

Gas Industry Standard

GIS/LC8-4:2006

Specification for

Methods of repairing leaking ferrous gas mains

Part 4: Pipe repair clamps, split collars and under pressure branch connections



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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

This engineering document is provided for use by Gas Transporters and such of their contractors as are obliged by the terms of their contracts to comply with this engineering document. Where this engineering document is used by any other party, it is the responsibility of that party to ensure that the engineering document is correctly applied.

Brief history

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1 Scope

This Gas Industry standard specifies the requirements relating to external methods of repairing leaking ferrous gas mains operating at a maximum working pressure of either 2 bar or 7 bar using split fittings suitable for use on grey cast iron, ductile iron and steel distribution mains.

The allied requirements of under pressure tees and service collars that are normally used for construction are also covered.

This standard applies to fittings suitable for use on vertically cast iron pipe in the size range 3 in to 48 in conforming to BS 78-2, grey spun iron pipe in the size range 3 in to 48 in conforming to BS 1211, ductile iron pipe in the size range 100 mm to 600 mm conforming to BS EN 969:1996, and steel pipe in the size range 3 in to 24 in (80 mm to 600 mm) conforming to BS EN 10216-1 and BS EN 10217-1.

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 78-2, *Specification for cast iron spigot and socket pipes (vertically cast) and spigot and socket fittings — Part 2: Fittings.*

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

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 1092-1, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Steel flanges.*

BS EN 1092-2, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Cast iron flanges.*

BS EN 1563, *Founding — Spheroidal graphite cast iron.*

BS EN 10088-2, *Stainless steels — Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes.*

BS EN 10216-1, *Seamless steel tubes for pressure purposes — Part 1: Technical delivery conditions.*

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

PD 970, *Wrought steels for mechanical and allied engineering purposes — Requirements for carbon, carbon manganese and alloy hot worked or cold finished steels.*

Gas Industry Standards

GIS/C8, *Specification for distribution split tee and collar pipe fittings cast in grey or ductile iron for use up to 7 bar maximum operating pressures.*

3 Material requirements

3.1 General

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

3.2 Elastomeric materials

Elastomeric materials shall satisfy the requirements of BS EN 682 for the appropriate hardness class.

3.3 Body castings

Grey or ductile iron body castings shall conform to the requirements of GIS/C8.

3.4 Stainless steel clamps

Fittings shall be formed from austenitic stainless steel sheet. Where clamps are liable to be welded, the grade nominated shall either be stabilized or of a low carbon grade. Examples of suitable materials are: BS EN 10088-2:2005 Grade 1.4404 where welding may be involved in the manufacturing process; and BS EN 10088-2:2005 Grade 1.4401 where welding is not involved in the manufacturing process.

Certification of analysis, mechanical properties and condition of steel (e.g. softened or cold rolled) shall be supplied by the contractor. Sheets shall be identified to this certification and shall bear an arrow showing the principal direction of rolling.

Sheet shall be cut so that the principal direction of rolling lies in the circumferential direction of the finished clamp. Following cutting, the sheet identity shall be maintained through the final product by indelibly marking (not stamping).

4 Design requirements

4.1 General

Fittings shall be designed to provide an effective seal on corroded and misaligned pipes for at least 50 years, without requiring further attention, in the internal and external environments present in and around gas mains. The design shall be capable of tolerating the effects of corrosive ground conditions.

Fittings shall be capable of accommodating subsequent specified pipe movements and resisting specified applied loads without failure.

NOTE Seals should preferably be of one piece construction for each half of the fitting and should be retained by the fitting when taken apart. Seals should preferably not require any cutting on site and should not require any adhesive to be applied.

Fittings and fasteners shall have a factory-applied corrosion resistant coating to provide long term environmental protection commensurate with the design life of the component.

4.2 Maximum working pressure

A fitting shall be designed for a maximum working pressure of either 2 bar or 7 bar.

Fittings intended for use on grey cast iron mains shall have a maximum working pressure of 2 bar. Fittings intended for use on ductile iron and steel mains shall have a maximum working pressure of either 2 bar or 7 bar.

4.3 Temperature ranges

Fittings shall be designed for the temperature range of -5°C to $+30^{\circ}\text{C}$.

4.4 Pipe diameters

The preferred fitting shall seal on all types of pipe of the specified nominal diameter.

4.5 Service connections

Split collars intended for making service connections shall incorporate a threaded boss conforming to the dimensions specified in Annex A. At the request of the purchaser, fittings may be supplied with the boss un-drilled.

On fittings of the stainless steel wrap around type, the dimensions of the boss shall enable standard drilling machines to be used, if necessary with adapters. The design shall take account of the need to drill and connect to a pressurized main without leakage of gas.

4.6 Under pressure tees

Fittings that incorporate a branch outlet terminating in a flange shall conform to the dimensions specified in Annex B, which also gives typical combinations of parent main and outlet flange diameters. Flanges shall conform to BS EN 1092-1 and BS EN 1092-2. Adequate clearance shall be provided between the flange and the body of the tee to facilitate bolt insertion.

4.7 Bolt head and nut clearances

Fittings shall be designed so as to provide adequate clearance for ring spanners, socket spanners and torque wrenches to be used for assembly.

4.8 Excavation

Fittings shall be designed to minimize the size of excavations consistent with safety.

4.9 Installation instructions

The contractor shall supply with each fitting detailed instructions for the installation.

4.10 Pipe surface preparation

The contractor shall specify a standard of preparation for the pipe surface which can be achieved by normal hand cleaning methods prior to installation of the fitting. This preparation shall have no deleterious effect on the main.

4.11 Bolt torque

The contractor shall specify a bolt torque and bolt tightening sequence with each fitting, if applicable. The specified bolt torque shall not exceed 100 Nm.

4.12 Backfill time

The design of fittings shall be such that an excavation can be safely backfilled and the normal mains operating pressure applied immediately after installation.

5 Performance requirements

Fittings shall satisfy the performance requirements specified in Annex C in order to be suitable for the duty required in service.

6 Type approval

6.1 General

Implementation of the tests in this standard shall be the responsibility of the contractor. Approval testing shall be undertaken in two parts, designated phase 1 (see **C.3** and **C.4**) and phase 2 (see **C.5**).

6.2 Documentation

Following completion of the type approval tests, the contractor shall compile a data folder which shall include 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 maintenance instructions.

The data shall be presented in a manner which clearly indicates compliance with the requirements of this standard.

7 Production testing

7.1 The contractor shall ensure that the dimensions of equipment components and assembly details conform to the approved drawings.

7.2 The contractor shall carry out a functional check to ensure conformity with the type-approved equipment.

8 Marking

All fittings conforming to GIS/LC8-4 and their packaging shall be clearly and indelibly marked with the following information:

- a) the number and date of this standard, i.e. GIS/LC8-4:2006 ¹⁾;
- b) the name or trademark of the manufacturer or their appointed agent;
- c) the manufacturer's contact details;
- d) pressure rating (2 bar or 7 bar);
- e) weight of fitting;
- f) fitting instructions if appropriate;
- g) nominal size;
- h) all sizes and materials of compatible pipes;
- i) product/batch identification;
- j) 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.

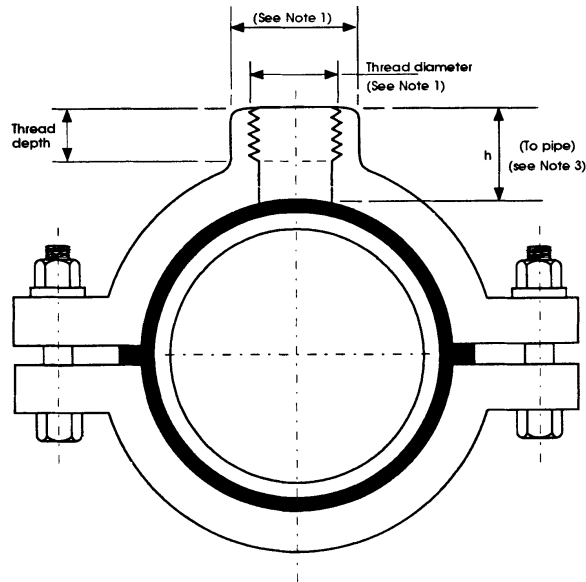
9 Packaging

The contractor shall provide adequate packaging of fittings to prevent damage by normal handling and storage.

¹⁾ Marking GIS/LC8-4:2006 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.

Annex A (normative)
Dimensions of service collars

Split collars intended for making service connections shall incorporate a threaded boss conforming to the dimensions specified in Figure A.1.



Thread diameter in BSP parallel	Minimum thread depth
in.	mm
0.75	19
1	19
1.5	23
2	23

NOTE 1 Boss diameters should enable standard drilling machines to be used, if necessary with adapters.

NOTE 2 Tapping should be concentric with boss outside diameter. Plain bore diameter of boss should not be less than appropriate thread tapping diameter.

NOTE 3 Boss height, *h*, should be minimum to ensure adequate drilling machine cutting depth.

Figure A.1 — Threaded service collar

Annex B (normative)
Dimensions of branch connections

Fittings that incorporate a branch outlet terminating in a flange shall conform to the dimensions specified in Table B.1 and Figure B.1, which also gives typical combinations of parent main and outlet flange diameters.

Table B.1 — Outlet dimensions for branch connections

Parent main nominal diameter		Nominal diameter
in	mm	mm
4	100	100
5	—	100
6	150	150, 100
7	—	150, 100
8	200	200, 150, 100
9	—	200, 150, 100
10	250	250, 200, 150, 100
12	300	300, 250, 200, 150, 100
14	—	300, 250, 200, 150, 100
15	—	400, 150, 100
16	—	400, 150, 100
—	400	400, 150, 100
18	450	450, 300, 150, 100
20	—	450, 300, 150, 100
21	—	450, 300, 150, 100
24	600	600, 300, 150, 100

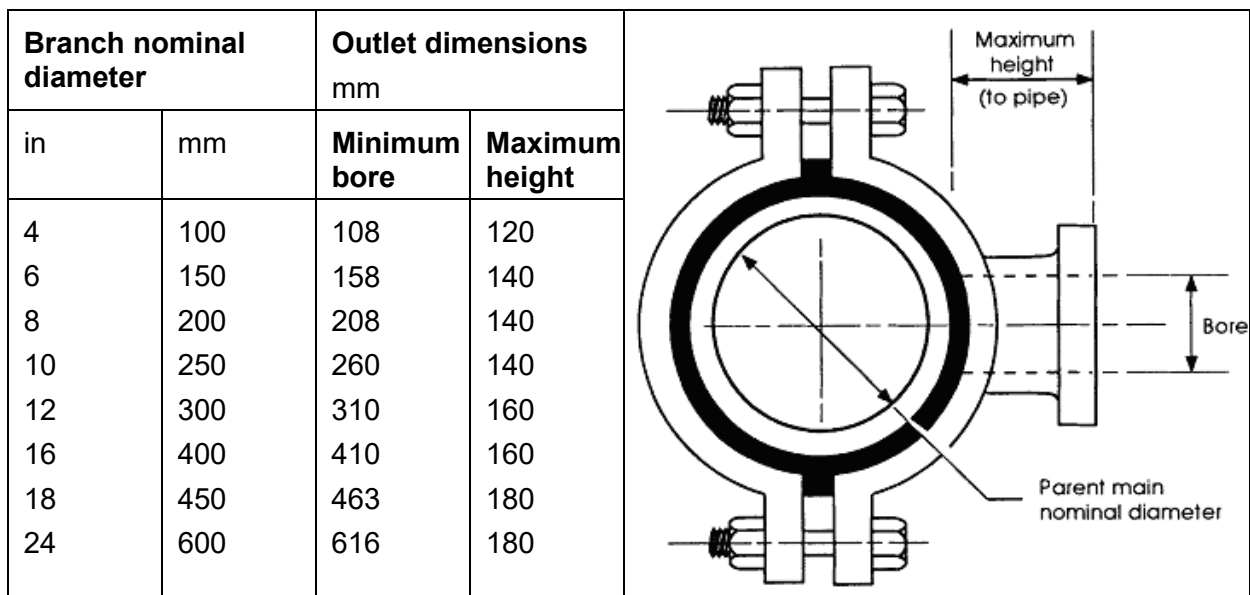


Figure B.1 — Flanged branch connections

Annex C (normative)

Type approval testing of fittings

C.1 General

C.1.1 Test pipes

The test pipes shall be manufactured from grade 420/12 spheroidal graphite iron in accordance with BS EN 1563:1997 and incorporating the surface defects shown in Figure C.1.

C.1.2 Test batch

Each of the specified tests shall be carried out on three fittings assembled on maximum diameter test pipes and three fittings assembled on minimum diameter test pipes, with the exception of the optional pressure life test, where the number of fittings is specified in the appropriate clause.

C.1.3 Test pipe sizes

All tests shall be carried out using 150 mm or 6 in nominal size test pipes, provided that the gas transporter is satisfied that the design is suitable for the whole range of sizes offered by the contractor. Application tests will be carried out on other sizes of fittings by the gas transporter. Satisfactory performance will then qualify the other sizes of fittings in the particular range.

C.1.4 Testing of pipe repair clamps, split collars and under pressure branch connections

The type tests referred to in Clause **C.3** shall apply to pipe repair clamps and split collars, i.e. for use on broken mains.

The type tests referred to in Clause **C.4** shall apply to under pressure branch connections, i.e. for use on intact mains. (The axial pull and angular deflection tests are undertaken on pipe sections to ensure that the fittings have the capability to resist pipe movements if a circumferential fracture of the pipe at the drilling point should subsequently occur.)

C.1.5 Number of fittings and test time-scale

Table C.1 summarizes the number of fittings required and the time-scale for each test.

C.1.6 Assembly of fittings

For each test, the fitting shall be assembled in accordance with the contractors installation instructions on test pipes which are either straight or deflected through an angle of 3° at their mid-point. The relative positions of the plane of deflection and surface defects of the test pipes and the axial joint of the fitting are shown in Figure C.2.

C.1.7 Standard test temperature

The standard temperature for system conditioning and performance testing shall be 20 °C ± 5 °C.

C.1.8 Standard test pressure

The standard test pressure shall be 1.5 times the maximum working pressure (either 3 bar or 10.5 bar depending on the duty intended by the contractor). Additionally, a special test pressure of 20 mbar shall be used for the low pressure application test.

Table C.1 — Summary of type approval tests

Reference Annex C	Parameter tested	Number of fittings	Conditioning time	Approximate test duration
Phase 1 testing				
C.3.1 C.4.1	Application	6	—	1 day
C.3.2 C.4.2	Strength and distortion	6	—	1 day
C.3.3 C.4.3	Axial pull	6	4 weeks	1 week
C.3.4 C.4.4	Angular deflection	6	4 weeks	4 weeks
C.3.5 C.4.5	Vibration	6	4 weeks	3 weeks
C.4.6	Branch angular deflection	6	4 weeks	4 weeks
Phase 2 testing				
C.5.1	Bolt load relaxation ^{a)}	6	—	3 months
C.5.2	Pressure/life ^{a)}	24	—	6 months
NOTE 1 See also Clauses C.1 and C.2				
NOTE 2 The total test time is the sum of the test duration and the conditioning time, where applicable.				
NOTE 3 The times above apply to each test specimen. The total time will depend on the number of fittings under test concurrently.				
^{a)} Either the bolt load relaxation test or the pressure/life test shall be carried out as appropriate.				

C.1.9 Failure criteria

A fitting shall be considered to fail when leakage occurs or when any individual component fails. If cracking or severe distortion that may lead to premature failure is suspected then this shall be established by using a suitable destructive or non-destructive technique.

C.1.10 Leakage testing

For leakage testing, the fitting assembly shall be pressurized with air or nitrogen. Depending on the design of fitting, the pressure shall be applied either through the test pipe or through a tapping in the wall of the fitting.

C.1.11 Leakage check

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

C.2 Safety precautions**C.2.1 Responsibility**

It is the responsibility of the contractor to ensure that the specified system performance tests can be carried out with safety.

C.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 times the test pressure.

If necessary, the seal components of fittings may be replaced after the hydrostatic pressure test.

C.2.3 Test precautions

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

C.3 Phase 1 approval tests for pipe repair clamps and split collars (deflected test pipes)**C.3.1 Application test****C.3.1.1 Principle**

This test determines the ability of the repair method to seal leaking pipes which are deflected to levels that could be encountered at operational site conditions.

C.3.1.2 Apparatus

C.3.1.2.1 Pneumatic pressure source, capable of delivering 25 mbar, 3 bar and where required 10.5 bar.

C.3.1.2.2 Leak detection fluid or water immersion bath.

C.3.1.2.3 Flow measuring equipment, capable of measuring flows up to 15 m³/h.

C.3.1.2.4 Support frame, capable of rigidly holding the test pipe sections at the required angle during installation of the repair method.

C.3.1.3 Test sample

C.3.1.3.1 Three test pipes on maximum diameter.

C.3.1.3.2 Three test pipes on minimum diameter.

C.3.1.4 Procedure

Set up the deflected test pipe section in the support frame as shown in Figure C.2.

Set the leak rate from the test pipe at a minimum of 10 m³/h at a pressure of 20 mbar ± 2 mbar.

Ensure the fitting is applied to the test pipe in accordance with the contractor's installation instructions.

Check for any leaks at the time of installation of the fitting and a minimum of 1 h after installation.

Remove the fitting and apply the standard test pressure ± 0.15 bar to the test pipe.

Then reapply the fitting to the test pipe in accordance with the contractor's installation instructions.

Check for any leaks at the time of installation of the fitting and a minimum of 2 h after installation.

NOTE Fitting assemblies may subsequently be used for other tests in **C.3**.

C.3.1.5 Expression of results

Record the angle of deflection ($^{\circ}$) on the test pipe before and after fitting installation.

Record the minimum leakage rate at 20 mbar (m^3/h).

Record if there is any leakage when the fitting is installed at 20 mbar.

Record if there is any leakage 1 h after the fitting is installed at 20 mbar.

Record the value of the standard test pressure (3 bar or 10.5 bar).

Record if there is any leakage when the fitting is installed at the standard test pressure.

Record if there is any leakage 2 h after the fitting is installed at the standard test pressure.

Record if there is any evidence of cracking or severe distortion of the fitting.

C.3.1.6 Test report

The test report shall include the following information:

- a) reference to this standard, i.e. GIS/LC8-4;
- b) the results of the determination;
- c) any additional factors which may have affected the results of the test.

C.3.2 Strength and distortion test

C.3.2.1 Principle

This test determines the ability of the repair method to seal leaking pipes when the bolts of a fitting are over-tightened.

C.3.2.2 Apparatus

C.3.2.2.1 Pneumatic pressure source, capable of delivering 3 bar and where required 10.5 bar.

C.3.2.2.2 Leak detection fluid or water immersion bath.

C.3.2.2.3 Support frame, capable of rigidly holding the test pipe sections straight during installation of the repair method.

C.3.2.2.4 Torque wrench, capable of tightening to a value of 200 N·m.

C.3.2.3 Test sample

C.3.2.3.1 Three test pipes on maximum diameter.

C.3.2.3.2 Three test pipes on minimum diameter.

C.3.2.4 Procedure

Set up the deflected test pipe section in the support frame as shown in Figure C.2.

Ensure the fitting is applied to the test pipe in accordance with the contractor's installation instructions (see Figure C.2).

Apply the standard test pressure to the test pipe.

Tighten each fitting to a torque of 150 Nm. However, if the use of a torque-limiting device is specified, tighten the bolts to 1.5 times the contractor's recommended torque values.

Check for any leaks and any evidence of cracking or severe distortion of the fitting.

Maintain the standard test pressure for a period of 7 days, and check for any leaks and any evidence of cracking or severe distortion of the fitting.

C.3.2.5 Expression of results

Record the value of the standard test pressure (3 bar or 10.5 bar).

Record the angle of deflection (°).

Record the torque level applied to the bolts.

Record if there is any leakage when the fitting bolts are over-tightened.

Record if there is any leakage 7 days after over-tightening the bolts.

Record if there is any evidence of cracking or severe distortion of the fitting.

C.3.2.6 Test report

The test report shall include the following information:

- a) reference to this standard, i.e. GIS/LC8-4;
- b) the results of the determination;
- c) any additional factors which may have affected the results of the test.

C.3.3 Axial pull test**C.3.3.1 Principle**

This test determines the ability of the repair method to seal leaking pipes when the test pipe is subject to an axial displacement to a level that could be encountered at operational site conditions.

C.3.3.2 Apparatus

C.3.3.2.1 Pneumatic pressure source, capable of delivering 3 bar and where required 10.5 bar.

C.3.3.2.2 Leak detection fluid or water immersion bath.

C.3.3.2.3 Support frame, capable of rigidly holding the test pipe sections straight during installation of the repair method.

C.3.3.2.4 Means of axially displacing the test pipe, by up to 8 mm.

C.3.3.3 Test sample

C.3.3.3.1 Three test pipes on maximum diameter.

C.3.3.3.2 Three test pipes on minimum diameter.

C.3.3.4 Procedure

Set up the straight test pipe section in the support frame as shown in Figure C.2.

Ensure the fitting is applied to the test pipe in accordance with the contractor's installation instructions (see Figure C.2).

Apply the standard test pressure to the test pipe for a period of 24 h.

Reduce the test pressure to zero and axially displace the test pipe by 6.5 mm at a rate of (1 ± 0.1) mm/min.

Apply the standard test pressure to the test pipe.

Check for any leaks and any evidence of cracking or severe distortion of the fitting.

Maintain the displacement and standard test pressure for a period of 7 days, and check for any leaks and any evidence of cracking or severe distortion of the fitting.

C.3.3.5 Expression of results

Record the value of the standard test pressure (3 bar or 10.5 bar) at the time of the installation and at the 24 h period.

Record if there is any leakage.

Record the level and rate of displacement (mm and mm/min).

Record if there is any leakage after axial displacement.

Record if there is any leakage 7 days after axial displacement.

Record if there is any evidence of cracking or severe distortion of the fitting.

C.3.3.6 Test report

The test report shall include the following information:

- a) reference to this standard, i.e. GIS/LC8-4;
- b) the results of the determination;
- c) any additional factors which may have affected the results of the test.

C.3.4 Angular deflection test**C.3.4.1 Principle**

This test determines the ability of the repair method to seal leaking pipes when the test pipe is subject to an angular displacement to a level that could be encountered at operational site conditions.

C.3.4.2 Apparatus

C.3.4.2.1 Pneumatic pressure source, capable of delivering 3 bar and where required 10.5 bar.

C.3.4.2.2 Leak detection fluid or water immersion bath.

C.3.4.2.3 Support frame, capable of rigidly holding the test pipe sections at an angular displacement of 4° installation of the repair method.

C.3.4.3 Test sample

C.3.4.3.1 Three test pipes on maximum diameter.

C.3.4.3.2 Three test pipes on minimum diameter.

C.3.4.4 Procedure

Set up the test pipe section in the support frame as shown in Figure C.2. Deflect the assembly by 3° and condition the sample at the standard test pressure for 24 h.

Ensure the fitting is applied to the test pipe in accordance with the contractor's installation instructions (see Figure C.2).

Depressurize the test pipe.

Further deflect the test pipes, at atmospheric pressure, through an angle of 1° to a final deflection of 4° between the axes of each test pipe.

Apply the standard test pressure and angular deflection for a period of 4 weeks.

Check for any leaks and any evidence of cracking or severe distortion of the fitting.

C.3.4.5 Expression of results

Record the value of the standard test pressure (3 bar or 10.5 bar) and the angular deflection at the installation of the fitting.

Record the value of the standard test pressure (3 bar or 10.5 bar) and the angular deflection at the beginning of the 4 week test period.

Record the value of the standard test pressure (3 bar or 10.5 bar) and the angular deflection at the end of the 4 week test period.

Record if there is any leakage at the end of the 4 week test period.

Record if there is any evidence of cracking or severe distortion of the fitting.

C.3.4.6 Test report

The test report shall include the following information:

- a) reference to this standard, i.e. GIS/LC8-4;
- b) the results of the determination;
- c) any additional factors which may have affected the results of the test.

C.3.5 Vibration test**C.3.5.1 Principle**

This test determines the ability of the repair method to seal leaking pipes when the test pipe is subject to a vibration level that could be encountered under operational conditions due to road traffic loading.

C.3.5.2 Apparatus

C.3.5.2.1 Pneumatic pressure source, capable of delivering 3 bar and where required 10.5 bar.

C.3.5.2.2 Leak detection fluid or water immersion bath.

C.3.5.2.3 Support frame, capable of rigidly holding the test pipe sections at an angular displacement of 4° installation of the repair method.

C.3.5.2.4 Means of vibrating test pipe at a frequency of up to 2 Hz, with an amplitude up to 1° for a period of 1.5×10^6 cycles.

C.3.5.3 Test sample

C.3.5.3.1 Three test pipes on maximum diameter.

C.3.5.3.2 Three test pipes on minimum diameter.**C.3.5.4** *Procedure*

Set up the test pipe section in the support frame as shown in Figure C.2. Deflect the assembly by 3° and condition the sample at the standard test pressure for 24 h.

Ensure the fitting is applied to the test pipe in accordance with the contractor's installation instructions (see Figure C.2).

Maintain the standard test pressure through the duration of the vibration test.

Continuously vibrate the test pipes at a frequency of 1 Hz ± 0.1 Hz with a peak to peak amplitude of 0.25° ± 0.025° between the limits of 3° and 3.25° to the axis for a total of 1.5 × 10⁶ cycles.

Check for any leaks and any evidence of cracking or severe distortion of the fitting.

Then continuously vibrate the test pipes at a frequency of 0.5 Hz ± 0.05 Hz with a peak to peak amplitude of 0.75° ± 0.075° between the limits of 3° and 3.75° to the axis for a total of 40 × 10³ cycles.

Check for any leaks and any evidence of cracking or severe distortion of the fitting.

C.3.5.5 *Expression of results*

Record the value of the standard test pressure (3 bar or 10.5 bar) and the angular deflection (°) at the installation of the fitting.

Record the frequency, cycles and the angular deflection for the test lasting 1.5 × 10⁶ cycles.

Record if there is any evidence of cracking or severe distortion of the fitting.

Record the frequency, cycles and the angular deflection for the test lasting 40 × 10³ cycles.

Record if there is any evidence of cracking or severe distortion of the fitting or any leakage from the fitting.

C.3.5.6 *Test report*

The test report shall include the following information:

- a) reference to this standard, i.e. GIS/LC8-4;
- b) the results of the determination;
- c) any additional factors which may have affected the results of the test.

C.4 Phase 1 approval tests for under pressure branch connections (straight test pipes)**C.4.1** *Application test***C.4.1.1** *Principle*

This test determines the ability of the repair method to seal leaking pipes.

C.4.1.2 *Apparatus*

C.4.1.2.1 *Pneumatic pressure source*, capable of delivering 25 mbar, 3 bar and where required 10.5 bar.

C.4.1.2.2 *Leak detection fluid or water immersion bath*.

C.4.1.2.3 *Flow measuring equipment*, capable of measuring flows up to 15 m³/h.

C.4.1.2.4 *Support frame*, capable of rigidly holding the test pipe sections straight during installation of the repair method.

C.4.1.3 *Test sample*

C.4.1.3.1 Three test pipes on maximum diameter.

C.4.1.3.2 Three test pipes on minimum diameter.

C.4.1.4 *Procedure*

Set up the straight test pipe section in the support frame as shown in Figure C.2.

Set the leak rate from the test pipe at a minimum of 10 m³/h at a pressure of 20 mbar ± 2 mbar.

Ensure the fitting is applied to the test pipe in accordance with the contractor's installation instructions.

Check for any leaks at the time of installation of the fitting and a minimum of 1 h after installation.

Remove the fitting and apply the standard test pressure ±0.15 bar to the test pipe.

Then reapply the fitting to the test pipe in accordance with the contractor's installation instructions.

Check for any leaks at the time of installation of the fitting and a minimum of 2 h after installation.

NOTE Fitting assemblies may subsequently be used for other tests in **C.4**.

C.4.1.5 *Expression of test results*

Record the minimum leakage rate at 20 mbar (m³/h).

Record if there is any leakage when the fitting is installed at 20 mbar.

Record if there is any leakage 1 h after the fitting is installed at 20 mbar.

Record the value of the standard test pressure (3 bar or 10.5 bar).

Record if there is any leakage when the fitting is installed at the standard test pressure.

Record if there is any leakage 2 h after the fitting is installed at the standard test pressure.

Record if there is any evidence of cracking or severe distortion of the fitting.

C.4.1.6 *Test report*

The test report shall include the following information:

- a) reference to this standard, i.e. GIS/LC8-4;
- b) the results of the determination;
- c) any additional factors which may have affected the results of the test.

C.4.2 *Strength and distortion test*

C.4.2.1 *Principle*

This test determines the ability of the repair method to seal leaking pipes when the bolts of a fitting are over-tightened.

C.4.2.2 *Apparatus*

C.4.2.2.1 *Pneumatic pressure source*, capable of delivering 3 bar and where required 10.5 bar.

C.4.2.2.2 *Leak detection fluid or water immersion bath.*

C.4.2.2.3 *Support frame*, capable of rigidly holding the test pipe sections straight during installation of the repair method.

C.4.2.2.4 *Torque wrench*, capable of tightening to a value of 200 Nm.

C.4.2.3 *Test sample*

C.4.2.3.1 Three test pipes on maximum diameter.

C.4.2.3.2 Three test pipes on minimum diameter.

C.4.2.4 *Procedure*

Set up the straight test pipe section in the support frame as shown in Figure C.2.

Ensure the fitting is applied to the test pipe in accordance with the contractor's installation instructions (see Figure C.2).

Apply the standard test pressure to the test pipe.

Tighten each fitting to a torque of 150 Nm. However, if the use of a torque-limiting device is specified, tighten the bolts to 1.5 times the contractor's recommended torque values.

Check for any leaks and any evidence of cracking or severe distortion of the fitting.

Maintain the standard test pressure for a period of 7 days, and check for any leaks and any evidence of cracking or severe distortion of the fitting.

C.4.2.5 *Expression of results*

Record the value of the standard test pressure (3 bar or 10.5 bar).

Record the torque level applied to the bolts.

Record if there is any leakage when the fitting bolts are over-tightened.

Record if there is any leakage 7 days after over-tightening the bolt.

Record if there is any evidence of cracking or severe distortion of the fitting.

C.4.2.6 *Test report*

The test report shall include the following information:

- a) reference to this standard, i.e. GIS/LC8-4;
- b) the results of the determination;
- c) any additional factors which may have affected the results of the test.

C.4.3 *Axial pull test*

This test shall be carried out in accordance with **C.3.3**.

C.4.4 *Angular deflection test*

This test shall be carried out in accordance with **C.3.4**.

C.4.5 Vibration test

C.4.5.1 Principle

This test determines the ability of the repair method to seal leaking pipes when the test pipe is subject to a vibration level that could be encountered under operational conditions due to road traffic loading.

C.4.5.2 Apparatus

C.4.5.2.1 Pneumatic pressure source, capable of delivering 3 bar and where required 10.5 bar.

C.4.5.2.2 Leak detection fluid or water immersion bath.

C.4.5.2.3 Support frame, capable of rigidly holding the test pipe sections straight during the installation of the repair method.

C.4.5.2.4 Means of vibrating test pipe, at a frequency of up to 2 Hz, with an amplitude up to 1° for a period of 1.5×10^6 cycles.

C.4.5.3 Test sample

C.4.5.3.1 Three test pipes on maximum diameter.

C.4.5.3.2 Three test pipes on minimum diameter.

C.4.5.4 Procedure

Set up the straight test pipe section in the support frame as shown in Figure C.2, and condition the sample at the standard test pressure for 24 h.

Ensure the fitting is applied to the test pipe in accordance with the contractor's installation instructions (see Figure C.2).

Maintain the standard test pressure through the duration of the vibration test.

Continuously vibrate the test pipes at a frequency of $1 \text{ Hz} \pm 0.1 \text{ Hz}$ with a peak to peak amplitude of $0.25^\circ \pm 0.025^\circ$ between the limits of 0° and 0.25° to the axis for a total of 1.5×10^6 cycles.

Check for any leaks and any evidence of cracking or severe distortion of the fitting.

Then continuously vibrate the test pipes at a frequency of $0.5 \text{ Hz} \pm 0.05 \text{ Hz}$ with a peak to peak amplitude of $0.75^\circ \pm 0.075^\circ$ between the limits of 0° and 0.75° to the axis for a total of 40×10^3 cycles.

Check for any leaks and any evidence of cracking or severe distortion of the fitting.

C.4.5.5 Expression of results

Record the value of the standard test pressure (3 bar or 10.5 bar) and the angular deflection at the installation of the fitting.

Record the frequency, cycles and the angular deflection for the test lasting 1.5×10^6 cycles.

Record if there is any evidence of cracking or severe distortion of the fitting.

Record the frequency, cycles and the angular deflection for the test lasting 40×10^3 cycles.

Record if there is any evidence of cracking or severe distortion of the fitting or any leakage from the fitting.

C.4.5.6 Test report

The test report shall include the following information:

- a) reference to this standard, i.e. GIS/LC8-4;
- b) the results of the determination;
- c) any additional factors which may have affected the results of the test.

C.4.6 Branch angular deflection test**C.4.6.1 Principle**

This test determines the ability of the repair method to seal leaking pipes when the test pipe is subject an angular deflection associated with lateral loads that could be seen during operating conditions.

C.4.6.2 Apparatus

C.4.6.2.1 Pneumatic pressure source, capable of delivering 3 bar and where required 10.5 bar.

C.4.6.2.2 Leak detection fluid or water immersion bath.

C.4.6.2.3 Support frame, capable of rigidly holding the test pipe sections at an angular displacement of 2° installation of the repair method.

C.4.6.3 Test sample

C.4.6.3.1 Three test pipes on maximum diameter.

C.4.6.3.2 Three test pipes on minimum diameter.

C.4.6.4 Procedure

Assemble the fitting on straight test pipe sections (see Figure C.2) and condition for 24 h at the standard test pressure.

With the fitting at atmospheric pressure, deflect the branch axis through an angle of 2° under the action of a force applied to the outlet flange as shown in Figure C.5.

Apply the standard test pressure.

The sample will have deemed to have passed if failure does not occur when the pressure and deflection are maintained for a period of 4 weeks.

C.4.6.5 Expression of results

Record the value of the standard test pressure (3 bar or 10.5 bar) at the time of fitting installation.

Record the angle of deflection.

Record the value of the standard test pressure (3 bar or 10.5 bar) after branch deflection.

Record if there is any evidence of cracking or severe distortion of the fitting.

Record the value of the standard test pressure (3 bar or 10.5 bar) after a period of 4 weeks

Record if there is any evidence of cracking or severe distortion of the fitting.

C.4.6.6 Test report

The test report shall include the following information:

- a) reference to this standard, i.e. GIS/LC8-4;
- b) the results of the determination;
- c) any additional factors which may have affected the results of the test.

C.4.7 Branch drilling test**C.4.7.1 Principle**

This test determines the ability of the repair method to be capable of withstanding all the loads associated with the under-pressure drilling of the branch.

NOTE 1 Consideration should be given to hydraulically pressure testing the test sample to a pressure equal to 2 times the maximum working pressure prior to carrying out this test.

NOTE 2 Consideration should be given to ensuring that the test sample is adequately restrained during the pneumatic pressurization.

C.4.7.2 Apparatus

C.4.7.2.1 Pneumatic pressure source, capable of delivering 3 bar and where required 10.5 bar.

C.4.7.2.2 Leak detection fluid or water immersion bath.

C.4.7.2.3 Under pressure drilling equipment.

C.4.7.3 Test sample

This test shall be carried out on one of each size of fitting that represents the largest, the smallest and one intermediate size of the range of fittings to be qualified by this process.

A single section of pipe shall be used to which the branch saddle is to be fitted.

C.4.7.4 Procedure

Assemble the fitting to the straight section of pipe in accordance with the contractor's instructions.

Pressurize the pipe to the standard test pressure.

Pressurize the fitting to the standard test pressure in accordance with the contractor's instructions.

Check for any leaks from the fitting.

Drill the pipe in accordance with instructions for the under pressure drilling equipment.

Check for any leaks and any evidence of cracking or severe distortion of the fitting.

After the end of drilling ensure that the standard test pressure is maintained for a period of 2 h and check for any leaks and any evidence of cracking or severe distortion of the fitting.

C.4.7.5 Expression of results

Record the value of the standard test pressure (3 bar or 10.5 bar) at the time of fitting installation.

Record the pressure to which the fitting is pressurized.

Record if there is any evidence of cracking or severe distortion of the fitting before drilling.

Record the pressure after drilling.

Record if there is any evidence of cracking or severe distortion of the fitting after drilling.

C.4.7.6 Test report

The test report shall include the following information:

- a) reference to this standard, i.e. GIS/LC8-4;
- b) the results of the determination;
- c) any additional factors which may have affected the results of the test.

C.5 Phase 2 approval

C.5.1 Bolt load relaxation test

C.5.1.1 Principle

This test determines the ability of the bolts to maintain sufficient clamping force over the predicted life of the fitting.

The bolt load relaxation test is an alternative to the pressure/life test (see **C.5.2**) as a method of determining the useful working life of a fitting. The choice of method will depend upon the design of the fitting.

C.5.1.2 Apparatus

C.5.1.2.1 Pneumatic pressure source, capable of delivering 3 bar and where required 10.5 bar.

C.5.1.2.2 Leak detection fluid or water immersion bath.

C.5.1.2.3 Strain gauge load cells.

C.5.1.2.4 Data logger.

C.5.1.3 Test sample

C.5.1.3.1 Three test pipes on maximum diameter.

C.5.1.3.2 Three test pipes on minimum diameter.

C.5.1.4 Procedure

Assemble each fitting on straight test pipes with a minimum of four bolts fitted with strain gauge load cells and spherically seated washers as shown in Figure C.3a).

NOTE Guidance on the design and use of load cells is given in Annex D. It may be necessary to use special long bolts for the test, but it is essential that the diameter, material and thread form of these bolts are the same as those of the bolts normally fitted.

Pressurize the test pipe to the standard test pressure with a free air flow of $10 \text{ m}^3\text{h}^{-1}$.

Tighten the fitting to the contractor's recommended torque and adjust the test pipe pressure to the standard test pressure and store in air. Note the bolt loads over a period of 10 min to 3 months after completion of bolt tightening, recording a minimum of two results of average bolt load (F_m) per logarithmic decade of time.

Then determine the bolt load (F_l) at which leakage just occurs at the test pressure. Loosen the bolts progressively, maintaining the bolt loads as even as possible, until leakage occurs and record the average bolt load.

Plot a graph of F_m against \log_{10} time as shown in Figure C.3b) and draw a straight line through the points, based on the least sum of the squares of the errors in the value of F_m .

Ensure that the estimated bolt load after 50 years life is not less than the bolt load at which leakage occurs (F_1).

C.5.1.5 Expression of results

Record the standard test pressure.

Record the free air flow.

Record the bolt loads over a 3 month period.

Plot the bolt loads as per Figure C.3b) and show extrapolation to 50 year period.

C.5.1.6 Test report

The test report shall include the following information:

- a) reference to this standard, i.e. GIS/LC8-4;
- b) the results of the determination;
- c) any additional factors which may have affected the results of the test.

C.5.2 Pressure/life test

C.5.2.1 Principle

This test determines the ability of the bolts to maintain sufficient clamping force over the predicted life of the fitting.

The pressure/life test is an alternative to the bolt load relaxation test (see **C.5.1**) as a method of determining the useful working life of a fitting. The choice of method will depend upon the design of the fitting.

C.5.2.2 Apparatus

C.5.2.2.1 Pneumatic pressure source, capable of delivering 3 bar and where required 10.5 bar.

C.5.2.2.2 Leak detection fluid or water immersion bath.

C.5.2.2.3 Strain gauge load cells.

C.5.2.2.4 Data logger.

C.5.2.3 Test sample

C.5.2.3.1 Twelve fittings assembled on maximum diameter straight test pipes.

C.5.2.3.2 Twelve fittings assembled on minimum diameter straight test pipes.

C.5.2.4 Procedure

Carry out the test on 12 fittings assembled on maximum diameter straight test pipes and 12 fittings assembled on minimum diameter straight test pipes. All 24 fittings need not necessarily be under test simultaneously.

The steps in the test procedure specified below apply to each set of 12 fittings.

Subject three fittings to a pressure that will ensure failure within 1 h. Note the pressure at which failure occurs, P , and the time to failure, T_p . Plot the results on a log/log plot of pressure against time in minutes of the type shown in Figure C.4.

Pressurize three fittings and hold them at a pressure P_1 , a second set of three fittings at a pressure P_2 and a third set of three fittings at a pressure P_3 .

Establish the pressure P_1 by drawing a straight line joining the initial point (T_p, P) to the 50 year/1.5 times specified maximum working pressure point. P_1 is the pressure corresponding to 6 months on the time axis.

Determine pressures P_2 and P_3 to give points equidistant on a logarithmic scale between P_1 and P .

Ensure the duration of the tests is 6 months or until failure occurs, whichever is the shorter period.

Plot the results obtained on the graph to show the failure band. When the lower edge of their failure band is extrapolated to 50 years, ensure the corresponding pressure is not less than 1.5 times the contractor's maximum recommended working pressure.

C.5.2.5 *Expression of results*

Record the pressure to cause failure within 1 h.

Record pressures P_1 , P_2 and P_3 .

Plot pressures as per Figure C.4 and show extrapolation to 50 year period.

C.5.2.6 *Test report*

The test report shall include the following information:

- a) reference to this standard, i.e. GIS/LC8-4;
- b) the results of the determination;
- c) any additional factors which may have affected the results of the test.

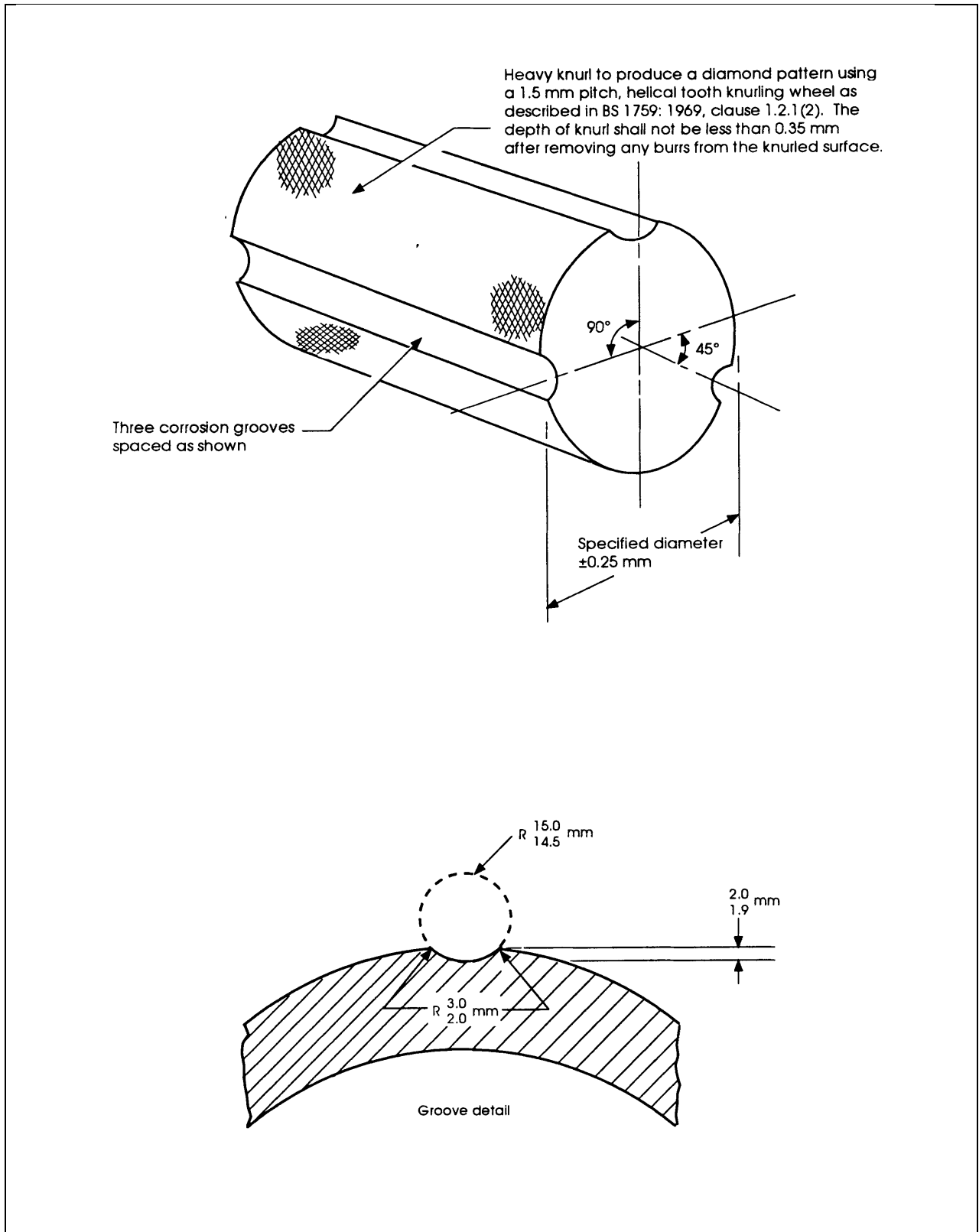


Figure C.1 — Surface defects for test pipes

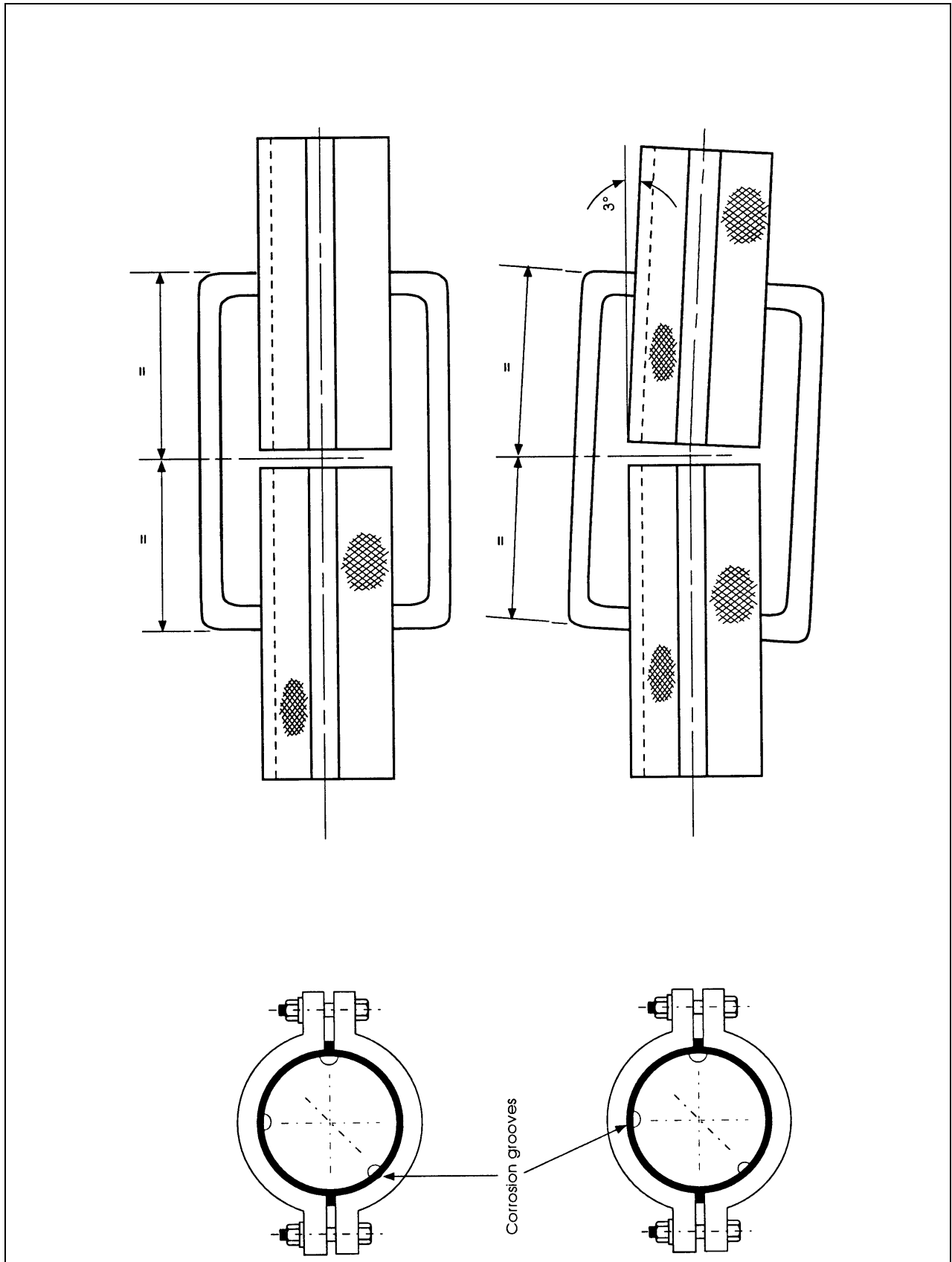
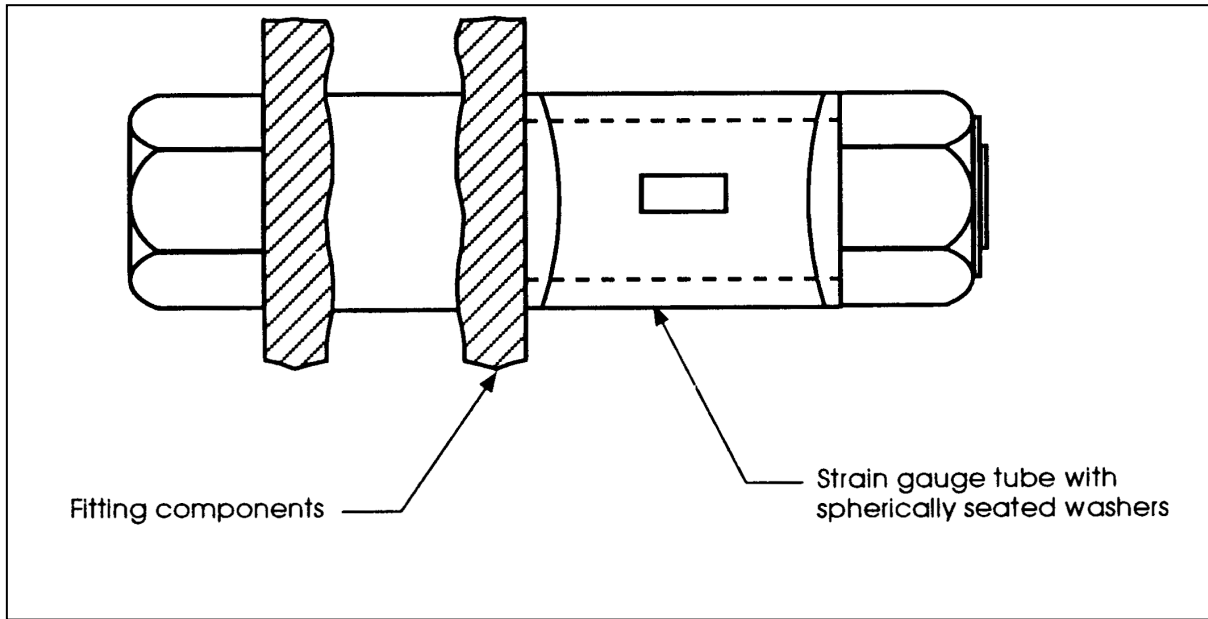
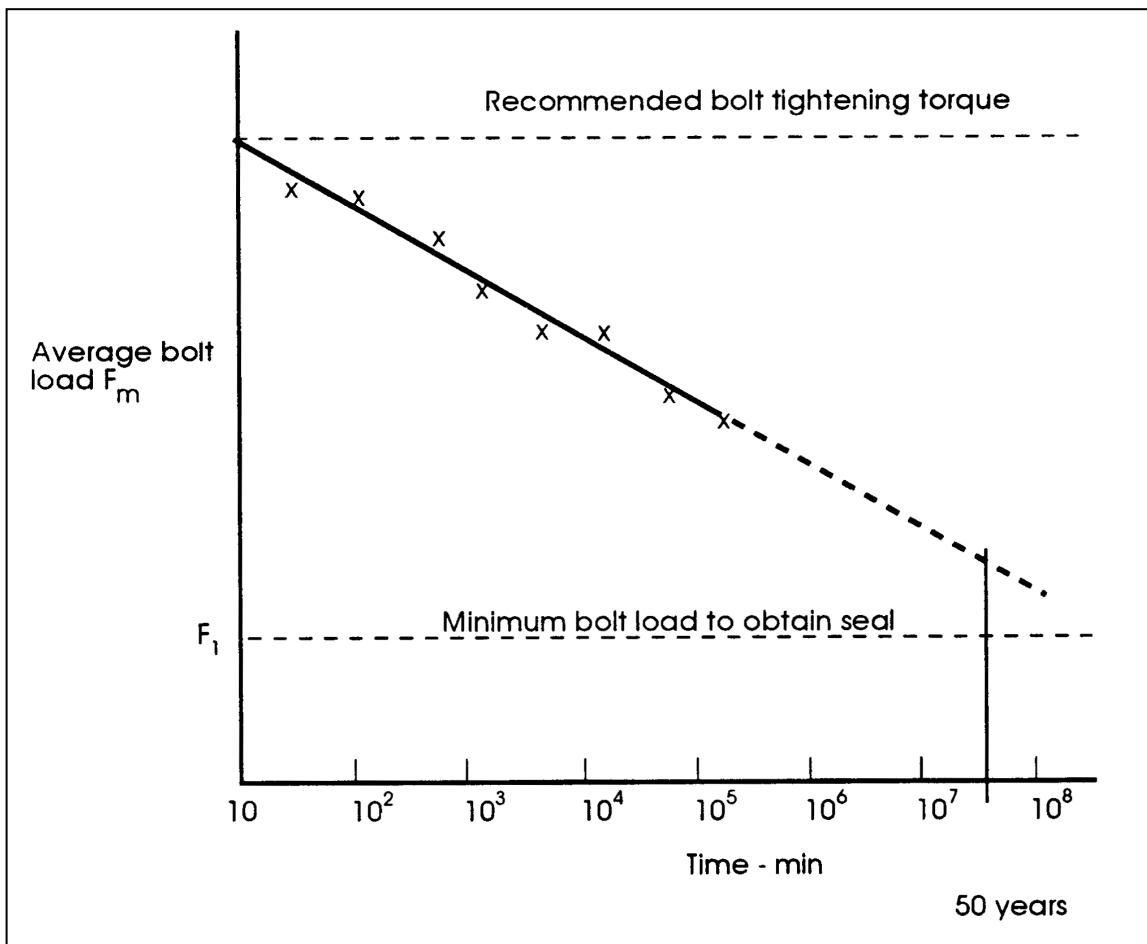


Figure C.2 — Straight and deflected test assemblies



a) Fitting with strain gauge load cell



b) Estimation of bolt load after 50 years' relaxation

Figure C.3 — Bolt load relaxation test

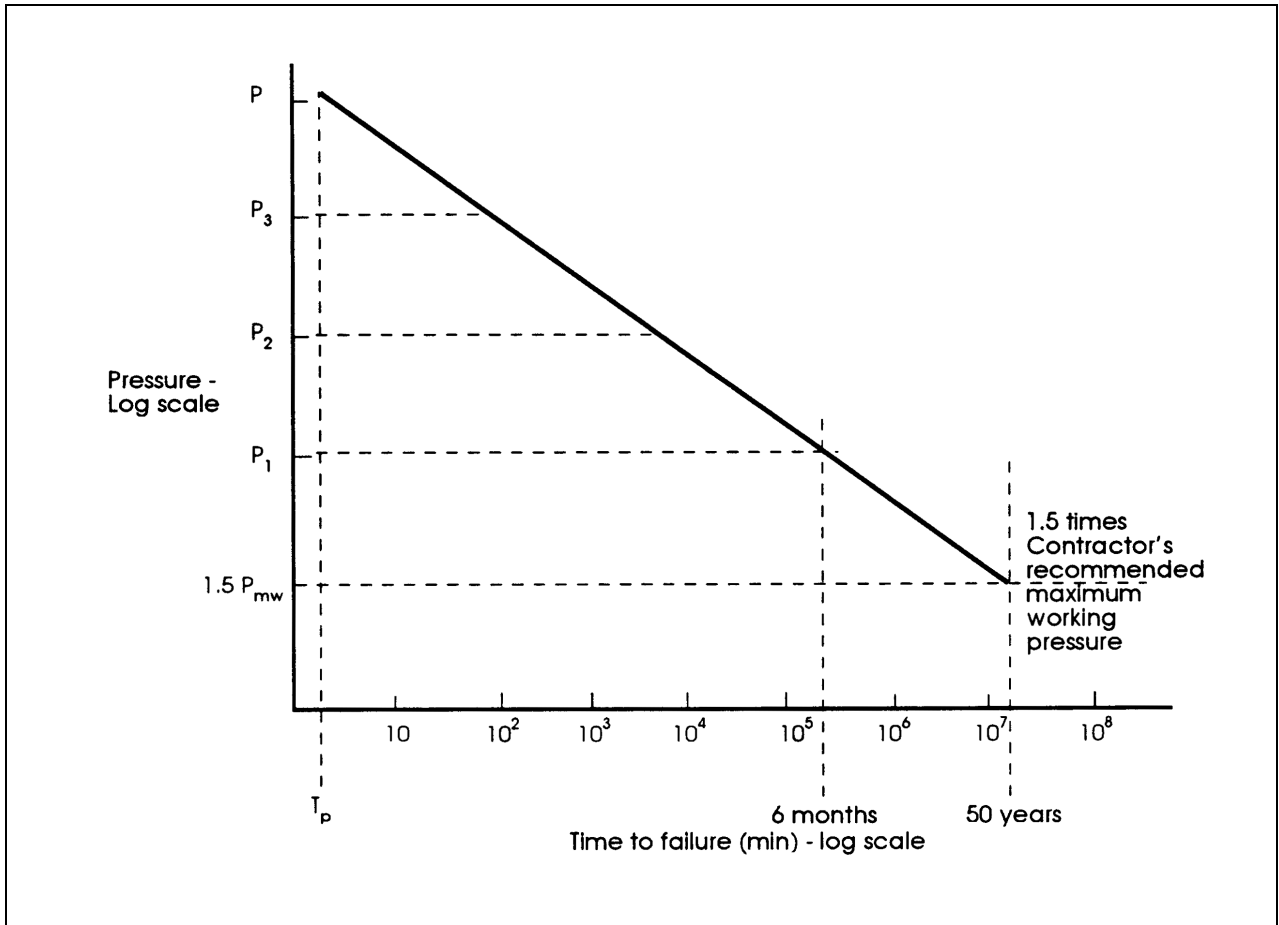


Figure C.4 — Pressure/life testing

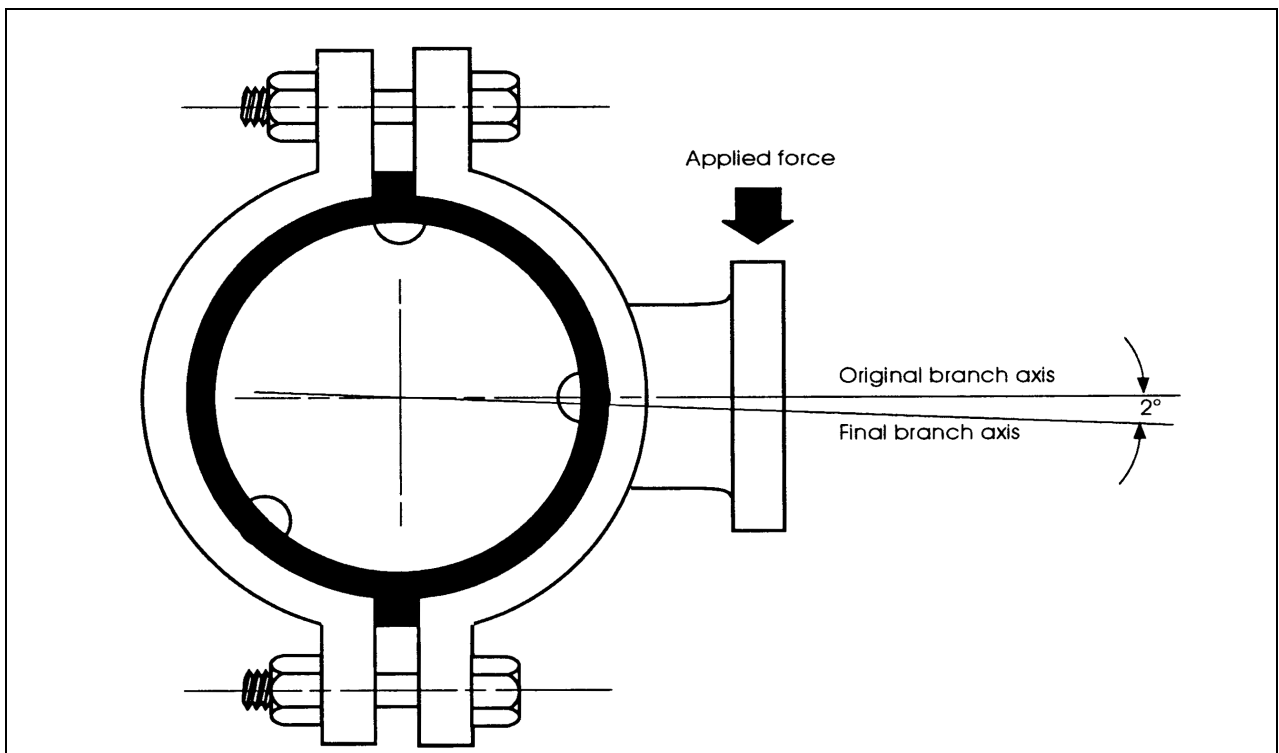


Figure C.5 — Branch angular deflection test

Annex D (informative)

Guidance on the design and use of strain gauged load cells

D.1 Load cell assembly

A load cell assembly consists of a barrel fitted with spherical washers at each end to ensure that axial loads are transmitted.

D.2 Load cell blank

Details of a typical load cell blank are shown in Figure D.1a). For a specific application, the barrel inside diameter, d , should be a clearance fit over the bolt and the outside diameter, D , should be chosen to give a maximum strain in the tube wall of 800 micro-strain (equivalent to a stress of 165 MN/m²) at the maximum design load. The material should be a high yield strength steel, e.g. PD 970 605 M 36T (formerly En 16T), which has a minimum yield stress of 680 MN/m².

D.3 Strain gauge arrangement

A typical strain gauge arrangement is shown in Figure D.1b). The barrel has a total of eight foil resistance strain gauges equally spaced around the circumference; four measuring axial strain alternating with four measuring circumferential strain. The gauges are connected to form a Wheatstone bridge with individual gauges arranged in the bridge arms to minimize bending effects. The strain gauges and the adhesive used to bond them to the barrel should be selected to minimize errors due to non-linearity, hysteresis and zero drift. The latter is particularly important in a gasket relaxation test.

D.4 Instrumentation

Instrumentation in the form of a stabilized dc power supply and a digital voltmeter with a resolution of 1 mV are needed, connected as shown in Figure D.1c).

D.5 Load cell calibration

Before a test, each load cell should be calibrated on a compression test machine, to give applied load against millivolt output.

D.6 Load cell stability

For maximum stability during a test, the load cells should be permanently energized. Before each set of readings, the power supply output should be checked using the digital voltmeter and adjusted as necessary. At the end of the test, the bolt load should be completely released and the new load cell zero should be determined. The difference between the final reading and the new zero represents the final bolt load, which allows a correction to be applied for load cell drift.

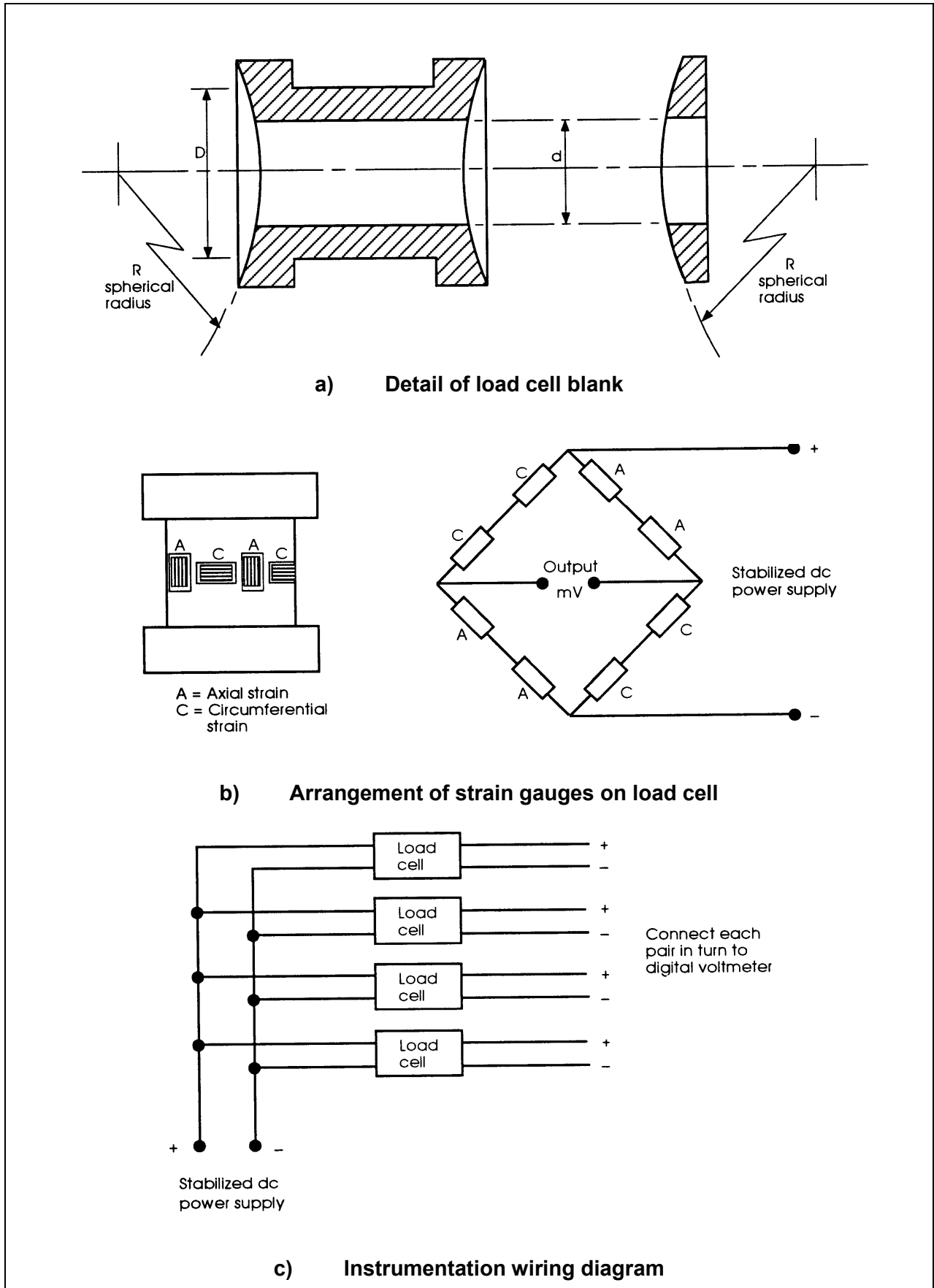


Figure D.1 — Load cell strain gauge and instrumentation