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

Part 2: Flexible pipe systems for subsea and marine applications

Industries du pétrole et du gaz naturel — Conception et exploitation des systèmes de production immergés —

Partie 2: Systèmes de canalisations flexibles pour applications sous-marines et en milieu marin

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

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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 3.

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 part of ISO 13628 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

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

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: Flexible pipe systems for subsea and marine applications*

— *Part 3: Through flowline (TFL) systems*

— *Part 4: Subsea wellhead and tree equipment*

— *Part 5: Subsea control umbilicals*

— *Part 6: Subsea production control systems*

— *Part 7: Workover/completion riser systems*

— *Part 8: Remotely Operated Vehicle (ROV) interfaces on subsea production systems*

— *Part 9: Remotely Operated Tool (ROT) intervention systems*

Annexes A and B of this part of ISO 13628 are for information only.

Introduction

This part of ISO 13628 is based on API Spec 17J, *Unbonded Flexible Pipe*, first edition, December 1996.

This part of ISO 13628 is complementary to ISO 10420 [29]. API Spec 17J was the result of a Joint Industry Project to develop a worldwide industry standard specification for the design, material selection, manufacture, testing, marking and packaging of flexible pipes.

Users of this part of ISO 13628 should be aware that further or differing requirements may 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: Flexible pipe systems for subsea and marine applications

1 Scope

This part of ISO 13628 specifies the minimum requirements and recommendations for the design, material selection, manufacture, testing, marking and packaging of flexible pipes, and defines the technical requirements and recommendations for safe, dimensionally and functionally interchangeable flexible pipes.

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 covers applications in both sweet and sour service production, including export and injection applications. Production fluids 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 cover flexible pipes of bonded structure, and does not apply to flexible pipe ancillary components.

This part of ISO 13628 does not apply to flexible pipes for use in choke and kill line applications.

NOTE Guidelines for bend stiffeners and bend restrictors are given in annex B and guidelines for other components are given in API RP 17B [1].

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 13628. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 13628 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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*.

ANSI/NACE MR0175, *Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment*.

ANSI/NACE TM0177, *Laboratory Testing of Metals for Resistance to Specific Forms of Environment*.

API Spec 16C, *Choke and Kill Systems*.

API Std 1104, *Welding of Pipelines and Related Facilities*.

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

ASTM A 29, *Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought and Cold-Finished — General Requirements*.

ASTM A 182, *Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings and Valves and Parts for High-Temperature Service*.

ASTM A 370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*.

ASTM A 388, *Standard Practice for Ultrasonic Examination of Heavy Steel Forgings*.

ASTM A 480, *Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip*.

ASTM A 668, *Standard Specification for Steel Forgings, Carbon and Alloy for General Industrial Use*.

ASTM A 751, *Standard Test Methods, Practices and Terminology for Chemical Analysis of Steel Products*.

ASTM D 695, *Standard Test Methods for Compressive Properties of Rigid Plastics*.

ASTM D 789, *Standard Test Methods for Determination of Relative Viscosity, Standard and Moisture Content of Polyamide (PA)*.

ASTM D 1238, *Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer*.

ASTM D 1418, *Standard Practice for Rubber and Rubber Latices — Nomenclature*.

ASTM D 4019, *Standard Test Method for Moisture in Plastics by Coulometric Regeneration of Phosphorus Pentoxide*.

ASTM D 5028, *Standard Test Method for Curing Properties of Pultrusion Resins by Thermal Analysis*.

ASTM E 10, *Standard Test Method for Brinell Hardness of Metallic Materials*.

ASTM E 18, *Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*.

ASTM E 92, *Standard Test Method for Vickers Hardness of Metallic Materials*.

ASTM E 94, *Standard Guide for Radiographic Testing*.

ASTM E 165, *Standard Test Method for Liquid Penetrant Examination*.

ASTM E 384, *Standard Test Method for Microindentation Hardness of Materials*.

ASTM E 428, *Standard Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Inspection*.

ASTM E 709, *Standard Guide for Magnetic Particle Examination*.

ASTM E 1356, *Standard Test Method for Assignment of the Glass Transition Temperatures by Differential Scanning Calorimetry or Differential Thermal Analysis*.

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

EN 287-1, *Approval testing of welders — Fusion welding — Part 1: Steels*.

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

Lloyds Fire Test, *Lloyds Register of Shipping, Fire Testing Memorandum ICE/Fire OSG 1000/499*.

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this part of ISO 13628, the following terms, definitions, symbols and abbreviated terms apply.

3.1 Terms and definitions

3.1.1
ancillary component
component used to control the flexible pipe behaviour

EXAMPLES Bend stiffeners and buoyancy modules.

3.1.2
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.

3.1.3
anti-wear layer
non-metallic layer, either extruded thermoplastic sheath or tape wrapping, used to minimize wear between structural layers

3.1.4
bellmouth
part of a guide tube, formed in the shape of a bellmouth and designed to prevent overbending of the flexible pipe

3.1.5
bend limiter
device used to restrict bending of the flexible pipe

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

3.1.6
bend radius
radius of curvature of the flexible pipe measured to the pipe centreline

NOTE Storage and operating MBRs are defined in 5.3.1.6 and 5.3.1.7.

3.1.7
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

3.1.8
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 attached to either an end fitting or a support structure if the flexible pipe passes through the bend stiffener.

3.1.9
bending stiffness
property 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 and the resultant bend radius of the pipe.

3.1.10
burst-disk
weak point 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 localised area.

3.1.11
carcass
interlocked metallic construction that can be used as the innermost layer to prevent total or partial collapse of the internal pressure sheath or pipe due to pipe decompression, external pressure, tensile armour pressure and mechanical crushing loads

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

3.1.12
choke and kill line
flexible pipe jumper located between a choke manifold and a blow-out preventer

3.1.13
connector
device used to provide a leak-tight structural connection between an 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.

3.1.14
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 of the manufacturer's design methodologies

NOTE The design methodology verification report may include occasional amendments or revisions to address the exceeding of previous limits or changes in methodologies.

3.1.15
design pressure
minimum or maximum pressure, inclusive of operating pressure, surge pressure including shut-in pressure and, if applicable, vacuum conditions and static pressure head

3.1.16
dynamic application
application in which the 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 and torsional cycles.

3.1.17
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 fittings in such a way as to transfer the load between the flexible pipe and the connectors.

3.1.18
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 polymer layers. The term “pipe” is used in this part of ISO 13628 as a generic term for flexible pipe.

3.1.19
fish-scaling
tendency of one tensile armour wire edge to become detached from the underlying layer either because of deflection or because of incorrect twist deformation during armour winding

3.1.20
independent verification agent
independent party or group, selected by the manufacturer, that can verify the indicated methodologies or performance in the light of 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.

3.1.21
insulation layer
additional layer added to the flexible pipe to increase its thermal insulation properties

NOTE The layer is usually located between the outer tensile armour layer and the outer sheath.

3.1.22
intermediate sheath
extruded polymer layer located between internal pressure and outer sheaths

NOTE This layer may be used either as a barrier to external fluids in smooth bore pipes or as an anti-wear layer.

3.1.23
internal pressure sheath
polymer layer that ensures internal fluid integrity

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

3.1.24
jumper
short flexible pipe used in subsea and topside, static or dynamic applications

3.1.25
lay angle
angle between the axis of a spiral wound element (e.g. armour wires) and a line parallel to the flexible pipe longitudinal axis

3.1.26
outer sheath
polymer layer used to protect the pipe against penetration by sea water and other external environments, corrosion, abrasion and mechanical damage, and to keep the tensile armours in position after forming

3.1.27
piggyback
two pipes attached at regular intervals with clamps

NOTE Either or both of the pipes may be flexible.

3.1.28
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 to mechanical crushing loads

NOTE The layer also 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.

3.1.29
quality
conformance to specified requirements

3.1.30
quality assurance
planned, systematic and preventive actions which are required to ensure that materials, products or services will meet specified requirements

3.1.31
quality control
inspection, test or examination to ensure that materials, products or services conform to specified requirements

3.1.32
rough bore
flexible pipe with a carcass as the innermost layer

3.1.33
service life
period of time during which the flexible pipe fulfils all performance requirements

3.1.34
smooth bore
flexible pipe with an internal pressure sheath as the innermost layer

3.1.35
S-N curves
curves showing stress range versus number of cycles

3.1.36
sour service
service conditions with an H_2S content exceeding the minimum specified by ANSI/NACE MR0175 at the design pressure

3.1.37
static application
application in which the flexible pipes are not exposed to significant cyclically varying loads or deflections during normal operations

3.1.38
sweet service
service conditions with an H_2S content not exceeding the minimum specified by ANSI/NACE MR0175 at the design pressure

3.1.39
tensile armour layer
structural layer consisting of helically wound metallic wires, typically with a lay angle of between 20° and 55°

NOTE Tensile armour layers are typically counter-wound in pairs, and are used to sustain, totally or partially, tensile loads and internal pressure.

3.1.40
third party
independent party qualified to witness, confirm or approve the referenced data, result, procedure, test or qualification

3.1.41
torsional balance
pipe characteristic that is achieved by designing the structural layers in the pipe so that axial and pressure loads do not induce significant twist or torsional loads in the pipe

3.1.42
tensile strength
maximum tensile stress which a material is capable of sustaining; calculated from the maximum load during a tension test carried to rupture and the original cross-sectional area of the specimen

3.1.43
unbonded pipe
construction consisting of separate unbonded polymeric and metallic layers, which allows relative movement between layers

3.1.44
visual examination
examination of parts and equipment for visible defects in material and workmanship

3.1.45
yield strength
engineering stress at which, by convention, it is considered that plastic elongation has commenced

NOTE It is specified in terms of either a specified deviation from a linear stress-strain relationship, or a specified total extension attained, or maximum or minimum engineering stresses measured during discontinuous yielding.

3.2 Symbols and abbreviated terms

ASNT American Society of Nondestructive Testing

DNV Det Norske Veritas

DSC differential scanning calorimetry

FAT factory acceptance test

HAZ heat-affected zone

HIC hydrogen-induced cracking

ID internal diameter

MBR minimum bend radius

NDE non-destructive examination

PA polyamide

PE polyethylene

PVC polyvinylchloride

PVDF polyvinylidene fluoride

RAO response amplitude operator

S-N stress range — number of cycles

SSC sulfide stress cracking

TAN titrated acid number

TFL through flowline

UV ultraviolet

WPS welding procedure specification

WPQR welding procedure qualification record

σ_y material yield strength

σ_u material tensile strength

σ_t tensile hoop stress

σ_e equivalent stress (Von Mises or Tresca)

n permissible utilization factor as specified in Table 7

P_c combined probability of occurrence (yearly)

4 Functional requirements and recommendations

4.1 General

4.1.1 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.

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

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 throughout 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 in this part of ISO 13628.

4.2.2 End fittings

The manufacturer shall demonstrate that the end fittings, as a minimum, meet the same functional requirements as the flexible pipe. If relevant, the following shall be demonstrated:

a) the end fittings shall provide a structural interface between the flexible 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, including the requirements given in 4.4, 4.5, 4.6 and the following:

a) nominal ID;

b) length and tolerances of flexible pipe, including end fittings;

c) service life.

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 throughout service life;

— factory and field-test pressure requirements of governing and/or certifying authorities.