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

Part 10: Specification for bonded flexible pipe

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

Partie 10: Spécification pour canalisations flexibles composites

Reference number
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Contents

Page

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 13628-10 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*.

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 system*

— *Part 10: Specification for bonded flexible pipe*

— *Part 11: Flexible pipe systems for subsea and marine riser applications*

The following part is under preparation:

— *Part 12: Dynamic production risers*

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.

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

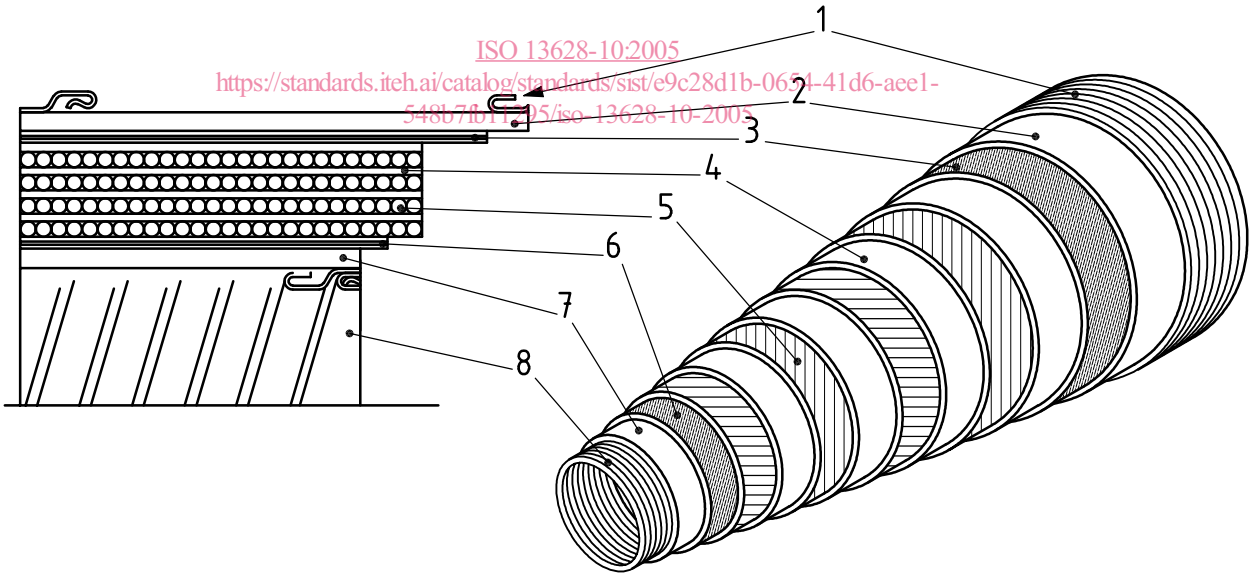
Part 10: Specification for bonded flexible pipe

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 H_2S-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*

API[1] Standard 1104, *Welding of Pipelines and Related Facilities*

ASME[2] Section IX, Boiler & Pressure Vessel Code, *Welding and Brazing Qualifications*

ASTM[3] 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*

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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 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*

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*

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

DIN[5] 53505, *Shore A and Shore D hardness testing of rubber*

DIN 53516, *Testing of rubber and elastomers; determination of abrasion resistance*

EN[6] 287-1, *Qualification test of welders — Fusion welding — Part 1: Steels*

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4) Det Norske Veritase.

5) Deutsches Institut für Normung e.V.

6) European Committee for Standardization.

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 H_2S Environments*

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 H_2S 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 H_2S 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