INTERNATIONAL STANDARD

ISO 13628-11

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

Part 11:
Flexible pipe systems for subsea and marine applications

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

Partie 11: Systèmes de canalisations flexibles pour applications sous-marines et en milieu marin

Reference number
ISO 13628-11:2007(E)

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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 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 13628-11 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 first edition of ISO 13628-11 cancels and replaces ISO 10420:1994, 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*

A part 12 dealing with dynamic production risers, a part 13 dealing with remotely operated tools and interfaces on subsea production systems and a part 15 dealing with subsea structures and manifolds are under preparation.

Introduction

This part of ISO 13628 is based on API RP 17B and on matching ISO procedures and API procedures. This ISO standard has been technically updated and revised to cater for the needs of the international oil and natural gas industries. This part of ISO 13628 provides information complementary to ISO 13628-2 and ISO 13628-10.

Users of this International Standard should be aware that further or differing requirements can 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 can 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 11: **Flexible pipe systems for subsea and marine applications**

1 Scope

This part of ISO 13628 provides guidelines for the design, analysis, manufacture, testing, installation and operation of flexible pipes and flexible pipe systems for onshore, subsea and marine applications. This part of ISO 13628 supplements ISO 13628-2 and ISO 13628-10, which specify minimum requirements for the design, material selection, manufacture, testing, marking and packaging of unbonded and bonded flexible pipe, respectively.

This part of ISO 13628 applies to flexible pipe assemblies, consisting of segments of flexible pipe body with end fittings attached to both ends. Both bonded and unbonded pipe types are covered. In addition, this part of ISO 13628 applies to flexible pipe systems, including ancillary components.

The applications covered by this part of ISO 13628 are sweet- and sour-service production, including export and injection applications. This part of ISO 13628 applies to both static and dynamic flexible pipe systems used as flowlines, risers and jumpers. This part of ISO 13628 does cover, in general terms, the use of flexible pipes for offshore loading systems.

NOTE Refer also to Reference [30] for offshore loading systems.

This part of ISO 13628 does not cover flexible pipes for use in choke and kill lines or umbilical and control lines.

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 13628-2:2006, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 2: Unbonded flexible pipe systems for subsea and marine applications*

ISO 13628-3:2000, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 3: Through flowline (TFL) systems*

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

NACE TM0177, *Laboratory testing of metals for resistance to sulfide stress cracking and stress corrosion cracking in* H_2S *environments*

3 Terms, abbreviated terms, definitions and symbols

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

3.1 Terms and definitions

3.1.1
annulus
space between two concentric plastic sheaths of an unbonded flexible pipe cross-section

3.1.2
Arrhenius plot
log-linear scale used to plot service life against the inverse of temperature for some polymer materials

3.1.3
basket
device used for storage and transport of flexible pipe

NOTE All pipes are laid freely into the basket.

3.1.4
bird-caging
buckling of the tensile-armour wires, usually caused by extreme axial compression, which results in significant radial deformation

3.1.5
buoyancy module
buoys used in significant numbers at discrete points over a section of riser to achieve wave-shape riser configurations

NOTE See 4.4.6.

3.1.6
carousel
device used for storage and transport of very long lengths of flexible pipe and which rotates about a vertical axis

NOTE Pipe is wound under tension around the centre hub.

3.1.7
Chinese fingers
woven steel wire or fabric sleeve that can be installed over a flexible pipe and drawn tight to grip it for support or applying tension to the pipe

3.1.8
end fitting
termination in a flexible pipe

3.1.9
flexible pipe system
fluid conveyance system for which the flexible pipe(s) is/are the primary component and which includes ancillary components attached directly or indirectly to the pipe

3.1.10
free-hanging catenary
riser configuration that spans the water column in a catenary shape modified by the bending stiffness of the riser

NOTE See Figure 4.

3.1.11
integrated service umbilical
ISU™[1)]
structure in which the inner core is a standard flexible pipe construction

NOTE 1 Umbilical components are wound around the core pipe and covered with a protective outer sheath (see 4.3.6).

NOTE 2 ISU is a trademark of Coflexip Stena Offshore.

3.1.12
lazy wave
free-hanging catenary modified by a section with distributed buoyancy modules

NOTE See Figure 4.

3.1.13
lazy-S
free-hanging catenary modified by a section with concentrated buoyancy modules

NOTE See Figure 4.

3.1.14
multibore
multiple flexible pipes or umbilicals contained in a single construction with an outer sheath extruded over the bundle

NOTE See 4.3.7.

3.1.15
multiple configuration
riser system with more than one riser connected at a mid-depth location

3.1.16
ovalization
out-of-roundness of the pipe, calculated as follows:

$$\frac{D_{\text{max}} - D_{\text{min}}}{D_{\text{max}} + D_{\text{min}}}$$

where D_{max} and D_{min} are maximum and minimum pipe outside diameter, respectively.

3.1.17
piggy back
attachment of two parallel and adjacent independent pipes, rigid or flexible, over a significant length

3.1.18
prototype test
test to establish or verify a principal performance characteristic for a particular pipe design, which may be a new or established design

3.1.19
rapid decompression
sudden depressurization of a system during which gas in the pipe expands rapidly and can cause blistering or collapse of the internal pressure sheath or other gas-saturated layers

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1) ISU™ is an example of a suitable product available commercially. This information is given for the convenience of users of this part of ISO 13628 and does not constitute an endorsement by ISO of this product.

3.1.20
reel
large-diameter structure used for storage of long lengths of flexible pipe, which rotates about a horizontal axis

3.1.21
riser base
structure positioned on the seabed, used to provide a structural and pressure-tight connection between a flexible riser and a flowline

NOTE 1 See 4.4.8.

NOTE 2 It may be a PLET or a PLEM.

3.1.22
riser hang-off
structure for supporting a riser at the connection to a platform

EXAMPLE Jacket, semi-sub, tanker, etc.

3.1.23
steep wave
lazy wave with a touchdown point fixed to the seabed

NOTE See Figure 4.

3.1.24
steep-S
lazy-S with a touchdown point fixed to the seabed

NOTE See Figure 4.

3.1.25
subsea buoy
concentrated buoyancy system

NOTE This system generally consists of steel or syntactic foam tanks, as used in S-type riser configurations (4.4.5). See also buoyancy module (3.1.4).

3.1.26
tensioner
mechanical device used to support or apply tension to a pipe during installation

3.1.27
umbilical
bundle of helically or sinusoidally wound small-diameter chemical, hydraulic, and electrical conductors for power and control systems

3.2 Symbols and abbreviated terms

The following symbols and abbreviated terms are used in this document.

CPE chlorinated polyethylene

CR polychloroprene

DA dynamic application

DBS dibutyl sebacate

DOF degrees of freedom

EPDM	ethylene propylenediene monomer rubber
FAT	factory acceptance test
FPS	floating production system
FPSO	floating production storage and offloading
HDPE	high density polyethylene
HIC	hydrogen-induced cracking
HNBR	hydrogenated nitrile rubber
ID	inside diameter
ISU	integrated service umbilical
MBR	minimum bend radius
MDPE	medium density polyethylene
MWL	mean water level
NBR	nitrile butadiene rubber
NR	natural rubber
OD	outer diameter
PA	polyamide
PE	polyethylene
PP	polypropylene
PLEM	pipeline end manifold
PU	polyurethane
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
REF	riser end fitting
ROV	remotely operated vehicle
SA	static application
SBR	storage bend radius
SSC	sulfide stress cracking
TFL	through flowline
UV	ultraviolet

VIV vortex-induced vibration

XLPE cross-linked polyethylene

C_d hydrodynamic drag coefficient

C_m hydrodynamic inertia coefficient

D_{max} maximum pipe outside diameter

D_{min} minimum pipe outside diameter

σ_u material ultimate stress

σ_y material yield stress

4 System, pipe, and component description

4.1 Introduction

4.1.1 General

Clause 4 provides a general overview of flexible pipe systems, pipe cross-section designs and ancillary components. In addition, Clause 4 gives an overview of all aspects of flexible pipe technology and identifies the clauses and subclauses of this part of ISO 13628 and of ISO 13628-2:2006 and ISO 13628-10:2005 to be consulted for relevant issues.

In general, flexible pipe is a custom-built product that can be designed and manufactured in a variety of methods. It is not the intent of this part of ISO 13628 to discourage novel or new developments in flexible pipe. On the contrary, it is recognized that a variety of designs and methods of analysis are possible. For this reason, some topics are presented in general terms to provide guidance to the user while still leaving open the possibility of using alternative approaches.

The reader should be aware that flexible-pipe technology (concepts, design and analysis methodologies and criteria, components manufacturing and testing, operational roles and demands, maintenance and inspection, etc.) is in a state of rapid and continuing evolution. Potential users shall, therefore, apply care in their application of the recommendations within this part of ISO 13628.

4.1.2 Recommended practice and specification overview

4.1.2.1 This part of ISO 13628 provides the current best practice for design and procurement of flexible pipe systems and gives guidance on the implementation of the specification for standard flexible-pipe products. In addition, the recommended practice shows guidelines on the qualification of prototype products.

4.1.2.2 All aspects of flexible-pipe technology, from functional definition to installation, are addressed in either this part of ISO 13628 or in ISO 13628-2 and ISO 13628-10. Some issues are addressed in all three documents. The various stages in the procurement and use of flexible pipes are defined in Figure 1.

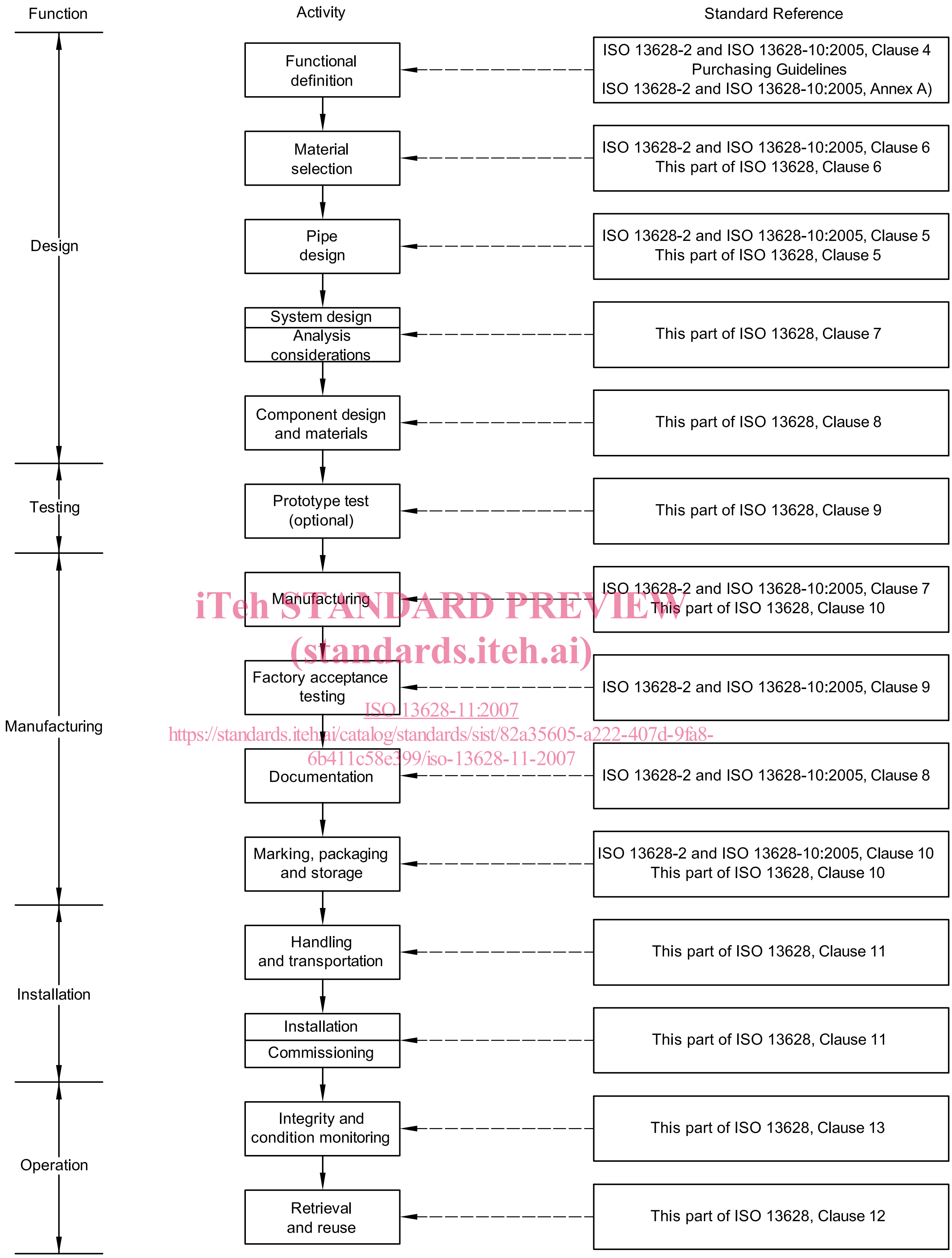


Figure 1 — Flexible pipe overview

4.2 Flexible pipe systems

4.2.1 Definition of system

4.2.1.1 The flexible pipe system is an important part of the overall field development and can influence or be influenced by the design and specification of other components in the development. The definition of the flexible pipe system should therefore commence at the initiation of the overall project as development strategies evolve. Aspects of the development strategy that can influence the flexible pipe system include field layout (template versus satellite wells) and production-vessel type (platform, tanker including turret location, semi-sub, etc.). Current limitations in flexible-pipe technology, such as application range and manufacturing capability, can also fundamentally influence potential overall field development options.

4.2.1.2 It is necessary to address the flexible pipe system and the flexible pipe or pipes within that system. It is necessary to consider the relevant parameters, as well as the interactions between the pipe design and the system design. Critical parameters that can affect the pipe design should be identified early in the process and can include the following:

a) severe internal conditions, such as high H_2S content (sour service);

b) extreme external environmental conditions;

c) difficult installation conditions (such as extreme environment);

d) frequent, cyclic, large-amplitude pressure and temperature fluctuations;

e) large vessel offsets.

4.2.1.3 To define accurately all relevant parameters, interaction between the purchaser and manufacturer is required at an early stage in the project. An important aspect of this is the identification of critical system issues, such as interfaces. See 7.6 for potentially critical interfaces that should be considered at project commencement.

4.2.1.4 ISO 13628-2 and ISO 13628-10:2005, Annex A, provide purchasing guidelines, which may be used in the definition of the flexible pipe system and which address all aspects from general design parameters to detailed flowline- and riser-specific requirements.

4.2.2 Applications

4.2.2.1 General

4.2.2.1.1 Flexible pipe for offshore and onshore applications is grouped into either a static or dynamic category (Figures 2 and 3). It is used for a multitude of functions, including the following:

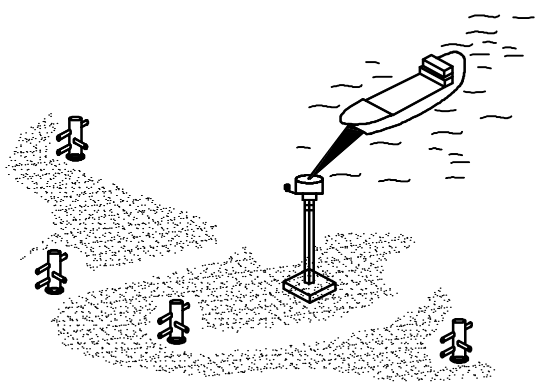
a) production: oil, gas, condensate, water;

b) injection: water, gas, downhole chemicals;

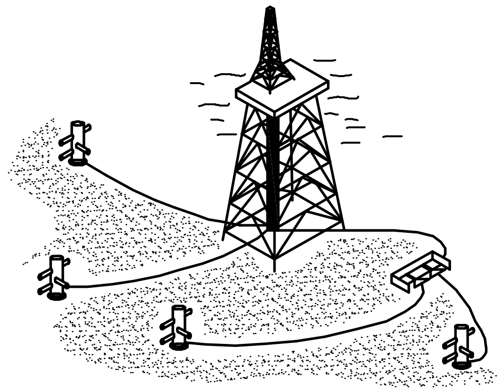
c) export: semi-processed oil and gas;

d) services: wellhead chemicals, control fluids.

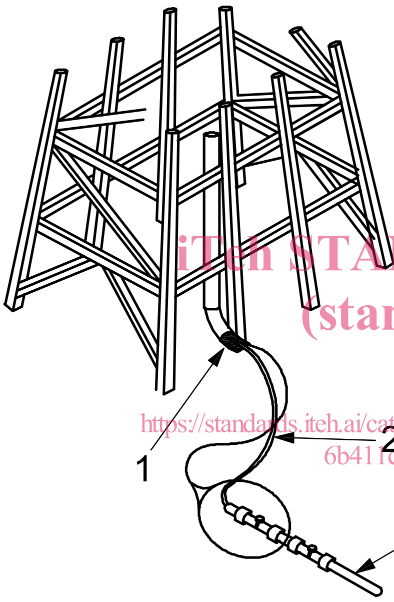
4.2.2.1.2 The static and dynamic categories place different physical demands on the pipe. While both require long life, mechanical strength, internal and external damage resistance and minimal maintenance, dynamic service pipes also require pliancy and high fatigue resistance.



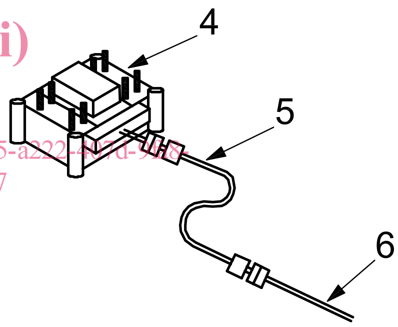
a) Early field production scheme



b) Flowlines repositioned for mature field production scheme



c) Flexible pipe connected to a J-tube



d) Flexible pipe connected to the manifold

Key

1 J-tube
2 flexible pipe
3 rigid pipe
4 manifold
5 flexible pipe spool piece
6 rigid steel flowline

Figure 2 — Examples of static applications for flexible pipe