Gas Industry Standard

GIS/PL4-1:2018

Specification for

Elastomeric diaphragms

Part 1: Homogeneous diaphragms

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Contents

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.

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Brief history

First published as BG/PS/PL4: Part 1	September 1988
Editorial update to reflect demerger November 2000	June 2001
Editorial update to reflect merger October 2002	November 2002
Editorial update to comply with GRM	August 2004
Edited by BSI in accordance with BS 0-3:1997	August 2006
Reviewed on behalf of the Gas Distribution Networks' Technical Standard Forum by BSI	September 2013
Reviewed by TSF and editorial updates completed	November 2018

1 Scope

This Gas Industry Standard specifies requirements and test methods for homogeneous elastomeric diaphragms used in equipment such as governors, relief valves, actuators and other controls operating at pressures up to 7 bar and at temperatures of −20 °C to 60 °C, in contact with air, natural gas and suitable manufactured gas in accordance with BS EN ISO 13686, BS EN 437 and BS 4250.

The tests defined in this standard are designed to ensure that equipment in which diaphragms are used will function correctly, that the materials used in manufacture of diaphragms are suitable for the above conditions of use and will provide adequate durability and life.

Test requirements take into account the presence of conditioning agents in the gas.

Additional tests may be required if the diaphragms are to be used at higher pressures or in contact with other fluids.

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 ISO 2781, *Rubber, vulcanized or thermoplastic. Determination of density*

BS ISO 815, *Rubber, vulcanized or thermoplastic. Determination of compression set.*

BS ISO 1432, *Rubber, vulcanized or thermoplastic. Determination of low-temperature stiffening (Gehman test).*

BS ISO 188, *Rubber, vulcanized or thermoplastic — Accelerated ageing and heat resistance tests.*

BS ISO 48*, Rubber, vulcanized or thermoplastic. Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

BS ISO 3302-1, *Rubber. Tolerances for products. Dimensional tolerances.*

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

BS ISO 132, *Rubber, vulcanized or thermoplastic — Determination of flex cracking and crack growth (De Mattia).*

BS ISO 1431-1, *Rubber, vulcanized or thermoplastic — Resistance to ozone cracking — Part 1: Static and dynamic strain testing.*

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

BS ISO 2230, *Rubber products — Guidelines for storage.*

BS 3F 69, *Specification for packaging and identification of vulcanized rubber items.*

BS 4250, *Specification for commercial butane and commercial propane.*

BS EN 437, *Test gases — Test pressures — Appliance categories.*

BS EN ISO 13686:2005, *Natural gas — Quality designation.*

3 Performance requirements

3.1 Compound acceptance tests

3.1.1 When the diaphragms are tested in accordance with Clause **8** their properties shall conform to Table 1. Diaphragms shall not exhibit defects as specified in BS ISO 132, grade 3 at any point.

NOTE 1 The purpose of these tests is to supply data values which will be logged for use in later comparative tests and for quality control of subsequent batches. These datum values may be modified by agreement with the gas transporter on the basis of results from subsequent production batches.

NOTE 2 Compound acceptance ensures the compound used is suitable for the manufacture of diaphragms to this standard (compound acceptance).

3.1.2 The accepted nominal hardness and nominal hardness tolerance range, determined in accordance with the appropriate method in BS ISO 48, shall be in accordance with Table 1.

3.1.3 The compound shall be free from reclaimed rubber, vulcanized waste, vegetable oils and factice or any substance which may have a deleterious effect on the performance of the diaphragm or other materials in contact with it.

3.1.4 Flash shall be kept to a minimum, and shall not impair the sealing properties of beaded edges.

3.2 Component acceptance tests

3.2.1 Diaphragms shall be homogeneous, free from porosity and shall have no surface defects or irregularities which could affect their function. The diaphragm assembly shall meet the requirements of the compound acceptance tests specified in **3.1** and dimensions and tolerances shall conform to Clause **4** before being considered for any component tests. When tested in accordance with **3.2.2** and **3.2.3** diaphragms shall not exhibit defects as specified in BS ISO 132, grade 3 at any point.

NOTE 1 Elastomeric diaphragms should not be moulded to a thickness less than 0.2 mm.

NOTE 2 This recommendation is intended to minimize the potential risk of perforation resulting from possible hidden inclusions introduced during manufacture or installation.

NOTE 3 The purpose of these tests is to supply data values which will be logged for use in later comparative tests and for quality control of subsequent batches. These datum values may be modified by agreement with the gas transporter on the basis of results from subsequent production batches.

NOTE 4 Component acceptance ensures the suitability of the diaphragm for a particular application.

3.2.2 All component acceptance tests shall be carried out on diaphragms made from one production batch.

3.2.3 When the diaphragm assembly is tested in accordance with Annex A there shall be no visible damage or deformation.

Table 1 — Outcome of compound acceptance tests

Hardness	**Units**	**Requirements**		
Accepted range of nominal hardness Hardness values shall be determined in accordance with BS 903-A26	IRHD [a)]	46-55	56-65	66-75
Physical tests				
Tensile strength minimum	MPa [b)]	9	9	9
Elongation to break minimum	%	400	300	200
Compression set maximum at 23 °C for 72 h	%	8	8	8
Compression set maximum at 70 °C for 22 h	%	12	12	12
Creep maximum at 23 °C for 7 days	%	8	8	8
Stress relaxation maximum at 23 °C	%	10	10	10
Accelerated ageing (7 days at 70 °C)				
Tensile strength change from original maximum	%	10	10	10
Elongation at break change from original maximum	%	25	25	25
Hardness change from original maximum	IRHD	5	5	5
Liquid B immersion (7 days at 23 °C)				
Volume change maximum	%	35	35	35
Hardness change maximum	IRHD	16	15	15
Tensile strength minimum	MPa [b)]	4	4	4
Elongation at break minimum	%	225	175	125
Water immersion (7 days at 23 °C)				
Volume change maximum	%	25	25	25
Hardness change maximum	IRHD	10	10	10
Tensile strength minimum	MPa [b)]	7	7	7
Elongation at break minimum	%	350	250	150
Desorption (4 days at 70 °C)				
Decrease in volume maximum	%	18	15	13
Low temperature flexibility (–20 °C)				
Relative modulus maximum at –20 °C		1.4	1.4	1.4
Ozone resistance (50 pphm [c)] at 40 °C for 2 days)	No cracks			
Density Density shall be determined in accordance with BS 903-A1	See BS 903-A1			

[a)] IHRD is the International Rubber Hardness Degrees.

[b)] MPa is megapascals and 1 Nm^{-2} = 1 Pa (pascal).

[c)] pphm is the industry accepted standard term for parts per hundred million.

4 Dimensions and tolerances

Dimensions and tolerances shall be in accordance with BS ISO 3302-1, Class M2.

5 Marking

5.1 Where possible (see **5.3**), products conforming to GIS/PL4-1 shall be permanently marked with the following information.

a) the number and date of this standard, i.e. GIS/PL4-1:2018 [1)];

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

c) the manufacturer's contact details;

d) diaphragm batch number;

e) where authorized, the product conformity mark of a third party certification body, e.g. BSI Kitemark;

f) month and year of manufacture (e.g. 12/86).

NOTE This may be colour coded in accordance with BS 3F 69.

5.2 Marking shall not adversely affect the diaphragm either in storage or operation.

5.3 Any markings that cannot be achieved shall be agreed between purchaser and manufacturer or at BSI kitemarking stage.

NOTE There may be difficulties in getting some of these markings on the diaphragm by virtue of the diaphragm physical size, soft material, effect on porosity and sealing properties.

6 Cleanliness

On despatch from the manufacturer, all surfaces shall be visually clean and free from foreign matter when examined with the naked eye under a bright white light. Packaging shall prevent the diaphragms becoming contaminated with foreign matter.

NOTE The presence of a uniform dusting of talc or french chalk is allowable, see Clause **7**.

7 Storage and packaging

7.1 At all stages between manufacture and use, diaphragms shall be stored in accordance with the requirements of BS ISO 2230.

7.2 Diaphragms shall be:

a) dusted with talc or french chalk; or

b) packaged in such a way that they cannot come into contact with each other.

c) In addition:the storage temperature shall be below 25 °C and preferably below 15 °C;

d) vulcanized rubber shall be protected from light, particularly from direct sunlight and strong artificial light with a high ultraviolet content;

[1)] Marking GIS/PL4-1:2018 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.

e) as ozone is particularly deleterious, storage rooms shall not contain any equipment that is capable of generating ozone, such as mercury vapour lamps, high voltage electrical equipment, electric motors or other equipment which may give rise to electric sparks or silent electrical discharges;

NOTE Vulcanized rubber should, wherever possible, be stored in a relaxed condition free from tension, compression or other deformation.

8 Compound acceptance test methods

8.1 Density

Density shall be determined in accordance with and meet the requirements of BS 2781903 Al.

8.2 Tensile strength and elongation at break

Tensile strength and elongation at break, determined in accordance with BS ISO 37 using type 2 dumb-bell test pieces, shall be in accordance with Table 1.

8.3 Compression set

Compression set, be determined in accordance with BS ISO 815, method A using type 1 test pieces, shall be in accordance with Table 1.

8.4 Creep

When tested in accordance with B.4 the 7 day (168 Hour) results for maximum creep shall be in accordance with Table 1.

8.5 Stress relaxation

When tested in accordance with B.5 the stress relaxation shall conform to Table 1.

8.6 Accelerated ageing

When tested in accordance with **B.6** the tensile strength change, elongation at break change and hardness change all from original maximum shall conform to Table 1.

8.7 Liquid immersion

When tested in accordance with **B.7** the volume change maximum, hardness change maximum, tensile strength minimum , elongation at break minimum for liquid B and water shall conform to Table 1.

8.8 Desorption

When tested in accordance with **B.8** the decrease in volume maximum shall conform to Table 1. There shall be no sign of blistering when examined under good illumination.

8.9 Low temperature flexibility

When tested in accordance with **B.9** the relative modulus maximum, calculated from the mean of the three determinations shall conform to Table 1.

8.10 Ozone resistance

When tested in accordance with **B.10** there shall be no cracks in the body of the specimen.

NOTE Small cracks at the edges of the specimen may be ignored.

Annex A (normative)
Component acceptance test: fatigue resistance

A.1 Principle

The suitability of a diaphragm for a particular application required by the gas transporter is determined.

NOTE These tests may also supply data values which can be logged for use in later comparative tests and for quality control of subsequent batches.

A.2 Apparatus

A.2.1 *Diaphragm assembly*, shall be designed and manufactured for the particular application to be tested.

A.3 Test sample preparation

All component acceptance tests shall be carried out on diaphragms made from one production batch.

A.4 Procedure

Cycle the diaphragm assembly over its full stroke and maximum operating pressure range in an assembled control or simulator agreed by the gas transporter for 500,000 cycles at the maximum practical cycling rate. Carry out the test at ambient temperature and humidity.

Annex B (normative)
Compound acceptance tests

B.1 General

All compound tests shall be carried out on one identifiable batch, which may be laboratory produced. These tests shall be carried out at least annually.

NOTE These tests may also be used to supply data values which can be logged for use in later comparative tests and for quality control of subsequent batches.

B.2 Apparatus

B.2.1 *Type 1 test pieces*, in accordance with BS ISO 815.

B.2.2 *Type 2 dumb-bell test pieces*, in accordance with BS ISO 37.

B.2.3 *Bulldog clips*.

B.3 Test sample preparation

Tests shall be carried out using specially moulded sheets or specimens from one identifiable batch of the same formulation, state of cure and method of preparation as the finished diaphragm.

B.4 Creep test

B.4.1 *Principle*

The maximum creep is determined using the constant stress extension method which measures the strain resulting from a fixed stress.

B.4.2 *Apparatus and test samples*

Apparatus and test samples shall be in accordance with **A.2** and **A.3**.

B.4.3 *Procedure*

Creep tests shall be carried out at 23 °C ± 2 °C. Test type 2 dumb-bell specimens in accordance with BS ISO 37 by the constant stress extension method which measures the strain resulting from a fixed stress.

Apply the load to each specimen to produce an elongation of approximately 50%, 30 minutes after the load has been applied.

Apply the load slowly, without oscillation, and spread evenly over the specimens, e.g. by the attachment of bulldog clips to the upper and lower extremities.

Take recorded measurements for three specimens used of extension between 25 mm marker lines to an accuracy of ±0.01 mm.

Take extension readings after 30 minutes (L_1) and after 168 h (L_2).

B.4.4 *Expression of results*

The percentage creep shall be calculated as follows:

$$\text{Creep} = \frac{L_2 - L_1}{L_1} \times 100\,\%$$

Three test specimens shall be used and the result expressed as the mean of the three determinations.

B.5 Stress relaxation test

B.5.1 *Principle*

The stress relaxation is determined by subjecting the specimens to a constant elongation test and then calculation the percentage stress relaxation.

B.5.2 *Apparatus and test samples*

Apparatus and test samples shall be in accordance with **A.2** and **A.3**.

B.5.3 *Procedure*

Stress relaxation tests shall be carried out using type 2 dumb-bell specimens in accordance with BS ISO 37.

Three test specimens shall be used. Subject each specimen to a constant elongation test at 23 °C ± 2 °C using an elongation of 50 mm ± 2%.

Measure the stress after 30 minutes (S_1) and after 168 hours (S_2) by an appropriate method.

B.5.4 *Expression of results*

The percentage stress relaxation shall be calculated as follows:

$$\text{stress relaxation} = \frac{S_1 - S_2}{S_1} \times 100\,\%$$

The results shall be expressed as the mean of the three determinations.

B.6 Accelerated ageing test

B.6.1 *Principle*

The tensile strength change, elongation at break change and hardness of test pieces are determined after ageing in an air oven for 7 days.

B.6.2 *Apparatus and test samples*

Apparatus and test samples shall be in accordance with **A.2** and **A.3**.

B.6.3 *Procedure*

Accelerated ageing test shall be carried out using Type 2 dumb-bell test pieces in accordance with BS ISO 37.

Age the test pieces in an air oven at 70 °C ± 1 °C for 7 days in accordance with method A (the cell oven method) of BS ISO 815.

B.7 Liquid immersion tests

B.7.1 *Principle*

The tensile strength change, elongation at break change and hardness of test pieces are determined after immersion in liquid.

B.7.2 *Apparatus and test samples*

Apparatus and test samples shall be in accordance with **A.2** and **A.3**.

B.7.3 *Procedure*

Liquid immersion tests shall be conducted in accordance with BS ISO 1817, at 23 °C ± 2 °C using the following swell times:

a) liquid B (a 70:30 volume-to-volume mixture of iso-octane and toluene) for 96 hours;

b) distilled water for 168 hours.

Allow the specimens to swell for the time specified in a) and b).Measure the volumetric swell and note the maximum.

Immerse type 2 test pieces in the same liquid for the period corresponding to maximum swell.

Remove each test piece from the liquid, wipe dry and test within 2 minutes, to determine tensile strength, elongation at break and hardness.

Record the volume change, hardness change, tensile strength minimum and elongation at break minimum.

B.8 Desorption test

B.8.1 *Principle*

The desorption of test specimens is determined by measuring volume change following the liquid immersion tests and a period of drying.

B.8.2 *Apparatus and test samples*

Apparatus and test samples shall be in accordance with **A.2** and **A.3**.

B.8.3 *Procedure*

Following the liquid immersion tests, dry the specimens in air for 96 hours (4 days) at 70 °C ± 2 °C. Measure the volume.

B.9 Low temperature flexibility test

B.9.1 *Principle*

The stiffness of specimens is determined at different temperatures and the low temperature flexibility is expressed as the relative modulus.

B.9.2 *Apparatus and test samples*

Apparatus and test samples shall be in accordance with **A.2** and **A.3**.

B.9.3 *Procedure*

Determine the stiffness at 23 °C ± 2 °C in accordance with BS ISO 815.

Three test specimens shall be used.

Cool the same specimens to –20 °C and hold at this temperature for not less than 15 min and repeat the measurement.

B.9.4 *Expression of results*

The results shall be expressed as the relative modulus, calculated from the mean of the three determinations.

B.10 Ozone resistance test

B.10.1 *Principle*

The ozone resistance of the specimens is determined by placing them in an ozone test chamber for 48 hours and then examining for cracks.

B.10.2 *Apparatus and test samples*

Apparatus and test samples shall be in accordance with **A.2** and **A.3**.

B.10.2.1 *Specimen holders,* shall be in the form of grips manufactured from a material, such as aluminium, which neither absorbs ozone nor reacts with it.

B.10.3 *Procedure*

Specimens shall be tested in accordance with BS ISO 1431-1, procedure A.

Specimens shall be cut from material of 2.0 mm±0.2mm thickness, width not less than 10 mm and length not less than 40 mm between grips before stretching. Three specimens shall be tested.

Stretch the specimens to an elongation of 20 % ± 2 %. Store the specimens in darkness for at least 72 hours after curing and then hold in the stretched condition for 72 hours before commencing the ozone resistance test.

Carry out the test with an ozone concentration of 50 pphm ± 5 pphm (parts per hundred million), at a temperature of 40 °C ± 2 °C and with air at a relative humidity of 55%±5%.

Specimens shall not be inserted into the test chamber until the required conditions for ozone concentration, temperature and relative humidity have been reached. After insertion, re-establish the required conditions within 30 minutes.

Remove specimens after 48 hours and examine for cracks.