

DIN EN ISO 13679

ICS 75.180.10

Entwurf

Einsprüche bis 2010-12-18
Vorgesehen als Ersatz für
DIN EN ISO 13679:2007-01;
Ersatz für
E DIN EN ISO 13679:2009-07

**Erdöl- und Erdgasindustrie –
Prüfverfahren an Verbindungen für Futter- und Steigrohre
(ISO/DIS 13679:2010);
Englische Fassung prEN ISO 13679:2010, nur auf CD-ROM**

Petroleum and natural gas industries –
Procedures for testing casing and tubing connections (ISO/DIS 13679:2010);
English version prEN ISO 13679:2010, only on CD-ROM

Industries du pétrole et du gaz naturel –
Modes opératoires d'essai des connexions pour tubes de cuvelage et de production
(ISO/DIS 13679:2010);
Version allemande prEN ISO 13679:2010, seulement en CD-ROM

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2010-10-18 wird der Öffentlichkeit zur Prüfung und
Stellungnahme vorgelegt.

Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses
Entwurfes besonders zu vereinbaren.

Stellungnahmen werden erbeten

- vorzugsweise als Datei per E-Mail an noeg@din.de in Form einer Tabelle. Die Vorlage dieser Tabelle
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- oder in Papierform an den Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) im DIN, 10772 Berlin
(Hausanschrift: Burggrafenstr. 6, 10787 Berlin).

Die Empfänger dieses Norm-Entwurfs werden gebeten, mit ihren Kommentaren jegliche relevanten
Patentrechte, die sie kennen, mitzuteilen und unterstützende Dokumentationen zur Verfügung zu stellen.

Gesamtumfang 166 Seiten

Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) im DIN

Nationales Vorwort

Dieses Dokument (prEN ISO 13679:2010) wurde vom Technischen Komitee ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“, Subkomitee SC 5, Working Group WG 2 „Casing and tubing connections and performance properties“ in Zusammenarbeit mit dem Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ (Sekretariat: AFNOR, Frankreich) erarbeitet.

Für Deutschland hat hieran der Arbeitskreis NA 109-00-01-05 AK „Futter-, Steig- und Bohrröhre — Spiegel-ausschuss zu ISO/TC 67/SC 5“ im Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) des DIN Deutsches Institut für Normung e. V. mitgearbeitet.

Diese europäische Norm enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die englische Originalfassung der ISO Norm.

Diese Norm enthält neben den gesetzlichen Einheiten auch die Einheiten „°F“, „ft“, „in (inch)“, „ksi“, „lb (pound)“, „lbf“, „psi (psig)“ und „r/min“ die in Deutschland nicht zugelassen sind. Es wird ausdrücklich darauf hingewiesen, dass die Anwendung dieser Einheiten im nationalen amtlichen und geschäftlichen Verkehr aufgrund des Gesetzes über Einheiten im Messwesen nicht zulässig ist.

Umrechnung:

Nicht-SI-Einheit	SI-Einheit	Umrechnung	
°F	°C	°C	= (5/9) (°F-32)
ft	m	1 ft	= 0,304 8 m
in (inch)	mm	1 inch	= 25,4 mm
ksi	MPa	1 ksi	= 6,894 757 MPa
lb (pound)	kg	1 lb	= 0,453 592 37 kg
lbf	N	1 lbf	= 4,448 222 N
psi (psig)	kPa	1 psi	= 6,894 757 kPa
r/min	min ⁻¹	1 r/min	= 1 min ⁻¹

Für die in diesem Dokument zitierten Internationalen Normen wird im Folgenden auf die entsprechenden Deutschen Normen hingewiesen:

ISO 11960	siehe	DIN EN ISO 11960
ISO 13678	siehe	DIN EN ISO 13678
ISO 13680	siehe	DIN EN ISO 13680

Änderungen

Gegenüber DIN EN ISO 13679:2007-01 wurden folgende Änderungen vorgenommen:

- a) Aktualisierung der Normativen Verweisungen;
- b) Aktualisierungen der Begriffsdefinitionen u. a. zu „100 % pipe body load envelope“;
- c) Erweiterung des Abschnitts 4.2 „Quality control“ zu „thread compound“;
- d) Überarbeitung der „Connection application level (CAL)“ in Abschnitt 5.1 „Test Principle“;
- e) Erweiterte Anforderungen zu „Previous Tests“ in Abschnitt 5.1.2 „Previous Tests“;
- f) Überarbeitung der „Connection application level (CAL)“ in Tabelle 1 „Test series and specimen identification numbers“;
- g) Ersatz der ehemaligen Bilder 1 bis 4 zu „Connection application level test programm“ durch Tabellen 2 bis 7;
- h) Erweiterung von Abschnitt 5.5 „Material property test“ durch weitere Definitionen von „material coupons“;
- i) neue Berechnung des maximalen und minimalen Drehmoments in Abschnitt 5.6.3 „Make-up Torques“;
- j) Überarbeitung der Tabelle 8 „Connection test specimen objectives for all CAL“;
- k) Lösung der Datenblätter C.6 (Test series B) bis C.9 (Test load calculation sheet) in Anhang C „Data forms“;
- l) der normative Anhang D „Connection full test report“ beinhaltet den alten gleichnamigen Anhang D und Anhang E „Connection testing summary report“;
- m) neuer normativer Anhang E „Calculations for Pipe Body Load Envelope and Examples of load schedules for each test series“;
- n) Überarbeitung der Anhänge G bis J;
- o) neuer Anhang K „Summary of changes to ISO 13679:2002 as of July 2010“.

Nationaler Anhang NA (informativ)

Begriffe, Symbole und Abkürzungen

Die Benennung der folgenden Begriffe, Symbole und Abkürzungen ist identisch mit der Benennung in der englischen Fassung.

3 Begriffe, Symbole und Abkürzungen

3.1 Begriffe

Für die Anwendung dieses Dokuments gelten die folgenden Begriffe, Symbole und Abkürzungen.

3.1.1

Hüllkurve der 100%igen Last auf dem Rohrkörper

Diagramm, das die Extremwerte des auf tatsächlichen Eigenschaften beruhenden Leistungsvermögens des Rohrkörpers umfasst

ANMERKUNG Das Leistungsvermögen des Rohrkörpers ist auch als VME-Fließen oder ISO TR 10400/API TR 5C3 für das Zusammenfallen (Überschreiten der Tragfähigkeit) bekannt.

3.1.2

Umgebungstemperatur

tatsächliche Temperatur der Prüfstellenumgebung zum Zeitpunkt der Prüfung

3.1.3

Diagramm der Axialdrucklast

Darstellung der Axiallast in Abhängigkeit vom Druck, die die Hüllkurve der Prüflast auf Rohr und/oder Verbindung oder die Extremwerte der Grenzlast zeigt

3.1.4

Verbindung

ein Gewindezapfen und die/das zugehörige Muffe oder Innengewinde

3.1.5

Verbindungsleck

Undichtigkeit, die an einer Verbindung auftritt

ANMERKUNG Siehe 8.2 zu Annahmekriterien der Druckdichtung.

3.1.6

Durchmesserüberschneidung

Außendurchmesser des Innenelements abzüglich des Innendurchmessers des Außenelements

3.1.7

Versagenslast

Last, bei der der Rohrkörper oder die Verbindung katastrophal versagt, beispielsweise in Form einer axialen Trennung, eines Bruchs, einer starken bleibenden Verformung (z. B. Ausknicken oder Zusammenfallen [Überschreitung der Tragfähigkeit]) oder eines Verlustes der Unversehrtheit der Dichtung

3.1.8**Fressen**

Form der Oberflächenbeschädigung, die zu Kaltverschweißen der Kontaktflächen zwischen Werkstoffen führt, gefolgt von Rissbildung im Metall während des weiteren Gleitens/der weiteren Drehbewegung

ANMERKUNG Unter 8.1 sind verschiedene zu Reparatur- und Berichtszwecken verwendete Grade des Fressens definiert.

3.1.9**Überschneidung**

Ausmaß der durch die Auslegung und die Toleranzen der Elemente entstandenen Überlappung im Durchmesser zusammengefügtter Elemente

3.1.10**Leck/Leakage**

Austreten des leitungsgeführten Prüfmediums außerhalb des umschlossenen Raumes; kann in der Ausrüstung oder in der Verbindung auftreten

3.1.11**geringfügiges Fressen**

Fressen, das sich durch den Einsatz von Schleifpapier beheben lässt

3.1.12**Grenzlast**

Extremwert der Lastkombination (Axiallast und/oder -druck), der die Versagensbedingungen für die Verbindung definiert, oder Lastkombination, die vor dem katastrophalen Versagen zu starker bleibender Verformung (z. B. Ausknicken) führt

3.1.13**Los**

Rohrlängen mit denselben festgelegten Maßen und derselben festgelegten Güte aus derselben Stahlschmelze, die als Teil der kontinuierlichen Fertigung (oder einer Charge) einer Wärmebehandlung unterzogen werden

3.1.14**Probestück des Werkstoffs**

Zylinder aus dem Werkstoff des zu prüfenden Rohres und/oder Muffenvorrohres, aus dem die Zugprobekörper geschnitten werden

3.1.15**Metall-Metall-Dichtung**

Dichtung oder Dichtungssystem, deren/dessen Dichtwirkung auf einer üblicherweise hohen Spannung beruht, die durch einen engen Kontakt zwischen den zusammengefügtten metallischen Oberflächen bewirkt wird

ANMERKUNG Das Bohrgewindefett kann die Leistung einer Metall-Metall-Dichtung sowohl positiv als auch negativ beeinflussen.

3.1.16**mäßiges Fressen**

Fressen, das sich durch den Einsatz von feinen Feilen und Schleifpapier beheben lässt

3.1.17**Mutterrohr**

Abschnitt des Rohres oder Muffenvorrohres, von dem kurze Abschnitte für die Herstellung von Verbindungs-Probekörpern abgelängt werden

3.1.18**Mehrfachdichtung**

Dichtungssystem, das aus mehr als einer unabhängigen Barriere besteht und wobei jede Barriere selbst eine Dichtung bildet

3.1.19**Rohrstrang**

Rohrkörper und zugehörige Verbindung

3.1.20**Passstange**

kurzer Rohrabschnitt, üblicherweise mit Gewindeenden

3.1.21**elastische Dichtung**

Dichtung oder Dichtungssystem, deren/dessen Dichtwirkung auf dem Einschluss eines Dichtrings innerhalb eines Abschnitts der Verbindung (z. B. im Gewindeprofil, auf einer Dichtfläche usw.) beruht

3.1.22**Dichtung**

Druckbarriere, die dazu dient, den Durchgang des Prüfmediums zu verhindern

3.1.23**Ovalität der Dichtung****Unrundheit der Dichtung**

größter Dichtungsdurchmesser abzüglich des kleinsten Dichtungsdurchmessers, dividiert durch den mittleren Dichtungsdurchmesser, multipliziert mit 100

ANMERKUNG Die Ovalität (Unrundheit) der Dichtung wird als Prozentsatz angegeben.

3.1.24**starkes Fressen**

Fressen, das sich nicht durch den Einsatz von feinen Feilen und Schleifpapier beheben lässt

3.1.25**Einzeldichtung**

eine oder mehrere Barriere(n), die in ihrer Funktion nicht physikalisch voneinander unterschieden werden kann/können

3.1.26**Probekörper**

ein Probekörper besteht aus zwei Verbindungen mit gemeinsamer Muffe oder einer Verbindung mit Innengewinde

3.1.27**Hüllkurve der Prüflast**

Extremwerte der Last (Axiallast, Druck, Biegung) für eine spezifische Temperatur, innerhalb der die Verbindung in Übereinstimmung mit dieser Internationalen Norm geprüft wird/wurde

3.1.28**Gewindeloses**

alle während eines Zyklus der kontinuierlichen Fertigung an einer bestimmten Maschine hergestellten Produkte, wobei der Fertigungszyklus nicht durch ein katastrophales Werkzeugversagen oder eine beschädigende Fehlfunktion der Maschine (Ausnahmen: verschlissene Werkzeuge oder geringfügige Bruchschäden an den Werkzeugen), einen Austausch des Werkzeughalters (Ausnahme: Vorbohrstange) oder jegliche weitere Fehlfunktion der Ausrüstung zur Gewindeherstellung oder der zur Inspektion eingesetzten Messgeräte unterbrochen wird

3.1.29**Gewindedichtung**

Dichtung oder Dichtungssystem, deren/dessen Dichtwirkung auf genauer Passung des Gewindeprofils sowie üblicherweise dem Einschluss des Bohrgewindefetts innerhalb des Gewindeprofils beruht

3.1.30**VME-Spannung**

Hüllkurve der äquivalenten Spannung auf der Grundlage des Kriteriums der Mindest-Verformungsenergie nach von Mises und Hencky

3.2 Symbole

A_p	mittlere Querschnittsfläche des Rohrkörpers
A^a	Zyklus in Prüfreihe A bei Umgebungstemperatur unter Verwendung von Gas für den Innendruck und Flüssigkeit für den Außendruck
A^e	Zyklus in Prüfreihe A bei 180 °C (356 °F) für CAL III und CAL IV unter Verwendung von Gas für den Innendruck und Flüssigkeit für den Außendruck
B^a	Zyklus in Prüfreihe B, ohne Biegen, bei Umgebungstemperatur mit Gas für CAL II bis CAL IV; mit Gas oder Wasser für CAL I-E; mit Wasser für CAL I
B_b^a	Zyklus in Prüfreihe B, mit Biegen, bei Umgebungstemperatur mit Gas für CAL II bis CAL IV; mit Gas oder Wasser für CAL I-E; mit Wasser für CAL I
B_b^e	Zyklus in Prüfreihe B, mit Biegen, bei 180 °C (356 °F) mit Gas für CAL III Umgebung A, CAL III und CAL IV; bei 135 °C (275 °F) für CAL II unter Verwendung von Gas
C	Axialdruckkraft
D	festgelegter Außendurchmesser des Rohres oder mittlerer gemessener Außendurchmesser des Probekörpers für die Prüfung von Axiallast oder Drucklast
D_i	Innendurchmesser
D_o	Außendurchmesser
D_{leg}	effektiver Knickgrad, in Grad je 30 Meter
d_{wall}	Höchstwert des Rohres D_i
E_r	Fehler bei der Kalibrierung des Lastrahmens
E_{rp}	Fehler bei der Kalibrierung des Lastrahmens, in Prozent
F	Versagen
F_a	Gesamt-Axialkraft (Zug- oder Druckbeanspruchung)
F_b	äquivalente Axialbiegekraft
F_c	angegebene Verbindungsfestigkeit des Anschlusses, wobei die Verbindungsfestigkeit die Nenn-Drucklast des Anschlusses ist

F_f	tatsächliche mit dem Lastrahmen aufgebrachte Axiallast (Zug- oder Druckbeanspruchung)
F_i	angegebene mit dem Lastrahmen aufgebrachte Axiallast (Zug- oder Druckbeanspruchung)
F_y	tatsächlich gemessene Mindest-Streckgrenze des Probekörpers oder des Mutterrohres
F_{ymn}	festgelegte Mindest-Streckgrenze des Werkstoffs
I	Trägheitsmoment
I_{max}	maximale Nenn-Überschneidung zwischen Verschraubungs- oder Dichtungselementen aufgrund der Festlegung und der Grenzabmaße für den Durchmesser von Gewindezapfen und Muffe
I_{min}	Mindestwert der Nenn-Überschneidung zwischen Verschraubungs- oder Dichtungsbauteilen aufgrund der Festlegung und der Grenzabmaße für den Durchmesser von Gewindezapfen und Muffe
I_{range}	Bereich der Nenn-Überschneidung zwischen Verschraubungs- oder Dichtungselementen, entspricht $I_{max} - I_{min}$
k_i, k_o	geometrische Variablen
K_{wall}	Mindestwert von $[t_{ac}/t]$ oder 0,95
L_A	Länge von Gewindezapfen A zwischen Stirnfläche der Muffe (oder der Verbindung) und Endverschluss oder Einstecktiefe
L_B	Länge von Gewindezapfen B zwischen Stirnfläche der Muffe (oder der Verbindung) und Endverschluss oder Einstecktiefe
L_C	Länge von Muffe oder der Verbindung, sofern mit Innengewinde
L_{pj}	nicht aufgelagerte Mindestlänge der Passstange
M	Biegemoment
p_c	Nennwert für das Zusammenfallen (Überschreiten der Tragfähigkeit) für festgelegten OD, festgelegte Wanddicke und festgelegte Streckgrenze des Probekörpers (siehe ISO TR 10400, Abschnitt 8)
p_i	Innendruck
p_{ib}	Innendruck bei Biegeverformung
p_{ih}	hoher Innendruck
p_{in}	normalisierter Innenprüfdruck
p_{il}	niedriger Innendruck
p_o	Außendruck
p_{ob}	Außendruck bei Biegeverformung
p_{on}	normalisierter Außenprüfdruck

q_{ac}	anzugebende tatsächliche Leckrate
q_{max}	maximal zulässige Leckrate der Verbindung während der Prüfhaltzeit
q_o	beobachtete Leckrate
R	Krümmungsradius des Rohrkörpers an der Rohrachse
t	festgelegte Wanddicke des Rohres
t_{ac}	kleinste gemessene Wanddicke
t_{ave}	mittlere gemessene Wanddicke des Probekörpers für die Berechnung der Axiallast
T	axiale Zuglast
η_{ds}	Wirksamkeit des Leckerkennungssystems
σ	Spannung
σ_a	Axialspannung ohne Biegeverformung
σ_{ab}	Axialspannung mit Biegeverformung
σ_b	Axialspannung aufgrund von Biegeverformung
σ_c	Streckgrenze für axiale Druckbeanspruchung, sofern vorhanden, oder andernfalls Streckgrenze für axiale Zugbeanspruchung
σ_e	tatsächlich gemessene Mindest-Streckgrenze des Probekörpers oder des Mutterrohres
σ_h	Umfangsspannung
σ_{ho}	Umfangsspannung am Außendurchmesser
σ_r	Radialspannung
σ_{ro}	Radialspannung am Außendurchmesser
σ_t	Streckgrenze für Zugbeanspruchung in Querrichtung, sofern vorhanden, oder andernfalls Streckgrenze für axiale Zugbeanspruchung
σ_{tc}	festgelegte Streckgrenze für Druckbeanspruchung in Querrichtung, sofern vorhanden, oder andernfalls Streckgrenze für axiale Zugbeanspruchung
σ_v	äquivalente Spannung nach von Mises
σ_y	Streckgrenze für axiale Zugbeanspruchung

3.2 Abkürzungen

A	Verbindungsanschluss A
B	Verbindungsanschluss B
AMYS	tatsächliche Mindest-Streckgrenze
CAL	Bewertungsstufe der Verbindung
CCS	kritischer Querschnitt
CCW	entgegen dem Uhrzeigersinn um die Prüflast-Hüllkurve
cm ³ /min	Kubikzentimeter je Minute
cm ³ /s	Kubikzentimeter je Sekunde
CW	im Uhrzeigersinn um die Prüflast-Hüllkurve
CEPL	Drucklast (Zugbeanspruchung) auf dem verschlossenen Ende bei festgelegtem Druck
CEYP	Versagensdruck auf dem verschlossenen Ende
CRA	korrosionsbeständige Legierung
EUE	äußere Stauchverbindung
FEA	Finite-Elemente-Analyse
FMU	Zustand des Probekörpers bei abschließender Verschraubung
H	vom Hersteller festgelegter Höchstwert für Gewinde oder Dichtung
H/H	vom Hersteller festgelegte Höchstmenge an Bohrgewindefett/vom Hersteller festgelegter Höchstwert des Drehmoments
H/L	vom Hersteller festgelegte Höchstmenge an Bohrgewindefett/vom Hersteller festgelegter Mindestwert des Drehmoments
IJ	Innengewinde
I _{max}	vom Hersteller festgelegter Höchstwert der Dichtungs- und Gewindeüberschneidung (H oder XH)
I _{min}	vom Hersteller festgelegter Mindestwert der Dichtungs- und Gewindeüberschneidung (L oder XL)
I _{range}	vollständiger vom Hersteller festgelegter Bereich der Dichtungs- und Gewindeüberschneidung
kN	Kilonewton
kips	1 000 Pound (Kraft)
ksi	1 000 Pound (Kraft) je Quadratzoll
lb(lbf)	Pound (Masse)

L	vom Hersteller festgelegter Mindestwert für Gewinde oder Dichtung
L/H	vom Hersteller festgelegte Mindestmenge an Gewindefett/vom Hersteller festgelegter Höchstwert des Drehmomentes
LL	Grenzlast
LP	Lastaufbringungspunkt
LP1	Grenzlast Prüfpfad 1
LP2	Grenzlast Prüfpfad 2
LP3	Grenzlast Prüfpfad 3
LP4	Grenzlast Prüfpfad 4
LP5	Grenzlast Prüfpfad 5
M/B	Verschrauben/Lösen
MBG	Verschrauben/Lösen; Zustand des Probekörpers hinsichtlich Fressen
MC	mechanischer Zyklus
MPa	Megapascal
MT	Probestück des Werkstoffs
MTC	Metalldichtverbindung mit Gewinde und Muffe
MTM	Metall-Metall-Dichtung
MU	Verschraubung
OCTG	Ölfeldrohre
PBVME	Hüllkurve des Rohrkörpers nach von Mises
PBY	Rohrkörperversagen
PEL	axiale Drucklast
psi	Kraft Pound je Quadratzoll
psig	Nennkraft Pound je Quadratzoll
PF-BS	Gewindezapfen steile Steigung/Muffe flache Steigung
PS-BF	Gewindezapfen flache Steigung/Muffe steile Steigung
PTFE	Polytetrafluorethylen
U/min	Umdrehungen je Minute
RS	elastische Dichtung

SMYS	festgelegte Mindest-Streckgrenze
SRG	Dichtringnut
Std	Standard
TC	Wärmezyklus
TLE	Hüllkurve der Prüflast
TS-A	Prüfreihe A
TS-B	Prüfreihe B
TS-C	Prüfreihe C
TSC	Dichtung mit Schraubverbindung
T&C	mit Gewinde und Muffe
VME	äquivalente Spannung nach von Mises
XH	extrem hoher Überschneidungsbereich
XL	extrem niedriger Überschneidungsbereich

Nationaler Anhang NB (informativ)

Literaturhinweise

DIN EN ISO 11960, *Erdöl- und Erdgasindustrie — Stahlrohre zur Verwendung als Futter- oder Steigrohre für Bohrungen*

DIN EN ISO 13678, *Erdöl- und Erdgasindustrie — Beurteilung und Prüfung von Gewindefetten zur Verwendung an Futter-, Steig- und Leitungsrohren und an Bohrgestängeteilen*

DIN EN ISO 13680, *Erdöl- und Erdgasindustrie — Nahtlose Rohre aus korrosionsbeständigen Legierungen zur Verwendung als Futter- oder Steigrohre sowie Muffenvorrohre — Technische Lieferbedingungen*

— Leerseite —

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English Version

**Petroleum and natural gas industries —
Procedures for testing casing and tubing connections
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This draft European Standard is submitted to CEN members for second parallel enquiry. It has been drawn up by the Technical Committee CEN/TC 12.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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Foreword

This document (prEN ISO 13679:2010) has been prepared by Technical Committee ISO/TC 67 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” in collaboration with Technical Committee CEN/TC 12 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” the secretariat of which is held by AFNOR.

This document is currently submitted to the second parallel Enquiry.

This document will supersede EN ISO 13679:2006.

Endorsement notice

The text of ISO/DIS 13679:2010 has been approved by CEN as a prEN ISO 13679:2010 without any modification.

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 Recommended Practice 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 and 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, which falls within these limits will meet or exceed 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 design analysis is required to define worst-case tolerance combinations.

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 a purchaser from accepting, alternate equipment or engineering solutions for the individual application. This may be particularly applicable when there is innovative or developing technology. Where an alternative is offered, the vendor should 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 is to be provided 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 give an example of a load frame calibration. Annex G gives considerations for possible connection product line qualifications. Annex H provides guidelines for supplemental tests, which may 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 which are tested separately. Annex K is a summary of changes to ISO 13679:2002.

Supplementary tests may appropriate for specific applications that are not evaluated by the tests herein. The user and manufacturer should 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 may 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 indication that a provision is a REQUIREMENT, i.e. MANDATORY;
- SHOULD is used to indicate that a provision is a RECOMMENDATION to be used as good practice, but is not mandatory;
- MAY is used to indicate that a provision is OPTIONAL, i.e. indicate a course of action permissible within the limits of the document;
- CAN is used to indicate statements of POSSIBILITY and CAPABILITY.

1 Scope

This International Standard establishes minimum design verification testing procedures and **test** acceptance criteria for casing and tubing connections for the oil and natural gas industries. These physical tests are part of a design verification process and provide objective evidence that the connection conforms to the manufacturer's claimed test load envelope and limit loads.

It categorizes test severity into **six test programmes**.

This International Standard does not provide the statistical basis for risk analysis.

This International Standard addresses only three of the five distinct types of primary loads to which casing and tubing strings are subjected in wells: fluid pressure (internal and/or external), axial force (tension or compression), bending (buckling and/or well bore deviation), as well as make-up torsion. It does not address rotation torsion and non-axisymmetric (area, line or point contact) loads.

This International Standard specifies tests to be performed 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, *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 13678, *Petroleum and natural gas industries — Evaluation and testing of thread compounds for use with casing, tubing and line pipe*

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*

API Spec 5B, *Specification for Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads*

API Spec 5L, *Specification for Line Pipe*

ASTM A370, *Standard Testing Methods and Definitions for Mechanical Testing of Steel Products*

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 or 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 Clause 8.2 for pressure sealing acceptance criteria.

3.1.6

diametrical interference

the 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 will fail 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

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

NOTE 1 There are several degrees of galling used for repair and reporting purposes as defined in Clause 8.1.

3.1.9

interference

amount of 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) which 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 which are heat-treated as part of a continuous operation (or batch)

3.1.14

material test coupon

cylinder of material from the to be 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 seals

sealing system, which consists of more than one independent barrier, and of which each barrier forms a seal itself

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, which relies on entrapment of a seal ring within a section of 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 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

a specimen is two connections with a shared coupling or one integral connection.

3.1.27

test load envelope

extremes of loads (axial load, pressure, bending) 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, which 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_p average area of pipe body cross section

A^a Cycles in Test Series A at ambient temperature using gas for internal pressure and liquid for external pressure

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.

B^a_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.

B^e_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 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
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,
F_b	bending equivalent axial force
F_c	published joint strength of the connection when the joint strength is the compressive rated load of the connection
F_f	actual load frame axial force, tension or compression
F_i	indicated load frame axial force, tension or compression
F_y	actual measured minimum yield strength of the specimen or the source mother tube
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 $I_{\text{max}} - I_{\text{min}}$
k_i, k_o	geometric variable
K_{wall}	minimum of $[t_{ac} / t]$ or 95
L_A	length of pin A end from coupling face (or connection) to end cap or grip length
L_B	length of pin B end from coupling face (or connection) to end cap or grip length
L_C	length of coupling or connection if integral
L_{pj}	minimum unsupported pup joint length
M	bending moment
p_c	collapse rating for specified OD, specified wall thickness and specified specimen yield strength (see ISO TR 10400, Clause 8)
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 min
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	Manufacturer's maximum specified thread or seal value
H/H	Manufacturer's maximum specified amount of thread compound / manufacturer's maximum specified torque value
H/L	Manufacturer's maximum specified amount of thread compound / manufacturer's minimum specified torque value
IJ	Integral joint
I _{max}	Manufacturer's maximum seal and thread interference (H or XH)
I _{min}	Manufacturer's minimum seal and thread interference (L or XL)
I _{range}	Manufacturer's full range of seal and thread interference
kN	kiloNewton
kips	1 000 pound force
ksi	1 000 pound force per square inch
lb (lbf)	pound mass
L	Manufacturer's minimum specified thread or seal value
L/H	Manufacturer's minimum specified amount of thread compound / manufacturer's maximum specified torque value
LL	Limit load

LP	Load point
LP1	Limit load test path 1
LP2	Limit load test path 2
LP3	Limit load test path 3
LP4	Limit load test path 4
LP5	Limit load test path 5
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	Pounds force/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
SRG	Seal ring groove
Std	Standard
TC	Thermal cycle
TLE	Test load envelope
TS-A	Test series A
TS-B	Test series B

TS-C Test series C

TSC Thread sealing connection

T&C Threaded and coupled

VME von Mises equivalent stress

XH Extreme high interference range

XL Extreme low interference range

4 General requirements

4.1 Connection data sheet

Prior to beginning a test, the manufacturer shall provide a connection data sheet for the product stating its **intended** connection **assessment** level, its geometry, and **claimed** performance properties in terms of tension, compression, internal pressure, external pressure, bending, and torque (see Table A.1 for the connection data sheet). The manufacturer shall provide a drawing, which is representative of the cross-sectional area of the connection. The manufacturer shall also provide the following in graphical form (VME plot): 100 % Pipe Body Load Envelope, 95 % Pipe Body Load Envelope (or as otherwise agreed to between user and manufacturer), and **claimed** Test Load Envelope and should quantify limit loads (see Clauses 7.4 and 7.5). The manufacturer's own method of calculation should be used to derive the **claimed** test load envelope and to calculate the test loads. Performance data or the method described in Annex B may be used.

Annex B has been provided as a means by which a manufacturer or user may estimate the test load envelope using a connection performance model based on capacities of specific critical cross-sections in the connection.

The manufacturer should define as completely as possible the limit loads for each connection. A user may also make an independent estimate of the limit loads. Limit loads shall be greater than the test load envelope.

It is critical that the combined load capacity described by the test load envelope be defined near and throughout the conditions where the dominant load sensitivity of the connection may change from pressure to axial force and/or bending or vice versa

Since casing and tubing connection designs and the resultant performance can vary widely, no overall requirement for the minimum number of values in a tabular data format can be mandated. However, it is expected that approximately 10 combined load values of pressure and axial force per quadrant should be sufficient to define the test and limit loads. If a connection design exhibits changes in load sensitivities, the loads at which the changes in load sensitivity occur shall be provided.

In the calculation of both pipe body and connection load capacities, it is the intent of this International Standard to test the specimens to as high a load or combination of loads as safely practical.

In the event that unanticipated events result in deviations to the detailed requirements and or procedures, such deviations shall be clearly identified in the documentation **and test report**.

4.2 Quality control

All quality control procedures for the manufacturing of test specimens shall be documented and shall be consistent with procedures used for connections manufactured for well service. The connection manufacturer shall ensure that the connections manufactured for the purpose of these design verification tests are of the same design and manufactured to the same dimensions and extremes of tolerances (see Clause 6.5) as those supplied for well service. The connection manufacturer shall issue a declaration of conformity (see ISO/IEC Guide 22 for an example). The manufacturer shall provide the process control plan. This process control plan shall include the product drawing number(s) and associated revision level(s) as well as the

procedure number and the associated revision levels for all applicable sub-tier documents (manufacturing, gauge calibration, gauging procedure, surface treatment, thread compound [type and quantity, or other amount indicators], make-up procedures, etc.). These procedures and any others determined necessary to provide a consistent product for well service shall be used during manufacturing of all test specimens (see Clause A.4 in Annex A).

5 General test requirements

5.1 Test Principle

5.1.1 Overview

Connection performance data are generated by testing. Passing the tests demonstrates conformance of the connection to a specified level of assessment. Test failures may result in a revision of the connection design or a revision of the test loads or limit loads. In the first case (connection redesign), the testing shall be repeated. In the second case (test load revision), the individual test specimens shall be retested unless the tests conform to the revised performance envelope.

Six test programmes, known as connection assessment levels (CAL) are presented. The increasingly arduous test programs are developed to provide means to assess connection performance to satisfy the variety of service requirements that have been driven by well design. These test programs increase in rigor by increasing the number of test parameters and test specimens.

The test programmes do not include all possible service scenarios. For example, the presence of a corrosive fluid that may influence the service performance of a connection is not considered and beyond the scope of this International Standard.

The user of this International Standard shall specify the connection assessment level required based upon the needs for the particular service intended. Users of the connection should be familiar with the defined connection test rigor, the performance limits and limit loads. The connection assessment levels (CAL) are defined as follows:

a) Connection assessment level IV (5 specimens) – most testing rigor

CAL IV is the most rigorous test plan. CAL IV test matrix exposes the connection to cyclical test loads including internal pressure, external pressure, tension, compression and bending at ambient and elevated temperature. CAL IV test conditions subject the connection to extensive thermal cycling, with approximately 77 hours of cumulative exposure to gas loading conditions at an elevated temperature of 180°C (356°F). Limit load tests are performed to failure in all four quadrants of the axial-pressure load diagram.

b) Connection assessment level III (5 specimens) – significant testing rigor

CAL III is a rigorous test plan of significance. As with CAL IV, CAL III test matrix exposes the connection to cyclical test loads including internal pressure, external pressure, tension, compression and bending at ambient and elevated temperature. CAL III test conditions subject connections to less severe thermal cycling levels than CAL IV. Elevated temperature requirements are maintained at 180°C (356°F); however, cumulative exposure time is reduced to approximately 45 hours. Limit loads tests are performed in quadrant I on two separate specimens.

c) Connection assessment level III-Ambient A (5 specimens) – less significant testing rigor

CAL III-Ambient A is a less significant testing plan than CAL III as Test Series A is performed at ambient temperature with no Q1-Q3 cycling. As with CAL III, CAL III-Ambient A test matrix exposes the connection to cyclical test loads including internal pressure, external pressure, tension, compression and bending at ambient and elevated temperature. Elevated temperature requirements are maintained at 180°C (356°F); however, cumulative exposure time is reduced to approximately 34 hours. Limit loads tests are performed in quadrant I on two separate specimens.

d) Connection assessment level II (3 specimens) – moderate testing rigor

CAL II is a moderate rigor test plan. The CAL II test matrix exposes the connection to cyclical test loads including internal pressure, tension, compression, and bending at ambient and elevated temperature. External pressure is evaluated only at ambient temperature and has a reduced number of cycles. Internal pressure testing temperatures are limited to 135°C (275°F). Connection test samples are subjected to elevated temperature testing conditions for approximately 16 hours. Limit load test is performed in quadrant I on one specimen.

e) Connection assessment level I-E (2 specimens) – less testing rigor

CAL I-E is a reduced rigor test plan that may utilize liquid or gas as an internal pressurization medium. All testing is conducted at ambient temperature with one test specimen exposed to internal pressure testing under tension and compression loading and bending. External pressure is evaluated at ambient temperature and has a reduced number of cycles. Limit load test is performed in quadrant I on one specimen.

f) Connection assessment level I (2 specimens) – least testing rigor

CAL I is the least rigorous test. CAL I exposes the connection to internal pressure testing performed with liquid under tension and compression loading at ambient temperature. External pressure loading and bending are not included. The limit load test is performed in quadrant I on one specimen.

5.1.2 Previous tests

Connections successfully tested to prior versions of this International Standard shall retain the CAL test class to which they were successfully tested, regardless of the technical changes made to the applicable CAL in later versions of this International Standard.

Connection test data obtained from tests performed prior to the establishment of this International Standard may also be used as part of a design verification process or application test sequence, provided that parties to agreements based on this International Standard can agree such tests were substantially conducted to the technical and documentation requirements of this International Standard and that they give comparable results.

5.1.3 Abbreviated tests and deviations

Some of the tests herein, rather than the complete test programme, may be adequate to verify suitability for specific applications when experience and related test data, for example on other sizes, are available. Deviations to the tests specified herein are acceptable, provided:

- a) the planned deviations are clearly documented in advance,
- b) there is clear agreement between the parties involved, and
- c) the deviations are clearly identified in the full test report.

A discussion of product line qualification and use of interpolation and extrapolation considerations is provided in Annex G. More stringent acceptance requirements, sensitivity requirements and/or more extended informative data may be agreed by the user and manufacturer.

5.2 Test matrix

Table 1 shows a matrix relating the connection assessment level to the relevant total number of test specimens, their identification numbers and the relevant tests. Tables 2 through 7 are a summary of the each CAL test programme and should be read and followed from the top down. When testing multiple specimens in series, the applied test loads shall be determined using the highest strength specimen.

Table 1 — Test matrix — Test series and specimen identification numbers

Connection assessment level	Series A 4 quadrants with mechanical cycles (see Clause 7.3.3)	Series B 2 quadrants with mechanical cycles (see Clause 7.3.4)	Series C Thermal cycling Thermal/pressure and tension cycling (see Clause 7.3.5)	Bake and elevated temperature tests	Internal test pressure medium (external is liquid)
IV	At ambient and elevated	Bending required at ambient and elevated temperatures	10 thermal with pressure/tension 5 mechanical cycles at $\leq 35\text{ °C}$ (95 °F)	180 °C (356 °F)	Gas
Total number of specimens 5	Specimens 1, 2, 3, 4	Specimens 1, 2, 3, 4	Specimens 1,2,3,4		
III	At ambient and elevated	Bending required at ambient and elevated temperatures	10 thermal with pressure/tension 5 mechanical cycles at $\leq 35\text{ °C}$ (95 °F)	180 °C (356 °F)	Gas
Total number of specimens 5	Specimen 1	Specimens 1,2,3,4	Specimens 1, 2		
III-Ambient A	At ambient	Bending required at ambient and elevated temperatures	10 thermal with pressure/tension 5 mechanical cycles at $\leq 35\text{ °C}$ (95 °F)	180 °C (356 °F)	Gas
Total number of specimens 5	Specimen 1	Specimens 1,2,3,4	Specimens 1, 2		
II	At ambient (reduced cycles)	Bending required at elevated temperature	Not Applicable	135 °C (275 °F)	Gas
Total number of specimens 3	Specimen 1	Specimens 1, 4			
I-E	At ambient (reduced cycles)	At ambient with bending	Not applicable	Bake out not required ambient	Gas or liquid
Total number of specimens 2	Specimen 1	Specimen 1			
I	Not applicable	At ambient; no bending	Not applicable	Bake-out not required; ambient	Liquid
Total number of specimens 2		Specimens 1			

Table 2 — ISO CAL I Test Requirements and Sequence

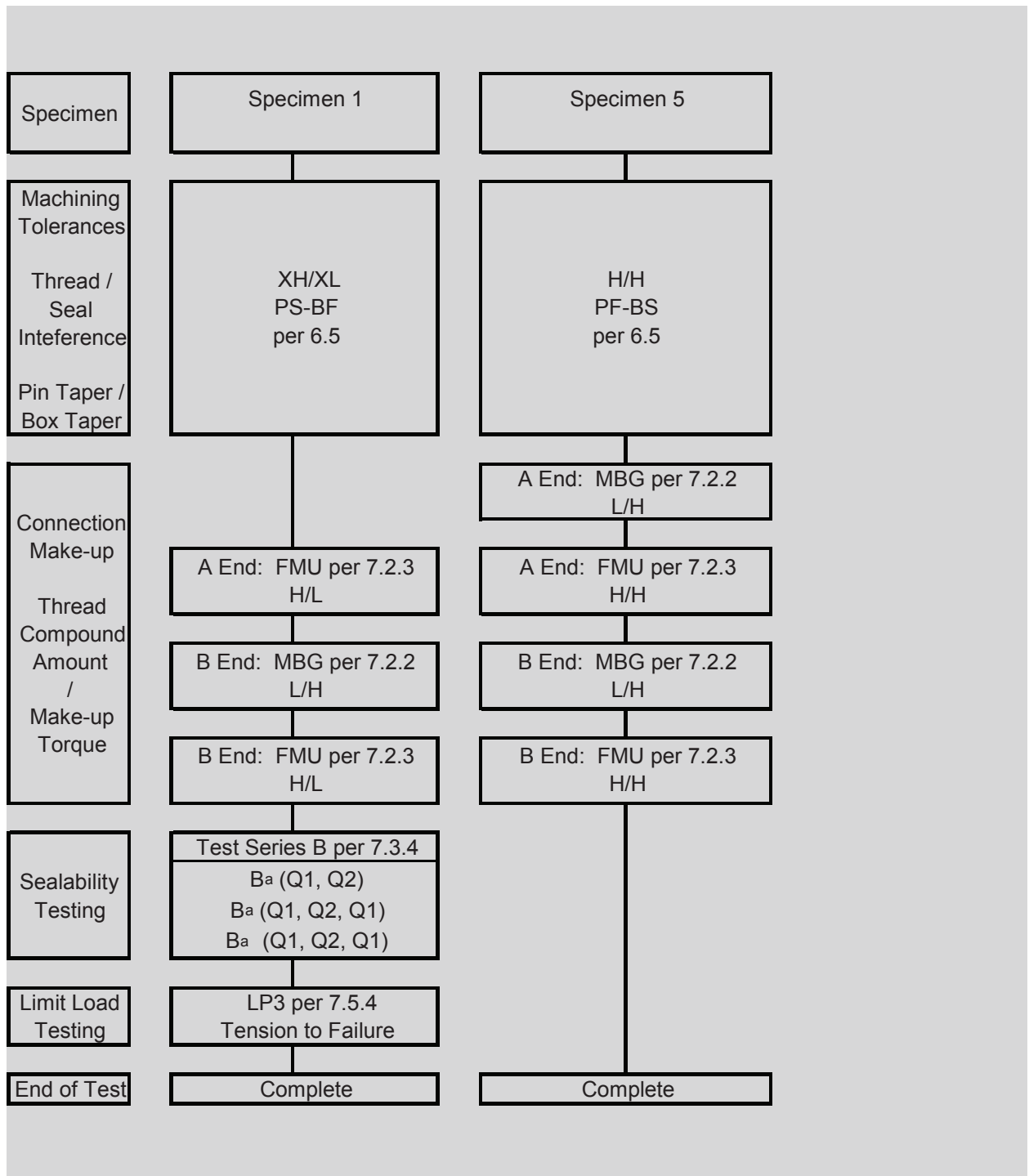


Table 3 — ISO CAL I-E Test Requirements and Sequence

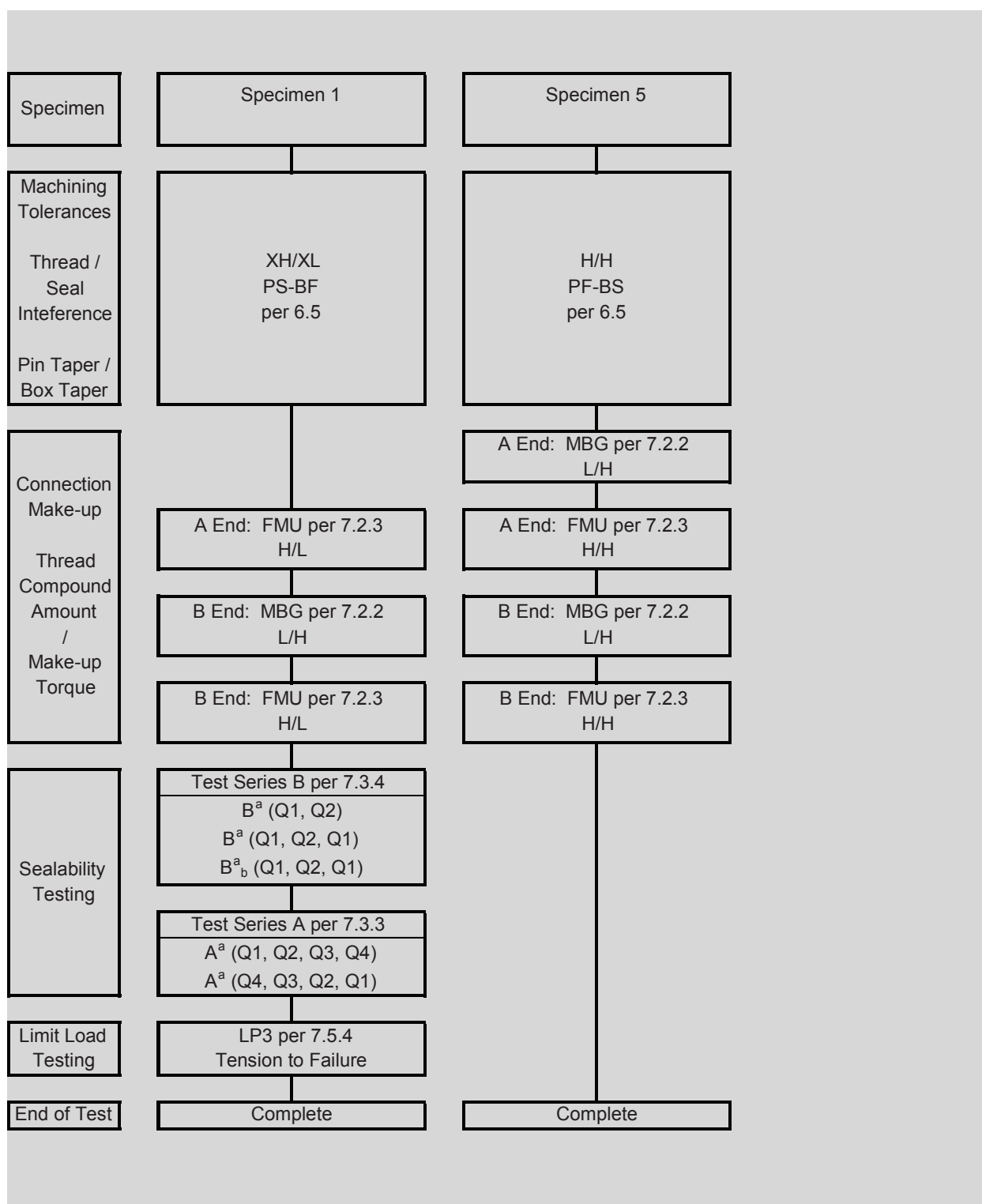


Table 4 — ISO CAL II Test Requirements and Sequence

Specimen	Specimen 1	Specimen 4	Specimen 5
Machining Tolerances			
Thread / Seal Interference	XH/XL PS-BF per 6.5	L/L PS-BF per 6.5	H/H PF-BS per 6.5
Pin Taper / Box Taper			
Connection Make-up			A End: MBG per 7.2.2 L/H
Thread Compound Amount / Make-up Torque	A End: FMU per 7.2.3 H/L	A End: FMU per 7.2.3 H/H	A End: FMU per 7.2.3 H/H
	B End: MBG per 7.2.2 L/H	B End: MBG per 7.2.2 L/H	B End: MBG per 7.2.2 L/H
	B End: FMU per 7.2.3 H/L	B End: FMU per 7.2.3 H/H	B End: FMU per 7.2.3 H/H
Connection Bake-out	12 hr at 135°C (275°F) per 7.3.2	12 hr at 135°C (275°F) per 7.3.2	
Sealability Testing	Test Series B per 7.3.4 B ^a (Q1, Q2) B ^a (Q1, Q2, Q1) B ^e _b (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1)	Test Series B per 7.3.4 B ^a (Q1, Q2) B ^a (Q1, Q2, Q1) B ^e _b (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1)	
	Test Series A per 7.3.3 A ^a (Q1, Q2, Q3, Q4) A ^a (Q4, Q3, Q2, Q1)		
Limit Load Testing	LP3 per 7.5.4 Tension to Failure		
End of Test	Complete	Complete	Complete

Table 5 — ISO CAL III-Ambient A Test Requirements and Sequence

Specimen	Specimen 1	Specimen 2	Specimen 3	Specimen 4	Specimen 5
Machining Tolerances					
Thread / Seal Interference	XH/XL PS-BF per 6.5	XH/XL PS-BF per 6.5	L/H PF-BS per 6.5	L/L PS-BF per 6.5	H/H PF-BS per 6.5
Pin Taper / Box Taper					
Connection Make-up			A End: MBG per 7.2.2 L/H		A End: MBG per 7.2.2 L/H
Thread Compound Amount / Make-up Torque	A End: FMU per 7.2.3 H/L	A End: FMU per 7.2.3 H/L	A End: FMU per 7.2.3 H/H	A End: FMU per 7.2.3 H/H	A End: FMU per 7.2.3 H/H
	B End: MBG per 7.2.2 L/H			B End: MBG per 7.2.2 L/H	B End: MBG per 7.2.2 L/H
	B End: FMU per 7.2.3 H/L	B End: FMU per 7.2.3 H/L	B End: FMU per 7.2.3 H/H	B End: FMU per 7.2.3 H/H	B End: FMU per 7.2.3 H/H
Connection Bake-out	12 hr at 180°C (356°F) per 7.3.2	12 hr at 180°C (356°F) per 7.3.2	12 hr at 180°C (356°F) per 7.3.2	12 hr at 180°C (356°F) per 7.3.2	
Sealability Testing	Test Series B per 7.3.4 B ^a (Q1, Q2) B ^a (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1)	Test Series B per 7.3.4 B ^a (Q1, Q2) B ^a (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1)	Test Series B per 7.3.4 B ^a (Q1, Q2) B ^a (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1)	Test Series B per 7.3.4 B ^a (Q1, Q2) B ^a (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1)	
	Test Series C per 7.3.5 10 Thermal Cycles 5 Mechanical Cycles	Test Series C per 7.3.5 10 Thermal Cycles 5 Mechanical Cycles			
	Test Series A per 7.3.3 A ^a (Q1, Q2, Q3, Q4) A ^a (Q4, Q3, Q2, Q1) A ^a (Q1, Q2, Q3, Q4) A ^a (Q4, Q3, Q2, Q1) A ^a (Q1, Q2, Q3, Q4)				
Limit Load Testing	LP3 per 7.5.4 Tension to Failure				LP5 per 7.5.6 50% T + IP to Failure
End of Test	Complete	Complete	Complete	Complete	Complete

Table 6 — ISO CAL III Test Requirements and Sequence

Specimen	Specimen 1	Specimen 2	Specimen 3	Specimen 4	Specimen 5
Machining Tolerances					
Thread / Seal Interference	XH/XL PS-BF per 6.5	XH/XL PS-BF per 6.5	L/H PF-BS per 6.5	L/L PS-BF per 6.5	H/H PF-BS per 6.5
Pin Taper / Box Taper					
Connection Make-up			A End: MBG per 7.2.2 L/H		A End: MBG per 7.2.2 L/H
Thread Compound Amount / Make-up Torque	A End: FMU per 7.2.3 H/L B End: MBG per 7.2.2 L/H B End: FMU per 7.2.3 H/L	A End: FMU per 7.2.3 H/L B End: FMU per 7.2.3 H/L	A End: FMU per 7.2.3 H/H B End: FMU per 7.2.3 H/H	A End: FMU per 7.2.3 H/H B End: MBG per 7.2.2 L/H B End: FMU per 7.2.3 H/H	A End: FMU per 7.2.3 H/H B End: MBG per 7.2.2 L/H B End: FMU per 7.2.3 H/H
Connection Bake-out	12 hr at 180°C (356°F) per 7.3.2	12 hr at 180°C (356°F) per 7.3.2	12 hr at 180°C (356°F) per 7.3.2	12 hr at 180°C (356°F) per 7.3.2	
Sealability Testing	Test Series B per 7.3.4 B ^a (Q1, Q2) B ^a (Q1, Q2, Q1) B ^e _b (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1) Test Series C per 7.3.5 10 Thermal Cycles 5 Mechanical Cycles Test Series A per 7.3.3 A ^a (Q1, Q2, Q3, Q4) A ^a (Q4, Q3, Q2, Q1) A ^e (Q1, Q2, Q3, Q4) A ^e (Q4, Q3, Q2, Q1) A ^e (Q1, Q2, Q3, Q4) 5 Q1-Q3-Q1 Cycles A ^a (Q4, Q3)	Test Series B per 7.3.4 B ^a (Q1, Q2) B ^a (Q1, Q2, Q1) B ^e _b (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1) Test Series C per 7.3.5 10 Thermal Cycles 5 Mechanical Cycles	Test Series B per 7.3.4 B ^a (Q1, Q2) B ^a (Q1, Q2, Q1) B ^e _b (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1)	Test Series B per 7.3.4 B ^a (Q1, Q2) B ^a (Q1, Q2, Q1) B ^e _b (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1)	
Limit Load Testing	LP3 per 7.5.4 Tension to Failure				LP5 per 7.5.6 50% T + IP to Failure
End of Test	Complete	Complete	Complete	Complete	Complete

Table 7 — ISO CAL IV Test Requirements and Sequence

Specimen	Specimen 1	Specimen 2	Specimen 3	Specimen 4	Specimen 5
Machining Tolerances					
Thread / Seal Interference	XH/XL PS-BF per 6.5	XH/XL PS-BF per 6.5	L/H PF-BS per 6.5	L/L PS-BF per 6.5	H/H PF-BS per 6.5
Pin Taper / Box Taper					
Connection Make-up			A End: MBG per 7.2.2 L/H		A End: MBG per 7.2.2 L/H
Thread Compound Amount / Make-up Torque	A End: FMU per 7.2.3 H/L	A End: FMU per 7.2.3 H/L	A End: FMU per 7.2.3 H/H	A End: FMU per 7.2.3 H/H	A End: FMU per 7.2.3 H/H
	B End: MBG per 7.2.2 L/H			B End: MBG per 7.2.2 L/H	B End: MBG per 7.2.2 L/H
	B End: FMU per 7.2.3 H/L	B End: FMU per 7.2.3 H/L	B End: FMU per 7.2.3 H/H	B End: FMU per 7.2.3 H/H	B End: FMU per 7.2.3 H/H
Connection Bake-out	12 hr at 180°C (356°F) per 7.3.2	12 hr at 180°C (356°F) per 7.3.2	12 hr at 180°C (356°F) per 7.3.2	12 hr at 180°C (356°F) per 7.3.2	
Sealability Testing	Test Series B per 7.3.4 B ^a (Q1, Q2) B ^a (Q1, Q2, Q1) B ^e _b (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1)	Test Series B per 7.3.4 B ^a (Q1, Q2) B ^a (Q1, Q2, Q1) B ^e _b (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1)	Test Series B per 7.3.4 B ^a (Q1, Q2) B ^a (Q1, Q2, Q1) B ^e _b (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1)	Test Series B per 7.3.4 B ^a (Q1, Q2) B ^a (Q1, Q2, Q1) B ^e _b (Q1, Q2, Q1) B ^a _b (Q1, Q2, Q1)	
	Test Series C per 7.3.5 10 Thermal Cycles 5 Mechanical Cycles	Test Series C per 7.3.5 10 Thermal Cycles 5 Mechanical Cycles	Test Series C per 7.3.5 10 Thermal Cycles 5 Mechanical Cycles	Test Series C per 7.3.5 10 Thermal Cycles 5 Mechanical Cycles	
	Test Series A per 7.3.3 A ^a (Q1, Q2, Q3, Q4) A ^a (Q4, Q3, Q2, Q1) A ^e (Q1, Q2, Q3, Q4) A ^e (Q4, Q3, Q2, Q1) A ^e (Q1, Q2, Q3, Q4) 5 Q1-Q3-Q1 Cycles A ^a (Q4, Q3)	Test Series A per 7.3.3 A ^a (Q1, Q2, Q3, Q4) A ^a (Q4, Q3, Q2, Q1) A ^e (Q1, Q2, Q3, Q4) A ^e (Q4, Q3, Q2, Q1) A ^e (Q1, Q2, Q3, Q4) 5 Q1-Q3-Q1 Cycles A ^a (Q4, Q3)	Test Series A per 7.3.3 A ^a (Q1, Q2, Q3, Q4) A ^a (Q4, Q3, Q2, Q1) A ^e (Q1, Q2, Q3, Q4) A ^e (Q4, Q3, Q2, Q1) A ^e (Q1, Q2, Q3, Q4) 5 Q1-Q3-Q1 Cycles A ^a (Q4, Q3)	Test Series A per 7.3.3 A ^a (Q1, Q2, Q3, Q4) A ^a (Q4, Q3, Q2, Q1) A ^e (Q1, Q2, Q3, Q4) A ^e (Q4, Q3, Q2, Q1) A ^e (Q1, Q2, Q3, Q4) 5 Q1-Q3-Q1 Cycles A ^a (Q4, Q3)	
Limit Load Testing	LP3 per 7.5.4 Tension to Failure	LP2 per 7.5.3 50% C + EP to Failure	LP1 per 7.5.2 95% IP + T to Failure	LP4 per 7.5.5 70% IP + C to Failure	LP5 per 7.5.6 50% T + IP to Failure
End of Test	Complete	Complete	Complete	Complete	Complete

Key for Tables 2–7Test method titles abbreviations

A	Connection A end
B	Connection B end
L	Manufacturer's minimum specified thread or seal value
H	Manufacturer's maximum specified thread or seal value
XL	Manufacturer's extreme minimum specified thread or seal value
XH	Manufacturer's extreme maximum specified thread or seal value
PS-BF	Pin slow taper — box fast taper
PF-BS	Pin fast taper — box slow taper
H/L	Manufacturer's maximum specified amount of thread compound / manufacturer's minimum specified torque value
H/H	Manufacturer's maximum specified amount of thread compound / manufacturer's maximum specified torque value
L/H	Manufacturer's minimum specified amount of thread compound / manufacturer's maximum specified torque value
MBG	Make-up/break-out test for galling resistance (see Clause 7.2.2)
FMU	Final make-up (see Clause 7.2.3)
Bake	Principle (see Clause 7.3.2)
Test Series A	Tension, compression, internal and external pressure. See Clause 7 for loads and temperatures applied for each of the CAL's
Test Series B	Tension, compression, with internal pressure. See Clause 7 for loads, bending, and temperatures applied for each of the CAL's
Test Series C	Pressure and tension cycling between ambient and elevated temperatures as defined in Clause 7 for each of the CAL's.
CW	Clockwise direction around VME
CCW	Counter clockwise direction around VME
A ^a	Test Series A at ambient temperature using gas for internal pressure and liquid for external pressure
A ^e	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	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.
B ^a _b	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.
B ^e _b	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
LP 1	High internal pressure with tension increasing to failure (see Clause 7.5.)
LP 2	Compression with external pressure increasing to failure (see Clause 7.5.)
LP 3	Tension increasing to failure (see Clause 7.5.)
LP 4	Internal pressure with compression increasing to failure (see Clause 7.5.)
LP 5	Tension with internal pressure increasing to failure (see Clause 7.5.)

5.3 Test programme

5.3.1 Physical testing

Conduct a physical test programme of make-up/break-out tests, test load envelope tests and limit load tests in accordance with the procedures stated in this International Standard.

Instructions in this International Standard shall be followed. If adverse conditions not specifically addressed in this International Standard are encountered, all deviations from this International Standard shall be documented in the **required** test report. In addition, a statement or statements should be provided to justify why the tests should be considered adequate.

5.3.2 Assessment of test results

5.3.2.1 General

Assess the results of the physical test programme, in accordance with Clause 8, following the procedure given in Clauses 5.3.2.2 to 5.3.2.4.

5.3.2.2 Test results that conform to the stated connection **assessment** level

By successfully conforming to the requirements for all the make/break tests, the test load envelope tests and the limit load tests, the connection in the size, mass (label: weight) and grade of material (i.e. same yield strength and chemistry) tested has demonstrated conformance to the validated test load envelope at the stated connection **assessment** level.

Limit load tests have termination criteria as defined in Clause 7.4.2. The loads at test termination shall be compared to the anticipated failure load calculated by the manufacturer as defined in Clause A.9. All limit loads shall exceed the test load envelope. If the limit load does not exceed the TLE, the TLE may be revised such that it is smaller than the limit load results and no further testing is required.

5.3.2.3 Test results that do not conform to the stated connection **assessment** level

When the test results do not conform to the requirements of the test load envelope tests, the results may be evaluated for:

- a) a connection design revision followed by a full re-test; or
- b) a revision of the test load envelope followed by re-test of all test specimen(s) which did not meet the requirements of the revised test load envelope for that specimen.

To complete the CAL III limit load tests, if a specimen is destroyed during CAL IV testing, a new specimen may be used for limit load testing without repeating the sealing tests; however, make-up/break-out tests shall be repeated as required for the specimen being replaced.

In case of the malfunctioning of testing facilities or test execution, which is not related to product design, neither a connection design revision, test load envelope revision nor limit load revision is required, but the specimen(s) or replacement specimen(s) shall be re-tested in full. Any event not conforming to acceptance criteria shall be reported. The number of retests and the need for the retests shall be included **in the** test report.

5.3.2.4 Reporting of test results

Report the test results **in the required test reporting** accordance with Clause 9. All leakage, whether during the **connection hold periods, load changes, or with the equipment, regardless of volume or rate,** shall be reported on the data sheets and identified on the pressure plots.

5.4 Calibration and accreditation requirements

5.4.1 Accreditation

The laboratory conducting these tests shall be either:

- a) accredited by a recognized national or international accreditation body, or
- b) at a minimum, comply in full with Clauses 5.4.2 to 5.4.5.

5.4.2 Equipment calibration

Before testing begins, ensure that all load frames to be used for the tests have a valid calibration. In addition, based on the connection manufacturer's or test laboratory's experience, measuring and recording instruments, such as pressure gauges and thermocouples, shall be calibrated periodically. The test laboratory standards for calibration and all of the calibrations shall be documented. Copies of current calibration test reports for the load frame, temperature, pressure and torque measuring devices shall be included in the detailed test report.

Equipment calibration during a test programme may be appropriate based on the required test loads and past equipment usage.

5.4.3 Annual load frame calibration

Each load frame used in an axial load or combined load test shall be calibrated in both tension and compression modes at least annually with device(s) (i.e. load cells) traceable to national standards.

The calibration should consist of two passes of a minimum of 10 equal increments ranging from the minimum calibration load to the maximum calibration load (defined as the "loading range"). The calibration range of the load frame shall cover the range of loads that will be applied in the test programme. The maximum frame calibration load shall be greater than the maximum anticipated failure load of the connection/pipe being evaluated.

The error, E_r , and the percent error, E_{rp} are calculated as follows:

$$E_r = F_i - F_f \quad (1)$$

$$E_{rp} = 100 \frac{E_r}{F_f} \quad (2)$$

where

F_i is the indicated load;

F_f is the actual load.

The percent error for all loads within the loading range of the frame shall not exceed $\pm 1,0$ % (see Annex F for an example).

5.4.4 Load frame verification

In the event that the load frame is subjected to unusual loads, such as applying a load beyond the calibration range or if a failure occurs at an unexpected load that could indicate a calibration problem, a calibration bar shall be used to verify the load frame calibration. This calibration bar shall be traceable to national standards bodies and certified annually. In lieu of using the calibration bar, a full annual calibration may be performed.

5.4.5 Pressure transducer calibrations

Each pressure transducer shall be calibrated at least annually. The percent error for pressures within the loading range shall not exceed $\pm 1,0\%$.

5.5 Material property tests

5.5.1 General

Test the pipe and coupling stock mechanically to determine the yield strength for calculation of the connection testing loads.

The mechanical properties of the material shall be characterized by a documented procedure consistent with the specification for the material. Typically this is ISO 11960 (API 5CT) for low alloy steel or ISO 13680 for corrosion-resistant alloys. For connections machined on line pipe the procedure shall be in accordance with ISO 3183 (API Spec 5L).

Report the material property data required on the material property data sheet, Form C.1.

5.5.2 Material test specimens

Material property tests shall be conducted on tensile test specimens. Tensile test specimens shall be cut from material coupons. The material coupons shall be extracted from all lengths of pipe and coupling stock used to manufacture the full-scale test specimens. Material coupons shall be extracted from the pipe and coupling mother tubes as follows:

- a) Mother tube shorter than 3 m (9,8 ft) requires at least one material coupon cut at any location within the pipe.
- b) Mother tube longer than 3 m (9,8 ft) and shorter than 6 m (19,6 ft) requires at least two material coupons one at each end.
- c) Mother tube longer than 6 m (19,6 ft) requires at least three material coupons, one at each end and one in the middle.
- d) Distances between multiple coupon locations within any single mother tube shall be greater than 2 m (6,5 ft).

Extraction of tensile test specimens from the material coupons is as follows:

- a) Machine tensile test specimens from each material coupon with at least one for an ambient test (all CAL's) plus at least one for an elevated temperature test for those CAL's requiring elevated temperature tests (see Clause 5.5.4)
- b) Circumferential locations of the required tensile test specimens within each coupon shall be adjacent (as close as practical).

The material coupons, the tensile test specimens and results of the material property tests shall be traceable to the mother tubes and the axial and circumferential locations within the tube. See Clause 6.3 to ensure sufficient pipe and coupling stock is tested and that mechanical properties meet the requirements stated in this International Standard.

Recommended layout for full-scale specimen pups, material coupons, and the tensile test specimens is given in Figure C.1. This layout provides the material strength directly adjacent to the connection. If the full-scale specimens or the material coupons or the tensile test specimens are not cut as specified in Figure C.1, the manufacturer shall modify the material property data sheet, as shown in Form C.1, and the manufacturer shall provide a sketch similar to Figure C.1 showing the actual location of the specimen pups and the material coupons and the tensile test specimens.

5.5.3 Geometry of tensile test specimens

Either a tensile test strip specimen or the largest practical ASTM tensile test round specimen (see ASTM A370) shall be used. All material tests at the same temperature shall be performed with the same specimen geometry. Sketches of the geometries and location selected for the tensile test specimens, from the pipe body and the coupling stock at ambient and elevated temperatures shall be shown in the material property data sheet, Form C.1.

5.5.4 Minimum test scope

The minimum scope of the material property tests is as follows:

- At least one tensile test at ambient temperature from each material coupon for all CAL levels
- At least one tensile test at elevated temperature from each material coupon for CAL II, CAL III-Ambient A, CAL III, and CAL IV

The elevated temperature tests shall be performed at the following temperatures:

- For CAL II this is 150°C (302 °F), +0°C/-5°C (+0°F/-9°F)
- For CAL III-Ambient A, CAL III, and CAL IV this is 195°C (383 °F), +0°C/-5°C (+0°F/-9°F).

For each tensile test, report the acquired stress-strain plot from zero strain to 2% strain or to specimen failure, whichever occurs first, yield strength as defined by ISO and API references, ultimate strength and total elongation. Additionally, the 0,2 % offset proof stress should be reported for information.

For each elevated temperature test, monitor the actual coupon temperature with a thermocouple attached to the material test specimen, and include the temperature history data in the test report.

5.5.5 Yield strength for calculation of full-scale test loads

For each mother tube, the lowest measured yield strength from all material tests conducted at room temperature on tensile test specimens from that mother tube shall be the yield strength used to calculate the test loads applied at room temperature to all full-scale specimens made of that mother tube.

For each mother tube, the lowest measured yield strength from all material tests conducted at elevated temperature on tensile test specimens from that mother tube shall be the yield strength used to calculate the test loads applied at elevated temperature to all full-scale specimens made of that mother tube.

5.5.6 Other material property calculations

In cases where the sample material exhibits strength anisotropy (e.g., cold-worked CRA), additional mechanical property tests may be performed to characterize the anisotropy. Specifically, the tensile yield should be determined in the transverse direction and the compression yield strength should be determined in the axial and transverse directions. The minimum values may be used unless otherwise agreed to between user and manufacturer.

Elastic modulus should be determined at ambient and at elevated temperatures and used where applicable. ASTM E111 may be used as a reference for performing these tests evaluations.

5.6 Make-up and break-out procedures

5.6.1 Principle

Make-up and break-out procedures and the thread compound used during testing should be consistent with normal industry practice used in the field.

5.6.2 Make-up thread compound

The connection manufacturer shall specify the type and amount, with tolerances, of thread compound that shall be applied to the connection, as well as the areas to which the thread compound shall be applied. These thread compound criteria shall be the same as those used for field applications. The same thread compound shall be used for all test specimens. Preferably, the maximum and minimum quantities should be specified as mass. In addition, the manufacturer shall provide photographs and descriptions of how the thread compound is to be applied. This includes photographs of connections with minimum and maximum thread compound.

It is recognized that connections exist in the industry that have special surface treatments that do not require thread compound and therefore Clause 5.6.2 may not apply.

5.6.3 Make-up torques

The make-up torques specified in Clause 7 is either the maximum or minimum torque recommended by the manufacturer. For a high-specified torque, the test sample make-up is acceptable if the torque is more than the sum of (80 % of the maximum torque recommended by the manufacturer plus 20 % of the minimum torque recommended by the manufacturer). For a low specified torque, the test sample make-up is acceptable if the torque is less than the sum of (80 % of the minimum torque recommended by the manufacturer plus 20% of the maximum torque recommended by the manufacturer).

For each of the single make-up specimens in a test series, if the actual make-up torque is less than the manufacturer's minimum because of a testing error, the specimen may be broken out and reassembled a second time to achieve the manufacturer's minimum torque. If the second make-up also does not achieve the manufacturer's minimum torque, that specimen may be tested as-is or it shall be replaced. Any additional single make-up specimens that do not achieve the manufacturer's minimum torque shall be tested as-is or shall be replaced.

Initial rotation speed for make-up shall not be less than 90% of the maximum recommended rotational frequency (r/min). For shouldering connections, this rotational frequency shall be maintained until the joint naturally begins to tighten, rotation slows and the connection shoulders. For non-shouldering connections, this rotational frequency shall be maintained until the joint naturally begins to tighten causing rotation speed to decrease.

Set-up tests may be used to calibrate dump valve settings on the make-up equipment so that the desired final torques are obtained during testing.

5.6.4 Make-up procedure

Make-up each connection in the manner described below. Record the results in the specimen make-up/break-out data sheet, Form C.2.

For each make-up, clean and dry the connection completely, then weigh and record the amount of lubricant applied to each connection member (pin and coupling side or integral box). Monitor and record make-up and break-out torques on torque-versus-turn plots. The turn resolution shall be at least 1/1 000 th of a turn. Torque-versus-turn plots for all make-ups of Clause 7 and any additional make-ups considered relevant shall be included in the full test report (see Clause 9 and Annex D). At the time of make-up, annotate each plot to indicate the test specimen, pin-end and box-end, make-up number, date, time and any unusual observations.

Connections should be made up using tongs and tong dies typical of those used in the field. Vertical make-up should be used. For coupled connections, floating of the coupling is prohibited (i.e. each side shall be made up separately). Photograph all make-up equipment and at least one connection being made up. When gripping couplings (or boxes), clamping forces should be controlled to prevent adverse distortion of the internally threaded member.

When performing the make-up and break-out procedure, it is recommended to have a plug in the end that is not being made up to help avoid damage.

Use of strain gauges is optional (see Clause 5.10.3).

5.6.5 Break-out procedure

Break-out the connection test specimen with the same tongs and instrumentation as in Clause 5.6.4 in accordance with the manufacturer's procedure. Record the results in the specimen make-up/break-out data sheet, Form C.2.

5.6.6 Break-out refurbishment

Following each break-out, pins and boxes may be refurbished using only techniques, equipment, and tools stipulated by the connection manufacturer for field use. All such repairs shall be fully documented including repair time. Any galling or other nonconformity shall be reported. A galling evaluation, including a clear description of the size and nature of the damage, shall be part of the final report. Photographs shall be made of the galled surface, repaired surface, repaired surface after the next break-out and the repaired surface after the final break-out and shall be included in the final report.

5.6.7 Connection test specimen inspection

Inspect the connection test specimens carefully following each break-out. Evaluate and document on the torque-versus-turn plots any correlation with observed connection galling. On the torque-versus-turn plots, document any observations or variances that contributed to other make-up concerns (coupling or pin spinning in tong dies, computer glitch/electrical spike which results in no torque-versus-plot printout, etc.). Record dimensional inspection results on the specimen geometry data sheet, Form C.3.

5.7 Internal pressure leak detection for Test Series B and Test Series C

5.7.1 Principle

Leak detection requirements are critical for those connections that need to be gas or liquid tight. Alternative methods of leak detection are shown below for use on different types of connections. Casing and tubing specimens that are subjected to internal pressure shall be monitored with a system capable of trapping and measuring leakage volume or flow rate.

5.7.2 Pressurization media

For CAL II, CAL III-Ambient A, CAL III, and CAL IV, all tests with internal pressure to verify the test load envelope shall be conducted with dry nitrogen. For CAL I-E, all tests with internal pressure to verify the test load envelope shall be conducted with solids-free liquid or dry nitrogen as agreed in the test plan. At the option of any of the parties to the test, a helium tracer gas may be added. For CAL I, all tests with internal pressure to verify the test load envelope shall be conducted with solids-free liquid. All limit load tests (i.e. planned failure tests) shall be conducted with liquid as the pressuring medium unless otherwise specified and agreed in the test plans.

Leaks (leakage) during load changes shall be recorded on the data sheets; however, these leaks are not considered as a connection leak. Pressure sealing acceptance criteria is shown in Clause 8.2. Connection leaks shall be identified on the pressure plots.

For the elevated temperature cycles in Test Series B and Test Series C the requirements in Clause 5.11 apply.

5.7.3 Test safety

For safety considerations, specimens subjected to gas pressure testing should include an inserted filler bar. The filler bar material should either not be porous or should bleed off the test medium quickly to avoid problems with interpreting the test results. The bar should be dimensioned to reduce the internal specimen volume substantially but shall not result in any mechanical interference with the specimen when the specimen deforms during test execution (see Figure 7). Filler bars located at or in the connections in the specimen shall be radially positioned in such a way that there is no contact with connection D_i . The length of no contact shall be at least one pipe D beyond the face of the box and the end of the pin.

5.7.4 Internal pressure leak detection sensitivity

The monitoring and measuring system for internal pressure leak detection shall meet a minimum leak indication sensitivity of $0,9 \text{ cm}^3/15 \text{ min}$ time period using a graduated cylinder of $0,1 \text{ cm}^3$ graduations or a sensitivity of $1 \times 10^{-4} \text{ cm}^3/\text{s}$ under standard conditions for gas chromatograph or spectrometer system. If helium tracer gas is used, the graduated cylinder based system shall have the capability of capturing the accumulated gas for the analysis of helium content to verify or discount leak events.

When using a graduated cylinder, take care to compensate for changes in barometric pressure or other non-test relevant events because these changes may affect the leak detection sensitivity. It is recommended that prior to beginning any tests, a separate graduated cylinder (see Figure 1) replicating the leak detection device be set-up. This separate graduated cylinder would be used during analysis to determine if a connection is leaking or if the change is due to a change in barometric pressure. The separate graduated cylinder should contain a gas bubble consistent with the size of the bubble in the inverted graduated cylinders of the connections being monitored.

5.7.5 Leak Indicators

Leak indicators may be evaluated regarding their source if there is reason to believe the leakage is not from the connection. A sensor calibrated to detect helium may be used to verify that any bubbles detected are coming from the pressure medium and not from the thread compound de-gassing or from thermal expansion of the connection or test equipment. Evaluation of the leakage source shall be based on conclusive analysis of the leakage gas. If leakage is generated from a source other than the connection (e.g. the end caps), the leakage source shall be repaired and testing continued. Report all leaks and their source (pressure fitting, valve, connection, etc.). All leak indicators shall be reported and the basis for discounting leakage clearly explained in the test report.

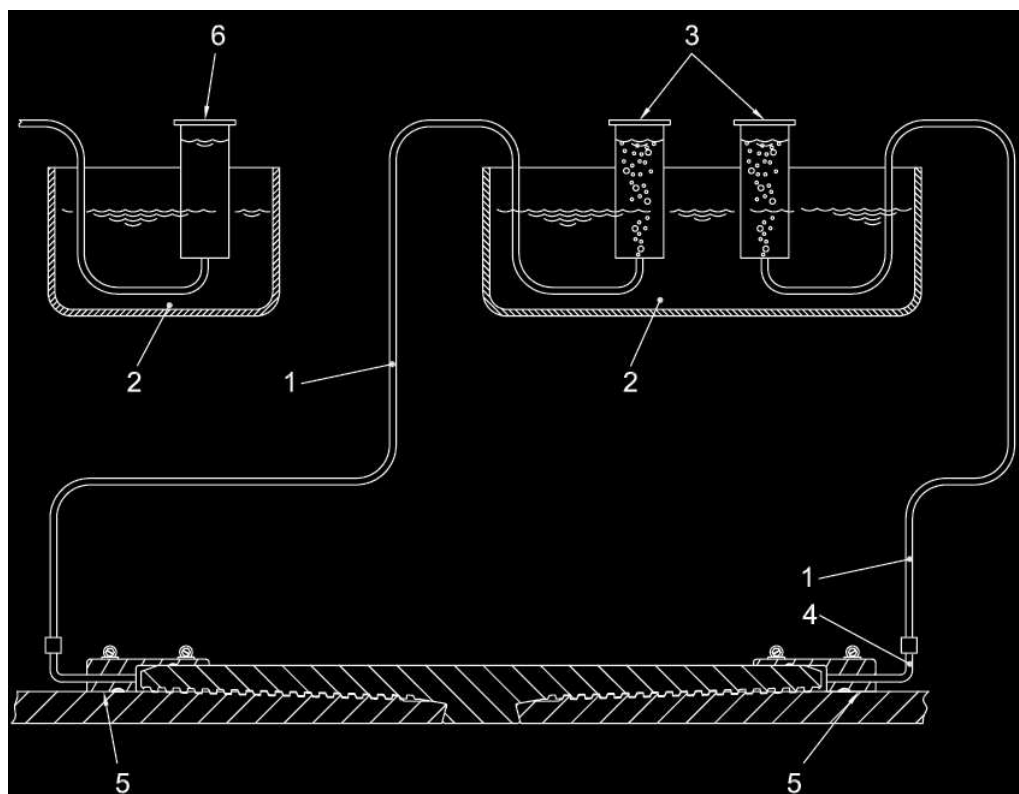
5.7.6 Internal pressure leak detection by bubble method

5.7.6.1 Principle

A leak detection system based on the bubble method is shown in Figure 1. The system is based on capturing any and all gas that passes through a connection and collecting the gas in a container for measuring the volume. The main components of the system are:

- a) a means of trapping the gas, such as the leak trap devices described **below**;
- b) a tube or flexible hose that connects the leak trap device to a bubble collection tube;
- c) a bubble collection tube that consists of a clear graduated cylinder with $0,1 \text{ cm}^3$ or smaller scale divisions. The cylinder is filled with water and a flexible hose is placed inside the open end of the cylinder. The cylinder and the end of the hose are submerged in a container of water and then inverted (see Figure 1).
- d) **Pressure sealing acceptance criteria are stated in Clause 8.2.**

A connection leak is visually detected if bubbles rise in the cylinder. The gas from the bubbles is measured using the scale on the cylinder.



Key

- 1 flexible hose
- 2 water tank
- 3 graduated cylinders
- 4 heat resistant tube
- 5 leak trap devices
- 6 dummy graduated cylinder (same size and height above top of water as cylinders, see Key 3)

Figure 1 — Internal pressure leak detection by bubble method

5.7.6.2 System verification for bubble method

Verify all internal pressure leak detection systems prior to a test programme by testing for leaks and assessing sensitivity.

- a) Test the system for leaks by applying 0,007 MPa to 0,014 MPa (1 psig to 2 psig) air or nitrogen gas pressure. When the pressure stabilizes, close off the gas supply. Observe the pressure gauge for 2 min for stability. Any drop in pressure indicates a system leak. Locate and repair any system leaks. Repeat this procedure until the gas pressure remains stable for a minimum 2-min hold period.
- b) Determine the sensitivity efficiency of the bubble leak detection system by introducing air and measuring the output air in each bubble tube. Inject the air in 1 cm³ increments up to at least 10 cm³. Determine the average relationship of output volume to input volume by plotting the data as shown in Figure 2. The initial amount of input air required to start output air in the bubble tube (pre-charge) shall be recorded, but will not affect the calculated leak rate and is therefore not considered in this sensitivity efficiency. The sensitivity efficiency shall be at least 70 %; if less than 70 %, reconfigure the system to increase sensitivity. This sensitivity efficiency shall be used to correct all observed leak rates and volumes during test execution according to Equation (3).

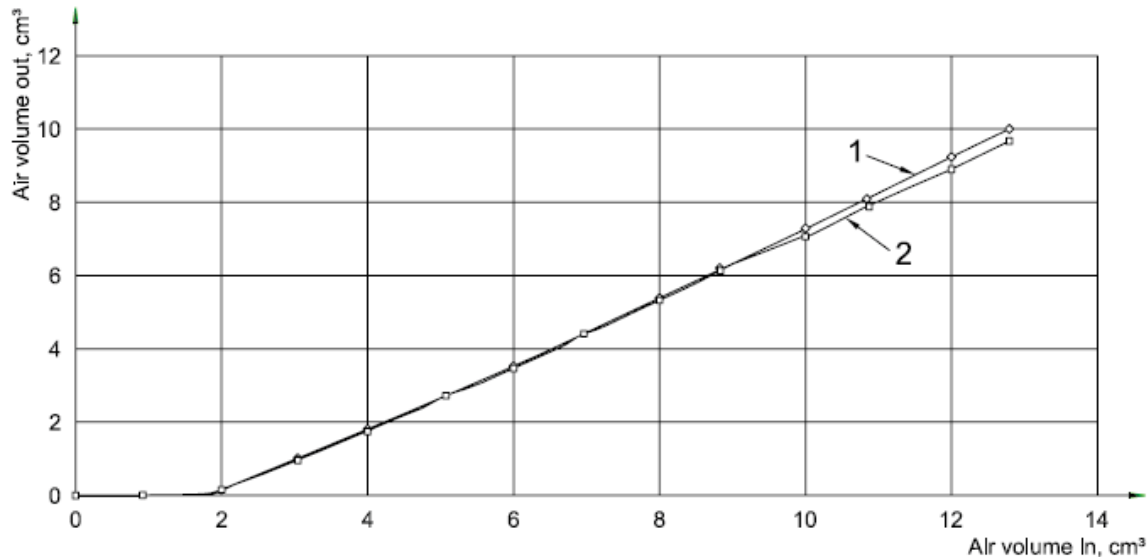
$$q_{ac} = \frac{q_o}{\eta_{lds}} \quad (3)$$

where

q_{ac} is the actual leak rate to be reported;

q_o is the observed leak rate;

η_{lds} is the leak detection system efficiency.



Key

- 1 specimen end A
- 2 specimen end B

Figure 2 — Example of a plot for determining leak detection sensitivity

5.7.6.3 Start of test

Before starting internal pressure tests, pre-charge each leak detection system by injecting air into the system near the box thread until a small amount of air collects in the bubble tube. Record this volume as the initial amount of gas to be subtracted from any additional gas collected in the tube. This pre-charge volume shall be sufficient to lower the water level to the scales on the graduated cylinder prior to the initiation of the test sequences and to demonstrate that the lines are not plugged.

5.7.7 Internal pressure leak detection by helium mass spectrometer method

5.7.7.1 Principle

A leak detection system using a helium mass spectrometer (see Figure 3) includes the following:

- a) a means of trapping the gas;
- b) a tube or flexible hose connecting the leak trap device to a carrier gas line;
- c) a pure nitrogen carrier gas line that connects to a mass spectrometer;
- d) a helium mass spectrometer (generally, the mass spectrometer uses a sniffing method of leak measurement, and consequently, much care shall be taken to ensure the sniffer is working properly at atmospheric pressure).