BS 7531:2006

BRITISH STANDARD

Rubber bonded fibre jointing for industrial and aerospace purposes – Specification

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Publishing and copyright information

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 20, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard was published by BSI and came into effect on 31 October 2006. It was prepared by Technical Committee PSE/2, *Jointing materials and compounds*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes both BS 7531:1992 and BS F 130:1987, which are withdrawn.

Information about this document

This new edition represents a full revision of the standard, and introduces the following principal change:

Expansion of the Scope and amendment to the text to include two grades for use in aerospace applications which were previously covered in BS F 130:1987.

Hazard warnings

WARNING. This British Standard calls for the use of substances and/or procedures that can 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.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is “shall”.

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

Contractual and legal considerations

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

Compliance with a British Standard cannot confer immunity from legal obligations.

The BSI copyright notice displayed in this document indicates when the document was last issued.

1 Scope

This British Standard specifies the requirements for the manufacture, quality and finish, thickness and testing of elastomer bonded compressed fibre jointing materials.

This British Standard provides for four grades as follows:

a) Grades X and Y for general industrial use.

b) Grades AX and AY for use in aerospace applications.

In addition to the definitive requirements, this standard also requires the items detailed in Clause **4** to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be met.

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.

BS 6920-1, *Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water – Part 1: Specification*

BS 870, *External micrometers*

BS 907, *Specification for dial gauges for linear measurement*

BS 3643-1, *Specification for ISO metric screw threads – Part 1: Principles and basic data*

BS EN 10269, *Steels and nickel alloys for fasteners with specified elevated and/or low temperature properties*

BS EN ISO 7500-1, *Metallic materials – Verification of static uniaxial testing machines – Part 1: Tension/compression testing machines – Verification and calibration of the force-measuring system*

DIN 3535-6, *Gaskets for gas supply – Part 6: Gasket materials based on synthetic fibres, graphite or polytetrafluoroethylene (PTFE) for gas valves, gas appliances and gas mains*

BS ISO 1817, *Rubber, vulcanized – Determination of the effect of liquids*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1 jointing
manufactured solid run single-ply material supplied in sheets, from which required shapes can be cut and used for the purpose of sealing mating faces of components from the ingress or egress of fluids

3.2 manufacturing run
amount of jointing all of one grade in units of a maximum of 5 t

3.3 batch of material
single mix of ingredients that is uniquely identified and traceable

4 Information to be supplied by purchaser

The following information to be supplied by the purchaser shall be fully documented. For compliance with the standard both the definitive requirements specified throughout the standard and the following documented items shall be satisfied.

a) the number of this British Standard, i.e. BS 7531:2006 (see **10.1**);

b) for Grades AX and AY the fibre type (see **5.2**);

c) the grade of jointing required (see Scope);

d) the thickness required (see **7.1**);

e) the dimensions of sheets required;

f) the quantity of sheets required;

g) if wire mesh reinforcement is required and, if so the wire material, diameter and mesh size (see **5.3**);

h) if the jointing will or is likely to come into contact with potable water (see **5.4**);

i) if the manufacturer's identification mark is not required to be indelibly marked on the jointing (see **10.3**);

j) for Grades AX and AY if a test certificate is required (see **11.1**);

k) if one or both surfaces shall be treated with a suitable release agent, e.g. graphite (see Clause **6**).

5 Grades and materials

5.1 Grades

For grades AX and AY the binder shall be acrylonitrile-butadiene (NBR) elastomer.

5.2 Material

NOTE Examples of fibres that can be used (singly or in combination) are aramid, carbon and glass.

The material shall consist of fibres and inorganic fillers bonded with a suitable elastomer or blend of elastomers, and shall be manufactured in the form of sheets. The fibres shall be uniformly dispersed throughout the jointing.

For Grades AX and AY the purchaser shall state which fibre type is required.

5.3 Reinforcement

All grades shall be available with or without wire mesh reinforcement.

The purchaser shall state if wire mesh reinforcement is required and the wire material, diameter and mesh size should be specified.

5.4 Contact with potable water

When used under the conditions for which they are designated, non-metallic products in contact with or likely to come into contact with potable water shall comply with the requirements of BS 6920-1.

NOTE 1 Non-metallic products for installation and use in the United Kingdom which are verified and listed under the UK Water Fitting Byelaws Scheme are deemed to satisfy the requirements of this clause. Details of the Scheme are obtainable from WRC plc, 660 Ajax Avenue, Slough SL1 4BG.

NOTE 2 Non-metallic products approved by the Department of the Environment Committee on Chemicals and Materials of construction for use in Public Water Supply and Swimming Pools are considered free from adverse health effects for the purposes of compliance with this clause.

A list of approved chemicals and materials and details of the approvals scheme are available from the Secretary of the Committee at the Department of the Environment, Water Division, Romney House, 43 Marsham Street, London SW1P 3PY.

The purchaser shall state whether, when used under the conditions for which they are designated, non-metallic products come or are likely to come into contact with potable water.

6 Finish

The sheets of all grades of jointing shall be solid run (not laminated), of uniform texture, smooth on both sides and free from irregularities such as blisters, tears and lumps.

The purchaser shall state whether, and which, surfaces shall be treated with an acceptable release agent, e.g. graphite.

7 Thickness

7.1 Nominal thickness

The nominal thickness of all grades of jointing shall be one of the following:

a) 0.4 mm;

b) 0.5 mm;

c) 0.75 mm;

d) 1.0 mm;

e) 1.5 mm;

f) 2.0 mm.

NOTE For any grade of material the compressive strength at elevated temperature decreases with increasing thickness.

The purchaser shall state the thickness required.

7.2 Thickness tolerance

The maximum variation of any sheet from the nominal thickness, and the maximum possible variation in thickness between any points not more than 250 mm apart on a sheet, shall be in accordance with Table 1.

Table 1 **Tolerance for thickness of sheet**

Nominal thickness of sheet mm	**Maximum permissible variation from nominal thickness** mm	**Maximum permissible variation in thickness between points not more than 250 mm apart** mm
0.4 and 0.5	± 0.05	0.05
0.75 and 1.0	± 0.10	0.10
1.5 and 2.0	± 0.15	0.10

7.3 Thickness measurement

The thickness shall be measured with either:

a) a ratchet micrometer complying with BS 870 and having an anvil of 6 mm to 16 mm in diameter. The reading shall be taken after three clicks of the ratchet; or

b) a dial type micrometer complying with BS 907, with a flat pressure foot of not less than 6 mm diameter and a flat anvil of diameter not less than that of the pressure foot.

8 Tests

8.1 Samples

The manufacturer shall select from each manufacturing run for Grades X and Y and each batch for Grades AX and AY, a sample or samples including those treated with release agent, e.g. graphite, where appropriate sufficient to provide the test pieces for one complete series of tests as specified in this clause.

The manufacturer shall carry out tests in accordance with **8.2** to **8.6** for each manufacturing run of each grade of jointing and additionally shall carry out tests in accordance with **8.2**, **8.4** and **8.6** (Oil No. 3 only) for each batch of grades AX and AY.

8.2 Residual stress

The residual stress when determined in accordance with Annex A shall be not less than 25 MPa for grades X and AX or 22 MPa for grades Y and AY.

8.3 Flexibility

When tested in accordance with Annex B in the as supplied condition all grades shall not crack or delaminate.

8.4 Compressibility

NOTE Values for thicknesses of 0.4 and 0.5 mm have been omitted owing to the practical difficulty of making satisfactory measurements.

When determined in accordance with Annex C jointing of 0.75 mm nominal thickness and above shall show a depth of the impression, expressed as a percentage of the original thickness under preload, of not less than 6% for all grades and not more than 14% for grades AX and AY.

8.5 Gas permeability

NOTE Due to the nature of their construction wire reinforced materials are unable to meet this requirement and hence are excluded from this test.

When determined in accordance with Annex D the leakage for non-wire reinforced material shall not exceed 1 ml/min for all grades.

8.6 Resistance to fluids

When tested in accordance with Annex E the materials shall meet the requirements shown in Table 2.

After immersion the samples shall not crack or delaminate when tested in accordance with Annex B nor shall their surfaces show signs of tackiness but discoloration and surface blistering is permitted.

Table 2 **Resistance to fluids**

Fluid	**Oil No. 1 at 150 °C**		**Oil No. 3 at 150 °C**	**Liquid 101 at 150 °C**		**Liquid B at 23 °C**		**Water at 100 °C**
Grade	Thickness increase % max	Mass increase % max	Thickness increase % max	Thickness increase % max	Mass increase % max	Thickness increase % max	Mass increase % max	Thickness increase % max
X and Y	N/A	N/A	20 up to 0.75 mm, 10 above	N/A	N/A	N/A	N/A	15
AX and AY	12	15	20 up to 0.75 mm, 10 above	12	15	12	15	N/A

9 Retest

If any sample fails to comply with the requirements related to any appropriate test, two further samples shall be selected from the same manufacturing run for retesting. If either of the retest samples fails the test the whole manufacturing run of material shall be deemed not to comply with this British Standard.

10 Marking

10.1 Every sheet of jointing shall be indelibly marked with the number of this British Standard and the grade of material, e.g. BS 7531:2006[1)] Grade X.

10.2 Every sheet of jointing to Grades AX and AY shall additionally be marked with its batch number and month and year of manufacture.

10.3 If the jointing is marked with the manufacturer's identification mark this shall be indelibly marked on every 300 mm × 300 mm of the jointing.

The purchaser shall state if the manufacturer's identification mark is not required.

11 Test certificate

11.1 For jointings to Grades AX and AY each batch of material shall be uniquely identified and supplied with a test certificate.

11.2 Where a test certificate is to be provided it shall be worded as follows.

"We hereby certify that the …….. jointing supplied complies in all respects with the requirements of BS 7531, Specification for rubber bonded fibre jointing for industrial and aerospace purposes.

Grade ……."

The certificate shall also state the batch number and month and year of manufacture.

NOTE Except in the case of Grades AX and AY a test certificate is not normally provided.

The purchaser shall state whether a test certificate is required.

1) Marking BS 7531:2006 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

Annex A (normative) Method of carrying out residual stress test

A.1 Principle

The measurement of residual stress after 16 h at 300 °C from an initial stress of 40 MPa.

A.2 Apparatus

A.2.1 The general arrangement and details of the apparatus are given in Figure A.1 to Figure A.3.

Figure A.1 **General assembly of residual stress testing apparatus**

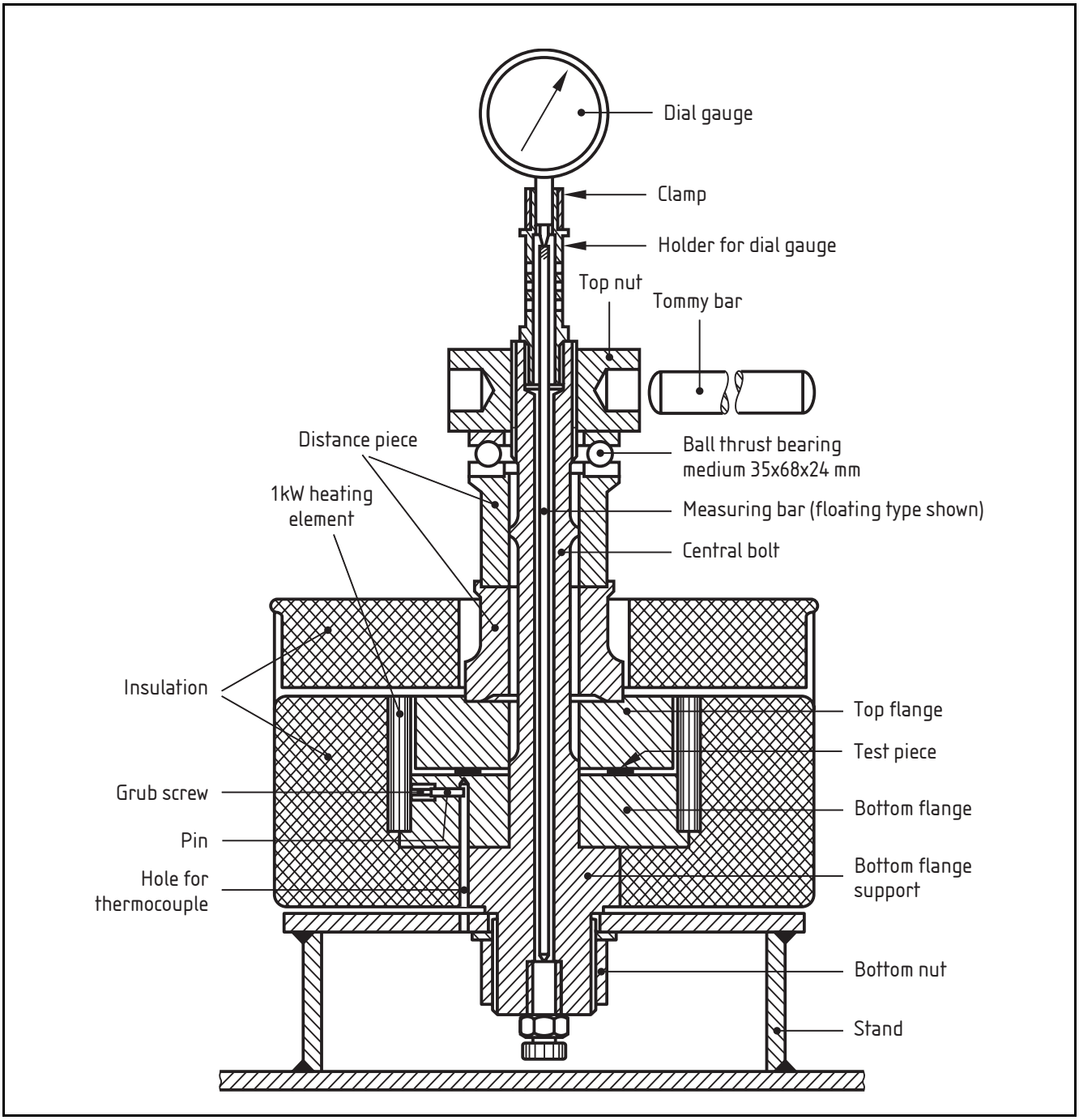
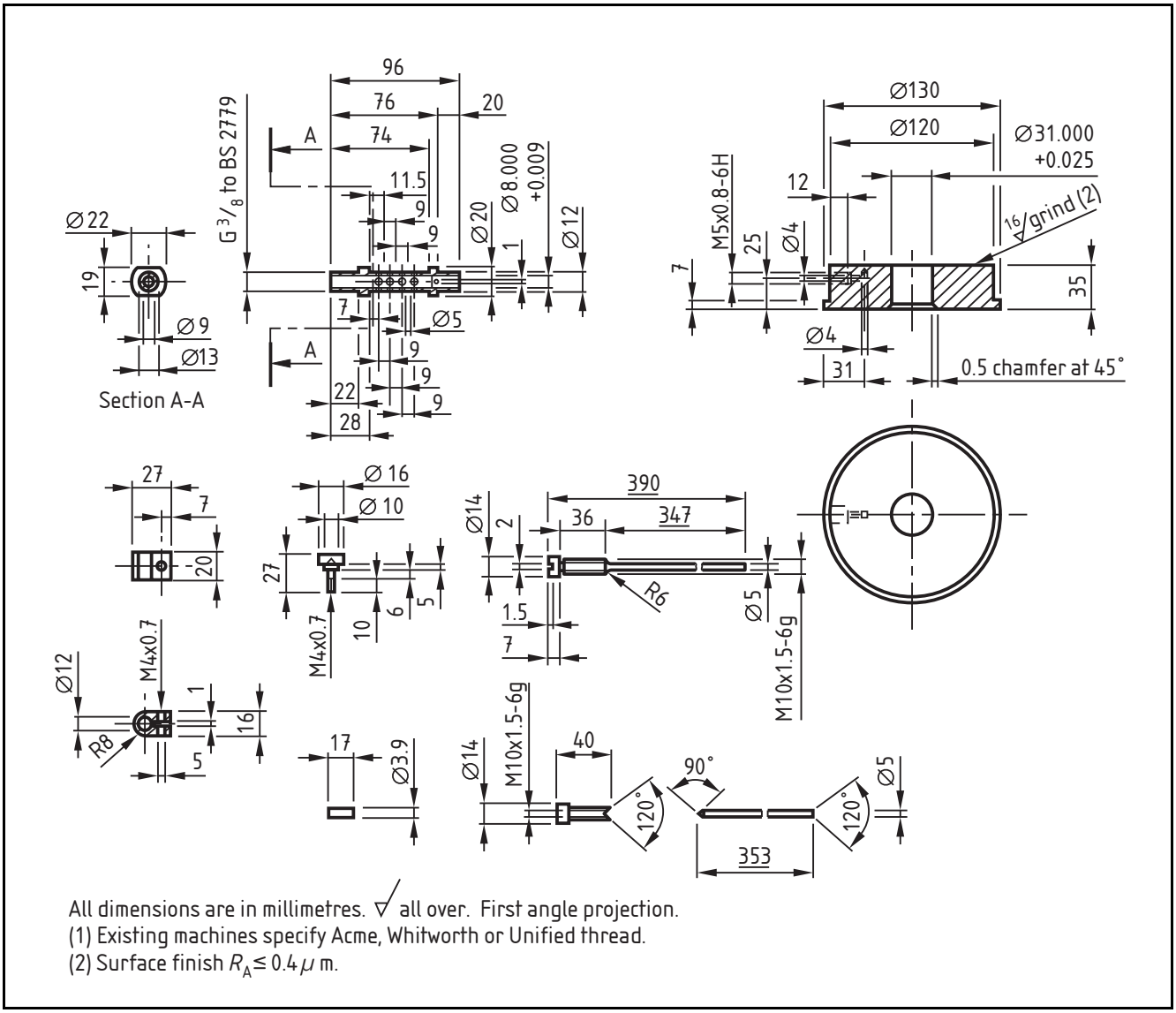
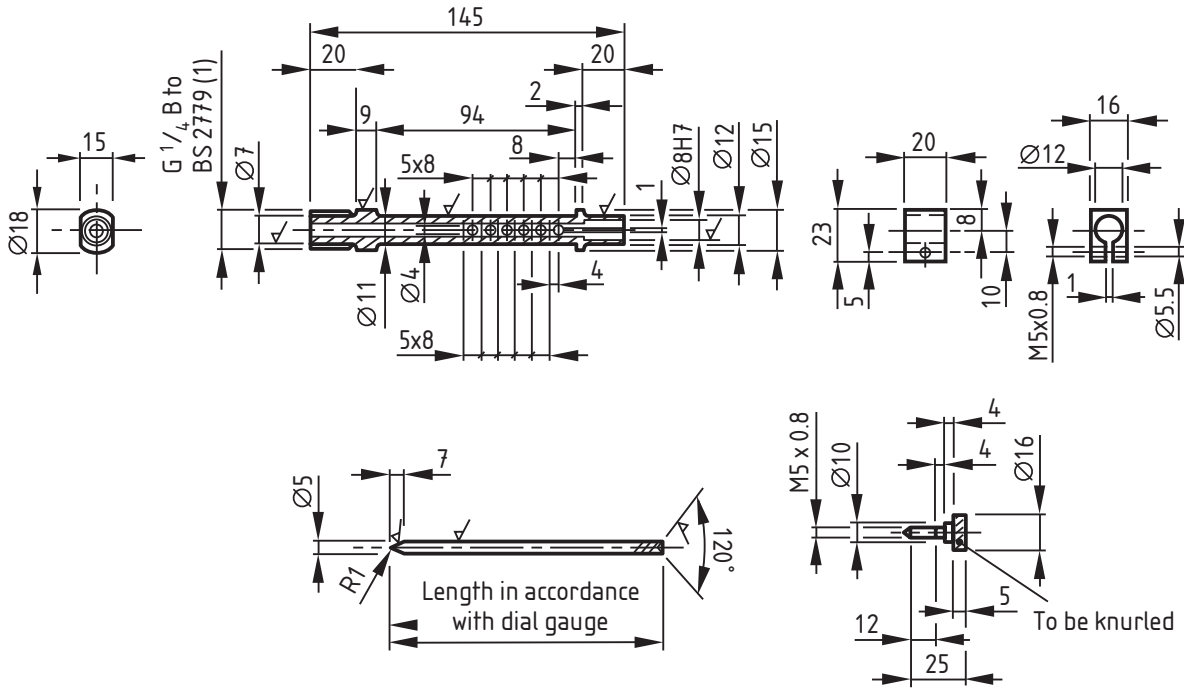


Figure A.2 **Details of residual stress testing apparatus**



All dimensions are in millimetres. ∇ all over. First angle projection.
(1) Existing machines specify Acme, Whitworth or Unified thread.
(2) Surface finish $R_A \leq 0.4 \mu$ m.

Figure A.3 **Details of dynamometer for calibration of residual stress testing apparatus**



All dimensions are in millimetres.

(1) Existing machines specify ACME, Whitworth or Unified thread.

A.2.2 The *central bolt and bottom flange support* are made in one piece. Threads on the bolt are in accordance with Figure A.2 and of ISO metric form to BS 3643-1. The bottom flange is fitted with a thermocouple junction pressed and fixed firmly against the end of the thermocouple hole**.**

NOTE It is recommended that the remaining parts of the apparatus should also be made of this material. The preferred diameter of the central portion of the loading bolt is 19 mm, but this dimension can be adjusted to ensure that the required relationship exists between the stress and bolt extension

A.2.3 The *central bolt incorporating the bottom flange support* is made of steel to BS EN 10269, heat treated to give a hardness of 255 to 310 HB. This shall be measured on the 22 mm diameter section of the bolt. The same steel is used for the distance pieces above the top flange.

A.2.4 *Heating apparatus* capable of giving a uniform temperature rise from room temperature to 300 °C in 1 h and to hold the temperature within ± 5 °C of this uniform rate at any time.

A.2.5 Arrange for the elasticity of the apparatus to be such that the bolt extension (as given by the dial gauge at the top of the apparatus) required to produce an initial stress of 40 MPa[2)] on the gasket, shall be not less than 230 μm and not more than 300 μm.

2) 1 N/mm^2 = 1 MN/m^2 = 1 MPa.

A.2.6 The thermal characteristics of the apparatus are to be such that when a steel ring of the same size as the test piece is used instead of a test piece the maximum stress is within the limits of 43 MPa to 47 MPa. This shall be verified in accordance with Annex G.

A.2.7 The apparatus shall be shielded from draughts or any severe changes in ambient temperature when in use.

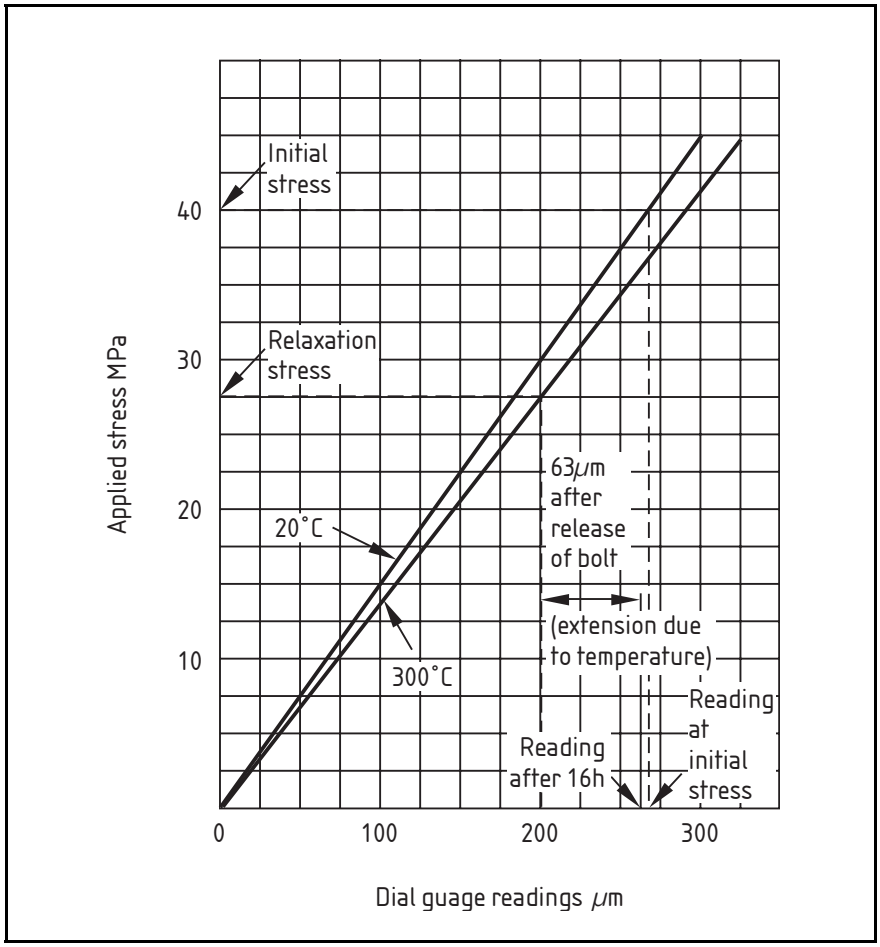
A.3 Calibration of residual stress testing apparatus

NOTE Any calibration method used should ensure that the central bolt is loaded in the same manner as occurs when the apparatus is in use (i.e. the extension is measured between the bottom flange and the top nut).

Calibrate the residual stress testing apparatus (**A.2**) before use and prepare a calibration curve in accordance with Annex F so that the load applied to the test piece can be read at different temperatures as a function of the extension of the central bolt.

Figure A.4 gives a typical calibration curve.

Figure A.4 **Typical calibration curve for residual stress testing apparatus**



A.4 Test pieces

Cut a minimum of three test pieces from1.5 mm thick jointing in the form of an annulus, with an external diameter of 75 mm and an internal diameter of 55 mm. The two diameters are to be concentric and both edges free from projecting fibres.

Condition the test pieces by placing in a desiccator at room temperature for a minimum of 48 h.

A.5 Procedure

NOTE If preferred, thin aluminium foil can also be placed between the flanges and the test piece, and a release agent may be necessary between the foil and the flange.

A.5.1 Rub french chalk or graphite on both sides of the test piece. Assemble the apparatus and place the test piece concentrically between the flanges. Set the dial gauge to zero.

A.5.2 Stress the test piece by tightening the nut (without jerking) to the initial compressive stress of 40 MPa, i.e. by tightening until the dial gauge reading reaches the figure corresponding to 40 MPa on the 20 °C calibration diagram.

A.5.3 Retighten the nut after 5 min to compensate for the relaxation that has occurred.

A.5.4 Press the thermocouple junction firmly against the end of the thermocouple hole.

A.5.5 Switch the heat on and control the rate of heating to give a uniform temperature rise from room temperature to 300 °C in 1 h.

A.5.6 Commence the timing of the test after the apparatus has reached a stable test temperature of 300 °C.

Maintain the test temperature at 300 ± 5 °C for 16 h.

A.5.7 Record the dial gauge reading again at the end of the 16 h.

A.5.8 Release the tension and immediately record the dial gauge reading.

A.5.9 Switch the heat off.

A.5.10 Repeat the above procedure for each test piece.

A.6 Evaluation

The difference between the dial gauge readings (in micrometres) at the end of the test (see **A.5.7**) before and after releasing the tension (see **A.5.8**) is used to obtain the residual stress value (in MPa) from the calibration diagram (see Figure A.4, which is marked to show the value obtained from the example given in the test report in **A.7**).

A.7 Test report

An example of the required test report is given in Table A.1.

Table A.1 **Residual stress: Test report**

Manufacturer		Messrs. X		
Jointing		BS 7531: Compresses non-asbestos fibre		
Grade		X		
Batch number		10277		
Nominal thickness of test piece		1.5 mm		
Dimensions of test piece		55 mm bore; 75 mm outside diameter		
Test temperature		300 °C		
Room temperature		20 °C		
Duration of test		16 h		
Initial stress		40 MPa		
		1	2	3
Readings of dial gauge (μm)	At initial stress and 20 °C (a)	269	269	269
	After 16 h at 300 °C (b)	265	265	265
	After releasing tension at 300 °C (c)	63	65	63
Difference of readings (b) and (c) (μm)		202	200	202
Residual stress of the jointing (MPa) (from calibration diagram)		27.72	27.45	27.72

Annex B (normative) Method of carrying out flexibility test

B.1 Principle

Evaluates the ability of the material to be bent without cracking, delamination or other signs of distress.

B.2 Apparatus

B.2.1 *Mandrel*, with a diameter of 12 times the nominal thickness of the material.

B.3 Test piece

The test piece shall consist of a strip 12.5 mm wide and 150 mm long, cut with its longitudinal axis at right angles to the direction of rolling of the sheet.

B.4 Procedure

B.4.1 Bend the test piece, at room temperature, through an angle of 180° around and normal to the axis of the test mandrel, taking no more than 2 s. The force used shall be just sufficient to hold the test piece in contact with the mandrel.

B.4.2 Hold the test piece in the bent position around the mandrel for 10 s and examine it visually.

B.4.3 Repeat **B.4.1** and **B.4.2** on a different section of the strip but with the other face of the material in contact with the mandrel.

Annex C (normative) Method of carrying out compressibility test

C.1 Principle

The depth of impression in the material caused by an indentor (**C.2.2**) is measured under a constant load and expressed as a percentage of the original thickness.

C.2 Apparatus

C.2.1 *Hardened and ground steel anvil*, with a minimum diameter of 30 mm.

C.2.2 *Cylindrical steel indentor*, of 6.4 ± 0.025 mm diameter with the cylinder end hardened and ground and guided normal to the surface of the anvil.

C.2.3 *Indicating gauge*, or gauges graduated in 0.005 mm to show the thickness of the specimen during the test.

C.2.4 *Preload*, including the weight of the indentor itself and added weights to give a preload of 22.2 ± 0.3 N.

C.2.5 *Loading device*, for applying the major load of 1 112 ± 11 N (including the preload) in a controlled manner to the indentor.

C.3 Test piece

Cut from the sample a minimum of three test pieces each in the form of a square having a minimum surface area of 6.5 cm^2. Each test piece consisting of a single thickness or a number of superimposed thicknesses to give a minimum nominal thickness of 1.5 mm.

C.4 Conditioning

Condition the test pieces by the following controlled heating and cooling. Heat the test pieces for 1 h in an oven maintained at 100 ± 2 °C, remove and place in a desiccator for a minimum of 1 h to cool to ambient temperature.

C.5 Temperature of test

Conduct the test with both specimen and apparatus at a temperature of 20 ± 5 °C.

NOTE Current ASTM standards (ASTM F36-99) require that the test should be conducted with both specimen and apparatus at a temperature of 21 °C to 30 °C.

C.6 Procedure

Centre the test piece on the anvil (**C.2.1**) in the loading device (**C.2.5**) so that no edge is nearer than 5 mm to the outside diameter of the indentor and fit the indentor (**C.2.2**) and gauges (**C.2.3**) and apply the preload (**C.2.4**) and maintain for a period of 15 s and record the preloaded thickness of the test piece.

Immediately apply the major load in a slow, uniform manner so that the total load is obtained within 10 s.

Maintain the total load for a period of 60 s and record the thickness of the test piece. Carry out this procedure on each test piece and carry out a minimum of three tests.

C.7 Result

Calculate the difference between the indicating gauge(s) reading for each test and express this depth of impression as a percentage of the preloaded thickness of the material. Report the average of the three results.

Annex D (normative) Method of carrying out gas permeability test

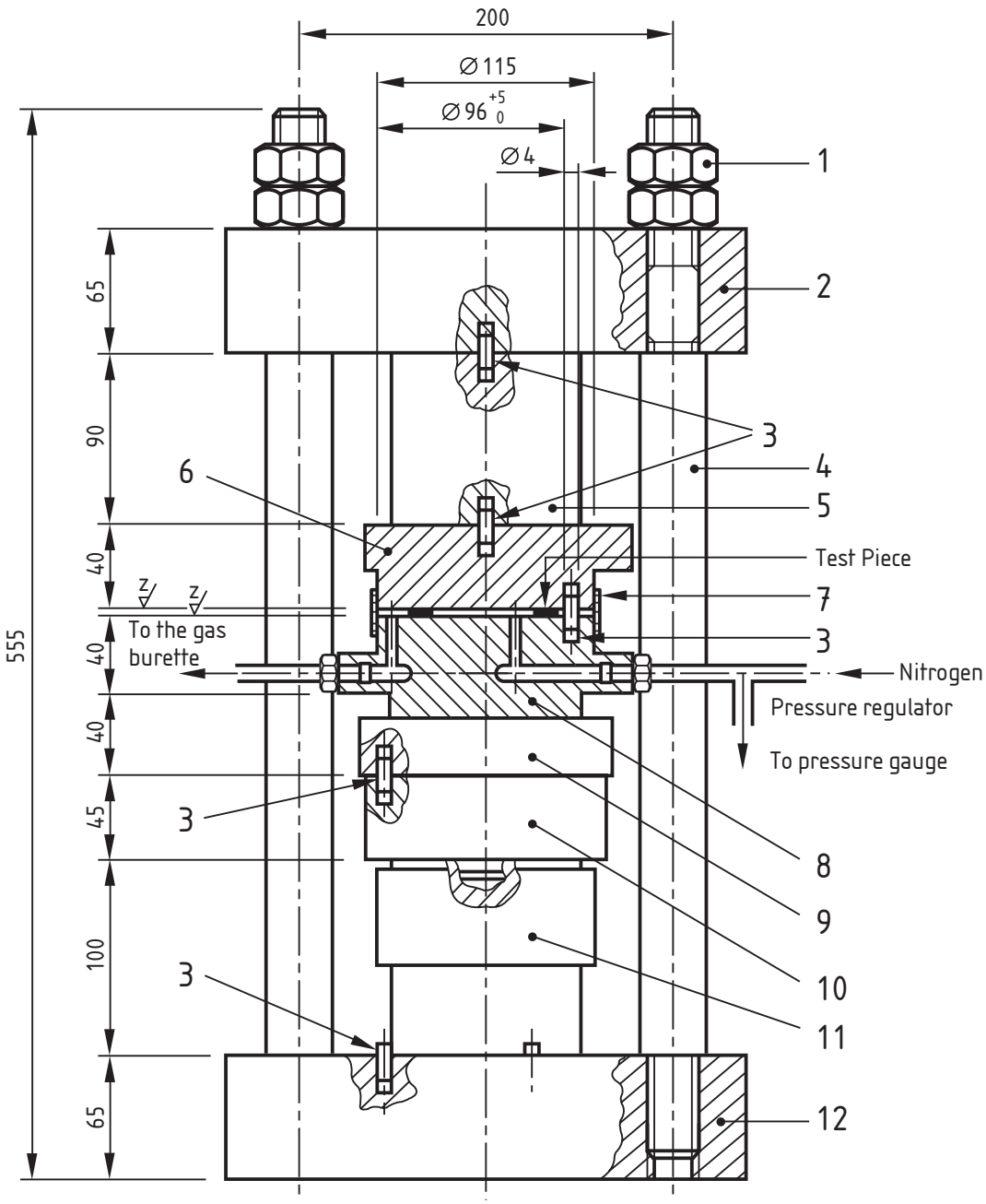
D.1 Principle

This test assesses permeability properties of a gasket material at ambient temperature. The method indicates a measure of gas leakage through the body of the gasket.

D.2 Apparatus

The test apparatus is as specified in DIN 3535-6 (see Figure D.1 for a typical layout). All parts including the test piece are centred relative to each other. Suitable measures are taken to ensure that the test piece is uniformly loaded. The surfaces of the two sealing flanges shall be machined so that the mean roughness (R_z) as defined in BS 1134-1 does not exceed 2 μm.

Figure D.1 **Typical layout of test apparatus for gas permeability**



All dimensions are in millimetres.

Key

1	Nut	5	Spacer block	9	Dynamometer with ball joint
2	Cross piece	6	Flange	10	Spacer block
3	Parallel pin	7	Rubber packing	11	Hydraulic press
4	Pillar	8	Flange	12	Baseplate

D.3 Test piece

The specimen is of annular form with an outside diameter of $90\,^{+0}_{-1}$ mm, width of $20\,^{+0}_{-1}$ mm and thickness $1.5^{+0.15}_{-0.15}$ mm. Test specimens are stored for at least 48 h at 50 ± 6% relative humidity at 23 ± 2 °C.

D.4 Test medium

Nitrogen gas of pressure 40 ± 1 bar[3)].

D.5 Test method

D.5.1 Place a 0.05 mm thick ring of polythene film, of the same dimensions as the specimen on both sides of the specimen. Centre the specimen and film between the compression plates after the plates have been carefully cleaned.

D.5.2 Load the specimen uniformly with a stress of 32 MPa.

D.5.3 After 10 min during which time the tightness of the gas leakage measuring device is to be checked, introduce nitrogen gas inside the ring. Ensure the pressure increase is uniform and the final internal pressure is 40 1 bar.

D.5.4 Hold the pressure of 40 ± bar for 4 min. After a further 2 h measure the quantity of gas escaping for a period of 10 min.

D.6 Test result

Express the gas permeability in ml/min as the mean value obtained from measurements on three specimens.

Annex E (normative) Method of carrying out resistance to fluids tests

E.1 Principle

Measuring the thickness and/or weight of the conditioned test pieces before and after immersion in the test fluid gives a gain in thickness and/or weight from which the absorption can be determined as a percentage of the original value.

E.2 Apparatus

E.2.1 *Oven*, capable of maintaining temperatures up to 150 ± 2°C.

E.2.2 *Desiccator*, containing dry silica gel.

E.2.3 *Thickness measuring instrument*, in accordance with **7.3**.

E.2.4 *Covered vessel*, for water tests maintained at 100 °C.

E.2.5 *Weighing scales*, capable of an accuracy of ± 0.001 g.

E.2.6 *Test fluids*, as follows:

a) For all grades; Oil No. 3 (IRM 903) as defined in BS ISO 1817.

b) For grades X and Y; demineralized water.

c) For grades AX and AY; Oil No. 1 (ASTM Oil No. 1), Liquid 101, Liquid B all as defined in BS ISO 1817.

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3) 1 bar = 10^5 N/m^2 = 1 kPa.

E.3 Test pieces

E.3.1 For Oil No. 3 and Water

For each test three pieces of material shall be cut, free from projecting fibres of dimensions 50 mm × 25 mm with the longitudinal axis running in the direction of rolling of the sheet.

E.3.2 For Oil No. 1, Liquid 101 and Liquid B

For each test one piece of material shall be cut, free from projecting fibres of dimensions 150 mm × 12.5 mm with the longitudinal axis running perpendicular to the direction of rolling of the sheet.

E.4 Conditioning

Condition the test pieces by heating for 1 h (± 5 min) in the oven maintained at 100 ± 2°C. Remove the test pieces and place in the desiccator for a minimum of 1 h to cool to ambient temperature.

E.5 Procedure

E.5.1 Measure and record the thickness of the test pieces and where necessary (see Table 2) weigh to the nearest 0.001 g and record the mass.

E.5.2 Immerse the test pieces in sufficient volume of the test fluid to ensure complete immersion throughout the test and keep each test piece separate. For the water test use a covered vessel.

Place the immersed test pieces in the oven (except for Liquid B test) and maintain at the test temperature for the test period as shown in Table E.1.

E.5.3 At the end of the test period remove the test pieces and allow to cool to below 25 °C for the period shown in Table E.1.

E.5.4 Lightly blot the surfaces of the test pieces and measure and record the thickness and where required the mass. In the case of Liquid B this shall be done within 20 s of removal from the fluid.

E.6 Calculation

Calculate the increase in thickness and, where required, the mass and report the gain as the average of the determinations expressed as a percentage of the original value.

Table E.1 **Resistance to fluids test conditions**

Test fluid	**Test temperature** (°C)	**Test duration**	**Cooling time**
Oil No. 1	150 ± 2	22 h ± 2 h	30 min
Oil No. 3	150 ± 2	5 h +20/-0 min	30 min
Liquid 101	150 ± 2	22 h ± 2 h	30 min
Liquid B	23 ± 2	22 h ± 2 h	20 s
Water	100 ± 2	5 h +20/-0 min	15 min

Annex F Method of calibration of residual stress testing apparatus

F.1 Apparatus

F.1.1 *Residual stress testing apparatus*, as detailed in Annex A.

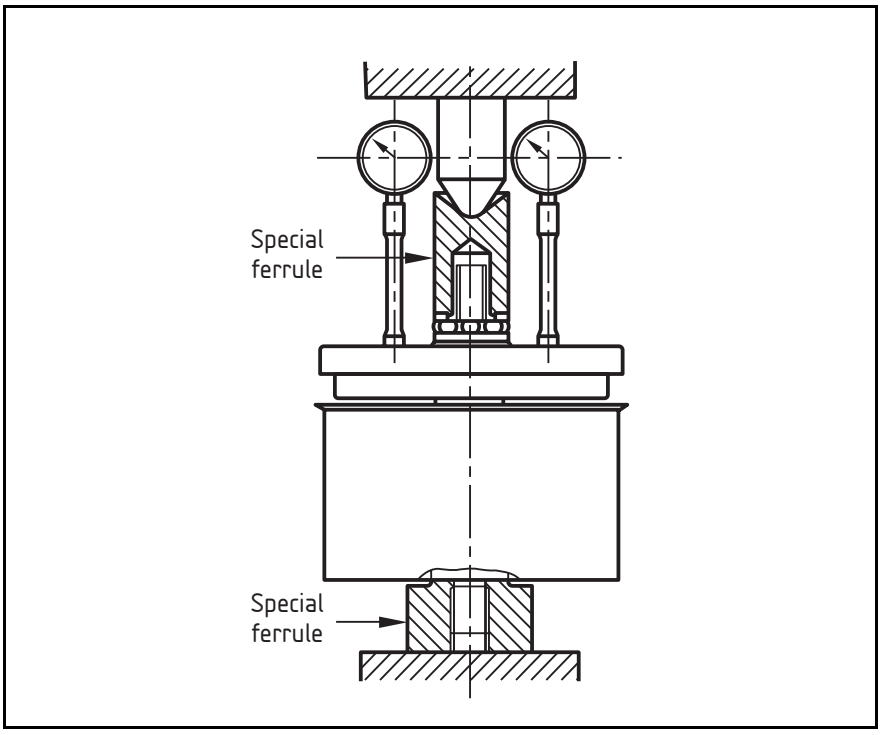
F.1.2 *Special disc dynamometer*, with dial gauges and special loading ferrules for the residual stress testing apparatus (Figure A.3).

F.1.3 A *loading device*, complying with the requirements of EN ISO 7500-1 with sufficient distance between the platens to allow the apparatus to be calibrated.

F.2 Calibration of the disc dynamometer

F.2.1 Fit the disc dynamometer (**F.1.2**) to the residual stress testing apparatus (**F.1.1**) in place of the upper distance piece. Replace top and bottom nuts by special ferrules (Figure F.1).

Figure F.1 **Arrangement for calibration of dynamometer at increased temperatures**



F.2.2 Place the apparatus in the loading device (**F.1.3**).

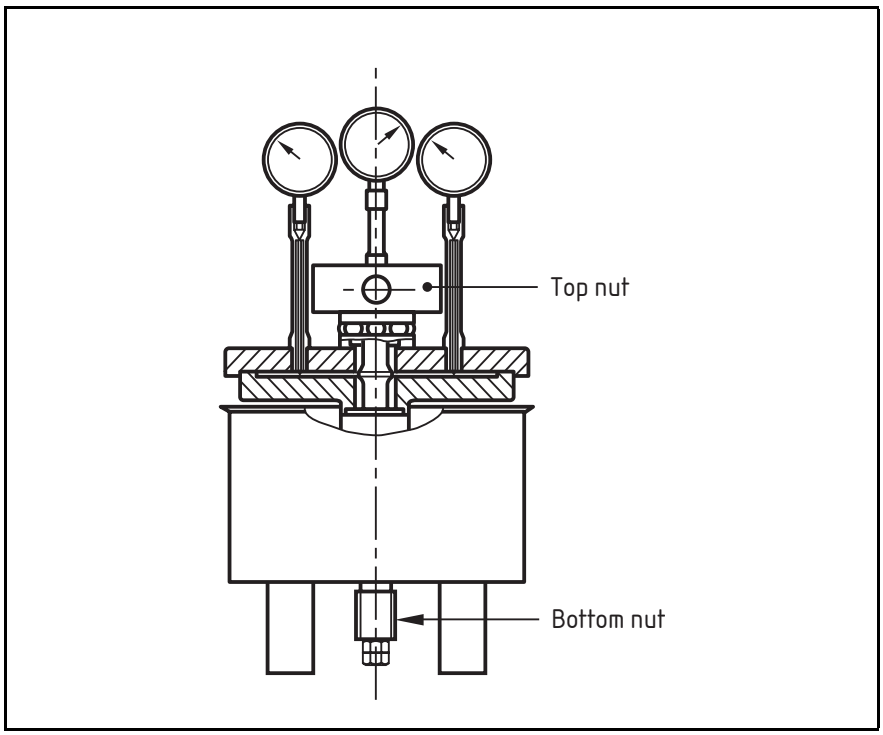
F.2.3 Apply loads at room temperature in suitable increments up to a maximum of 103 kN. Record load against dial gauge readings. Remove the load.

F.2.4 Allow the apparatus to heat up to 300 °C as recorded by the thermocouple and wait 1 h for it to stabilize at this temperature. Repeat the calibration procedure in **F.2.3**.

F.3 Calibration of the residual stress testing apparatus

F.3.1 Re-assemble the apparatus, fitted with the disc dynamometer and top and bottom nuts, legs and centre bolt dial gauge (Figure F.2).

Figure F.2 **Dynamometer**



F.3.2 Apply a series of loads with the top nut at room temperature to give dial gauge readings on the disc dynamometer corresponding to those obtained in **F.2.3**. Record load against centre bolt dial gauge readings.

F.3.3 Allow the apparatus to heat up to 300 °C as recorded by the thermocouple and wait 1 h for it to stabilize at this temperature. Repeat the calibration procedure in **F.3.2**.

F.3.4 Plot gasket stress/dial gauge reading to give the working calibration curve as shown in Figure A.4 from the information obtained in **F.3.2** and **F.3.3**.

Annex G Method of test to determine maximum stress value

G.1 Apparatus

G.1.1 *Steel ring*, an annular steel ring of the same size as the test piece.

G.1.2 *Residual stress testing apparatus*, as detailed in Annex A.

G.2 Procedure

G.2.1 Calibrate the residual stress testing apparatus (**G.1.2**) in accordance with **A.1**.

G.2.2 Place the steel ring (**G.1.1**) between the compression flanges on the residual stress unit, assemble the apparatus and set the dial gauge to read zero.

G.2.3 Switch on the heater, without the application of load and allow the temperature to increase uniformly to 300 °C in 1 h. Record the dial gauge readings every 5 min throughout the test period (i.e. from the time of switch on) and plot these against suitable time/temperature scales.

G.2.4 Allow the apparatus to cool to room temperature, apply a load by means of the loading nut to give a stress of 40 MPa and repeat the heating procedure detailed in **G.2.3** again recording dial gauge readings every 5 min.

G.2.5 Subtract dial gauge readings obtained in **G.2.3** from those resulting from **G.2.4** and relate the subsequent data to units of stress by reference to the appropriate calibration curves.

NOTE 1 The temperature at the point of maximum stress is normally less than 300 °C. Therefore it is necessary to interpolate the appropriate stress values from the two calibration curves obtained at room temperature and at 300 °C.

NOTE 2 The maximum stress value on a steel ring usually occurs some 50 min after the commencement of the test (i.e. 10 min before the maximum temperature recorded by the thermocouple reads 300 °C).

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