Gas Industry Standard

GIS/LC8-1:2013

Specification for

Methods of repairing leaking ferrous gas mains

Part 1: External encapsulation systems

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Contents

Contents *(continued)*

Foreword

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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

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Brief history

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1 Scope

This part of GIS/LC8 specifies requirements for external encapsulation systems for the repair of joints in gas mains operating at a maximum working pressure of 2 bar and in the temperature range −20 °C to 50 °C. It does not cover the use of joint or pipe clamps.

This standard applies to external repair systems suitable for use on 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 EN 1561:1997, *Founding — Grey cast irons.*

BS EN ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings.*

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

BS ISO 34-1:2004, *Rubber, vulcanized or thermoplastic — Determination of tear strength — Part 1: Trouser, angle and crescent test pieces*.

3 Terms and definitions

For the purposes of this standard the following term and definition applies.

3.1
joint deflection
angle between the centre line of the pipe spigot and the centre line of the pipe socket

4 Materials

4.1 Variation of cure rate

Additives shall not be used to alter the cure rate of repair systems.

NOTE Repair systems with different rates of cure may be used to account for the range of working temperatures and joint sizes.

4.2 Safe working life of the encapsulant (if applicable)

The encapsulant shall be designed to allow enough time after mixing for the encapsulation mould to be filled and pressurized, taking into account the range of pipe sizes [75 mm (3 in) to 1 200 mm (48 in)] and ambient conditions (–5 °C to 30 °C) for which the repair system is recommended.

5 Design

5.1 General

The repair system and all parts of the repair kit shall be designed to provide an effective seal for 50 years, without further attention, in the internal and external environments present in and around ferrous gas mains (see **7.11**). The design shall be capable of tolerating the effects of corrosive ground conditions.

NOTE Attention is drawn to the Control of Substances Hazardous to Health Regulations [1].

5.2 Temperature range and site conditions

The repair system shall be suitable for the following working temperatures:

— for in-ground use: −5 °C to 20 °C;

— for above ground use: −20 °C to 50 °C.

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

5.3 Excavation

Repair systems shall be designed so as to minimize the size of the required access excavation to enable their safe application.

5.4 Surface preparation

Any surface preparations that are required prior to the application of the external system shall be applied to the test samples that are used during the pressure life test (see **7.16**) to give confidence that there will be no deleterious effects on the main.

5.5 Time before backfilling

The system shall be such that the repaired joint can be safely backfilled and the normal mains operating pressure applied with no damage to the repair. The period required before backfilling can commence shall be not more than 4 h (within the temperature range −5 °C to 20 °C) after the completion of the repair.

6 Type approval – general

Approval testing shall be undertaken in two parts, designated Phase 1 and Phase 2 in accordance with Table 1.

Phase 1 testing shall be carried out on one identifiable batch of the proposed repair system materials. Phase 2 testing shall be carried out on production material.

Table 1 — Schedule of tests

Phase 1 testing	**Phase 2**
Annexes A and B	**D.1**
C.3	**D.5**
D.7	**D.6**
D.2	**D.7**
D.3	—
D.4	—
D.5	—

7 Performance

7.1 Cleavage strength

When tested in accordance with Annex A, the cleavage strength of the repair system shall be not less than 2.7 kN from an average of three samples, and any one sample result shall not be less than 2.4 KN.

7.2 Gel time

When tested in accordance with **B.1**, the gel time of the repair system shall be 9 min to 15 min.

7.3 Shelf life

When tested in accordance with **B.2**, the shelf life of the repair system shall be 18 months minimum.

7.4 Repaired test joints

7.4.1 A repaired test joint shall be considered to have failed when leakage occurs through the repair, or when the repair material exhibits visual evidence of surface cracking or disbondment. In cases where significant internal cracking or disbondment is evident, this shall be established by a suitable destructive or non-destructive technique.

7.4.2. When tested in accordance with **C.3.2** and **C.3.3**, the repaired test joint shall show no evidence of failure, see **7.4.1**.

7.4.3 When tested in accordance with **C.3.2**, **C.3.3.2** and **C.4.2**, the repaired test joint shall show no evidence of failure, see **7.4.1**.

7.4.4 When tested in accordance with **C.4**, the test pressure and application temperature shall be maintained for 24 h without evidence of leakage.

7.4.5 After conditioning in accordance with **C.6**, no failure shall occur when the repaired joint is tested in accordance with **D.4** at room temperature.

7.4.6 The contractor shall demonstrate that the repair can be successfully applied on to a moist surface (minimum moisture level 1 mg/cm^2) in accordance with **C.5**.

NOTE Under the conditions of high atmospheric humidity and low mains temperature, condensation on to the prepared joint can occur. When surface water loadings of up to 1 mg/cm^2 are present, the pipe may still appear visually to be dry.

7.4.7 No failure shall occur when three repair joints in accordance with **C.5**, are tested in accordance with **D.4**.

7.5 Deflection

When tested in accordance with **D.1**, failure times for the measured deflections shall be not less than those predicted by the line (T_f, 5°), (50 years, 0.3°).

7.6 Vibration

Vibration testing shall be carried out in accordance with **D.2**. No failure shall occur (see **7.4.1**) when each of the three repaired joints are vibration tested in the sequence:

a) 1×10^6 cycles of small amplitude vibration test (see **D.2.3.2**);

b) 40×10^3 cycles, offset, of large amplitude vibration test (see **D.2.3.3**).

7.7 Impact strength

When tested in accordance with **D.3**, no failure shall occur.

7.8 Axial pull

When tested in accordance with **D.4**, no failure of the repaired joint shall occur.

7.9 Pressure

7.9.1 *General*

Pressure testing shall be carried out in accordance with **D.5**.

7.9.2 *Air test*

When tested in accordance with **D.5.3.2**, no failure shall occur.

7.9.3 *Hydrostatic test*

When tested in accordance with **D.5.3.3**, no failure shall occur.

7.10 Accelerated corrosion

7.10.1 If a repair system fails the test specified in **D.6.1** or such testing is found to be impractical, or if a repair system incorporates features which are particularly susceptible to corrosion, full scale testing shall be carried out in accordance with **D.6.2**.

7.10.2 *Small scale test*

When tested in accordance with **D.6.1** the corrosion of the metal shall not have penetrated more than 5 mm into the interface between the repair material and the metal surface at any point.

7.10.3 *Full scale test*

When tested in accordance with **D.6.2.3.1** no leakage shall occur from the repaired joint.

When tested in accordance with **D.6.2.3.2** the minimum deflection of the joint before failure of the repair shall be 2°.

7.11 Pressure/life

When tested in accordance with **D.7**, failure times for the measured pressures shall be not less than those predicted by the line P/1.5P_{mw}.

7.12 Environmental testing

When tested in accordance with **D.8**, the material properties of the repair system shall not change by more than 20 % when compared to the results when tested in accordance with Annex A.

8 Marking

All repair systems' packaging conforming to GIS/LC8-1 shall be indelibly marked with the following information:

a) the number and date of this standard, i.e. GIS/LC8-1 :2013 [1)];

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.

e) pressure rating;

f) application instructions;

g) nominal size of joint for repair;

h) type of joint to be repaired.

9 Packaging

Packaging of repair systems shall be provided to prevent damage by normal handling and storage.

[1)]Marking GIS/LC8-1 :2013 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)
Cleavage strength test

A.1 Principle

A measure of shear strength for the repair material is determined.

A.2 Apparatus

A.2.1 *Cleavage test pieces*, see Figure A.1.

A.2.2 *Moulding arrangement,* see Figure A.2.

A.2.3 *Tensile testing machine*, capable of generating a minimum load of 5 kN and a minimum traverse of 100 mm at a rate of 10 mm per minute.

A.3 Preparation of test samples

A.3.1 The cleavage test pieces shall be made from 50 mm x 50 mm x 25 mm long cast iron angle in accordance with BS 1452, Grade 220. They shall be machined to the dimensions specified in Figure A.1.

A.3.2 The faces of the cleavage test pieces (see Figure A.1) shall be grit blasted to BS EN ISO 8501-1, first quality finish, to have a mean roughness within the overall range 5 µm to 15 µm with a standard deviation of not more than 15 % after grit blasting.

All loose material shall be removed after grit blasting by an air blast followed by degreasing.

A.3.3 Where applicable, test pieces shall be painted with primer. Before any deterioration of the surface occurs (as specified in BS EN ISO 8501-1) primers and sealants shall be applied to the test pieces.

A.4 Procedure

A.4.1 Position the faces of the test pieces so that they are parallel and separated by a distance of 10 mm ± 1 mm (see Figure A.2).

NOTE A spacer should be used.

Fit removable base and side plates to enable the sealant to be poured and contained between the grit blasted faces (see Figure A.2). These plates shall be metal, card or plastic and, if treated with a mould release compound, there shall be no contamination of the grit blasted faces.

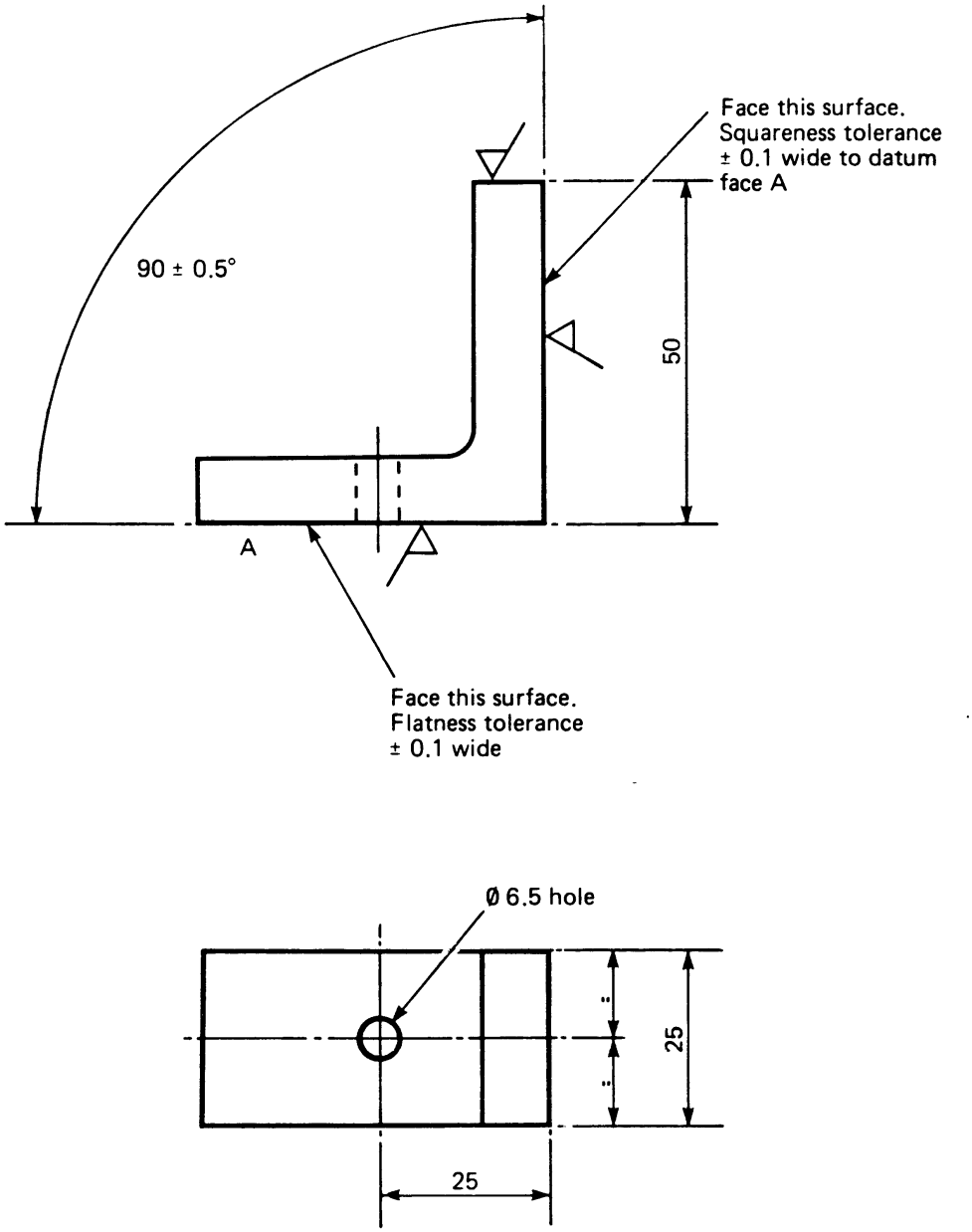
A.4.2 The sealant shall be correctly proportioned and mixed according to the contractor's recommendations for use.

A.4.3 Fill the space between the faces with the system. Filling shall be completed within the useful working life of the system.

A.4.4 Cure the test pieces under standard conditions, and subsequently demould by removal of the base and side plates. The test pieces shall be conditioned at the test temperature of 23 °C ± 2 °C for 24 h.

A.4.5 Fit the test pieces into a suitable tensile testing machine, ensuring that the mountings allow free movement to produce a cleavage movement at the failure edge (see Figure A.3). The test pieces shall be separated at a crosshead rate of 10 mm/min ± 1 mm/min.

Dimensions in millimetres



NOTE 1 General tolerances: ±0.1 mm.

NOTE 2 Machine where marked thus ▽.

NOTE 3 Remove all burrs and sharp edges.

Figure A.1 — Cleavage test piece

A.4.6 Record the measured load and displacement during the test relating to separation..

Test after cure time of 3 h, 1 day, 7 days, 14 days and 21 days, nominal and ±10 basic mix ratio.

A.4.7 Carry out short term aqueous environmental test specified in **D.8**.

Pulling rate shall be 10 mm/min. Basic mix ratio. After a cure time of 7 days followed by immersion in water at 40 °C, determine cleavage strength after 4 weeks and 8 weeks and compare with values for air after the same period.

A.5 Expression of results

Results presented in tabular form shall be quoted as the mean, standard deviation and number of tests.

Results presented in graphical form shall show all test points.

A.6 Test report

The test report shall include the following information:

a) reference to this standard, i.e. GIS/LC8-1:2013;

b) results of determination, see **A.5**;

c) any additional factors which may have affected the results of the test.

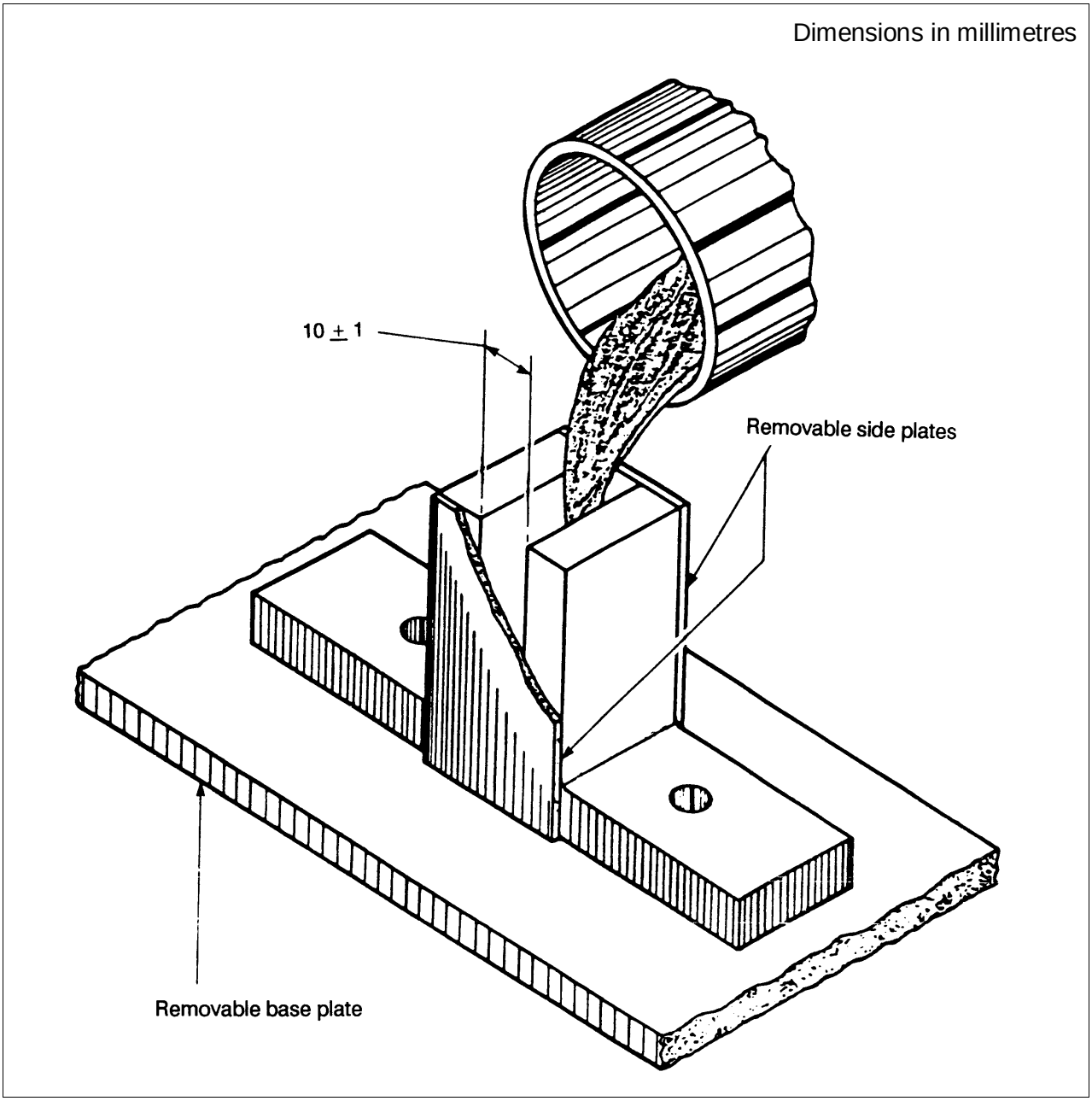


Figure A.2 — Moulding of cleavage test specimen

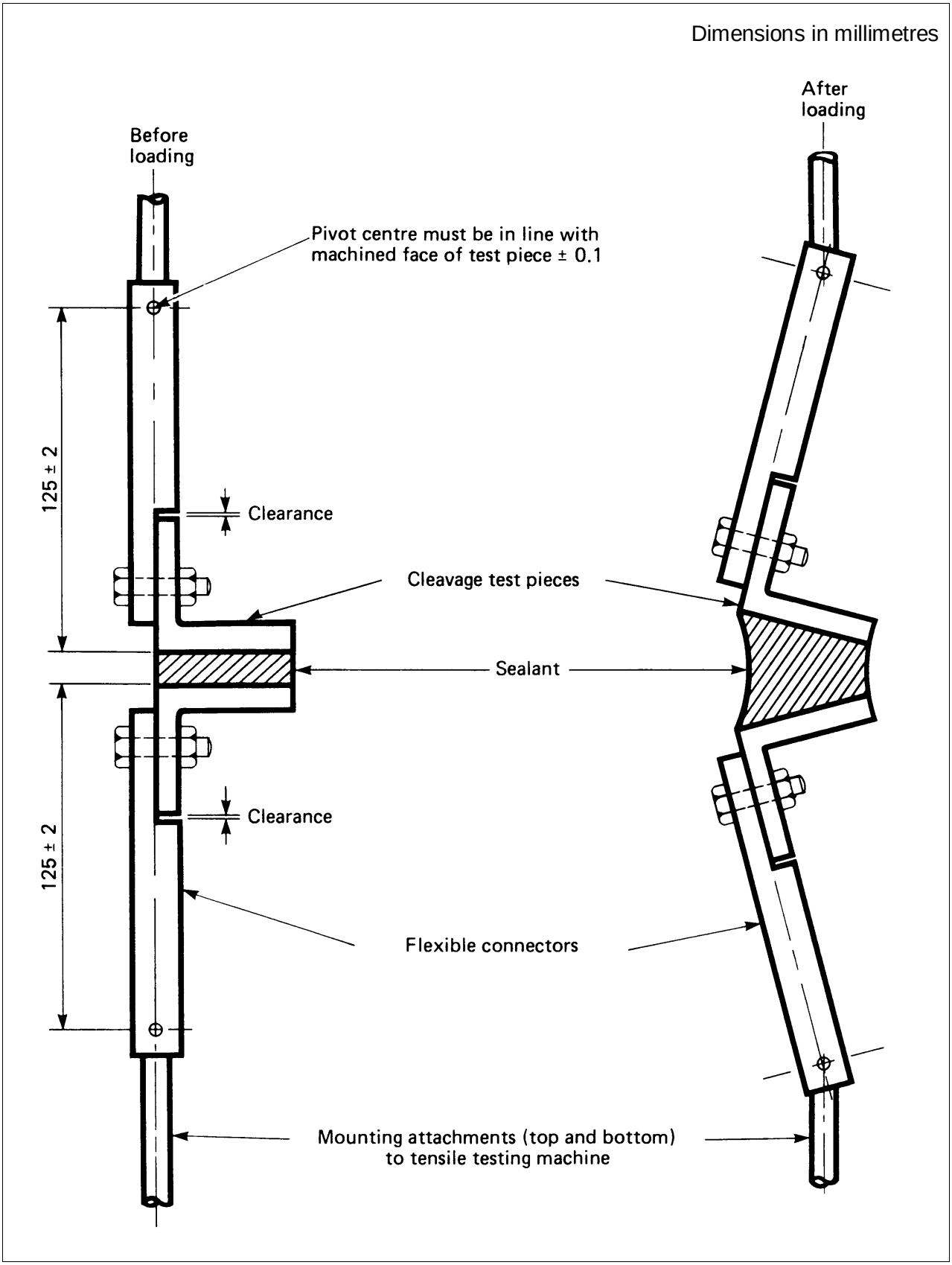


Figure A.3 — Mounting of test piece in tensile testing machine

Annex B (normative)
Test methods for repair system properties

B.1 Test method for gel time

B.1.1 *Principle*

The time beyond which the material is not suitable for any further working is determined by means of applying to a joint.

B.1.2 *Apparatus*

B.1.2.1 *Brookfield viscometer*, fitted with a No.7 spindle.

B.1.2.2 *250 ml tin.*

B.1.2.3 *Stopwatch.*

B.1.3 *Procedure*

Condition the repair system elements at 23 °C for a period of 24 h.

Mix the elements together.

Pour the mixed materials into a 250 ml tin until just flush with rim of the tin.

Check viscosity using the viscometer fitted with a No.7 spindle at 10 rpm.

Record time to achieve a reading of 70 and deduct 1 min, this is taken as the gel time.

B.1.4 *Expression of results*

Record and report the time taken for a reading of 70 to be recorded.

B.1.5 *Test report*

The test report shall include the following information:

a) reference to this standard, i.e. GIS/LC8-1:2013;

b) results of determination, see **B.1.4**;

c) any additional factors which may have affected the results of the test.

B.2 Test method for shelf life

B.2.1 *Principle*

The shelf life is evaluated by conducting a cleavage test in accordance with Annex A and comparing the results obtained when the product is new and after particular shelf life has elapsed.

B.2.2 *Apparatus*

Apparatus shall be in accordance with **A.2**.

B.2.3 Preparation of test samples

The product used in this test shall have been produced 18 months before the time of this test in accordance with **A.3**.

B.2.4 *Procedure*

The procedure shall be in accordance with **A.4**.

B.2.5 *Expression of results*

Expression of results shall be in accordance with **A.5**.

B.2.6 *Test report*

The test report shall include the following information:

a) reference to this standard, i.e. GIS/LC8-1:2013;

b) results of determination, see **B.2.4**;

c) any additional factors which may have affected the results of the test.

Annex C (normative)
Type approval testing of repair system

C.1 General

C.1.1 WARNING For reasons of safety, and where practicable, all air/nitrogen pressure tests specified shall be preceded by a hydrostatic test in accordance with **D.5.3.3**, except that hydrostatic pressure high enough to cause failure of the repair material shall be applied. All subsequent applied pneumatic pressure shall then be limited to a level of 2/3 of the maximum applied hydraulic pressure.

C.1.2 The number of test joints to be tested during each test and the time scale for each test shall be in accordance with Table C.1.

C.1.3 All tests shall be carried out using 150 mm (6 in) nominal size cast iron pipe joints.

Table C.1 — Schedule of repaired joints for test programme

Clause reference	Properties to be tested	Number of test joints	Approximate duration of test
C.3	Application of system	3 (may be subsequently re-used for other tests)	See **C.3**
D.1	Deflection and hold to failure	12	6 months
D.2	Vibration	3	24 days
D.3	Impact	3	1 month
D.4	Axial pull	3	7 days
D.5	Pressure	3	14 days
D.6	Accelerated corrosion	3	9 weeks
D.6.1	Small scale tests		
D.7	Pressure/life	12	6 months
The test times shall apply to each test specimen. NOTE The duration of test depends on how many joints are under test concurrently**.**			

C.2 Preparation of test joints

C.2.1 The 150 mm (6 in) nominal size test pipe shall contain the type of joint profile (i.e. lead/yarn or mechanical) for which the repair method is recommended by the contractor.

C.2.2 If the repair method is recommended by the contractor for use on both lead/yarn and mechanical type joints, the tests specified in this annex shall be carried out on both types of joint.

C.2.3 Because of the difficulty in obtaining the older types of mechanical joints, the tests on mechanical joints may be carried out on currently available mechanical joints. If joints having an internal circlip are used, they shall be assembled without the internal circlip.

C.2.4 The lead/yarn test joints shall be assembled with paper and a suitable filler flush with the socket face, in place of the lead and yarn, to ensure that leakage occurs around the annulus of the joint to be tested.

C.2.5 All the test joints shall be assembled straight, i.e. with the pipe spigot in line and concentric with the pipe socket.

C.2.6 Each of the test joints shall be set up to leak at the pressure and leakage values specified in **C.3.2** and**C.3.3**.

C.2.7 For leakage testing of the repaired joint, the test pipes shall be pressurized with air or nitrogen after the removal of any mould, muff or retaining material used during application. Leakage shall be determined by checking with soapy water. Some systems may be difficult to test for leakage in this manner and, in such cases, each repaired joint shall be totally immersed in a water bath.

C.3 Procedure for testing the application of the repair system on a leaking joint

C.3.1 ***General***

C.3.1.1 Fit three test joints with the repair system.

NOTE These repaired joints may be used for the testing specified in subsequent clauses.

C.3.1.2 Only the cleaning and fitting methods that are used on site shall be used when fitting the repair system to the test joints.

C.3.2 ***Pressure in the test pipe at the time of fitting the repair***

C.3.2.1 Apply a pressure inside the test joint 1.5 times that recommended by the contractor as being the maximum pressure in the main at the time of repairing the joint.

C.3.2.2 Maintain this pressure during the entire repair operation including, if applicable, the cure time of the repair material.

C.3.3 ***Leakage rate from the test joint at the time of fitting the repair***

C.3.3.1 The leakage rate of low pressure joints (up to and including 75 mbar) shall be 1 m^3 (st)/h to 2 m^3 (st)/h.

C.3.3.2 The leakage rate of medium pressure *(*above 75 mbar up to 2 bar inclusive) test joints shall be 10 m^3 (st)/h to 20 m^3 (st)/h.

C.4 Procedure for low temperature application test

C.4.1 ***General***

Fit one joint with the repair system.

C.4.2 ***Application temperature***

C.4.2.1 Clean the joint, as stated in the data folder. Protect the joint from moisture (by polyethylene sheet) and condition at the application temperature of -5 °C to 0 °C for 24 h.

Condition all components of the repair system at the application temperature for 24 h.

Carry out the repair at the application temperature.

C.4.3 *Demould time*

Maintain the repair at the application temperature and demould after the Contractor's recommended demould/backfill time.

C.5 Sensitivity to application on a moist surface

Fit three joints with minimum surface moisture loadings of 1 mg/cm^2 with the repair system. Determine suitable moisture levels in accordance with Annex E.

C.6 Conditioning and testing of the repaired test joint

C.6.1 After the joint repair has been fitted, leave the test joint for 24 h.

C.6.2 The standard temperature for system performance testing shall be 23°°C ± 2°°C.

C.6.3 If the repair material exhibits a significant change in properties over the working temperature range (as specified in **5.2**) as demonstrated by thermal analysis techniques or other test methods, testing at additional temperatures shall be required.

Annex D (normative)
Repair system tests

D.1 Deflection testing

D.1.1 *Principle*

The ability of the repair system to resist angular deflection is determined.

D.1.2 *Apparatus*

D.1.2.1 *Framework*, to support test item and also capable of holding the socket end of the joint stationary.

D.1.2.2 *Framework*, capable of allowing angular displacement of the test item in a single plane.

D.1.2.3 *Means of measuring angular displacement,* of up to 10° in increments of 0.1° per minute.

D.1.2.4 *Pressure gauge*, capable of measuring up to 5 bar.

D.1.2.5 *Pressure source*, up to 4 bar.

D.1.3 *Preparation of specimens*

Twelve repaired joints in accordance with **C.2** shall be used to carry out deflection and hold to failure test.

D.1.4 *Procedure*

D.1.4.1 Apply an internal pressure of twice the contractor's recommended maximum working pressure to the test joint before the joint is deflected and maintain this pressure throughout the test.

D.1.4.2 Deflect three repaired joints at a constant rate of 1 °/min ± 0.1 °/min until a deflection of 5° is reached (having first ensured that the unrepaired joint is capable of this deflection). The pipe joint shall be deflected by holding the socket end stationary and deflecting the spigot end. The axis of rotation shall be in the plane of the socket face.

Hold this condition until failure occurs (record the time to failure T_f) or six months, whichever is the shorter period.

If no failure has occurred after six months, further testing of the repaired joints under this clause is not required.

D.1.4.3 Deflect three repaired joints at an angle of α_{f1}, a second set of three joints at an angle of α_{f2} and a third set of three joints at an angle of α_{f3}.

Deflect the joints at a rate of 1 °/min ± 0.1 °/min until the specified deflection is reached.

D.1.5 *Expression of results*

D.1.5.1 The time to failure, recorded in **D.1.4.2**, shall be plotted as a point having co-ordinates (T_f, 5°) on the log/log plot of deflection angle, α ,in degrees against time, T, in min (see Figure D.1), for each joint.

D.1.5.2 α_{f1} shall be established by drawing a straight line joining the point (T_f, 5°) to the soil loading deflection point 50 year/0.3°. α_{f1}, α_{f2} and α_{f3} shall be determined to give points equidistant

on a logarithmic scale between α_{f1} and 5°. α_{f1} shall be the deflection angle corresponding to six months on the time axis.

D.1.5.3 The results obtained shall be plotted on a graph.

D.1.6 *Test report*

The test report shall include the following information:

a) reference to this standard, i.e. GIS/LC8-1:2013;

b) results of determination, see **D.1.5**;

c) any additional factors which may have affected the results of the test.

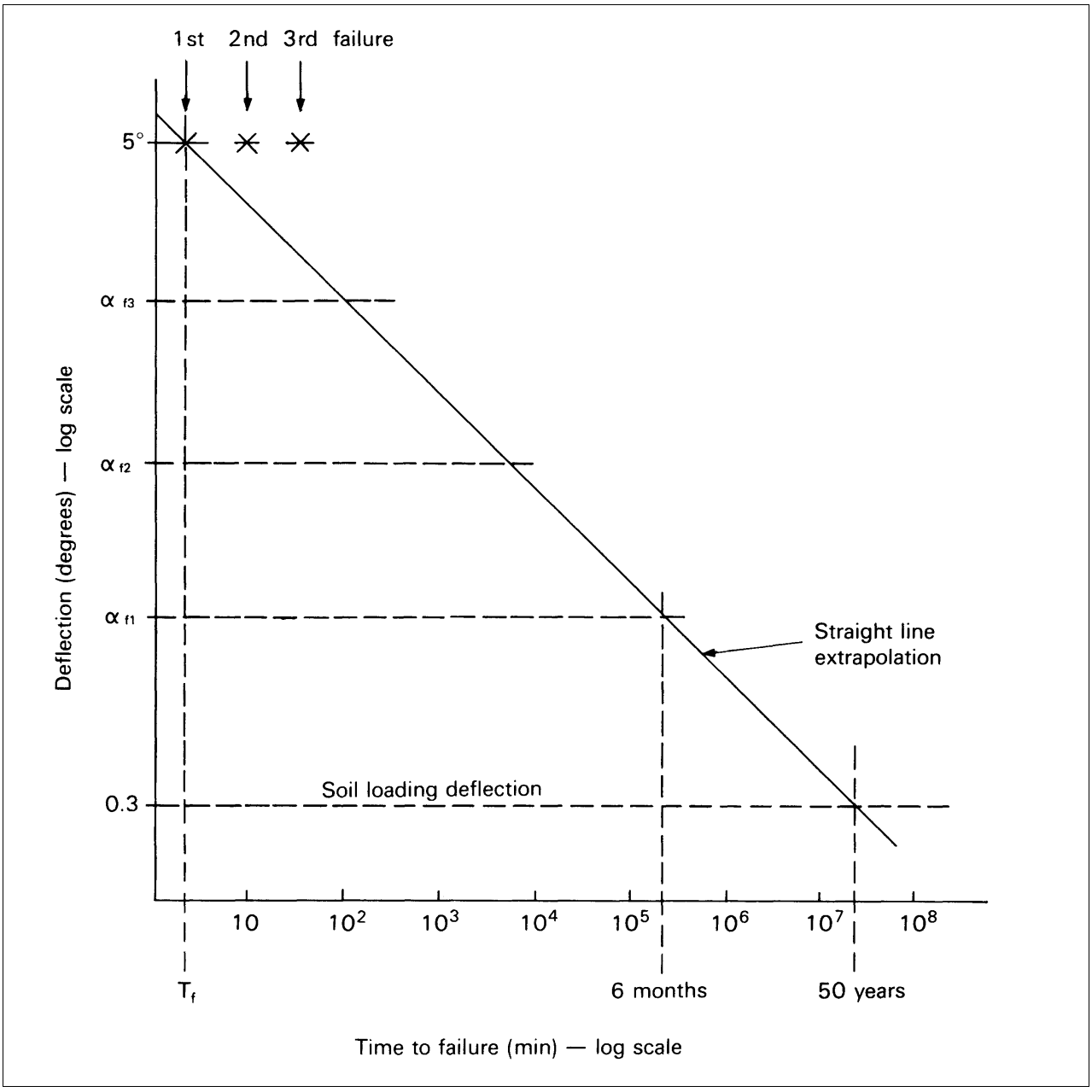


Figure D.1 — Deflection/hold to failure testing

D.2 Vibration testing

D.2.1 *Principle*

The capability of the repaired joint to withstand vibration levels associated with above ground traffic loadings is determined.

D.2.2 *Apparatus*

D.2.2.1 *Framework*, to support test item and also capable of holding the socket end of the joint stationary.

D.2.2.2 *Framework*, capable of allowing angular displacement of the test item in a single plane.

D.2.2.3 *Actuator*, capable of inducing angular displacements of the repaired joint by up to 1° at a frequency of up to 1 Hz.

D.2.2.4 *Pressure gauge*, capable of measuring up to 5 bar.

D.2.2.5 *Pressure source*, up to 4 bar.

D.2.3 *Procedure*

D.2.3.1 *General*

Fit three test joints with the repair system.

Maintain internal pressure in the test joints during the period of vibration. This pressure shall be twice the Contractor's recommended maximum working pressure.

Hold the socket end of the pipe stationary and vibrate the spigot end. The axis of rotation shall be in the plane of the socket face.

D.2.3.2 *Small amplitude vibration test*

Vibrate the repaired joint at a frequency of 1 Hz ± 0.1 Hz continuously between limits of 0° and 0.25° ± 0.025° to the axis.

D.2.3.3 *Large amplitude vibration test*

Vibrate the repaired joint at a frequency of 0.5 Hz ± 0.05 Hz continuously, between limits of 0.25° ± 0.025° and 0.75° ± 0.075° to the axis.

D.2.4 *Expression of results*

D.2.4.1 *Small amplitude vibration test*

Record and report the following:

a) angular displacement;

b) number of cycles and frequency;

c) test pressure at start of test;

d) test pressure at end of test;

e) any leakage from the joint.

D.2.4.2 *Large amplitude vibration test*

Record and report the following:

a) angular displacement;

b) number of cycles and frequency;

c) test pressure at start of test;

d) test pressure at end of test;

e) any leakage from the joint.

D.2.5 *Test report*

The test report shall include the following information:

a) reference to this standard, i.e. GIS/LC8-1:2013;

b) results of determination, see **D.2.3.4**;

c) any additional factors which may have affected the results of the test.

D.3 Impact testing

D.3.1 *Principle*

The capability of the repaired joint to withstand an impact load of the kind that it might experience during periods where the joint is still excavated, is determined.

D.3.2 *Apparatus*

D.3.2.1 *Vee blocks*, to support repaired joint.

D.3.2.2 *Impact tool*, (see Figure D.2), with a mass of 5 kg ± 0.1 kg.

D.3.2.3 *Pressure gauge*, capable of measuring up to 5 bar.

D.3.2.4 *Pressure source*, up to 4 bar.

D.3.3 *Procedure*

Fit three test joints with the repair system.

Mount the repaired joint horizontally in vee blocks.

Apply the impact at top dead centre with a tool as shown in Figure D.2, with the centre line of the tool 6 mm from the spigot side of the socket face.

Subject the repaired joint to one blow of 135 J resulting from a free fall of between 2.7 m and 2.8 m.

Remove the impact tool from the repair, and apply an internal pressure of twice the contractor's recommended maximum working pressure to the repaired joint.

Maintain this pressure for a period of one month.

D.3.4 *Expression of results*

Record and report the following:

a) mass of the impact tool;

b) free fall height;

c) test pressure at start of test;

d) test pressure at end of test;

e) any leakage from the joint.

D.3.5 *Test report*

The test report shall include the following information:

a) reference to this standard, i.e. GIS/LC8-1:2013;

b) results of determination, see **D.3.4**;

c) any additional factors which may have affected the results of the test.

Dimensions in millimetres

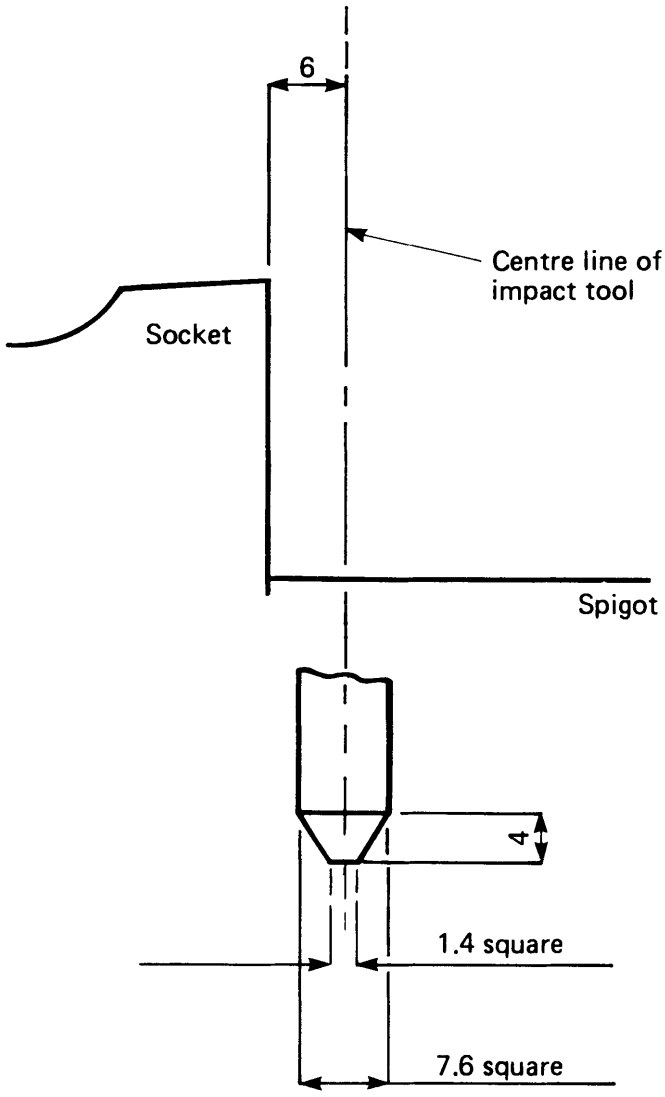


Figure D.2 — Impact testing

D.4 Axial pull test

D.4.1 *Principle*

The capability of the repaired joint to withstand a level of axial displacement that could be experienced during normal operations, over the lifetime of the joint, is determined.

D.4.2 *Apparatus*

D.4.2.1 *Framework*, to support test item and also capable of holding the socket end of the joint stationary.

D.4.2.2 *Framework*, capable of allowing axial displacement of the test item.

D.4.2.3 *Actuator*, capable of inducing axial displacement of the repaired joint by up to 10 mm in steps of 0.1 mm/min.

D.4.2.4 *Pressure gauge*, capable of measuring up to 5 bar.

D.4.2.5 *Pressure source*, up to 4 bar.

D.4.3 *Procedure*

Fit three test joints with the repair system.

Axially displace each repaired joint at a rate of 1 mm/min ± 0.1 mm/min until the axial displacement reaches 6.5 mm.

Maintain this displacement whilst an internal pressure of twice the contractor's recommended maximum working pressure is applied to the repaired joint.

Maintain this displacement and pressure for seven days.

D.4.4 *Expression of results*

Record and report the following:

a) the maximum axial displacement of the joint;

b) test pressure at start of test;

c) test pressure at end of test;

d) any leakage from the joint.

D.4.5 *Test report*

The test report shall include the following information:

a) reference to this standard, i.e. GIS/LC8-1:2013;

b) results of determination, see **D.4.4**;

c) any additional factors which may have affected the results of the test.

D.5 Pressure tests

D.5.1 *Principle*

The capability of the repaired joint to withstand a short term high level of pressure is determined.

D.5.2 *Apparatus*

D.5.2.1 *Framework*, capable of restraining axial displacement of joint under pressure.

D.5.2.2 *Pneumatic pressure gauge*, capable of measuring up to 5 bar.

D.5.2.3 *Pneumatic pressure source*, up to 4 bar.

D.5.2.4 *Hydraulic pressure gauge,* capable of measuring up to 15 bar.

D.5.2.5 *Hydraulic pressure source*, up to 10 bar.

D.5.3 *Procedure*

D.5.3.1 *General*

Fit three test joints with the repair system.

The test joints shall be suitably restrained to prevent axial movement between the pipe spigot and socket during the pressure testing.

NOTE This can be done by mounting the test joints within a frame which can limit the degree of movement.

D.5.3.2 *Air test*

Commence the air test within 3 h of completion of the repair. Apply an internal pressure of twice the contractor's recommended maximum working pressure to the repaired joint.

Maintain the air pressure shall be maintained for a period of seven days.

D.5.3.3 *Hydrostatic test*

Hydrostatically test each repaired joint to five times the contractor's recommended maximum working pressure.

Apply the internal pressure at a uniform rate such that the required test pressure is reached in approximately 1 min.

Maintain this pressure for 10 min.

D.5.4 *Expression of results*

Record and report the following:

a) pneumatic pressure and duration of test;

b) any pneumatic leaking;

c) hydraulic pressure and duration of test;

d) any hydraulic leaking.

D.5.5 *Test report*

The test report shall include the following information:

a) reference to this standard, i.e. GIS/LC8-1:2013;

b) results of determination, see **D.5.4**;

c) any additional factors which may have affected the results of the test.

D.6 Accelerated corrosion testing – Small scale test

D.6.1 *Principle*

The capability of the repair material to withstand the effects of a corrosive environment is determined.

D.6.2 *Apparatus*

D.6.2.1 *Cast iron plate,* 150 mm × 150 mm × 6 mm.

D.6.2.2 *Sodium chloride.*

D.6.2.3 *Water.*

D.6.2.4 *Immersion bath.*

D.6.2.5 *Stainless steel cathode.*

D.6.2.6 *Source of current,* up to 50 mA.

D.6.2.7 *Current meter.*

D.6.2.8 *Grit blast equipment.*

D.6.3 *Procedure*

Prepare three test specimens. Each test specimen shall consist of a cast iron plate across the width of which a sample of the repair system has been applied. The cross-section of the repair material shall be of a similar magnitude to that obtained on a full scale repair, e.g. a sample 25 mm thick, 50 mm wide and 100 mm long on a plate 150 mm square x 6 mm thick.

Grit-blast the metal on each side of the repair material taking precautions not to damage the repair material itself.

Apply a protective coating (e.g. epoxy paint) to the grit-blasted surface, leaving an unprotected strip of bare metal approximately 12 mm wide on each side of the repair material and immediately adjacent to it. Also protect the edge and reverse side of the plate.

Completely immerse the test specimen in a bath containing a solution of 1 % to 3 % sodium chloride (NaCl) (by weight) in water and, apply a current of $15 \pm 0.75 \times 10^{-3}$ mA/mm^2 to the unprotected metal surface area by means of a stainless steel cathode.

Remove the test specimen from the bath after a period of eight weeks, , grit-blast clean to remove the corrosion products and strip the repair material off the plate to examine the repair material/metal surface interface.

D.6.4 *Expression of results*

Record and report the following:

a) dimensions of the test sample with the repair material in place;

b) applied current;

c) duration of immersion in salt bath;

d) degree of corrosion penetration into the region where the repair material was.

D.6.5 *Test report*

The test report shall include the following information:

a) reference to this standard, i.e. GIS/LC8-1:2013;

b) results of determination, see **D.6.1.4**;

c) any additional factors which may have affected the results of the test.

D.7 Pressure/life testing

D.7.1 *Principle*

The integrity of the repaired joint over a 50 year lifetime is determined.

D.7.2 *Apparatus*

D.7.2.1 *Restraint system*, to ensure that the repaired joint assembly shall not become detached from itself.

D.7.2.2 *Pneumatic pressure gauge*, capable of measuring up to 5 bar.

D.7.2.3 *Pneumatic pressure source*, up to 4 bar.

D.7.2.4 *Hydraulic pressure gauge*, capable of measuring up to 15 bar.

D.7.2.5 *Hydraulic pressure source*, up to 15 bar.

D.7.3 *Procedure*

D.7.3.1 Fit twelve test joints with the repair system

NOTE All twelve joints need not necessarily be under test simultaneously.

The duration of the tests shall be either until failure occurs or six months, whichever is the shorter period.

Subject three repaired joints to a hydraulic pressure which shall ensure failure within 1 h and 3 h. Note the pressure at which failure occurs, P, and the time to failure, T_p.

D.7.3.2 Pneumatically pressurize three repaired joints at a pressure, P_1, hold a second set of three joints at a pressure P_2, and hold a third set of three joints at a pressure P_3.

D.7.4 *Expression of results*

The results obtained in **D.7.3.2** shall be plotted on a log/log plot of pressure against time, in min, in accordance with Figure D.3.

P_1 shall be established by drawing a straight line joining the initial point (T_p,P) to the 50 year/1.5P_{max}, specified maximum working pressure point. P_1 shall be the pressure corresponding to six months on the time axis.

P_2 and P_3 shall be determined as follows:

$$P_2 = P_1 + \frac{(P - P_1)}{3}$$

$$P_3 = P_1 + \frac{2(P - P_1)}{3}$$

The results obtained in **D.7.3.2** shall be plotted on the graph.

D.7.5 *Test report*

The test report shall include the following information:

a) reference to this standard, i.e. GIS/LC8-1:2013;

b) results of determination, see **D.7.4**;

c) any additional factors which may have affected the results of the test.

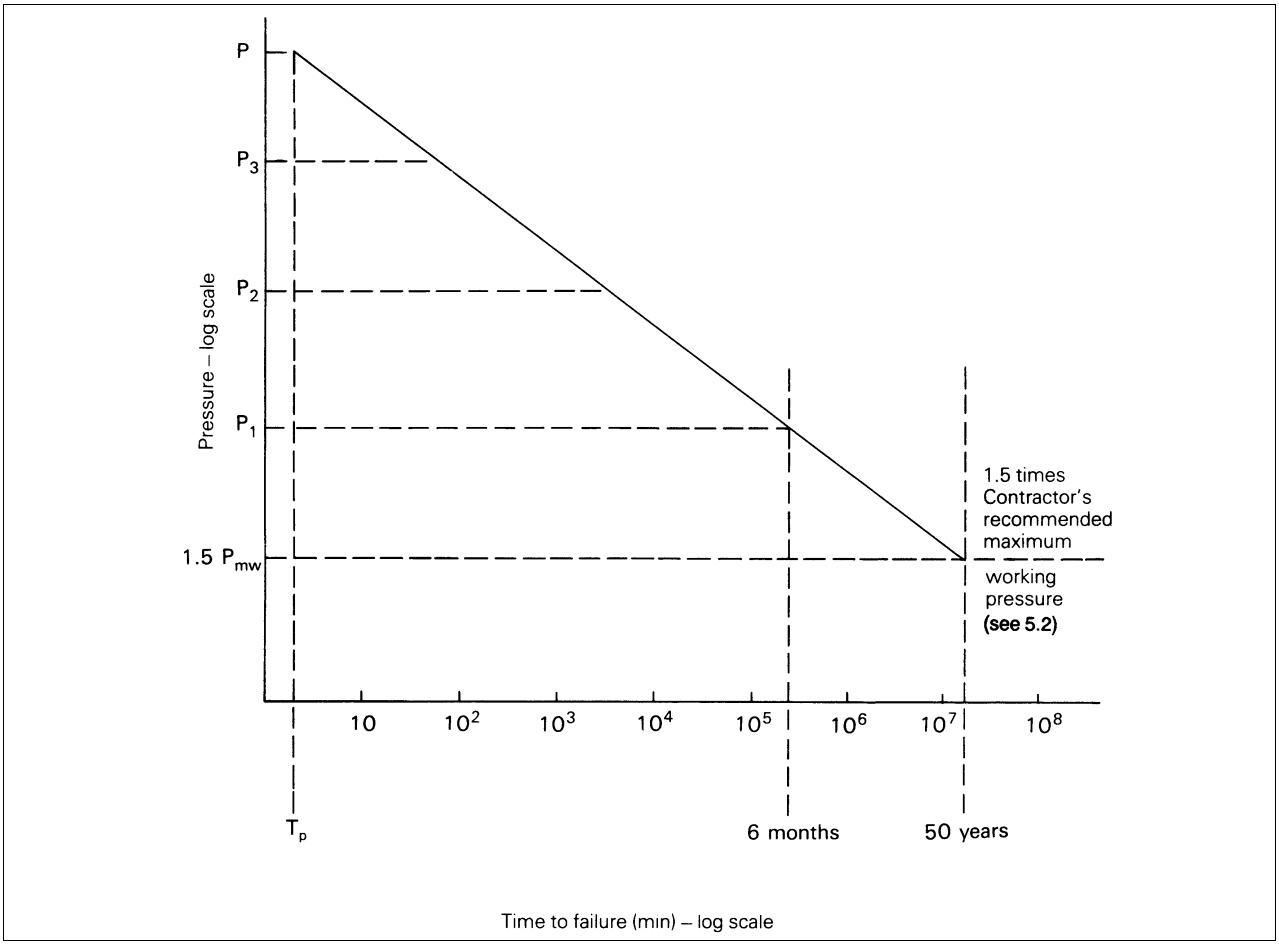


Figure D.3 — Pressure/life testing

D.8 Short term aqueous test

D.8.1 *Principle*

The effect of water upon the repair method is determined.

D.8.2 *Test specimens*

Prepare test samples in accordance with **A.1** to **A.3** and allow to cure for 7 days.

D.8.3 *Procedure*

Immerse a test sample in water at 40 °C for a period of 4 weeks then determine the cleavage strength in accordance with **A.4.5** and **A.4.6**.

Immerse a test sample in water at 40 °C for a period of 8 weeks then determine the cleavage strength in accordance with **A.4.5** and **A.4.6**.

Annex E (normative)
Test method for determination of moisture loading on 150 mm (6 in) performance test joints

E.1 Principle

The moisture loadings (of 1 mg/cm^2 to 2 mg/cm^2) of 150 mm (6 in) pipe joints is determined.

E.2 Apparatus

E.2.1 *Small room*, with temperature control between 25 °C (± 2 °C) and 30 °C (± 2 °C) (T_2) and ability to achieve more than 95 % RH.

E.2.2 *Test joints* (6), of 150 mm (6 in), where the spigot end is milled to accommodate thin cast iron discs (see Figure E.1).

E.2.3 *Balance*, capable of reading to an accuracy of 0.1 mg.

E.2.4 *Small re-sealable plastics bags*.

E.3 Procedure

E.3.1 The test laboratory shall be controlled to between 18 °C and 22 °C (T_1) and 50 % to 70 % relative humidity (RH).

At least 4 h before the test is due to commence set the conditions in the humidity room.

NOTE The temperature differential ($T_2 - T_1$) should be between 3 °C and 6 °C and the RH should exceed 90 %.

Accurately weigh numbered plastics bags (1 per disc). Store in desiccator.

Grit-blast only the upper face of the discs.

Place one disc in each pre-weighed plastics bag and re-weigh. Return plastics bags and discs to desiccator.

Thoroughly grit-blast the test joint at least 3 h before the test is due to commence. Return joint to laboratory temperature (T_1) to re-condition. Take care not to grit-blast the disc recesses.

Approximately 30 min before the test is due to start lightly grit-blast the joint again. Return joint to laboratory temperature (T_1).

Fit discs into recesses (see Figure E.2) and allow pipe and discs to condition at T_1 for a minimum of 20 min. Monitor pipe surface and discs with a thermocouple to confirm that constant temperature has been reached.

When conditions in the humidity room are stable and the pipe discs are at constant temperature the test can proceed.

E.3.2 Move joint into the humidity room.

Monitor surface moisture loading by removing discs from the joint, placing them in the appropriate numbered plastics bag and weighing. Remove the first disc after 5 min and at 2 min intervals thereafter (see **E.4** for sample calculation).

When moisture loading has attained a minimum level of 0.75 mg/cm^2 the repair of the joint shall commence.

As the repair reaches the stage where further condensation of water is either not possible or unimportant (i.e. fitting of an encapsulation mould, or shrink sleeve or thermoplastic seal)remove and weigh the remaining discs to find the final moisture loading.

NOTE Initial cure or cooling of the repair should take place in the humidity room.

E.4 Sample calculations

The following is a sample calculation.

- Weight of plastics bag: 1.0055 g;
- Weight of plastics bag + disc: 42.2379 g;
- Weight of plastics bag + disc + water: 42.2436 g;
- Weight of water: 0.0057 g;
- Surface area (top of disc): 7.11 cm^2;
- Moisture loading: 0.81 mg/cm^2.

E.5 Expression of results

For each test joint the following facts shall be recorded:

a) T_2 and T_1 and the RH at T_2 and T_1;

b) initial moisture loading (commencement of repair);

c) final moisture loading (see E.3.2).

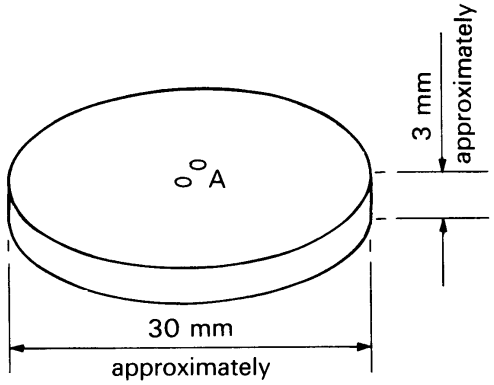
E.6 Test report

The test report shall include the following information:

a) reference to this standard, i.e. GIS/LC8-1:2013;

b) results of determination, see **E.5**;

c) any additional factors which may have affected the results of the test.



Small holes to be drilled at A are to accommodate either a thermocouple, or tweezers to remove disc from pipe.

NOTE – Discs are flat on both sides therefore the recesses in the pipe need to be milled flat at the bottom.

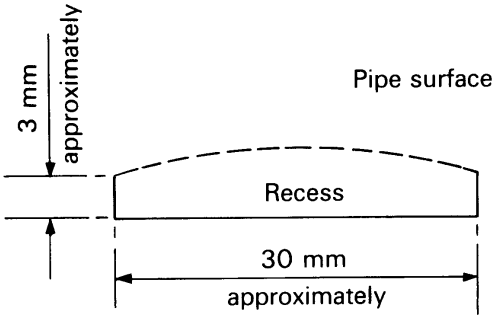


Figure E.1 — Size of discs

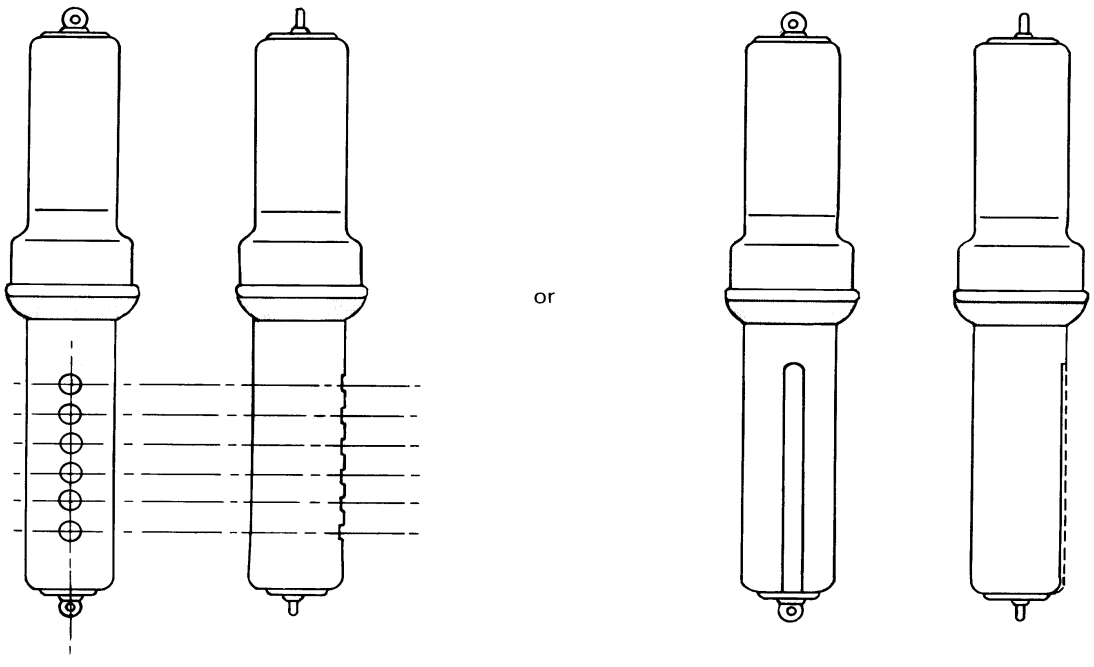


Figure E.2 — Modified test joint for moisture sensitivity test

Bibliography

[1] GREAT BRITAIN. Control of Substances Hazardous to Health Regulations 2002. London: The Stationery Office.