Gas Industry Standard

GIS/LC1:2022

Leak Repair and annular sealants for metallic gas mains and services up to 7bar

Cadent Your Gas Network

Gas Networks Ireland

Northern Gas Networks

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Foreword

Publishing information

This Gas Industry Standard (GIS) has been developed by the Energy Networks Association (ENA), with draft development facilitated by BSI Standards Ltd. All copyrights, trade secrets and all other rights subsisting in the document are owned by ENA.

This GIS is not to be regarded as a British Standard.

Information about this document

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

Use of this document

It has been assumed in the preparation of this GIS that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions - 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;

pressures all pressures quoted are gauge pressures

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

History

Table 1 – Scheme specifications and history

Specification & Date	Specification Title	Amendment No.(s)	Technical Committee
GIS/LC1:2022	Leak repair and annular sealants for metallic gas mains and services up to 7bar	July 2022	TSF
GIS/LC1:2018	Leak Repair and annular sealants for metallic gas mains and services up to 7bar	October 2018	TSF
This Gas Industry Standard (GIS) was approved by the Technical Standards Forum (TSF) in October 2018. It was developed to replace the previous suite of Leak Repair standards in order to reflect future innovations in product development and new test methods to evaluate chemical properties and system performance for leak repairs.			

GIS/LC14:2009	Annular gap sealants First issued as T/SP/LC14 in November 1993	Apr 2009	TSF
GIS/LC25:2006	External sealant injection systems for joint repair on metallic distribution pipe operating at pressures of 2bar or less First issued as T/SP/LC25 in September 2002	Aug 2006	TSF
GIS/LC8-1:2006	Methods of repairing leaking ferrous gas mains Part 1: External encapsulation systems First issued as BGC/PS/LC8:Part 1 in March 1981	Aug 2006	TSF
GIS/LC8-3:2006	Specification for Methods of repairing leaking ferrous gas mains Part 3: Internal sealing methods First issued as PS/LC8: Part 3 in July1984	Aug 2006	TSF
GIS/LC9:2006	Specification for Methods of repairing threaded joints on screwed pipework First issued as GBE/LC9 in August 1993	Aug 2006	TSF
GIS/LC12:2006	Sealant systems for joint repair on metallic distribution pipe systems operating at pressures equal to or less than 2bar, buried in locations subject to low traffic loadings (minor roads and footpaths) First issued as PS/LC8: Part 5 in October 1986	Aug 2006	TSF

Contractual and legal considerations

This GIS does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with this GIS cannot confer immunity from legal obligations.

1 Scope

This Gas Industry Standard (GIS) specifies the physical, chemical and mechanical performance requirements of sealant materials used to repair an existing metallic pipe over its lifetime, at an in service temperature range of between -5°C to +30°C for below ground applications and -20°C to +50°C for above ground applications, operating at pressures of up to and including 75mbar or 2bar.

NOTE Where designed to do so, some products could be used with pressures of up to 7bar but the primary use of repair sealants should be up to 2bar.

It also details the tests carried out in evaluating the effectiveness of a permanent repair system.

It includes methods involving:

- internal or external injection into pipe joints;
- internal or external application onto pipework;
- encapsulation of joints; and
- annular gap sealant used to prevent the passage of gas along the annulus formed between an inserted plastic pipe and an existing metallic pipe.

The repair system may be for localized repairs (e.g. leaking joints), where the original main continues to act as the primary gas carrying component or for pipe renovation (e.g. structural liners), which take over as the primary gas carrying component following breakage of the original main.

NOTE This may involve manual installation or via robotics within the pipe system. Spray applied techniques would be included, delivered by an operator and/or robotic methods. It does not include "gas borne particles" fed into the pipeline as a repair method.

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.

2.1 British Standards

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

BS EN 549*, Specification for rubber materials for seals and diaphragms for gas appliances and gas equipment*

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

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

BS ISO 1817, *Rubber, vulcanized or thermoplastic — Determination of the effect of liquids*

2.2 Gas Distribution Network Procedures (GDN)

GDN procedures for mains repairs and pressure testing may differ from GDN to GDN.

3 Terms and definitions

For the purposes of this GIS the following definitions apply.

3.1 low pressure

operating pressure not greater than 75mbar

3.2 medium pressure

operating pressure greater than 75mbar but not greater than 2bar (4bar in Gas Networks Ireland)

3.3 intermediate pressure

operating pressure greater than 2bar but not greater than 7bar (4 and 7bar in Gas Networks Ireland).

3.4 joint deflection

angle between the centre line of the pipe spigot and the centre line of the pipe socket

3.5 International Rubber Hardness (IRHD)

hardness scale chosen so that “0” represents the hardness of material having a Young’s modulus of zero and “100” represents the hardness of a material of infinite Young’s modulus, with the following conditions being fulfilled over most of the normal range of hardness:

a) one international rubber hardness degree always represents approximately the same proportionate difference in the Young’s modulus; and

b) for highly elastic rubbers, the scales of IRHD and the Shore A durometer are comparable.

4 General requirements

4.1 Repair methods

This GIS considers a range of pipe type and leak repair methods, as detailed in **4.2** to **4.6**.

4.2 Pipe types

The leak repair system shall be used in sealing pipes or forming an annulus between an inserted plastic pipe and an existing metallic pipe manufactured from:

a) cast iron pipes, fittings, accessories and their joints for gas pipelines conforming to BS 78-2 or BS 1211;

b) ductile iron pipes, fittings, accessories and their joints for gas pipelines conforming to BS EN 969;

c) steel conforming to BS EN 10216-1; and

d) PE Pipe to GIS/PL2 standards forming an annulus between an inserted plastic pipe and an existing metallic pipe.

NOTE Annular sealants should be deployed to ensure no voiding or tracking.

4.3 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 may be encountered. The seals shall be capable of withstanding subsequent movement of the ends of the pipes.

4.4 Joint penetrating method

This sealant material is for internal or external application (injected or sprayed), to pipes using either lead/yarn or mechanical type joints and operating at a maximum working pressure equal to or less than 2bar.

4.5 Sealants for threaded joints method

This sealant material is applicable to sealants for threaded joints of metallic gas pipework carrying fuel gas of the second family (natural gas). Products may be used with Intermediate pressure of up to 7bar but the primary use of repair sealants shall be up to 2bar. The GIS is applicable for repair methods included in but not limited to, the following categories:

- anaerobic or jointing compounds;

- non-hardening jointing compounds (as used to repair threaded joints);
- external encapsulating compounds; and
- heat shrink sleeves.

4.6 Annular gap sealants

This sealant material is for internal application of sealant materials (which may be applied externally, being pumped into the annulus from an external source) used to prevent the passage of gas along the annulus formed between an inserted plastic pipe and an existing metallic pipe.

5 Leak repair material requirements

5.1 Properties for materials

NOTE Both one-part and two-part (i.e. base plus additive) sealant systems may be used. Foams or friable materials may not be used.

5.1.1 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 An effective seal would remain leak tight and leakage rates should not exceed 2.8 l/hr.

5.1.2 The sealant shall be non-biodegradable.

5.1.3 The sealant shall still fully conform to all the requirement of this GIS at the end of the specified shelf life.

5.1.4 There shall be no adverse effect on the sealant when it is in contact with common substances found in pipes, including mono-ethylene glycol, diethylene glycol, water, light lubricating oil, and distillate.

5.1.5 The sealant shall remain stable within the temperature range of -20 °C to +50 °C.

5.1.6 The sealant shall not have any deleterious effects on the material properties of any elastomeric components encountered in the pipeline, as the following:

a) Hardness: the change in hardness value after immersion in the sealant for 7 days shall not be greater than 10%; and

b) Swell: the volume change after immersion in the sealant for 7 days shall not be greater than 20%, as determined by the method specified in BS ISO 1817.

5.1.7 For all sealants likely to be in contact with polyethylene pipe, there shall be no adverse chemical effects (e.g. dissolution or softening) by the reacted sealant or by individual unreacted components.

5.1.8 Sealants specific to internally applied materials shall not result in reduction in pipe bore diameter due to the fitting of the repair. It shall be such that the system maintains at least 85% of the original flow capacity.

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.

6 Test requirements

NOTE See Table 2 for guidance on which tests are applicable to each product type.

6.1 Chemical and physical properties of materials

6.1.1 Viscosity

Materials shall have a useable viscosity to ensure adequate penetration of joints/coverage of pipes. When tested in accordance with Annex A, measured viscosity shall comply with manufacturer's declared data.

6.1.2 Reactivity to natural gas – applicable to single and two part sealants only

Joint repair materials should not be adversely affected by exposure to natural gas and when tested in accordance with Annex B, the sealants shall start to cure in not less than 6 h or more than 48 h in a temperature range from 5 °C to 20 °C.

6.1.3 Gel time and accelerated ageing – applicable to single and two part sealants

When tested in accordance with Annex C, this test is used to determine when a product, stored at an elevated temperature, begins to gel or polymerise. The object of the test is to ascertain the expected shelf life of the product under normal storage conditions. When tested in accordance with Annex C, both aerobic and anaerobic tests shall be conducted. For the aerobic test, the sealant shall not gel or polymerise in less than 6 hrs. For the anaerobic test, the sealant shall not gel or polymerise in less than 2 hrs. If the sealant passes both parts of the test this is equivalent to a shelf life of 12 months.

NOTE This test applies to two part sealants in their un-mixed state and not after mixing. An additional test is specified in Annex C for single part sealants.

6.1.4 Sealant slump – applicable to annular gap sealants only

The annular gap sealant shall successfully fill the annulus when large volumes of material are required, when subject to the test specified in Annex D.

6.1.5 Effect on rubber and elastomeric seals

The sealant should not have any deleterious effects on the material properties of any elastomeric components encountered in the pipeline.

When tested in accordance with Annex E, the increase in mass due to swelling shall not exceed 10% and the change in hardness shall not exceed 10%. The decrease in mass after drying shall not be in excess of 5%.

6.1.6 Effect on polyethylene pipe and stress corrosion

There shall be no adverse chemical effects (e.g. dissolution or softening) by the reacted sealant or by individual unreacted components when used on polyethylene pipe. The test for stress corrosion cracking shall be performed in accordance with Annex F.

6.1.7 Accelerated corrosion testing

The test plate shall show no pitting or corrosion due to the effect of the sealant and the sealant shall remain in-place following exposure to a corrosive environment. The test for corrosion testing shall be performed in accordance with Annex G.

6.2 System performance testing – repair methods

6.2.1 Application temperature

A test joint of each type shall be sealed at -5 °C and 20 °C. Joints and sealing materials shall be stored for a minimum of 12 h at the appropriate test temperature before sealing.

6.2.2 Sensitivity to application on a moist surface

Materials might be adversely affected by exposure to moisture or water ingress. For externally applied repair sealants the pipe surface shall be dried to remove trace of moisture before applying the sealant.

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.

6.2.3 Pressure test

Two test joints shall be prepared in accordance with the test methods described in Annex H, maintained at an internal pressure of twice the maximum working pressure for one week.

On completion of each test the leakage rate shall not exceed 2.8 l/h from the joint or the termination fitting.

6.2.4 Deflection test

Two test joints shall be tested in accordance with Annex I, deflected at a constant rate of 1 °/min ± 0.1 °/min until a deflection of 5° is reached. There shall be no leakage from these joints between 0° and 0.1°, and between 0.1°and 5°, and the leakage rate shall not exceed 2.8 l/h.

6.2.5 Axial pull test

Two test joints shall be tested in accordance with Annex J and are axially displaced at a rate of 1 mm/min ± 0.1 mm/min until the axial displacement reaches 6.5 mm.

There shall be no leakage from these joints between 0 and 0.2 mm displacement, and between 0.2 mm and 6.5 mm displacement the leakage rate shall not exceed 2.8 l/h.

6.2.6 Impact test – applicable to all repaired joints

The repaired joint (see Table 2 – heat shrink and annular gap sealant are excluded) shall have the capability to withstand an impact load of the kind that it might experience during periods where the joint is still excavated, is determined. When tested in accordance with Annex K the repaired joint shall exhibit no visible leakage when using leak detection fluid whilst pressurized at 3.0bar.

6.2.7 Vibration test – below ground – applicable to all leak repair methods

Vibration testing shall be carried out in accordance with Annex L.

No failure shall occur. 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.

6.2.8 Vibration test – above ground – applicable to all leak repair methods

Vibration testing shall be carried out in accordance with Annex M.

Each specimen shall be deemed to be tight if the leakage rate does not exceed 10 ml/h at a test pressure of 150mbar.

6.2.9 Ageing test – above ground – applicable to all leak repair methods

Ageing testing shall be carried out in accordance with Annex N.

Each specimen shall be deemed to be tight if the leakage rate does not exceed 10 ml/h at a test pressure of 150mbar.

6.2.10 Thermal cycling test – applicable to all leak repair methods

Thermal cycling testing shall be carried out in accordance with Annex O.

Each specimen shall be deemed to be tight if the leakage rate does not exceed 10 ml/h at a test pressure of 150mbar.

It shall be deemed to have passed the test if there is no evidence of repair method disbonding or deterioration.

Table 2 –Test requirements for specific product types

	Product →	Anaerobic or Aerobic jointing compounds (two part sealant)	Non-hardening jointing compounds including threaded joint repair	External encapsulating compounds	Heat shrink sleeves	Annular gap sealant	Anaerobic jointing compound- blown or fogged
Test Requirements ↓	Applicable Clauses →	All Tests described in Clauses **6.1.1** to **6.1.7** excluding Clause **6.1.4** and including Clauses **6.2.3** to **6.2.10**.	All Tests described in Clauses **6.1.1** to **6.1.7** excluding Clause **6.1.2** and including Clauses **6.2.3** to **6.2.10**.	All Tests described in Clauses **6.1.1** to **6.1.7** excluding Clauses **6.1.2** and **6.1.4** and including Clauses **6.2.3** to **6.2.10**	All Tests described in Clauses **6.2.3** to **6.2.10**.	All Tests described in Clauses **6.1.1** to **6.1.7** excluding Clause **6.1.2** and including Clause **6.2.3**.	All Tests described in Clauses **6.1.1** to **6.1.7** excluding Clause **6.1.4** and including Clauses **6.2.3** to **6.2.10** excluding Clause **6.2.6**.
Viscosity [6.1.1]		✓	✓	✓	×	✓	✓
Reactivity to natural gas (Applicable to single and two part sealants only) [6.1.2]		✓	×	×	×	×	✓
Gel time and accelerated ageing (Applicable to single and two part sealants) [6.1.3]		✓	✓	✓	×	✓	✓
Sealant slump (Applicable to annular gap sealants only) [6.1.4]		×	✓	×	×	✓	×
Effect on rubber and elastomeric seals [6.1.5]		✓	✓	✓	×	✓	✓
Effect on polyethylene pipe and stress corrosion [6.1.6]		✓	✓	✓	×	✓	✓
Accelerated Corrosion Testing [6.1.7]		✓	✓	✓	×	✓	✓
Pressure test [6.2.3]		✓	✓	✓	✓	✓	✓
Deflection test [6.2.4]		✓	✓	✓	✓	×	✓
Axial pull test [6.2.5]		✓	✓	✓	✓	×	✓
Impact Test [6.2.6]		✓	✓	✓	✓	×	×
Vibration Test – below ground [6.2.7]		✓	✓	✓	✓	×	✓
Vibration Test – above ground [6.2.8]		✓	✓	✓	✓	×	✓
Ageing Test – above ground [6.2.9]		✓	✓	✓	✓	×	✓
Thermal Cycling Test [6.2.10]		✓	✓	✓	✓	×	✓

7 Marking

Products conforming to GIS/LC1:2022 shall be permanently marked with the following information:

a) the number and date of this standard, i.e. GIS/LC1:2022;

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

c) the manufacturer's contact details;

d) batch traceability number;

e) best before or product expiry date;

f) storage temperature;

g) EU Hazard symbols;

h) any limits on the application of the product; and

NOTE An example would be pressure rating "e.g. Low pressure use".

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

NOTE An example of this is the BSI Kitemark.

8 Installation instructions

8.1 The leak repair kit shall be accompanied by adequate installation instructions to minimize the risk of incorrect or inappropriate installation.

8.2 All materials used in the repair system shall be subjected to a COSHH assessment and sufficient information supplied to the end user to enable them to meet their own COSHH obligations, to determine if there are any hazards and or special handling requirements.

8.3 A Risk Assessment and Methods Statement shall be provided by the manufacturer to provide guidance to installation contractors.

8.4 The instructions shall include as a minimum, reference to the following:

- minimum and maximum pipe diameters applicable to this repair method;
- type of joint, defect or fittings within scope of repair system;
- recommended maximum working pressure, either 75mbar, 2bar, 5bar (4bar for Gas Networks Ireland) or 7bar;
- necessary installation tools include pressure gauges and/or leak detection fluid (LDF);
- excavation depths, if applicable;
- surface preparation and cleaning, if applicable;
- site conditions with reference to minimum and maximum curing temperatures -20 °C to +50 °C;
- method of deployment (internal/external, spray/direct injection) in the gas pipework;
- post repair test methods;
- tightness test before commissioning; and
- warning not to mix component chemicals/sealants from differing repair method kits.

9 Product packaging

9.1 Leak repair sealant and accessories shall be protected against damage and deterioration throughout all stages of processing, storage and delivery, and shall be well protected.

9.2 The type and use of packaging materials and their potential impact on the environment shall be taken into account.

9.3 To facilitate safe handling of leak repair sealant and accessories, the Manual Handling Operations Regulations 1992, as amended in 2002, shall be taken into account. Leak repair sealant and accessories shall be supplied in normal trade packs.

Annex A (normative)
Viscosity measurement

A.1 Principle

This test is to determine whether the viscosity of each sealant product is within manufacturer's declared specification.

A.2 Apparatus

A.2.1 *An appropriate viscometer*; commonly used models are Brookfield Spinning Plate Viscometer and Bolin Cone and Plate Viscometer and low viscosity fluid measured using glass U-tube device.

A.3 Procedure

A.3.1 Operate the Viscometer in accordance with the equipment manufacturers operating instructions.

A.4 Expression of results

Record the measured viscosity and compare this to the manufacturer's declared data, measured values shall be within with the manufacturers declared tolerances.

Annex B (normative)
Reactivity measurement – applicable to two part sealants

B.1 Principle

This test is to determine the reactivity of the sealant using two tests, one at 5 °C and one at 20 °C, carried out in cast iron test pots.

B.2 Apparatus

B.2.1 *Two cast iron test pots.*

B.2.2 *Stopwatch*

B.2.3 *Water bath or environmental chamber, with ±1 °C accuracy.*

B.3 Test sample

The sample shall consist of 20 ml sealant and any required catalyst.

B.4 Procedure

B.4.1 Allow all the test components to soak at the test temperature for 1 h before testing.

B.4.2 Connect the pots to a supply of natural or inert gas as shown in Figures B.1

B.4.3 Put 20 ml of sealant into the pots and replace the “0-ring” seal and lid. Secure the lid with screws.

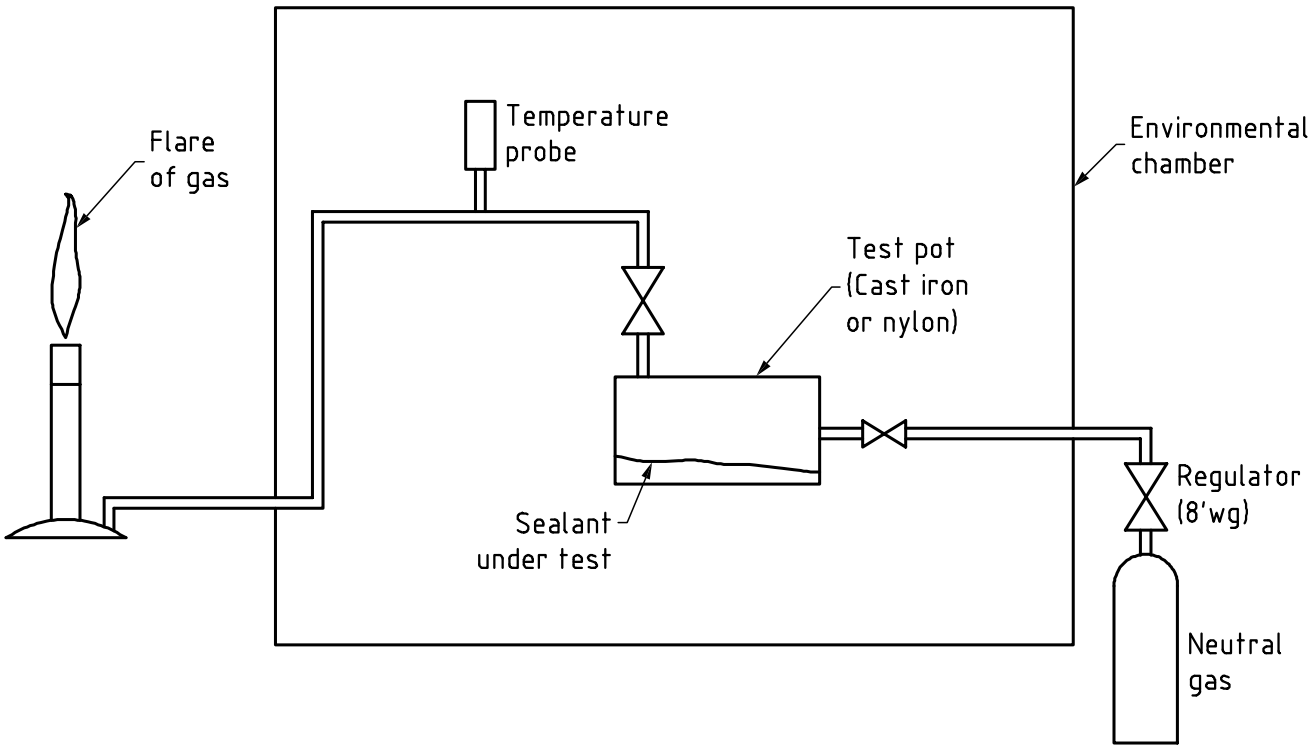


Figure B.1 –Reactivity measurement apparatus

B.4.4 Turn on the gas supply and allow gas to pass over the sealant under test. Start the stopwatch.

B.4.5 Establish whether the sealant has cured by tilting the test posts in a direction perpendicular to the axis of the gas inlet/outlet holes.

NOTE The sealant is deemed to have cured once an obvious change in its viscosity has occurred.

B.4.6 Turn off the gas supply and vent any entrained gas.

B.4.7 Stop the stopwatch.

B.5 Expression of results

The sealant shall take no less than 6 h and no more than 48 h to cure.

Annex C (normative)
Shelf life test – applicable to two part sealants only

C.1 Application – Aerobic test

This procedure is used to determine when a product, stored at an elevated temperature, will begin to gel or polymerise. The object of the test is to ascertain the expected shelf life of the product under normal storage conditions. This test is carried out under aerobic conditions.

C.2 Apparatus

C.2.1 *Calibrated heating block*, controlled to 82 °C ± 1 °C.

C.2.2 *Test tube*, Pyrex or equivalent, size 75 mm x 12 mm.

C.2.3 *Wooden applicator stick*.

C.2.4 *Calibrated timer*.

C.2.5 *Pipette*.

C.3 Method

C.3.1 Fill the test tube with the sample.

C.3.2 Place test tube in the heating block previously adjusted to 82 ºC ± 1 ºC.

C.3.3 Place the wooden applicator stick in the test tube and start the timer. For UV samples place a square of aluminium foil over the top of the test tube to prevent light from entering the sample.

C.3.4 Check for gel particles every 30 min by sliding the applicator stick up the side of the tube until it reaches the top. DO NOT STIR SAMPLE.

C.4 Result

When the first gel particles are observed the stability, in hours, must be recorded. The Aerobic sealant should not gel or polymerise in less 6 h.

C.5 Application – Anaerobic test

This procedure is used to determine when a product, stored at an elevated temperature, will begin to gel or polymerise. The object of the test is to ascertain the expected shelf life of the product under normal storage conditions. This test is carried out under anaerobic conditions.

C.6 Apparatus

C.6.1 *Calibrated heating block* controlled to 82 °C ±1 °C.

C.6.2 *Test tube*, Pyrex or equivalent, size 75 x 12 mm.

C.6.3 *Rubber bung* to tightly fit test tube.

C.6.4 *Calibrated timer*.

C.6.5 *Pipette*.

C.6.6 *Fine wire*, e.g. paper clip.

C.7 Method

C.7.1 Fill the test tube with the sample until it reaches approximately 10 mm from the top.

C.7.2 Place a fine wire (e.g. a paper clip) inside the tube so it just touches the liquid and insert the bung until it touches the sample. The air should be expelled by the side of the wire as the wire is withdrawn.

C.7.3 Gently withdraw the wire so the bung stays sealed and place the sample in the heater block. It is important to ensure that there are no air bubbles in the sample at this stage.

C.7.4 Regularly invert the sample. After a certain period of time, a bubble should appear. Record the time that this bubble no longer moves when the test tube is inverted.

C.8 Result

The stability is recorded as the time when there is no significant movement of the bubble or the product has gelled. The Anaerobic sealant should not gel or polymerise in less than 2 h.

C.9 Shelf life test – applicable to single part sealants only

C.9.1 Method

C.9.1.1 Store a sample of the sealant, in the standard packaging at an elevated temperature of 55 ºC ± 1ºC for 5 days.

C.9.1.2 Re-test the viscosity in accordance with Annex A.

C.10 Result

A deviation from the manufacturer's declared viscosity by + 20% shall be deemed a failure.

Annex D (normative)
Service sealant slump test – applicable to annular gap sealants only

D.1 Principle

This test determines the ability of the sealant to be able to fill the annular gap without slumping.

D.2 Apparatus

D.2.1 *Service head adaptor*.

D.2.2 *Steel pipe*, 2 in.

D.2.3 *Polyethylene pipe*, 32 mm.

D.2.4 *Pressure source*, capable of supplying pressure at 120mbar.

D.2.5 *Water manometer*, capable of reading up to 120mbar.

D.2.6 *Environmental chamber*, capable of being maintained at -5 °C.

D.2.7 *Environmental chamber*, capable of being maintained at 30 °C.

D.3 Test samples

Two samples of polyethylene pipe inserted into steel pipe.

D.4 Procedure

Degrease the sections and threads of the 2 inch diameter steel service pipe. Assemble as shown in Figure D.1. Two assemblies are required, one maintained at a temperature of -5 °C and the other at a temperature of 30 °C. Ensure all screwed joints are leak proof, i.e. use an approved jointing paste.

Insert the 32 mm diameter polyethylene pipe and fit the service head adapter.

Carry out two tests: one test using the sealant material that has been stored at a temperature of 5 ℃ and the other at a temperature of 25 °C, both for a minimum period of 12 h before the test.

Carry out annular gap filling via the service head adapter by following the sealant manufacturer's instructions. Ensure the volume of sealant kit used fills the annulus to excess. Use the sealant stored at a temperature of 5 °C in the assembly maintained at a temperature of -5 °C and the sealant stored at a temperature of 25 °C in the assembly maintained at a temperature of 30 °C.

Allow a maximum of 24 h cure time and remove the service head adapter. Then cut the assembly into two 300 mm lengths. Check the degree of annular fill.

Subject the two 300 mm lengths to a pneumatic pressure test so that only the sealed annular gap has a pressure of 100mbar applied to it for 5 min.

Allow a minimum time period of 7 days to elapse before subjecting the sealed annular gap to a further pneumatic pressure test of 100mbar for 5 min.

During and at the completion of each test the leakage rate shall not exceed 20cm³/h.

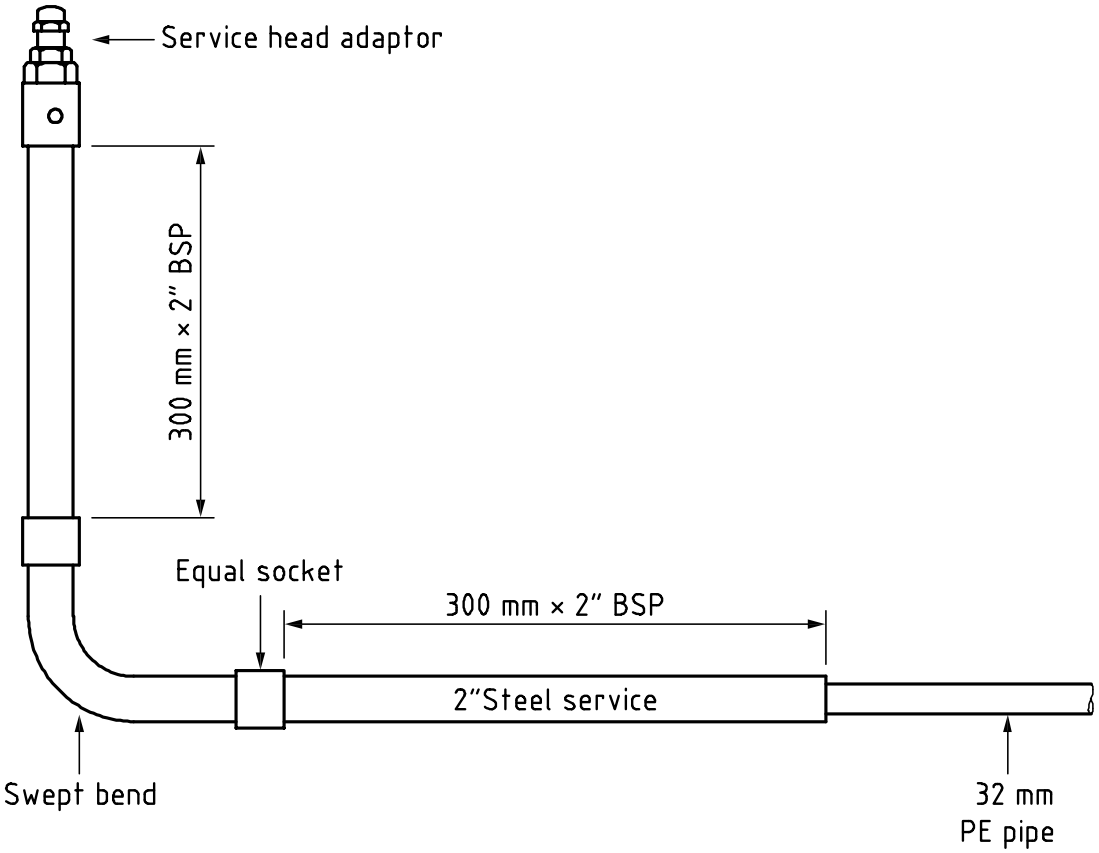


Figure D.1 – Service sealant slump test

Annex E (normative)
Effect on rubber – applicable to all sealant types

E.1 Principle

This test is to determine the effect of the sealant on any rubber seals used within gas pipework.

E.2 Apparatus

E.2.1 *Digital weighing scales* with 20g range with an accuracy to three decimal places.

E.2.2 *Laboratory 50ml glass beakers*

E.2.3 *Drying oven*

E.2.4 *Nitrile butadiene rubber (NBR) O-ring seals* of approximately 3g in weight with an IRHD hardness of 75 ± 5.

E.3 Procedure

Testing shall be in accordance with BS EN 549:1995, **7.6**, using the leak repair sealant (instead of pentane) and assessing its behaviour on specimens made from nitrile butadiene rubber (NBR).

When tested, the increase in mass due to swelling shall not exceed 10% and the change in hardness shall not exceed 10%. The decrease in mass after drying shall not be in excess of 5%.

Annex F (normative)
Environmental stress cracking of polyethylene pipe

F.1 Principle

This test is used to determine the ability of the leak repair sealants to promote environmental stress cracking in polyethylene pipe. For two-part sealants, each part is tested separately.

F.2 Apparatus

F.2.1 *250 ml airtight glass container*.

F.2.2 *Nylon cable ties*.

F.2.3 *Razor blade*.

F.2.4 *Magnifying glass*, low magnification level (×10) with an illumination lamp.

F.2.5 *500 mm length of 25 mm PE80 Gas Pipe*.

F.3 Procedure

F.3.1 Cut four test pieces, each 12.7 mm wide from the pipe (see Figure F.1).

F.3.2 Cut a notch 19 mm long and 0.64 mm deep in each ring using the razor blade, as Indicated in Figure F.1. Place the notch in the centre of the ring and parallel to the edge.

F.3.3 Compress the rings until the inner section of the middle areas touch. Secure this compression using a nylon cable tie. During compression, place the notched area parallel to the direction of compression, i.e. on the short radius (see Figure F.1).

F.3.4 Immediately immerse three of the rings (the fourth ring being the control sample) into 125 ml of the unreacted liquid component in a 250 ml capacity sealed glass container, maintained at a temperature of (23 ± 2) °C.

F.3.5 Examine samples for crack initiation in the notched area after one week and one month, using the magnifying glass. Compare with control sample.

F.4 Results

No cracking shall be observed.

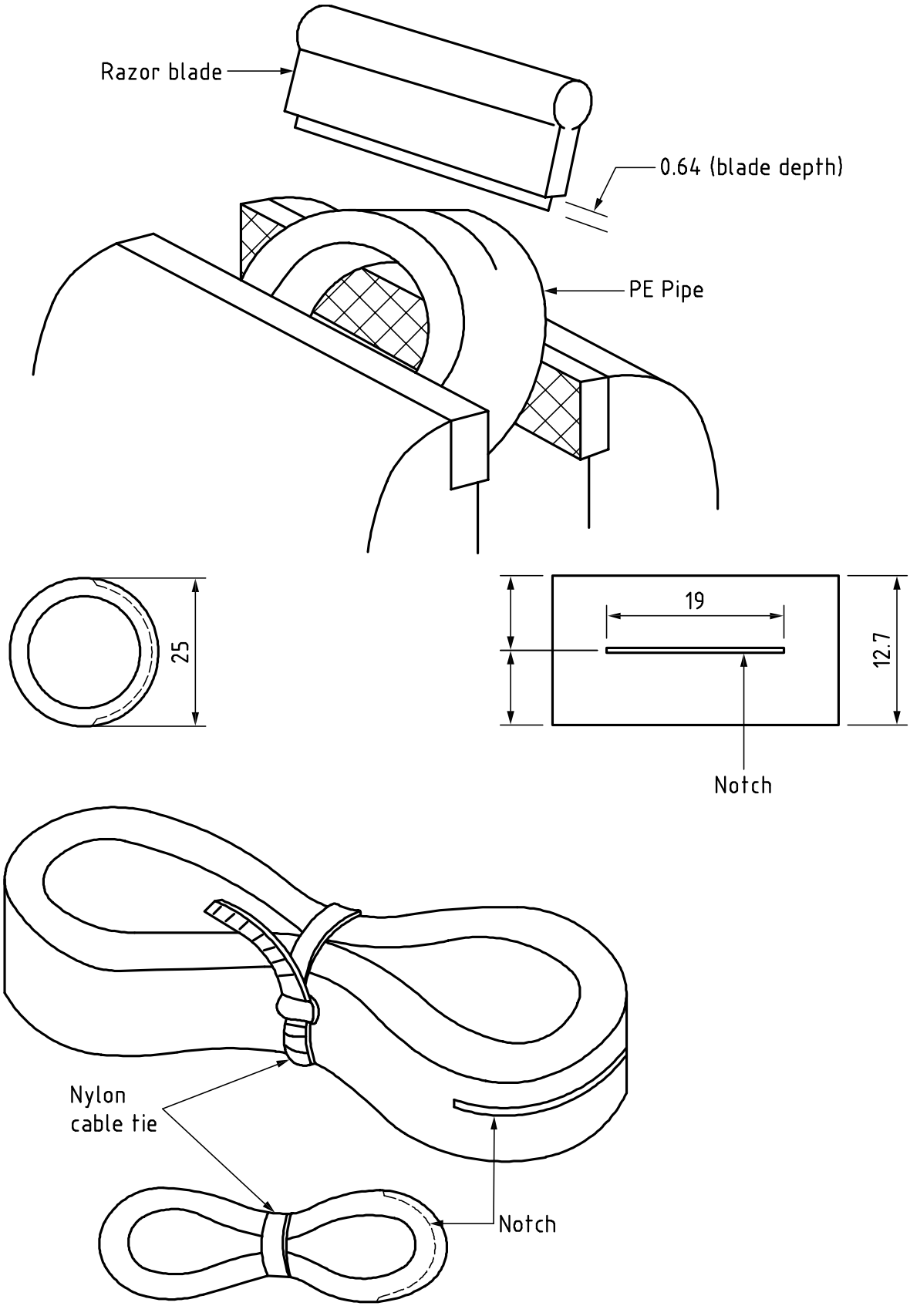


Figure F.1 –Test piece for environmental cracking

Annex G (normative)
Accelerated corrosion testing – Small scale test

G.1 Principle

To determine the capability of the repair material to withstand the effects of a corrosive environment and to determine the corrosive effect of the sealant material.

G.2 Apparatus

G.2.1 *Cast iron plate, 150 mm × 150 mm × 6 mm.*

G.2.2 *Sodium chloride*.

G.2.3 *Water*.

G.2.4 *Immersion bath*.

G.2.5 *Stainless steel cathode*.

G.2.6 *Source of current*, up to 50 mA.

G.2.7 *Current meter*.

G.2.8 *Grit blast equipment*.

G.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.

G.4 Results

On completion of the test, the test plate shall show no pitting or corrosion due to the effect of the sealant and the sealant shall remain in-place following exposure to a corrosive environment.

Annex H (normative)
Pressure test – applicable to all leak repair methods

H.1 General

H.1.1 All test work shall be carried out using cast iron pipe joints with a nominal diameter of 6 in (150 mm), of a design conforming to BS 1211.

H.1.2 Joints shall be repaired in accordance with the contractor's fitting instructions. Care shall be taken to inject the sealant in such a manner that ensures the whole of the joint is treated (to prevent drain down).

H.2 Preparation of test joints

H.2.1 Method for standard lead/yarn joint

The test joint shall be prepared as follows:

a) Cleaning of the surfaces to be in contact with sealant by grit blasting to produce a uniform surface with no oxides or other coatings.

b) Insertion of the spigot into the socket: contact between the end of the spigot and the socket shall be prevented by insertion of three cardboard spacers with a thickness of 0.25 in at approximately 120° intervals.

c) Three turns of standard 11-strand or 13-strand 5/8 in (16 mm) yarn packed into the joint annulus and tamped down to 38 mm from the end of the socket face.

d) Lead poured into the joint to fill the annulus completely and caulked into the joint until the joint is leak tight at the appropriate test pressure.

e) At normal (standard) temperature and pressure (STP), a leakage rate of between 20 l/h and 40 l/h (for 75mbar) or between 100 l/h and 160 l/h (for 2bar) established by shock impact with a wooden block and hammer.

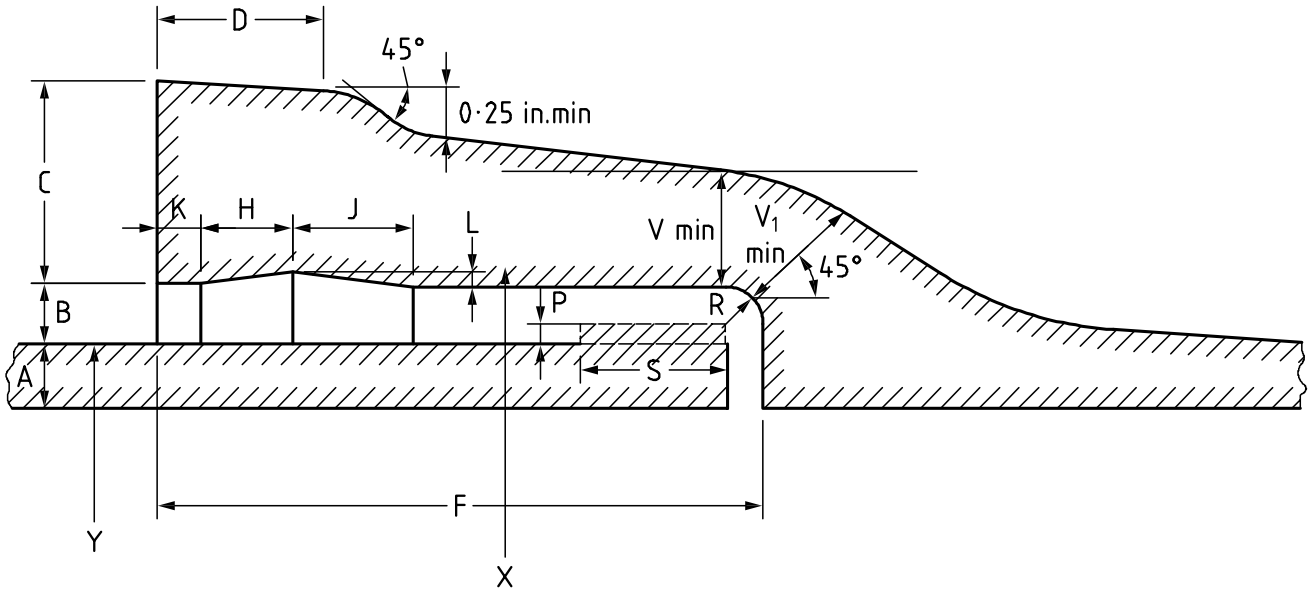


Figure H.1 –Test joint dimensions as given in BS 1211, Cast iron pressure pipes

H.2.2 Test joint Dimensions as given in BS 4772:1988

Table H.1 – BS 1211 Table 10 (Extract) Dimensions of spigots and socket

	Classes B, C and D					
Nominal internal diameter of pipe	**3**	**4**	**5**	**6**	**7**	**8**
A – Class B	0.29	0.30	0.31	0.33	0.34	0.36
B	0.38	0.38	0.38	0.38	0.38	0.38
C min	0.98	1.02	1.05	1.08	1.12	1.15
D	1.40 +/- 0.25					
F	3.50	3.50	3.50	3.50	3.50	3.50
H	0.36	0.36	0.36	0.42	0.42	0.48
J	0.56	0.56	0.56	0.63	0.63	0.69
K	0.33	0.33	0.33	0.33	0.33	0.33
L	0.13	0.13	0.13	0.13	0.13	0.13
P	0.19	0.19	0.19	0.19	0.19	0.19
R	0.25	0.25	0.25	0.25	0.25	0.25
S	13/16 +/- 3/16					
V min	0.54	0.56	0.57	0.59	0.61	0.63
V1 min	0.59	0.61	0.62	0.64	0.67	0.69
X	4.52	5.56	6.66	7.74	8.82	9.90
Y	3.76	4.80	5.90	6.98	8.06	9.14

H.2.3 Method for standard mechanical joints

The standard test joint shall be a proprietary joint, sealed with a lead or nylon tipped rubber gasket. It shall be prepared as follows:

a) made up and tightened to a torque of 68 Nm or in accordance with manufacturer's instructions, held for a period of 24 h;

b) the bolts completely slackened and the test joint allowed to relax for 24 h; and

c) after this time, the test joint re-tightened evenly until a leakage rate of between 20 l/h and 40 l/h (for 75mbar) or between 100 l/h and 160 l/h (for 2bar) is established.

H.2.4 Where injection point terminations are engineered to create a durable seal, it shall be subject to an additional test. An additional injection point termination shall be fitted to the wall of the pipe so that when the joint (whether a lead yarn joint or a standard mechanical joint) is tested in accordance with post repair leakage test, the injection point termination shall also be subject to the test pressure.

H.2.5 Conditioning

All joints shall be conditioned at ambient temperature for seven days following sealing (no leakage shall be permitted after sealing).

H.3 Repair application

A joint of each type shall be tested.

Not more than two 0.4 in (9 mm) maximum diameter holes shall be drilled and tapped to 1/8 in (3 mm) British Standard Pipe (BSP) at the back of the joint socket.

A test joint of each type shall be sealed at -5 °C and 30 °C. Joints and sealing materials shall be stored for a minimum of 12 h at the appropriate test temperature before sealing. The means, volume and rate of injection and sealing of injection points shall be that recommended in the manufacturer's fitting instructions.

All joints shall be conditioned at ambient temperature for seven days following sealing.

H.4 Short term internal pressure test

Two test joints shall be maintained at an internal pressure of twice the maximum working pressure for 1 week.

Following the test the leakage rate shall be measured and shall not exceed 2.8 l/h.

Annex I (normative)
Deflection test – applicable to all leak repair methods

I.1 Deflection testing

I.1.1 Principle

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

I.2 Apparatus

I.2.1 *Framework*, to support test item and also capable of holding the socket end of the joint stationary.

I.2.2 *Framework* which is capable of allowing angular displacement of the test item in a single plane.

I.2.3 *Means of measuring angular displacement*, of up to 10° in increments of 0.1° per minute.

I.2.4 *Pressure gauge*, capable of measuring up to 5bar.

I.2.5 *Pressure source*, up to 4bar.

I.3 Preparation of specimens

Two repaired joints shall be used to carry out deflection and hold to failure test.

I.4 Procedure

I.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.

I.4.2 Deflect two repaired joints from 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 test shall be terminated after 2 h at the maximum deflection of 5° and the leakage rate shall not exceed 2.8 l/h.

Annex J (normative)
Axial pull test

J.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.

J.2 Apparatus

J.2.1 *Framework*, to support test item and also capable of holding the socket end of the joint stationary.

J.2.2 *Framework* which is capable of allowing axial displacement of the test item.

J.2.3 *Actuator*, capable of inducing axial displacement of the repaired joint by up to 10 mm in steps of 0.1 mm/min.

J.2.4 *Pressure gauge*, capable of measuring up to 5bar.

J.2.5 *Pressure source*, up to 4bar.

J.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.

J.4 Result

There shall be no leakage from these joints at an axial displacement of 6.5 mm at the start of the test and after seven days; the leakage rate shall not exceed 2.8 l/h.

Annex K (normative)
Impact testing – applicable to all leak repair methods

K.1 Principle

The repaired joint should be capable of withstanding an impact load of the kind that it might experience during periods where the joint is still excavated, is determined.

K.2 Apparatus

K.2.1 *Vee blocks*, to support repaired joint.

K.2.2 *Impact tool*, (see Figure K.1), with a mass of 5 kg ± 0.1 kg.

K.2.3 *Pressure gauge*, capable of measuring up to 5bar.

K.2.4 *Pressure source*, up to 4bar.

K.3 Procedure

Use one test joint complete 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 K.1, with the centre line of the repaired pipe.

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 3.0bar to the repaired joint.

Maintain this pressure for a period 24 h.

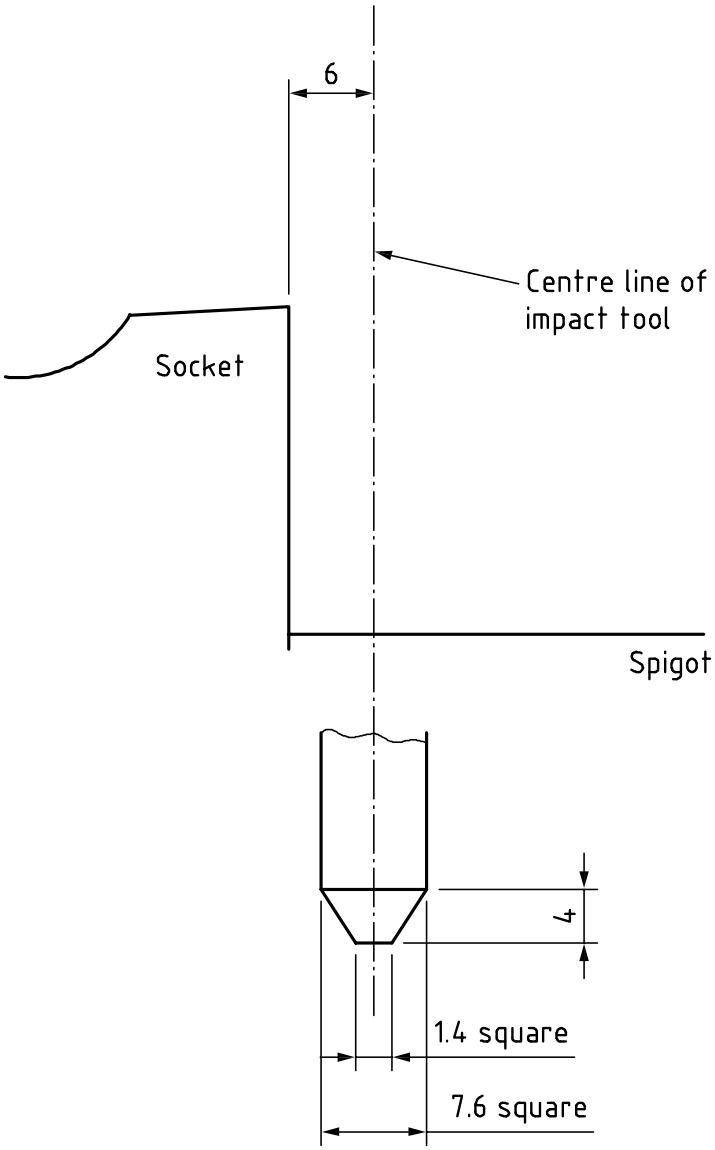


Figure K.1 – Impact test

K.4 Results

The repaired joint shall exhibit no visible leakage when using leak detection fluid whilst pressurized at 3.0bar.

Annex L (normative)
Vibration test – below ground: applicable to all leak repair methods

L.1 Principle

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

L.2 Apparatus

L.2.1 *Framework*, to support test item and also capable of holding the socket end of the joint stationary.

L.2.2 *Framework*, capable of allowing angular displacement of the test item in a single plane.

L.2.3 *Actuator*, capable of inducing angular displacements of the repaired joint by up to 1° at a frequency of up to 1 Hz.

L.2.4 *Pressure gauge*, capable of measuring up to 5bar.

L.2.5 *Pressure source*, up to 4bar.

L.3 Procedure

L.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.

Each of the three repaired joints are vibration tested in the sequence:

a) × 106 cycles of small amplitude vibration test (see **L.3.2**); and

b) × 103 cycles, offset, of large amplitude vibration test (see **L.3.3**).

L.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.

L.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.

L.4 Results

No failure shall occur. 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.

Annex M (normative)
Vibration test – above ground: applicable to all leak repair methods

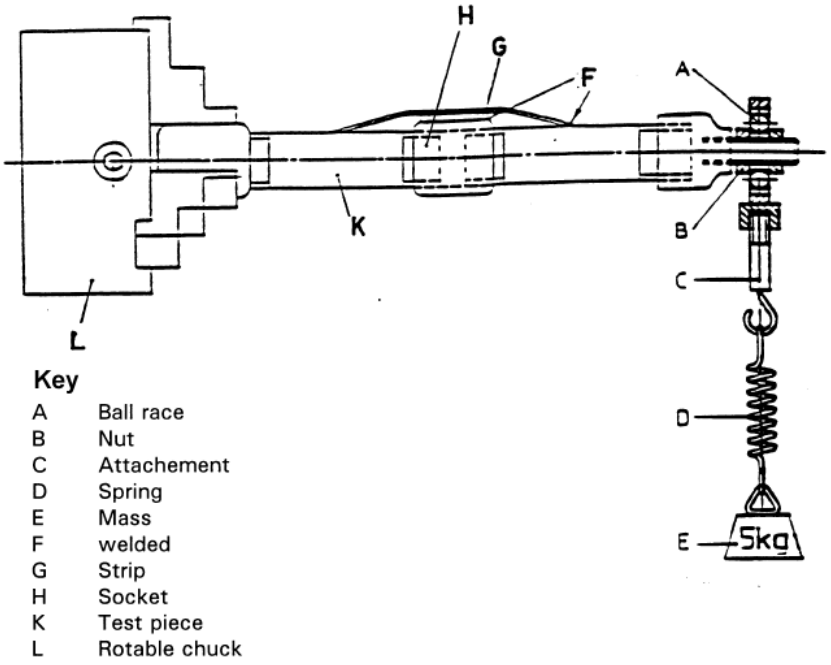
M.1 Principle

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

M.2 Apparatus

Test assembly, fitted with reducing sockets provided with a DN 15 nipple on which a bearing (ball race) is mounted.

Clamp the other end of the test assemblies successively in a rotating chuck (see figure M.1). Suspend a 5 000 ± 50 g mass from a spring (spring constant approx. 5 000 Nm-1) attached to the bearing.



Key

A	Ball race
B	Nut
C	Attachement
D	Spring
E	Mass
F	welded
G	Strip
H	Socket
K	Test piece
L	Rotable chuck

Figure M.1 – Vibration rig

M.3 Procedure

Fit three test joints with the repair system.

Rotate each test assembly at a rotation frequency of (700 ± 20) min-1 for a period of (30 ± 1) min.

Each test assembly is tested for leaks under a test pressure of 150mbar with a device capable of measuring leakage rates of ≤ 2 ml/h.

The temperature of the test assembly during the soundness test shall not vary more than ± 0,5 °C to avoid any significant disturbance of the measurement. The temperature influence may be further lessened by inserting a plastic cylinder into the test assemblies.

M.4 Results

Each specimen shall be deemed to be tight if the leakage rate does not exceed 10 ml/h at a test pressure of 150mbar.

Annex N (normative)
Ageing test – above ground: applicable to all leak repair methods

N.1 Principle

The capability of the repaired joint above ground to withstand ageing.

N.2 Apparatus

N.2.1 *Environmental chamber*

N.2.2 *Heat exchanger*

N.2.3 *Air circulator*

N.3 Procedure

Fit three test joints with the repair system.

Heat the test assemblies to (50 ± 2) °C for 1 000 h during which air heated by passage through a heat exchanger inside the oven to (50 +2/-5) °C is passed through the test assemblies at a flow rate of (100 ± 10) l/h.

Each test assembly is tested for leaks under a test pressure of 150mbar with a device capable of measuring leakage rates of ≤ 2 ml/h.

The temperature of the test assembly during the soundness test shall not vary more than ± 0,5 °C to avoid any significant disturbance of the measurement. The temperature influence may be further lessened by inserting a plastic cylinder into the test assemblies.

N.4 Results

Each specimen shall be deemed to be tight if the leakage rate does not exceed 10 ml/h at a test pressure of 150mbar.

Annex O (normative)
Thermal cycling test: applicable to all leak repair methods

O.1 Principle

This test determines whether or not the repair method is resistant to temperature effects that can be encountered during normal operating conditions.

O.2 Apparatus

O.2.1 *Means of controlling temperature of test samples*, between -5 °C to +30 °C.

O.2.2 *Water bath*.

O.2.3 *Pneumatic pressure source*, at 150mbar.

O.2.4 *Pressure gauge*, capable of measuring up to 170mbar in steps of 1mbar.

O.3 Procedure

Cap four of the test assemblies carefully using fittings with a non-setting jointing paste.

Partially immerse the test assemblies within the water bath.

Subject the test pieces to 400 freeze/thaw cycles from -5 °C to +30 °C with a minimum cycle time of 4 h.

Each test assembly is tested for leaks under a test pressure of 150mbar with a device capable of measuring leakage rates of ≤ 2 ml/h.

The temperature of the test assembly during the soundness test shall not vary more than ± 0,5 °C to avoid any significant disturbance of the measurement. The temperature influence may be further lessened by inserting a plastic cylinder into the test assemblies.

Examine the test assemblies internally for visual evidence of repair method disbonding or deterioration.

O.4 Results

Each specimen shall be deemed to be tight if the leakage rate does not exceed 10 ml/h at a test pressure of 150mbar.

There shall be no evidence of repair method disbonding or deterioration.

Bibliography

Other relevant standards publications

BS 78-2, *Specification for cast iron spigot and socket pipes (vertically cast) and spigot and socket - Fittings*

BS 1452, *Specification for flake graphite cast iron*

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*

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