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Petroleum and natural gas industries — Pipeline transportation systems — Test procedures for mechanical connectors

Industries du pétrole et du gaz naturel — Systèmes de transport par conduites — Modes opératoires d'essai des connecteurs mécaniques

Reference number
ISO 21329:2004(E)

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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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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 21329 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 2, *Pipeline transportation systems*.

Introduction

In some circumstances mechanical connectors provide a lower cost and/or enabling advantage to welded connectors usually used for pipelines. However, use of mechanical connectors has raised concerns about pipeline integrity due to the potential for leak paths and absence of a direct method of inspection. In the past, reassurance of the integrity of mechanical pipeline connectors has relied upon design information provided by the manufacturer, the results of finite element analysis and past experience.

This International Standard is primarily applicable to connectors to be used in a large number, and hence there is a significant burden in the number of connectors that need to be tested. However, it is recognized that the test burden can be reduced in project-specific cases, for example if there is no concern about fatigue, if the connector will not be subjected to fully restrained forces and/or if the connector design is less sensitive to accuracy of tolerance matching of components at assembly.

The tests specified in this International Standard provide a physical demonstration of the integrity of the pipeline connector. This International Standard has been developed from three main sources.

The first is the *Low cost pipeline connector systems joint industry project (JIP),* (1995-1997)[14], which defined the load envelopes for pipelines, identified the practical issues of installation, and conducted demonstration physical tests on three types of mechanical connectors.

The second source is ISO 13679, which has a parallel function for downhole connections.

The third is the *Connection testing specification JIP*, (1999-2000)[15]. The JIP was sponsored by oil companies, connector suppliers, pipeline construction contractors and design consultants.

Petroleum and natural gas industries — Pipeline transportation systems — Test procedures for mechanical connectors

1 Scope

This International Standard specifies requirements and provides guidance for the testing of mechanical connectors for use in pipeline transportation systems for the petroleum and natural gas industries as defined in ISO 13623.

The tests specified in this International Standard are intended to form part of the design verification process for connectors. They provide objective evidence that connectors conform to a defined performance envelope.

This International Standard does not cover the use of design procedures as part of the qualification process for mechanical connectors, nor does it address fabrication and quality control. However, it can be used as input to a qualification procedure.

Although its principles can be applied, this International Standard does not address

a) connectors that are designed to rotate in use,

b) manifolds,

c) topsides pipework or piping,

d) flanges,

e) connectors used in pipelines installed by reeling or J-tube pulls,

f) factory acceptance testing,

g) statistical bases for risk analysis.

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 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 783:1999, *Metallic materials — Tensile testing at elevated temperature*

ISO 3183-1, *Petroleum and natural gas industries — Steel pipe for pipelines — Technical delivery conditions — Part 1: Pipes of requirement class A*

ISO 3183-2, *Petroleum and natural gas industries — Steel pipe for pipelines — Technical delivery conditions — Part 2: Pipes of requirement class B*

ISO 3183-3, *Petroleum and natural gas industries — Steel pipe for pipelines — Technical delivery conditions — Part 3: Pipes of requirement class C*

ISO 6892:1998, *Metallic materials — Tensile testing at ambient temperature*

ISO 9327, *Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions*

ISO 13623, *Petroleum and natural gas industries — Pipeline transportation systems*

ISO 13679:2002, *Petroleum and natural gas industries — Procedures for testing casing and tubing connections*

EN 10213, *Technical delivery conditions for steel castings for pressure purposes*

EN 10222-1, *Steel forgings for pressure purposes – Part 1: General requirements for open die forgings*

ASTM A 370[1)], *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A 487/A 487M, *Standard Specification for Steel Castings Suitable for Pressure Service*

ASTM A 694/A 694M, *Standard Specification for Carbon and Alloy Steel Forgings for Pipe Flanges, Fittings, Valves, and Parts for High-Pressure Transmission Service*

3 Terms and definitions

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

3.1
actual yield strength
yield strength of material determined from specimens directly related to components used in construction of the test samples

3.2
application level
service loading envelope encompassing a group of pipeline and riser applications

3.3
batch
group of items manufactured or machined under controlled conditions to ensure consistent chemical composition, processing and heat treatment such that the group can be considered as a single population

3.4
by agreement
unless otherwise indicated, agreement between the manufacturer and purchaser at the time of enquiry and order

NOTE Adapted from ISO 3183-2:1996.

3.5
connector
mechanical device used to connect adjacent components in the pipeline

1) American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA

3.6
galling
localized damage to material surfaces resulting from contact conditions

NOTE Galling can be caused by cold welding of contacting material surfaces followed by tearing of the weld during further sliding or rotation.

3.7
heat, noun
batch of steel prepared in one steel-making operation

[ISO 15590-1:2001]

3.8
liner
internal layer of a material different to that of the pipe body

NOTE The liner material may be, for example, plastic or non-ferrous.

3.9
load envelope
limit of loads (axial, pressure, torsion, bending, fatigue and temperature) within which a connector operates during service or is tested

3.10
manufacturer
organization responsible for the design and manufacture of the equipment

NOTE 1 The manufacturer is not necessarily the vendor.

NOTE 2 Adapted from ISO 13707:2000.

3.11
operational restrained test
simulation of the loads due to operational cycling on a section of pipeline that is fully axially constrained

3.12
operational unrestrained test
simulation of the loads due to operational cycling on a section of pipeline or riser that is not axially constrained and may have axial tension due to self-weight or externally applied tension

3.13
pipeline
those facilities through which fluids are conveyed, including pipe, pig traps, components and appurtenances up to and including the isolating valves

[ISO 13623:2000]

3.14
purchaser
individual or organization that issues the order and specification to the vendor

NOTE The purchaser may be the owner or the owner's agent.

[ISO 13707:2000]

3.15
reverse torque
Z
torque applied during tests to simulate loads that might cause the connector to rotate or unscrew, if applicable

3.16
riser
that part of an offshore pipeline, including subsea spool pieces, which extends from the seabed to the pipeline termination on an offshore installation

[ISO 13623:2000]

3.17
seal
barrier that resists the passage of fluids

[ISO 13678:2000]

3.18
multiple seals
sealing system that consists of more than one independent barrier and of which each barrier forms a seal itself

3.19
specified minimum yield strength
minimum yield strength required by the specification or standard under which the material is purchased

[ISO 13623:2000]

3.20
test sample
assembly of a connector and two pieces of pipe specifically for testing

4 Symbols and abbreviated terms

4.1 Symbols

$A_{F,un}$ operational unrestrained axial factor

A_s specified cross-sectional area of pipe

$B_{F,hy}$ bending factor for hydrostatic pressure test

$B_{F,in}$ bending factor for installation

$B_{F,un}$ bending factor for unrestrained operation tests

D_i specified pipe inside diameter

D_o specified pipe outside diameter

E_p Young’s modulus of pipe

F_{re} axial force for restrained operation

F_{un} axial force for unrestrained operation

f_{vM} von Mises' factor

H_r depth rating

K load multiplication factor

K_F torque factor

K_{cc} ratio of actual to specified minimum yield stress of the critical connector component material

K_p ratio of actual to specified minimum yield stress of the pipe body material

K_{SCF} stress concentration factor

L length of test sample between inner supports

L_g grip length of pipe

L_p unsupported pipe length for test sample

L_s length between scribe mark and coupling on test sample

M_{in} bending moment for installation

M_{hy} bending moment for hydrostatic pressure test

M_{un} bending moment for unrestrained operation

N_c total number of cycles

p_d design pressure

p_{ex} external hydrostatic pressure

p_H internal pressure value to be used for testing

p_{op} operating pressure based on MAOP at the connector

p_r manufacturer's rated pressure

p_t hydrostatic test pressure

S_L lowest fatigue stress range

S_M middle fatigue stress range

S_H highest fatigue stress range

S-N stress versus number of cycles in fatigue curve

$\sigma_{ax,re}$ restrained axial stress

σ_{ayc} actual yield stress of the connector critical component

σ_{ayp} actual yield stress of the pipe body material

σ_{syc} specified minimum yield stress of the connector critical component

σ_{syp} specified minimum yield stress of the pipe body material

$T_{d.max}$ maximum design temperature

$T_{d.min}$ minimum design temperature

T_{HT} maximum test temperature

T_{LT} minimum test temperature

T_{max} maximum rated temperature

T_{min} minimum rated temperature

$T_{op,max}$ maximum operating temperature

$T_{op,min}$ minimum operating temperature

t specified wall thickness

t_{min} minimum wall thickness accounting for manufacturing tolerances

υ Poisson ratio of the pipe body

Z reverse torque

Z_{mu} make-up torque

4.2 Abbreviated terms

CRA corrosion-resistant alloy

FEA finite element analysis

ID inside diameter

MAOP maximum allowable operating pressure

OD outside diameter

5 Test categories

5.1 General

Connectors shall be tested according to the

- pressure, temperature and depth ratings, as defined in 5.2,
- intended application level, as defined in 5.3,
- confidence level as defined in 5.4.

The application level sets the loading and the confidence level the number of test samples. The general intention of the test is to demonstrate that the connector is stronger than the associated pipe under all applicable conditions of static and fatigue loadings, and remains leak-tight.

It is recommended that the connectors be tested to the highest application and confidence levels for which they are suitable. If the loading exceeds that defined in application level 4, the loading to be applied in the test shall be increased accordingly and recorded in the test report.

5.2 Pressure, temperature and depth ratings

5.2.1 Pressure rating

Connectors shall be tested according to the pressure defined in 11.3. The rated pressure shall take into account any reduction in material strength at the rated temperature. For a specific pipeline or riser duty, connectors may be de-rated to the pipeline/riser design pressure, p_d, or MAOP, p_{op}, at the connector location by agreement.

5.2.2 Temperature rating

Connectors shall be tested to the minimum and maximum temperatures as defined in 11.3. For a specific pipeline or riser duty, connectors may be de-rated to the pipeline/riser design or operating temperature at the connector location by agreement.

5.2.3 Depth rating

Connectors intended for use underwater shall be tested according to their rated depth, H_r. Connectors may be de-rated to the pipeline/riser operating depth for a specific pipeline or riser duty at the connector location and by agreement.

5.3 Application levels

A total of four application levels are defined, with increasing severity from application level 1 upwards. The loading factors for each application level are detailed in Table 1. Testing to a given application level validates connectors for lower application levels.

Annex A specifies application levels.

5.4 Confidence levels

The purchaser shall specify the required confidence level. Two confidence levels are defined in Table 2, with increasing consequence of failure.

— Normal: for temporary conditions where failure implies risk of human injury, significant environmental pollution or very high economic or political consequences. For this confidence level, no frequent human activity is anticipated along the pipeline route.

— High: for operating conditions where failure implies high risk of human injury, significant environmental pollution or very high economic or political consequences. This is the confidence level required for areas with frequent human activity, e.g. those parts of the pipeline or riser near the platform or in areas populated with more than 50 persons/km^2.

Table 1 — Test load factors

Test	Subclause	Load factor for application level			
		1	2	3	4
Make, break and torque tests Torque factor – K_F	10.5, C.1	0	0	0,05	0,05
Installation tests[a] Bending factor – $B_{F,in}$	11.4	0,3	0,85	0,95	0,95
Hydrostatic pressure tests Bending factor – $B_{F,hy}$	11.5	0	1,0	1,0	1,0
Operational cycles unrestrained tests Bending factor – $B_{F,un}$ Axial factor – $A_{F,un}$	11.6	0,3 0 [b]	0,3 0 [b]	0,9 0 [b]	0,9 0,2
Other von Mises' factor – f_{vM}	C.2.2	NA	0,96	0,96	0,96

[a] In all cases, if the water depth H_r > 500 m the effect of external hydrostatic pressure shall be considered.

[b] In the case of a suspended riser, the connector may have $A_{F,un}$ > 0. Allowance should be made for this when defining an application level within the range 1 to 3.

Table 2 — Test requirements, test sample numbers and confidence levels

Requirements		Subclause reference	Confidence level: normal	Confidence level: high
Connector geometry and performance data		7.3	In all cases	
Number of test samples to prepare		6.5	8 numbered 1 to 4 and 9 to 12	12 numbered 1 to 12
			Test sample number(s)	
Make, break and torque tests	Repeated make-up and breakout	10.3	1 to 4	1 to 8
	Final make-up	10.4	All	All
	Reverse torque	10.5	1 to 4	1 to 8
Service load tests	Installation tests	11.4	1 to 4	1 to 8
	Hydrostatic pressure tests	11.5	1 to 4	1 to 8
	Operational unrestrained tests Total number of cycles, N_c	11.6	1, 3 20	1, 3, 5, 7 100
	Operational restrained tests Total number of cycles, N_c	11.7	2, 4 20	2, 4, 6, 8 100
Limit load tests	Pressure-to-failure test	12.4	1	1
	Compression-to-failure test	12.3	NA	5
	Bending-to-failure test	12.5	4	4
	Tension-to-failure test	12.2	NA	7
Fatigue tests	Bending fatigue-to-failure test S_L, see 13.2.4 S_M, see 13.2.4 S_H, see 13.2.4	13	 2, 9 10, 11 3, 12	 2, 6, 9 10, 11 (see NOTE) 3, 8, 12

'All' signifies all test samples shall undergo the specific test.

NOTE In many applications some modes of testing may not be necessary, e.g. where fully restrained conditions cannot occur, and where it may not be necessary to conduct limit compression tests to failure. This would make the third connector available for fatigue testing.

6 Test requirements

6.1 General

Connectors intended for a specific application level shall be tested according to the sequence shown in Table 2.