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**Erdöl- und Erdgasgewinnung –
Konstruktion und Betrieb von Unterwasser-Produktionssystemen –
Teil 10: Anforderungen an miteinander verklebte Leitungen
(ISO 13628-10:2005);
Englische Fassung EN ISO 13628-10:2006**

Petroleum and natural gas industries –
Design and operation of subsea production systems –
Part 10: Specification for bonded flexible pipe (ISO 13628-10:2005);
English version EN ISO 13628-10:2006

Industries du pétrole et du gaz naturel –
Conception et exploitation des systèmes de production immergés –
Partie 10: Spécification pour canalisations flexibles composites (ISO 13628-10:2005);
Version anglaise EN ISO 13628-10:2006

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Nationales Vorwort

Diese Europäische Norm (EN ISO 13628-10:2006) wurde vom Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ (Sekretariat: Frankreich) erstellt. Es handelt sich dabei um die unveränderte Übernahme von ISO 13628-10:2005, erarbeitet von ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“, SC 4 „Drilling and production equipment“.

Für Deutschland war der Normenausschuss Erdöl- und Erdgasgewinnung (NÖG), Arbeitsausschuss 109-00-1-04 AK „Bohr- und Fördereinrichtungen“, beteiligt.

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Diese Norm enthält neben den gesetzlichen Einheiten auch SI-fremde Einheiten, die im Deutschen Normenwerk nicht zugelassen sind. Es wird jedoch ausdrücklich darauf hingewiesen, dass die Anwendung dieser Einheiten im nationalen amtlichen und geschäftlichen Verkehr aufgrund des Gesetzes über Einheiten im Messwesen nicht zulässig ist.

English Version

Petroleum and natural gas industries — Design and operation of
subsea production systems - Part 10: Specification for bonded
flexible pipe (ISO 13628-10:2005)

Industries du pétrole et du gaz naturel — Conception et
exploitation des systèmes de production immergés —
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von Unterwasser-Produktionssystemen —
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(ISO 13628-10:2005)

This European Standard was approved by CEN on 6 October 2006.

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Foreword

The text of ISO 13628-10:2005 has been prepared by Technical Committee ISO/TC 67 „Materials, equipment and offshore structures for petroleum and natural gas industries 0147“ of the International Organization for Standardization (ISO) and has been taken over as EN ISO 13628-10:2006 by Technical Committee CEN/TC 12 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2007, and conflicting national standards shall be withdrawn at the latest by April 2007.

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Endorsement notice

The text of ISO 13628-10:2005 has been approved by CEN as EN ISO 13628-10:2006 without any modifications.

Introduction

This part of ISO 13628 has been based on API Spec 17K, First Edition, September 2001.

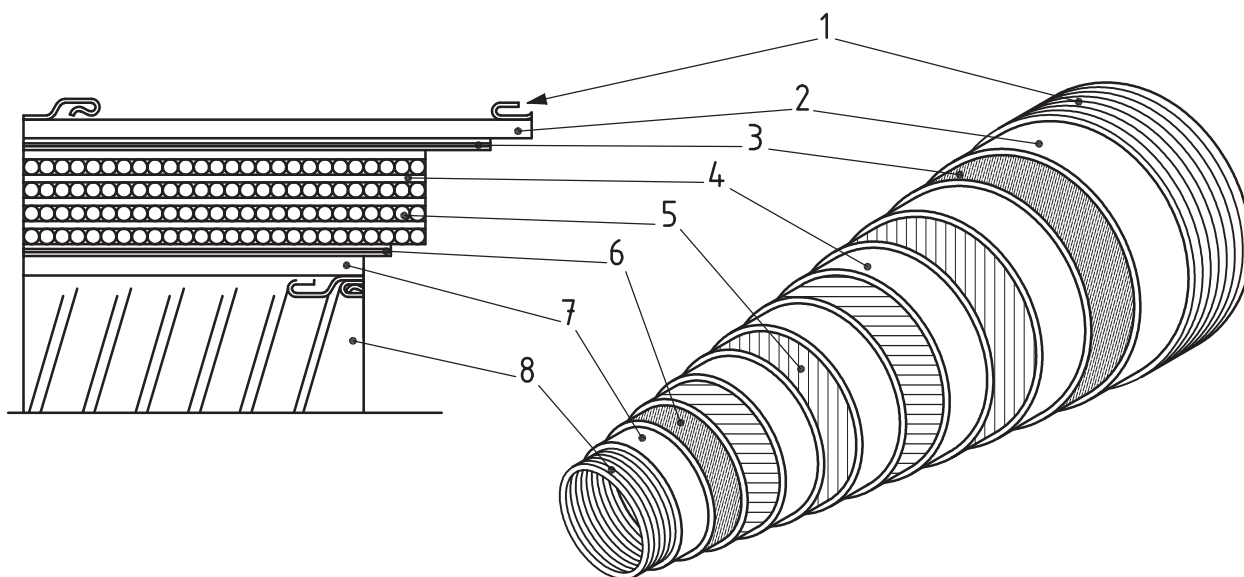
Users of this International Standard should be aware that further or differing requirements might be needed for individual applications. This International Standard is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the 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 International Standard and provide details.

1 Scope

1.1 Purpose

1.1.1 This part of ISO 13628 defines the technical requirements for safe, dimensionally and functionally interchangeable bonded flexible pipes that are designed and manufactured to uniform standards and criteria. See Figure 1 for explanatory figure on typical bonded flexible pipe.

1.1.2 Minimum requirements are specified for the design, material selection, manufacture, testing, marking and packaging of bonded flexible pipes, with reference to existing codes and standards where applicable. See API RP 17B for guidelines on the use of flexible pipes and ancillary components.



Key

1	outer wrap	5	reinforcement layer
2	cover	6	breaker layer
3	breaker layer	7	liner
4	cushion layer	8	carcass

Figure 1 — Typical bonded flexible pipe

1.2 Products

1.2.1 This part of ISO 13628 applies to bonded 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 unbonded structure. See ISO 13628-2 for guidance on unbonded flexible pipes.

NOTE For the purposes of this provision, API Spec 17J^[10] is equivalent to ISO 13628-2.

1.2.2 This part of ISO 13628 does not apply to flexible pipe ancillary components. Guidelines for ancillary components are given in API RP 17B.

1.2.3 This part of ISO 13628 can be applied to flexible pipes that include non-metallic reinforcing layers, though no effort was made to address the specific and unique technological aspects of this product.

1.2.4 This part of ISO 13628 can be applied to a bonded construction pipe that includes a material or layer construction that is covered in ISO 13628-2.

NOTE For the purposes of this provision, API Spec 17J^[10] is equivalent to ISO 13628-2.

1.3 Applications

1.3.1 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, jumpers and offshore loading and discharge hoses. This part of ISO 13628 applies to pipes with a design pressure greater than or equal to 1,5 MPa (15 bar). This part of ISO 13628 can be used for lower design pressure pipes, though the requirements of these pipes have not been specifically addressed. Reference OCIMF^[30] for guidelines on these pipes.

1.3.2 This part of ISO 13628 does not apply to flexible pipes for use in choke and kill line applications. See API Spec 16C for guidance on choke and kill line applications. This part of ISO 13628 can be applied to flexible pipes for pile hammer, gas flare, water supply and jetting applications, though no effort was made to address the specific and unique technological aspects relating to each of these requirements.

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 34-2, *Rubber, vulcanized or thermoplastic — Determination of tear strength — Part 2: Small (Delft) test pieces*

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

ISO 75 (all parts), *Plastics — Determination of temperature of deflection under load*

ISO 812, *Rubber, vulcanized — Determination of low-temperature brittleness*

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

ISO 1431-1:2004, *Rubber, vulcanized or thermoplastic — Resistance to ozone cracking — Part 1: Static and dynamic strain testing*

ISO 1817, *Rubber, vulcanized — Determination of the effect of liquids*

ISO 2781, *Rubber, vulcanized — Determination of density*

ISO 4647:1982, *Rubber, vulcanized — Determination of static adhesion to textile cord — H-pull test*

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

ISO 6506-1, *Metallic materials — Brinell 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 6892, *Metallic materials — Tensile testing at ambient temperature*

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

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

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

ISO 13665, *Seamless and welded steel tubes for pressure purposes — Magnetic particle inspection of the tube body for the detection of surface imperfections*

ISO 15156 (all parts), *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production*

ISO 16120-1, *Non-alloy steel wire rod for conversion to wire — Part 1: General requirements*

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

API¹⁾ Standard 1104, *Welding of Pipelines and Related Facilities*

ASME²⁾ Section IX, Boiler & Pressure Vessel Code, *Welding and Brazing Qualifications*

ASTM³⁾ A29/A29M:2005, *Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought — General Requirements for*

ASTM A182/A182M:2005, *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 A668/A668M:2004, *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 D256, *Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics*

ASTM D395, *Standard Test Methods for Rubber Property — Compression Set*

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers — Tension*

ASTM D413, *Standard Test Methods for Rubber Property — Adhesion to Flexible Substrate*

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

ASTM D664, *Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration*

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

ASTM D746, *Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact*

ASTM D974, *Standard Test Method for Acid and Base Number by Color-Indicator Titration*

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

1) American Petroleum Institute, 1220 L St NW, Washington DC 20005, USA.

2) American Society of Mechanical Engineers.

3) American Society for Testing and Materials.

- ASTM D2084, *Standard Test Method for Rubber Property — Vulcanization Using Oscillating Disk Cure Meter*
- ASTM D2583, *Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor*
- ASTM D5028, *Standard Test Method for Curing Properties of Pultrusion Resins by Thermal Analysis*
- ASTM E92, *Standard Test Method for Vickers Hardness of Metallic Materials*
- ASTM E94, *Standard Guide for Radiographic Examination*
- ASTM E165, *Standard Test method for Liquid Penetrant Examination*
- ASTM E328, *Standard Test Methods for Stress Relaxation Tests for Materials and Structures*
- ASTM E428, *Standard Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Examination*
- ASTM E1356, *Standard Test Method for Assignment of the Glass Transition Temperatures by Differential Scanning Calorimetry*
- ASTM G48, *Standard Test Method for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution*
- ISO 36, *Rubber, vulcanized or thermoplastic — Determination of adhesion to textile fabrics*
- DNV⁴⁾ Fire Test, *DNV Classification Note 6.1 Test (Fire Test)*
- DIN⁵⁾ 53505, *Shore A and Shore D hardness testing of rubber*
- DIN 53516, *Testing of rubber and elastomers; determination of abrasion resistance*
- EN⁶⁾ 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*
- 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, *Metallic products — Types of inspection documents*
- Lloyds Fire Test, *Lloyds Register of Shipping, Fire Testing Memorandum ICE/Fire OSG 1000/499*
- NACE TM0177, *Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H₂S Environments*

4) Det Norske Veritas.

5) Deutsches Institut für Normung e.V.

6) European Committee for Standardization.

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.1.1

ancillary components

components used to control the flexible pipe behaviour, such as buoyancy aids and fire hoods/boxes

3.1.2

API Monogram

registered mark of the American Petroleum Institute

3.1.3

bellmouth

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

3.1.4

bend limiter

any device used to restrict bending of the flexible pipe

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

3.1.5

bend radius

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

NOTE Storage and operating minimum bend radii are defined in 5.3.1.6 and 5.3.1.7.

3.1.6

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

3.1.7

bend stiffener

ancillary conically shaped component, which locally supports the pipe to limit bending stresses and curvature of the pipe to acceptable 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.

3.1.8

bending stiffness

analogous to the structural stiffness of a rigid beam or pipe (modulus of elasticity times the second area moment of inertia), except that it can vary to a large extent with temperature and pressure

NOTE It is often quantified as the product of an applied bending moment times the resultant bend radius of the pipe.

3.1.9

bonded pipe

flexible pipe where the steel reinforcement is integrated and bonded to a vulcanized elastomeric material

NOTE Textile material is included in the structure to obtain additional structural reinforcement or to separate elastomeric layers.

3.1.10**breaker**

textile layer impregnated with rubber included in various layers in the pipe cross-section to give additional strength to the pipe, to aid in reducing propagation of cuts in the pipe and to aid the manufacturing process

NOTE This layer can be incorporated into either or all of the cover, reinforcing layer and liner.

3.1.11**cable**

series of round wires of steel or fabric (circular cross-section) spirally wound (stranded) together and used for structurally reinforcing the pipe

NOTE Cable wires for flexible pipes are usually brass or copper coated to promote chemical bonding of the elastomer to the wires.

3.1.12**calendering**

process of passing elastomer compound between rollers to produce smooth sheets of elastomer

NOTE This process is also used to cover reinforcing cables and textiles with elastomer to form sheets for winding onto pipes.

3.1.13**carcass**

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

NOTE It can be used externally to protect the external surface of the pipe.

3.1.14**choke and kill line**

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

3.1.15**compound**

mix of elastomer material and various additives immediately prior to the curing process

3.1.16**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 can be designed for diver-assisted makeup or for diverless operation using either mechanical or hydraulic apparatus.

3.1.17**cover**

layer of elastomer between the reinforcing layer and the external environment (or external carcass if provided) used to protect the pipe against penetration of seawater and other external environments, corrosion, abrasion and mechanical damage

3.1.18**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.

3.1.19

curing

process of changing irreversibly, usually at elevated temperatures, the properties of a thermosetting resin or an elastomer compound by chemical reaction

NOTE Cure can be accomplished by the addition of curing (cross-linking) agents, with or without heat and pressure.

3.1.20

design pressure

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

3.1.21

dynamic application

service in which flexible pipe is exposed to cyclically varying loads and deflections during normal operation

NOTE The pipe is specially constructed to withstand a large number of bending/tensile/torsional cycles.

3.1.22

elastomer

material that substantially recovers its original shape and size at room temperature after removal of a deforming force; material that shows a reversible elasticity up to a very high strain level (~ 100 %)

3.1.23

embedding compound

elastomeric compound in which the steel reinforcing cables are embedded

NOTE The compound assures bonding between the steel cables and surrounding layers.

3.1.24

end fitting

mechanical device which forms the transition between the flexible pipe body and the connector

NOTE The 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.

3.1.25

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.

3.1.26

flexible pipe

assembly of a pipe body and end fittings

NOTE The pipe body comprises a composite of layered materials that form a pressure-containing conduit. The pipe structure allows large deflections without a significant increase in bending stresses. Normally, the pipe body is built up as a composite structure comprising metallic and elastomer layers. The term *pipe* is used in this document as a generic term for flexible pipe.

3.1.27

flexible riser

flexible pipe connecting a platform/buoy/ship to a flowline, seafloor installation or another platform

NOTE The riser can be freely suspended (free catenary), restrained to some extent (buoys, chains), totally restrained or enclosed in a tube (I- or J-tube).

3.1.28

floating loading and discharge hose

flexible pipe with integral buoyancy or clamped-on buoyancy modules so as to enable the buoyancy pipe to float on the water surface

3.1.29**gas service**

service conditions with a gas content, i.e. gas applications or live crude containing gas

3.1.30**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 agent is also called upon to witness some measurements and tests related to material qualification.

3.1.31**insulation layer**

additional layer added to the flexible pipe to increase the thermal insulation properties

NOTE The layer is usually located between the outer reinforcement layer and the cover.

3.1.32**jumper**

short flexible pipe used in subsea and topside, static or dynamic applications, e.g. turret jumpers and drag chain jumpers

3.1.33**lay angle**

angle between the axis of a spiral wound element (e.g. cables of reinforcing layer) and a line parallel to the longitudinal axis of the flexible pipe

3.1.34**liner**

layer of elastomer in contact with the internal fluid which ensures internal fluid integrity

3.1.35**loading and discharge hose**

flexible pipe jumper used in the loading and offloading of tankers in both static and dynamic applications

3.1.36**piggyback**

two pipes attached at regular intervals with clamps

NOTE Either or both of the pipes can be flexibles.

3.1.37**quality**

conformance to specified requirements

3.1.38**quality assurance**

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

3.1.39**quality control**

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

3.1.40**quality programme**

established documented system to ensure quality

3.1.41

reinforcing layer

structural layer with a specific lay angle, typically around 55°, which consists of helically wound cables embedded in elastomer, and is used to sustain, totally or partially, tensile loads and internal pressure

3.1.42

rough bore

flexible pipe with a steel strip carcass as the innermost layer

3.1.43

service life

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

3.1.44

smooth bore

flexible pipe with an elastomer layer as the innermost layer

3.1.45

sour service

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

NOTE For the purposes of this provision, NACE MR0175 is equivalent to ISO 15156.

3.1.46

static application

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

3.1.47

sweet service

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

NOTE For the purposes of this provision, NACE MR0175 is equivalent to ISO 15156.

3.1.48

tensile strength

tensile strength of elastomeric materials in this part of ISO 13628 is defined in accordance with ISO 37

NOTE For the purposes of this provision, ASTM D638 is equivalent to ISO 37.

3.1.49

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

3.1.50

ultimate strength

ultimate strength in this part of ISO 13628 is defined in accordance with ISO 6892

NOTE For the purposes of this provision, ASTM A370 is equivalent to ISO 6892.

3.1.51

unbonded pipe

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

3.1.52

visual examination

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

3.1.53**yield strength**

yield strength in this standard for steel materials is defined as 0,2 % yield offset strength, as specified in ISO 6892

NOTE For the purposes of this provision, ASTM A370 is equivalent to ISO 6892.

3.1.54**vulcanization**

process of cross-linking the elastomer chains to reduce the plasticity of the elastomer

NOTE Otherwise referred to as "curing".

3.2 Symbols and abbreviations

The following symbols and abbreviations are used in this document:

DSC	Differential scanning calorimetry
FAT	Factory acceptance test
GA	General arrangement
HIC	Hydrogen-induced cracking
HV	Hardness on Vickers Scale
ID	Internal diameter
MBR	Minimum bend radius
MPI	Magnetic particle inspection
NDE	Non-destructive examination
ODR	Oscillating disk rheometer
RAO	Response amplitude operator
S-N	Curves showing stress range vs. number of cycles
SSC	Sulfide stress cracking
TAN	Titrated acid number
TFL	Through flowline
UNS ⁽¹⁾	Unified National Standard
UNS ⁽²⁾	Unified Numbering System
UV	Ultraviolet
σ_y	Material yield stress
σ_u	Material ultimate stress

4 Functional requirements

4.1 General

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

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

4.1.3 Regulatory authority functional requirements that may affect the design, materials, manufacturing and testing of the pipe shall be specified by the purchaser.

4.1.4 If the purchaser does not specify a requirement, and 4.1.2 does not apply, the manufacturer may assume that there is no requirement.

4.1.5 If a purchaser wishes to use this part of ISO 13628 for the procurement of pipes with non-metallic reinforcing layers, that purchaser should prepare a supplemental specification with requirements for the manufacturer to meet in demonstrating by analysis and tests that the level of safety during the service life is not less than that given by this part of ISO 13628 for metallic reinforced pipes.

4.1.6 If a purchaser wishes to purchase pipe that includes a material or layer construction that is covered in ISO 13628-2, that purchaser should prepare a supplemental specification with requirements for the manufacturer to meet in demonstrating by analysis and tests that the levels of safety are not less than those required by ISO 13628-2 and this part of ISO 13628.

4.2 Overall requirements

4.2.1 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.

4.2.2 End fitting

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

- a) The end fitting shall provide a structural interface between the pipe and the support structure.
- b) The end fittings 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.

4.3 General design parameters

The purchaser shall specify any project-specific design requirements, which may include the requirements of 4.4 to 4.6 and the following:

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

4.4 Internal fluid parameters

4.4.1 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 should be specified for the internal fluid parameters of Table 1. Expected variations in the internal fluid parameters over the service life should be specified.

Table 1 — Internal fluid parameters

Parameter	Comment
Internal pressure	See 4.4.2
Temperature	See 4.4.3
Fluid composition	See 4.4.4
Service definition	Sweet or sour in accordance with 4.4.4 (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

4.4.2 Internal pressure

The following internal pressures shall be specified:

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

The following internal pressures should be specified:

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

4.4.3 Temperature

4.4.3.1 The following temperatures shall be specified:

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

The operating temperature or temperature profile through service life should be specified.

4.4.3.2 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.

4.4.4 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). This should be specified for all phases including storage, transport and installation conditions. In the specification of the internal fluid composition, the following should be defined:

- a) all parameters which define service conditions, including partial pressure of H_2S and CO_2 , pH of aqueous phase, TAN (as specified in 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.

4.5 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
Ozone exposure	Length of pipe exposed during operation and storage conditions
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

4.6 System requirements

4.6.1 Minimum system requirements

4.6.1.1 General

4.6.1.1.1 The purchaser shall specify the system functional requirements of the project. The requirements of 4.6.1.2, 4.6.1.9 and 4.6.1.10 shall be specified by the purchaser. Specification of the other system requirements defined in 4.6.1 should be considered. Annex A may be referenced for guidelines.

4.6.1.1.2 The purchaser should specify the documentation, as listed in Clause 8, to be delivered by the manufacturer.

4.6.1.2 Application definition

The flexible pipe system shall be specified as one of the following: flowline, riser, jumper, (floating) loading and discharge hose. 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.

4.6.1.3 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.

4.6.1.4 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.

4.6.1.5 Gas permeation

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

- a) allowable gas permeation rates;
- b) interface requirements;
- c) gas-monitoring system.

NOTE The requirements of 4.6.1.5 apply to pipes intended for live crude and gas service only.

4.6.1.6 Pigging and TFL requirements

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

4.6.1.7 Fire resistance

Fire resistance requirements for the pipe design should be specified, with reference to Lloyds or DNV fire test requirements (see 5.4.6).

4.6.1.8 Piggyback lines

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

4.6.1.9 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.

4.6.1.10 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.

4.6.1.11 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.

4.6.1.12 Installation requirements

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

- a) For installation by the purchaser, the purchaser should specify any requirements on load restrictions, clamping/tensioner loads, overboarding requirements, installation tolerances and port facility limitations.

- b) For installation by the manufacturer, the purchaser should specify any requirements for season, environment, location, vessel limitations, installation tolerances, restrictions due to conflicting activities, and installation scope (including trenching, burial, testing, inspection, surveying and documentation).

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

4.6.1.13 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.

4.6.2 Static pipe parameters

The purchaser should specify to the manufacturer the purchaser's requirements for design and analysis of the static pipe or static jumper system additional to the requirements of Clause 5. The parameters listed in Table 3 should be considered.

Table 3 — Static pipe parameters

Parameter	Details
Pipe routing	Route drawings, topography, seabed/soil conditions, obstacles, installed equipment and pipelines.
Connection systems	Descriptions of upper and lower connection systems, including quick disconnection systems and buoy disconnection systems, connection angles and location tolerances.
Guides and supports	Proposed geometry of guides, I-tubes, J-tubes and bellmouths through which pipe 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, etc., and attachment methods.
Load cases	Definition of yearly probability for installation, normal and abnormal operation. Specification of accidental load cases and yearly probabilities.

4.6.3 Dynamic pipe parameters

The purchaser shall specify to the manufacturer the purchaser's requirements for design and analysis of the dynamic pipe, or dynamic jumper system additional to the requirements of Clause 5. The parameters listed in Table 4 should be considered.

Table 4 — Dynamic pipe parameters

Parameter	Details
Pipe 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.
Operations	Specification of reeling/unreeling requirements.
Connection systems	Descriptions of upper and lower connection systems, including quick disconnection systems and buoy disconnection systems, connection angles and location tolerances.
Guides and supports	Proposed geometry of guides and tanker rails over which the pipe is to be deployed.
Pipe attachments	Bend stiffeners, buoys, lifting & towing apparatus, clamps etc., and attachment methods.
Attached vessel data	Data for attached floating vessels, including the following: a) vessel data, dimensions, drafts, etc.; 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, etc., and definition of allowable interference/clashing.
Load cases	Definition of yearly probability for installation, normal and abnormal operation. Specification of accidental load cases and yearly probabilities.

5 Design requirements

5.1 Loads and load effects

5.1.1 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 4. All relevant information shall be defined in the design premise (see 8.2) including design load cases. Results of the design load case analyses shall be included in the design load report (see 8.3).

5.1.2 Definition of load classes

5.1.2.1 As listed in Table 5, loads are classified as functional, environmental (external) or accidental, defined as follows.

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

- a) Functional loads are all loads on the pipe in operation, including all loads which 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.

5.1.2.2 The design load cases shall be defined to analyze, as applicable, the effect on the flexible pipe of functional, environmental and accidental loads. Reference API RP 17B for guidelines on the analysis techniques to be used for the loads given in Table 5.