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Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Test methods to prove the design of bolted flange joints

Tubes et raccords en plastiques thermodurcissables renforcés de verre (PRV) — Méthodes d'essai pour confirmer la conception des assemblages à brides boulonnées

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

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ISO 8483 was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 6, *Reinforced plastics pipes and fittings for all applications*.

Introduction

In a pipework system, pipes and fittings of different nominal pressures and stiffness may be used.

A joint may be made between pipes and/or fittings and should be designed such that its performance is equal to or better than the requirements of the pipeline, but not necessarily of the components being joined.

The requirements for the assembly of the joint are not included in this standard, but they should be in accordance with the manufacturer's recommendations.

Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Test methods to prove the design of bolted flange joints

1 Scope

This International Standard specifies methods of test for bolted flange joints for plastics piping systems made of glass-reinforced thermosetting plastics (GRP). This standard is only applicable to the joint, and covers methods of test to prove its design. It assumes that the joint either is or is not intended to be subject to the effects of hydrostatic end thrust.

These test procedures are applicable to joints betwen pipes and fittings of all nominal sizes. The tests are applicable for evaluating joints intended for applications conveying liquids at temperatures specified in the referring specifications.

2 Principle

A joint is subjected to a specified internal pressure and, if appropriate for the joint design, the consequent hydrostatic end thrust. The procedure includes prolonged static tests at elevated pressures and cyclic testing.

A method is also included to test the resistance of the joint to an internal negative pressure. This also simulates an external positive pressure.

NOTE 1 The only reason for testing the resistance to external pressure differential is to ensure adequate safety against infiltration of pollutants through the joint into the fluid carried in the piping system. Under these test conditions, pipes with low stiffness may require support to prevent buckling.

At the end of each of the tests the joint is inspected for signs of leakage and damage and, unless otherwise specified, if either has occurred then the joint has failed.

If the joint is to be used in systems where the maximum operating temperature is higher than the value given in the referring specification, the test conditions can be modified accordingly.

NOTE 2 It is assumed that the following test parameters are set by the standard making reference to this standard:

a) length, L, of the assembled test piece (see 4.1);

b) number of test pieces to be used (see 4.2);

c) if applicable, conditioning other than as given in Clause 5;

d) test temperature and its permissible deviations (see Clause 6);

e) nominal pressure relevant to the joint under test (see 4.1 and Clause 7);

f) if applicable, any criteria indicative of damage to the joint components [see Clause 7 and item j) of Clause 8];

g) whether the joint is or is not to be tested with end loads;

h) whether GRP to GRP or GRP to metal flange tests are to be performed (see Clause 4);

i) acceptable increase in pressure over 1 h for negative pressure test (see 7.2).

3 Apparatus

3.1 End-sealing devices

The end-sealing devices shall be of a size and type appropriate to the joint system under test and shall conform to 3.1.1 or 3.1.2 as applicable.

3.1.1 Capable of applying the end loads

If the joint is to be tested with an end load [see item g) of Note 2 to Clause 2] then the end-sealing devices shall be anchored to the pipes to transmit the end thrust loads.

3.1.2 Not capable of applying the end loads

If the joint is to be tested without the end load [see item g) of Note 2 to Clause 2] then the end-sealing devices shall not be anchored to the pipes (see 7.6).

3.2 Supports

3.2.1 End thrust supports, if required, comprising part of the rig, which shall be capable of supporting the end thrust induced by the internal pressure, but which shall not otherwise support the joint.

3.2.2 Special supports, if necessary, to prevent buckling of the pipe barrel during external pressure differential (see 7.2) testing.

3.3 Source of hydrostatic pressure

A source of hydrostatic pressure capable of meeting the needs of the test.

3.4 Means of measuring the gauge pressure

A means of measuring the gauge pressure at the top of the pipe to an accuracy within $\pm$ 1 % and checking conformity to the specified pressures (see 7.2 to 7.4).

3.5 Vacuum pump or equivalent

A vacuum pump or equivalent capable of applying the required negative gauge pressure (see 7.2).

3.6 Bolt torque test apparatus

The bolt torque test apparatus shall incorporate the following items:

a) a flat-faced metallic flange of the same mating dimensions as the GRP flange;

b) a calibrated wrench with means of measuring the torque applied;

c) bolts, nuts and washers for assembling the metallic flange to the flange under test.

4 Test pieces

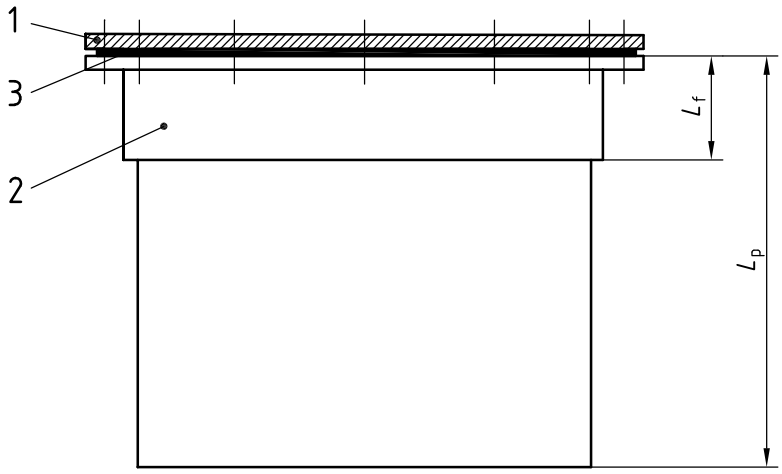
4.1 Test arrangement

When testing in accordance with 7.2 to 7.4 and 7.6 the test arrangement shall be one of those shown in Figure 2a). When testing in accordance with 7.8 the test arrangement shall be one of those shown in Figure 2b). It should be noted that there are two different joint conditions shown, namely metallic flange to GRP flange and GRP flange to GRP flange. These two conditions will not necessarily give the same results due to different stresses and strains being induced. The referring specification shall state which condition is to be used. For the test detailed in 7.5 the arrangement shall be as shown in Figure 3. See Annex A for details on determining the maximum deflection, Δ (see item 6 in Figure 3), at mid-span and the magnitude of the additional force, F (see Annex A). In all these arrangements a joint of the same size and design shall be used. The same test piece may be used for more than one test procedure providing it is undamaged and of sufficient size to enable the test conditions to be achieved.

The test piece shall comprise an assembly of one or two pieces of pipe of the same size and pressure class as the joint being tested, and the joint to be tested. The total effective length, L, of the assembly shall be not less than that specified in the referring specification and shall allow, if required, the joint under test to be located in the middle of the test arrangement. For the test detailed in 7.5 the length, L, of the assembly shall be not greater than 8 m and the joint under test shall be located in the middle of the test arrangement.

The joint shall be assembled in accordance with the manufacturer's recommendations, including gasket type (inside bolt circle or full face), gasket material, bolt and nut lubrication and, if applicable, the requirements of the referring specification.

Conditioning, in accordance with Clause 5, shall commence immediately after assembly of a test joint.



Key

1	metal blank flange	L_f	length of flange
2	GRP flange and over-wrapping	L_p	length of pipe
3	gasket		

Figure 1 — Typical test arrangement for tests detailed in 7.7

For bolt torque testing (see 7.7 and Figure 1) the test piece shall comprise a GRP flange joined to a GRP pipe having a length L_p not less than the value derived from Equation (1). The GRP flange is assembled to a metallic flange using bolts and a gasket.

$$L_p = 3{,}3 \times (\mathrm{DN} \times e)^{0{,}5} + L_f \quad (1)$$

where

DN is the nominal size of the pipe, when expressed in millimetres;

e is the wall thickness of the pipe, expressed in millimetres;

L_f is the length of the flange from the flange face to the end of any wrapping, expressed in millimetres;

L_p is the minimum length of the pipe, expressed in millimetres.

Conditioning, in accordance with Clause 5, shall commence immediately after assembly of a test joint.

NOTE Overtightening of the bolts can result in damage to the flange.

4.2 Number of test pieces

The number of test pieces shall be as specified in the referring specification.

5 Conditioning

For any interval between assembly of the test piece in accordance with Clause 4 and conditioning performed in accordance with the following paragraph, store the test piece at a temperature which does not exceed the test temperature (see Clause 6).

Following assembly, unless otherwise specified in the referring specification, condition the test piece by storing at the test temperature (see Clause 6) for (24 ± 2) h prior to performing any of the procedures in Clause 7.

NOTE The conditioning period starts when the individual parts of the test piece (see Clause 4) have been joined.

6 Test temperature

Conduct the following procedures at the temperature specified in the referring specification.

7 Procedures

7.1 General

WARNING — When carrying out the procedures detailed in this clause, care should be taken to provide suitable protection from flying objects resulting from catastrophic failure.

Subject each test piece (see Clause 4) to those of the following tests specified in the referring specification and summarised in Table 1 that are either detailed in 7.2 to 7.6 for joints intended to carry end thrust, or 7.8 for joints not intended to carry end thrust. In either case for the tests detailed in 7.5 the test piece shall have a length not exceeding 8 m and use a joint of the same size and design as that used for 7.2 to 7.4 and 7.6.

Carry out the procedures without any retightening of the bolts except as specified e.g. to replace a failed component, or to test in accordance with 7.7.

NOTE Each reference to hydrostatic pressure specifies a positive internal gauge pressure (i.e. relative to atmospheric pressure) and the nominal pressure is that relevant to the joint under test.

If a test is interrupted, record the details in the test report and repeat the particular test before carrying on to the next in the series of tests, if applicable. Failure at the end-sealing devices or the pipe shall not constitute failure of the joint but, if the test conditions are invalidated thereby, repeat the particular test after replacing the failed component.

7.2 Leaktightness when subjected to an external pressure differential

7.2.1 Using a test piece conforming to Clause 4, assemble the test arrangement as shown in Figure 2a), using supports (see 3.2) as appropriate.

7.2.2 Connect the end-sealing devices (see 3.1.1) to the pipes in such a way that the full loads induced by the internal pressure will be transmitted along the pipes to the joint under test.

7.2.3 Condition the test piece in accordance with Clause 5.

7.2.4 Connect the test piece to the vacuum pump (see 3.5).

7.2.5 Reduce the pressure to at least 0,8 bar below atmospheric pressure (approximately 0,2 bar absolute). Record the pressure achieved.

7.2.6 Close the valve between the test piece and the vacuum pump and leave for 1 h.

7.2.7 After this time record any increase in pressure.

7.2.8 If an increase in pressure in excess of the acceptable level specified in the referring specification [see item i) of Note 2 to Clause 2] has occurred then inspect for sources of leakage other than the joint. If any such sources are found then return the test piece to atmospheric pressure, seal the leaks and repeat the test in 7.2.2 to 7.2.7. Otherwise stop the test and record the observations.

7.2.9 If an increase in pressure in excess of the acceptable level specified in the referring specification [see item i) of Note 2 to Clause 2] has not occurred then restore atmospheric pressure and inspect for and record any signs of damage to the joint [see item f) of Note 2 to Clause 2]. If any signs of damage are found then stop the test. Otherwise proceed to the next test.

7.3 Initial leakage

7.3.1 Using a test piece conforming to Clause 4, assemble the test arrangement as shown in Figure 2a), using supports (see 3.2) as appropriate.

7.3.2 Connect the end-sealing devices (see 3.1.1) to the pipes in such a way that the full loads induced by the internal pressure will be transmitted along the pipes to the joint under test.

7.3.3 Condition the test piece in accordance with Clause 5.

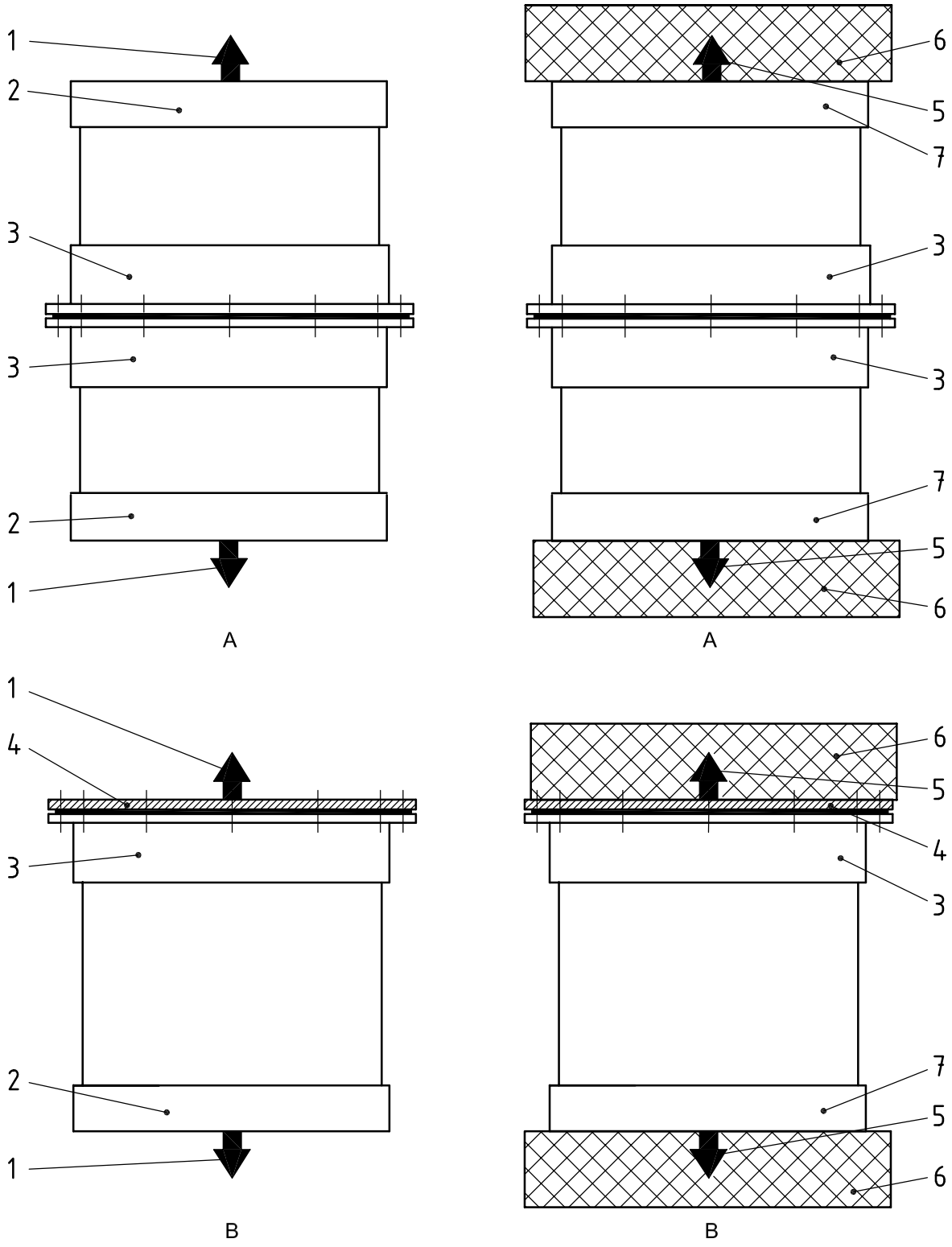
7.3.4 Fill the test piece with water and vent to remove any air.

7.3.5 Connect the test piece to the source of hydrostatic pressure (see 3.3).

7.3.6 Apply an internal hydrostatic pressure of 1,5 times the nominal pressure of the joint, expressed in bars[1)], and maintain within $\pm$ 2 % for 15 min (see Table 1).

7.3.7 Inspect the joint for signs of leakage or damage. If neither are present proceed to the next test. Otherwise stop the test and record the observations.

1) 1 bar = 10^5 N/m^2 = 0,1 MPa.



a) Arrangements with end loads **b) Arrangements without end loads**

Key

1 thrust carried by test piece
2 end-sealing device connected to test piece
3 GRP flange being tested
4 metallic blank flange
5 thrust resisted by test rig
6 test rig
7 end-sealing device not connected to test piece
A test joint located centrally
B test joint located at one end

NOTE The test arrangement may be either horizontal, or vertical as shown.

Figure 2 — Typical test arrangements for the tests detailed in 7.2 to 7.4 and 7.6

7.4 Resistance to internal pressure

7.4.1 Under positive cyclic pressure

7.4.1.1 Perform the initial leaktightness test in accordance with 7.3.

7.4.1.2 Reduce the pressure to atmospheric pressure.

7.4.1.3 Steadily raise the internal pressure to 1,5 times the nominal pressure of the joint, expressed in bars, and reduce again to atmospheric pressure so as to complete the cycle in between 1,5 min and 3 min.

7.4.1.4 Repeat the cycle described in 7.4.1.3 a further 9 times.

7.4.1.5 Inspect the joint and record any signs of leakage or damage. If neither are present proceed to the next test. Otherwise stop the test and record the observations.

7.4.2 Under maintained pressure

7.4.2.1 Maintain the hydrostatic pressure of 1,5 times the nominal pressure of the joint, expressed in bars, within ± 2 % for not less than 24 h.

7.4.2.2 Inspect the joint for signs of leakage or damage and record the observations.

7.4.2.3 If neither are present then reduce the pressure to atmospheric and proceed to the next test. Otherwise stop the test, record the observations and reduce the pressure to atmospheric.

7.5 Resistance of the joint to bending and pressure including hydrostatic end thrust

7.5.1 Assemble the test arrangement as shown in Figure 3 using a test piece conforming to Clause 4 and having an effective length not exceeding 8 m. Determine the values of F and Δ in accordance with Annex A.

7.5.2 Connect the end-sealing devices to the pipes in such a way that the full loads induced by the internal pressure will be transmitted along the pipes to the joint under test.

7.5.3 Position the stop at mid-span to ensure a deflection up to Δ can occur.

7.5.4 Condition the test piece in accordance with Clause 5.

7.5.5 Fill the test piece with water, and vent to remove any air.

7.5.6 Apply, if required, the additional force, F.

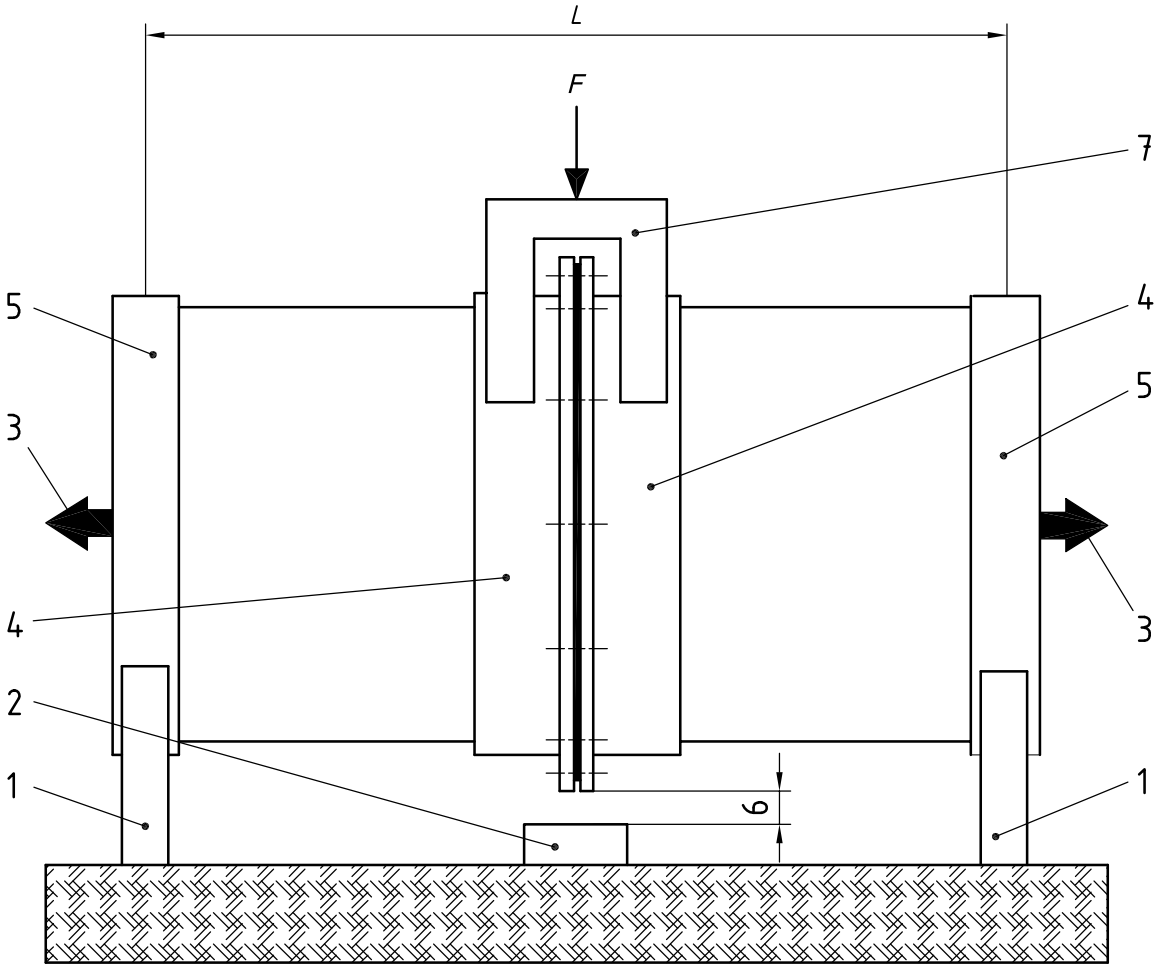
7.5.7 Apply an initial hydrostatic pressure of 1,5 times the nominal pressure of the joint, expressed in bars, and maintain within ± 2 % for 15 min. Inspect the joint for signs of leakage or damage. If either has occurred stop the test and disassemble. Otherwise continue in accordance with 7.5.8.

7.5.8 Maintain the hydrostatic pressure of 1,5 times the nominal pressure of the joint, expressed in bars, within ± 2 % for not less than 24 h.

7.5.9 Check and record whether or not the joint is resting on the stop.

7.5.10 Reduce the pressure to atmospheric.

7.5.11 Inspect the joint and record any signs of leakage or damage.



Key

1 support
2 stop
3 thrust carried by test piece
4 GRP flange being tested
5 end-sealing device fixed to test piece
6 limiting deflection at mid-span, Δ
7 support or cradle for the application of force F
L length not exceeding 8 m
F additional force (if required)

Figure 3 — Typical test arrangement for the test detailed in 7.5

7.6 Short-duration resistance to internal pressure including hydrostatic end thrust

7.6.1 Using a test piece conforming to Clause 4, together with supports, straps or cradles (see 3.2) if required, assemble the test arrangement as shown in Figure 2a).

7.6.2 Connect the end-sealing devices to the pipes in such a way that the full loads induced by the internal pressure will be transmitted along the pipes to the joint under test.

7.6.3 Condition the test piece in accordance with Clause 5.

7.6.4 Fill the test piece with water and vent to remove any air.

7.6.5 Either increase the pressure to 2,5 times the nominal pressure of the joint, expressed in bars, and maintain that pressure within ± 2 % for 100 h (see Table 1) or increase the pressure to 3 times the nominal pressure of the joint, expressed in bars, and maintain that pressure within ± 2 % for 6 min. During this time the joint shall not fracture. Leakage of the joint, however, does not constitute a failure.

7.6.6 Reduce the pressure to atmospheric, empty the test piece and disassemble.

7.6.7 Inspect the joint and record any signs of fracture.

7.7 Resistance to bolt-tightening torque

7.7.1 If required by the flange manufacturer lubricate the bolt and nut threads and their bearing surfaces. Record the chemical nature of the lubricant, e.g. graphite, molybdenum disulfide or petroleum-based grease.

7.7.2 Assemble the test flange to the metallic flange (see 3.6 and Figure 1), using the appropriate gasket and using the tightening sequence and torque recommended by the manufacturer of the flange under test.

7.7.3 Condition the test piece in accordance with Clause 5.

7.7.4 Using the same tightening sequence, increase the torque to 1,5 times the manufacturer's recommended value used in 7.7.2.

7.7.5 Using the reverse of the tightening sequence, decrease the torque in small stages and disassemble.

7.7.6 Following disassembly inspect the tested flange and record any visible damage, paying particular attention to the bearing surfaces.

7.8 Testing excluding hydrostatic end thrust (see 7.1)

Perform the procedures detailed in 7.2 to 7.7 inclusive except that the end-sealing devices shall not be connected to the pipe and the end thrust shall be carried by external supports.

8 Test report

The test report shall include the following information:

a) a reference to this International Standard and to the referring specification;

b) whether the joint was tested with or without end thrust;

c) whether the joint was located centrally [Figure 2a) A] or at the end [Figure 2a) B];

d) full identification of the pipes and joint tested;

e) the nominal pressure class (PN) of the pipes and joint;

f) details of the jointing materials and procedures used;

g) the temperature range during the test;

h) a description of the tests to which the joint was subjected;

i) the positive and negative pressures applied, in bars;

j) any observations on the leaktightness of the joint during each test;

k) any observations on the condition of the joint after each test;

l) details of interruptions, if any, to the test sequence;

m) any factors which may have influenced the results, such as any incidents or any operating details not specified in this International Standard;

n) the dates and times of the period of each test.

Table 1 — Summary of test requirements

Test	Pressure sequence	Test pressure	Duration	Subclause number
External pressure differential	Negative pressure	−0,8 bar (−0,08 MPa)	1 h	7.2 and Figure 2a)
Initial leakage	Initial pressure	1,5 times PN	15 min	7.3 and Figure 2a)
Resistance to internal pressure and end thrust	Preliminary pressure	1,5 times PN	15 min	7.4.1.1 to 7.4.1.2 and Figure 2a)
	Positive cyclic pressure	Atmospheric to 1,5 times PN and back to atmospheric	10 cycles of 1,5 min to 3,0 min each	7.4.1.3 to 7.4.1.5 and Figure 2a)
	Maintained pressure	1,5 times PN	24 h	7.4.2 and Figure 2a)
Resistance to bending with end thrust	Preliminary pressure	1,5 times PN	15 min	7.5.1 to 7.5.7 and Figure 3
	Maintained pressure	1,5 times PN	24 h	7.5.8 to 7.5.11 and Figure 3
Short-duration resistance	Maintained pressure	2,5 times PN or 3,0 times PN	100 h 6 min	7.6.1 to 7.6.5 and Figure 2a)
Bolt-tightening torque	Visual inspection	Not applicable	Not applicable	7.7 and Figure 1

NOTE 1 Nominal pressure (PN) is an alphanumeric designation of pressure related to the resistance of a component of a piping system to internal pressure. For the purposes of this table PN is expressed in bars.

NOTE 2 A test sequence other than that given in this table may be used.

Annex A
(normative)

Equations for calculating the additional force, F, and limiting deflection, Δ, for the bending test described in 7.5

The test arrangement for 7.5 is a simply supported pipe with a span, L, not exceeding 8 m. The load is provided by the self-weight of the pipe plus contents. The pipe is allowed to deflect before coming into contact with a stop that supports the pipe if it tries to deflect more than a limiting deflection, Δ.

The test is performed with the arrangement shown in Figure 3 with an additional force, F, determined in accordance with Equation (A.1), applied at mid-span and the stop positioned at a distance Δ (see item 6 in Figure 3) below the joint, which is determined from Equation (A.2).

$$\text{Additional force } F = \left(\frac{32}{L} - \frac{L}{2}\right) \times \left(m_{\mathrm{p}} + m_{\mathrm{w}}\right) + \left(\frac{8}{L} - 1\right) \times m_{\mathrm{j}} \qquad \text{(A.1)}$$

$$\text{Limiting deflection } \Delta = 5{,}75 \times L \qquad \text{(A.2)}$$

where

F is the additional force applied at mid-span, in kilonewtons;

Δ is the limiting deflection at mid-span, in millimetres;

L is the span, in metres;

m_{p} is the weight of the empty pipe, in kilonewtons per metre;

m_{w} is the weight of water in the pipe when full, in kilonewtons per metre;

m_{j} is the weight of the joint, in kilonewtons.

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