

DIN EN ISO 21329

ICS 75.200

**Erdöl- und Erdgasindustrie –
Rohrleitungstransportsysteme –
Prüfverfahren für mechanische Verbindungen (ISO 21329:2004);
Englische Fassung EN ISO 21329:2004**

Petroleum and natural gas industries –
Pipeline transportation systems –
Test procedures for mechanical connectors (ISO 21329:2004);
English version EN ISO 21329:2004

Industries du pétrole et du gaz naturel –
Systèmes de transport par conduites –
Modes opératoires d'essai des connecteurs métalliques (ISO 21329:2004);
Version anglaise EN ISO 21329:2004

Gesamtumfang 88 Seiten

Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) im DIN

Nationales Vorwort

Diese Europäische Norm wurde vom Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Off-shore-Bauwerke für die Erdöl-, petrochemische- und Erdgasindustrie“ (Sekretariat: Frankreich) erstellt. Es handelt sich dabei um die unveränderte Übernahme der Norm ISO 21329:2004, erarbeitet von ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“, Subkomitee SC 2 „Pipeline transportation systems“.

Für Deutschland war der Normenausschuss Erdöl- und Erdgasgewinnung (NÖG), Arbeitsausschuss NÖG 2 „Fernleitungssysteme“ an der Erarbeitung dieser Norm beteiligt.

Diese Europäische Norm enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 13/1983 nur die englische Originalfassung der ISO-Norm.

English version

Petroleum and natural gas industries - Pipeline transportation
systems - Test procedures for mechanical connectors
(ISO 21329:2004)

Industries du pétrole et du gaz naturel - Systèmes de
transport par conduites - Modes opératoires d'essai des
connecteurs métalliques (ISO 21329:2004)

Erdöl- und Erdgasindustrie - Rohrleitungstransportsysteme
- Prüfverfahren für mechanische Verbindungen
(ISO 21329:2004)

This European Standard was approved by CEN on 23 September 2004.

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. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists 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 Central Secretariat has the same status as the official versions.

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Foreword

This document (EN ISO 21329:2004) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum 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 European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2005, and conflicting national standards shall be withdrawn at the latest by April 2005.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of ISO 21329:2004 has been approved by CEN as EN ISO 21329:2004 without any

Introduction

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

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

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

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

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

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

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1 Scope

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

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

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

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

- a) connectors that are designed to rotate in use,
- b) manifolds,
- c) topsides pipework or piping,
- d) flanges,
- e) connectors used in pipelines installed by reeling or J-tube pulls,
- f) factory acceptance testing,
- g) statistical bases for risk analysis.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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

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

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

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

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

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

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

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

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

ASTM A 370¹⁾, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

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

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

3 Terms and definitions

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

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

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

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

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

NOTE Adapted from ISO 3183-2:1996.

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

3.6
galling
localized damage to material surfaces resulting from contact conditions

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

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

[ISO 15590-1:2001]

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

3.8**liner**

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

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

3.9**load envelope**

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

3.10**manufacturer**

organization responsible for the design and manufacture of the equipment

NOTE 1 The manufacturer is not necessarily the vendor.

NOTE 2 Adapted from ISO 13707:2000.

3.11**operational restrained test**

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

3.12**operational unrestrained test**

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

3.13**pipeline**

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

[ISO 13623:2000]

3.14**purchaser**

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

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

[ISO 13707:2000]

3.15**reverse torque**

Z

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

3.16**riser**

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

[ISO 13623:2000]

3.17**seal**

barrier that resists the passage of fluids

[ISO 13678:2000]

3.18

multiple seals

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

3.19

specified minimum yield strength

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

[ISO 13623:2000]

3.20

test sample

assembly of a connector and two pieces of pipe specifically for testing

4 Symbols and abbreviated terms

4.1 Symbols

$A_{F,un}$	operational unrestrained axial factor
A_s	specified cross-sectional area of pipe
$B_{F,hy}$	bending factor for hydrostatic pressure test
$B_{F,in}$	bending factor for installation
$B_{F,un}$	bending factor for unrestrained operation tests
D_i	specified pipe inside diameter
D_o	specified pipe outside diameter
E_p	Young's modulus of pipe
F_{re}	axial force for restrained operation
F_{un}	axial force for unrestrained operation
f_{VM}	von Mises' factor
H_r	depth rating
K	load multiplication factor
K_F	torque factor
K_{cc}	ratio of actual to specified minimum yield stress of the critical connector component material
K_p	ratio of actual to specified minimum yield stress of the pipe body material
K_{SCF}	stress concentration factor
L	length of test sample between inner supports
L_g	grip length of pipe
L_p	unsupported pipe length for test sample
L_s	length between scribe mark and coupling on test sample

M_{in}	bending moment for installation
M_{hy}	bending moment for hydrostatic pressure test
M_{un}	bending moment for unrestrained operation
N_c	total number of cycles
p_d	design pressure
p_{ex}	external hydrostatic pressure
p_H	internal pressure value to be used for testing
p_{op}	operating pressure based on MAOP at the connector
p_r	manufacturer's rated pressure
p_t	hydrostatic test pressure
S_L	lowest fatigue stress range
S_M	middle fatigue stress range
S_H	highest fatigue stress range
$S-N$	stress versus number of cycles in fatigue curve
$\sigma_{ax, re}$	restrained axial stress
σ_{ayc}	actual yield stress of the connector critical component
σ_{ayp}	actual yield stress of the pipe body material
σ_{sys}	specified minimum yield stress of the connector critical component
σ_{syp}	specified minimum yield stress of the pipe body material
$T_{d, max}$	maximum design temperature
$T_{d, min}$	minimum design temperature
T_{HT}	maximum test temperature
T_{LT}	minimum test temperature
T_{max}	maximum rated temperature
T_{min}	minimum rated temperature
$T_{op, max}$	maximum operating temperature
$T_{op, min}$	minimum operating temperature
t	specified wall thickness
t_{min}	minimum wall thickness accounting for manufacturing tolerances
ν	Poisson ratio of the pipe body
Z	reverse torque
Z_{mu}	make-up torque

4.2 Abbreviated terms

CRA	corrosion-resistant alloy
FEA	finite element analysis
ID	inside diameter
MAOP	maximum allowable operating pressure
OD	outside diameter

5 Test categories

5.1 General

Connectors shall be tested according to the

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

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

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

5.2 Pressure, temperature and depth ratings

5.2.1 Pressure rating

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

5.2.2 Temperature rating

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

5.2.3 Depth rating

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

5.3 Application levels

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

Annex A specifies application levels.

5.4 Confidence levels

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

- Normal: for temporary conditions where failure implies risk of human injury, significant environmental pollution or very high economic or political consequences. For this confidence level, no frequent human activity is anticipated along the pipeline route.
- High: for operating conditions where failure implies high risk of human injury, significant environmental pollution or very high economic or political consequences. This is the confidence level required for areas with frequent human activity, e.g. those parts of the pipeline or riser near the platform or in areas populated with more than 50 persons/km².

Table 1 — Test load factors

Test	Subclause	Load factor for application level			
		1	2	3	4
Make, break and torque tests					
Torque factor – K_F	10.5, C.1	0	0	0,05	0,05
Installation tests ^a					
Bending factor – $B_{F,in}$	11.4	0,3	0,85	0,95	0,95
Hydrostatic pressure tests					
Bending factor – $B_{F,hy}$	11.5	0	1,0	1,0	1,0
Operational cycles unrestrained tests					
Bending factor – $B_{F,un}$	11.6	0,3	0,3	0,9	0,9
Axial factor – $A_{F,un}$		0 ^b	0 ^b	0 ^b	0,2
Other					
von Mises' factor – f_{VM}	C.2.2	NA	0,96	0,96	0,96
^a In all cases, if the water depth $H_r > 500$ m the effect of external hydrostatic pressure shall be considered.					
^b In the case of a suspended riser, the connector may have $A_{F,un} > 0$. Allowance should be made for this when defining an application level within the range 1 to 3.					

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

Requirements		Subclause reference	Confidence level	
			normal	high
Connector geometry and performance data		7.3	In all cases	
Number of test samples to prepare		6.5	8 numbered 1 to 4 and 9 to 12	12 numbered 1 to 12
			Test sample number(s)	
Make, break and torque tests	Repeated make-up and breakout	10.3	1 to 4	1 to 8
	Final make-up	10.4	All	All
	Reverse torque	10.5	1 to 4	1 to 8
Service load tests	Installation tests	11.4	1 to 4	1 to 8
	Hydrostatic pressure tests	11.5	1 to 4	1 to 8
	Operational unrestrained tests	11.6	1, 3	1, 3, 5, 7
	Total number of cycles, N_C		20	100
	Operational restrained tests	11.7	2, 4	2, 4, 6, 8
	Total number of cycles, N_C		20	100
Limit load tests	Pressure-to-failure test	12.4	1	1
	Compression-to-failure test	12.3	NA	5
	Bending-to-failure test	12.5	4	4
	Tension-to-failure test	12.2	NA	7
Fatigue tests	Bending fatigue-to-failure test	13		
	S_L , see 13.2.4		2, 9	2, 6, 9
	S_M , see 13.2.4		10, 11	10, 11 (see NOTE)
	S_H , see 13.2.4		3, 12	3, 8, 12
'All' signifies all test samples shall undergo the specific test. NOTE In many applications some modes of testing may not be necessary, e.g. where fully restrained conditions cannot occur, and where it may not be necessary to conduct limit compression tests to failure. This would make the third connector available for fatigue testing.				

6 Test requirements

6.1 General

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

6.2 Purpose of tests

6.2.1 Introduction

The purpose of the tests is to simulate conditions that can occur during installation, commissioning and operation. The test requirements comprise four sets of procedures as outlined below. The tests shall be witnessed either by an inspector appointed by the purchaser or an independent third party. The fatigue-loading test is optional, and for a specific project it is the responsibility of the purchaser to define the fatigue loading.

6.2.2 Make, break and torque tests

The make-and-break procedures determine the ability of the connectors to resist wear and galling during repeated make-up, if applicable. The torque procedures assess the ability of the connector to resist torque, which could cause the connector to become undone or else cause loss of sealing integrity.

6.2.3 Service-load tests

The service-load tests simulate the installation loads, the hydrostatic pressure test loads, and the operational loads on a connector. For example, operational unrestrained tests simulate the loads due to operational cycling on a portion of pipeline or riser that is not axially constrained and may have axial tension due to self-weight or externally applied tension. Operational restrained tests simulate the loads due to operational cycling on a portion of pipeline that is fully axially constrained.

6.2.4 Limit-load tests

Limit-load tests are conducted to establish the structural and sealing limits of the connector. These limits are important for establishing the reliability limits of connectors under field conditions, and are also useful for correlating with strain gauge and finite element analysis results. Procedures are given for the following:

- tension-to-failure test, which applies to pipelines where there is a risk of inducing a high tensile load during operation;
- compression-to-failure test, which applies to pipelines where there is a credible risk of high compressive loads during operation, particularly if used with axial strains beyond yield, or where there is a risk of local buckling of the pipe;
- pressure-to-failure test, which applies to pipelines where there is a credible risk of high internal or external pressure loads during operation. These tests give a measure of the margin of safety against internal and external overpressurization, the latter only being required for deep-water pipelines and risers.

6.2.5 Bending-fatigue tests

The fatigue test is a full-scale design verification test requiring the connector to achieve without failure the minimum number of stress cycles predicted by the manufacturer.

The purposes of the fatigue test are to

- a) verify the manufacturer's prediction of the fatigue performance,
- b) allow the purchaser to select a connector with sufficient fatigue strength for the required duty.

6.3 Basis for mechanical loads

The performance of the connector as determined in this International Standard shall be related to actual yield values, σ_{ayc} rather than to specified minimum yield values, σ_{syC} .

In addition, the mechanical loads applied to the connector according to the requirements of this International Standard are based on the specified minimum yield stress, σ_{syp} and physical dimensions of the pipe body.

Consequently, the test loads are adjusted up to take into account the actual material strength being greater than the minimum. This is done by applying a load factor to the calculated loads based on the ratio between actual and specified yield stress.

The tests carried out in accordance with this International Standard shall determine the

- actual yield strength of the critical connector component material, σ_{ayc} in accordance with 7.6.3,
- actual yield stress σ_{ayp} , of the pipe body used in the test sample(s) in accordance with 7.6.3.

Factors shall be determined in accordance with Equations (1) and (2).

$$K_{cc} = \frac{\sigma_{ayc}}{\sigma_{syc}} \quad (1)$$

where

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

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

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

$$K_p = \frac{\sigma_{ayp}}{\sigma_{syp}} \quad (2)$$

where

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

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

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

The mechanical loads applied in the test shall be multiplied by the factor K , which is the lesser of K_p or K_{cc} for the relevant materials.

The factor K is applied in the calculation of loads given in Annex C.

6.4 Test-house selection

The testing facilities shall satisfy the requirements in Clause 8. The testing shall be carried out either by a test house independent of the manufacturer, or by the manufacturer with independent verification.

6.5 Selection of tests and number of test samples

The test samples shall be numbered as shown in Table 2 and shall retain their designated number throughout the tests.

Table 1 defines the load factors to be applied during the tests for a given application level. The test shall take into account external hydrostatic pressure if the specified depth exceeds 500 m. Tests to take into account external pressure at shallower depths may also be carried out if specified.

Tests shall be carried out in the lifetime sequence of loading of the connector, as shown in Figure 1, for each test sample, i.e. running from top to bottom of Table 2.

Tests on different samples may be run in parallel. If the same service-load test is required on multiple test samples, a single assembly of those test samples may be used.

The number of tests and test samples may be reduced for a particular application level if it can be shown that there is no need to carry out the tests.

EXAMPLE Tests to simulate high installation and operational restrained-loading conditions may not be applicable for a connector intended for use on a spool piece. Similarly there is no need to test for bending fatigue if it can be shown that fatigue loading, for example due to vortex-induced vibration, will not occur.

If tests are project-specific, pipe of the same dimensions, tolerances and material properties as the project pipe shall be used for the tests.

NOTE Annex F provides guidance on the choice of sizes to be tested if multiple sizes of connectors are used in a project. Annex F also indicates how the results of testing can be extended to other sizes and grades of connector.

6.6 Additional tests

The purchaser should consider the additional tests described in Annex G for connectors subject to special applications. These applications can include, but are not limited to, the following:

- a) connectors with elastomeric seals;
- b) misalignment at make-up;
- c) rapid cool-down conditions;
- d) severe sour service;
- e) fire exposure;
- f) compression beyond yield;
- g) crevice corrosion;
- h) impact;
- i) J-lay.

6.7 Prior test results

Prior connector test results meeting the requirements of this International Standard may be substituted for repeat tests.

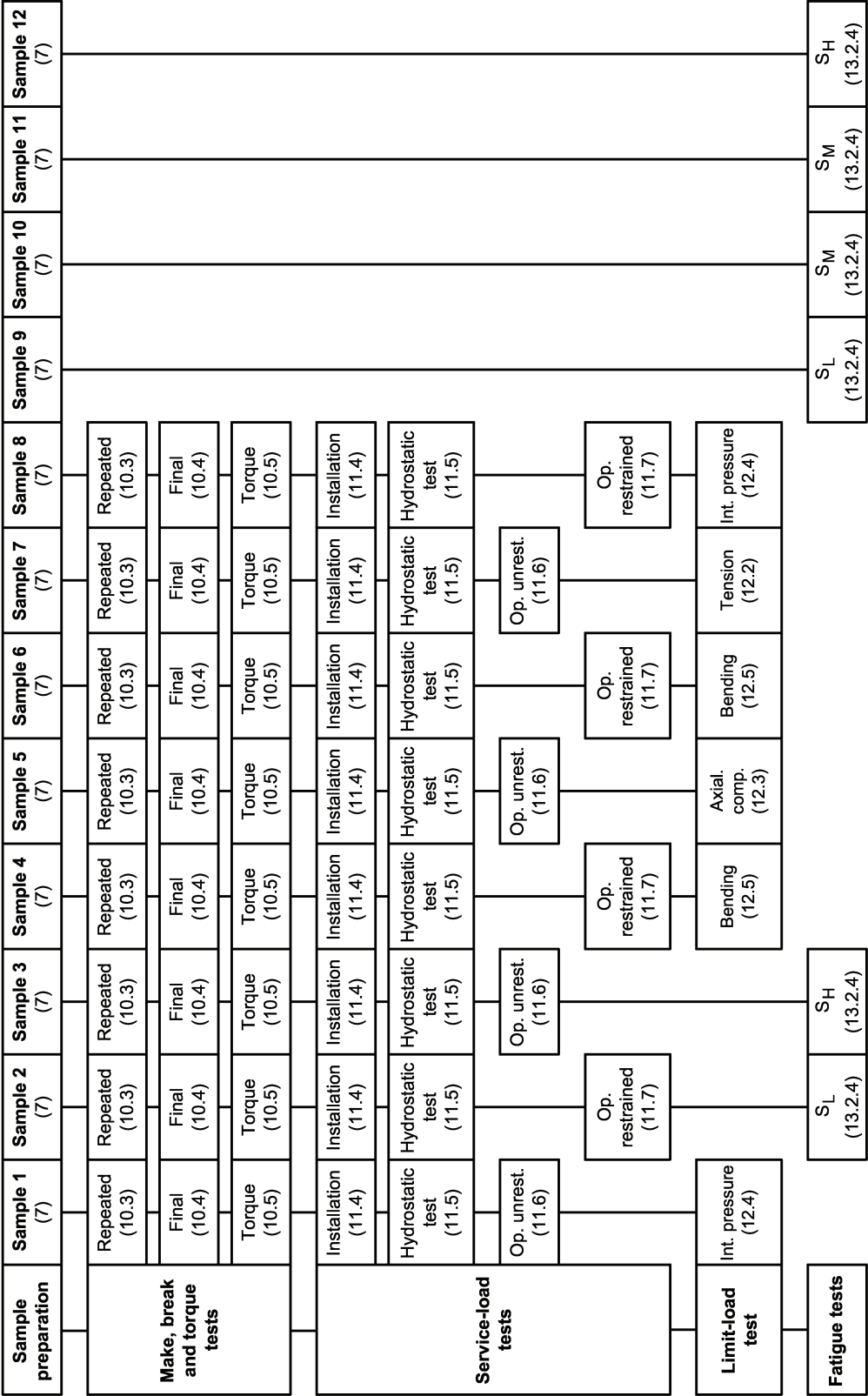


Figure 1 — Flow diagram showing test sequence, with relevant subclause number

7 Connector manufacturer requirements

7.1 General

The manufacturer shall issue a declaration of conformity stating that the connectors manufactured for the purpose of these tests are of the same design, temperature and pressure ratings and extremes of tolerances (see 7.5) as those to be supplied for pipeline service.

NOTE ISO/IEC Guide 22 contains information on declaration of conformity.

7.2 Quality control

Quality control procedures for the manufacturing of test samples shall be documented and shall be consistent with procedures used for connectors manufactured for pipeline service.

The manufacturer shall provide a quality plan. This shall include procedure or drawing numbers as well as associated revision levels for all applicable sub-tier documents (e.g. manufacturing, gauge calibration, gauging procedure, surface treatment, etc.).

7.3 Connector geometry and performance data

The manufacturer shall provide connector geometry and performance data (see Annex B) describing the connector's geometry and performance properties in terms of tension, compression, internal pressure, external pressure, bending and torque. The data shall also specify the minimum failure loads for the connector and identify the component that is the cause of failure.

The data shall specify the make-up torque or force and speed of make-up if appropriate. If the application of pipeline torque can cause damage to the connector, e.g. screwed connector, the manufacturer shall specify the torque rating of the connector.

The manufacturer shall identify the critical dimensions and tolerances in the data provided. In addition to the data required herein, the manufacturer should document other data, e.g. seal material limitations, considered pertinent to these tests.

The manufacturer shall develop a minimum failure load or load surface for load combinations. The actual failure load can then be used to determine the safety factor.

7.4 Selection of diameter

The test connectors should be of the same size as intended for the pipeline service.

NOTE Guidance on test sizes and extrapolation of test data to other sizes is given in Annex F.

7.5 Setting tolerances

7.5.1 Worst-case performance objectives

For design verification, connectors shall be tested at the worst-case configuration and condition determined from drawings, quality plan, running/doping procedures, make-up torques/forces, etc.

The manufacturer shall use analytical, computational [such as finite element analysis (FEA)], and/or experimental techniques such as strain-gauge testing to provide objective evidence that the extreme dimensional configurations of the product resulting in worst-case performance are tested.

To select worst-case performance objectives, the manufacturer shall take into account the minimum and maximum extremes of local seal contact pressure, total seal load, and total active seal contact length as influenced by machining parameters. For threaded and coupled connections, side A and side B shall be machined to identical dimensional objectives.

NOTE The specific machining dimensions depend on the type of connector.

Machining tolerances shall be set by the manufacturer to produce the worst-case performance of the connector, including, but not limited to, considerations of the tolerances on

- seal interferences,
- pin nose thickness,
- surface roughness,
- thread tapers,
- thread interferences.

7.5.2 Example of machining tolerances

As an example, for metal-to-metal sealing, tapered thread, connections with pin nose torque shoulders, Table 3 shows combinations of seal and thread diameters, thread tapers and final make-up torques which have been found to provide the worst-case performance extremes corresponding to the test objectives in Table 2. For this type of connection, the manufacturer should machine the specimens to the extremes in Table 4 unless the techniques described in 7.5.1 indicate other tolerances should be tested.

Table 3 — Example of test sample tolerances

Test sample No.	Body	Seal	Torque	Lubricant	Pin body taper	Box body taper	Misalignment
1 ^a	High	Low	High	Low	Slow ^c	Fast ^c	None
2 ^b	Low	High	High	Low	Fast	Slow	None
3	Low	Low	Low	Low	Slow	Fast	Maximum
4	High	High	High	High	Nominal	Nominal	None
5	High	Low	High	High	Slow	Fast	None
6	Low	High	Low	Low	Fast	Slow	None
7	Low	Low	High	Low	Slow	Fast	None
8	High	High	Low	High	Nominal	Nominal	None
9-12	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	None
^a Tolerances test for body galling. ^b Tolerances test for seal galling. ^c "Fast" refers to a steep taper that enables rapid make-up; "slow" has a shallow taper and takes longer to make up.							

Table 4 — Tolerance limits on machining objectives

Item	Positive tolerance	Negative tolerance
Maximum body tolerance	No limit	0,025 mm (0,001 in)
Maximum seal tolerance	No limit	0,025 mm (0,001 in)
Minimum body tolerance	0,025 mm (0,001 in)	No limit
Minimum seal tolerance	0,025 mm (0,001 in)	No limit
Maximum pin/body taper (fast)	No limit	0,001 mm/mm (0,001 in/in)
Minimum pin/body taper (slow)	0,001 mm/mm (0,001 in/in)	No limit
Taper increments shall apply to every incremental measurement of taper along the body		

7.6 Connector material requirements

7.6.1 General

As a minimum:

- connector material shall be from one batch;
- the manufacturer shall provide material mill certificates for the materials used in the connector;
- material shall be in compliance with material specification.

For integral connectors, material for both pin and box shall come from the same heat.

7.6.2 Material properties

If the critical connector component is made from forged material the manufacturer shall provide test coupons in accordance with EN 10222-1 and ISO 9327.

NOTE 1 For the purposes of this provision, ASTM A 694/A 694M is equivalent to EN 10222-1 and ISO 9327.

If the critical connector component is made from cast material, the manufacturer shall provide test coupons in accordance with EN 10213 or ASTM A 487/A 487M respectively. Either a strip coupon (recommended) or the largest practical round coupon, conforming to ISO 148-1 or ISO 6892, shall be used.

NOTE 2 For the purposes of this provision, ASTM A 370 is equivalent to ISO 148-1 or ISO 6892.

If the critical connector component is machined on steel line pipe, mechanical test coupons shall be provided in accordance with ISO 3183-1, ISO 3183-2 or ISO 3183-3. The coupon shall be taken from the middle of the pipe joint.

If the connector is manufactured from a material other than carbon steel, those references that are specific to steel shall be replaced by the most relevant standard for the connector material.

For each set of test samples the connector material properties shall be determined in accordance with 7.6.3.

The ratios of yield stress K_{cc} , shall be determined in accordance with Equation (1), see 6.3.

7.6.3 Procedures for material testing

The following procedures shall apply.

- a) A tensile test shall be performed at room temperature in accordance with ISO 148-1 or ISO 6892.

NOTE For the purposes of this provision, ASTM A 370 is equivalent to ISO 148-1 or ISO 6892.

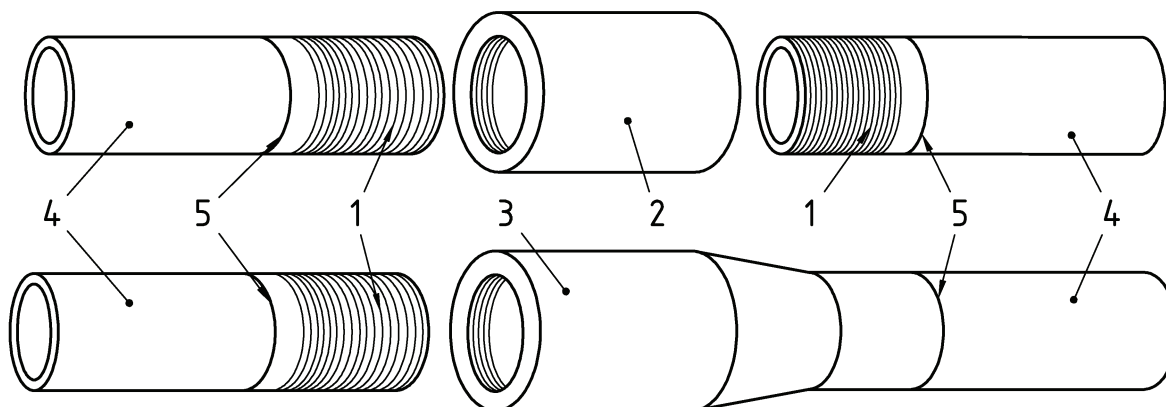
- b) A further tensile test shall be performed at $T_{\max}$. The actual coupon temperature shall be monitored and reported in accordance with ISO 783.
- c) The material property test data for the room- and elevated-temperature tests shall be reported on separate material property data records, see Table D.1. The stress-strain curves shall be attached to the data record.

Consideration needs to be given to the limits of qualification of a connector if, within a specific strength grade, high-strength pipe is tested. Consideration needs to be given to the possible effects of anisotropy on mechanical properties and of residual stress in cold-worked CRA pipe (see ISO 13680 for information). Axial tensile testing may not be sufficient to adequately characterize the pipe.

7.7 Preparation of test samples

7.7.1 Test sample layout

The layout of components making up the test sample is shown in Figure 2.



Key

- 1 pin or hub
- 2 coupling or clamp
- 3 integral coupling
- 4 pipe piece to which pin or integral coupling is joined
- 5 weld of connector pin or hub to pipe piece

NOTE 1 The connector comprises items 1, 2 and 3. The test samples comprise items 1 to 5.

NOTE 2 A test sample connects at least two pieces of pipe pups (i.e. one coupling or clamp and two pins or hubs for coupled connectors, or one box and one pin for integral connectors).

Figure 2 — Test sample layout

7.7.2 Length of test samples

For each individual test sample, each pipe piece shall have as a minimum:

- a) an unsupported pipe length L_p (see Figure 3) calculated from the following formula:

$$L_p \geq D_o + 6\sqrt{D_o t} \quad (3)$$

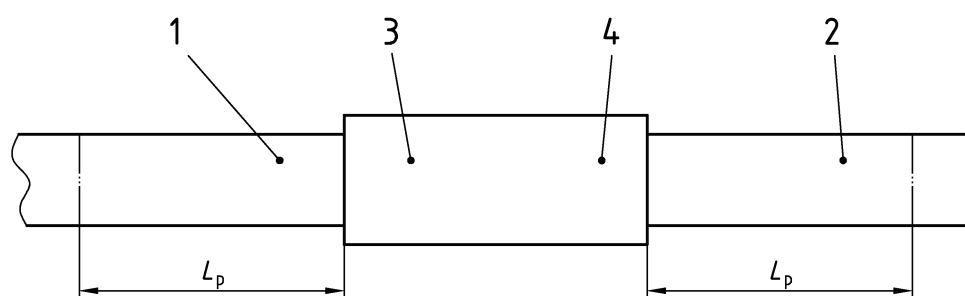
where

D_o is the specified pipe outside diameter;

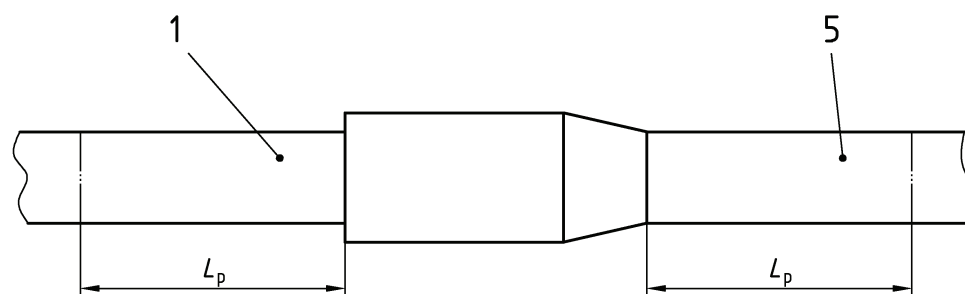
t is the specified wall thickness.

- b) additional length for gripping.

The test house may also require a certain minimum length of test piece to fit its equipment.



a) Coupled connector test sample



b) Integral connector test sample

Key

- 1 pin — A side
- 2 pin — B side
- 3 coupling — A side
- 4 coupling — B side
- 5 integral coupling — B side

The connector number shall be clearly identified on each component.

Figure 3 — Test sample nomenclature

7.7.3 Connectors made from machined pipe

If connectors are made from machined pipe, the connector test samples should be manufactured in a manner consistent with standard mill and thread practices as follows:

- a) machine connectors for upset pipe on upset pipe;
- b) machine connectors for swaged pipe on swaged pipe;
- c) machine flush connectors for as-rolled pipe on as-rolled pipe.

Connector test samples may be manufactured from material stock by machining external upsets to replicate the product configuration. If the upsets are machined, the length and depth of the configuration that is not normally machined shall be to the minimum dimensions allowed by the manufacturer.

7.7.4 Additional pipe pup piece

It may be necessary to weld the connectors to a pipe pup piece to provide the required length of test sample as defined in 7.7.2.

If applicable, the connectors shall be welded to pipe pups having the same size and the same specification as that used in service. The pipe pup piece shall be manufactured consistent with standard mill practices.

NOTE The assumption is made that the pipe has been designed to withstand the service loads, e.g. external collapse if applicable, that are applied in Clause 11.

The welding of the connector pin or hub to the pup pieces shall be in accordance with procedures specified by the connector manufacturer as agreed with the user.

With regard to the additional pipe pup pieces, for each set of test samples the following apply:

- a) all pipe pup material shall come from one batch;
- b) material mill certificates shall be obtained from the suppliers of the pipe pup pieces;
- c) all pipe pup material shall be in compliance with a specified material specification;
- d) the actual minimum pipe pup body wall thickness shall be within the tolerance allowed by ISO 3183-1, ISO 3183-2 or ISO 3183-3;
- e) the pipe pup material properties shall be determined in accordance with 7.6.3.

The ratios of yield stress K_p shall be determined in accordance with Equation (2), see 6.3.

7.7.5 Grooved torque shoulder

For connectors with a torque shoulder on the front of the pin, the A ends (B ends for integral connections) of test samples 1, 3, 5 and 6 shall have torque shoulders grooved as shown in Figure 12 of ISO 13679:2002 in order to simulate possible handling damage. Grooves shall be applied before first make-up. Other test samples may have the torque shoulder grooved by agreement.

Other types of connector may also have the torque shoulder crippled by agreement.

7.7.6 Multiple seals

If multiple metal or resilient seals are arranged in series, the additional seals (extraneous seals) not providing the primary sealing function shall be bypassed. This shall include torque shoulders that cannot be disabled with porting. Disabling of the seals shall consist of a positive-pressure bypass with a minimum structural disturbance of the connector. All bypassing grooves shall be deburred. If an extraneous seal does not prevent pressure from reaching the primary seal, it shall not be disabled.

7.7.7 Test sample labelling

The test samples shall be clearly identified before delivery to the test house, taking into account the requirements of 6.5 and Table 2.

Figure 3 presents information for a set of test samples and the nomenclature to be used. The nomenclature is designed to identify each set of test samples, each test sample in the set, each pin and box, and each make-up configuration.

7.8 Ports

For connectors with multiple seals that have not been disabled or bypassed, a port for pressure monitoring should be inserted between each adjacent seal and the pressure recorded whenever internal or external pressure is applied to the connector.

If appropriate, the port shall be plugged during make-up of the connector. The plug shall be flush with the inside surface of the connector.

NOTE Testing seals individually enables an understanding of connection seal redundancy, evaluation of seal independence and the effect of the resilient seal on the metal-to-metal seal.

7.9 Replacement test samples

If a test sample is damaged before testing is completed, a replacement test sample is required. This test sample shall be machined and assembled to the same tolerances as the damaged test sample, and all testing required for the original test sample shall be repeated. Replacement and/or re-machined components of test samples shall be identified by "R1" after the "A" or "B" identification, see Figure 3, the first time they are reworked, "R2" the second time they are reworked, etc.

7.10 Test record retention

The manufacturer is required to maintain a file on each test, including any retest that may have been required to qualify a particular connector. As a minimum, this file shall contain sufficient documentation to satisfy the reporting documentation requirements as described in Annex E and shall be maintained until 10 years after cessation of manufacture.

The test results shall be assembled into a test report. All photographs specified in this International Standard shall include identification of significant items shown in the photographs and shall be included in the test report.

8 Test-house preparations

8.1 General

The test house conducting the tests shall either be accredited by a recognized national or international accreditation organization or comply in full with 8.2.

NOTE Typical test-house standards are ISO/IEC 17025, EN 45001, EN 45002 and EN 45003.