INTERNATIONAL STANDARD

ISO 13628-2

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

Part 2: Unbonded 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 non collées 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.org
Web www.iso.org

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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 13628-2 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 pip*e, 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 H_2S-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*

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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 Latices — 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*

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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 H_2S 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 H_2S 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 H_2S 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.