Classified as Public

Gas Industry Standard

GIS/F16:2023

Specification for

In-pipe close fit lined pipe service fittings

Contents

Foreword

Gas Industry Standards (GIS) are revised, when necessary, by the issue of new editions. Users should ensure that they are in possession of the latest edition. Contractors and other users external to Gas Transporters should direct their requests for copies of a GIS to the department or group responsible for the initial issue of their contract documentation.

Comments and queries regarding the technical content of this document should be directed in the first instance to the contract department of the Gas Transporter responsible for the initial issue of their contract documentation.

This standard calls for the use of procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Compliance with this engineering document does not confer immunity from prosecution for breach of statutory or other legal obligations.

Mandatory and non-mandatory requirements

For the purposes of a GIS the following auxiliary verbs have the meanings indicated:

can indicates a physical possibility;

may indicates an option that is not mandatory;

shall indicates a GIS requirement;

should indicates best practice and is the preferred option. If an alternative method is used then a suitable and sufficient risk assessment needs to be completed to show that the alternative method delivers the same, or better, level of protection.

Disclaimer

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Brief history

First draft issued	March 2005
Edited by BSI in accordance with BS 0-3:1997	August 2006
Reviewed on behalf of the Gas Distribution Networks' Technical Standard Forum by BSI	September 2013
Reviewed by TSF	June 2018
Normative references updated to reflect where Gas Industry Standards have replaced individual gas distribution network specifications	April 2023

1 Scope

This Gas Industry Specification (GIS) specifies requirements relating to metallic-bodied fittings for connecting ancillary fittings such as service fittings, plugs, by-pass riders and flow stop equipment to steel, grey or ductile cast iron in-pipe close fit lined pipes at pressures not greater than 2 bar.

It specifies requirements only for fittings that are normally fitted using under pressure drilling equipment.

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.

Formal standards

BS 78, *Cast iron spigot and socket pipes (vertically cast) and spigot and socket fittings.*

BS 1211, *Centrifugally cast (spun) iron pipes for water gas and sewage*.

BS 4622, *Centrifugally cast (spun) iron pipes for water gas and sewage (metric sizes)*.

BS 1387, *Specification for screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe threads*.

BS EN 1562, *Founding — Malleable cast irons*.

BS EN 682, *Elastomeric seals — Materials requirements for seals used in pipes and fittings carrying gas and hydrocarbon fluids.*

BS EN 969, *Specification for ductile iron pipes, fittings, accessories and their joints for gas pipelines — Requirements and test methods.*

BS EN 10216-1, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 1: Non-alloy steel tubes with specified room temperature properties.*

BS EN 10217-1, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 1: Non-alloy steel tubes with specified room temperature properties.*

BS EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories.*

BS EN 13445-2, *Unfired pressure vessel*s *— Part 2: Materials.*

ASME 16.34, *Valves – Flanged, threaded and welding end.*

Gas Industry Standards

GIS/C6, *Specification for distribution pipe fittings cast in ductile iron for use up to 7 bar maximum operating pressures.*

GIS/CW5, *Specification for field applied external coatings for buried pipework and systems.*

GIS/CW6, *Specification for the external protection of steel line pipe and fittings using fusion bonded powder and other coating systems — Requirements and methods of test for coating materials and factory applied coatings.*

GIS/E1, *Specification for combined drilling, tapping and service fitting insertion machines for use up to 2 bar.*

Individual Gas Distribution Network Standards

*/SP/F1, *Specification for carbon and carbon manganese steel forgings and forged components for operating pressures greater than 7 bar.*

* = Denotes each gas distribution network reference

3 Terms and definitions

For the purposes of this GIS the following definition applies.

3.1
close fit lined pipe
pipe rehabilitated by means of cured-in-place liners

4 Material requirements

4.1 General

All materials shall conform to the relevant British Standard or other recognised standard.

Fittings shall be made from materials with inherent corrosion resistance, or they shall be protected against corrosion in accordance with GIS/CW5 and GIS/CW6. If the fitting is made from mild steel it shall be protected in accordance with GIS/CW5.

For below ground fittings the fitting shall be protected by applying an appropriate coating to give a 50-year life in a corrosive environment. This is in addition to any wrapping that might take place at the time of installation.

4.2 Elastomeric materials

Elastomeric materials shall conform to BS EN 682 for the appropriate hardness class.

4.3 Metallic materials

Components shall be made from one of the following.

a) Ductile iron that conforms to either GIS/C6 or ISO 5922 grade B35-10 or W40-5;

b) Blackheart malleable iron that conforms to BS EN 1562 grade EN-GJMB-350 –10;

c) Whiteheart malleable iron that conforms to BS EN 1562 grade EN-GJMW- 400-5;

d) Forged steel that conforms to */SP/F1.

Metallic pressure containing parts shall be of material listed in BS EN 13445-2 or ASME 16.34.

4.4 Internal sealing plug

The internal sealing plug shall be made from unfilled Nylon 6, or an equivalent material.

5 Design requirements

5.1 General

5.1.1 Fittings shall be designed to:

a) provide an effective seal on a close fit lined metallic pipe for at least 50 years without requiring further attention, in the internal and external environments present in and around pipes; and

b) tolerate the effects of corrosive ground conditions.

5.1.2 Fittings shall be suitable for connecting to cast iron pipes that conform to BS 78, BS 1211 and BS EN 969, and steel pipes that conform to BS EN 10216-1 and BS EN 10217-1.

5.2 Internal plug

The internal plug shall be held by friction against the wall of the fitting but need not provide a perfect seal.

A leak tight connection shall then be made.

NOTE This could be performed using a service fitting, plug or cap.

Provision shall be made for retracting the internal plug without leakage of more than 5 l/m.

The fitting manufacturer shall ensure the availability of any special internal plug-lifting tool to suit the design of the fitting.

5.3 Overall dimensions

The fittings shall have dimensions allowing them to be fitted to a pipe using under pressure drilling equipment that conforms to GIS/E1.

5.4 Maximum working pressure

Fittings shall be designed for a maximum working pressure of 2 bar.

5.5 Temperature range

Fittings shall be designed for an operating temperature range of –5 °C to 30 °C.

5.6 Pipe diameters

Fittings shall seal on the following pipe types with the nominal diameters given in Table 1.

a) Cast iron pipes that conform to BS EN 969 and BS 4622.

b) Steel pipes that conform to BS EN 10216-1, BS EN 10217-1 and BS 1387.

Table 1 — Pipe diameters

Nominal pipe diameter in	**Nominal pipe diameter** mm
8	200
9	-
10	250
12	300
14	350
15	-
16	400
18	450
20	500
21	-
24	600
27	-
30	-
36	-
42	-
48	-

5.7 Installation instructions

The contractor shall provide detailed instructions for the installation with each fitting. The contractor shall specify a recommended torque setting for the fitting.

5.8 Reduction in pipe bore diameter

Fitting components shall not restrict the lined pipe bore by more than 15 % of the minimum permitted bore. Internal restrictions shall not hinder the free passage of pipeline inspection gear.

5.9 Connections

5.9.1 The fittings shall have connections compatible for use with components of sizes ¾, 1, 1½, 2, 2½, 3, 4 and 6 in.

5.9.2 The fittings shall have connections compatible for use with service connection fittings, plugs, nipples, bushes and plugs.

6 Type approval

6.1 General

Fittings shall satisfy the requirements specified in Annex A and Annex B.

6.2 Documentation

Following completion of the type approval tests, the contractor shall compile a data folder including details of all test results and a set of drawings showing all critical information, i.e. dimensions, materials, finishes, manufacturing and assembly techniques, operating, safety and installation instructions.

7 Marking

All fittings and any packaging shall be clearly and indelibly marked incorporating the following information:

a) the number and date of this specification, i.e. GIS/F16:2023 [1)];

b) the name or trademark of the manufacturer or their appointed agent;

c) the manufacturer's contact details;

d) the pressure rating;

e) fitting instructions;

f) nominal size;

g) all sizes and materials of compatible pipes;

h) product/batch identification;

i) where authorized, the product conformity mark of a third party certification body, e.g. BSI Kitemark.

NOTE Attention is drawn to the advantages of using third party certification of conformance to a standard.

[1)] Marking GIS/F16:2023 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is therefore solely the responsibility of the person making the claim. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

8 Packaging

The contractor shall provide packaging of fittings that prevents damage by normal handling and storage.

Annex A (normative)
Type approval tests

A.1 General

A.1.1 *Leakage testing*

For leakage testing, the fitting assembly shall be pressurised with air or nitrogen. Depending on the design of the fitting, the pressure should be applied through the cap or plug in the fitting.

A.1.2 *Leakage check*

Leakage shall be determined by checking with a recommended leak detection fluid or by immersion of the fitting assembly in clear water.

A.2 Safety precautions

A.2.1 *Responsibility*

The contractor shall be responsible for ensuring that the specified system performance tests can be carried out safely.

A.2.2 *Hydrostatic pressure test*

Before commencing the system performance tests, consideration shall be given to hydrostatically pressure testing all fittings and test equipment to be used at 1.5 × test pressure.

A.2.3 *Test precautions*

In the system performance tests loads or deflections shall be applied to a fitting assembly with the pressure released wherever possible. Particular care shall be exercised when the assembly is re-pressurized and during the inspection of a pressurized system.

A.3 Summary of type approval tests

A summary of the type approval tests is given in Table A.1.

Table A.1 — Summary of type approval tests for each test pipe diameter

Reference Annex A	Parameter tested	Number of fittings	Test duration
A.4	Pneumatic leakage tests	3	1 h
A.5	Pullout test	3	1 h
A.6	Bending test	3	1 h
A.7	Long term test	3	6 months
A.8	Tracking test	3	24 h
A.9	Impact test	1	26 h
A.10	Pressure drop test	1	1 h
A.11	Elevated temperature test	1	500 h

A.4 Pneumatic leakage tests

A.4.1 *Principle*

These tests are to determine whether the assembly leaks under different levels of pressure.

A.4.2 ***Apparatus***

A.4.2.1 *6 lined test pipes*, 3 of nominal size 10 in (250 mm) and 3 of 18 in (450 mm).

A.4.2.2 *6 fittings,* assembled in accordance with the contractor's installation instructions on test pipes, and either capped or plugged.

A.4.2.3 *Pressure source,* at 3 bar.

A.4.2.4 *Pressure gauge,* capable of measuring up to 3.5 bar.

A.4.3 ***Procedure***

A.4.3.1 Assemble the test pipes in accordance with the contractor's instructions.

A.4.3.2 For the low pressure test, pressurise three test pipes to 15 mbar for a period of not less than 1 h, at a temperature of (20 ± 5) °C.

A.4.3.3 For the elevated pressure test, pressurise the test pipes used in **A.4.3.2** to 3 bar for a period of not less than 1 h, at a temperature of (20 ± 5) °C.

A.4.3.4 For the simulated pressure test on corroded pipe, assemble the fitting on three further test pipes at 50 % of the recommended torque, then carry out the elevated and low pressure tests given in **A.4.3.2** and **A.4.3.3**.

A.4.4 ***Results***

No leakage shall occur nor shall any individual component fail.

If cracking or severe distortion that could lead to premature failure is suspected this shall be established by using either destructive or non-destructive techniques.

A.5 Pullout test

A.5.1 ***Principle***

This test is to determine whether the fittings are capable of resisting pull out loads that could be experienced during operational conditions.

A.5.2 ***Apparatus***

A.5.2.1 *6 lined test pipes, 3* of nominal size 10 in (250 mm) and 3 of 18 in (450 mm).

A.5.2.2 3 *fittings,* assembled in accordance with the contractor's installation instructions on test pipes, and either capped or plugged.

A.5.2.3 *Support framework.*

A.5.2.4 *Eye bolt.*

A.5.2.5 *Test load,* 250 kg.

A.5.2.6 *Pressure source,* at 3 bar.

A.5.2.7 *Pressure gauge,* capable of measuring up to 3.5 bar.

A.5.3 *Procedure*

A.5.3.1 Install an eyehook on the fitting, then assemble the fitting on the test pipe.

A.5.3.2 Fix the test pipe horizontally in the test assembly (see Figure A.1) with the fitting located at the bottom.

A.5.3.3 Suspend the test load from the eyehook.

A.5.3.4 Pressurize the test pipe to 3 bar for a period of not less than 1 h, at a temperature of (20 ± 5) °C.

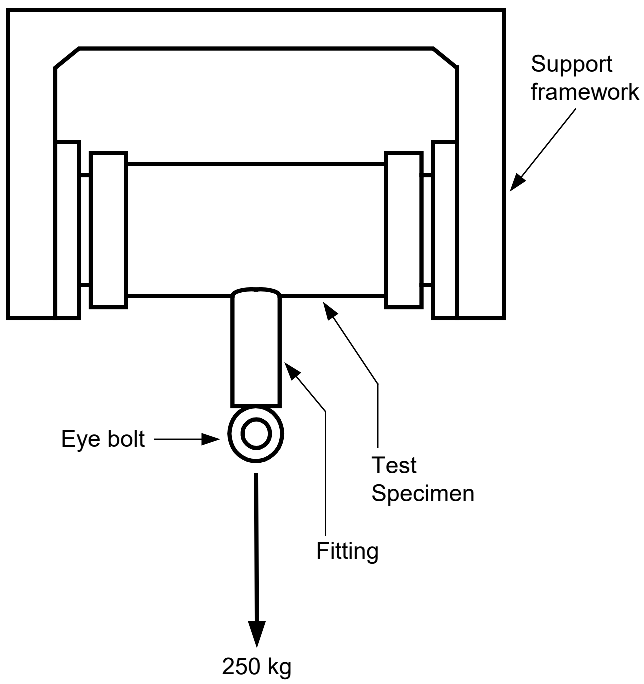

Figure A.1 — Pullout test assembly

A.5.4 *Results*

No leakage shall occur nor shall any individual component fail.

If cracking or severe distortion that could lead to premature failure is suspected this shall be established by using either destructive or non-destructive techniques.

A.6 Bending test

A.6.1 *Principle*

This test is to determine whether the fittings are capable of resisting loads that could be generated during normal operating conditions from an attached service pipe.

A.6.2 *Apparatus*

A.6.2.1 *6 lined test pipes,* 3 of nominal size 10 in (250 mm) and 3 of 18 in (450 mm).

A.6.2.2 *3 fittings,* assembled in accordance with the contractor's installation instructions on test pipes, and either capped or plugged.

A.6.2.3 *Support framework.*

A.6.2.4 *Eye bolt.*

A.6.2.5 *Test load,* 100 kg.

A.6.2.6 *Pressure source,* at 3 bar.

A.6.2.7 *Pressure gauge, capable of measuring up to 3.5 bar.*

A.6.3 *Procedure*

A.6.3.1 Install an eyehook on the fitting, then assemble the fitting on the test pipe.

A.6.3.2 Fix the test pipe horizontally in the test assembly (see Figure A.2) with the fitting located at the bottom.

A.6.3.3 Suspend the test load from the eyehook.

A.6.3.4 Pressurize the test pipe to 3 bar for a period of not less than 1 h, at a temperature of (20 ± 5) °C.

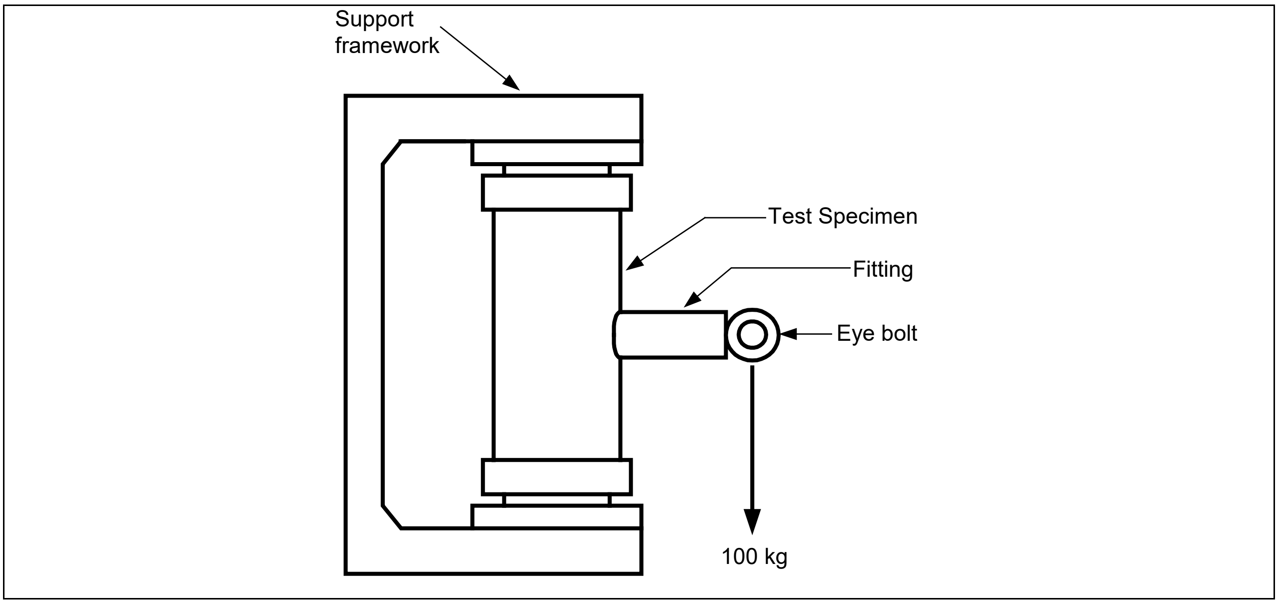

Figure A.2 — Bending test assembly

A.6.3.5 *Results*

No leakage shall occur nor shall any individual component fail.

If cracking or severe distortion that could lead to premature failure is suspected this shall be established by using either destructive or non-destructive techniques.

A.7 Long term test

A.7.1 *Principle*

This test calculates the working life of a fitting designed to maintain a compression seal using externally fitted bolts.

A.7.2 *Apparatus*

A.7.2.1 *6 straight lined test pipes,* 3 of nominal size 10 in (250 mm) and 3 of 18 in (450 mm), fitted with strain gauge load cells and spherically seated washers as shown in Figure A.3a)

A.7.2.2 *3 fittings,* assembled in accordance with the contractor's installation instructions on test pipes, and either capped or plugged.

A.7.2.3 *Strain gauge load cells*, conforming to GIS/F16.

A.7.2.4 *Spherically seated washers.*

A.7.2.5 *Pressure source,* at 3 bar.

A.7.2.6 *Pressure gauge,* capable of measuring up to 3.5 bar.

A.7.2.7 *Data logger.*

A.7.3 *Procedure*

A.7.3.1 Assemble each fitting on the test pipes.

A.7.3.2 Tighten the fitting to the contractor's recommended torque.

A.7.3.3 Adjust the test pipe pressure adjusted to 3 bar and store in air for 6 months, at a temperature of (20 ± 5) °C.

A.7.3.4 Record the bolt loads for the 6 month period, starting from 10 min after tightening (see **A.7.3.2**), recording a minimum of two results of average bolt load (F_m) per logarithmic decade of time.

A.7.3.5 Determine the bolt load (F_1) at which leakage occurs by loosening the bolts progressively (keeping the bolt loads as even as possible) until leakage occurs.

A.7.3.6 Record the average bolt load at this point.

A.7.3.7 Plot a graph of F_m against Log time as shown in Figure A.3b). Draw a straight line through the points, based on the least sum of the squares of the errors in the value of F_m.

A.7.3.8 Calculate and record the compressive load on the pipe generated by the fitting.

A.7.4 *Results*

The estimated bolt load after 50 years shall not be less than the bolt load at which leakage occurs (F_1).

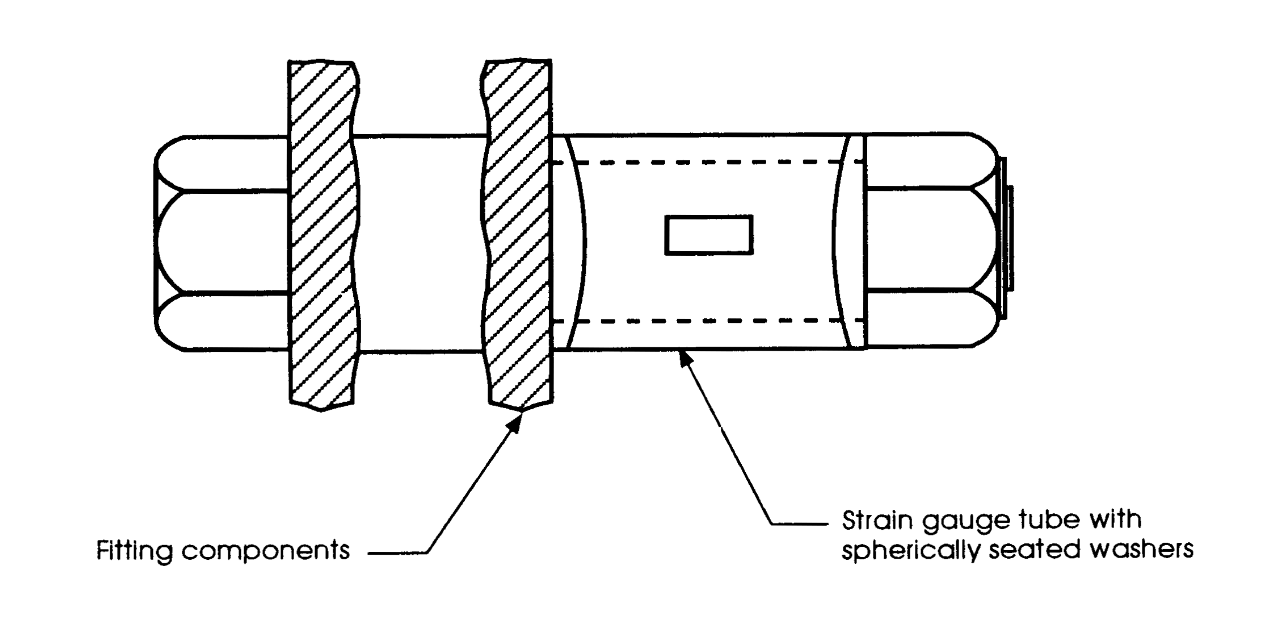

Figure A.3a) — Long term test: fitting with strain gauge load cell

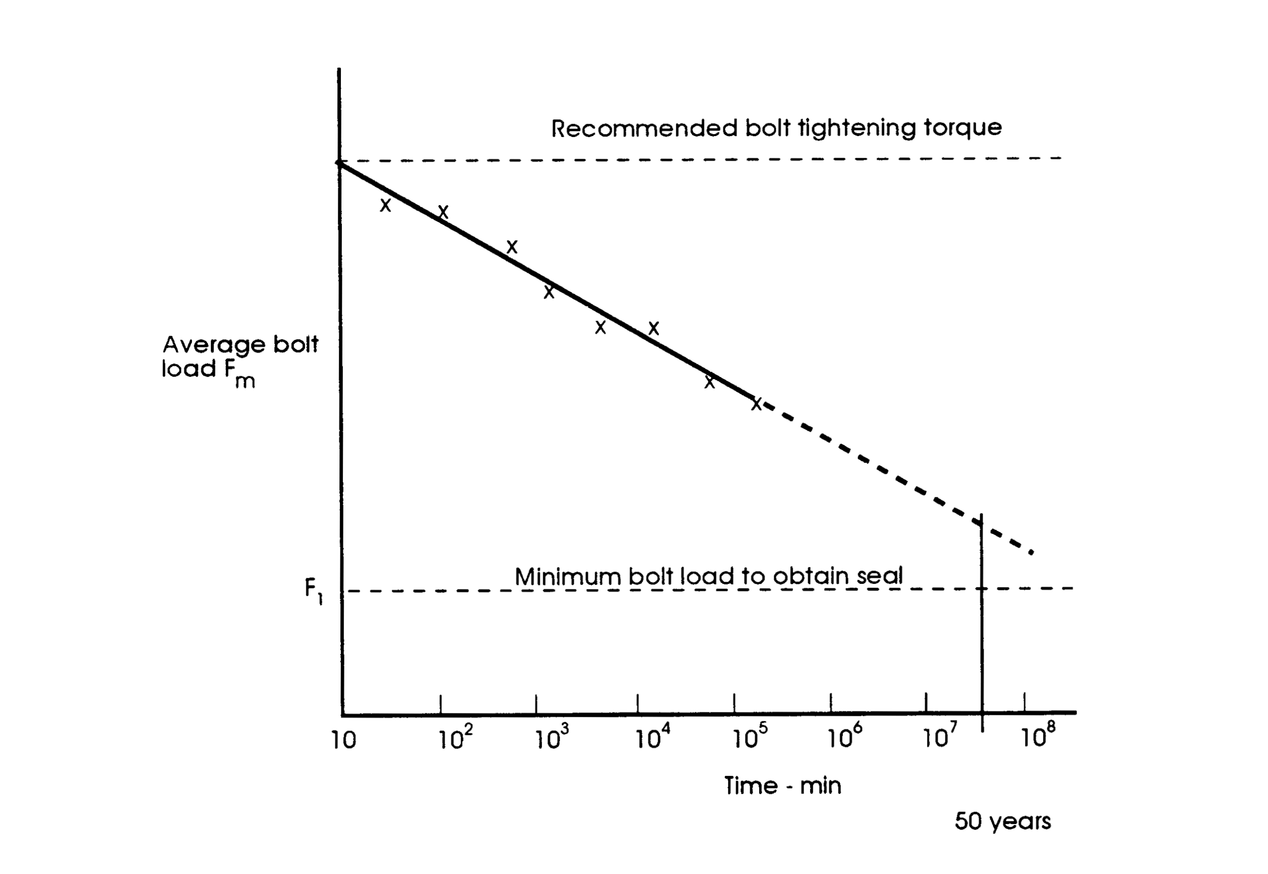

Figure A.3b) — Long term test: estimation of bolt load after 50 years' relaxation

A.8 Tracking test

A.8.1 *Principle*

This test is to determine whether the fitting prevents tracking of gas between the lines and the inner bore of a pipe.

A.8.2 *Apparatus*

A.8.2.1 *6 straight lined test pipes,* 3 of nominal size 10 in (250 mm) and 3 of 18 in (450 mm).

A.8.2.2 *3 fittings,* assembled in accordance with the contractor's installation instructions on test pipes, and either capped or plugged.

A.8.2.3 *3 bubble flowmeters.*

A.8.2.4 *Pressure source,* at 3 bar.

A.8.2.5 *Pressure gauge,* capable of measuring up to 3.5 bar.

A.8.3 Procedure

A.8.3.1 Drill two test port holes through the pipe wall without drilling through or damaging the liner.

A.8.3.2 Drill a hole for the location of the fitting through the pipe wall and liner ensuring that the liner is not damaged.

A.8.3.3 Disbond the liner from the pipe for a distance of at least ½ in beyond each test port hole and around each of the openings to create a tracking path across all three [see Figure A.4a)]. Ensure that the liner is disbonded with a minimum of distortion.

A.8.3.4 Install the fitting in accordance with the contractor's instructions [see Figure A.4b)].

A.8.3.5 Connect a bubble flowmeter to each of the test port holes.

A.8.3.6 Pressurize the test pipe to 3 bar, at a temperature of (20 ± 5) °C, and check for leakage at the flowmeters. Leave the test pipe for 24 h then check again for leakage.

A.8.4 *Results*

No leakage shall occur nor shall any individual component fail.

If cracking or severe distortion that could lead to premature failure is suspected this shall be established by using either destructive or non-destructive techniques.

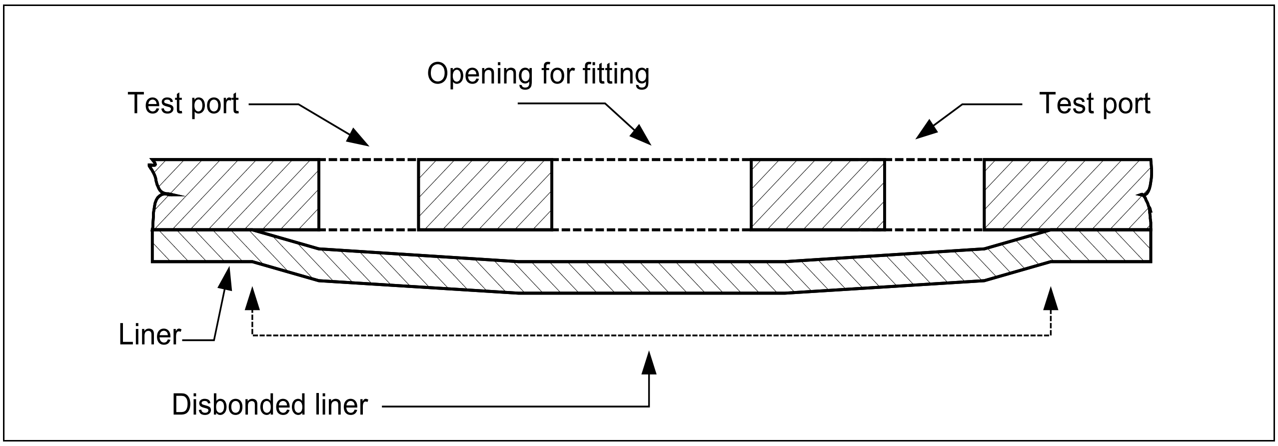

Figure A.4a) — Specimen preparation for tracking test

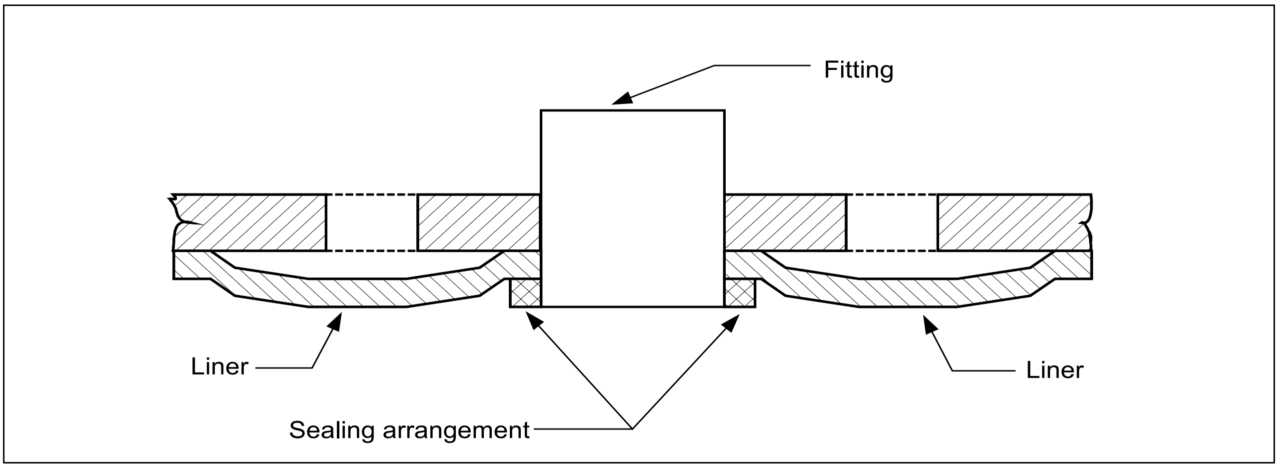

Figure A.4b) — Fitting installation for tracking test

A.9 Impact test

A.9.1 *Principle*

This test is to determine whether the fitting assembly can survive an impact.

A.9.2 *Apparatus*

A.9.2.1 *2 straight lined test pipes,* 1 of nominal size 10 in (250 mm) and 1 of 18 in (450 mm), of a length 3× the normal outside pipe diameter.

A.9.2.2 *1 fitting,* assembled in accordance with the contractor's installation instructions on test pipes, and either capped or plugged.

A.9.2.3 *Test impact weight,* made of hardened steel with mass (5 ± 0.1) kg and hemispherical striking face 25 mm in diameter.

A.9.2.4 *Pressure source,* at 3 bar.

A.9.2.5 *Pressure gauge,* capable of measuring up to 3.5 bar.

A.9.2.6 *Support frame.*

A.9.3 ***Procedure***

A.9.3.1 Fit the fitting to the test specimen (see Figure A.5).

A.9.3.2 Fit end plugs to either end of the test specimen, suitable for mounting it to a base plate to prevent rotation during impact. Ensure that the end plugs offer no support to the fitting.

A.9.3.3 Carry out the impact testing no less than 24 h after fitting and testing of the test assembly.

A.9.3.4 At least 1 h before impact testing, place the test assembly in a conditioning chamber at a temperature of (-5 ± 2) ºC.

A.9.3.5 Carry out the impact testing at (23 ± 2) ºC, within 5 min of removing the test assembly from the conditioning chamber.

A.9.3.6 Fix the specimen to the rigid base plate.

A.9.3.7 Release the test impact weight from a height of 2 m above the test assembly. Ensure that the weight strikes the assembly 25 mm below its highest point, parallel with the main pipe axis and perpendicular to the surface under test.

A.9.3.8 Turn the test specimen upside down and impact the service fitting on the opposite face from the same height.

A.9.4 ***Results***

The assembly shall be subjected to a minimum 3 bar pneumatic pressure test for a period of 1 h, at a temperature of (20 ± 5) °C.

No leakage shall occur nor shall any individual component fail.

If cracking or severe distortion that could lead to premature failure is suspected this shall be established by using either destructive or non-destructive techniques.

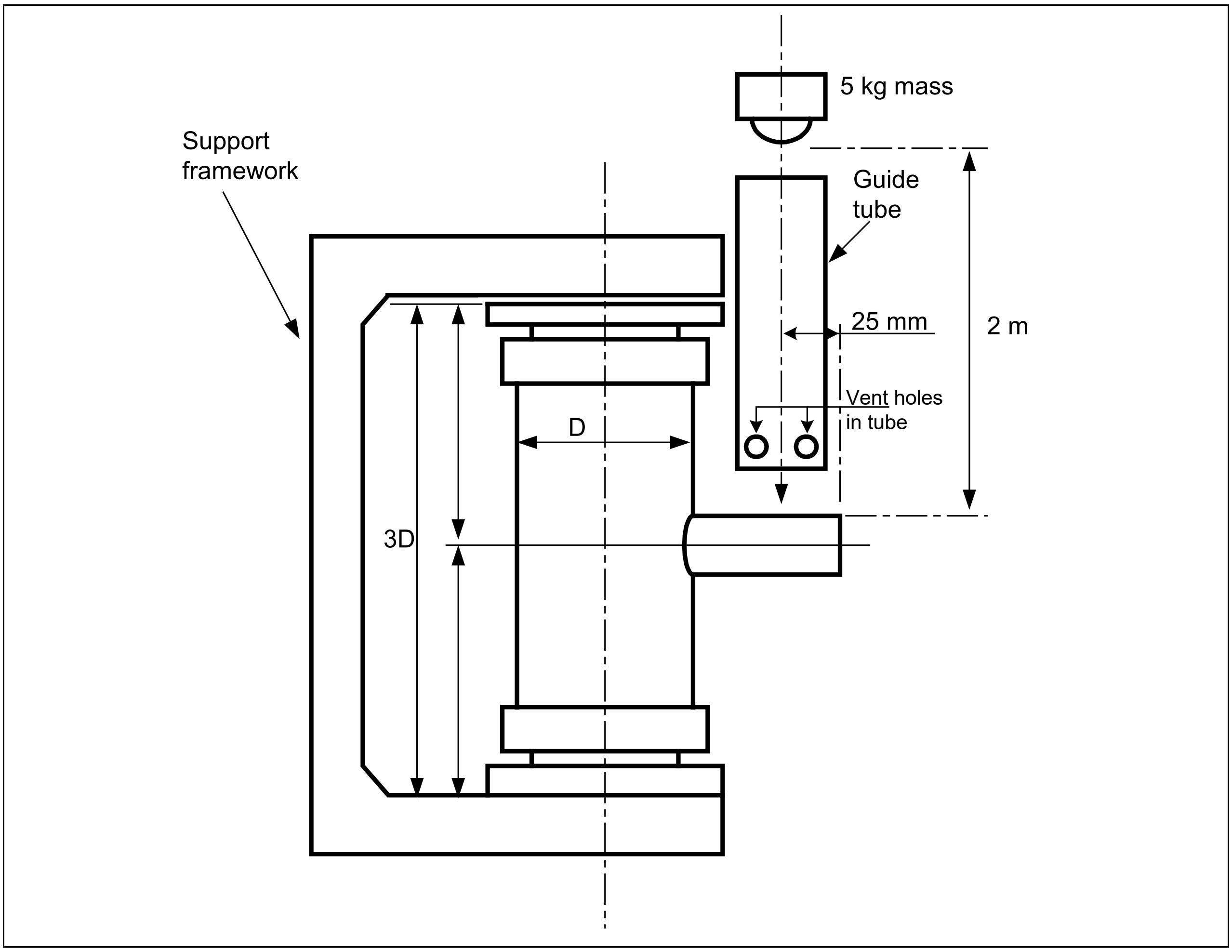

Figure A.5 — Impact test assembly

A.10 Pressure drop test (flow characteristics)

The test procedure is specified in Annex B.

A.11 Elevated temperature test

A.11.1 *Principle*

This test is to determine the assembly's resistance to extremely high temperatures.

A.11.2 *Apparatus*

A.11.2.1 *2 straight lined test pipes,* 1 of nominal size 10 in (250 mm) and 1 of 18 in (450 mm), of a length 3 times the normal outside pipe diameter.

A.11.2.2 *3 fittings,* assembled in accordance with the contractor's installation instructions on test pipes, and either capped or plugged.

A.11.2.3 *Water immersion tank,* with a temperature of 80 ºC.

A.11.2.4 *Pressure source,* at 3 bar.

A.11.2.5 *Pressure gauge,* capable of measuring up to 3.5 bar.

A.11.3 *Procedure*

A.11.3.1 Assemble the fittings on the test specimens in accordance with the contractor's instructions.

A.11.3.2 Cap the specimen and install a tie bar to transfer the end loads from the end cap (see Figure A.6).

A.11.3.3 Pressurize the test specimen to 3 bar for a period of not less than 500 h, at a temperature of (20 ± 5) °C.

A.11.3.4 Suspend the specimen in a water bath at (80 ± 2) °C for a period of 500 h.

A.11.4 *Results*

No leakage shall occur nor shall any individual component fail.

If cracking or severe distortion that could lead to premature failure is suspected this shall be established by using either destructive or non-destructive techniques.

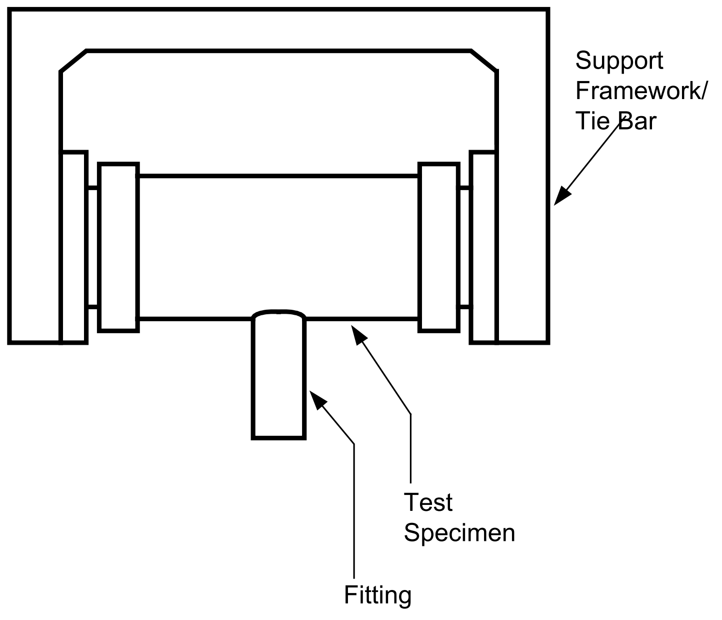

Figure A.6 — Elevated temperature test assembly

Annex B (normative)
Service connection pressure drop test

B.1 Principle

This test is to determine that pressure drop across a complete service assembly does not exceed four pipe velocity heads for the appropriate natural gas flow (see Table B.1) at a working pressure of 25 mbar.

Table B.1 — Gas flow rates for testing pressure drop through service connection fittings

Plastics outlet nominal outside diameter mm	**Flow rate** m^3/h
20	3
25	3
32	4.3
63	18

B.2 Apparatus

B.2.1 *Pressure controller,* capable of giving a steady output of 25 mbar.

B.2.2 *Flow meter,* accurate to ±5 % and of the positive displacement or turbine meter type.

B.2.3 *Inclined manometer* (for mains pressure).

B.2.4 *Inclined manometer* (for differential pressure).

B.2.5 *Outlet valve.*

B.2.6 *3 fittings,* assembled in accordance with the contractor's installation instructions on test pipes, and either capped or plugged.

B.3 Procedure

B.3.1 Set up the apparatus and test service connection assembly as shown in Figure B.1, at a temperature of (20 ± 5) °C.

B.3.2 Ensure that the pressure tappings are at least 2D (D = relevant pipe diameter) from any fitting or valve and, in the case of the service connection assembly, diametrically opposite it and upstream of it.

B.3.3 Install the flowmeter in accordance with the requirements of the device selected.

B.3.4 Connect the inclined manometer across the service fitting and partially open the outlet valve (E).

B.3.5 Open the inlet valve so that gas starts to flow and check that gas flows from the outlet valve only.

B.3.6 By means of pressure controller (A), regulate the mains pressure (C) to 25 mbar and measure and record the gas flow rate (Q) on flow meter (B) and the pressure drop (ΔP) on manometer (D).

B.3.7 Open the outlet valve (E) sufficiently to reduce the pipe pressure (C) by approximately 5 mbar.

B.3.8 Increase the flow rate until the mains pressure (C) returns to 25 mbar and measure and record the gas flow rate (Q) and the pressure drop (ΔP).

B.3.9 Repeat the operations detailed in d) and c) above until the outlet valve (E) is fully open.

B.4 Results

The procedure specified in **B.3** gives a number of pressure drop values and the corresponding flow rate for each.

From the relationship:

$$\Delta P = FQ^2$$

where:

ΔP is the pressure drop, in mbar

Q is the gas flow rate, in m^3/h

F is a factor

The factor F should be calculated for each set of readings and the average value determined.

Using the average value, the pressure drop (ΔP) should be determined for a gas flow rate (Q) appropriate to the size of service fitting (see Table A.2 and **A.3.8**).

NOTE If air or nitrogen is used for this test, the flow rates should be corrected using the following relationship:

$$Q_{nat} = Q_{med} \sqrt{\rho_{med} / \rho_{nat}}$$

where

Q_{nat} is the flow rate using natural gas

Q_{med} is the flow rate using other gas

ρ_{med} is the density of other gas.

ρ_{med} is the density of natural gas

The number of velocity heads lost across the fitting should be calculated from:

$$K = \left(\left(\frac{\Delta P}{\rho} \right) \frac{200}{V_2{}^2} + \left(\frac{V_1^2}{V_2^2} - 1 \right) \right)$$

where:

K is the velocity head lost in the fitting based on the velocity in the service pipe

ΔP is the measured pressure drop, in mbar

ρ is the density of natural gas = 0.71 kg/m^3

V_1 is the velocity in main = Q_{na^*}/A_1 in m/s

where:

A_1 is the bore area of the main

V_2 is the velocity in service pipe = Q_{na^*}/A_2 in m/s

where:

A_2 is the bore area of service pipe under test.

NOTE The equation assumes the density effects due to velocity are negligible.

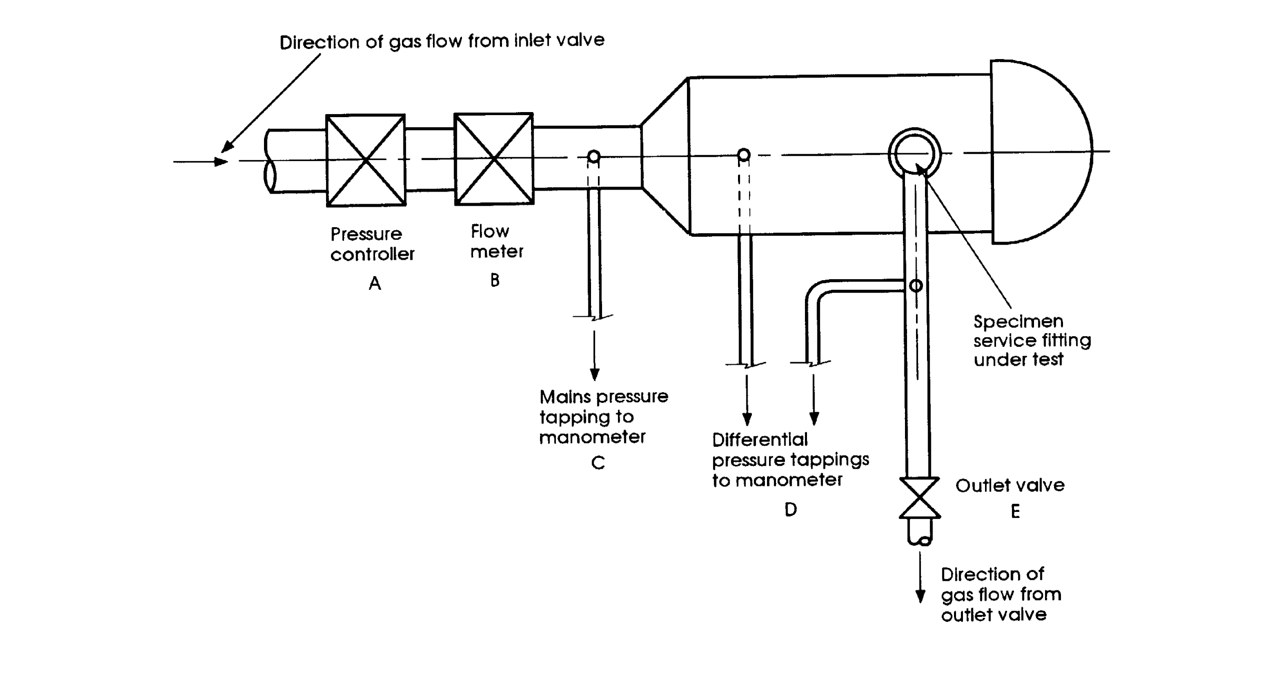

Figure B.1 — Layout of test rig for service connection fitting pressure drop test