

Gas Industry Standard

GIS/LC8-3:2006

Specification for

Methods of repairing leaking ferrous gas mains

Part 3: Internal sealing methods

nationalgrid

Northern
Gas Networks 

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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.

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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.

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Brief history

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1 Scope

This Gas Industry Standard specifies the requirements relating to internal methods of repairing leaking ferrous gas mains operating at a maximum working pressure of up to 2 bar. These requirements apply to internal repairs to grey cast iron, ductile iron and steel distribution mains 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

BS 21, *Specification for pipe threads for tubes and fittings where pressure-tight joints are made on the threads (metric dimensions)*.

BS 78:1917, *Cast iron spigot and socket pipes (vertically cast) and spigot and socket fittings*.

BS 903-A15, *Physical testing of rubber — Part A15: Method for determination of creep in compression or shear*.

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

BS 3601, *Specification for carbon steel pipes and tubes with specified room temperature properties for pressure purposes*.

BS 4772, *Specification for ductile iron pipes and fittings*.

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

BS ISO 34-1, *Rubber, vulcanized or thermoplastic — Determination of tear strength — Trouser, angle and crescent test pieces*.

BS ISO 37, *Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties*.

Gas Industry Standards

GIS/LC8-4, *Specification for methods of repairing leaking ferrous gas mains — Part 4: Pipe repair clamps, split collars and under pressure branch connections*.

GIS/PL2-1, *Specification for polyethylene pipes and fittings for natural gas and suitable manufactured gas — Part 1: Pipes for use at pressures up to 5.5 bar*.

GIS/PL2-4, *Specification for polyethylene pipes and fittings for natural gas and suitable manufactured gas — Part 4: Fusion fittings with integral heating element(s)*.

3 Material requirements

3.1 General

All materials shall conform to the relevant British Standard or other recognized standard listed in Table 1.

3.2 Elastomeric compression seals

Elastomeric compression seals shall satisfy the requirements of BS EN 682 for the appropriate class of hardness, with the additional requirements specified in **B.21.3**.

4 General requirements

4.1 General

The repair system and all components shall be designed to provide an effective seal for at least 50 years, without requiring further attention, in the internal and external environments present in and around gas mains.

NOTE The internal surface of a gas main is made up of iron corrosion products which may be contaminated with glycols, liquid aliphatic and aromatic hydrocarbons, tar and possibly water which may have ingressed.

Two distinct types of repair system shall be recognized:

- type (a) for localized repairs (e.g. leaking joints) where the original main continues to act as the primary gas carrying component;
- type (b) for pipe renovation (e.g. structural liners) to take over as the primary gas carrying component following breakage of the original main.

4.2 Safety

All materials used in the repair system shall be subjected to a COSSH assessment to determine if there are any hazards and or special handling requirements.

4.3 Site conditions

The repair system shall be designed for a temperature range of $-5\text{ }^{\circ}\text{C}$ to $30\text{ }^{\circ}\text{C}$.

All repair systems shall be suitable for use under all site conditions.

4.4 Excavation

The repair system shall be designed so as to minimize the size and number of excavations consistent with safety.

4.5 Internal pipe diameters

Repair systems shall be designed to seal pipes and fittings manufactured from:

- a) sand cast grey iron conforming to BS 78:1917;
- b) spun cast grey iron conforming to BS 1211;
- c) ductile cast iron conforming to BS 4772; and
- d) steel conforming to BS 3601.

Repair systems shall be capable of accommodating a wide variation in internal diameters.

NOTE Measurements of a sample of grey cast iron pipes have shown that outside diameters and wall thicknesses can vary between -10 mm and $+7.6\text{ mm}$ and -15% and $+30\%$ respectively of the specified dimensions. Additionally:

- a) steps of up to 15 mm can occur in the pipe bore at joints;
- b) casting defects can be present in the form of flat spots or protrusions;
- c) larger diameter pipes (e.g. 20 in) can exhibit significant ovality.

4.6 Joint gaps and pipe movement

The repair system shall be capable of sealing joint gaps in the range 1 mm to 50 mm , dependent on the pipe diameter. However, larger joint gaps in fittings can be encountered. The seals shall be capable of withstanding subsequent movement of the ends of the pipes.

4.7 Cranked joints

The repair systems shall be capable of traversing and sealing joints deflected through an angle of 4 °C.

4.8 Surface preparation and cleaning

The contractor shall specify the surface preparation for the application of the repair system. This preparation shall have no deleterious effect on the main.

The contractor shall carry out this surface preparation and cleaning, and also remove all loose material from the main, including any which may be caused by the repair process.

4.9 Connection to existing mains system and fitting of services

In the case of a liner system, the contractor shall provide means of connecting new and existing services and of reconnecting the repaired main to the existing mains network.

4.10 Subsequent repairs

For type (b) liner systems, the contractor shall provide means of rectifying interference damage to the liner and of making reconnections to lined mains from which “cut-outs” have been performed.

4.11 Reduction in pipe bore diameter

The reduction in pipe bore diameter due to the fitting of the repair shall be such that the system maintains at least 85 % of the original flow capacity (see Annex A).

5 Performance requirements

The internal sealing system shall satisfy the requirements of Annex B 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 and phase 2 (see Annex B).

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. materials, manufacturing techniques, safety and application instructions.

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

Table 1 — Basic properties of the repair materials

Item	Material property	Test method	Test conditions and general comments
A			
1	Viscosity	Couette flow, cone and plate or other suitable method	Application temperature $-5\text{ }^{\circ}\text{C}$ to $+30\text{ }^{\circ}\text{C}$. Shear rates over range related to method of application
2	Yield stress (or maximum non-slump coating thickness)	Slump rate, comb test or viscometer data	Temperature as in item 1. Over range of recovery times appropriate to mixing and method of application
3	Specific gravity (SG)	A suitable SD test method for the material used	Temperature $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$
4	Shelf life	The sealing materials shall meet the full standard shelf life period	Storage $-5\text{ }^{\circ}\text{C}$ to $+30\text{ }^{\circ}\text{C}$
B			
5	Gel time	Tecam or other standard method	Ambient temperature range $-5\text{ }^{\circ}\text{C}$ to $+30\text{ }^{\circ}\text{C}$
6	Safe working life (pot life)	<p>This test is specific to materials whose cure commences on mixing the components</p> <p>Store the components at the designated temperature ($-5\text{ }^{\circ}\text{C}$, $+5\text{ }^{\circ}\text{C}$, $+15\text{ }^{\circ}\text{C}$ and $+30\text{ }^{\circ}\text{C}$) for 24 h</p> <p>Mix as per manufacturer's instructions</p> <p>Monitor the change in viscosity of mixture maintained at the designated temperature</p> <p>Record the time taken to reach the viscosity stated by the manufacturer to be the maximum acceptable for the recommended application method. This shall be noted as the 'safe working life' at the temperature</p>	Ambient temperature range $-5\text{ }^{\circ}\text{C}$ to $+30\text{ }^{\circ}\text{C}$

Item	Material property	Test method	Test conditions and general comments
7	Shrinkage/cracking (relaxation of shrinkage stress)	<p>Coatings, three times thickness normally applied. Mix (or otherwise prepare) the material as per the manufacturer's instructions</p> <p>Coat a clean and degreased mild steel plate, 250 mm × 50 mm to a thickness three times that recommended by the manufacturer. (Depending on the viscosity of the mixture, it may be necessary to place a retaining piece around the plate thus converting it into a dish)</p> <p>Allow the cure under simulated system application conditions</p> <p>Visually examine the cured material for cracking and/or thermal warping</p> <p>The coating shall be visually flat and crack-free</p>	Temperature 23 °C ± 2 °C
8	Time to become fully operational	<p>Store the components at the test temperature for 24 h before use</p> <p>Mix the materials (under the specified conditions) and maintain at the test temperature until a physical property designated by the manufacturer reaches the value stated by the manufacturer to be adequate to meet operational requirements</p>	<p>Temperature 0 °C, 10 °C, 20 °C (all ±2 °C). Basic mix ratio and ±10 % basic mix ratio</p> <p>Temperature 23 °C ± 2 °C:</p> <p>a) exposure of components to 90 % to 100 % relative humidity for 24 h before mixing;</p> <p>b) 0.1 %, 0.5 % and 1 % distilled water added at time of mixing</p>

Item	Material property	Test method	Test conditions and general comments
9	Gassing/foaming during curing	<p>Mix the material under the specified (see item 8) conditions, and allow to cure</p> <p>Mix the material under dry conditions, with no added water and allow to cure</p> <p>The products cured under wet conditions shall not exhibit signs of gas evolution when compared with the dry cured material</p> <p>The SG of the products cured under wet conditions shall not vary from that of the dry cure material by more than 1 %</p>	<p>Temperature 23 °C ± 2 °C. Basic mix ratio and ±10 % basic mix ratio</p> <p>As for item 8 above</p>
C 10	<p>Fully cured and dried material</p> <p>Adhesive/cohesive strength. Maximum stress and extension at maximum stress.</p> <p>Mode to failure</p>	Cleavage test lapshear or other suitable test. (Three samples per test point)	<p>Temperature 23 °C ± 2 °C. Pull rate 10 mm/min ± 1 mm/min. Cure time 3 days, 7 days, 14 days, 21 days and 28 days. Basic mix ratio and ±10 % basic mix ratio</p> <p>Temperature 23 °C ± 2 °C. Pull rate 10 mm/min ± 1 mm/min. Basic mix ratio. Environments:</p> <ul style="list-style-type: none"> – tap water; – monoethylene; – glycol, distillate (50% saturated vapour) <p>Full immersion results for minimum of 2 days, 7 days, 14 days, 21 days and 28 days, then test at 28-day intervals for 52 weeks (full acceptance)</p>

Item	Material property	Test method	Test conditions and general comments
D	Fully cured or dried materials		
11	Tensile strength. Maximum stress and strain at break. Modulus at 100 % strain	Type 1 dumb-bells to BS ISO 37 (three samples per test point)	Temperature 23 ° ± 2 °C. Pull rates 1 mm/min, 10 mm/min and 100 mm/min (cure time to be agreed). Basic mix ratio ±10 % basic mix ratio
12	Tear resistance (as appropriate)	BS ISO 34-1	As in item 10. Test after 7 days cure at 23 °C ± 2 °C, test at cross-head speeds of 1 mm/min, 10 mm/min and 100 mm/min. Basic mix ratio
13	Phase changes and transitions	Differential thermal analysis or other standard method	As in item 10 Temperature range to cover operating range
14	Item 10 (cleavage) and item 11 (tensile)		Shall be repeated at temperatures to cover the claimed operating temperature range using basic mix ratio, pull rate of 10 mm/min and 7 days cure
E	Elastomeric seals		
15	Items 11, 12 and 13		
16	*Stress relaxation: in air	Residual stress measurement of cylindrical samples (14.3 mm diameter × 635 mm long) (conforming to BS 903-A15, Test 4.2) under 20 % uniaxial compression strain. Three samples per test point	Test intervals at 0.1 days, 0.2 days, 0.3 days, 1 day, 2 days, 5 days, 7 days, then weekly to 52 weeks or to 20 % residual stress, whichever occurs first. Temperature 20 °C, 70 °C, 100 °C, 120 °C (all ±1 °C)
17	*In 'gas main' environments	As item 16. Samples stored completely immersed	Test intervals 0 weeks, 1 week, 10 weeks, 50 weeks. Temperature 23 °C ± 1 °C Environments: – tap water, monoethylene glycol, distillate (50 % saturated vapour)
F	Hose liners		
18	Polymer coating thickness	Travelling microscope	Dependent on size of liner

Item	Material property	Test method	Test conditions and general comments
19	Tensile strength	25 mm wide strip	Test at cross-head speed of 1 mm/min, temperature 23 °C ± 1 °C Environments: – tap water, monoethylene glycol, distillate (50 % saturated vapour) 0 and 28 day immersion (limited acceptance) and 52 weeks (full acceptance)
20	Burst pressure	A suitable hydrostatic pressure test. 50 mm diameter pressure cell is shown in Figure 1	Temperature 23 °C ± 1 °C. Full scale tests on unsupported hose to be performed by manufacturer
21	Polymer/fibre adhesive	50 mm diameter pressure cell as shown in Figure 1	Temperature 23 °C ± 1 °C. Reverse burst test to detach polymer from fabric
G 22	Polyethylene All properties		Shall conform to GIS/PL2-1 before and after deformation
NOTE 1 Stress relaxation measurement should be carried out using a standard instrument.			
NOTE 2 Tests marked with an asterisk (*) should be completed for phase 2 testing.			

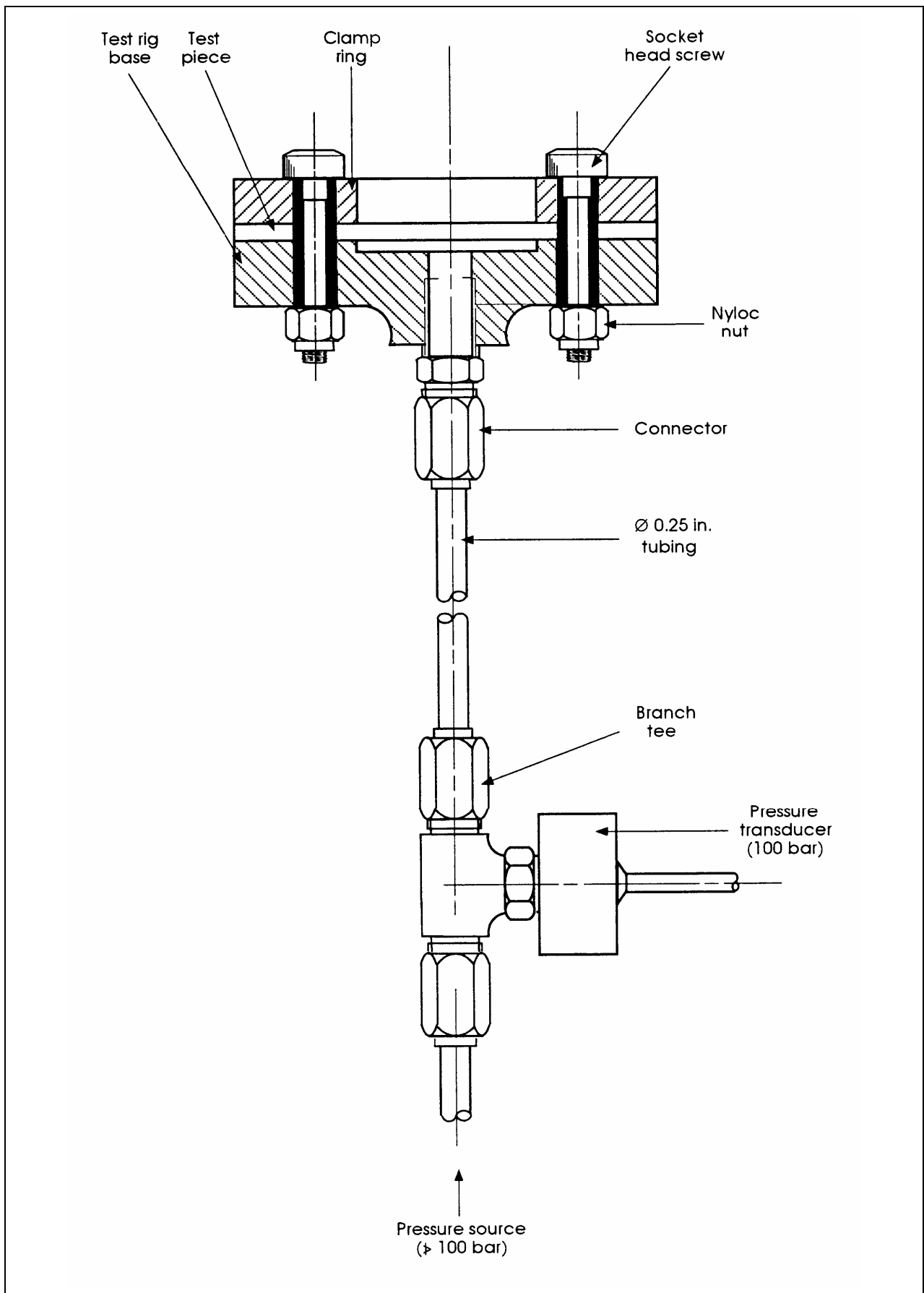


Figure 1 — 50 mm diameter pressure cell

7 Marking

Products conforming to GIS/SP/LC8-3 shall be permanently marked with the following information:

- a) the number and date of this standard, i.e. GIS/SP/LC8-3:2006¹⁾);
- b) the name or trademark of the manufacturer or their appointed agent;
- c) the manufacturer's contact details;
- d) 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/SP/LC8-3:2006 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 Introduction**

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 gas carrying capacity is due to pipe surface roughness.

This annex applies to lining systems which are considered hydraulically smooth, i.e. 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 and results

The average bore of the lined pipe shall be obtained at five separate positions along the pipe and an average value obtained.

The efficiency of the system shall be calculated from the following formula:

$$\text{Efficiency} = \left(1 - \frac{\text{Bore of CI main} - \text{Bore of lined pipe}}{\text{Bore of CI main}} \right) \frac{5}{2}$$

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

Annex B (normative)

Type approval testing of internal sealing system

B.1 General

B.1.1 The contractor shall carry out a full scale demonstration of the repair system. The following phase 1 system performance approval tests shall be carried out on joints removed from the sealed pipe.

Type (a)

- a) Internal pressure (see **B.7**).
- b) Short term water back pressure (see **B.8**).
- c) Axial pull (joint) (see **B.9**) (not required for unrestrained structural liners).
- d) Short term continuous deflection (joint) (see **B.10**).
- e) Vibration (joint) (see **B.11**).

Type (b)

- f) Axial pull (pipe) (see **B.12**).
- g) Short term continuous deflection (pipe) (see **B.13**).
- h) Vibration (pipe) (see **B.14**).
- i) Shear test (pipe) (see **B.15**).
- j) Short term internal pressure (pipe) (see **B.16**).
- k) Water back pressure (self-supporting liners) (see **B.17**) (for non-adhered liners).
- l) Impact test (pipe and liner) (see **B.18**).

Type (b) liner and full internal pipe coating systems shall meet the following additional requirements.

- m) Fining of new or existing services (see **B.19**).
- n) Reconnection of liner systems (see **B.20**).

B.1.2 A field demonstration shall be carried out by the contractor to verify the repair system under field conditions and the effectiveness of leak sealing in the short term under different ambient conditions and to establish the costs involved.

The site will be made available by the gas transporter.

B.2 System performance testing

B.2.1 General

B.2.1.1 Table B.1 shows the test requirements for specific systems.

B.2.1.2 A minimum of 12 joints shall be required. Table B.2 details the number of test joints required for the various test clauses together with the time scale for each performance test. The test rig will contain leaking and non-leaking joints.

A minimum of six butt joints shall be required. Table B.1 for type (b) details the schedule of testing using butted joints for renovation systems.

B.2.1.3 All test work shall be carried out on a single pipe diameter. The pipe shall normally be 150 mm nominal bore, except for repair systems applied by entry of personnel, when the pipe shall be 600 mm nominal bore. Additional testing shall be carried out to ensure that the design is suitable for the whole range of pipe sizes offered.

B.2.1.4 A repair system shall be considered to have failed when leakage occurs through the repair, or when any repair system component exhibits visual evidence of cracking or severe distortion. In cases where significant cracking or severe distortion, which may lead to premature failure, is apparent, this shall be checked with a standard destructive or non-destructive method.

B.2.1.5 The contractor's recommended maximum working pressure is the maximum pipe pressure which the contractor considers the repair system will satisfactorily withstand for a design life of 50 years.

B.3 Preparation of test joints

B.3.1 If the pipe used is jointed ductile iron, it shall be assembled without circlips.

B.3.2 All the pipe joints shall be assembled straight with the exception of the test pipe (see **B.4.4**) where the pipe joints are deflected through 4°. Three joint gaps shall be used: 1 mm (butted up), 10 mm and 50 mm.

B.3.3 Each joint shall be provided with tappings at the top and bottom of the socket for back-pressure testing. Leakage may be induced through the tappings or through the joint.

B.3.4 For liner and total internal coating systems, each pipe length shall be fitted with a line of 3/4 in BSP tapped holes conforming to BS 21 with adjacent holes spaced at approximately 45°.

B.3.5 For type (b) repairs, three pairs of pipe lengths shall be butted together with no visible gaps. An additional three pairs of pipe shall be assembled in line with a 50 mm gap. The gaps shall be temporarily filled during the lining process by an axially split 50 mm length of pipe, coated with release agent compatible with the lining system, held in place by a pipe repair clamp. (This will prevent over-expansion of liners at these points.) At least one pair of pipe lengths should be cast iron.

B.3.6 The pipe inner surface shall be coated with bitumenized, lean sand/cement mixture (see Annex C) applied to a minimum thickness of 1 mm and allowed to harden for 7 days. The internal surface shall be wetted with distillate, water and glycol.

B.3.7 Compressed air or nitrogen shall be used as the pressurizing medium for leakage testing. The methods for determining leakage and test pressure are specified in each test clause.

B.3.8 The test sections of pipe shall be provided with suitable anchorages to the ground to enable the pressure testing to be carried out safely.

B.4 Testing the application of the repair system

B.4.1 Only the cleaning, surface preparation and application methods which the contractor proposes to use on site shall be used when applying the repair system to the test sections of pipe.

B.4.2 For repair systems applied to the 150 mm nominal size pipe, a minimum of 12 joints shall be sealed. These shall be located within a rig at least 50 m long.

B.4.3 Three joints shall have a 1 mm joint gap and three joints shall have a 50 mm joint gap.

B.4.4 Three joints shall have a 10 mm joint gap and then be deflected through 4°.

B.4.5 Three joints shall have a 10 mm joint gap and water ingressing.

B.4.6 For type (b) repairs, six pairs of butted plain pipe ends shall be included.

B.4.7 Three pairs of pipe ends shall be butted with no visible gap and three pairs shall have a 50 mm gap, enclosed as in **B.3.5**.

B.4.8 The test rig shall include bends, tees and service fittings.

B.4.9 For repair systems applied by the entry of personnel, sealing of 12 discrete joints shall be carried out. These shall have the joint gaps as specified in **B.4.3**, **B.4.4** and **B.4.5**.

B.4.10 After application, each test section of the repaired pipe shall be subjected to the testing sequence specified in **B.6**.

B.5 Application on a pipe where there is water ingress at the joints

B.5.1 A standpipe arrangement shall be fitted to the upper tapped hole specified in **B.3.3** on each joint so that a 2 m head of water (equivalent to a pressure of 196 mbar) measured from the top of the pipe can be maintained at each joint.

B.5.2 Each standpipe shall be fitted with a control device to set the input of water into the pipe on each standpipe to 1 ml/min.

B.5.3 The head of water (see **B.5.1**) shall be maintained during the entire cleaning and repair operation, including any cure time of the repair material.

B.5.4 Only methods which would normally be used on site shall be used to diagnose, locate and overcome water ingress into the pipe.

B.5.5 All stand pipes shall be removed before commencing the testing specified in **B.6**.

B.6 Test sequence of the repair joints (type (a) repairs) and of the renovated pipe (type (b) repairs)

B.6.1 Test sequence of the repair joints (type (a) repairs)

Each of the repaired joints shall be subjected to internal pressure (see **B.7**), short term water back pressure (see **B.8**), axial pull (see **B.9**), short term continuous deflection (see **B.10**) and vibration (see **B.11**) tests in sequence. Liner and full pipe internal coating systems shall be subjected to the additional tests specified in **B.19** before the axial pull test (see **B.9**).

B.6.2 Test sequence of the renovated pipe (type (b) repairs)

Each of the close-butted pipe pairs shall be subjected to axial pull (see **B.12**, with the exception of unrestrained liners) deflection (see **B.13**) vibration (see **B.14**) and shear (see **B.15**). Each of the 50 mm gap butt jointed pairs shall be subjected to internal pressure (see **B.16**) and unsupported impact (see **B.18**). Liner end seals shall be fitted to three pipe sections and the water back pressure test (see **B.17**) performed on non-adhered liners. Two impact tests (see **B.18**) shall be performed on the cast iron pipe lengths.

B.7 Internal pressure

B.7.1 An internal pressure of 1.5 times the contractor's recommended maximum working pressure or 350 mbar, whichever is the greater, shall be applied to the test sections.

B.7.2 An internal test pressure of 1.5 times the contractor's recommended maximum working pressure subject to a minimum test pressure of 350 mbar shall be maintained for a period of 48 h. Thereafter, a pressure of 1.5 times the contractor's recommended maximum working pressure shall be maintained for 1 month. No failure shall occur.

B.8 Short term water back pressure

B.8.1 With no internal pressure in the pipe, a back pressure of 2 m head of water measured from the top of the pipe shall be applied to the tappings on the sockets and, if applicable, on the pipe lengths.

B.8.2 The back pressure shall be maintained for a period of 1 month and no leakage shall occur through the repair.

B.8.3 When under back pressure there shall be no evidence of disbondment or collapse of the repair.

B.9 Axial pull (joint)

Each repaired joint (excluding the cranked joints) shall satisfy the following test requirements.

- a) Each repaired joint shall be axially displaced at a rate of 0.25 mm/h until the axial displacement reaches 3 mm.
- b) The displacement of 3 mm shall be maintained while an internal pressure of 138 mbar (to permit leak detection) is applied to the repaired joint.
- c) The displacement specified in a) above shall be maintained for 7 days with an internal pressure of 1.5 times the contractor's recommended maximum working pressure. No failure shall occur.

B.10 Short term continuous deflection (joint)

B.10.1 In **B.10**, "joint deflection" is defined as the angle between the centre line of the pipe and the centre line of the pipe socket.

B.10.2 Each repaired joint shall satisfy the specified test requirements.

B.10.3 The preferred method of deflecting the pipe joint shall be to hold the socket end stationary and to deflect the spigot end. The axis of rotation shall be in the plane of the socket face.

B.10.4 An internal pressure of 138 mbar (to permit leak detection) shall be applied to the repaired joint and the pressure maintained during the testing.

B.10.5 The repaired joint shall be deflected at a constant rate of $1\%/min \pm 0.1\%/min$.

B.10.6 The joints shall be deflected by $1^\circ \pm 0.1^\circ$ so as to increase the original crank angle. They shall be held at this angle for 7 days with an internal pressure of 1.5 times the contractor's recommended maximum working pressure. No failure shall occur.

B.11 Vibration (joint)

B.11.1 Each repaired joint shall satisfy the specified test requirements.

B.11.2 Internal pressure shall be maintained in the test joints during the periods of vibration. This pressure shall be 138 mbar (to permit leak detection).

B.11.3 The preferred method of vibration shall be to hold the socket end of the pipe stationary and to vibrate the spigot end.

B.11.4 The repaired joint shall be vibrated at a frequency of $1 \text{ Hz} \pm 0.1 \text{ Hz}$ continuously between limits of 0° and $0.1 \pm 0.01^\circ$ to the original axis.

B.11.5 The joint shall be vibrated for a total 1×10^6 cycles.

B.11.6 Following this test an internal pressure of 1.5 times the contractor's recommended maximum working pressure shall be applied for one week. No failure shall occur.

B.12 Axial pull (pipe)

End-seals shall be fitted to the close-butt pipe pair which shall satisfy the following axial pull (pipe) test requirements.

- a) Each pipe pair shall be axially displaced at a rate of 12.5 mm/h until the axial displacement reaches 3 mm.
- b) The displacement of 3 mm shall be maintained while an internal pressure of 138 mbar (to permit leak detection) is applied to the repaired pipe.
- c) The displacement specified in a) above shall be maintained for seven days with an internal pressure of 1.5 times the contractor's recommended maximum working pressure. No failure shall occur.

B.13 Short term continuous deflection (pipe)

B.13.1 In **B.13**, "pipe deflection" is defined as the angle between the centre line of the pipe lengths.

B.13.2 Each pipe pair shall satisfy the specified test requirements.

B.13.3 An internal pressure of 138 mbar (to permit leak detection) shall be applied to the repair and the pressure maintained during the testing.

B.13.4 The pipe pairs shall be deflected as a constant rate of $1 \pm 0.1 \%$ /min.

B.13.5 The pipe shall be deflected by $1 \pm 0.1^\circ$. They shall be held at this angle for seven days with an internal pressure of 1.5 times the contractor's recommended maximum working pressure. No failure shall occur.

B.14 Vibration (pipe)

B.14.1 Each repaired pipe pair shall satisfy the specified test requirements.

B.14.2 Internal pressure shall be maintained in the test pipes during the periods of vibration. This pressure shall be 138 mbar (to permit leak detection).

B.14.3 The pipe pair shall be vibrated at a frequency of $1 \text{ Hz} \pm 0.1 \text{ Hz}$ continuously between limits of 1° and $1.1 \pm 0.01^\circ$ and $0.1^\circ \pm 0.01^\circ$ to the original axis.

B.14.4 The pipe shall be vibrated for a total 1×10^6 cycles.

B.14.5 Following this test an internal pressure of 1.5 times the contractor's recommended maximum working pressure shall be applied for one week. No failure shall occur.

B.15 Shear test (pipe)

B.15.1 Each pipe pair shall satisfy the specified test requirements.

B.15.2 An internal pressure of 138 mbar (to permit leak detection) shall be applied to the repair and pressure maintained during the testing.

B.15.3 The pipe pair shall be laterally displaced at a rate of 12.5 mm/h in 12.5 mm steps. Each step shall be held for 1 h up to a maximum shear when the offset shall be equal to 25 % of the nominal pipe diameter.

B.15.4 The displacement shall be maintained for 7 days with an internal pressure of 1.5 times the contractor's recommended maximum working pressure. No failure shall occur.

B.16 Short term internal pressure (pipe)

B.16.1 The short term internal pressure (pipe) test shall be performed on pipe pairs with 50 mm gaps, after the constraining clamps have been removed.

B.16.2 An internal pressure of twice the contractor's recommended maximum working pressure shall be maintained for 7 days. No failure shall occur.

B.16.3 A hydrostatic internal pressure of five times the contractor's recommended maximum working pressure shall be maintained for 1 h. No failure shall occur.

B.17 Water back pressure (self-supporting liners)

B.17.1 The water back pressure (self-supporting liners) test shall be performed on pipe pairs with 50 mm gaps, after the constraining clamps have been replaced by a LC8-4 tapped bossed repair clamp (glanded) spanning the exposed liner.

B.17.2 With no internal pressure in the pipe, a back pressure of 5 m head of water, measured from the top of the pipe, shall be applied via the bossed clamp.

B.17.3 The back pressure shall be maintained for 1 month and there shall be no evidence of collapse of the liner.

B.18 Impact test (pipe and liner)

B.18.1 An impact test shall be performed both on the exposed liner (using the pipe pairs with 50 mm gaps with the protection clamps removed) and on lined cast iron pipe lengths.

B.18.2 The pipe shall be mounted horizontally in "vee" blocks.

B.18.3 The impact shall be applied at top dead centre with a tool as shown in Figure B.1.

B.18.4 The exposed liner and the lined cast iron pipe shall be subjected to one blow of energy 135 J resulting from a free fall of the tool from a height of between 1.5 m and 3 m.

B.18.5 An internal pressure of 1.5 times the contractor's recommended maximum working pressure shall be maintained for 7 days. No failure shall occur.

B.19 Fitting of new or existing services

B.19.1 The contractor shall demonstrate that services can be satisfactorily fitted to the repaired pipe. A minimum of four service connections shall be made. For polyethylene pipe conforming to GIS/PL2-1, these shall be fittings conforming to GIS/PL2-4.

B.19.2 The repaired main shall be capable of being cleanly drilled (and tapped if applicable) using standard drilling and tapping equipment.

B.19.3 When the fitting has been installed there shall be no leakage between the lining and the pipe wall when the test pipe is pressurized to 1.5 times the contractor's recommended maximum working pressure. This pressure shall be maintained for 1 month.

B.19.4 Where a non-standard service fitting is used, fitness for purpose shall be demonstrated.

B.20 Reconnection of liner systems

B.20.1 The contractor shall demonstrate the reconnection of the liner to the existing main. A minimum of four reconnections shall be made.

B.20.2 Two of the reconnections shall be subjected to the pressure test specified in **B.7**.

B.20.3 Two of the reconnections shall be subjected to the water back pressure test specified in **B.8**.

B.21 Testing of elastomeric compression seal components

B.21.1 Elastomeric materials subject to compression as a necessary part of the seal shall conform to BS EN 682 and shall satisfy the compression set and the stress relaxation tests set out in Table 1, items 15, 16 and 17.

B.21.2 The contractor shall demonstrate that after 50 years relaxation there would still be adequate loading on the seal for the repair system to meet the requirements of the internal pressure (see **B.7**) and short term water back pressure tests (see **B.8**).

B.21.3 The contractor shall provide the gas transporter with the following data (see Table 1):

- a) item 16, stress relaxation in air at 23 °C and 100 °C for 14 days;
- b) item 17, after 14 days in "gas main" environments.

Acceptable results for Item 16 are as follows:

- 1) at 14 days at 23 °C, stress relaxation per decade shall be equal to or less than 6 %;
and
- 2) at 14 days at 100 °C percentage retained stress shall be equal to or greater than 40 %.

For item 17, the percentage retained stress shall not change by more than 10 % of the value in air.

B.22 Phase 2 testing

B.22.1 Outstanding tests from Table 1

Outstanding tests marked with an asterisk in Table 1 shall be completed in full.

B.22.2 General

Tests specified in **B.22.3**, **B.22.4** and **B.22.5** shall be carried out on the same joints that were used in the corresponding short term performance testing (see **B.10**).

B.22.3 Axial pull

B.22.3.1 The provisions of **B.9a)** and **b)** shall apply.

B.22.3.2 Six joints shall be used in this test. These shall be the three joints with the 1 mm joint gap (see **B.4.3**) and the three joints which were sealed against ingressing water [10 mm joint gap (see **B.4.5**)].

B.22.3.3 The spigot shall be pulled 3 mm from the socket and then returned to its original position at a frequency of three cycles per day for 50 cycles while an internal pressure of 138 mbar (to permit leak detection) is applied to the repaired joint.

B.22.3.4 Following this test, an internal test pressure of 1.5 times the contractor's recommended maximum working pressure shall be applied for 1 week. No failure shall occur.

B.22.4 Long term water back pressure

B.22.4.1 With no internal pressure in the pipe, a back pressure of 2 m head of water measured from the top of the pipe shall be applied to the tappings on the sockets and, for liner and full internal pipe coating systems on the pipe lengths

B.22.4.2 This test shall be carried out on six repaired joints. These shall be the three joints with the 10 mm joint gap (see **B.4.5**) and the three joints with the 50 mm joint gap (see **B.4.3**).

B.22.4.3 The back pressure shall be maintained for a period of 6 months and no leakage shall occur into the bore of the pipe. The diameter of the repair at any point shall be recorded to within ± 1 mm and over 6 months there shall be no significant reduction in diameter over this period.

B.22.5 Pressure/life test

The pressure/life test shall be performed on unrestrained liners, using pipe pairs with 50 mm separation, after removal of the constraining clamps. The test conditions shall be as follows.

- a) Three liners shall be subject to a pressure which will ensure failure between 1 h and 3 h. The pressure at which failure occurs, P , and the time to failure, T_p , shall be noted.
The results shall be plotted on a log/log plot of pressure against time in minutes of the type shown in Figure B.2.
- b) Three liners shall be pressurized and held at a pressure, P_1 , a second set of three liners at a pressure of P_2 and a third set of three liners at a pressure of P_3 .
- c) P_1 shall be established 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_{mw}). P_1 shall be the pressure corresponding to 6 months on the time axis.
- d) P_2 and P_3 shall be determined to give points equidistant on a logarithmic scale between P_1 and P .
- e) The duration of the tests shall be either 6 months or until a failure occurs, whichever is the shorter period.

- f) The results obtained shall be plotted on the graph to show the failure band. When the lower edge of the failure band is extrapolated to 50 years, the corresponding pressure shall not be less than 1.5 times the contractor's maximum recommended working pressure.

B.22.6 External buckling

The external buckling test shall be performed on unrestrained liner, using pipe pairs with 50 mm separation. After replacement of the constraining clamps by pressurizing devices such as tapped bossed split collars (cast iron split collars conforming to LC8-4 and rated for use up to 7 bar have been pressure tested to 10.5 bar), hydrostatic pressure can be applied to the exposed liners via the tapping on the split collar. The liner shall not be internally pressurized during the test. The test conditions shall be as follows.

- a) Three liners shall be subject to a pressure which will ensure failure between 1 h and 3 h. The pressure at which failure occurs, P , and the time to failure, T_p , shall be noted. The results shall be plotted on a log/log plot of pressure against time in minutes of the type shown in Figure B.2.
- b) Three liners shall be pressurized and held at a pressure, P_1 ; a second set of three liners at a pressure of P_2 and a third set of three liners at a pressure of P_3 .
- c) P_1 shall be established by drawing a straight line joining the initial point (T_p , P) to the 50 year/pressure point (0.5 bar). P_1 shall be the pressure corresponding to 6 months on the time axis.
- d) P_2 and P_3 shall be determined to give points equidistant on a logarithmic scale between P_1 and P .
- e) The duration of the tests shall be either 6 months or until a failure occurs, whichever is the shorter period.
- f) The results obtained shall be plotted on the graph to show the failure band. When the lower edge of the failure band is extrapolated to 50 years, the corresponding pressure shall not be less than 0.5 bar.

B.22.7 Thermal cycling

B.22.7.1 Lined pipe lengths terminated by the contractor's end seals shall be subjected to the thermal cycling test specified in **B.22.7.2**, **B.22.7.3** and **B.22.7.4**.

The temperature range for systems submitted for below ground use only shall be -5°C to 20°C . Systems submitted for all locations including above ground use shall be tested over the range -20°C to 50°C .

B.22.7.2 Lined pipe lengths of a minimum of 2 m shall be fitted at both ends with the contractor's end seal. When more than one type of end seal is recommended, all shall be subjected to this test. The pipe length shall have pressure tappings located within 250 mm of the end seals.

B.22.7.3 The lined pipe with end seals shall be cycled between the lower specified temperature and higher specified temperature so that one complete temperature cycle takes 48 h. The test sample shall be subjected to 50 temperature cycles.

B.22.7.4 The sample shall be equilibrated at 20°C for 24 h before testing the integrity of the end seals. End caps shall be fitted to the lined pipe and the assembly pressurized to 1.5 times the contractor's recommended maximum working pressure. The pressure tappings on the pipe shall be used to monitor end-seal leakage. No failure shall occur.

B.22.8 Environmental performance

B.22.8.1 Environmental performance testing is conditional on the results of short and long term environmental tests (see Table 1, items 10,11 and 17). No environmental performance tests will be required if:

- a) the material properties do not change by more than 20 %; and
- b) the material properties are stable at the end of the test period.

If these requirements are not met by the test material, the test procedure specified in **B.22.8.2** shall be applied.

B.22.8.2 A minimum of three joints and associated tappings shall be subjected to this test. Each test section of the pipe shall be positioned horizontally and filled with the internal environmental medium (liquids to a depth of approximately 50 mm), shown by **B.22.8.1** to induce the greatest change in material properties. If more than one liquid induces excessive change, a mixture may be used.

The test joints shall then be subjected to the internal pressure test (see **B.7**).

Environmental, lapshear or other adhesion tests as given in Table 1 shall be carried out over a period of 12 months using the same batch of test materials. Each test condition, including air control, shall be tested at minimum intervals for 4 months, 8 months and 12 months.

B.22.8.3 No failure of the pressure test shall occur and the long-term materials tests shall show that any deterioration in properties has reached a limiting value after 12 months.

B.22.9 Bacterial test

The contractor shall supply the gas transporter with information on the basic constituents of the repair materials to meet the requirements of the acceptance scheme [see **B.1.1a**], together with evidence that the submitted system will not be adversely affected by soil micro-organisms.

B.23 Procedure for modification to approved repair systems

B.23.1 the gas transporter shall be notified of any proposed changes in design, ancillary equipment, application, materials and/or material supplies. The contractor shall produce evidence confirming that the proposed changes will have no detrimental effect on the safety, effectiveness and practicability of the repair system.

B.23.2 If the proposed changes alter the original sealing mechanism and/or result in materials properties that do not conform to the original quality assurance limits, then the system shall be retested.

Table B.1 — Test requirements for specific systems

Type (a) - Repair			Type (b) - Renovation		
Joints		Linings	Adhered linings		Self supporting
Phase 1					
B.7	Internal pressure	B.7	B.7	Internal pressure	B.7*
B.8	Water back-pressure	B.8	B.8	Water back-pressure	B.17
B.9	Axial pull (J)	B.9	B.12	Axial pull (P)	B.12+
B.10	Deflection (J)	B.10	B.13	Deflection (P)	B.13
B.11	Vibration (J)	B.11	B.14	Vibration (P)	B.14*
-	Fittings	B.19	B.15	Shear	B.15*
-	Re-connection	B.20	B.16	Internal pressure	B.16
			B.18	Impact	B.18
			B.19	Fittings	B.19*
			B.20	Re-connections	B.20*
Phase 2					
B.22.3	Axial pull	B.22.3	B.22.3	Axial pull	B.22.3
B.22.4	Water back-pressure	B.22.4	B.22.4	Water back-pressure	B.22.4
			B.22.5	Pressure life	B.22.5
			-	External buckling	B.22.6
			B.22.7	Thermal cycling	B.22.7*
B.22.8	Environmental	B.22.8	B.22.8	Environmental	B.22.8
B.22.9	Bacteriological	B.22.9	B.22.9	Bacteriological	B.22.9
(J) Joint. (P) Pipe. + Only required if liner movement is constrained. * Only additional tests required for PE pipe meeting the requirements of GBE/PL2: Part 1 in full (before and after deformation). (Proven for use on unsupported gas mains).					

Table B.2 — Summary of system performance tests

Clause reference	Parameter tested	Number of joints (see Note 1)	Approximate test duration
	1. Application		
B.4	Contaminated pipe	9	-
B.5	Water ingress at joints	3	-
	2. Performance testing		
	a) Phase 1 - Limited Acceptance		
B.7	Internal pressure	12	1 month
B.8	Water back pressure	12	1 month
B.9	Axial pull	9	1 week
B.10	Continuous deflection	9	1 week
B.11	Vibration	9	3 weeks
B.12	Axial pull)	3	1 week
B.13	Deflection) see	3	1 week
B.14	Vibration) Note 4	3	3 weeks
B.15	Shear)	3	1 week
B.16	Internal pressure)	3	1 month
B.17	Water back pressure) see Note 5	3	1 week
B.18	Impact)	+ 2 (Note 6)	1 week
B.19	Fitting of services (see Note 2)	4 lengths	-
B.20	Re-connection of liner system	4 lengths	1 month
	b) Phase 2 - Full Acceptance		
B.22.3	Axial pull	6	50 days
B.22.4	Water back pressure	6	6 months
B.22.5	Pressure life) see	12	6 months
B.22.6	External buckling) Note 7	12	6 months
B.22.7	Thermal cycling (see Note 8)	3	100 days
B.22.8	Environmental performance	3	12 months
NOTES			
1. A total of 12 joints shall be required.			
2. For liner and full internal coating systems only.			
3. Tests in clauses B.7 to B.11 inclusive and B.22.3, B.22.4 and B.22.5 shall be carried out consecutively.			
4. Butted pipe pairs (see clauses B.12 to B.15 inclusive) shall be carried out consecutively.			
5. 50 mm gap pipe pairs (see clauses B.16, B.17 and B.18) shall be carried out consecutively.			
6. Cast iron pipe.			
7. 50 mm gap pipe pairs (Type (b) renovation only).			
8. Lined pipe lengths with end seals (Type (b) renovation only).			

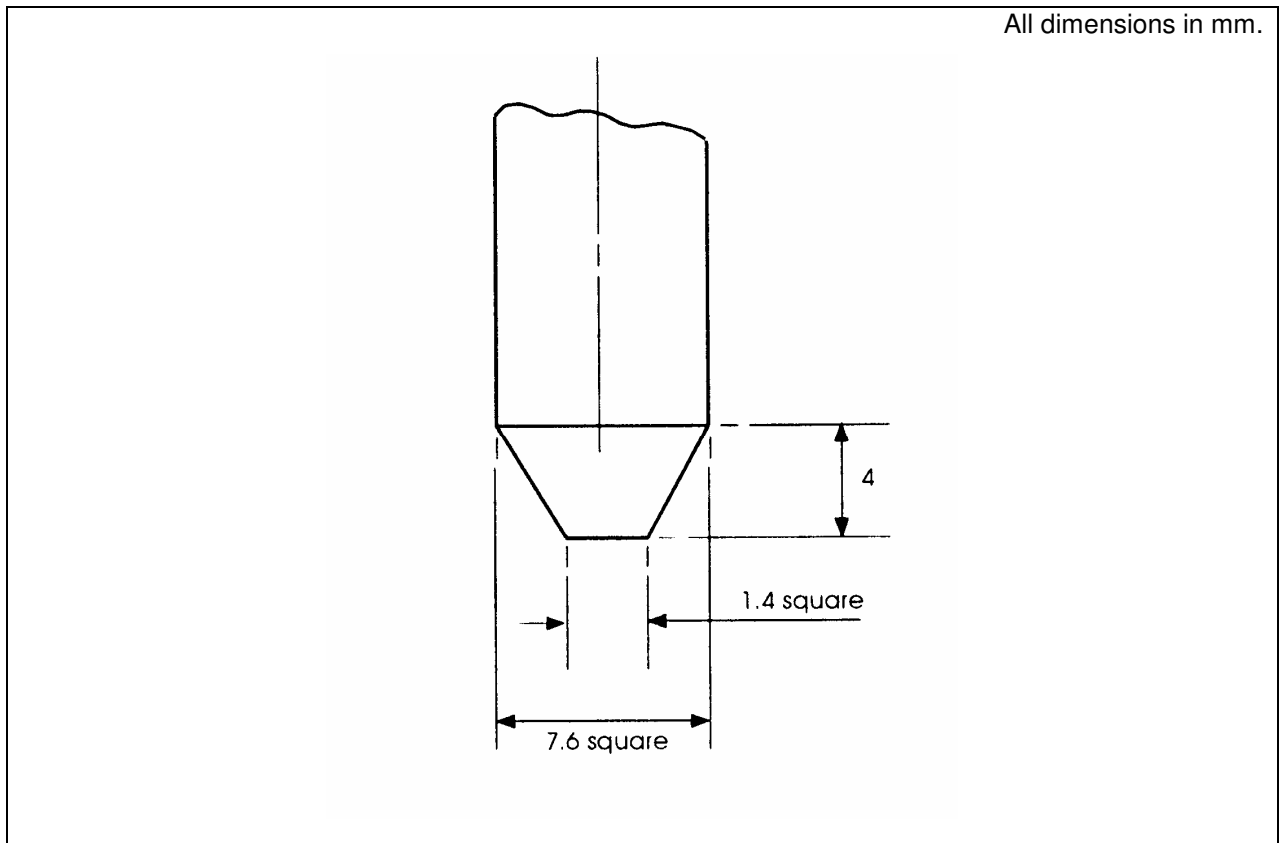


Figure B.1 — Impact testing tool

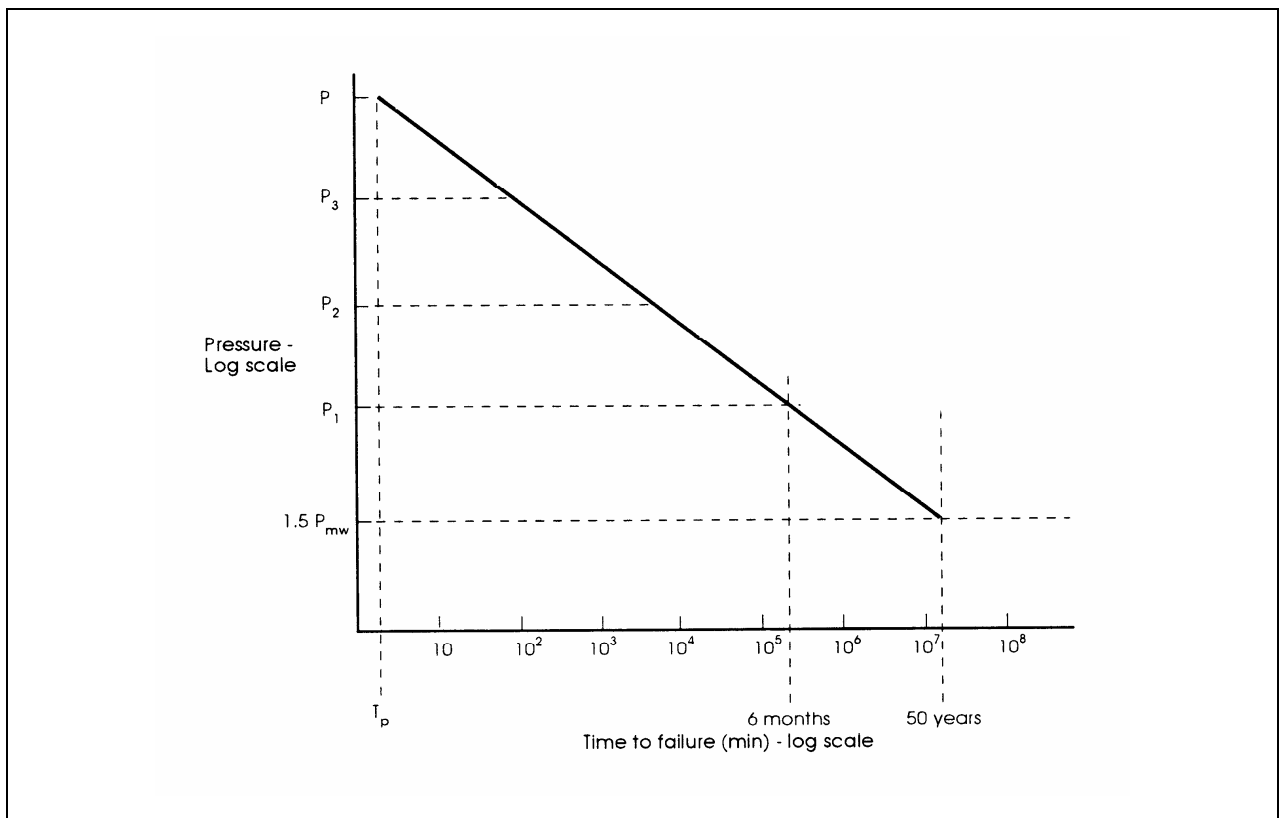


Figure B.2 — Pressure/life testing

Annex C (normative)**Synthetic debris and rust deposits for interior of gas mains****C.1 General**

Most gas mains are contaminated with adherent rust, dust, oils, glycols, etc., which have been built up over a number of years. As part of every sealing operation, the contractor shall demonstrate that his normal cleaning process is adequate to deal with the loadings of debris.

Old pipes in this condition are difficult to obtain. A special coating can be used (see Table C.1) which is applied to the inside of new pipes to simulate the normal condition of old pipes. Pipes which have been specially treated with the coating shall be used for test purposes.

C.2 Preparation of coating material

The dry sand and cement used for the special coating referred to in C.1 shall be mixed thoroughly according to the proportions in Table C.1. Part of the water, the latex and bitumen emulsion shall be mixed thoroughly and then worked into the sand and cement to give a creamy consistency. Sufficient water shall be added to produce a slurry giving a slump value between 2 and 3 (see Annex D).

C.3 Application

Each pipe shall be stood on end and a simple rubber pig inserted at the top so that it rests approximately 300 mm below the top. The slurry shall be poured on to the pig which shall then be drawn through the pipe. Any slurry left over may be re-used after checking its slump value (see Annex D). A small amount of water may be added, if necessary, to maintain the slump value between 2 and 3.

Table C.1 — Constituents of the pipe coating

Materials	Parts by weight
Fine sharp sand	80
Portland cement	10
Bitumen emulsion (non-ionic or anionic type suitable for mixing with cement - not less than 45% bitumen)	5
SBR latex mortar additive (not less than 45% rubber)	4
Water	At least 14

Annex D (normative)
Determination of slump value of cement slurry**D.1 Equipment**

Open-ended perspex or equivalent tube	– internal diameter 57 mm – outside diameter 65 mm – length 50 mm
Tube target plate	300 mm × 300 mm engraved with a series of concentric circles of diameters 65 mm, 125 mm, 145 mm, 165 mm, 185 mm and 205 mm numbered 0 to 5 respectively.

D.2 Method

The tube, which shall be dry, shall be placed on the target plate concentric with the innermost ring. It shall be completely filled with the slurry, care being taken to expel any trapped air bubbles.

The tube shall then be lifted vertically off the target plate by hand, to allow the slurry to flow over the target plate area of concentric circles of flow. The slump value is given by the extent of flow after 5 min and is expressed by the nearest value 0 to 5.

D.3 Experimental details

D.3.1 The test shall be carried out on a bench that is free from vibration.

D.3.2 The tube and target plate shall be washed and dried between each measurement.

D.3.3 The slump value of the cement slurry will vary with time. Only sufficient slurry should be prepared for immediate use and tested at a time appropriate to the application procedure.