Gas Industry Standard

GIS/F17:2006

Specification for

In-pipe close fit lined mains connection 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.

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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

First draft issued as EPSG/ T05/1468 Second draft issued EPSG/ T05/1468 Edited by BSI in accordance with BS 0-3:1997 Reviewed on behalf of the Gas Distribution Networks' Technical Standard Forum by BSI Reviewed by TSF	February 2005 November 2005 August 2006 September 2013 June 2018

1 Scope

This Gas Industry Standard (GIS) specifies requirements relating to fittings for pipe connections to in-pipe close fit lined pipes operating at a maximum working pressure of up to 2 bar.

It applies to connections to grey cast iron, ductile iron and steel distribution pipes with either lead yarn or mechanical type joints.

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

ASME B16.34, *Valves — Flanged, threaded and welding end*.

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

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

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

BS EN 13445-2, *Unfired pressure vessels — Materials.*

Gas Industry Standards

GIS/C8, *Specification for grey or ductile iron castings for split tee type fittings, including collars, for use at pressures up to 7 bar*.

Individual Gas Distribution Network Standards

Gas Distribution Networks' mainlaying procedures and anchorage procedures.

*/SP/CW/5, *Specification for field applied external coatings for buried pipework and systems*.

*/SP/CW/6-1 *Specification for the external protection of steel line pipe and fittings using fusion bonded powder and other coating systems — Part 1: Requirements for coating materials and methods of test*.

*/SP/F/1, *Technical 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 definitions apply.

3.1
CIPP
cured-in-place pipe

3.2
close fit lined pipe
pipe rehabilitated by means of cured-in-place liners

4 Material requirements

4.1 Elastomeric compression seals

Elastomeric compression seals shall conform to BS EN 682 for the appropriate class of hardness.

4.2 Fitting body materials

Grey or ductile iron body castings shall conform to GIS/C8. Forging shall conform to */SP/F/1. Metallic pressure containing parts shall be made of material conforming to BS EN 13445-2 or ASME B16.34.

4.3 Stainless steel materials

Fittings shall be formed from austenitic stainless steel. Where welds are required, the grade nominated shall either be stabilized or of a low carbon grade. Examples of suitable materials are:

a) BS EN 10088-2 Grade 1.4404 where welding might be involved in the manufacturing process;

b) BS EN 10088-2 Grade 1.4401 where welding is not involved in the manufacturing process.

5 Design requirements

5.1 General

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

Fittings and fastenings shall have a factory-applied corrosion resistant coating to provide long-term environmental protection commensurate with the design life of the component. Fittings should be made from materials with an inherent resistance against corrosion, in accordance with */SP/CW/5 and */SP/CW/6-1. Dissimilar materials shall not be used directly in contact with one another, as this can lead to accelerated corrosion.

When assembled, no part of the elastomeric seal shall be left unsupported by either the fitting body or the host pipe.

5.2 Maximum working pressure

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

5.3 Temperature ranges

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

5.4 Excavation

Fittings shall be designed to minimize the size and number of excavations.

5.5 Bolt head and nut clearances

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

5.6 Installation instructions

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

5.7 Surface preparation and cleaning

The contractor shall specify any necessary surface preparation for the installation of the fitting. This preparation shall have no deleterious effect on the pipe.

The contractor shall carry out this surface preparation and cleaning and remove all loose material from the pipe.

5.8 Bolt torque

The contractor shall specify a bolt torque and bolt tightening sequence with each fitting (if bolts are used to make the connection). The specified bolt torque range shall not exceed 100 Nm.

5.9 Backfill time

The fitting shall be designed so that an excavation can be safely backfilled and the normal pipe operating pressure applied immediately after installation.

5.10 Reduction in pipe bore diameter

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

5.11 Anchorage

NOTE Fittings designed for use on grey or ductile iron pipes are not end load bearing and therefore require anchorage to prevent longitudinal movement in accordance with Gas Distribution Networks' mainlaying and anchorage procedures.

The contractor shall design fittings to allow anchorage, for example, by including lugs for encasement in concrete, in accordance with Gas Distribution Networks' mainlaying and anchorage procedures.

5.12 Gas tracking

NOTE The connection of fittings on CIPP pipes requires the inner liner to be gripped and sealed from the possibility of gas tracking between the liner and the pipe bore.

The fitting design shall incorporate a device to allow the operator to check for gas tracking, for example, a bleed point on the body of the fitting.

5.13 Internal hoop stress

The fitting shall not induce excessive loading within the pipe. The interference pressure shall be calculated or measured and recorded during the performance testing of the fitting.

6 Type approval

6.1 General

Approval testing shall be undertaken in two parts, designated Phase 1 and Phase 2 (see Annexes B, C and D).

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.

7 Marking

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

a) the number and date of this standard, i.e. GIS/F17:2006 [1)];

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

c) the manufacturer's contact details;

d) the pressure rating;

e) weight of fitting;

f) fitting instructions (if appropriate);

g) nominal size;

h) all sizes and materials of compatible pipes;

i) produc*/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.

8 Packaging

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

[1)] Marking GIS/F17:2006 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)
Pipe flow efficiency test procedure

A.1 Principle

NOTE The flow capacity of a cast iron (CI) pipe, when compared against smooth pipe law theory, results in an average efficiency, ignoring fittings, of 0.88. This reduction in capacity is due to pipe surface roughness.

This annex applies to lining systems considered hydraulically smooth, i.e. that obey the smooth pipe law. Polyethylene and resin-based hose liner systems are considered to be hydraulically smooth pipes for test purposes.

A.2 Test procedure

Obtain the average bore of the lined pipe by taking measurements at five separate positions along the pipe and obtaining an average value.

Calculate the efficiency of the system from the following equation:

$$\text{Efficiency} = \left[1 - \frac{\text{Bore of main} - \text{Bore of lined pipe}}{\text{Bore of main}}\right] 5/2$$

A.3 Results

The efficiency calculated shall be greater than 0.75, i.e. greater than 85 % of 0.88.

Annex B (normative) Type approval testing

B.1 General

B.1.1 *Test pipes*

Where tests are carried out on new pipe samples, these shall incorporate an internal CIPP liner and be manufactured from grade 420/12 spheroidal graphite iron that conforms to BS EN 1563.

B.1.2 *Test pipe sizes*

Performance tests shall be carried out for the range size of fittings to be approved. To cover the full range of pipe sizes between 10 in (250 mm) and 18 in (450 mm) it shall be sufficient to test the following nominal size pipes:

a) 12 in (300 mm);

b) 18 in (450 mm).

Once the set of tests for these sizes of fittings has been carried out, application tests shall be carried out for all size of fittings in the range 10 in (250 mm) to 18 in (450 mm).

B.1.3 *Number of fittings and test time-scale*

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

B.1.4 *Assembly of fittings*

For each test, the fitting shall be assembled in accordance with the contractor's installation instructions.

B.1.5 *Standard test temperature*

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

B.1.6 *Standard test pressure*

The standard test pressure shall be 3 bar (1.5 times the maximum working pressure). Additionally, a special test pressure of 20 mbar shall be used for the low-pressure application test.

B.1.7 *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.

B.1.8 *Leakage testing*

For leakage testing, the fitting assembly shall be pressurized to 3 bar (1.5 times the maximum working pressure) with air or nitrogen. Depending on the design of the fitting, the pressure should be applied either through the test pipe or a tapping in the wall of the fitting.

B.1.9 *Leakage check*

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

B.2 Safety precautions

B.2.1 *Responsibility*

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

B.2.2 *Hydrostatic pressure test*

Before commencing the system performance tests, consideration should be given to hydrostatically pressure testing all fittings and test equipment to be used at 3 bar (1.5 times the test pressure).

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

B.2.3 *Test precautions*

NOTE 1 The system performance tests are designed to apply loads or deflections to a fitting assembly with pressure released wherever possible.

Particular care shall be exercised when the assembly is re-pressurized and during the inspection of a pressurized assembly.

Where a test requires fitting loads to be adjusted under pressure, fitting movement shall be contained to prevent full bore failure.

NOTE 2 This can be achieved by using internal tie bars connected to the fitting and anchored to the test sample.

B.3 Phase 1 and phase 2 type approval tests

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

Table B.1 — Summary of type approval tests

Reference	Parameter tested	No. of fittings	Conditioning time	Approximate test duration	Acceptance criteria
C.1 Phase 1	Application	3	—	1 day	The test sample shall remain sealed for at least 2 h
C.2 Phase 1	Strength and distortion	3	—	7 days	The fitting assembly shall not leak when the pressure is maintained for a period of 7 days
C.3 Phase 1	Axial load	3	1 week	3 weeks	Failure shall not occur when the pressure and displacement are maintained for a period of 7 days
C.4 Phase 1	Bending moment	3	1 week	2 weeks	Failure shall not occur when the pressure and deflection are maintained for a period of 7 days
C.5 Phase 1	Elevated temperature	1	—	3 weeks	Leakage from the specimen in less than the specified time periods is considered a failure
C.6 Phase 1	Pneumatic leak	1	—	1 day (short term test) 3 weeks (long term)	Leakage from the specimen in less than the specified time periods is considered a failure
C.7 Phase 1	Transverse shear	1	—	1 h	As **B.3.6**
D.1 Phase 2	Compression ring [a)]	3	—	3 months	The estimated bolt load after 50 years shall not be less than the load at which leakage occurs
D.2 Phase 2	Inner compression ring – relaxation [a)]	3	—	3 months	The estimated compression load after 50 years shall not be less than the load at which leakage occurs
NOTE 1 The total test time is the sum of the test duration and the conditioning time, where applicable. NOTE 2 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 relaxation test or the inner compression ring test should be carried out as appropriate.					

Annex C (normative)
Phase 1 type approval tests

C.1 Application test

The following application test shall be carried out.

C.1.1 *Principle*

This test is to determine that the fitting can be applied to a main containing a CIPP liner.

Fitting assemblies may subsequently be used for other tests in this clause.

C.1.2 *Apparatus*

C.1.2.1 *Test pipes*.

C.1.2.2 *Fittings.*

C.1.2.3 *Pressure source*, capable of supplying 3 bar pressure and 20 mbar.

C.1.2.4 *Pressure gauge(s)*, capable of measuring up to 3.5 bar and also down to 25 mbar in steps of 1 mbar.

C.1.3 Procedure

C.1.3.1 Assemble each fitting in accordance with the contractor's installation instructions on the un-pressurized test pipes.

C.1.3.2 Apply to (20 ± 2) mbar of pressure and leave the test sample sealed for at least 1 h.

C.1.3.3 Apply 3 bar of pressure.

C.1.3.4 Leave the test sample sealed for at least 2 h.

C.1.4 Results

Note any pressure drop during the first hour of pressurization at 20 mbar. Note any pressure drop during the next 2 h of pressurization at 3 bar.

No pressure drop is permitted on either of the tests.

C.2 Strength and distortion test

C.2.1 *Principle*

This test is to determine that the fitting will not become distorted and non-functional if the mechanism for applying the internal sealing mechanism is over-tightened.

C.2.2 *Apparatus*

C.2.2.1 *Test pipes*.

C.2.2.2 *Fittings.*

C.2.2.3 *Pressure source*, capable of supplying 3 bar pressure.

C.2.2.4 *Pressure gauge*, capable of measuring up to 3.5 bar.

C.2.3 *Procedure*

C.2.3.1 Assemble each fitting on straight test pipe sections and then tighten the bolts or inner compression ring to a level which is 1.5 times the contractor's recommended value.

C.2.3.2 Apply a pressure of 3 bar and hold for a period of 7 days. After the 7 days period, disassemble the fitting so that the internal seal can be inspected.

C.2.4 *Results*

Check that there is no pressure drop at start of the 3 bar test.

Check that there is no pressure drop after 7 days.

Check that there is no severe distortion or that the fitting is not broken.

C.3 Axial load

C.3.1 *Principle*

This test is to establish that the fitting will resist the stresses imposed when correctly anchored.

Polyethylene pipe is known to contract when ambient temperatures reduce and it is recommended that the fitting is restrained by anchoring the body of the fitting in mass concrete in accordance with Gas Distribution Networks' mainlaying and anchorage procedures to ensure imposed loads are not transferred to the seals of the fitting.

C.3.2 *Apparatus*

C.3.2.1 *Test pipes*.

C.3.2.2 *Fittings.*

C.3.2.3 *Pressure source*, capable of supplying 3 bar pressure.

C.3.2.4 *Pressure gauge*, capable of measuring up to 3.5 bar.

C.3.2.5 *Means of applying tensile loading to the fitting*, up to a value of 550 kN.

C.3.3 *Procedure*

C.3.3.1 Assemble each fitting on straight pipe sections in accordance with the contractor's installation instructions.

C.3.3.2 Condition the fittings for 1 week at a pressure of 3 bar with a cap end or blank bolted to the flanged end. Restrain the barrel of the fitting to simulate being buried in mass concrete or other axial restraining mode (see Figure C.1).

C.3.3.3 After 1 week, load the test pipes axially with the following loads.

Table C.1 — Applied load

Diameter of fitting in	**Load** kN
10	169
12	269
18	548

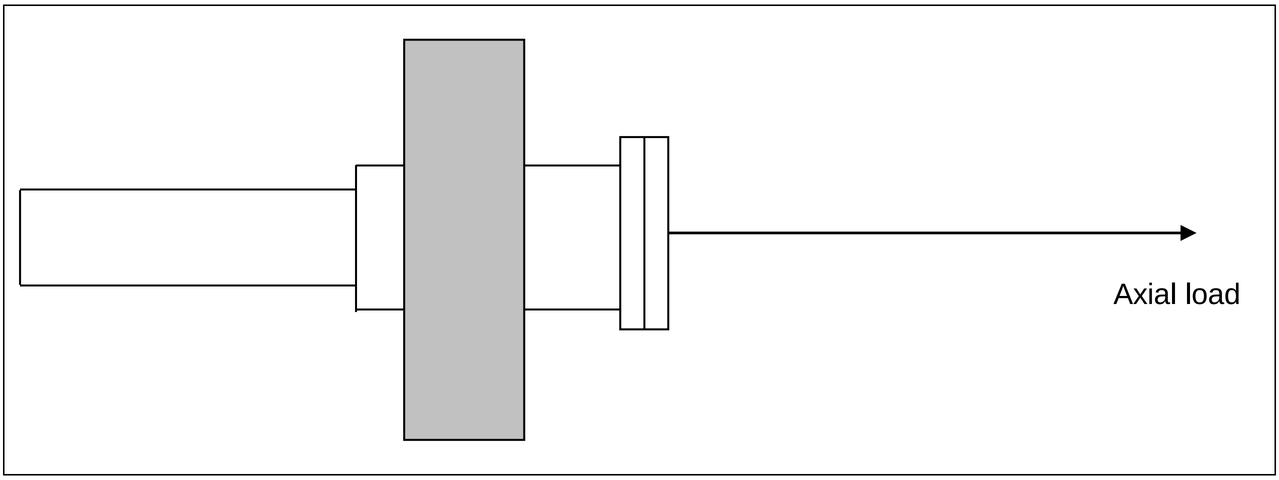


Figure C.1 — Axial load test diagram

C.3.3.4 Apply 3 bar of pressure and maintain the load and pressure for 7 days.

C.3.4 *Results*

No leakage shall occur nor shall any individual component fail. 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.4 Bending moment test

C.4.1 *Principle*

This test is to establish that the fitting will resist the stresses transmitted by the installation components to which it is rigidly secured without unacceptable change in the performance of the fitting at mean temperature between 60 °C and –20 °C.

C.4.2 *Apparatus*

C.4.2.1 *Test pipes*.

C.4.2.2 *Fittings.*

C.4.2.3 *Pressure source*, capable of supplying 3 bar pressure.

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

C.4.2.5 *Means of applying bending moments to the fitting*, up to a value of 40 kNm.

C.4.3 *Procedure*

C.4.3.1 Set up the fitting for a cantilever-bending test (see Figure C.2).

C.4.3.2 Subject the fitting to the required test temperature and then a bending moment applied as specified in Table C.2.

C.4.3.3 Subject the fitting to a standard pressure test for the test duration in Table B.3.

C.4.3.4 The test period shall not commence until the pressure and temperature have stabilized to the required test conditions.

C.4.3.5 The test temperature shall be held to within ±1 °C for the test duration.

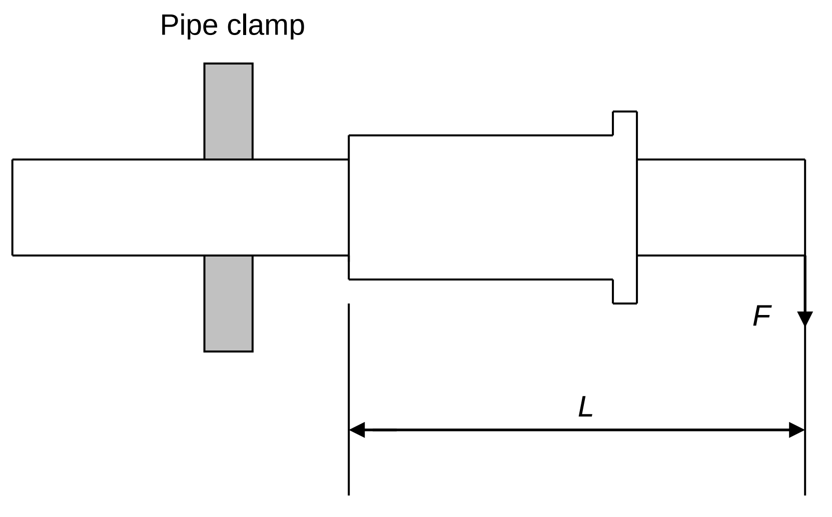
Table C.2 — Bending moment

Nominal size in	**Bending moment** N·m
10	11 000
12	15 000
14	19 000
16	32 000
18	40 000

C.4.4 *Results*

Failure shall not occur when the pressure and bending moment are maintained for a period of seven days.

The apparatus shall be capable of applying the bending moment to an accuracy of ±2 %.



NOTE Bending moment = $F \times L$.

Figure C.2 — Bending strength test

C.5 Elevated temperature test (internal seal and spool/gasket)

C.5.1 *Principle*

This test is to determine that the seal will have sufficient integrity to give assurance that it will perform during its intended life.

C.5.2 *Apparatus*

C.5.2.1 *Test pipes*.

C.5.2.2 *Fittings*.

C.5.2.3 *Pressure source*, capable of supplying 3 bar pressure.

C.5.2.4 *Pressure gauge*, capable of measuring up to 3.5 bar.

C.5.2.5 *Support framework*.

C.5.2.6 *Water immersion bath*, capable of maintaining a temperature of 80 °C.

C.5.3 *Procedure internal seal*

C.5.3.1 Assemble the fittings on the test specimens in accordance with the contractor's instructions.

C.5.3.2 Cap the specimen and install a tie bar to transfer the end loads from the end cap (see Figure C.3).

C.5.3.3 Pressurize the test specimen to 3 bar for a period of not less than 500 h.

C.5.3.4 Suspend the specimen in a water bath at (80 ±2) °C for a period of 500 h.

C.5.4 *Results*

No leakage shall be observed.

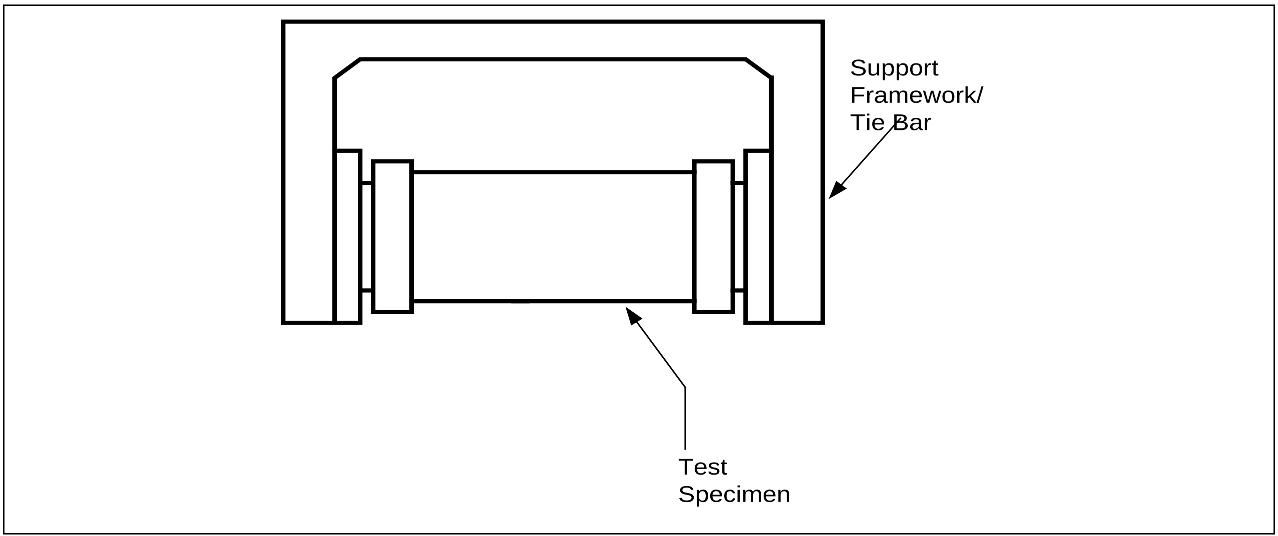


Figure C.3 —Elevated temperature test assembly

C.6 Pneumatic pressure leak test

C.6.1 *Principle*

This test determines the ability of the fitting to be assembled to a test pipe.

C.6.2 *Apparatus*

C.6.2.1 *Pressure source*, capable of being connected to the test specimen and holding the specified test pressure.

C.6.2.2 *Pressure gauge*, fitted to the apparatus*.*

C.6.2.3 *Test pipes*, generally as specified in **C.5.3.1** and **B.3.2**.

C.6.2.4 *Fittings*.

C.6.3 *Procedure*

Attach the test specimen to the pressure source (nitrogen or air) and apply a test pressure of (20 ± 2) mbar for a period of 1 h followed by a further period of 1 h at a pressure of not less than 3 bar.

C.6.4 *Results*

There shall be no leakage from the specimen until the specified time periods have passed.

C.7 Transverse shear test

C.7.1 *Principle*

This test is to determine that the fitting will be able to resist transverse loads that could occur during normal operating conditions.

C.7.2 *Apparatus*

C.7.2.1 *Test pipes*, generally as specified in **C.5.3.1** and **B.3.2**.

C.7.2.2 *Fittings.*

C.7.2.3 *Test rig,* capable of applying the transverse loads into the fitting (see Figure C.4).

C.7.2.4 *Pressure source*, capable of supplying 3 bar pressure.

C.7.2.5 *Pressure gauge*, capable of measuring up to 3.5 bar.

C.7.2.6 *Mass*, of 250 kg.

C.7.2.7 *Means of supporting the test specimen*.

C.7.3 *Procedure*

Apply the load to the fitting for 1 h and conduct the pneumatic pressure leak test as detailed in **C.5.3.1** and **B.3.2**.

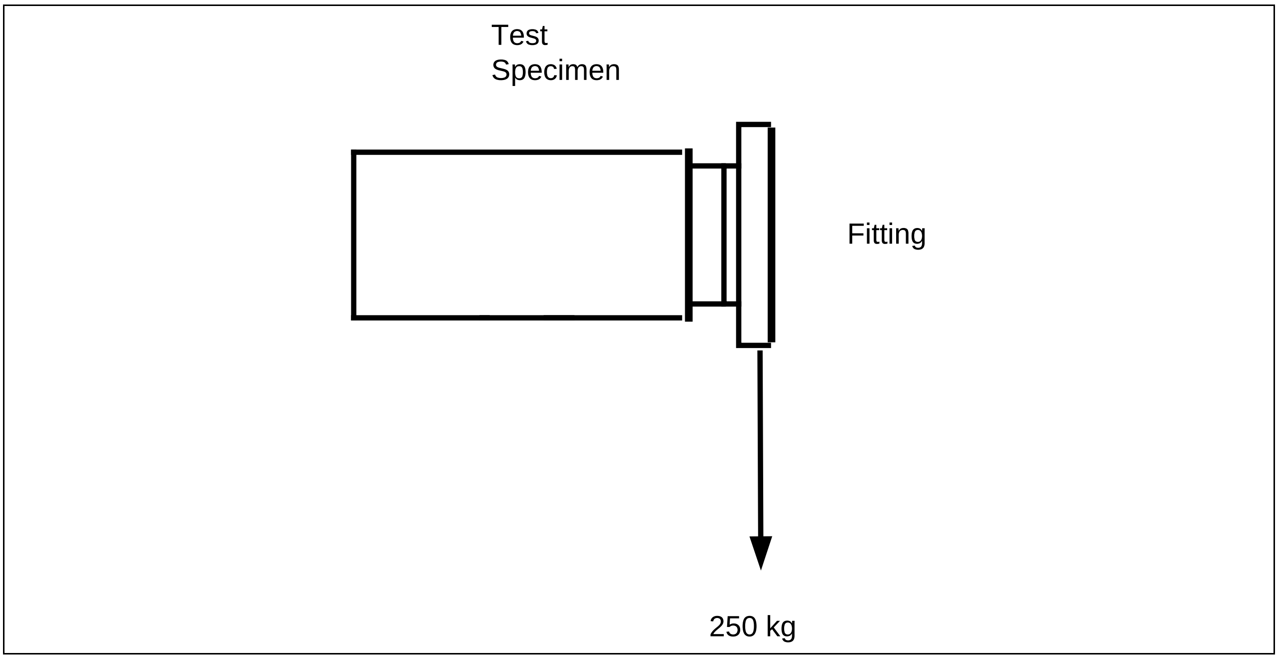


Figure C.4 —Transverse shear test

Annex D (normative)
Phase 2 type approval tests

D.1 Compression ring test

D.1.1 *Principle*

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

D.1.2 *Apparatus*

D.1.2.1 *Test pipes*.

D.1.2.2 *Fittings*.

D.1.2.3 *Pressure source*, capable of supplying 3 bar pressure.

D.1.2.4 *Pressure gauge*, capable of measuring up to 3.5 bar.

D.1.2.5 *Strain gauges.*

D.1.2.6 *Data logger.*

D.1.3 *Procedure*

D.1.3.1 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 D.1a).

NOTE Guidance on the design and use of load cells is given in Annex E.

D.1.3.2 Tighten the fitting to the contractor's recommended torque and adjust the test pipe pressure to 3 bar.

NOTE The maximum interface pressure should not generate excessive load on the parent main and the hoop loads should be calculated or measured and recorded.

D.1.3.3 Store the assembly in air.

D.1.3.4 Record the bolt loads over a period of 10 min to three months after completion of bolt tightening, recording a minimum of two results of average bolt load (F_m) per logarithmic decade of time.

D.1.3.5 Once the 3 month data collection period has elapsed, determine the bolt load (F_1) at which leakage occurs at the test pressure by loosening the bolts progressively, (maintaining the bolt loads as even as possible) until leakage occurs and record the average bolt load at this point. Once the data has been collated, ensure two sets of data are plotted to produce the graph as shown in Figure D.1b).

D.1.3.6 Plot F_m against Log time, as shown in Figure D.1b), and draw a line through the points, based on the least sum of the squares of the errors in the value of F_m. Plot the bolt load (F_1) at which leakage occurs.

D.1.4 *Results*

The extrapolated F_m data gradient shall fall above the minimum bolt load to obtain a seal at 50 years.

The estimated compression load after 50 years shall not be less than the compression load at which leakage occurs (F_1). A graph of F_m against Log time shall be plotted as shown in Figure D.1b) and a line drawn through the points, based on the least sum of the squares of the errors in the value of F_m.

D.2 Inner compression ring relaxation test

D.2.1 *Principle*

This test is a method of determining the useful working life of a fitting that utilizes an inner compression ring to compress an elastomeric seal.

D.2.2 *Apparatus*

D.2.2.1 *Test pipes.*

D.2.2.2 *Fittings.*

D.2.2.3 *Pressure source*, capable of supplying 3 bar pressure.

D.2.2.4 *Pressure gauge*, capable of measuring up to 3.5 bar.

D.2.2.5 *Strain gauges.*

D.2.2.6 *Data logger.*

D.2.3 *Procedure*

D.2.3.1 Assemble each fitting on straight test pipes with a minimum of eight strain gauge load cells fitted around the inner circumference of the compression ring.

NOTE Guidance on the design and use of strain gauges is given in Annex F.

D.2.3.2 It may be necessary to use a specially designed compression ring for the test, but ensure the diameter, material and thickness are the same as that used for the ring normally fitted.

D.2.3.3 Tighten the compression ring to the contractor's recommended compression load and adjust the test pipe pressure to the standard test pressure.

NOTE The maximum interface pressure should not generate excessive load on the parent main and the hoop loads should be calculated or measured and recorded.

D.2.3.4 Store the assembly in air.

D.2.3.5 Record the compression loads over a period of 10 min to 3 months after completion of the tightening of the compression ring, recording a minimum of two results of average compression load (F_m) per logarithmic decade of time.

a) Once the 3 month data collection period has elapsed, then determine the compression load (F_1) at which leakage occurs at the test pressure by iterative means by reducing the compression ring load progressively until leakage occurs and recording the average compression load at this point. To achieve this, it may be necessary to reduce the test pressure to atmospheric pressure and reduce the compression load in increments, each time re-pressurizing to the standard pressure to check for leakage. Where de-pressurizing and re-pressurizing, ensure due care is taken to contain the fitting on the test pipe (see **D.2.3**).

b) Once the data has been collated, plot two sets of data to produce the graph as shown in Figure D.1b).

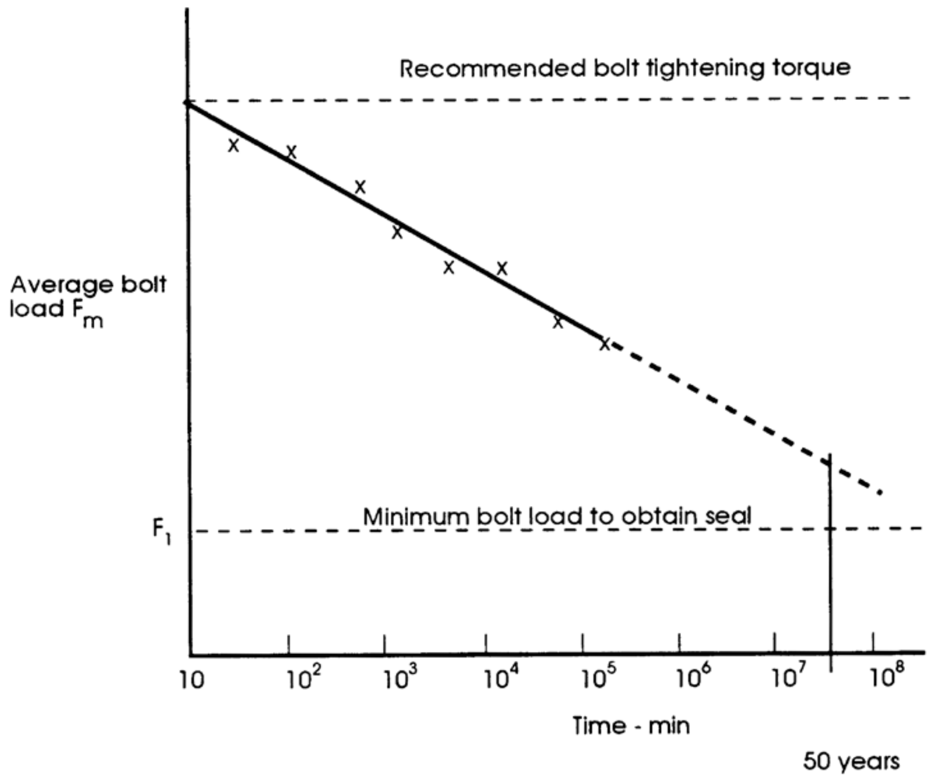
c) Plot F_m against Log time, as shown in Figure D.1b), and draw a straight line through the points, based on the least sum of the squares of the errors in the value of F_m.

Also plot the compression load (F_1) at which leakage occurs by reducing the compression load progressively until leakage occurs and recording the average compression load at this point. To achieve this, it may be necessary to reduce the test pressure to atmospheric pressure and reduce the compression load in increments, each time re-pressurizing to the standard pressure to check for leakage.

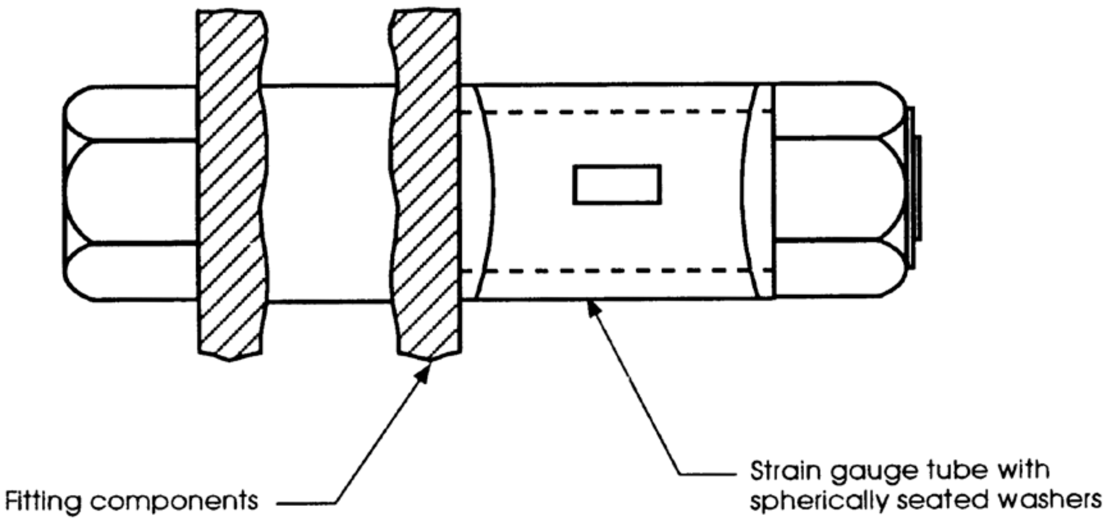
D.2.3.6 Plot a graph of F_m against Log time as shown in Figure D.1b) and draw a straight line through the points, based on the least sum of the squares of the errors in the value of F_m.

D.2.4 *Results*

The extrapolated compression data gradient shall fall above the minimum bolt load to obtain a seal at 50 years. The estimated compression load after 50 years shall not be less than the compression load at which leakage occurs (F_1).



a) Fitting with strain gauge load cell



b) Estimation of bolt load after 50 years relaxation

Figure D.1 — Bolt load relaxation test

Annex E (informative)
Guidance on the design and use of strain gauged load cells

E.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.

E.2 Load cell blank

Details of a typical load cell blank are shown in Figure E.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/m^2) at the maximum design load. The material should be a high yield strength steel, e.g. BS 970-1 605 M 36T (formerly En 16T), which has a minimum yield stress of 680 MN/m^2.

E.3 Strain gauge arrangement

A typical strain gauge arrangement is shown in Figure E.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.

E.4 Instrumentation

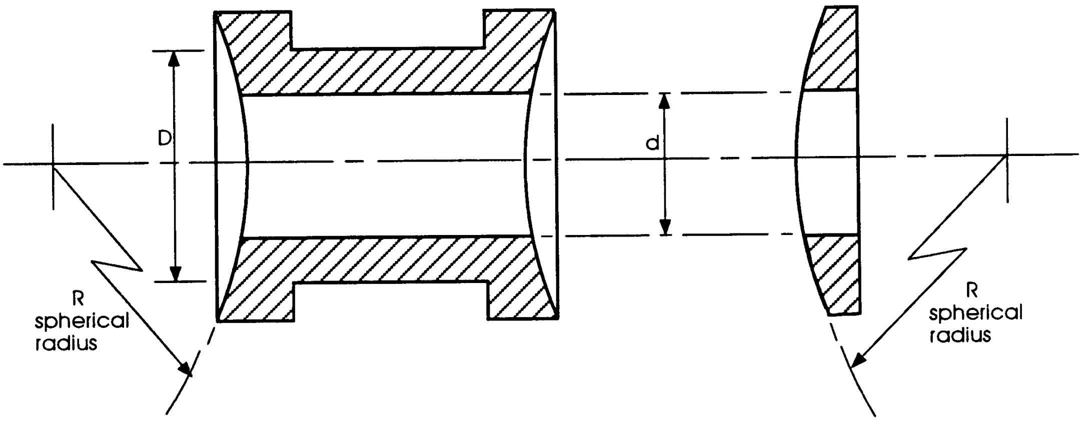
Instrumentation in the form of a stabilized dc power supply and a digital voltmeter with a resolution of 1 mV are needed, connected as shown in Figure E.1c).

E.5 Load cell calibration

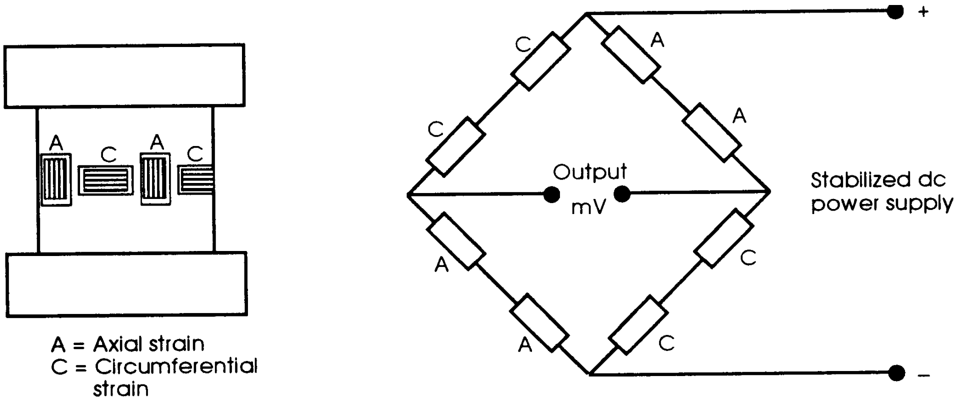
Before a test, each load cell should be calibrated on a compression test machine, to give applied load against millivolt output.

E.6 Load cell stability

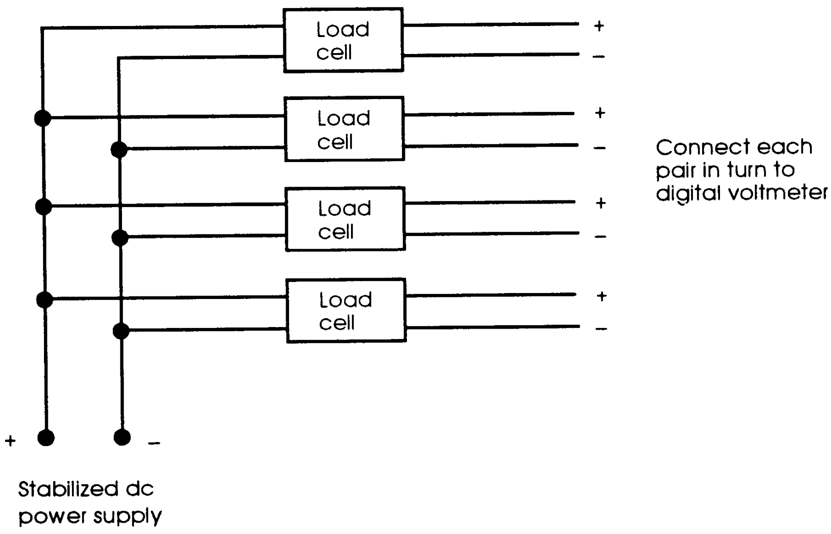
For maximum stability during a test, the load cells should be permanently energized. Before each set of readings, the power supply output should be checked using the digital voltmeter and adjusted as necessary. At the end of the test, the bolt load should be completely released and the new load cell 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.



a) Detail of load cell blank



b) Arrangement of strain gauges on load cell



c) Instrumentation wiring diagram

Figure E.1 — Load cell strain gauge and instrumentation

Annex F (informative)
Guidance on the use of strain gauged load cells used on compression rings

F.1 General

An Engineers strain gauge should be chosen according to the diameter of the compression ring under test. These are covered face gauges that are easier to use compared to open face gauges where solder and other debris can cause problems with partial short circuits of the gauge element.

F.2 Strain gauge arrangement

A typical strain gauge arrangement is shown in Figure F.1. Eight gauges, two full bridge configurations placed around the circumference of the compression ring will measure the average strain in the ring. The two full bridge configurations of the gauges should be positioned at 180° intervals on the centre line around the inside of the compression ring arranged as shown. Two gauges mounted to measure axial strain and the other pair mounted to measure compressive strain.

F.3 Instrumentation and wiring of the gauges

Details of the wiring of the gauges are shown in Figure F.2. The wiring should be kept as short as possible using (screened if possible) twisted pair cable. Electronic amplifier drift over the long test times can mask any change to strain variation and therefore a strain indicator and recorder unit should be used to allow the results to be down loaded directly to a computer without the use of power supplies or separate amplifiers.

F.4 Mounting materials and gauges

For best creep performance over long periods of testing, heat cured epoxy adhesives should be used. Typical cure time and temperatures are 1 h at 95 °C. For shorter test times, Cyanocrylate adhesives can be used where adhesive creep is minimal.

F.5 Strain gauge suppliers – optional

The following information is supplied to contractors as a guide only – users should confirm with the company that items are of the latest specification.

NOTE Advice and parts can be obtained from Measurement Group Ltd. This information is given for the convenience of users of this standard and does not constitute an endorsement by National Grid of this organisation. Equivalent services may be used if they can be shown to lead to the same results.

1) Epoxy adhesiveM Bond AE-15 kit;
2) Protective coatingM Coat D+RTV 3145; or
3) Cyanocrylate adhesiveM Bond 200;
4) CatalystM Bond 200 catalyst;
5) Protective coatingM Coat D+RTV 3145;
6) Cellophane TapePCT-2A (used to position gauges).

Surface preparation procedure for steel (both types of adhesive):

a) CSM-1A Degreaser;
b) 220 – Grit abrasive paper or 320 Grit abrasive paper;
c) gauge location layout;
d) M Prep Conditioner A (Scrub);
e) M Prep Neutralizer 5A.

It is recommended that for this application, the following strain gauge is used as shown in Figures F.1 and F.2:

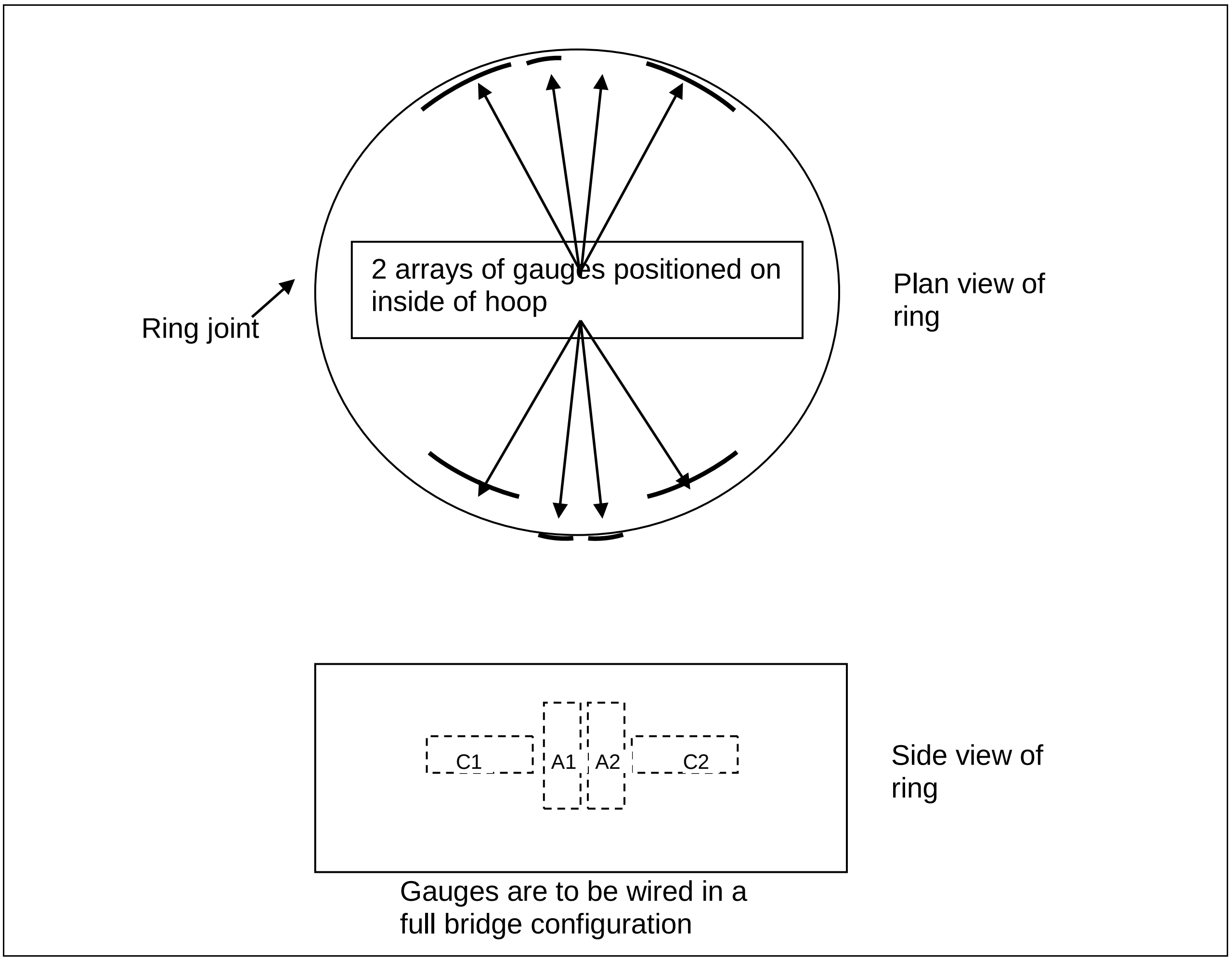


Figure F.1 — Gauge layout

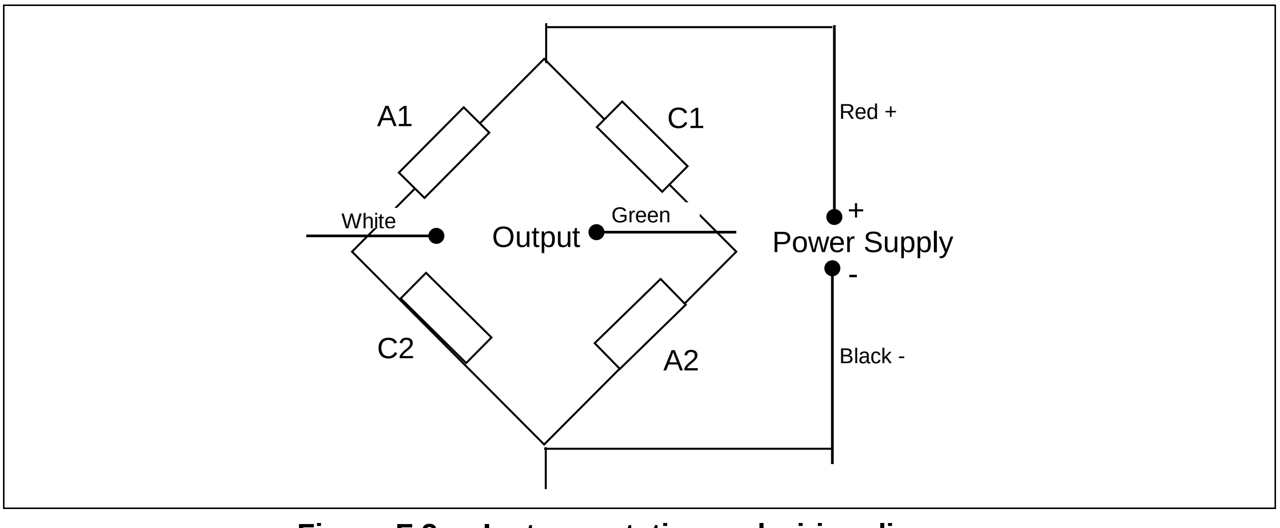


Figure F.2 — Instrumentation and wiring diagram