Loads due to weight and buoyancy of pipe, contents, and attachments, both temporary and permanent.	X	X	X
b Internal pressure as specified in 5.4.2.	Max./Min. operating pressure	Design pressure	Design pressure
c Loads from pressure and temperature variations.	X	X	X
d External pressure.	X	X	X
e External soil or rock reaction forces for trenched, buried, or rock dumped pipes.	X	X	X
f Static reaction and deformation loads from supports and protection structures.	X	X	X
g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
k Interaction effects of bundled or clamped pipes.	X	X	X
l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
Accidental loads			
Loads and motions caused directly or indirectly by accidental occurrences, including the following:	Not applicable	See ^a	See ^b
1 Dropped objects	"	"	"
2 Trawl board impact	"	"	"
3 Internal over-pressure	"	"	"
4 Compartment damage or unintended flooding	"	"	"
5 Failure of thrusters	"	"	"
6 DP failure	"	"	"
7 Anchor line failure	"	"	"
8 Failure of turret drive system	"	"	"
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d External pressure.	X	X	X
e External soil or rock reaction forces for trenched, buried, or rock dumped pipes.	X	X	X
f Static reaction and deformation loads from supports and protection structures.	X	X	X
g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
k Interaction effects of bundled or clamped pipes.	X	X	X
l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
m Loads due to positioning tolerances during installation.	X	X	X
n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
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3 Internal over-pressure	"	"	"
4 Compartment damage or unintended flooding	"	"	"
5 Failure of thrusters	"	"	"
6 DP failure	"	"	"
7 Anchor line failure	"	"	"
8 Failure of turret drive system	"	"	"
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h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
i Loads and displacement due to pressure and tension-induced rotation.	X	X	X
j Testing pressures, including installation, commissioning, and maintenance pressures.	As specified by Tables 6 and 7	As specified by Tables 6 and 7	As specified by Tables 6 and 7
k Interaction effects of bundled or clamped pipes.	X	X	X
l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
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Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
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4 Compartment damage or unintended flooding	"	"	"
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6 DP failure	"	"	"
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e External soil or rock reaction forces for trenched, buried, or rock dumped pipes.	X	X	X
f Static reaction and deformation loads from supports and protection structures.	X	X	X
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h Residual installation loads, which remain as permanent loads in the pipe structure during service.	X	X	X
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l Loads due to rigid or flexible pipe crossings, or spans.	X	X	X
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n Loads from inspection and maintenance tools.	X	X	X
Environmental loads			
Loads caused directly or indirectly by all environmental parameters specified in Table 2.	Conditions to meet $P_c = 10^{-2}$	Conditions to meet $P_c = 10^{-2}$	Survival conditions
Accidental loads			
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4 Compartment damage or unintended flooding	"	"	"
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6 DP failure	"	"	"
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e External soil or rock reaction forces for trenched, buried, or rock dumped pipes.	X	X	X
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g Temporary installation or recovery loads, including applied tension and crushing loads, impact loads, and guidance-induced loads.	X	X	X
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4 Compartment damage or unintended flooding	"	"	"
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- c) The requirements contained in the API product specification(s) for which the organization desires to be licensed,
- d) The requirements contained in the API Monogram Program License Agreement.

C.3.2 When an API Licensed organization is providing an API monogrammed product, conformance with API specified requirements, described in API Specification Q1, including Annex A, is required.

C.3.3 Each Licensee shall control the application of the API Monogram in accordance with the following:

- a) Each Licensee shall develop and maintain an API Monogram Marking Procedure that documents the marking / monogramming requirements specified by the API product specification to be used for application of the API Monogram by the Licensee. The marking procedure shall define the location(s) where the Licensee shall apply the API Monogram and require that the Licensee's license number and date of manufacture be marked on monogrammed products in conjunction with the API Monogram. At a minimum, the date of manufacture shall be two digits representing the month and two digits representing the year (e.g., 05-07 for May 2007) unless otherwise stipulated in the applicable API product specification. Where there are no API product specification marking requirements, the Licensee shall define the location(s) where this information is applied.
- b) The API Monogram may be applied at any time appropriate during the production process but shall be removed in accordance with the Licensee's API Monogram Marking Procedure if the product is subsequently found to be nonconforming with API specified requirements. Products that do not conform to API specified requirements shall not bear the API Monogram.
- c) Only an API Licensee may apply the API Monogram and its license to API monogramable products. For certain manufacturing processes or types of products, alternative Monogram marking procedures may be acceptable. The current API requirements for Monogram Marking are detailed in the API Policy Document, *Monogram Marking Requirements*, available on the API Monogram Program website at <http://www.api.org/certifications/monogram/>.
- d) The API Monogram shall be applied at the licensed facility.
- e) The authority responsible for applying and removing the API Monogram shall be defined in the Licensee's API Monogram Marking Procedure.

C.3.4 Records required by API product specifications shall be retained for the period of time specified therein. Records specified to demonstrate achievement of the effective operation of the quality system shall be maintained for a minimum of 5 years.

C.3.5 Any proposed change to the Licensee's quality program to a degree requiring changes to the quality manual shall be submitted to API for acceptance prior to incorporation into the Licensee's quality program.

C.3.6 Licensee shall not use the API Monogram on letterheads or in any advertising (including company-sponsored web sites) without an express statement of fact describing the scope of Licensee's authorization (license number).

C.4 Marking Requirements

These marking requirements apply only to those API licensees wishing to mark their products with the API Monogram. Manufacturers shall either mark equipment with "API 17J" alone or "API 17J" in addition to the marking requirements of Section 11. The API Monogram License number shall not be used unless it is marked in conjunction with the API Monogram.

C.5 API Monogram Program: API Responsibilities

C.5.1 The API shall maintain records of reported problems encountered with API monogrammed products. Documented cases of nonconformity with API specified requirements may be reason for an audit of the Licensee involved, (also known as Audit for "cause").

C.5.2 Documented cases of specification deficiencies shall be reported, without reference to Licensees, Customers or Users, to API Subcommittee 18 (Quality) and to the applicable API Standards Subcommittee for corrective actions.

Bibliography

- [1] ISO 13628-3, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 3: Through flowline (TFL) systems*
- [2] ISO 13628-10, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 10: Specification for bonded flexible pipe*
- [3] ISO 13628-11:—, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 11: Flexible pipe systems for subsea and marine applications*
- [4] ISO 15589-2, *Petroleum and natural gas industries — Cathodic protection of pipeline transportation systems — Part 2: Offshore pipelines*
- [5] API Spec 17D, *Specification for Subsea Wellhead and Christmas Tree Equipment*
- [6] API Spec 17J, *Specification for Unbonded Flexible Pipe*
- [7] API Std 1104, *Welding of Pipelines and Related Facilities*
- [8] API 17TR2, *The Aging of PA-11 in Flexible Pipes*
- [9] ASTM C335, *Standard Test Method for Steady-State Heat Transfer Properties of Pipe Insulation*
- [10] ASTM D256, *Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics*
- [11] ASTM D570, *Standard Test Method for Water Absorption of Plastics*
- [12] ASTM D624, *Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers*
- [13] ASTM D638, *Standard Test Method for Tensile Properties of Plastics*
- [14] ASTM D648, *Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position*
- [15] ASTM D664, *Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration*
- [16] ASTM D746, *Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact*
- [17] ASTM D790, *Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*
- [18] ASTM D792, *Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement*
- [19] ASTM D974, *Standard Test Method for Acid and Base Number by Color-Indicator Titration*
- [20] ASTM D1044, *Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion*
- [21] ASTM D1525, *Standard Test Method for Vicat Softening Temperature of Plastics*
- [22] ASTM D2240, *Standard Test Method for Rubber Property — Durometer Hardness*

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- [23] ASTM D2583, *Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor*
 - [24] ASTM D2857, *Standard Practice for Dilute Solution Viscosity of Polymers*
 - [25] ASTM D2990, *Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics*
 - [26] ASTM D4060, *Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser*
 - [27] ASTM E328, *Standard Test Methods for Stress Relaxation Tests for Materials and Structures*
 - [28] ASTM E831, *Standard Test Method for Linear Thermal Expansion of Solid Materials by Thermomechanical Analysis*
 - [29] ASTM E1269, *Standard Test Method for Determining Specific Heat Capacity for Differential Scanning Calorimetry*

Date of Issue: October 2007

Affected Publication: API Bulletin 2INT-MET, *Interim Guidance on Hurricane Conditions in the Gulf of Mexico*, May 2007.

ERRATA

Please insert the following changes to Bulletin 2INT-MET:

Section 4.2.1, *Add the following sentence to the end of the second paragraph:*

“In shallow water, the local crest height will not, however, exceed the breaking-constrained crest height.”

Table 4.5.2-1A, *Replace the title:*

“West Gulf”

with

“West Central Gulf”

Table 4.5.2-1B, *Replace the title:*

“Western”

with

“West”

Figure 4.5.2-4B, *Replace current figure with the following:*

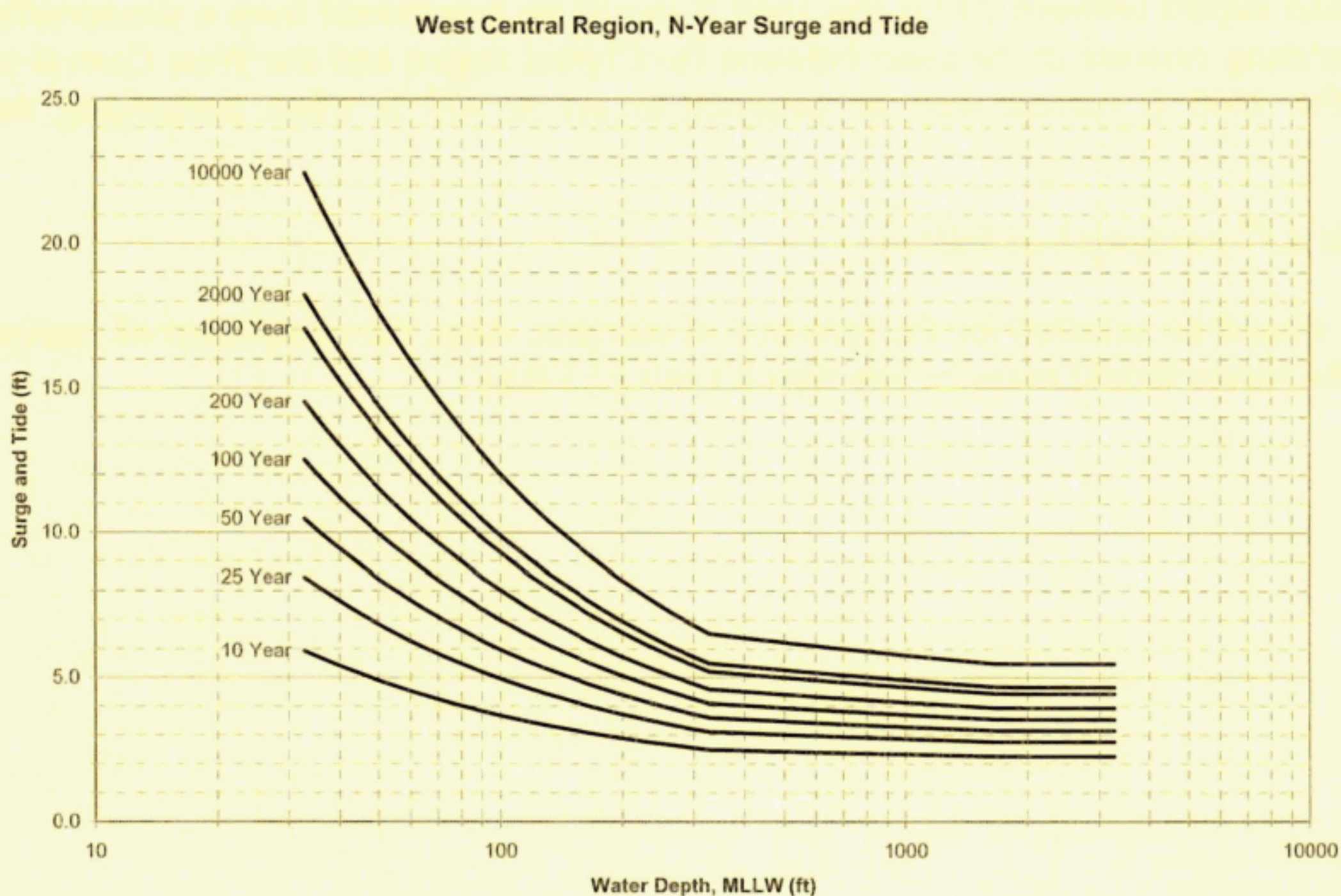


Table 4.5.3-1A left-hand column, Replace:

“Currents, WD \geq 150m”

with

“Currents, WD \geq 500m”

Table 4.5.3-1A in the Notes, Replace:

“Currents in water depths between 70m and 150m....”

with

“Currents in water depths between 70m and 500m should be determined from a site-specific study. If interpolating currents in the areas between the Central region and the West Central or East regions, the 500m current may be assumed to act at 150m when performing the interpolation.”

Table 4.5.3-1A left-hand column, Replace:

“Currents, WD \geq 492 ft”

with

“Currents, WD \geq 1640 ft”

Table 4.5.3-1B in the Notes, Replace:

“Currents in water depths between 230 ft and 492 ft....”

with

“Currents in water depths between 230 ft and 1640 ft should be determined from a site-specific study. If interpolating currents in the areas between the Central region and the West Central or East regions, the 1640 ft current may be assumed to act at 452 ft when performing the interpolation.”

Section 5, Add a 5th paragraph as follows:

“Wave periods should be adjusted for the presence of currents. Also, the component of current collinear with the waves should never be less than 0.1 m/s (0.3 ft/s).”

