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Petroleum and natural gas industries — Procedures for testing casing and tubing connections

Industries du pétrole et du gaz naturel — Modes opératoires d'essai des connexions pour tubes de cuvelage et de production

Please see the administrative notes on page iii

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ISO/CEN PARALLEL PROCESSING

This final draft has been developed within the International Organization for Standardization (ISO), and processed under the **ISO-lead** mode of collaboration as defined in the Vienna Agreement. The final draft was established on the basis of comments received during a parallel enquiry on the draft.

This final draft is hereby submitted to the ISO member bodies and to the CEN member bodies for a parallel two-month approval vote in ISO and formal vote in CEN.

Positive votes shall not be accompanied by comments.

Negative votes shall be accompanied by the relevant technical reasons.

In accordance with the provisions of Council Resolution 15/1993, this document is **circulated in the English language only**.

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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 13679 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 5, *Casing, tubing and drill pipe*.

This second edition cancels and replaces the first edition (ISO 13679:2002). Refer to Annex K for a listing of the parts of this document that have been technically revised.

Introduction

This International Standard is part of a process to provide reliable tubing and casing connections for the oil and natural gas industry which are fit for purpose. It has been developed based on improvements to API RP 5C5 and proprietary test procedures, with input from leading users, manufacturers and testing consultants from around the world. This International Standard represents the knowledge of many years of testing and qualification experiences.

The validation of connection test load envelope and failure limit loads is relevant to design of tubing and casing for the oil and natural gas industries. Tubing and casing are subject to loads which include internal pressure, external pressure, axial tension, axial compression, bending torsion, transverse forces and temperature changes. The magnitude and combination of these loads result in various pipe body and connection failure modes. Although pipe body test and limit loads are well understood in general, the same cannot be stated for the connection. These failure modes and loads are generally different and often less than that of the pipe. Consequently, experimental validation is required.

The validation of test and limit loads requires testing at the extremes of performance parameters to these defined loads. Testing at the extremes of the performance parameters assures that the production population that falls within these limits meets or exceeds the performance of the test population. Thread connection performance parameters include dimensional tolerances, mechanical properties, surface treatment, make-up torque and the type and amount of thread compound. For typical proprietary connections, worst-case tolerances are known and defined in this International Standard. For other connections designs, analysis is required to define worst-case tolerance combinations.

It is necessary that users of this International Standard 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 a purchaser from accepting, alternate equipment or engineering solutions for the individual application. This is particularly applicable when there is innovative or developing technology. Where an alternative is offered, it is the responsibility of the vendor to identify any variations from this International Standard and provide details.

This International Standard consists of the following major parts. Based on manufacturer's supplied data specified in Annex A and/or calculations in Annex B, tests are conducted in accordance with Clauses 4 to 8 and reported on the data forms given in Annex C. Annex D lists all the information that it is necessary to provide in the full test report. Annex E provides methodology for calculating and examples of pipe body load envelopes, the test load envelope and the test load points. Annex F gives an example of a load frame calibration. Annex G gives considerations for possible connection product line qualifications. Annex H provides guidelines for supplemental tests that can be used for special applications. Annex I gives the design rationale for this International Standard. Annex J gives requirements for connections that contain both a metal-to-metal seal and a resilient seal that are tested separately. Annex K is a summary of changes to ISO 13679:2002.

For specific applications that are not evaluated by the tests herein, supplementary tests can be appropriate. It is necessary that the user and manufacturer discuss well applications and limitations of the connection being considered.

Representatives of users and/or other third party personnel are encouraged to monitor the tests. ISO 13679 covers the testing of connections for the most commonly encountered well conditions. Not all possible service scenarios are included. For example, the presence of a corrosive fluid, which can influence the service performance of a connection, is not considered.

This International Standard includes various provisions. These are identified by the use of certain verbal forms:

— SHALL is used to indicate requirements that strictly need to be followed in order to conform to this International Standard and from which no deviation is permitted.

— SHOULD is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required, or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

— MAY is used to indicate a course of action permissible within the limits of the document.

— CAN is used to indicate statements of possibility and capability, whether material, physical or causal.

In addition, for Standard International (SI) units, the thousands separator is a space and the decimal separator is a comma. For United States Customary (USC) units, the thousands separator is a comma and the decimal separator is a period.

The “Highlighting in gray change-identification system” and the “Summary of changes” shown in informative Annex K identify sections of this document where committee-agreed changes (additions, modifications, and/or deletions) affecting the performance of the product(s) or the technical requirement(s) applicable to the product(s) have been made from the previous edition of this International Standard. While efforts have been made to ensure the accuracy and consistency of the application of the change-identification system, the user of this International Standard is both encouraged to consider the totality of the technical content of this International Standard rather than those changes identified, and is ultimately responsible for recognizing any differences between this and previous editions of the International Standard.

ISO/CS expressly disclaims any liability or responsibility for loss or damage resulting from inappropriate use of this International Standard based on inaccuracy of the “change-identification” system.

Petroleum and natural gas industries — Procedures for testing casing and tubing connections

1 Scope

This International Standard specifies tests to perform to determine the galling tendency, sealing performance and structural integrity of casing and tubing connections. The words “casing” and “tubing” apply to the service application and not to the diameter of the 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 3183, *Petroleum and natural gas industries — Steel pipe for pipeline transportation systems*

ISO/TR 10400:2007, *Petroleum and natural gas industries — Equations and calculations for the properties of casing, tubing, drill pipe and line pipe used as casing or tubing*

ISO 11960, *Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells*

ISO 13680, *Petroleum and natural gas industries — Corrosion-resistant alloy seamless tubes for use as casing, tubing and coupling stock — Technical delivery conditions*

API TR 5C3, *Technical report on equations and calculations for casing, tubing, and line pipe used as casing or tubing; and performance properties tables for casing and tubing)*

ANSI/API Spec 5L, *Specification for Line Pipe*

3 Terms and definitions and symbols and abbreviations

3.1 Terms and definitions

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

3.1.1
100 % pipe body load envelope
diagram containing the extremes of pipe body performance based on actual properties

NOTE Pipe body performance is also known as VME yield. See ISO/TR 10400 (API TR 5C3) for collapse.

3.1.2
ambient temperature
actual current temperature of the test lab environment at the time of testing

3.1.3
axial-pressure load diagram
plot of axial load versus pressure showing pipe and/or connection test load envelope or limit load extremes

3.1.4
connection
one pin and its adjoining coupling side or integral box

3.1.5
connection leak
leak that occurs across a connection.

NOTE See 8.2 for pressure sealing acceptance criteria.

3.1.6
diametrical interference
outer diameter of the inner member minus the inner diameter of the outer member

3.1.7
failure load
load at which the pipe body or connection fails catastrophically as in an axial separation, a rupture, large permanent deformation (e.g. buckling or collapse) or loss of sealing integrity

3.1.8
galling
form of surface damage resulting from cold welding of contacting material surfaces followed by tearing of the metal during further sliding/rotation

NOTE There are several degrees of galling used for repair and reporting purposes as defined in 8.1.

3.1.9
interference
amount of geometric overlap of mating members created by the design and tolerances of the members

3.1.10
leak
leakage
passage of contained test medium outside of the containment space whether in the equipment or the connection

3.1.11
light galling
galling that can be repaired by the use of abrasive paper

3.1.12
limit load
load combination extreme (axial load and/or pressure) that defines the failure conditions for the connection or load combination resulting in large permanent deformation (such as buckling) prior to catastrophic failure

3.1.13
lot
lengths of pipe with the same specified dimensions and grade from the same heat of steel that are heat-treated as part of a continuous operation (or batch)

3.1.14
material test coupon
cylinder of material from the tested pipe and/or coupling stock from which tensile test specimens are cut

3.1.15
metal-to-metal seal
seal or sealing system that relies on intimate and usually high contact stress of mating metal surfaces to achieve a seal

NOTE The thread compound can affect, both beneficially and detrimentally, the performance of a metal seal.

3.1.16
moderate galling
galling that can be repaired by the use of fine files and abrasive paper

3.1.17
mother joint
length of pipe or coupling stock from which short lengths are cut for machining connection test specimens

3.1.18
multiple seal
sealing system having more than one independent barrier, with each barrier forming a seal

3.1.19
pipe string
pipe body and the connection

3.1.20
pup joint
short pipe length usually with threaded ends

3.1.21
resilient seal
seal or sealing system that relies on entrapment of a seal ring within a machined groove in the connection (e.g. in the thread-form, on a seal area, etc.) to achieve a seal

3.1.22
seal
pressure barrier to prevent the passage of the test medium

3.1.23
seal ovality
maximum seal diameter minus the minimum seal diameter divided by the average seal diameter multiplied by 100

NOTE Seal ovality shall be reported as a percentage.

3.1.24
severe galling
galling that cannot be repaired by the use of fine files and abrasive paper

3.1.25
single seal
one barrier or multiple barriers that cannot be physically differentiated in their function

3.1.26
specimen
two connections with a shared coupling or one integral connection

3.1.27
test load envelope
extremes of loads (axial load, pressure, bending) based on actual measured mechanical properties and dimension of the specimen for a specific temperature to which the connection has been or will be tested in accordance with this International Standard

3.1.28
thread lot
all products manufactured on a given machine during a continuous production cycle that is not interrupted by a catastrophic tool failure or injurious machine malfunction (excluding worn tools or minor tool breakage), tool

holder change (except rough boring bar) or any other malfunction of either threading equipment or inspection gauges

3.1.29
thread seal
seal or sealing system that relies on intimate fitting of the thread-form and usually entrapment of the thread compound within the thread-form to achieve a seal

3.1.30
VME stress
equivalent stress based on the von Mises-Hencky minimum distortion energy criterion

3.2 Symbols

A^{a} cycles in test series A at ambient temperature using gas for internal pressure and liquid for external pressure. For CAL I-E, either gas or liquid shall be used.

A^{e} cycles in test series A at 180 °C (356 °F) for CAL III and CAL IV using gas for internal pressure and liquid for external pressure

B^{a} cycles in test series B, without bending, at ambient temperature with gas for CAL II through CAL IV; with gas or water for CAL I-E; with water for CAL I

$\mathrm{B}^{\mathrm{a}}_{\mathrm{b}}$ cycles in test series B, with bending, at ambient temperature with gas for CAL II through CAL IV; with gas or water for CAL I-E; with water for CAL I

$\mathrm{B}^{\mathrm{e}}_{\mathrm{b}}$ cycles in test series B, with bending, at 180 °C (356 °F) using gas for CAL III-Ambient A, CAL III, and CAL IV; at 135 °C (275 °F) for CAL II using gas

C compressive axial force

D specified pipe outside diameter or measured average outside diameter of a specimen used for axial load or pressure load

D_{i} inside diameter

D_{o} outside diameter

D_{leg} effective dogleg severity, expressed in degrees per thirty metres

d_{wall} maximum pipe D_{i}

E_{r} error in load frame calibration

E_{rp} error in load frame calibration, expressed in percent

F failure

F_{a} total axial force, tension or compression (sum of applied loads: F_{b}, F_{i}, F_{CEPL})

F_{b} bending equivalent axial force

F_{c} test load envelope compression load at 0 pressure (uniaxial compression)

F_{CEPL} capped-end pressure load acting on the connection

F_{f} actual load frame axial force, tension or compression

F_{i} indicated load frame axial force, tension or compression

F_{p} 95 % of pipe body tension or compression yield load at 0 pressure (uniaxial load)

F_t TLE tension load at 0 pressure (uniaxial tension)

F_{ymn} specified minimum material yield strength

I moment of inertia

I_{max} maximum design interference between thread or seal members, resulting from pin and box diameter specification and tolerances

I_{min} minimum design interference between thread or seal members, resulting from pin and box diameter specification and tolerances

I_{range} range of design interference between thread or seal members, equal to I_{max} minus I_{min}

k_i, k_o geometric variable

K_{wall} minimum of (t_{ac}/t) or 0,95

p_c collapse rating for specified OD, specified wall thickness and specified specimen yield strength (see ISO/TR 10400:2007,Clause 8)

P_d TLE pressure at 0 axial load (uniaxial internal pressure)

p_i internal pressure

p_{ib} internal pressure with bending

p_{ih} high internal pressure

p_{in} normalized internal test pressure

p_{il} low internal pressure

p_o external pressure

p_{ob} external pressure with bending

p_{on} normalized external test pressure

q_{ac} actual leak rate to be reported

q_{max} maximum connection leak rate that is acceptable during a test hold period

q_o observed leak rate

R radius of curvature of the pipe body at the axis of the pipe

t specified pipe wall thickness

t_{ac} minimum measured wall thickness

t_{ave} average measured wall for the specimen used for axial load calculations

T tension axial force

η_{lds} leak detection system efficiency

σ stress

σ_a axial stress without bending

σ_{ab} axial stress with bending

σ_b axial stress due to bending

σ_c axial compressive yield strength if available or otherwise axial tensile yield strength

σ_e actual measured minimum yield strength of the specimen or the source mother tube

σ_h hoop (tangential) stress

σ_{ho} hoop (tangential) stress at outside diameter

σ_r radial (normal) stress

σ_{ro} radial (normal) stress at outside diameter

σ_t transverse tensile yield strength if available or otherwise axial tensile yield strength

σ_{tc} defined transverse compressive yield strength if available or otherwise axial tensile yield strength

σ_v von Mises equivalent stress

σ_y axial tensile yield strength

3.3 Abbreviations

A connection A end

B connection B end

AMYS actual minimum yield strength

CAL connection assessment level

CCS critical cross-section

CCW counter-clockwise direction around the test load envelope

cm^3/min cubic centimetres per minute

cm^3/s cubic centimetres per second

CW clockwise direction around the test load envelope

CEPL capped end pressure load (tension) at the designated pressure

CEYP capped end yield pressure

CRA corrosion-resistant alloy

EUE external upset end

FEA finite element analysis

FMU final make-up specimen condition

H high thread or seal interference range

H/H maximum specified amount of thread compound / maximum specified torque value in Figures 1 to 6; and maximum thread interference / maximum seal interference

H/L maximum specified amount of thread compound / minimum specified torque value and in Figures 1 to 6; maximum thread interference / minimum seal interference

IJ integral joint

kN kiloNewton

kips	1 000 pound-force
ksi	1 000 pound-force per square inch
lb	pound-force
L	low thread or seal interference range
L/H	minimum specified amount of thread compound / maximum specified torque value
LL	limit load
LL1	limit load test path 1
LL2	limit load test path 2
LL3	limit load test path 3
LL4	limit load test path 4
LL5	limit load test path 5
LP	load point
M/B	make-up/break-out
MBG	make-up/break-out galling test specimen condition
MC	mechanical cycle
MPa	megapascal
MT	material test coupon
MTC	metal seal threaded and coupled connection
MTM	metal-to-metal seal
MU	make-up
OCTG	oil country tubular goods
PBVME	pipe body von Mises envelope
PBY	pipe body yield
PEL	pressure end load
psi	pound-force per square inch
psig	pound-force per square inch gauge
PF-BS	pin fast taper - box slow taper
PS-BF	pin slow taper - box fast taper
PTFE	polytetrafluoroethylene
r/min	revolutions per minute
RS	resilient seal
SMYS	specified minimum yield strength